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Collective efficiency and commons in local productive systems

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Abstract. This paper goes back to the topic of collective efficiency (CE) in local productive systems and paths of territorial development. In general terms, such CE needs the integration of markets mechanisms with systemic conditions that have nature of public goods. The discussion of an extended framework of specific public-like goods helps unearthing related important commons' features, as the involvement of communities of local agents may be implied in their provision, use, and regulation. The paper aims at giving a solid foundation to the study of such features, and to show how the same foundation helps shedding light on various topics related to CE, commons, and territory.

Key words: collective efficiency, local productive systems, industrial districts, territorial development, specific public goods, commons

1 Introduction

The paper focuses on the relations between commons, local productive systems, and territorial development. A local productive system (LPS) is a place (or milieu) identified by the active daily overlapping of familial, civic, business and work experiences; and characterised by a prolonged and evolving presence of one or several localized industries (e.g. Dei Ottati 1994, Kebir et al. 2017).

Collective efficiency (CE) is at the core of healthy and autonomous paths of development in LPS, i.e. a class of territorial development. Unhealthy paths are based on pure exploitation of labour and natural resources; non-autonomous paths depend on the strategies of external and/or dis-embedded agents (Garofoli 2002). CE includes various forms of external economies and economies of joint action (Schmitz 1999), and refers in general to the differential and non-easily transferable realization of the advantages of a technical division of labour by means of a social division of labour, where the contributions of independent specialized firms, embedded within the LPS, complement in coordinated ways (Konzelmann, Wilkinson 2017). Market exchanges link the specialised contributions, but transactional and strategic difficulties hinder an effective integration if a joint access to public-like goods does not help (Brusco 1992, Amin 1994, Bellandi 2006, Crouch et al. 2004).

The paper goes back to this kernel of the literature on LPSs, industrial districts, and local development[1]. Firstly, it proposes a systematization of the kernel throughout an

[1] Industrial districts are a class of LPS whose main industries are characterized by a dense population of largely local specialized small and medium sized enterprises (Becattini 1990).

extended and unifying framework of related public-like goods built upon the classical matrix of Ostrom (2009). The frame allows looking at deep (i.e. sunk in more self-evident characters) 'commons' features. They refer to conditions where the LPS agents enjoying easy access to the public-like goods also support, in various ways and at different institutional levels, their provision and regulation. Indeed, a recent stream of research on industrial, cluster or innovation commons has already started to look at such features (Pisano, Shih 2009, Solvell 2015, Allen, Potts 2016, Jeannerat et al. 2017). This paper aims precisely at giving a solid foundation to the study of the same features, thanks to both the framework on public-like goods in LPS and the fertilization with concepts taken from core research on commons (e.g. Ostrom 2009). We will see how such a foundation helps to shed light on various related topics, such as the complex complementarities of individual, collective and public action at the root of CE in LPSs, the hindering factors that hit such complementarities and weaken CE, and the role of territory within multi-scalar evolutionary relations. References to case-studies in the LPS literature will help the conceptual articulation.

Following this, Section 2 recalls the sources of CE and how they need the integration of local and non-local markets with systemic conditions that have nature of public goods. Section 3 extracts a classification of public-like goods from the previous section and points out their specificity to CE in LPS. Section 4 identifies the commons' features of such public-like goods and relates their forms of provision and regulation to CE. Section 5 proposes an integrated foundation, i.e. the networked ecology of commons, which helps broaden the discussion to evolutionary questions. The paper does not enter the general debates on agglomeration economies in urban and regional sciences (Duranton, Puga 2004). Nonetheless, the conclusive Section 6 presents some related implications, together with suggesting routes to policies of territorial development and feedbacks to the literature on commons.

2 Collective efficiency and systemic conditions in LPS

Resounding classical Smithian thinking on the advantages of division of labour, a stream of contributions from Alfred Marshall (1927), on external economies in industrial districts to contemporary regional and urban studies, elaborates concepts on CE in LPS[2]. This section starts from a summary of the main fields of potential CE advantages and their traditional classification as specialisation, learning, and creativity economies.

2.1 Fields of CE in LPS

Firstly, in specialization economies, the advantages come from the efficient use of an extended and differentiated bundle of specialised production capacities already in place for the realization of complementary productive activities. The advantages include the sharing of resources that present an indivisible capacity of production, covering cases of both large infrastructures and combinations of multiple resources with smaller yet significant indivisibilities. The advantages also extend to the matching of differentiated needs and capacities in complementary productive activities, covering cases of both intra-industry organization of comparative advantages and massed reserves of non-routine service capacities or spare parts supplying lines with non-correlated risks.

Secondly, the collective development of human capital is supported by learning by interacting, which increases the impact that learning by doing and using has within the specialized firms of a LPS. This favours the adaptation of complementary know-hows and specializations to the evolving division of labour, as well as the matching of demand and supply of differentiated productive competences. Convergent educational

[2]The roots and fields of Marshallian external economies have been discussed for example by Robinson (1958), and since 1979 by Becattini (1990) and other neo-Marshallians trying to understand increasing returns in industrial districts (Konzelmann, Wilkinson 2017). Related concepts resonate for example in the classification of sharing, matching, and learning advantages of agglomeration in economic geography and spatial analyses (Duranton, Puga 2004), as well as in research on innovative milieus, local production systems, regional and national innovation systems, business clusters etc. (e.g. Kebir et al. 2017, Jensen et al. 2007).

investments complement the specific class of learning that develops from interactions of skilled producers (workers, entrepreneurs) with young people within families and other out-of-work encounters.

Thirdly, a rich variety and sequencies of novelty in technologies, organization, products/services emerge from a dense interplay between exchanges of complementary products/services and matching of ideas, within an open population of competent specialised producers helped by convergent investments in formal knowledge development, appropriation, and channels of external knowledge. This is the creative side of collective processes of learning by doing, using, and interacting.

2.2 CE and the communitarian market

An effective exploitation of the advantages mentioned above implies high levels of coordination and alignment of incentives among independent specialized economic and social agents. Competition and market mechanisms have an important role. Yet the evolving fine-grained division of labour is only partially regulated by general markets. Particular markets with small number of local actors and networks of relational contracts impregnated by information asymmetries and uncertainties are instead the norm (Dei Ottati 1994). The density of transactions within the agglomerated context of a LPS tend to reduce such problems. However, in many competitive contexts of LPSs, as for examples those featuring high level of variety/variability in demand of final users and a flexible quasi-decomposability of production processes (Salais, Storper 1992), the weight of transactions costs and/or non-regulated external effects could overwhelm the potential returns from specialization and division of labour and cancel CE results.

On that point, exemplary cases referred to successful Italian IDs in the last decades of the 20th century have highlighted the crucial role of a particular endowment of constructive attitudes encompassing the local actors in reducing transaction costs and externalities. It is a nexus that includes a shared bent towards trust in reciprocal exchanges, a diffuse attitude towards productive and innovative (vs. distributive or rent seeking) entrepreneurship and pro-activity of workers on the job, and a cognitive proximity or similarity of some basic knowhow (Becattini 1990). The frame of local markets at the core of the LPS division of labour, as combined with such a nexus, was termed a "communitarian market" (Dei Ottati 1994). We will come back later to its nature as a fundamental commons.

2.3 The need for goods with public-like features

Though fundamental, the pure combination of the constructive nexus with a dense frame of local markets is not enough for static and dynamic efficiency in LPS. Local product, service, and labour markets presuppose the effective provision or support of fine-tuned systemic conditions (Schmitz 1999). The need of such a provision/support corresponds to an explicit or implicit demand for goods with public-like features.

For example, within teams of firms tied by long term joint strategies, they are intangible goods, such as patented or private knowledge on innovative products and processes, private access to common financial or market channels, quality certification; or tangible goods, such as tools with high indivisible capacity.

At the local markets and LPS-wide industrial level, tangible infrastructures include focused vocational and professional schools, centres for collective market and technological services, specialized fairs, university-industry joint laboratories, etc. Intangible goods include agreements for orientating the definition or the adaptation of prices and contracts in crucial local transactions, technical standards and jargons, rules on socially acceptable imitation and bankruptcy, district trademarks of origin, fair labour and green performance labels, etc. The same pool of know-hows and R&D knowledge invested by the LPS firms is an intangible systemic condition, supporting learning and creative economies, insofar as it is the untraded stock from which productive knowledge circulation selectively spill overs within the LPS context[3].

[3]It may be seen as a case of "non-depletable multilateral externalities" (Mas-Colell et al. 1995, pp. 366–367), where the returns for each single agent in a set of n depend also on the access to a "good" that is not traded being the joint result of the n agents' investment or trade actions.

At the LPS-wide social and territorial level, various types of goods with public characters represent the ordinary target of urban planning. They are built and landscape heritage; green and other environmental resources; mobility and ICT infrastructure; logistic, industrial, and technological parks; collective water purifiers and other utilities, local social services, etc. (Venables 2018). Of course, this set could be seen as just related to the support to generic agglomeration economies of urbanization and/or to the reduction of territorial congestion costs. Nonetheless, its adherence to the need of the local division of labour may have a great relevance[4].

The continuous change in local and non-local contexts, under the influence of broad market, and technological, social and political tendencies, adds to the need for frequent adaptations to the structure of fine-tuned systemic conditions.

3 Public goods specific to CE in LPS

The following subsection proposes a matrix that lends a concise summary of the types of public goods introduced in Subsection 3.2, according concepts that the LPS literature has applied to understand their nature.

3.1 Types of goods exchanged in LPS

Elaborating on a matrix proposed by Elinor Ostrom allows to classify the different types of goods supporting CE in LPS (Table 1).

The matrix helps discuss in what sense the public-like goods in a LPS may be not just local as much as 'specific' to its differentiated features and related to a commons' nature.

3.2 Local collective competition goods

The concept of "local collective competition goods" (Crouch et al. 2004) directly expresses the relation between CE and classes of public-like goods[5].

What is the function or nature of the "local" qualification here? Some examples give a hint. First, "dress design firm located in a dynamic fashion district will benefit without cost from the tacit knowledge about new fashion concepts that circulate in the informal discourse of the district. A firm located remotely from any other firms in the sector will probably have to buy these ideas from consultants" (Crouch 2006, pp. 320–321). Second, "several decades of major military research contracts directed by the US Defense Department to southern California produced the rich scientific environment from which today's biopharmaceuticals and information technology industries grew" (ibid).

An "untraded" stock of knowledge (Table 1, I quarter) appears crucial, and more easily accessed and/or released and/or applied in a local context (Storper 2009). Similarly, the concept of "industrial commons" includes R&D know-how, development skills, manufacturing competencies and equipment, related to a specific technology and geographically rooted, especially in industries intensive in design or technological development (Pisano, Shih 2009). Development of technical and scientific knowledge needs face-to-face contacts and hopping of skilled and creative people, which for most workers is local (ibid). All this resounds the Marshall's "industrial atmosphere".

Other examples of local collective competition goods tell us about the application of specific institutional knowledge (Table 1, II quarter): "local government – and political parties – are nearly always involved in providing various resources [in industrial districts]:

[4] A well-known case concerns the constitution of a huge collective system of industrial water purification in the tanning district of Santa Croce sull'Arno, Tuscany, Italy (Amin 1994). A classic example at the beginning of the first industrial revolution was the central power facility supplying mechanical energy by a system of belts to a set of nearby manufacturing machines. In the contemporary ICT fields, it could be an extended digital facility, supplying enterprise resource planning, collaborative knowledge and innovation networks, branding methods, appropriate quality certification, integrated logistical solutions, trade channels and credit, etc. (Götz 2019).

[5] More precisely, "A competition good is a good, the acquisition of which assists a firm's competitiveness" ... "Collective competition goods are those competition goods that a firm does not have to buy in the market, but which it receives as club goods or as public goods" ... "Local collective competition goods identify those where the locality, rather than national, or sectoral, or some other level is involved in their provision" (Crouch 2006, pp. 320–321).

Table 1: Examples of types of products and services in LPS

		Subtractability of use	
		High	Low
Difficulty of excluding potential beneficiaries	High	**IV** *Common pool resources*: built and landscape heritage; green and other environmental resources; mobility and ICT infrastructure; local social and health services	**I** *Public goods*: cooperative nexuses; untraded stock of productive knowledge; rules on prices and contracts within local markets; technical and trade standards and rules; district trademarks of origin, fair labour and green performance labels; place or cluster certifications
	Low	**III** *Private goods*: specialized intermediate products and business services; professional labour and entrepreneurial services; financial services; technical capital goods; transport fleets; company patents and trademarks	**II** *Club or Toll goods*: restricted joint knowledge on innovations and financial or market channels; focused vocational and professional schools; specialized fairs; university-industry joint laboratories; industrial and technological parks; collective water purifiers and other utilities

Source: Elaboration by the author on Ostrom (2009, p. 413).

direct services (servizi reali), such as assistance with design techniques or marketing; or the establishment of the image and brand of the town as a famous centre for the product concerned" (Crouch 2006, pp. 320–321). The same concept of "cluster commons" is meant to identify meeting spaces at the core of cluster initiatives, favouring the collective use of untraded stocks of knowledge (Solvell 2015)[6].

Summing-up, it is not a generic 'urban' characteristic of public goods that supports CE in LPS, neither is just their use by localized 'sectoral' specializations[7]. It is their relation to a technical and social division of labour that has a specific territorial and sectoral composition in any LPS.

3.3 Specificity and public-like goods in LPS

The differentiation of benefits of a public good is a an accepted fact in textbooks and literature. Sometimes, differences distribute randomly among the population accessing the public good; in other cases, the population is segmented in sub-groups exhibiting different levels of benefits (e.g. Antonelli 2000).

The differences extend to the private costs of accessing benefits. We can distinguish the private costs of funding the public good and the spatial, technological, or organisational costs necessary to access it. The first ones take the form of taxes, tolls, fees, etc. The second ones depend on peculiarities and indivisibilities of the public good combining with differentiation of demand, which make easier the access to the good from certain places and/or for agents owning certain connecting qualities. Differently, the costs are higher.

Let us call the first one the (private) 'cost of funding', and the second one the (private) 'cost of accessing' the public good. The cases of public goods featuring a non-uniform distribution of (private) benefits after deducing the (private) costs of accessing (and before funding) sometimes relate to non-random factors (say nexuses) that tie the sub-groups of

[6]The concept of "servizi reali" was introduced by Sebastiano Brusco reflecting on experiences of deliberate collective support to contemporary Italian industrial districts (e.g. Brusco 1992). "Cluster" initiatives and organizations refer specifically to the Porterian tradition of studies on LPS started in the 1990s (Porter, Kramer 2011).

[7]This distinction could be related to urbanization vs. localization economies, as well as to Jacob's economies vs. MAR economies (Beaudry, Schiffauerova 2009). We do not deserve an explicit attention to such concepts here, since the approach followed in this paper is transversal to their fields. However, see Subsection 5.3 and the concluding Section 6.

agents with high net benefits (say B groups). These cases have suggested the concept of "specific" public goods (Bellandi 2006).

A nexus relates to various sources and qualities, which can be cultural (e.g. religious or racial minorities), political (e.g. a shared ideology with consequences on policies for social reform), local (the overlapping of daily life experiences), or professional (e.g. communities of interest) factors, separately or somehow combined. The nexus defines a B group and grants it a source of common interest (bridging), which is acknowledged within the group (bonding), and to which the provision of the public-like good is instrumental (Oliver, Marwell 1988, Putnam 2000).

Considering the classification of goods with public-like characteristics in Table 1, pure types (I quarter) are directly constituted by the actions (e.g. investments in R&D or human capital) of the agents of a LPS (or some sub-sets of them), such as in the case of localized industrial commons (Subsection 3.2). Otherwise, they incorporate features that fit specific needs, for example in the case of technical or trade standards. The efficient provision of common-pool resources is tied to some self-identified community (Ostrom 2009, p. 414), and this applies as well to LPS (IV quarter). Finally, a terminological distinction (Ostrom 2009, p. 413) recalls that toll goods need only paying the fee for becoming accessible, while club goods need also the "recommendation" of an incumbent, which is the sign of a nexus underlying the membership (II quarter). Some cases in Table 1 are necessarily club goods, like a private knowledge on innovative products shared within a business network. Others are local in access but may be either club or toll goods, like a collective water purifier whose services is or is not be calibrated to the needs of nearby companies (footnote 4).

An appropriate availability or provision of specific public-like goods may allow the firms of a LPS to obtain either the inputs of highly indivisible resources at relatively low prices or a higher productivity from the same inputs. Transaction costs could be reduced selectively and congestion/environmental costs as well. The exploitation of such potentialities depends on various factors, specifically on the presence of regulation mechanisms. The next section presents such mechanisms and how they relate to commons.

4 Chorality, provision by consent, governance, and commons

Consider the untraded stock of productive knowledge in Table 1 (I quarter), i.e. localized industrial commons (Subsection 3.2). The stock is constituted by the investments of the "setting"[8] of individual members who share its benefits (a B-group, according the definition in Subsection 3.3). In the other types presented in Table 1, the provision may be in principle independent (except for funding) from investments by individual members. Nonetheless, if a public-like good points to the needs and capabilities of a specific setting, the personal knowledge it embeds contributes to the constitutive and regulative processes of that good.

In this sense, specificity is also a 'commons' quality. The latter expresses the involvement of the members of a community (i.e. a setting sharing a nexus) in contributing to the provision, reproduction and/or regulation of common-pool resources and in general of public-like goods that they may access (Ostrom 2009). Concerning the last requirement, regulation by the community meets several difficulties, but it also enjoys inner advantages given by a direct awareness of specific needs and capabilities. The next points in this section expand on the commons' features of LPS specific public-like goods, following a classification of their regulative mechanisms.

4.1 Chorality, social customs, and the communitarian market

According to Becattini (2015), the persistent accumulation and the overlapping of experiences of work, consumption, dwelling, and local government create an evolving productive, socio-cultural and environmental heritage in a place. This heritage is shared by the resident population and perceived by visitors. Such a place has, in a way, a "conscience",

[8] Here "setting" is used in the sense proposed by Neal, Neal (2013, p. 724), as "a set of people engaged in social interaction, which necessarily occurs in, and is likely affected by the features of, a place".

a diffuse awareness of the common heritage, a related sense of belonging, and possibly a collective identity (Agnew 2011). The shared heritage and the conscience constitute, in other words, the bridging and bonding components of a place-based nexus (Subsection 3.2). It has public goods' characteristics, and it exists not only because of a previous accumulation of experiences in the place, but because the people working and dwelling in the place keep on sharing and acknowledging it. It is a fundamental commons. Even if its components may be the object of deliberate initiatives (Solvell 2015, Onesti 2017, Götz 2019), this place-based nexus is largely the outcome of evolutionary forces. Becattini (2015) calls it a "civil and productive chorality" when it assumes constructive and encompassing contents (Subsection 2.2).

Related to such nexus, sectoral immaterial public goods emerge with their regulation provided as 'social customs', i.e. informal norms enforcing conformism in individual preferences[9]. They concern, for example, accepted manners to signal an informal contractual agreement, or informally accepted technical standards. They extend the scope of communitarian markets. However, social customs are slow to adapt and coarse-grained. A complex and changing division of labour needs provision and regulation mechanisms that help a more agile and fine-tuned provision of many specific public-like goods recalled in Section 3. Building on previous analyses on collective and public action in LPS (e.g. Dei Ottati 1994, Schmitz 1999, Crouch et al. 2004), the next points recall further forms of provision and regulation, for and by the community.

4.2 Direct alignment

Social conventions express the selection of solutions allowing a direct alignment of individual and collective interests for the provision of a public good, out of a set of solutions where individual interests also diverge (North 1990).

Within a LPS, the agents of a (B-group) setting who behave regularly and respect a shared solution (e.g. sharing a non-depletable multilateral externality, see note 2) contribute not only to business exchanges and projects, but also to the confidence internal to the setting. Awards (e.g. social prestige), penalties (e.g. exclusion from all the settings of a LPS), and policing are rules that may support this quasi-automatic regulation[10].

The direct alignment is strengthened when the place-based nexus helps a positive inclusion of the utility of the other agents of the setting into the utility function of each one van Dijk, van Winden (1997), as when ideals of social-environmental sustainability, justice, and participation (Foster, Iaione 2019) join the goals of effectiveness and efficiency. The opposite case is interesting as well. A negative sign of social ties within the preferences would tend to generate depressed settings and work against the commons' features. A quite general implication would suggest that the place-based nexus may be more or less constructive and encompassing (qualities of chorality), thus associating to different proportions of cooperative and un-cooperative agents operating within the LPS. Together with the intervention by outside authorities (Ostrom 1995) and the flows of incoming external agents, this would help explain sharp differences in the support towards the provision of commons in the LPS (Schmitz 1999).

4.3 Provision by consent and joint private governance

When direct alignment is not possible, or not self-sufficient, mechanisms of deliberate collective action intervene (Schmitz 1999). First, considering joint private support, a point made by Oliver, Marwell (1988, pp. 6–7) suggests a relation with commons: "Collective action arises around those interests for which there is a group of especially interested and resourceful individuals who are socially connected to one another". Such support coalesces more easily when there is a nexus, the target thus being a public-like good specific to some B-group setting. When the individual incentives and the nexus work well,

[9] Marshall (1927, pp. 599–600) reflected deeply on social customs and industrial organization. More recently, a classical reference to consistent norms of behavior is North (1990). Examples are abundant in the contemporary literature on industrial districts.

[10] See Salais, Storper (1992) about rules and conventions in different types of LPS, and Brusco (1999) and Dei Ottati (1994) on industrial districts. More in general: Ostrom (2009, p. 420).

the good is provided and/or regulated by consent from within the setting[11]. Therefore, the goods are commons, for instance in the case of cluster commons promoted by cluster initiatives and organizations (Solvell 2015).

Popular examples concern collective contracts that define average fees, terms of payment, quality control methods, for an exchange of goods within the LPS. Individual entrepreneurs or business associations sponsor research of new technical standards. Local schools' programmes and university missions are discussed with business and social stakeholders helping the growth of basic competencies. Local bankers and industrial entrepreneurs find new financing schemes, adapted to the economic and technical peculiarities of the local investments (e.g. Amin 1994, Dei Ottati 1994).

4.4 Governance and public government

Initiatives and resources by local or localized public agencies (Subsection 3.2), even if non-necessary in principle, have a general role in regulating pure public goods (Table 1, I) within an extended network that incorporates important conflict of interests in spite of a common nexus (North 1990). "Innovation commons", where open knowledge is used to integrate environmental, social, and shared value innovations, may ask for the support of public agencies as well (Jeannerat et al. 2017, p. 17).

With regard to common-pool resources (Table 1, IV), exclusion is difficult, and congestion (and pollution) is often a negative feedback of economic growth led by the expansion of the local division of labour. In these fields, government initiatives (e.g. on norms of access) and public resources are sometimes mandatory and, even when not, they may be crucial due to difficulties in finding agreements on a pure private basis, especially in cases of large and differentiated networks of settings. For example, public incentives can support local agents avoiding private choices that exacerbate local congestion/pollution.

Similar considerations concern cases of specific "club" goods (Table 1, II), such as local public services or essential industrial facilities. With the first ones, public initiative is justified by a political acknowledgment of such services as related to rights of citizenship and/or universal access. They may be provided in ways contributing specifically to the needs of a community. An active involvement of the local users in the co-production of services and in some forms of local governance helps management of supply and provision (Alford 2014). To better understand essential industrial facilities, let's come back to complementary production phases at the core of an LPS, which need inputs from a facility with relevant indivisibility or relevant network economies (footnote 4). Consider a facility whose minimum optimal scale does not allow more than one supplier in correspondence to the local demand. If a private monopoly runs the essential facility, it could appropriate an excessive share of value, reducing both the economies enjoyed by independent local firms and CE. Private alternatives that restore efficiency are based on market contestability, direct alignment, or joint action. However, they may fail, for example when, given sunk costs and first-mover advantages, a private supplier carries out predatory strategies, breaking the place-based nexus directly or just selling the facility to some external player. Public support or direct initiative, possibly within a multi-scale frame of coordinated authorities (e.g. anti-trust), could tilt the balance towards solutions that preserve the appropriation of a fair value among the LPS agents.

To shape the solutions to the specific needs of the LPS, the actors of the public initiatives should be part of (or intersect in some sense) the network of involved settings (B-groups). The initiative is not taken by the government alone, being shared with at least some private leaders of the network. It is proper local "governance", as meant by Crouch (2006). Schmitz (1999, p. 476) refers to "joint action with government support" in LPSs, and Ostrom (2009) to "polycentric governance". This is again the field of regulation by the community, i.e. of commons features.

[11] "Selected incentives" may be implemented by "public good–making" entrepreneurs, as in the renowned case of the lighthouse services in U.K. discussed by Coase (1974).

5 Networked ecologies of commons

The previous section established the foundations of LPSs' CE in terms of its relationship with specific public-like goods that present commons features. This section proposes to subsume such relationship under the vision of a "networked ecology of commons"[12], which amplifies the evolutionary and multi-scalar correlates of the framework presented in the previous sections.

5.1 A networked ecology and the LPS as commons

Relevant literature on LPSs identifies the roots of their possible CE qualities in the strength of a constructive and encompassing place-based nexus, made of a shared cultural heritage and a conscience of place, which connects and bonds the people of the place (see Subsection 4.1). We have argued, first, that this is a fundamental commons shared at the LPS level and, second, that a structure of more operative commons may thrive upon this local "macrosystem" pattern (Neal, Neal 2013, p. 724), being related to public-like goods specific to CE, which an overlapping network of settings (B-groups) of the LPS agents support, provide, regulate and adapt (Subsections 4.2–4.4).

Even if each specific commons may refer to different local settings, sometimes even extending to non-local agents, sharing the place-based nexus gives the network of settings a focal point that helps identify the nature of joint needs and capabilities specific to each setting, as well as perceive some complementarity within the network. Conversely, the individual and collective experiences of constitution and use of specific commons, let's say "commoning" (Foster, Iaione 2019, p. 235), may be seen as the direct source of reproduction and variation of the same place-based nexus. This structure of co-evolving (B-groups) settings and commons is what we would call a 'networked ecology of commons'.

In ideal-typical conditions of the LPS 'as a commons'[13], such an ecology impregnates the place. It is the solid foundation of a CE that needs more than technical and transactional proficiency within a communitarian market. In real-world paths of local productive development, hampering factors can sometimes fragment the networked ecology and weaken its self-reproductive dynamics. They have an unavoidable but not always overwhelming impact on CE, being confronted by strengthening factors.

5.2 The interplay of strengthening and hampering factors

We present in this section just one class of strengthening and hampering factors, deferring more general considerations to Becattini (2015). We have suggested in Subsection 4.4 that an embedded local government plays important roles in the governance of specific public-like goods with commons' feature. It is part of a "place leadership", i.e. a set of key local actors able to express a crucial influence on the reproduction and variation of territorial development (Sotarauta et al. 2017), owning control or influence on important socio-economic resources, and possibly playing political and cultural mediation among the LPS settings on the features of public-like goods, on access to them, and on rules for negotiating conflicts on their provision and funding (Brusco 1999).

However, too much embeddedness of public actors has evil sides when it is conducive to either parochial approaches or protection of rent-seeking actors (Olson 1971). Large private resources sunk in traditional strategies may push a conservative coalition to obstruct the constitution of new commons that could help rerouting the LPS in face of disrupting challenges (Bellandi, Santini 2020). In the worse cases, the networked ecology deteriorates, and superior public authorities might subsume the provision of local public goods with a probable loss of specific features and CE (Beito 1993).

What type of balance prevails between progressive and conservative forces depends in part on the subjective characters of those who keep or aspire to place leadership, their political sub-cultures and styles towards local governance (Barca 2019), and their approaches towards policies of local development (Crouch et al. 2004). Other important

[12]The term comes from a variation on concepts of nested or networked ecological systems, as proposed in sociological and psychological studies (Neal, Neal 2013).

[13]This is a variation on the "city as a commons" in Foster, Iaione (2019).

factors include the property regimes and the local distribution of economic power (Ostrom 2009); the strategies of local investment taken by non-local actors (Trippl et al. 2017), in particular the relation with "shared value" strategies possibly played by local branches of large firms (Porter, Kramer 2011).

Finally, a polycentric governance of commons (Ostrom 2009) could support an active role of LPSs within the territorial relations of a large city-region and favour the combination of specialization economies at the sub-metropolitan level and diversification economies at the metropolitan level (Trullen-Thomas, Boix-Domenech 2017, Andersson et al. 2019)[14].

5.3 The networked ecology of commons within an enlarged frame

The remarks above contribute to understanding why paths of productive development do not distribute evenly across regions – the "world is not flat" (Pisano, Shih 2009) – as well as how their dynamics depend on the coupling with multi-scalar contexts. Indeed, the relationship between CE and networked ecologies of commons in LPSs contributes to some views on territorial development and multi-scalarity. Consider, as an exemplification, a possible set of stylized processes.

1. A population of economic, social, and institutional agents tied by a constructive and encompassing nexus is the social basis of a LPS. The nexus coagulates in a territory because of complex historical processes (Agnew 2011, Becattini 2015). A network of (B-group) settings pivots on the same nexus and associates to a structure of specific public-like goods with commons' features. It is an ecology whose low transferability explains a solid position of differential CE kept by the LPS with respect to competing organizations and territories. Related quasi-rents accrue to the settings of agents embedded in the context (Storper 2009).

2. Some sub-set of embedded agents enter cross-scale and specific sectoral markets, business and social networks, and institutional layers; some groups of migrants enter the LPS. They are gatekeepers of external knowledge and translational actors of local knowledge (Buciuni, Pisano 2018).

3. In time, thanks also to such cross-scale relations, specific public-like goods supporting the CE of an LPS become universal or less specific, and commons features tend to weaken (Storper 2009).

4. This means that some "local" sources of CE become, first, "mobile" (Robinson 1958), and then disappear as such. However new sources of CE regenerate ordinarily in lively LPS (Becattini, Rullani 1996), even if decline or mutation cannot be excluded[15].

5. Such evolving paths associate to different cases and forms of LPS, from classic industrial districts (Becattini 1990), to super-clusters (Feldman et al. 2019), or low-profile local systems in marginal areas (Ricci et al. 2019).

6 Concluding remarks

The paper started from a formulation of the basic tenet of a long stream of literature on local productive systems (LPSs) and related paths of territorial development, i.e. that the overall efficiency (statical and dynamical) of a LPS depends not only on what single business organizations do but also on a localized system-based support. The second component combines market and non-market mechanisms as well as production, socio-cultural, political, and territorial spheres featured by different structures of relations, cultural heritage, and senses of belonging. Performance based on the second component is collective efficiency (CE).

[14] Note that the configurations of the activities entering the productive specializations of a LPS often exceed the limits of statistical sectors.

[15] Feldman et al. (2019) have suggested recently that Marshallian external economies may combine with global monopolistic power and strategic barriers against external competition in some top-level LPS, e.g. Silicon Valley. A reading of such cases in terms of commons would be interesting.

In particular, the focus has concerned the foundation of that system-based support, which is the provision and regulation of a framework of specific public-like goods. After having argued that such goods have a more or less implicit nature as commons, it has been proposed to scrutinize this nature throughout a frame of interrelated and sometimes original concepts, such as the networked ecology of commons.

The frame could help future empirical research on LPS availing more extensively of the literature on commons, as well as suggest, on the other side, qualifications to the general "design principles" discussed by the literature on commons. The principles concern institutional regularities that feature "sustained regimes as contrasted to the cases of failure" (Ostrom 2009, p. 422). We have not referred explicitly to the original list proposed by the same Elinor Ostrom (ibid), nor to variations presented with innovation or urban commons (Allen, Potts 2016, Foster, Iaione 2019). A follow-up of this paper would further amplify the broad consistency of the conditions of provision and regulation of commons in LPS discussed in the previous sections with many such principles. It would add some variation as well. Indeed, ordinarily, the literature on commons applied to rural settings considers cases where the core social and productive resource is just a main single commons. Furthermore, in applications on (large) urban systems, which include many types of commons, the relations between such commons are not easily singled out, even though they are perceived (e.g. the "city as a commons" in Foster, Iaione 2019), because the territorial context is very complex or indefinite. The LPS are quite complex but well-defined territorial contexts where it is possible to conceive the presence of networked ecologies of commons or some proxies of them. Guidelines associated to industrial commons (Pisano, Shih 2009), cluster commons (Solvell 2015), and innovation commons (Jeannerat et al. 2017) could provide a starting point for both the extension of the design principles and the definition of non-traditional policy implications for territorial development.

Lastly, and also on the foundations of CE in LPS, it would be interesting to go deeper on their relationships with urban agglomeration economies and related basic principles, such as sharing, matching, and learning (Duranton, Puga 2004). The paper has briefly referred to combinations of such principles when discussing the fields of CE performances in Subsection 2.1. Furthermore, it has been suggested in Subsection 5.2 that concepts of commons in LPS could enter debates on specialization vs. diversification economies in regional studies (see footnote 7). However, the focus has not been the playing of general agglomerative and centrifugal forces as much as a class of endogenous economic, socio-cultural, and institutional factors that support or hamper development in different territories (Becattini 2015). A reappraisal of the above relationships in the light of this paper's concepts must be left to future theoretical and empirical research, starting from the territorial qualities of networked ecologies of commons and commoning processes. For example, the possibility of polycentric networks of communities is a bridge to be cultivated to understand fruitful combinations of specialized local paths and overlapping ecologies of commons within large diversified metropolitan areas or city-regions.

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Gating as exclusionary commoning in a post-socialist city – Evidence from Gdańsk, Poland

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Abstract. New-built gated condominiums in the suburbs of a post-socialist city are a well-studied phenomenon. However, in Poland, recent years have seen an expansion of residential gating into old inner-city neighbourhoods and socialist large housing estates. The resulting fragmentation and privatisation of public space have raised much controversy and debate on appropriation of urban common good. This paper presents outcomes of a research on the changing discourse of gating in Gdańsk, based on a discourse analysis of newspaper articles and interviews with key urban stakeholders. On the one hand, gating is seen as an anti-commoning practice criticised for its elitist character and undesirable socio-spatial consequences. On the other, a narrative of exclusionary commons has emerged to justify the need of gating in specific cases. Considering the varying motivations and types of gating in different urban areas, the authors have attempted a classification, relating gating practices to commoning strategies and their justification in localities typically characterised by atomistic individualism and social disintegration.

Key words: Gating, urban commons, common good, post-socialist city, Gdańsk

1 Introduction

Gating and commoning are two seemingly opposite, or alternative, phenomena taking place in contemporary cities around the world. The first term refers to the global trend of privatisation of public residential space through formation of enclosed housing developments with restricted access (Blakely, Snyder 1997), while the second consists in collective appropriation and regulation of shared concerns of the everyday beyond the state and the market (Kip et al. 2015). Even though both processes – albeit to varying degrees – involve exclusivity, the individualistic character of the former and the collectivist of the latter, render them "similar but disparate" This conflicting interrelation is pointed out by Harvey (2012) in his critique of appropriation of urban space through gating:

> The rich these days have the habit, for example, of sealing themselves off in gated communities within which an *exclusionary commons* becomes defined. This is in principle no different than fifty users divvying up common water resources among themselves without regard for anyone else.

Harvey's notion of gating as exclusionary commoning inspired the authors of this paper to apply this concept to analogous practices in a post-socialist city through a case study of Gdańsk – a Polish city, in which increased popularity of gating has been observed

since the early 1990s. Similarly to other Central and Eastern European countries, Poland after 1989 experienced a violent clash between the crisis-ridden socialist regime and the neoliberal doctrine. As a result, the concept of the 'common good' underwent a dramatic devaluation in favour of the increasing cult of private property (Czapiński 2013). At the beginning of the systemic transition especially, such a tendency, framed in the discourse of successful transformation to capitalism, was considered to be "natural" and "inevitable" (Koczanowicz 2011, Sagan 2017).

As underlined by Gądecki (2012, p. 109), "gated communities need to be analysed first of all in relation to their local contexts and purposes". It is of particular significance in the case of European post-socialist gating, characterised by especially intensive and heterogeneous development – changing over time and dependent on location within the city – against the background of corresponding processes ongoing in the rest of the continent. Responding to the lack of studies on this specific topic, the main aim of the paper is to demonstrate the shifting discourse on the relation of gating and the common good in a neoliberal post-socialist city, based on the example of Gdańsk in Poland. Three research questions were of our particular interest: 1) how have processes of gating affected the city through time? 2) how has the perception of gating as exclusionary commoning evolved in different residential environments? 3) what conditions should be met for gating to be called commoning? The paper is organised in two principal parts: a theoretical part, which conceptualises gating and commoning with an emphasis on the post-socialist specifics, and an empirical part, featuring a qualitative study undertaken in Gdańsk based on print-media discourse analysis and individual in-depth interviews, which introduces a classification of exclusionary commoning practices and their rationalisations. These are followed by a discussion of the results and a final conclusion.

2 Theoretical background: the interrelation of gating and commoning in contemporary cities

Residential gating is regarded as the outcome of creating and supplying individual residential needs of selected interest groups, "reinforced by planning practices and policing, implemented by zoning laws and regulations and subsidized by businesses and banks" (Merry 1993 after Low 2001, p. 47). Research literature on gating may be grouped into two categories in terms of demand-led motivations and reasons behind origins and development of the process. It is either considered to be connected to the growing fear and lack of sense of security in the postmodern society or regarded as a result of class changes and the increasing need for demonstrating status and prestige in urban social space. As established by Atkinson, Flint (2004), a decision to live in a gated estate may follow from the need for privacy and anonymity or be dictated by fear of criminal behaviours, cultural fears and any other anxieties. Low (2001) labels the latter as discourse of fear and argues that the addition of walls, gates and guards produces a landscape which encodes class relations and residential segregation in the built environment. Accordingly, Blakely, Snyder (1997) distinguish three types of gated communities: lifestyle, prestige and security zones. Lifestyle communities attract those whose common activities and interests influence residential choices, prestige communities appeal to those to whom status and privacy are paramount concerns and security zones reflect the fear of neighbourhood violence and crime. While these motivations may be interdependent, it should also be noted that gating varies in terms of measures of control and architectural design[1]. Regardless of the reasons behind the inclination for gating, the process itself is usually linked to socio-spatial segregation (Marcuse 1997, Caldeira 2000, Christopher 2001, Vesselinov 2008).

Residential gating is exclusionary by definition: it is an enclosed urban space for privileged social groups to share means while restricting the access for "others". Thus, meeting the conditions of being excludable and non-rivalrous, gated estates fall under the

[1]For instance, Grant, Mittelsteadt (2004) introduce a typology based on a continuum of enclosure – from ornamental gating with a marked entry way but no restriction of access to restricted entry roads with access-controlling guards, a full range of security measures and constant administrative surveillance. When only physical attributes are concerned, gated estates break up into two groups – enclosed apartment buildings (condominiums) and multi-building complexes, in reference to which the term "gated estates" was first used (Glasze 2001).

category of club goods (Manzi, Smith-Bowers 2005, Le Goix, Webster 2006). Maintenance costs of the collectively used elements – such as common infrastructure and facilities – are split between the users. Club membership eliminates the free-rider problem inherent to public goods. Moreover, the fact that "a club provision proffers an alternative to a central government provision of local public goods" (McNutt 1999, p. 946) may serve as justification of gating for the sake of the common (collective) good, wherever the government fails to do so sufficiently and/or effectively (Raposo, Cotta 2009, Warner 2011). According to Webster (2002, p. 397) "cities naturally fragment into many small publics, each of which may be thought of as a collective consumption club" and therefore gated communities should be regarded as urban consumption clubs in which "legal property rights over neighbourhood public goods are assigned by property-market institutions".

In his cutting-edge paper, Buchanan (1965) situated club goods between the neo-classical private goods and Samuelson's (1954) purely public ones. Given that consumption of any club good involves more than one person, but less than an infinite number of them, finding the "optimal sharing group" is key to the club's effectiveness:

> The central question in a theory of clubs is that of determining the membership margin, so to speak, the size of the most desirable cost and consumption sharing arrangement. (Buchanan 1965, p. 2).

Olson (1965) builds on this ground, maintaining that the smaller a group, the more likely it is to further its common interests and provide itself with a collective good. In addition, motivations for such clubs are not only economic. Smaller groups, whose members can be in close communication with another, are also prone to social pressure and social incentives. In an attempt to update Olson's theory, Sandler (2015) mentions homeowner associations in gated communities and condominiums among institutions fostering effective collective action. This point brings us closer to the idea of gating as exclusionary commons, however it misses the essential aspect of cooperation, in terms of teamwork and shared accountability.

Authors of a paper on community gardens in Singapore (Neo, Chua 2017, p. 667) reject the "implicit assumption that a good community garden must necessarily be inclusive or that, conversely, community gardens that are exclusionary are bad". At the same time, they introduce the argument of "responsibilization", which rationalises exclusionary practices on the grounds of the community's engagement not only in fulfilling "self-evident, mundane' responsibilities towards individual gardens but also a responsibility towards 'making the garden a space of community"' (p. 671). Our approach seeks to explore this paradox. While we do not reject the objective assumption that gated estates belong to the category of club goods, we focus on the subjective experience of their residents, to whom they are in fact collectively managed commons. To that end, we draw on the "commons on the inside/private property on the outside" conception proposed by Foster, Iaione (2016, p. 292):

> Although certain forms of private property are held "in common" by a collection of individuals and may include shared common space for the collection of rights-holders (e.g. a gated community or a condominium complex), in most respects this property follows the logic of and operates like private property. These and other "limited-access" common interest communities may look like traditional "commons on the inside" for those who have access through ownership or usage rights in the community, but very much operate like "[private] property on the outside" in that these communities are endowed with the right to exclude non-owners from their shared spaces or resources.

Hence, investigating the discourse on gating, we rely on the insiders' perspective and it is their narratives, based on perception and judgement 'from the inside', that we will examine in the Gdańsk case study. Our working definition of exclusionary commoning thus combines the interpretations of gating and commoning featured in the introduction: "collective appropriation and regulation of urban residential spaces beyond the state/market and behind closed gates". It would be expected that the investigation of residential gating from this angle might reveal a hidden potential for cooperation and/or community-building missed by the mainstream research.

3 Gating and the common good after socialism

In Central and Eastern Europe, emergence of gated housing estates has been closely connected with post-1989 transitional effects: augmented societal uncertainty, commodification of housing and general privatisation of urban space (Gądecki, Smigiel 2009). The proliferation of gating in the region may have several overlapping causes. On the one hand, gated estates "reproduce patterns of voluntary isolation from the surroundings" which were characteristic of the former *nomenklatura*, on the other – they offer a possibility to make up for decades of limited or negated right to "demarcation of social boundaries and distances", as well as repressed individualisation of lifestyle patterns and restricted consumer opportunities (Gąsior-Niemiec et al. 2007, pp. 80–81). Likewise, as argued by Gądecki, Smigiel (2009, p. 200), contemporary gated communities are 'promoted and presented as a post-modern lifestyle package', which further enhances the longed-for sense of superiority and prestige. The security factor is also significant in explaining the prevalence of gating in Central and Eastern Europe, an issue particularly emphasised by Jałowiecki (2018), who calls it "obsessive" and "paranoid". Thus, motivations for gating in post-socialist cities seem to be quite similar to those observed in old-democratic countries but deepened by the experience of socialism and the counterbalancing effect of transition to neoliberal capitalism (Szwarc 2014, Sagan 2016, Szmytkowska 2017, Jałowiecki 2018).

Expansion of gated estates in the region relies on combination of interests of three main stakeholders: developers, local authorities and middle-class residents (Sagan 2016). *Developers* pursue maximisation of profits from building high-density residential housing equipped with privately provided goods and services for collective consumption, which significantly increases the real-estate prices. To reach this goal, they actively influence potential customers, luring them to live in offered projects through marketing and branding (Brabec, Machala 2015). The interest of *local authorities* lies in attracting affluent taxpayers, representatives of higher social classes, without having to increase expenditure for the local infrastructure and public goods and services. Privileged *residents* move to gated enclaves in search of specific qualities, such as aesthetics, privacy and exclusiveness – even if the everyday reality in a gated community may not live up to their expectations (Gądecki 2013) – but also in order to close themselves off from the outside. As a result, gating of urban spaces leads to a division into two social worlds – the internal and the external, "ours" and "theirs", which resolves to growing spatial segregation and social disintegration (Marcińczak et al. 2015).

The discourse of post-socialist gating in academic literature is rather negative and the issue is presented as one of the major challenges of European cities after socialism (Tobiasz-Lis 2011, Kovács, Hegedűs 2014, Krupickaitė et al. 2014, Ptak, Serafin 2017) – not only because gated estates are perceived as microscale enclaves of wealth in which public space is reduced to communication routes and green areas (Grzegorczyk, Jaczewska 2018), but mainly because of the extent of the process of gating. In the view of Sagan (2016), the practice of gating leads to appropriation and privatisation of the common good of urban residents, namely urban public space in all its forms, on an unprecedented scale. Similarly, Jałowiecki (2010) acknowledges that gated and enclosed estates intersect existing streets, exclude vast urban areas from common use and significantly change daily routes, which in consequence decreases physical and temporal accessibility within the city.

Depletion of urban common good is particularly marked when gating concerns not the new greenfield residential developments but takes place inside older housing fabric. Enclosure of newly erected gated buildings or estates within existing urban structures in inner urban neighbourhoods, as well as raising fences around residential buildings which until now have not been gated, is referred to as secondary gating (Tobiasz-Lis 2010, Bierwiaczonek 2016, Drozda 2017, Leśniak-Rychlak 2018). Its specifics contribute to conflicts between the "old" and "new" residents, typically concerning competition over parking space or restricting access to previously fully open spaces. Raising fences and other spatial barriers in large housing estates – the flagship housing developments of the socialist era – is characteristic of the latter phase of post-socialist gating. Considering the relatively high level of safety in this type of residential milieu, any security claims justifying the need for fences remain unfounded (Szafrańska 2017). Moreover, the rejection of modernist

guidelines for the open-space arrangement in such neighbourhoods contributes to spatial chaos, visual congestion and a decline in quality of life.

Since the mid-1990s, Poland has become the leader among European post-socialist countries in terms of the rapidly augmenting number of enclosed housing developments (Polanska 2014). Increased popularity of gating in Polish cities may be explained both by contemporary deficiencies in housing and spatial planning and by historical conditions. The stage for the provision of new housing in the form of gated communities has been set as a consequence of laissez-faire policies and reduced state intervention after 1989 (Tsenkova, Polanska 2014). Likewise, it should not be forgotten that gating in Poland culturally originates from rural areas – both peasant and gentry traditions significantly and persistently shaped territorial behaviour patterns of Poles, resonating in residential preferences of the emerging new middle class (Kubicki 2016, Bouloc 2018). The ongoing development of suburbs observed in the last few decades has introduced gating which not only serves to demarcate the property area, but also "reinforces specific patterns of suburban social behaviour: focus on the self and close family and detachment from the social fabric of the countryside" (Kajdanek 2014, p. 200). Thus, according to Polanska (2014, p. 417), "[g]ated communities are private places where individual interests in the closest group/family are cultivated at the expense of collective values". It also needs to be underlined that despite idyllic names of the new gated estates – such as Green Retreat, Valley of Azure, Sunny Hillside – promising high-quality living in a close-knit community, the space inside of them is often mainly used for parking and neighbourly relations are practically non-existent (Zaborska 2007).

Commenting on the lack of shared spaces in suburban new housing developments, Szmytkowska (2014) speculates that it may be linked to the newcomers' conscious withdrawal from social interactions at the place of residence, in favour of enjoying them in the inner city. This goes in line with findings of Szczepańska (2012), who maintains that relations between residents of gated and non-gated estates are more or less alike in terms of their superficiality and conventionality. The same author takes notice of a motivational contradiction which explains the unusually low level of engagement in housing associations operating in gated estates (Szczepańska 2014). On the one hand, the residents appear to value the possibility of co-governance, but on the other, they choose not to make use of it unless the value of the property is at risk. Investment viability seems to be their top priority and the only worthwhile reason for commoning. An anonymous notice posted in one of gated communities in Warsaw that went viral on the social media extends this principle to the absurd point. It reads as follows:

> [Dear] Neighbour! Soon the value of your apartment will go down! Why? The sandpit in our backyard = noise [and] strangers outside the window. We chose a quiet, peaceful location, without people peeking into our windows and now others intend to disturb that harmony. Vote against! (Dziewit-Meller 2017)

This type of "commoning" hardly amounts to anything more than collective action for the sake of private interests. The reason behind it may lie in the insufficient recognition of the common good. As much as Poland – unlike old democratic European countries (Berge, McKean 2015) – has little tradition of urban commons, the discourse of urban common good has underwent multiple transformations in the last century. From a motivational slogan after the Second World War, during the country's reconstruction, through a celebrated motto in the decades of intense industrialisation and urbanisation, to a compromised catchphrase towards the end of the socialist period, it became redundant with the wake of neoliberal capitalism. Only recently the notion of urban common good has re-entered the public debate, with gating being one of its prevalent themes (Grabkowska 2018). However, until recently there existed no laws concerning enclosure of residential buildings and estates. Partly due to the fact that during the first phase of transformation gated estates had been developed mostly in the suburbs (Kajdanek 2012), regulations where introduced only later, after the process had spilt over to inner city neighbourhoods and socialist high-rise estates. The so-called Landscape Act (Kancelaria Sejmu 2015) enabled local governments to pass resolutions protecting the urban landscape from visual chaos created by large outdoor advertisement, but also restricting the right

to excessive and tasteless gating. In any case, the anti-gating pressure, justified by the concern for the urban landscape as the common good, came from 'the outside' and so far, no studies have been conducted to evidence the insiders' outlook on how enclosure may serve 'the common' in different housing environments of a post-socialist city.

4 Exclusionary gating in Gdańsk: case study

Gdańsk is an exemplary case for the study of post-socialist gating à la polonaise. The main urban centre in northern Poland, with population of around 465,000 in 2018, and heart of the Tricity agglomeration of a 1.2 million inhabitants, it experienced a rather chaotic greenfield development at its southern and western fringes after 1989. Since many of the new housing estates had been fenced, the city's peripheries promptly became areas of considerable concentration of gating (Polanska 2010b,a). With time, the trend of enclosing residential spaces began to affect new estates in more central locations and to penetrate the existing housing structures. To some extent this redirection followed from the local government's attempt to contain the galloping processes of suburbanisation and outmigration to adjoining communes, through a change in spatial planning priorities. The new policy of "inward urban development" turned out to be successful as it coincided with a partial retreat of disillusioned commuters who had previously fled to the suburbs – a change of residential preferences which was hastily picked up by developers.

Inner-city re-urbanisation brought new challenges connected to gating. For instance, in the historical centre of Gdańsk, the Main City, it has been adopted as the local residents' response to pressures of 'touristification' and appropriation of space by other users. The specific arrangement of open-plan backyards rebuilt after the Second World War in a departure the original medieval layout – dense and inaccessible, as well as the dominating residential function in a typically tourist area, have contributed to numerous spatial conflicts (Szechlicka et al. 2016). In 2015, the Mayor's Plenipotentiary for the City Centre (also called the Manager of the City Centre) was appointed to address these issues. Furthermore, in 2018 a local administrative body in charge of municipal property initiated a programme aimed at rearrangement of the backyards "in terms of spatial, functional and legal conditions by promoting civic engagement and responsibility" (Gdańskie Nieruchomości 2019). In essence, the Main City residents were encouraged to lease and manage the adjoining backyards, which would enable them to apply for funds assigned for renovation and fencing.

Other problems emerged in large housing estates, where open spaces between blocks of flats attracted developers willing to set up new investments irrespective of the local communities' interests (Figure 1). For instance, in May 2017 a local e-news platform reported on the controversial enclosure of a new development inside one of the socialist residential neighbourhoods, where a wire fence had intersected daily routes of the long-standing inhabitants (Koprowski 2017). The article featured an online survey in which two thirds of 3051 respondents claimed to be against the construction of gated estates (55 percent on the grounds that 'urban space should be open and not a collection of ghettos' and 11 percent because of their conviction that gating 'makes local residents' life harder'). Only every fourth respondent supported gating, maintaining that 'it is natural that communities prefer to keep the neighbourhood to themselves', while every tenth conceded that 'gating should just be allowed in peripheral urban areas'.

Another survey, conducted in 2014 among residents and district councillors in Gdańsk, confirms the overall negative perception of gating (Jaskulska 2014). Furthermore, according to its results, almost half of the respondents supported the local authorities' right to interfere with the type, shape and colour of fences enclosing private properties. Inclusion of regulations concerning historical fencing indicates that gating has been recognised as a pressing issue in the peripheral and inner-city neighbourhoods alike. Conclusions of the study were applied in the first legal document aiming at regulation of the so-far uncontrolled gating in Gdańsk – the Landscape Resolution passed by the city council on 22nd February 2018 (Rada Miasta Gdańska 2018). Fences made of concrete, reinforced concrete, metal, plastic, textile or foil, as well as other, insufficiently open-work, were banned and their height was limited to 2.2 metres in single-family housing units. Enclosure

Source: Picture taken by Maja Grabkowska on April 30^{th}, 2019

Figure 1: The divided landscape of exclusionary commoning after socialism: fencing between old and new residential developments in Przymorze Małe, Gdańsk

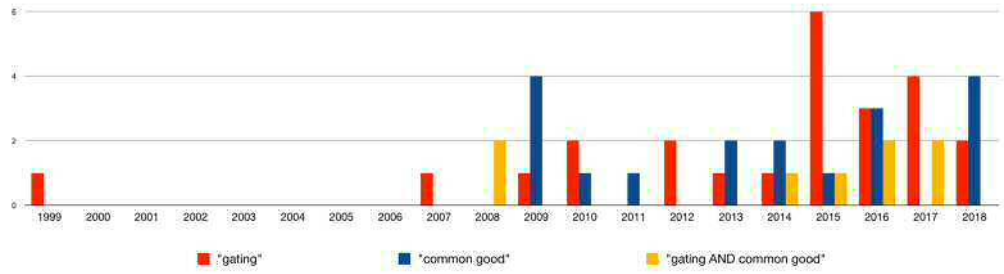
of multi-family buildings is no longer allowed, apart from the ground-floor private gardens (with maximum height established at 1.5 metres), dog parks and playgrounds. Some exceptions pertain to fences adjacent to historical buildings – they may correspond to the existing structures in terms of height and material used. As much as these regulations are a significant manifestation of the local authorities' increasing commitment in sorting out the issue of gating, at the same time they are nothing but technical adjustments, directed at the 'how to gate' rather than 'whether to gate at all' dilemma, nor do they endeavour to arbitrate the deadlock caused by the clashing visions of the common-good.

5 Research methods

The applied qualitative methodology consisted of a combination of two complementary research procedures – critical discourse analysis (CDA) of print media content, and individual in-depth interviews. Such approach was found to be to best suited for reaching the research aims. Even though critical discourse analysis originates in language studies, it focuses not as much on the language or narration per se, but on the assessment of social problems and issues in critical terms, based on the assumption that discourse is the key element in the construction of social life and relations of power (Fairclough, Duszak 2008). Print media content constitutes only a part of the public discourse, yet it plays a significant role in setting the agenda because of overall accessibility and high level of dissemination. While the analysis of press articles concerning gating in Gdańsk reveals general trends indicating how it has been represented and associated with the discourse of common good, outcomes of the conducted interviews complete the picture, enabling a detailed elaboration of the researched issues.

Applying the discourse analysis of print media content in research on gating in Poland has been successfully performed by other authors (see Gądecki 2009, Polanska 2010b). The primary aim of our research was to assess the prevalence of the notion of common good in reference to gating in Gdańsk over the last decades, as well as to identify concrete themes and narratives essentially related to different types of gating according to their location within the city. The body of texts was selected from the local pages of Gazeta Wyborcza – a liberal democratic journal established in 1989 and since then one of the most popular daily newspapers in Poland[2]. Gazeta Wyborcza Trójmiasto, which covers

[2]Analysis of a sole press title may cause a bias in terms of the worldview presented. Nevertheless, since the aim of the study was to find out the logic behind the pro-gating attitudes of residents of gated



Source: own elaboration

Figure 2: Timeline of articles in Gazeta Wyborcza Trójmiasto containing the searched keywords, 1999-2018

news from the Tricity agglomeration, first came out in 1990 (as Gazeta Morska) and apart from the print edition has been available online since 1994 (although the content has been kept behind a paywall since 2014). The analysed articles were searched from the newspaper's online archive comprising electronic versions of all texts published from 1992 onwards. Three keywords were used for search: "gating", "(urban) common good" and "gating AND common good", returning 50 results altogether – 24 for "gating", 18 for "common good" and 8 for the combination of the two terms[3].

The interviews took place in spring and summer of 2017 and involved 15 respondents who were selected by purposive sampling from 5 groups of urban stakeholders (3 per each group): activists, decision-makers, entrepreneurs, planners and residents[4]. The group included NGO representatives, city and district councillors, developer and local business representatives as well as inhabitants of different residential areas. Regardless of the sample's lack of representativeness in statistical terms, its diversity served to broaden the spectrum of subjective perspectives and opinions. Questions were formulated in a generalised manner, so that the interviewees had maximum liberty to discuss these issues, according to what they thought was key when applying the notion of common good to residential gating.

After all the research material had been collected, the electronic versions of selected articles and transcripts of interviews were coded with the use of MAXQDA, a qualitative data analysis software, and investigated in line with the CDA procedure. In the case of articles, general attitudes towards gating in and out of the context were identified, whereas the interview results were searched for specific rationalisations of gating by means of the exclusionary commons argument.

6 Results and discussion

6.1 Print media

The earliest of the 50 analysed articles dates from 1999; however, it is followed by an eight-year gap (Figure 2). Since 2007 there has been a clear growing trend in the total number of articles, which indicates the beginning of the debate on gating and the urban common good in the newspaper.

Until the early 2010s, articles featuring the issue of gating were neutral and mostly informational, simply stating whether the newly built or planned estates were (going to be) enclosed or not. Then, the discourse becomes more judgemental. In a text from 2012, a developer representative describing a future residential investment assures that it

estates, it seemed appropriate to focus on the daily newspaper whose readers originate mostly from the middle class. More importantly, apart from its widespread reach, GW is the only print medium in Poland which provides access to electronic versions of issues published as far back as in the 1990s.

[3]Articles containing the term "common good" in other contexts than the urban were excluded from the results.

[4]Anonymised quotations from the interviews are marked with corresponding letters: A, D, E, P and R.

would not be gated as 'some sort of a closed ghetto' (Sowula 2012). An urban planner interviewed a year later speaks of the importance of public space in order to prevent "creation of a new generation of projects, gated and concrete, where one cannot do much apart from sleeping" (Kozłowska 2013). From approximately 2015 onwards, the narrative focuses even more explicitly on the ills of gating, such as fragmentation of space or denying access to playgrounds to children from the neighbouring open estates. At around the same time the geographical focus of attention switches from peripheral districts in the upper terrace to inner city and concerns not only new developments but gating of existing properties and backyards as well. The notion of common good emerges specifically in reference to the latter.

Throughout the analysed period the total number of articles covering urban common good – under such diverse topics as spatial (dis)order, protection and management of industrial heritage, operation of public buildings, or urban space in general – amounted to 26. Almost a third of this collection involved gating and gated estates. In some of them only plain analogies to exclusionary commons are made, as in the case of a text reporting excessive use of beach windbreaks in summertime ("It doesn't matter whether it is a house, desk at work or several square metres of sand. What is enclosed, is mine"; Kozłowska 2015b). Other examine the problem more closely, pinpointing its complexity. For instance, an article discussing the redevelopment of backyards in the Main City presents gating as one of the necessary conditions for the project to succeed. The enclosure is said to be postulated by the local residents who "want it to be public space, but accessible only to themselves" (Karendys 2016). According to one of the participants in the project, both academic and architect, the Main City's open, modernist design and popularity among tourists are two factors legitimising the residents' demand:

> It was a huge mistake of modernism to efface the boundaries between public and private space. Until the tourists, restaurants and other attractions were few, fences, walls and gates weren't necessary for people from the outside to respect the residents' privacy. [Today] gating of the Main City backyards is the only chance to preserve it as a [city] centre with not only shops, restaurants, attractions, but its own residents as well.

Interviewed on the same issue, the Manager of the City Centre underlined the educational aspect of the project, namely building shared responsibility and integration among residents (Karendys 2017). Thus, apart from the overall change in the discourse the analysed articles also reveal an evolution of the stance taken by the local authorities – from "in Polish legislation there is no legal basis to ban gating" and "ban on gating strikes at property rights" (Kozłowska 2015b) in 2015, to treating gating as a necessary evil to safeguard the residents' common good while they "learn to manage the space in a shared, and not individual manner" (Karendys 2017).

The analysis of the articles not only signalled the quintessential issues of the research problem, but also confirmed the existence of three main representations of gating in Gdańsk, depending on temporal and locational settings and spatial consequences: primary suburban gating, secondary inner-city gating and combined gating in large-scale housing estates. *Primary suburban gating* equates gating in its 'classic' form – fenced new-build condominiums with security surveillance. Due to weak social ties between neighbours, rather than qualifying as gated communities, they are considered to be 'communities of anonymity'. However, peripheral location renders their enclosure relatively uncontroversial. Contrastingly, in the case of *secondary inner-city gating*, which concerns mostly multi-resident housing from before the Second World War and the decades shortly after, introduction of fences is often perceived as appropriation of common space. Gating of the existing residential buildings in a dense urban fabric results in cutting off long-established shortcuts, isolates neighbours and prevents their children from joint outdoor activities. On the other hand, the proponents of gating point to benefits following from the enclosure – most of all easier maintenance and control over immediate surroundings. Lastly, *combined gating in large housing estates* concerns both primary gating of new buildings erected in between the modernist tower-blocks from the socialist period and secondary gating of the latter, also in retaliation for limiting access to the previously shared space.

6.2 Interviews

As follows from the interviews, attitudes towards gating in general are mixed. Some respondents are decidedly against it for numerous reasons, while others try to be understanding, for instance by attributing it to the post-socialist legacy of the shortage economy:

> I kind of understand it, because I spent my childhood in People's Republic of Poland, without a room of my own [...]. Perhaps people from these older generations of our parents and grandparents were traumatised by being deprived of their property, own space [...] and [now] only look as far as to the confines of their fence or gates (A_4).

The same interviewee introduces the term *microcommons* to label residential space enclosed out of the need for private possession and security. It assumes that gating, regardless of its form and location, may be explained by cultural or historical factors. Yet, the majority of respondents who refer to gating in the context of commoning tend to differentiate between its types in accordance with the classification proposed in the previous section.

One of the most exploited narratives grants the owners of the homes in newly built residential estates the right to fence their 'common' property. The *common private property* argument relies on the analogy with detached housing:

> It is quite interesting that our culture takes it for granted that someone who owns a single-family house and a garden surrounds them with a fence [...], but in the case of multi-family buildings it is expected that they remain unfenced – it is a sort of inconsistency (E_7).

An interviewed planner insists that "the right to fencing" derives from the constitution and serves to protect interests of those who "spent a lot of money to have some greenery planted, a playground installed", preventing all these costly amenities from the potentially destructive impact of outsiders, e.g. stray dogs or loitering youngsters (P_13). This standpoint is supported by a decision-maker's view on immediate residential surroundings as a historically acknowledged "private public space" (D_11). While usually applied to exonerate primary suburban gating, the same reasoning appears also with reference to gating in the inner city and large housing estates. For instance, the non-residents' need for crossing inner-city backyards is questioned and it is noted that while spaces between the blocks of flats used to be "no-one's" and thus could serve "everyone" under socialism, they now have proper owners and cannot be treated as a fully accessible public space.

Another, though similar, way to look at gating is seeing it as counteraction or a defensive response against abuse of the common good. Such may be the case of secondary inner-city gating:

> It is generally a [result of] tourism and recreation pressures, all year round. I have always lived in the city centre and I have observed as year by year [...] the residents feel less and less at home, they feel pushed out. Therefore, [gating] is a counteraction, meaning that [...] they close this space, in a way reserving it for themselves (P_15).

Apart from accusing tourists and other non-residents who "ravage, park illegally [...], drop off their garbage, [...] relieve themselves" (A_6), some interviewees tend to blame the inappropriate urban design, which leaves residents with no other recourse than to install the fencing.

A contrasting approach highlights the notion of shared responsibility taking. Here gating is recognised as an act of commitment to taking care of the common good. The respondents apply this concept mostly to secondary inner-city gating, using it in praise of residents' readiness to getting involved in management of the dilapidated backyards. Instead of focusing on the residents' rights to gate their property, it underlines how their obligations towards the property generate the necessity of gating. In this sense, gating

is depicted as an almost altruistic enterprise. A related, but more elaborate attitude assumes that gating enables responsibility learning. One of the activists employs to that end a metaphor of a grave health condition of backyards in the Main City, incurable by natural methods, such as herbal teas and eating well, but requiring hard measures in the form of a shot of antibiotic, i.e. gating. The interviewee concludes that only then it is possible for the backyards to recover and for their guardians to start anew, gaining knowledge of how to take proper care of the backgrounds' well-being:

> Gating [...] clearly specifies to whom the backyard space belongs and who is responsible for it. Once we [gate the backyards], once the residents get the sense that they are managers of this space, [...] once they reckon that these benches are for them to sit down [...], and that the toys their children have left in the sandpit won't disappear overnight, once they learn to tend the grass growing here, which they will have to mow by themselves, and once they transfer this awareness to the next generation, then in about 20-30 years these backyards might spontaneously open up to the city. Because it will finally enter our minds that these are in fact semiprivate spaces of residents living there (A_3).

In other words, gating as a shock therapy is applied to restore the lost balance before the treatment may be continued with the use of more gentle procedures. Another activist claims that, "for the time being", it is in fact "the only way to sort things out" (A_6). It seems interesting that respondents see the learning process as two-way. On the one hand it concerns residents, accused either of helplessness or being arrogant and used to having things done by 'someone else' (e.g. the state, the city authorities, the housing administration). On the other – it also holds for non-resident users of the contested space, such as tourists, suppliers of shops and restaurants, individual drivers seeking parking opportunities and standard trespassers (or 'shortcutters').

To a lesser extent and in a slightly different context responsibility learning is applicable to gating in large housing estates. For instance, one of the interviewed residents mentions how a housing cooperative in her neighbourhood fenced a car park just to teach its users proper handling of a shared facility. In the long run responsibility learning is expected to foster civic engagement not only at the level of neighbourhood but the whole city as well:

> Local communities which [...] self-organise to manage their backyards, in a moment will do so also around the corner [...]. To me, it is the natural sequence – we first take action here and then move on to the next level (A_6).

The last strategy exposed in the interviews refers to *retaliation for anti-commoning* and is connected with combined gating in large housing estates. A singular reported case concerns a situation in which gating of new residential buildings implanted between the blocks of flats from the socialist period cut off an existing pedestrian route. In an act of 'revenge', seeking attention from the media and the local authorities, the outraged 'excluded' residents reciprocated and separated themselves as well.

What follows from the research results is that the narrative of gating as exclusionary commons has indeed emerged and persisted in Gdańsk throughout the last decade. Different rationales are used by the interviewees to justify gating in different types of residential neighbourhoods (Table 1). In the new housing estates in the suburbs, gating is considered to be 'naturally' following from exercising individual property rights by groups of residents who happen to live in the same estate. In the inner city the explanation is more about self-defence against appropriation of common good and self-organisation for protection of common interests. The issue of gating in large housing estates is relatively less pronounced in the interviewees' accounts and specifically involves a revanchist reaction to enclosure of infill residential development. On the whole, this diversity stems from dissimilarity of challenges and necessities typical of distinct urban built environments, but other factors may play an additional role.

All six arguments are arranged in the table in the order of increasing value of the responsibilization factor, forming a continuum of priorities: from collective private interests

Table 1: Rationalisation of exclusionary commoning in different types of gating

Exclusionary commons rationale	Type of gating			
	primary suburban	secondary inner-city	combined in large-scale housing estates	unspecified
establishing microcommons				+++
protecting common private property	+++	+	+	
counteraction against the abuse of the common good		+++		
taking responsibility for the common good		+++	+	
learning to share responsibility for the common good		+++	+	
retaliation for anti-commoning			++	

Source: own elaboration based on interview results.

to collective common interests. Perhaps the most striking result of the study is that while the principle of the sacred right to private property seems to apply in all three neighbourhood types, it is the only (and the most pronounced) rationale represented in the suburban estates. Conversely, the more 'communal' narratives, employing the notion of common good, are observed primarily in the inner city. This leads to two assumptions which would require further research to substantiate. Firstly, putting collective common interests before collective private interests may be easier in old neighbourhoods, where the existing local communities, consisting mainly of old-time neighbours, have a relatively greater capacity for collective action than their atomistic suburban counterparts. Secondly, the size of the gated residence probably matters. The estates in the suburbs, usually green-field developments, cover larger areas with adequately bigger numbers of residents, which goes against Olson's rule for effective collective action. Old tenement houses in the inner city comprise housing associations which rarely exceed 10 homeowners, who may find it harder to evade common responsibilities or, contrarywise, may find it easier to cooperate with fellow residents.

Post-socialist specifics relate to all six strategies, hinging on aspirational consumerist culture and harsh neoliberal jungle-law conditions affecting every-day urban life, but the key to their understanding may be hidden in the two extremities – the perspectives of microcommons and retaliation. Even though 30 years passed since the systemic change, the majority of consumers in the Polish housing market still seek compensation for the constraints of the socialist period but also simply lack experience of cooperation at the neighbourhood level. The ongoing direction of changes is nonetheless somewhat promising. With time, as the question of common good increasingly appears in public discourse, what we take today for the fiasco of commoning may turn out to have been its difficult early beginnings.

Processes of gating in Gdańsk have been heterogeneous both in space and time. Just like in other Polish cities, at the beginning of the research period they were restricted to developer investments in the suburbs, as an outcome of utterly market-driven management of space. Delayed but reasonable attempts to prevent urban sprawl by means of the inward urban development policy all the same contributed to the spillover of the gating trend, not only in the inner city, but in the post-socialist block-of-flats settlements as well. Another initiative which legitimised enclosure of common space in Gdańsk, was the Main City backyards' renovation programme. Its implementation endowed the process of gating with an upbeat narrative, according to which it served the common good of the local residents by weaving social ties and building a sense of community. Yet, this sort of reasoning has hardly been validated in reality. Thus far, exclusionary commoning initiatives – especially with regard to community-building through responsibilization – remain largely declaratory. Enclosed residential spaces, although increasingly functional and aesthetic, are still perceived through a prism of collective private interests, with

little social interaction between users. The residents' concern for these spaces usually resolves to paying contributions to the common renovation fund, which covers costs of their management by external companies. Interestingly, despite the change of social perception and evaluation of gating in Gdańsk – from full acceptance at the beginning to the mounting contestation in recent years – the exclusionary commoning rationale is not only still used to explain and justify gating but has become a ubiquitous excuse for residential enclosure. Nonetheless, the responsibilization thread which has appeared relatively recently in the public discourse and is present in our interviewees' accounts points toward a qualitative change worth additional investigation.

7 Conclusion

One of the most significant transformations ongoing in post-socialist cities is shrinkage of public space as a result of fierce privatisation of urban areas. Residential gating represents only one of its many variations. While it has been condemned for its detrimental effects on the urban common good – the undesired consequences of socio-spatial segregation and exclusion – some arguments speak against such unequivocal assessments. We find that residents of gated estates may rationalise their preference for enclosure with logic which diverges from the classical narrative focusing on individual needs in terms of security and prestige. Analysis of spatial distribution and motivations for residential gating in Gdańsk provides evidence of these practices being performed under the banner of the collective common interest by means of exclusionary commoning. For instance, the enclosure of backyards in the historical city centre, a popular tourist attraction, may be regarded from the outside as an example of transformation of public space, a commons, into a club good. However, from the residents' perspective, or an insider's point of view, it well as may be presented as a 'justified' regulation of a shared concern. In this specific case – a defensive reaction against appropriation of the common residential space by tourists. A more intricate justification of gating is based on the assumption that enclosure may prompt residents' concern for the shared space and motivate them to learn how to manage it collectively and effectively. While the proposition of looking at gated estates as actual platforms for building social relations and shared responsibility as of yet may be premature, we find that responsibilization does play a key role in rationalising exclusionary commoning and therefore it provides the answer to our third research question.

Considering the ongoing neoliberalisation of everyday life, the persistent 'sacredness' of right to individual property and the rather makeshift (re)actions of local authorities, the timing would not seem right for the gating trend to reverse. Then again, the discourse on gating and its socio-spatial consequences has been increasingly critical, accompanied by a growing awareness of the importance of cooperation and collective action – from the microlocal level upwards. This opens possibilities for a bottom-up evolution of informed involvement and concern for the common good in all spatial dimensions. After three decades of transformation in countries of Central and Eastern Europe, such a shift seems likely, even if social and mental changes usually take the longest to complete. On the one hand, certain traumas associated with the socialist period have already subsided, including the understandable reluctance towards the 'common' or 'collective'. On the other – the experience of neoliberal reality, with the imperative of acquiring private goods and demonstrating economic prestige in urban residential spaces, has instilled the counter-demand for cooperation, participation and implementation of common undertaking in local communities. It remains to be seen, whether the recent pandemic of COVID-19 completely overturns the current state of affairs in terms of social relations and urban commoning in residential contexts. A full range of reactions may be expected – from extreme social distancing, motivated by health and safety requirements, to a redefined social closeness, expressed in real cooperation, mutual care, solidarity and collective action. It is also possible that in the post-COVID-19 era the term 'exclusionary commoning' will take on new meanings.

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Outflow of Talents or Exodus? Evidence of youth emigration from one of the EU's peripheral regions in Poland

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Abstract. Human capital migration and its consequences for regional development are among the central issues discussed in migration and regional literature. A growing interest has been recently observed in student migration as a driver of brain exchange between regions and countries. Furthermore, poor sending areas are often considered to be severely affected by the brain drain. Nevertheless, firm empirical evidence on the degree of the human capital selectivity of youth migration is actually scarce due to measurement and methodological limitations.

This paper sheds some light on human capital redistribution across regions and countries by estimating the intensity and human capital selectivity of youth emigration from the Lubelskie Region (Poland) – one of the poorest, peripheral EU regions. A survey of ten thousand secondary school graduates allowed an analysis of mobility patterns in relation to school-leaving exam results being a proxy for human capital, as well as to sex, type of school, and former place of residence.

This study revealed, that roughly 20% of graduates leave their home region and predominantly continue education on higher education institutions. Migration rates across the youth characteristics followed by the results of logit regression model confirm that migration outflows, and particularly interregional moves, are a highly selective phenomenon. With regard to international mobility, student migration is positively selected as well, but economic migration among graduates electing not to continue education turns out to be adversely selected. Overall, the brain drain on the EU's peripheral areas in Poland with respect to the emigration of secondary school graduates should be regarded as a selective outflow of the most talented graduates to the leading academic centers, rather than massive migration of all graduates.

Key words: youth migration, student migration, brain drain, human capital, peripheral regions, interregional migration, international migration, regional development

1 Introduction

Migration is a highly selective phenomenon, as recognised by Ravenstein (1885, 1889) in his famous 'laws of migration'. Although the assumption that more educated and skilled individuals are more willing to migrate is now widely accepted, firm empirical evidence on human capital selectivity appears to lag behind. Concerning youth mobility, some major research-related issues deserve a mention. First, administrative sources or representative

surveys usually fail to capture the selectivity of human capital migration across regions. Second, migration selectivity measures often rely on the level of education, which in fact is a poor indication of actual human capital (Wößmann 2003). Third, most studies on regional mobility patterns investigate the migration of university graduates, whereas the mobility of secondary school graduates remains less explored. In the latter case, most contributions analyse only migration related to university enrolment, i.e., student migration, leaving the mobility of non-students unexplored. In the absence of nationwide data in many countries (including Poland), local research might shed some light on this issue.

Furthermore, youth emigration from less developed regions and cities in Poland deserves attention because of its country-specific context. Given the inclusive tertiary education system, considerable regional economic disparities and massive emigration after Poland's accession to the EU in 2004, one would expect to see youth exodus from less developed, peripheral areas with adverse effects on regional growth trajectories.

In this regard, the article aims to estimate the intensity of post-secondary school emigration from the peripheral Lubelskie Region as well as the patterns of human capital selectivity of youth mobility, considering both interregional and international moves. The research data was collected in three cross-sectional tracking studies conducted since 2016 on a total of approximately ten thousand secondary school graduates in Lublin (Poland).

Being a census rather than a sample study, the presented research offers several important contributions to the literature. Firstly, it analyses data on actual (rather than potential) youth emigration, allowing for precise estimations of migration intensity and selectivity among secondary school graduates. Secondly, it offers a thorough insight into post-secondary school mobility, entailing interregional and international student mobility as well as the moves of graduates who decide not to enter tertiary education. Thirdly, the article sheds light on post-secondary emigration from the perspective of the sending areas, which is also uncommon.

Another valuable contribution of this paper stems from the analysis of the migrants' human capital, which is measured by considering the school-leaving examination results, rather than the most commonly used and more general proxies based on the education level, years of schooling, or the quality of educational institutions. Finally, the article provides an in-depth analysis of emigration from peripherally located, poor EU region, adding new findings to the ongoing discussion about brain drain affecting less developed areas.

The remainder of the article is structured as follows: Section 2 presents the related literature pertaining to the size and selectivity of youth migration and its regional economic consequences. Section 3 provides a snapshot of the specific sending area: the Lubelskie Voivodeship with the capital city in Lublin, located in the eastern peripheries of the EU. Section 4 presents data and the adopted empirical strategy, while Section 5 provides descriptive statistics and regression logit model results. Section 6 contains a discussion of the main findings and concluding remarks.

2 Literature overview

2.1 Youth migration: intensity and regional differentiation

One of the most commonly recognised stylised facts about migration selectivity pertains to its strong age profile (Bailey 2009). Studies on migration intensity conducted across a variety of countries and at various spatial scales found that, in almost any society and regardless of strong country-to-country variations, the emigration rate follows a distinct pattern and peaks for young adults in their late teens and twenties, after which it steadily declines with increasing age all the way to the retirement level (e.g., Clark 2013, Findlay et al. 2015, Bernard, Bell 2015).

Literature offers considerable evidence for the prevalence of intra-regional mobility among migrating secondary school graduates, and the increasing distance of migration in subsequent life-cycle stages (e.g., White, Lindstrom 2005, Winters 2011, Ahlin et al. 2018). Nevertheless, as university enrolment continued to grow in recent decades, there has been a significant increase in the magnitude of international student migration (OECD 2018).

Many studies recognise increasing students' interregional mobility rates (e.g., Lundholm 2007 for Sweden, Smith, Sage 2014 for England and Wales, De Angelis et al. 2017 for Italy), despite parallel stable or even declining internal mobility trends observed in many developed countries (Champion et al. 2017).

Given the research scope of this paper, works offering evidence on the intensity of youth migration across regions deserve particular attention. The overwhelming majority of contributions offering such a perspective have been focused on individuals who completed tertiary education. Some examples include: Faggian, McCann (2009) for the UK, Venhorst et al. (2011) for the Netherlands, Haapanen, Tervo (2012) and Kotavaara et al. (2018) for Finland, Ahlin et al. (2018) for Sweden, Parey et al. (2017) for Germany, Oggenfuss, Wolter (2019) for Switzerland, Corcoran et al. (2010) for Australia, Capuano (2012) and Marinelli (2013) for Italy, Whisler et al. (2008) for the US, Herbst et al. (2017) for Poland, or the book edited by Corcoran, Faggian (2017). These studies generally confirm that university graduates who enter the labour market are more likely to leave less developed and peripheral regions and tend to move to economically developed areas, particularly to growing metropolitan cities.

In contrast, the empirical evidence of regional differentiation in migration intensity of the secondary school graduates is modest. Most contributions focus on interregional student migration and confirm high youth mobility as well as its significant regional differentiation.

Ciriaci (2014) analysed data on tertiary education enrolment in Italy and confirmed that in the northern regions, more than 95% of secondary school graduates remained in the region where they had lived before enrolling at university, while the respective rates for the southern regions varied from approximately 50% for Molise and Basilicata to 80% for Sicily, Sardinia and Campania.

In their work on interregional student migration in Greece, Psycharis et al. (2019) found that the number of students migrating out of their region of residence amounted to 66.7% in 2010 and 56.7% in 2012, with Athens and Thessaloniki identified as the main student destinations.

McClelland, Gandy (2012) examined student mobility between the UK regions and confirmed that 56% of UK students studied in their home region in 2008, but the situation varied for individual regions. Scotland and East of England were two extreme cases, with the percentage of students choosing their home region equal to 93% and 32%, respectively.

Smith, Sage (2014) presented a regional net migration rates in England and Wales calculated in absolute numbers and proved that the populations of 16-24-year-olds were declining in almost all regions with the exception of London, Yorkshire, and the Humber.

Kodrzycki (2001) estimated that inter-state migration rate in the US for all high school graduates was 25.5% for all graduates and 26.8% for graduates proceeding to continue their education at college. She also found regional differences in graduate outflows across nine US Census Divisions, although the exact rates should be interpreted with caution due to the small sample size. Later contributions pertaining to the US by Cooke, Boyle (2011), Winters (2011) and Faggian, Franklin (2014) confirmed the uneven geographical distribution of the migration of high school graduates applying for college admission.

In Poland, given the absence of reliable and publicly available statistics, research on the regional mobility patterns of secondary school graduates is scarce and usually takes the form of sample studies investigating the intention to move rather than actual migration. The notable exceptions are works by Herbst (2009) and Herbst, Rok (2016) who examined student migration by using a large and unique dataset from a Polish networking site. Their works revealed that, at least until 2008 when the data ends, roughly 70% of Polish students studied in their home regions, while at the same time, student mobility from rural areas and small towns to academic centers within said regions remains significant. They also confirmed that less developed and peripheral eastern regions are less successful in retaining their graduates, although cross regional differences (except for Mazowieckie Voivodeship with the Capital City of Warsaw) are not large. Nevertheless, their research does not incorporate any measure of the individual human capital of graduates.

Finally, it should be recognised that research on the migration of secondary-school graduates within a regional framework is hampered by serious data limitations, which

presumably explains its minor representation in literature compared to post-university mobility. Secondary school graduates who migrate within a given country often do not register a change in their place of residence, so official registries are in fact a useless source of information on youth mobility in general and student mobility in particular. Furthermore, nationally representative household surveys usually collect only basic migration data and migrant samples tend to be too small to reliably capture regional mobility patterns, particularly with respect to young people[1]. Last but not least, while the studies summarised above provide a fairly good depiction of differences in migration intensity across age-groups or particular areas in one country, rigorous cross-country comparisons are impeded by multiple measurement and methodological issues, as discussed more extensively by Bell et al. (2015).

2.2 Human capital selectivity of youth migration

A well-established fact on migration is that more educated and skilled individuals are usually more willing to migrate, particularly when a long-distance move is considered. Literature on the economics of migration usually explains this phenomenon by regarding migration as a decision of rational individuals who are maximizing returns on their human capital (Roy 1951, Sjaastad 1962, Borjas 1987). Although numerous migration studies have suggested multiple factors other than strictly economic gains that influence the decision to migrate[2], the positive human capital selection is prevalent both in the case of interregional and international migration (Greenwood 1975, Belot, Hatton 2012, Corcoran, Faggian 2017, Dao et al. 2018)[3]. Moreover, it is in the positive selection of migration that the popular concept of brain drain is embedded. However, research on brain drain tends to focus primarily on migration outflows from less-developed countries and offers cross-country, rather than cross-regional approach to the human capital selectivity of migration.

One drawback of research on migration is that human capital selectivity is usually measured relative to the migrants' educational level or, at best, number of years of schooling. Although such data are the most readily accessible indicators, these are in fact very poor proxies of human capital endowment, particularly given huge variation in quality of education institutions (Wößmann 2003, Folloni, Vittadini 2010).

Against this backdrop, there is a growing strand of literature analysing human capital selectivity of post-university migration which provides conclusive evidence that graduates with higher final grades are generally more willing to migrate (e.g, Faggian et al. 2007, Venhorst et al. 2010, Capuano 2012, Ahlin et al. 2018) and less prone to return to their home region (e.g., Marinelli 2013, Herbst et al. 2017). In contrast, evidence on the selectivity of post-secondary school migration is scarce, with only a handful of studies introducing some method of measuring human capital.

Tosi et al. (2019) investigated student mobility across Italian regions with a dataset based on secondary school graduation marks. They found that interregional migration inflows to the North are positively selective in terms of individual skills, while no such pattern occurs in the South. Overall, the predicted probability for interregional mobility in Italy gradually increases from 8.6% for students in the lowest grade band to 15.1% for top graduation marks students. Nevertheless, a precise estimation of the degree of human capital selectivity in the context of migration from individual Southern regions was hampered by the small sample size.

Psycharis et al. (2019) examined patterns of interregional student migration in Greece relative to the quartiles of students based on their exam grades, and found evidence on adverse migration selectivity. While the majority of Greek students enter the university outside their prefecture (NUTS III), students in the upper two quartiles (with higher

[1] See Bilsborrow (2016) for a comprehensive discussion on the limitations of household surveys in migration research.

[2] Factors underlying young people's decisions to migrate are not summarised here, however, the theoretical background of migration-related decision-making was discussed by Hagen-Zanker (2008), Corcoran, Faggian (2017) discussed empirical evidence pertaining thereto, while Dotti et al. (2013) and Beine et al. (2014) analysed the drivers of student migration.

[3] However, there are a few notable exceptions, as indicated in the studies on international migration (Moraga 2011, Beine et al. 2011).

grades) were more likely to stay within their home area or move shorter distances in comparison with low-performing students. Students with higher exam scores are more selective and able to choose a high-performing university in their home region, while those with lower scores have more limited choices and often have to move away. According to the Authors' explanations, the former group's preference to stay might results from the additional costs of studying away from home that some families cannot sustain, whereas the decision to move of the latter group may possibly stem from overall strong emphasis on the importance of university education in Greek society.

Faggian, Franklin (2014) used the Integrated Post-Secondary Education Database to analyse the interstate mobility of high-school leavers applying for college admission in the US. In the absence of precise measures of the graduates' human capital, they associated the quality of students with the quality of their respective high schools. Further, they compared states by net-inflows of students rather than emigration rates. Nevertheless, their study confirms significant regional differences in retaining and attracting high-school graduates showing, with a few exceptions, a West-East divide, with the Eastern states remaining firmly ahead in the race for high-quality students, particularly when the 'students' quality' is considered.

Findlay et al. (2010) investigated the international student mobility of graduates in the UK and found that pupils with the highest GCSE (The General Certificate of Secondary Education) results were over two times more likely to apply to study abroad (5.2% versus 2.3%), although this result was obtained for a non-representative sample of 1400 final-year pupils from schools in only two regions of England.

2.3 Regional consequences of human capital migration

Human capital accumulation was recognized as an important driving force of economic growth by the neoclassical growth theory and subsequently by the endogenous growth theory (Mankiw et al. 1992, Lucas 1988, Barro, Sala-i Martin 1995). The literature confirming its contribution to growth is already extremely extensive (see e.g., Fratesi 2014, Faggian et al. 2019). Consequently, given the fact that high-skilled individuals are more willing to migrate, human capital migration should have a significant impact on the development prospects of local and regional economies.

Most empirical research on the consequences of human capital migration is focused predominantly on international migration (see e.g., Nathan 2014). Nonetheless, some of its reported findings might be relevant also to the issue of interregional migration. Research studies on the consequences of migration for the sending countries, often conceptualized as a brain drain, deserve attention. In earlier contributions it was claimed that skilled migration contributes to the widening gap in human capital endowment between more affluent host countries and less developed sending areas, with adverse effects on the growth of the latter (Bhagwati, Hamada 1974, Miyagiwa 1991). Later works on brain drain suggested that skilled migration need not be a zero-sum game, as migration prospects can raise the expected returns to education and foster investment in human capital in the origin country, which subsequently enhances its growth prospects (Beine et al. 2001, Stark 2004, Kanbur, Rapoport 2005, Docquier, Rapoport 2012). Nonetheless, many empirical works confirm the overall negative effects of high-skilled emigration on growth. For example, Beine et al. (2008) found that although countries combining relatively low levels of human capital and low emigration rates are more likely to experience a beneficial brain drain, most countries experience negative net effects of emigration and, more importantly, their loss is more significant than the gains of countries enjoying positive net effects. Apart from increasing educational investment, literature on international migration indicates also other potential gains for the sending country, e.g., the remittances and the 'skilled diaspora effects' which might facilitate trade, capital flows, and knowledge diffusion between the host country and the country of origin (De Haas 2010, Bahar, Rapoport 2018).

Some of the abovementioned beneficial mechanisms revealed in international migration studies might be possibly applicable to interregional migration, although the specificity of the latter must also be taken into account. Compared to differences between countries, wage disparities or language and cultural differences within one country are usually less

pronounced. Consequently, the gains obtainable from increasing educational investment, remittances, or diaspora should not be substantial. Faggian et al. (2017) conclude that potential benefits from emigration for sending regions are yet to be examined in regional literature, but most recent research has not found any evidence on such positive outcomes in Southern Italy (Nifo et al. 2020). On the whole, the negative effects of emigration on the human capital accumulation and growth of the origin region appear to be prevalent.

The majority of recent empirical studies on the regional consequences of interregional migration indeed tend to highlight positive consequences for the host region and adverse effects for the sending areas. A meta-analysis conducted by Ozgen et al. (2010) confirms small, but statistically significant positive effects of net interregional migration on the growth of real income per capita within the regions. The authors also stress the need to incorporate the skill composition of migrant populations in further research. Winters (2011) proved that migration inflows attributable to university enrolment significantly contribute to the faster growth of American 'smart cities' relative to low human capital cities. Fratesi, Percoco (2014) investigated the impact of interregional migration on convergence among Italian NUTS 3 regions and found that although in general migration flows were usually a balancing factor, selective migration seemed to constitute a diverging force in the regional convergence process, while significant highly-skilled emigration deteriorated the growth of southern regions. Notably, in their study, human capital was quantified in relative terms to the years of attained education. Kubis, Schneider (2016) analysed the effects of regional migration on regional convergence and growth in post-reunification Germany. Their dynamic panel data model confirmed a negative, but modest effect of emigration on regional growth. Their results also revealed a decreasing regional skill level in the East Germany Regions. However, the migrants' human capital was not directly observed, therefore a variable representing the share of employees with an academic degree in the regions' workforce was designed instead. Faggian et al. (2017) presented a comprehensive review of recent research and highlighted the beneficial effects of high-skilled interregional migration on productivity, innovativeness, and wages in the destination region. When discussing the outcomes for sending areas, they focused on the adverse effects, particularly in terms of reduced growth and brain drain. However, they stressed that impact studies of migration on the origin regions are extremely limited due to data constraints. Fischer, Pfaffermayr (2018) found that migration increases convergence of income within the EU on the NUTS 2 level, however, their data did not include measures of migrant's human capital. Nonetheless, they admitted that the amount of human capital possessed by migrants determines the positive or negative impact of migration on income convergence.

3 Local and regional background for the migration of Lublin school graduates

As empirical evidence clearly confirms considerable regional differentiation of migration outflows, a short description of the sending area will allow for a better understanding of the applicable migration patterns. Lublin is the capital city of Lubelskie Voivodeship – a peripheral NUTS 2 region located on the eastern boarder of the EU (see Figure 1), neighbouring with Ukraine and Belarus.

The Region is one of the poorest in Poland and remains among the 20 poorest regions in the whole EU, with the GDP per capita at the level of 69% relative to the Polish average and 48% to the respective value for the EU (in PPS standards, 2017). Since Poland's accession into the EU in 2004, the rate of GDP growth in Lubelskie Voivodeship has remained, on average, below the nationwide rate, which might be partially explained by the region's predominantly agricultural profile. While the unemployment rate only slightly exceeds the national rate, wages continue to be ranked at the bottom of Polish regional statistics. The low job finding rate and sluggish non-agriculture employment growth clearly confirm the weakness of the region's labour demand. The predominance of rural population and underdeveloped transport infrastructure have further contributed to the region's peripherality. Not surprisingly, Lubelskie is therefore one of the most migratory Polish regions in terms both international and interregional migration outflows, and at

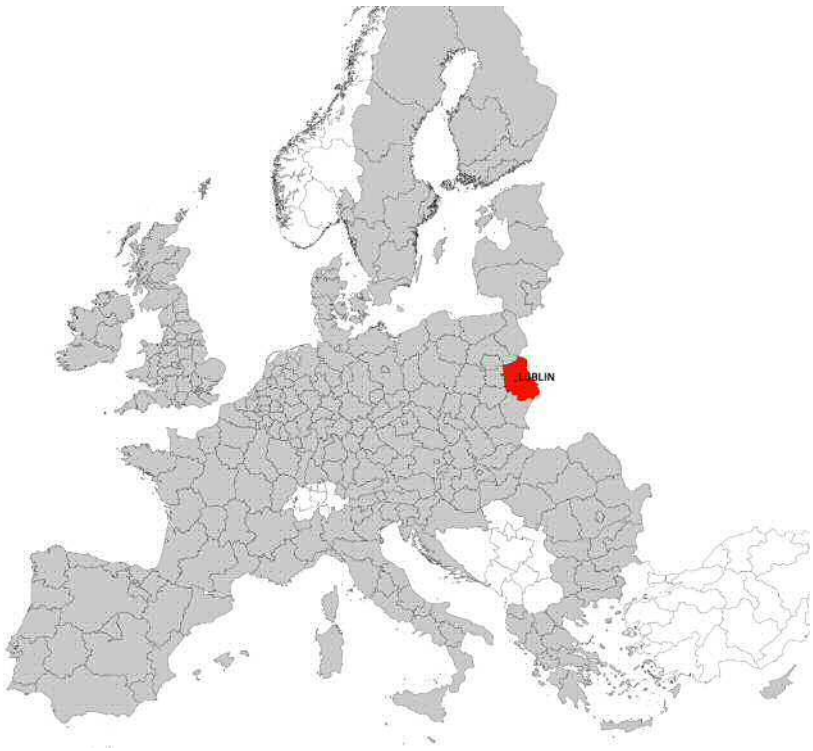


Figure 1: Location of Lublin and Lubelskie Voivodeship in the European Union

the same time one of six voivodeships in Poland clearly struggling with depopulation since Poland's accession into the EU.

Although Lubelskie Voivodeship clearly exhibits the characteristics of a peripheral area[4], the development patterns of Lublin, the region's capital city and 9th largest city in Poland by population size, are seemingly more favourable. The local GDP estimates indicate that, at least since 2008, GDP per capita has remained above the national average (Ciołek 2017, Makarewicz, Maleszyk 2018). The unemployment and wage changes are roughly in line with recent improvements observed nationwide, although demonstrate more favourable performance against Polish cities of similar size. Given the fact that teen mobility is largely driven by the university enrolment process, one of the distinct traits of the city is its strong academic profile with nearly one-fifth of the resident population studying at one of its nine academic institutions. On the downside, 'Perspektywy' - the most popular ranking of academic institutions in Poland - ranks the four leading universities in Lublin only in the third and fourth tenths out of 94 classified institutions. At the same time, the city continues to secure top positions in quality-of-life rankings, particularly in terms of safety, clean and green environment, and human and social capital, as well as cultural offerings.

4 Data and methods

Research on secondary-school graduate migration in Poland is hampered by the absence of publicly available statistics or representative surveys. This research aimed to partly fill this gap as it entails three waves of a cross-sectional tracking study conducted since 2016 in partnership with the local government in Lublin. The scope of the project covered 19-21-year-olds graduating from 33 secondary schools[5]. Graduates were interviewed 6 months

[4]See Flaga, Wesołowska (2018) for further discussion and empirical evidence.

[5]Specifically, 32 public secondary schools (20 three-year comprehensive schools and 12 four-year technical schools) and one private comprehensive school. Other private schools (approximately 5% of all graduates) refused to partake in the research. The study did not include special needs schools (less than 0.2% of graduates) and adult schools.

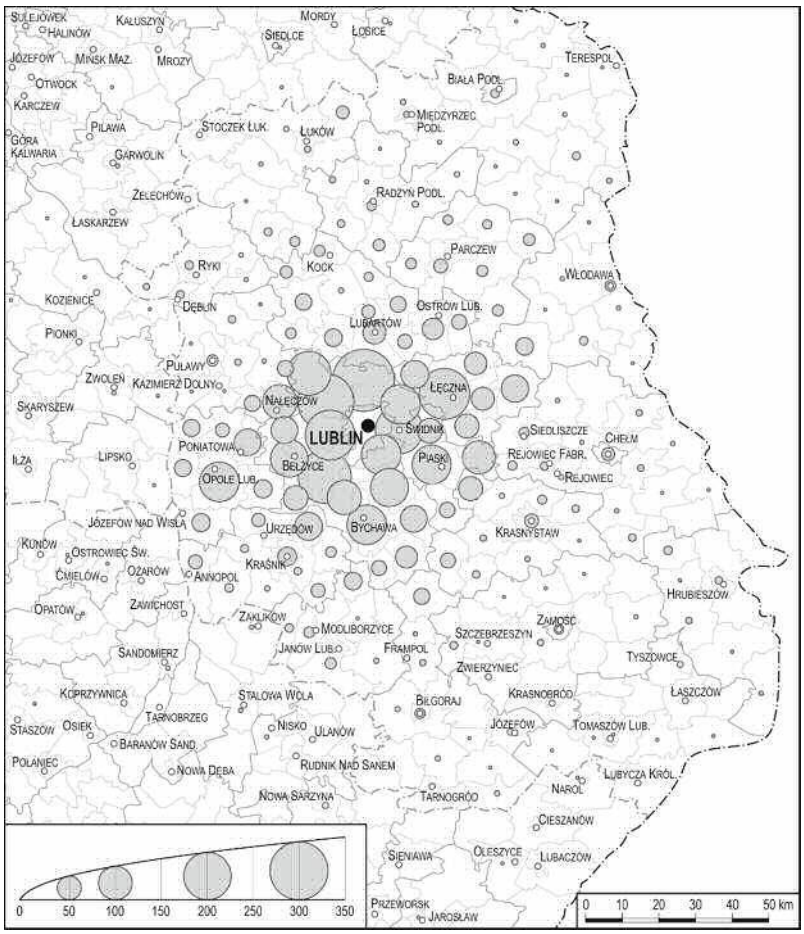


Figure 2: Spatial distribution of graduates residing outside Lublin before secondary school enrolment

after sitting the school-leaving examination (matura), which conditions the possibility of taking up further study at tertiary education institutions. The interviews were conducted by the respondent's former form tutors. The gathered information comprised the graduates' answers regarding their current place of residence and information on further tertiary education or work, matched by their tutors with individual school records including information on sex, place of residence before secondary school enrolment, and school-leaving exam results (on a 0-100% scale)[6]. During three editions of the survey, information was gathered on the place of residence of 91.2% of graduates from schools taking part in the research (see Table 1 for summary statistics) and approximately 85% of graduates from all public and private schools in Lublin. It is noteworthy that almost 45% of the young people were non-Lublin residents who came mostly from functional urban areas around Lublin (see Figure 2) Overall, graduates sitting the school-leaving examination whose mobility patterns were recognized accounted for over 20% of the respective graduates from the whole voivodeship. A summary of respondent statistics is presented in Table 1.

With a focus on human capital emigration from peripheral areas and its implications for local and regional development, the empirical part of the study aimed to address two research questions:

1. What is the intensity of secondary school graduate migration from the home region?
2. What is the degree of the human capital selectivity of the migration of secondary school graduates?

[6]Specifically, the exam result is the score obtained in the compulsory, written, advanced-level exam.

Table 1: Summary statistics

	observations	%
Graduates with identified mobility patterns	10,113	100.0
Type of school		
Comprehensive schools	7,164	70.8
Technical schools	2,949	29.2
Sex		
Male	4,295	42.5
Female	5,803	57.4
No answer	15	0.1
Residence before school		
Lublin	5,568	55.1
Outside Lublin	4,532	44.8
No answer	13	0.1
Continuing education?		
Yes	8,487	83.9
No	1,615	16.0
No answer	9	0.1
Survey year		
2016	3,198	31.6
2017	3,626	35.9
2018	3,289	32.5
No information on mobility	971	–

The following empirical analysis consists of two parts. The first presents a descriptive analysis of interregional and international migration rates across migrant characteristics. The second outlays the results of the logit regression model of graduate mobility with a set of available regressors: exam result adopted as a discrete variable, followed by dummy variables regarding sex, type of school, graduates' former residence and survey year. The results and some limitations of the study are then elaborated in the discussion.

My first hypothesis assumed that graduate migration rates from less developed, peripheral areas of the EU will be large in comparison to the migration rates in other regions. The second hypothesis was that youth emigration from peripheral areas is positively selected in terms of individual human capital endowment. If those hypotheses are proven correct, secondary school migration constitutes an important channel of human capital redistribution from less developed, peripheral areas to more prosperous ones, which might adversely affect the growth prospects of the former. In other words, the higher the migration rates, particularly among graduates with the highest potential productivity, the stronger the brain drain affecting the sending area. My results might also shed some light on the potential role of the academic role of regional capitals in poorly developed areas in terms of retaining talented young people within the region, which has important implications for urban and regional development policies.

Migration research offering a regional approach usually has to deal with some interpretative problems. In the remainder of this article, it will be assumed that migration intensity is measured by migration rates expressed as the relation between the number of respondents who left the region and the total number of surveyed graduates with identified post-graduation mobility patterns. As the definitions of 'a region' vary for one study to another (see e.g., Faggian et al. 2017, for discussion), emigration is interpreted as a movement outside the NUTS 2 Lubelskie Voivodeship, either to other voivodeships in Poland (interregional migration) or other countries (international migration). However, providing a precise definition of 'a migratory movement' in terms of residence duration poses a far greater challenge, particularly when student migration is considered. In fact, many students who migrate to other regions might spend much of their time in their

hometown. Nevertheless, I elected to associate the graduate's place of residence with the location of the university for several reasons. Firstly, the distinction between being 'a guest' and 'a settler' in the university's location is largely subjective and difficult to address empirically. Even more importantly, in this case, cross-regional commuting to universities on a daily basis is usually hardly feasible given the central location of Lublin and Warsaw (Lublin's closest and most popular destination for interregional migrants) within its regions' borders coupled with the low quality of cross-regional transport infrastructure. The case of students applying for part-time or extramural courses at universities located outside their home region is more ambiguous: they might either spend the rest of their time in their home area or permanently move to the university's location and seek employment there. The problem was partly explored by adding the question on type of studies, which revealed that approximately 90% of graduates continuing education chose full-time studies, while the overwhelming majority of those opting for weekend courses or external studies elected to stay in Lublin and combine education with work.

5 Results

5.1 Descriptive statistics

This section presents migration rates for the surveyed graduates across respondent characteristics. From the perspective of the first research question regarding migration intensity, one of the key findings concerns the total emigration rate which amounted to 20.5%. It is noteworthy that the rate calculated only for student migration did not differ greatly, and amounted to 21.6%. Almost one in six migrating graduates were moving abroad. Finally, each wave of the tracking study showed similar results. Table 2 presents the emigration rates across the different characteristics of the surveyed respondents.

As follows from the presented data, graduate mobility is intertwined with student migration: more than 80% of graduates continued their education and were 50% more likely to leave the region compared to those discontinuing formal education. However, the values of total emigration conceal strong differentials between interregional and international migration. Almost one in five graduates continuing education moved to other regions of Poland, while the corresponding rate for those discontinuing education was only 3%. International mobility patterns were completely the opposite, with young people not continuing education being roughly five times more likely to leave the country than those entering post-secondary education.

Furthermore, decisions concerning further education and migration were differentiated by the type of school: comprehensive school graduates were more likely to continue education and tended to leave the region more often than their peers from technical schools who were relatively more likely to immediately enter the labour market. The empirical evidence on emigration selectivity with regard to sex turned out to be inconclusive, with men slightly more likely to migrate to other Polish regions, although less prone to migrate abroad. Additionally, the role of place of residence in mobility patterns appeared to be secondary at best with slightly lower than the average migration rates for city non-residents.

Presumably the most valuable findings regarding mobility patterns pertained to the exam results, addressing the second research question concerning the degree of emigration selectivity. Emigration rates across exam results deciles (Figure 3a) clearly displayed distinctive positive human capital selection of graduate emigration, as the overall rate for graduates with the top 10% of exam results was three times higher than the rate for the middle deciles and more than 6 times higher compared to the values for graduates in the lowest deciles. The risk of migration remained low for the half of graduates with poorer exam results and gradually increased for higher deciles.

Furthermore, selectivity of migration resulted mostly from interregional migration, whereas international mobility is less selective. Referring to the latter (see Figure 3b), the overall migration rates across deciles do not vary substantially. Migrants seemed to be both positively and negatively selected, as graduates from top and bottom deciles were more likely to migrate than those with average results. The distinction between student and non-student mobility explains this U-shaped distribution well: migrants with the

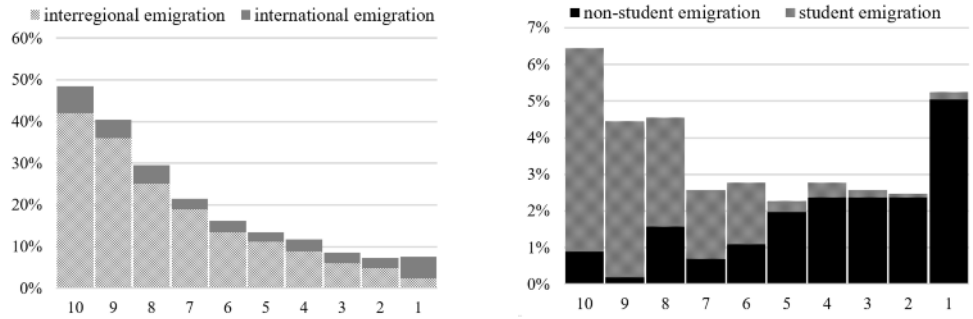
Table 2: Migration rates by selected respondent characteristics

Graduate characteristics	Interregional emigration rate	International emigration rate	Total emigration rate
Total	16.9	3.6	20.5
by type of school			
Comprehensive schools	19.5	3.5	23.0
Technical schools	10.5	3.8	14.2
by sex			
Male	18.1	3.3	21.4
Female	16.0	3.9	19.9
by former place of residence			
Lublin	17.7	3.7	21.4
Outside Lublin	15.9	3.5	19.4
by further education			
Yes	19.5	2.1	21.6
No	3.0	11.6	14.6
by survey year			
2016	16.1	3.3	19.4
2017	17.2	3.9	21.0
2018	17.3	3.6	20.9

highest scores continued their education in foreign higher education institutions, while those in the lowest grade band usually entered the labour market.

5.2 Logit regression model

The relationship between the set of respondent characteristics and their propensity to migrate was modelled with the use of a logit regression employing maximum likelihood estimation. The dependent variable is a dummy indicating whether the individual migrated from the Lubelskie Voivodeship (coded as 1) or stayed there (0). Given the fact that the migration patterns of Lublin residents might differ from those of young people coming from elsewhere in the region, I ran two regressions: one for all graduates of Lublin schools and one for Lublin residents only. To address the second hypothesis regarding positive human capital selection of migrants, explanatory variables included school-leaving examination result (discrete variable), followed by other available dummy-type variables regarding such characteristics as sex, type of school (comprehensive versus technical), and,



(a) Emigration rates (b) International emigration rates

Note: 10^{th} decile represents the 10% of graduates with the highest exam result.

Figure 3: Migration rates across exam results deciles: emigration rate (a) and international emigration rates (b), with its components

Table 3: Logit regression model results for total emigration from the region

Variables	Coefficients	Standard errors (SE)	Average marginal effects (AME)
	Model 1: all graduates		
Exam result	3.293***	0.117	0.0046
Sex(a)	-0.174***	0.055	-0.025
Place of residence(b)	0.196***	0.054	0.028
Type of school(c)	0.109	0.071	0.016
Survey year(d)	0.023	0.033	0.003
Constant	-3.332***	0.104	–
Observations	10,088		
P	0.000		
McFadden pseudo R^2	0.107		
Log-pseudo likelihood	-4,571.39		
χ^2	1,091.51		
	Model 2: Lublin residents		
Exam result	3.654***	0.166	0.0052
Sex(a)	-0.048	0.073	-0.007
Type of school(c)	0.082	0.106	0.012
Survey year(d)	0.023	0.044	0.003
Constant	-3.651***	0.143	–
Observations	5,552		
P	0.000		
McFadden pseudo R^2	0.121		
Log-pseudo likelihood	-2,536.25		
χ^2	697.66		

Note: Reference group: (a) men; (b) Lublin residents; (c) comprehensive schools; (d) 2016.
p-values for coefficients: * p<0.05; ** p<0.01; *** p<0.001

only in the first model, the former place of residence (Lublin vs. outside Lublin). The regressions also controlled survey year dummy variables (2016-2018). Thus, the model allows us to examine whether the selectivity patterns indicated in the previous section persist when other available variables are controlled. I calculated the average marginal effects (AME) and ran statistical significance tests and goodness of fit tests. Table 3 presents the results obtained from these models.

Initial analysis of the results suggested that the two estimated models yielded similar results concerning AME of 'examination results.' This led to the conclusion that migration patterns of graduates from Lublin and those from the region in terms of human capital selectivity are quite similar, although Lublin residents' human capital emigration seems slightly more selective. The low AME of place of residence on the likelihood to move in the first model additionally supported this interpretation. Furthermore, the variables for type of school and for survey year proved insignificant in both models. The female variable was negative and significant in the first model with respect to all graduates, however turned out to be insignificant in the second model for Lublin residents only. The survey year variable was insignificant in both models. Overall, the most telling results were found for human capital selectivity. As expected, the exam result variable was positive and significant. The extent of this effect, however, proved somewhat more unexpected: an increase in the exam result by 1 pp. (in 0-100% scale) correlated with an increase in the probability of a graduate's migration outside their home region by 0.46 pp. on average in the model regarding all graduates and by 0.52 pp. in the model for Lublin residents only.

As stated in the descriptive analysis in section 5.1, selectivity patterns concerning interregional and international migration seem to be different. To further explore this issue, I performed a separate logit regression estimation for international migration carried out

Table 4: Logit regression model results for international migration

Variables	Coefficients	Standard errors (SE)	Average marginal effects (AME)
Exam result	0.736***	0.209	0.0003
Sex(a)	0.243**	0.115	0.008
Place of residence(b)	-0.039	0.110	-0.001
Type of school(c)	0.338**	0.135	0.012
Survey year(d)	0.036	0.067	0.001
Constant	-3.943***	0.192	–
Observations	10,088		
P	0.004		
McFadden pseudo R^2	0.006		
Log-pseudo likelihood	-1,561.05		
χ^2	17.544		

Note: Reference group: (a) men; (b) Lublin residents; (c) comprehensive schools; (d) 2016.
p-values for coefficients: * p<0.05; ** p<0.01; *** p<0.001

for all graduates (see Table 4). The exam result variable appeared significant, nevertheless the value of AME was low. This might suggest that the positive selection to international migration is no more than moderate, which seems consistent with the earlier results found in the decile analysis. Nevertheless, the interpretation of the low AME value should be with caution since international migration rate was also low.

6 Discussion and conclusions

With respect to the first research question concerning emigration intensity, my research shows that one-fifth of secondary school graduates left their home region, with the interregional and international emigration rates at 16.9% and 3.6%, respectively, while student emigration rate equalled 21.6%. Bearing in mind the peripheral location of Lublin and poor economic development of the region, one might wonder whether such migration rates are indeed high? The answer is difficult, as any comparisons to the findings of other studies are hampered due to differences in measurement approaches. It should also be acknowledged that my research provided representative emigration figures for the region's capital or the graduates of schools located in the city, rather than graduates from the entire Lubelskie Voivodeship. Nevertheless, given the region's characteristics, as well as the rather average size of Lublin compared to other regional capital cities in Poland, I consider its emigration intensity as low. This tentative conclusion is consistent with other studies on youth mobility referred to in the literature review, which show generally greater emigration rates. Specifically, the rates of interregional student emigration from southern regions ranged from 20% to 50% in Italy (Ciriaci 2014), exceeded 50% in Greece (Psycharis et al. 2019), and varied between 30 and 70% for most UK regions (McClelland, Gandy 2012), while inter-state emigration rate for US high school graduates was 25.5% (Kodrzycki 2001). Moreover, graduate mobility revealed in this study seems low compared to earlier findings for Polish regions, as presented by Herbst (2009). Therefore, my results do not support the first hypothesis regarding the significant post-secondary migration outflows from peripherally located Lubelskie Region. Conversely, the results seem to confirm the stylised fact as to the dominance of local and regional moves among secondary school graduates, which turns out to be relevant even for poorer and peripheral areas.

One potential explanation for the low mobility of graduates from the Lubelskie Region relates to the drivers of student mobility. Poor economic development of the sending region might not be a decisive factor for moving away if a regional capital with an average economic performance could offer a wide range of studies, affordable costs of living, and vibrant cultural life. From this perspective, the beneficial role of universities in backward regions should not be limited only to creating educational spill-overs, but also to retaining human capital.

This assumption, although requiring further evidence, might have important implications for regional and urban policies and highlights the value of regional universities even if they do not excel on the national scale. However, the low out-migration rate of graduates compared to other countries could also be related to a relatively low overall internal mobility in Poland (Maleszyk, Kędra 2020).

Finally, I signalled that Poland has undergone a shift from elite to a mass tertiary education, which could exacerbate the interregional brain drain through student migration. Based on the empirical evidence, I assume that although emigration is clearly related to a decision regarding higher education studies, easing the access to tertiary education in Poland apparently has not led to a youth exodus from poorer, peripheral areas.

Regarding the second research question on the degree of human capital selectivity of youth emigration, results indicate the positive selection of migrants, which is not unexpected. My findings corroborate the second research hypothesis while at the same time providing several additional and more interesting insights into the correlation between mobility patterns and exam results. The evidence firmly indicates that the pattern of strong positive selection in the context of migration applies to interregional mobility, while international migration seems to be a more complex issue, with a moderately higher likelihood of migration attributable to respondents with the highest and the lowest exam results. This U-shaped relationship can be explained by considering the economic versus education dichotomy of migration motivation: the most talented graduates with the highest scores are more likely to continue their education at foreign universities, while those on the lower end of the grade scale face exam failure preventing further education at public universities and thus making them more prone to move abroad and seek employment. In other words, student migration from Poland is indeed positively selected, while the economic migration among secondary-school graduates turns out to be adversely selected. In terms of the latter, adverse selection can be linked to the empirical works by White (2013) who proved that young migrants from Poland often rely heavily on networks of friends and relatives, which makes them feel relatively secure about going abroad; as well as to the conclusion of Beine et al. (2011) who found that larger diasporas in the host countries might negatively influence the skill composition of new migrants.

The degree of youth emigration selectivity, and particularly the selectivity of interregional migration driven almost entirely by student migration, seems large also in the international context. Migration rates across exam result deciles obtained in this study confirm stronger human capital selectivity of migration relative to the results reported for Italy (Tosi et al. 2019), where emigration rate for top students was only two times higher than the rates for students with the average or low scores, or Greece, where a negative selection in student migration was observed (Psycharis et al. 2019). Furthermore, international student migration alone (see Figure 3b) is also more selective than that in the UK as analysed by Findlay et al. (2010). Finally, the estimated logit models prove that strong positive human capital selectivity of migration persists when other available variables (i.e., sex, place of residence, or type of school) are controlled.

This evidence might thus suggest that student migration could be an even more selective phenomenon than the scarce empirical literature on the subject would have us believe. Therefore, the brain drain through the channel of student migration affecting the peripheral Lubelskie Region should be regarded more as a highly selective outflow of most talented graduates to the leading academic centres in Poland, rather than massive exodus of all graduates.

The observed level of selectivity seems to have an adverse effect on the regional and local development prospects, although this general conclusion deserves further examination. In particular, I argue that empirical studies on brain drain which either do not incorporate human capital selectivity or introduce only very general measures of human capital endowment might severely understate the actual loss of human capital suffered by the sending regions. Nevertheless, the real extent of human capital redistribution, and subsequently the impact of emigration on the long-term growth potential of a given sending area, is also determined by the size of return migration, which has not been explored. The return of talented young people to their home region after graduating from one of the leading universities would be highly beneficial for the regional human capital.

Nevertheless, the selectivity of return migrants is rarely studied due to the lack of data, while the empirical findings are host–source-country specific (Wahba 2014). This issue requires further research, but I remain tentatively sceptical given the existing empirical evidence on the selectivity of Polish return migrants. Anacka, Fihel (2016) observed that migrants moving back to Poland are usually negatively selected, while Herbst et al. (2017) posited that migrants studying at leading universities in Poland's capital city of Warsaw are less likely to move back if they find employment during the last year of their university studies.

A major caveat regarding the results of this study refers to the short list of variables affecting the decision to move, which might be a source of bias in logit models (Mood 2010). This survey gathered limited information to ensure high response rate, therefore graduates were not asked questions on several additional characteristics. In particular, the model did not include variables regarding the graduate's household, such as parent educational background or income. Literature acknowledges that those variables correlate with both young people's school achievements and their propensity to migrate (e.g., Davis-Kean 2005, Capuano 2012, Tosi et al. 2019). In this context, the logit model presented in this study examines migration selectivity only when a number of other variables remain controlled (sex, former place of residence, type of school, and survey year), and therefore must not be considered a comprehensive model explaining migration. It should be noted that a logit model explaining migration with a larger set of variables could offer other AME values for exam results. Last but not least, the local geographical scope of this study calls for a follow-up research focusing on other areas or countries.

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Spatial health inequality and regional disparities: Historical evidence from Italy

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Abstract. Geography and the quality of the environment may have long lasting effects on the living standards of individuals and this, in its turn, may substantially affect the distribution of income and regional disparities. In this paper I consider exposure to malaria as a measure of "bad geography" and illustrate evidence showing that it was a major determinant of individuals' health, (as measured by the height of military conscripts) as well as its disparities between individuals and regions in Italy. To estimate the relationship between malaria exposure and height, I rely on the "fetal origins hypothesis"; I hypothesize that exposure to malaria in utero or during childhood has persistent effects on health. The periods under scrutiny in this paper are the last two decades of the XIX century, a period without major public health interventions, and the years around the malaria eradication era in the 1950s. My results support the hypothesis that geographically targeted policies may reduce health inequality between and within regions.

Key words: Health inequality, place-based policies, spatial disparities, regional development, malaria, height

1 Introduction

The quality of the environment where individuals live has long-lasting effects on their health and consequently on a variety of socio-economic outcomes, including education and labor productivity. This well-established evidence further implies that there is an association between the quality of the environment, health and local development, not only in developing, but also in developed countries. Health is also considered as a desirable outcome by individuals assessing the quality of life in their regional environments. Life expectancy and child mortality are among the variables used to construct synthetic indicators, as in the case of the EU Regional Human Development Index (Haderman, Dijkstra 2014) and the Italian regions under study (Ferrara, Nisticò 2015).

This paper contributes to the literature by presenting historical evidence from Italy, with specific reference to the burden of malaria across regions. More broadly, this paper aims to present historical evidence on spatial and individual inequality in health and living standards in Italy, a country where such inequalities are still persistent (see e.g. Franzini, Giannoni 2010, Perucca et al. 2019).

In the 19th century, most physicians believed malaria was caused by "miasma" (poisoning of the air), while others made a link between swamps, water and malaria, but did not make the further leap towards insects (Snowden 2006). As a result of these

theories, little was done to fight the disease before the end of the century. Italian scientists managed to predict the cycles of fever, but it was in Rome that the naturalist Giovanni Battista Grassi found that a particular type of mosquito was the carrier of malaria. After an extraordinary series of experiments on healthy volunteers in Italy (mosquitoes were released into rooms with volunteers), Grassi was able to make the direct link between the insects (all females of a certain kind) and the disease. The use of quinine to cure malarial fevers has been known for a long time. It has been systematically used since 1922 by the Italian Government to prevent malaria. The effects in Italy were so positive that its use as a preventive extended to other similarly situated countries; i.e., highly malarious farming countries. Although effective in reducing the burden of the disease, the use of quinine did not eradicate malaria, which was only eliminated in the 1945-1950 period, when the US government and the Rockefeller Foundation introduced DDT in the country.

Because of its impact on children's health, malaria has serious impacts on the individuals' physical growth and hence on their height. By relying on the 'fetal origins of adult outcomes' hypothesis and by taking a place-based perspective, this study estimates the impact of malaria eradication in Italy on the height distribution of military conscripts between and within regions. Taller individuals generally have higher income, so height is often used as a measure of historical living standards (Floud et al. 1990, Fogel 2004, Steckel 1995, 2004). This evidence also leads us to argue that the distribution of height across regions and across individuals can be considered as a measure of health and socio-economic inequality for periods in which data are not available.

In this paper, I present two pieces of evidence regarding the effect of malaria on adult height distribution in Italy. First, I illustrate that the quality of the environment, as proxied by malaria mortality rates, is crucial in predicting future height. In this case, I consider the average height of conscripts at regional level, born between 1889 and 1900, a period with no policy interventions to eradicate the disease. The second piece of evidence shows that the eradication of malaria that occurred between 1945 and 1950 has resulted in increased average height and distribution of height across individuals within regions, hence pointing to considerable redistributive effect of the policy.

The evidence reported in this paper indicates the clear effectiveness of place-based policies aiming at improving the individuals' quality of life, even in socio-economic terms.

2 Related literature

The aim of this paper is to examine the impact of malaria exposure in utero or during early childhood on height. My theoretical starting point is the so-called 'fetal origins' hypothesis (Barker 1990), i.e. the quality of the environment and the events to which a fetus or a child is exposed have major long-run impacts on health and cognitive abilities. The first evidence concerning the importance of the persistent effects of shocks during childhood was provided by Stein, Saenger (1975), who found adverse health outcomes for Dutch children born during the famine and the Nazi occupation. Barker (1990) has systematized the medical evidence available to date, arguing in favor of the 'fetal and infant origins' hypothesis of human development. A complete review of the evidence supporting the "fetal origins" hypothesis would fall outside the scope of this paper; hence, in what follows, I will focus mainly on the literature on malaria, with special emphasis on socio-economic outcomes.

Although the 'fetal origins' hypothesis has been proposed in the field of medical science, an increasing body of economic literature has shown that in utero and early life shocks may have relevant long-term effects on adults, especially in terms of educational attainments and income (see, among others Almond 2006, Barreca 2010, Bleakley 2010, Case, Paxson 2009, 2010, Chen, Zhou 2007, Cutler et al. 2010, Kim et al. 2010, Lucas 2010, Meng, Qian 2009, Neelsen, Stratmann 2011, Percoco 2013, 2016). Besides its theoretical appeal, one of the reasons for such a surge of economic studies relying on this hypothesis is that considering an environmental variable measured early in the lives of individuals significantly reduces the confoundedness due to adults' avoidance behavior. In other words, a given cognitive- and health-related outcome for an individual observed at a given point in time is probably not the result of exposure to certain environmental conditions

in the same year; rather, it is the result of a very long-term and often unobserved process in which an individual may systematically choose to avoid exposure to adverse conditions. Given these caveats in assessing the effects of exposure to pernicious diseases on adult outcomes, an increasing body of literature is focusing on the 'fetal origins' hypothesis in order to have a reliable lower bound estimate of the impact.

Regarding malaria, Bleakley (2007) finds that on average one year of exposure to the disease reduced citizens' years of schooling by approximately 0.05 in the United States, whereas Barreca (2010) shows that 10 deaths from malaria per 100,000 inhabitants decreased the length of schooling by 0.23 years for cohorts born in the United States between 1900 and 1930. Lucas (2010) investigates the effect of malaria on lifetime female educational attainment in Sri Lanka and Paraguay, finding evidence of a negative effect of the disease on years of education and literacy. Similar results have been obtained by Bleakley (2010) for Brazil, Colombia and Mexico. Percoco (2013) studies the eradication of malaria in Italian regions during the early 1950s and finds evidence of a long-term positive effect on education through inter-generational transmission channels.

In another study on malaria eradication in colonial Taiwan during the early twentieth century, Chang et al. (2011) find that malaria exposure around birth worsens old-age health status; it particularly increases the likelihood of cardiovascular diseases as well as the hazard of mortality and leads to worse cognitive functions. Similarly, Hong (2011) shows that Union Army recruits, who spent their early childhoods in malaria-endemic counties of mid-nineteenth century USA, were on average 2.8 centimeters shorter than their counterparts born in malaria free areas. A somewhat similar result was found by Bozzoli et al. (2008), who estimated an inverse relationship between post-neonatal (one month to one year) mortality, used as a measure of disease and nutritional conditions during childhood, and average adult height.

There are good reasons to hypothesize that height is affected by malaria. In fact, adult height is affected by the balance between the demand and supply of nutrients, by exposure to diseases and by physical exertion (Silventoinen 2003). Crimmins, Finch (2006) also argue that the inflammatory responses developed as a defense against many childhood diseases divert energy from growth and thus reduce adult height. These conditions are generally encountered in the cases of exposure to malaria, especially Falciparum malaria. The study of height is also important because it has been shown to be a good predictor of health outcomes, including mortality (Song et al. 2003) especially from strokes (McCarron et al. 2002, Song et al. 2003), and of earnings (Case, Paxson 2008).

The height of conscripts in Italy in particular has recently attracted the interest of scholars across several disciplines. Arcaleni (2006) presents a comprehensive, descriptive analysis of the height trends of Italian conscripts between 1854 and 1980, whereas Peracchi (2008) reviews the evidence on the relationship between height and economic development.

The distribution of height across individuals also points to distribution of living standards, although under relatively strict assumptions. Let us assume height of individual i, h_i, depends on his/her living standards, y_i, so that it is possible to predict height across individuals with the formula:

$$h_i = \alpha y_i^{\beta} \epsilon_i \tag{1}$$

where α and β are two scale parameters, and ϵ_i is an i.i.d. term. By considering the logarithms, it is possible to reformulate the expression as (Deaton 2008):

$$\ln h_i = \alpha + \beta \ln y_i + \epsilon_i \tag{2}$$

To achieve the linear correlation of the dispersions of height and living standards around their means, under strong assumption of orthogonality between y_i and ϵ_i, the variance of h_i can be expressed as:

$$var(\ln h_i) = \beta^2 var(\ln y_i) + \sigma_{\epsilon}^2 \tag{3}$$

In other words, observing and analyzing the distribution of adult height across regions and individuals, it is possible to have a picture of the distribution of living standards between and within regions. These arguments are of extreme importance for this paper,

since in the following sections I propose evidence supporting the negative association between malaria and height across regions and that a place-based policy aimed at eradicating the disease has had significant impact in terms of health inequality between and within regions.

3 An overview of the diffusion of malaria in Italian history

Italy was infested with malaria for hundreds of years until 1962, when its eradication was officially declared. Unlike other pernicious but sporadic diseases, malaria has been a persistent feature of many Italian regions, especially in the South. It shaped the socio-economic development of the entire country, so it was widely considered the "Italian national disease" (Snowden 2006).

Despite its importance, the attempts to document and report malaria incidence only started taking place in 1887, when health statistics began to be collected, and when it was made compulsory to register deaths classified by cause throughout the country. Even then, however, the impact of the disease was unclear and probably underestimated, owing, among other things, to uncertainty about the nature and causes of malaria itself[1].

The influential and fascinating work by Snowden (2006) provides a social history of the malaria eradication program which can be divided into four main phases.

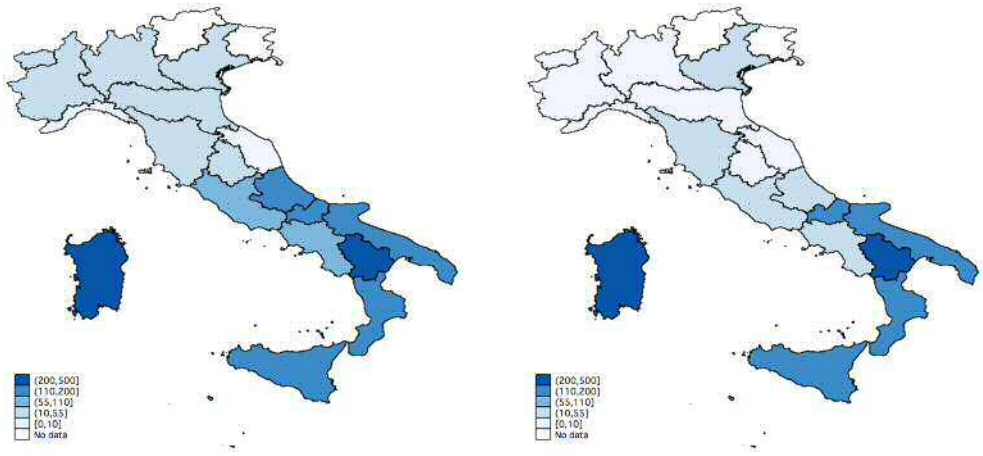
The first phase ranges from the Italian Unification to 1904. The territorial pervasiveness of malaria in Italian regions was one of the main social issues faced by the Government in the aftermath of the 1861 Unification of the country (Amorosa et al. 2005). At that time, almost one third of Italian municipalities were under malaria threat. Life expectancy, which was only 22.5 years in areas affected by malaria and 35.7 in relatively safe areas, presents a sufficient illustration of the burden imposed by the disease. As a result, the economic costs in terms of health care expenditure and loss of productivity were particularly high, so the Italian Government decided to engage in a vast scale campaign to eradicate malaria.

The second phase of the eradication process ranges from 1904 to 1928. In fact, prior to the studies carried out by the physicians Giovanni Battista Grassi and Angelo Celli, malaria was considered to be caused by a miasma, particularly as a result of some gases produced by certain types of terrain. Grassi instead argued that the disease was transmitted by mosquitoes, and that it could have been controlled by using quinine. In 1904, Grassi conducted the first large scale experiment in the Agro Pontino, in the surroundings of Rome, and convincingly demonstrated the validity of his theories. Given the declining price of quinine induced by the increase of coffee production, the Government engaged in a program called "Chinino di Stato", resulting in the free distribution of quinine through a network of health care offices. The effect of this program was very large, decreasing the number of deaths from 15,593 in 1900 to 6,333 in 1914. However, during World War I, as physicians employed in the anti-malaria program were sent to the war front, the death toll of malaria rose once again, with the number of deaths increasing up to 11,487 in 1918.

The third phase begins with the so-called "Legge Mussolini" (i.e. the Mussolini Act) in 1928. By recognizing the failure of the quinine in definitively eradicating malaria in Italian regions, Mussolini aimed to reclaim the entire marshlands in the Agro Pontino, Latium (the so-called bonifica integrale) in order to settle new cities and eradicate malaria. With the employment of advanced technology for hygienic and hydraulic control, malaria was almost eradicated in the area. However, land reclamation interventions put in place during the fascist period were limited to certain areas and insufficient to guarantee the complete eradication of malaria in Italy.

The fourth phase is the phase of the ultimate eradication of malaria by means of DDT, as firstly introduced by American troops in 1944 and massively used by the Italian

[1] Inter-regional mobility in the considered time period was almost nonexistent (Audenino, Tirabassi 2008). This is particularly relevant in my case because I use regional- and cohort-specific data matched with malaria mortality in the cohort's year of birth in the region, where height measurements took place. The substantial absence of inter-regional migration flows is important for the identification of the parameter of interest, so that the probability of birth in a given region and migration to another region where measurements took place is very low.



(a) Mortality in 1889 (b) Mortality in 1900

Figure 1: Malaria mortality in 1889 and 1900

Note: The figure illustrates the distribution of the malaria death rate in Italy during the two years. There is no data for Trentino-Alto Adige and Friuli-Venezia Giulia, which were not part of the Kingdom of Italy. *Data source*: (Istituto Centrale di Statistica 1958).

government in the years 1945-1950.

In this paper I first focus on the pre-quinine period in order to eliminate possible bias due to policy interventions which might result in lower estimates of the effect of malaria. My data particularly cover the period 1889-1900, a time interval during which the geography of the malaria death toll was remarkably stable with marginal intra-regional variations allowing for an estimation of a panel model (Figure 1). The second piece of evidence I present concerns the impact of the final eradication of malaria on the distribution of height between and within regions, that is I provide evidence of change in the distribution of height among individuals born in regions with high malaria mortality rates.

4 Data

The data for the 1889-1900 period is on the height of conscripts from Costanzo (1948), cohorts of males born between 1889 and 1900. The number of total conscripts from each region in each year and the number of conscripts whose heights were measured are also reported[2]. The regions considered are: Piemonte-Valle d'Aosta, Lombardia, Liguria, Veneto, Emilia Romagna, Marche, Umbria, Toscana, Lazio, Abruzzo-Molise, Basilicata, Campania, Calabria, Puglia, Sicilia, and Sardegna.

As for the analysis of the distribution of height within regions, the sample we used to is from the ISTAT time series[3]. It refers to data collected during the compulsory medical examinations for military service. In Italy, the latter has been mandatory until 2005 and implied a first general visit to confirm the fitness for service. The dataset provides average height for people born between 1918 and 1990 in each region, although the data used in this study is from the 1930-1960 period. Additionally, there are also frequencies for different height intervals, i.e. percentage of people (for a given year in a given region) whose height falls in the intervals: less than 150 cm, 150-154, 155-159, 160-164, 165-169, 170-174, 175-179, more than 180 cm.

Data on deaths resulting from malaria are available in the Cause di Morte: 1887-1955, published by the Istituto Centrale di Statistica (Istituto Centrale di Statistica 1958).

[2] A'Hearn et al. (2009) raise concerns about the non-normal distribution of height and propose a framework to adjust the empirical distribution. However, from their results, it seems that the adjusted time series does not significantly differ from the original one in the period considered in this paper; I therefore make use of the one observed originally.

[3] Data are available at the website: http://seriestoriche.istat.it/fileadmin/allegati/Sanita/tavole/-Tavola_4.16.1.xls.

Table 1: Summary of statistics (Italy)

	Mean	Std.Dev.	Min	Max	Median
Mean height	160.003	0.765	156.77	161.93	160.115
Malaria death rate	65.12	78.12	0.669	312.63	21.89
Average Temperature	12.958	1.83	9.46	17.04	12.87
Average Precipitation	65.733	13.39	40.37	85.98	68.16

Notes: The malaria death rate is the number of deaths per 100,000 residents. Average temperature and precipitation are annual means. The total number of observations is 224.

Table 2: Summary of statistics (Center-North vs South)

	Center-North				Non-North			
	Mean	Std.Dev.	Min	Max	Mean	Std.Dev.	Min	Max
Mean height	160.461	0.44	158.96	161.57	159.646	0.77	156.77	161.93
Malaria death rate	8.81	4.12	0.669	17.38	108.917	80.34	2.05	312.63
Average Temp.	11.868	1.42	9.46	15.5	13.805	1.67	10.13	17.04
Average Prec.	74.079	8.92	57.68	85.98	59.242	12.7	40.37	77.76

Notes: North comprises all the regions the capitals of which are located above 43° latitude. Non-north comprises all the other regions, including Latium, where Rome is located. North: Piedmont/Aosta Valley, Lombardy, Veneto, Liguria, Emilia-Romagna, Tuscany, Umbria. Non-north: Marche, Latium, Abruzzi-Molise, Campania, Apulia, Basilicata, Calabria, Sicily, Sardinia. Malaria Deaths: there are 98 observations for the North and 126 observations for the South. The malaria death rate is the number of deaths per 100,000 residents. Average temperature and precipitation are annual means.

The book reports the number of malaria deaths between 1887 and 1955 for each region. Data for previous years are not available for all regions and are unreliable: indeed, the compulsory registration of deaths classified by causes was extended to the whole country only in 1887. I construct 'annual malaria death rates' as the number of deaths due to malaria divided by the resident population of each region; the latter is estimated using census data. I have taken data on general mortality, which will be used as a further control variable, from the same source.

Data on regional population have been compiled using the Annali di statistica: Sviluppo della Popolazione Italiana dal 1861 al 1961 (anno 94, Serie VII-Vol.17), published by ISTAT[4].

Descriptive statistics on conscripts' height, malaria incidence and climatic conditions are reported in Tables 1 and 2. Table 1 reports results for the whole of Italy, whereas Table 2 distinguishes between Center-North and South.

The average malaria mortality rate for the entire Peninsula during the 1889-1900 period (i.e. the death rate averaged across all years and regions) is 69.12 deaths per 100,000 inhabitants, and the standard deviation is quite large (approximately 78 per 100,000). Indeed, as discussed above, there was considerable variation in mortality caused by fevers across areas, due to different degrees of pervasiveness of the disease and its different forms. In the North, in fact, the average number of malaria deaths per 100,000 inhabitants over the 1889-1900 period did not reach 9 units, whereas the mean malaria death rate in the South was nearly 109 units per 100,000 residents. In the North, the median malaria death rate was 9.18, whereas in the South, it was 90.77. The most malarial region was Sardinia, which recorded the highest average malaria death rate over the period under scrutiny (i.e. 265.5 deaths per 100,000), as well as the maximum number of deaths per 100,000 in a given year (i.e. 312.63 in 1889). Conversely, the least malarial region was Liguria, which had the lowest mean malaria mortality rate (i.e. 2.06) and the

[4]For each region, the book reports the resident and present population numbers recorded in census years (every ten years starting from 1861, with the exception of 1891, when no census was carried out) and the average annual growth rates of the population in the inter-census period. I estimate the resident and present population for all regions and years between 1889 and 1900 by applying the annual average inter-census growth rates to the population data from the 1881 census. Furthermore, data on GDP per capita, which will be used as a control variable, are from Daniele, Malanima (2007).

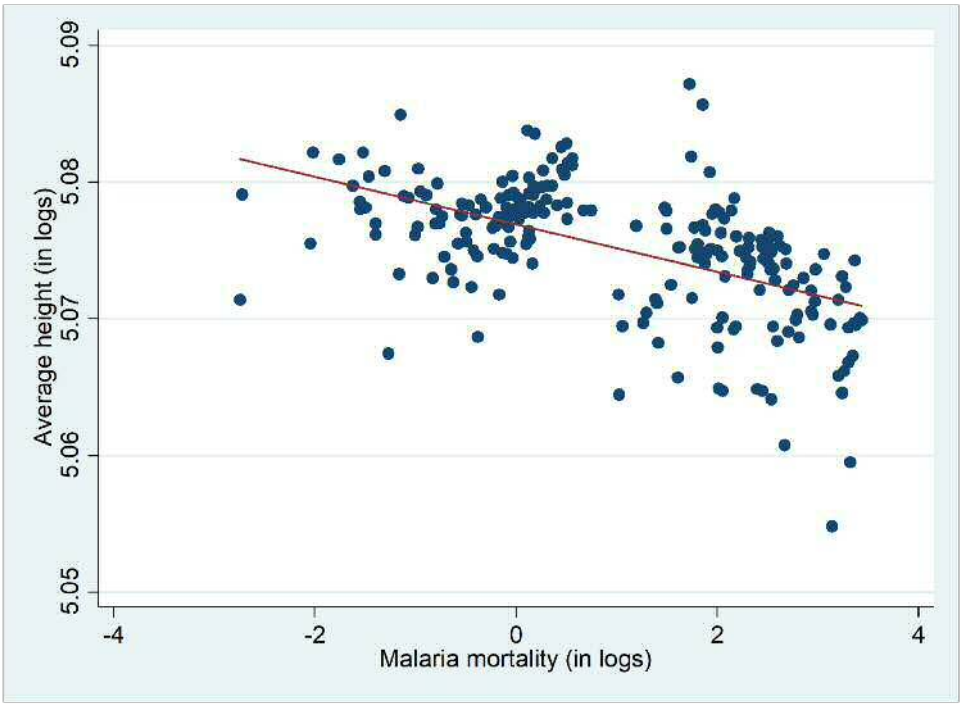


Figure 2: Malaria mortality and height

Table 3: Average height of conscripts

	Regions with high malaria mortality	Regions with low malaria mortality
Before the eradication	165.410	169.211
(1930-1944)	(1.976)	(2.167)
After the eradication	169.180	172.621
(1950-1960)	(1.998)	(1.910)

Notes: Regions with high malaria mortality: Abruzzo, Molise, Basilicata, Calabria, Lazio and Sardegna. Standard errors are in parentheses.

lowest number of deaths per 100,000 in a given year (i.e. 0.669 in 1900). Figure 2 reports the scatter plot for the pooled sample of the relationship between malaria in the year of birth and height. From the linear trend line, it seems that the correlation is negative, although far from being robust.

When it comes to climatic variables, average annual temperature was in general higher in southern regions, whereas rainfall was more abundant in the Center-North.

Table 3 reports descriptive statistics of the impact of malaria eradication on height of conscripts. In the table, regions are divided between the group with high mortality rates and the group with low mortality (i.e. above or below the national average), so the comparison is made between the averages of the 1930-1945 and 1946-1960 time periods. The difference between the two groups significantly decreased after the eradication. However, the observation of only one moment of the distribution of height may hide other, more significant changes occurring in the full distribution of the outcome of interest. To highlight those changes, Figures 3 and 4 plot kernel density for the high and the low mortality groups respectively. As evident, the most significant changes have occurred in the distribution of height of conscripts in regions with high malaria mortality with a sharp change in the tails, especially in the lower limit, implying an interesting change within regions more significantly affected by the treatment (i.e. the eradication).

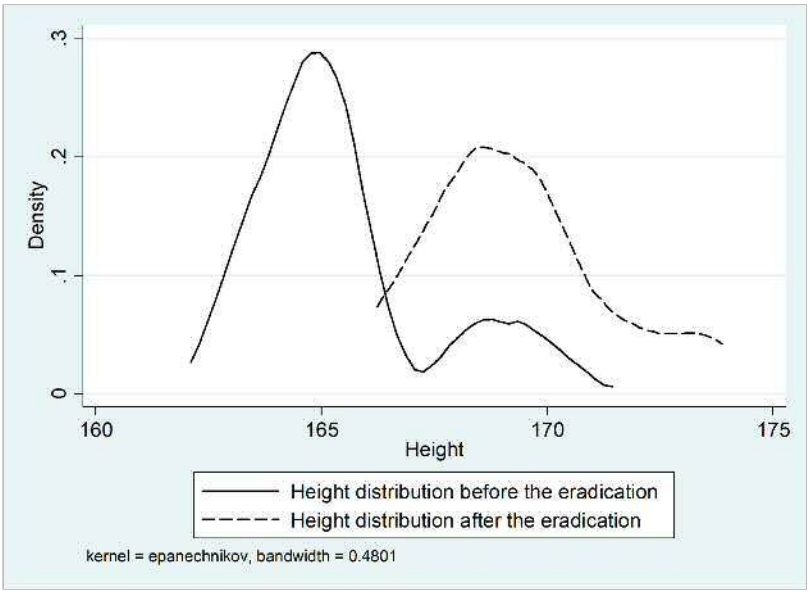


Figure 3: Change in height distribution in regions with high malaria mortality rates

5 The burden of malaria in the pre-eradication era

5.1 Methodology

I start my analysis by estimating OLS regressions where the dependent variable is the regional average height as a function of malaria mortality, controlling for region of birth fixed effects, year of birth fixed effects and region-specific time trends. The first specification is as follows:

$$MeanHeight_{it} = \beta Malaria_{it} + \delta_i Year_{cohort_t} + \gamma_t + \epsilon_{it} \tag{4}$$

where $MeanHeight_{it}$ is the average adult height of conscripts born in year t in region i; $Malaria_{it}$ is the incidence of malaria in region i in year t as measured by deaths per 100,000 inhabitants; δ_i is a set of region-of-birth fixed effects that captures features varying across regions but not across time (e.g. geographical characteristics, region-specific genetic backgrounds and even malaria endemicity); γ_t is a set of cohort (year of birth) fixed effects that accounts for birth conditions varying over time but remaining constant across regions (e.g. country-wide shocks). Finally, $\delta_i Year_{cohort_t}$ is a set of region-specific time trends used to account for the possibility that the evolution of mean height follows different linear paths in different regions, so that spurious time-series correlations may arise between height and malaria incidence. This latter set of variables is very important for the identification of β since it is meant to capture the evolution of living standards across regions, even in terms of access to healthcare facilities and local availability of food.

Equation (4) assumes that the effect of malaria on average height is only relevant in the conscripts' years of birth. In particular, this specification assumes that in utero and postnatal exposure may have an effect independent of the exposure in the following years. Equation (4) implicitly assumes that the height of individuals born in region i in year t reacts to malaria exposure only in time t, and that exposure in subsequent years is orthogonal to height by definition.

In order to relax this strong assumption, I propose an alternative specification, i.e.:

$$MeanHeight_{it} = \beta Malaria^{p}_{it} + \delta_i Year_{cohort_t} + \gamma_t + \epsilon_{it} \tag{5}$$

where $Malaria^{p}_{it}$ is a measure of malaria incidence over the time period t, which goes from the year of birth of the cohort (year 0) to some years after birth. For example, p may be a period of two years comprising the year of birth and the first year after birth, or a period of three years from the year of birth to the second year after birth, and so

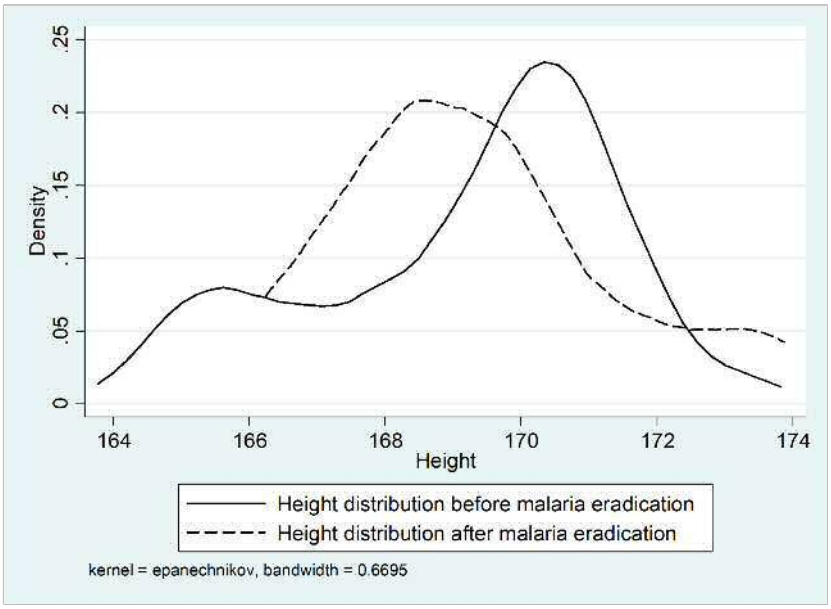


Figure 4: Change in height distribution in regions with low malaria mortality rates

on. In this way the effect of prolonged exposure to malaria during childhood is captured. As a measure of malaria over period p, I use the annual average malaria death rate (per 100,000 inhabitants) over the period under study[5].

There are good reasons to consider estimates of β via OLS to be biased. Firstly, malaria may be correlated with unobservable variables that also influence long-term health, thus creating a problem of endogeneity which would bias the estimation of the parameter β. Secondly, the way I measure malaria, i.e. by the number of deaths per 100,000 inhabitants, is only a proxy for the true incidence of the disease. Malaria deaths were often misreported and probably under-reported. Furthermore, since some forms of malaria are less deadly than others, mortality data do not capture the true pervasiveness of the disease, because the incidence of these mild forms is underrepresented by the number of deaths that they cause, so that β may be biased downward due to a measurement error. An instrumental variable estimation (IV) therefore seems more appropriate[6]. Craig et al. (1999) discuss the relationship between monthly temperature and rainfall surfaces and malaria prevalence. They argue that transmission below $18°C$ is unlikely, because few mosquitoes survive the 56 days necessary for sporogony to complete, whereas temperatures above $22°C$ are sufficient for stable transmission. The rate at which sporogony takes place increases with temperatures in the range of $15°C$-$40°C$ (Martens et al. 1995). Sporogony takes approximately 7-8 days in $30°C$, 8-10 days in $28°C$, 15-16 days in 20-$21°C$, and 200 days when the temperature is around $16°C$. Development stops below $16°C$ for Plasmodium falciparum and below $15°C$ for Plasmodium vivax, but temperatures above $32°C$ cause high vector population turnovers, weak mosquitoes and high mortality. Kirby, Lindsay (2009) find that rates of survival to adulthood are highest for mosquitoes' larvae reared at $25°C$ and decrease with increasing temperature. Furthermore, the time necessary for the development from larvae to the adult stage is also temperature dependent, taking a minimum of 7 days.

[5] A similar approach was also adopted in Percoco (2016) during the evaluation of the Spanish flu.

[6] This approach has already been taken by, among others, Barreca (2010), who uses climatic variables for instrumenting malaria, and Chang et al. (2011), who instead use the number of public health physicians and other medical personnel per 10,000 inhabitants as an instrument for measuring the malaria death rate in colonial Taiwan. Similarly, Hong (2011) predicts malaria risk using monthly average temperature. Barreca (2010) considers the malaria death rate to be a function of the fraction of the year in which the average daily temperature is between $22°C$ and $28°C$, i.e. the range in which malaria transmission is believed to be less constrained by temperature. The influence of climatic conditions on malaria transmission operates through three channels: mosquito larvae development, mosquito survival, and sporogonic duration – all of them depending on weather conditions.

Table 4: Malaria and height (OLS estimates)

	Malaria mortality					
	in $p = 0$	in $p = 0$	in $p = 3$	in $p = 3$	in $p = 5$	in $p = 5$
	(1)	(2)				
Malaria	0.000233	4.87e-05	–	–	–	–
			-0.00385***	-0.00465***	-0.00581***	-0.00647***
	(0.239)	(0.0512)	(-3.155)	(-2.636)	(-3.147)	(-3.280)
General mortality		0.0169**		-0.0266		-0.0204
		(2.565)		(-1.018)		(-0.524)
GDP per capita		-0.0221		0.0297***		0.0435***
		(-1.103)		(3.815)		(3.773)
R^2	0.825	0.834	0.829	0.840	0.830	0.840
# of Obs.	224	224	224	224	224	224
F test	12.84	12.30	13.62	13.80	13.46	13.41

Notes: All variables are in logarithms. Robust t-statistics are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Time dummies, region dummies and region-specific time trends are included.

According to Craig et al. (1999), it is important to use precipitation to indicate the probable presence of malaria vectors, their survival and the potential for malaria transmission. Another important aspect of malaria transmission is the fact that suitable conditions must persist for a period long enough for vector populations to increase and for the transmission period to be completed. Three months should be a long enough for transmission (Craig et al. 1999).

In the analysis presented in this paper, I follow Craig et al. (1999) and use climatic variables as instruments to explain the pervasiveness of malaria exogenously. I particularly use average temperature and average rainfall in the year and region of birth as instruments to identify β.

Data on both temperature and rainfalls are from various years of the *Annali del Regio Ufficio Centrale di Meteorologia e Geodinamica*, the data for which are available from several monitoring stations for each region. I consider the simple average across stations for both rainfall and temperature within each region.

5.2 Results

Table 4 presents estimates of OLS regressions, where the logarithm of average height is used as a dependent variable. It's important to note that I always include region and time fixed effects as well as regional time trends, although the associated coefficients are not reported. In model 1, the death rate in the year of birth is used as the only explanatory variable. The associated coefficient is not significant at conventional levels: a result that holds also when controlling for GDP per capita and general mortality (both in logarithms). In models 3 and 4, the average death rate for malaria during the first three years of life is used as an explanatory variable. Interestingly, the coefficient turns out to be highly significant and with a negative sign, a result that is confirmed also in models using average malaria mortality during the first five years of life, although with lower significance.

The results of the ordinary least square estimation prompt some considerations regarding the possible impact of childhood malaria on adult height, and hence on long-term health. In fact, it seems that only in utero or postnatal (i.e. where $p = 0$ and $p = 1$) exposure to the disease is not enough to explain differences in adult heights among different cohorts across regions. Consequently, it is necessary to consider the level of pervasiveness of malaria over a longer period of time. The average malaria death rate computed over the year of birth and the first three years after birth (or the total number of deaths per 100,000 inhabitants in the period) proved to have a statistically significant effect on mean height. The above analysis also suggests that malaria has a stronger long-term impact in the first few years of life of a cohort than in later childhood years.

Table 5: Malaria mortality and climatic variables (2SLS estimates; first stage regressions)

	Malaria mortality					
	in $p=0$ (1)	in $p=0$ (2)	in $p=3$	in $p=3$	in $p=5$	in $p=5$
Temperature	0.327***	0.320***	0.402***	0.293***	0.272***	0.631***
	(4.498)	(4.310)	(2.849)	(3.082)	(3.562)	(3.666)
Rainfalls	0.290**	0.201**	0.136**	0.294***	0.250**	0.307***
	(2.266)	(2.253)	(2.353)	(5.028)	(2.374)	(4.834)
General		0.885		0.846		0.882
mortality		(0.631)		(0.602)		(0.721)
GDP per		0.125		0.119		0.182
capita		(0.323)		(0.313)		(0.431)
F test	16.07	16.24	18.72	37.19	19.22	41.15

Notes: All variables are in logarithms. Robust t-statistics are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Time dummies, region dummies and region-specific time trends are included.

Table 6: Malaria and height (2SLS estimates; second stage)

	Malaria mortality					
	in $p=0$ (1)	in $p=0$ (2)	in $p=3$	in $p=3$	in $p=5$	in $p=5$
Malaria	0.000333	5.17e-05	–	–	–	–
			-0.00415***	-0.00517***	-0.00581***	-0.00718***
	(0.839)	(0.516)	(-4.055)	(-3.316)	(-3.147)	(-4.181)
General		0.0191**		-0.0218		-0.0204
mortality		(3.164)		(-1.182)		(-0.604)
GDP per		-0.0221		0.0207***		0.0421***
capita		(-1.200)		(3.815)		(3.443)
R^2	0.715	0.742	0.745	0.840	0.830	0.840
# of Obs.	224	224	224	224	224	224

Notes: All variables are in logarithms. Robust t-statistics are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Time dummies, region dummies and region-specific time trends are included.

As discussed in previous sections, the parameter of interest, β may be affected by endogeneity and can be instrumented by using temperature and rainfalls. To this end, Tables 5 and 6 report estimates of the first and second stages respectively. It should be noted that, in the case of 3-5 years average malaria mortality, instruments are averaged as well. This is confirmed by the results presented in Table 4, although it is important to note that the magnitude of the coefficient of interest is higher across all the six specifications with respect to the estimates in Table 4 – a result in line with the hypothesis of omitted variable bias in the OLS regressions.

The overall results presented in this section confirm the negative impact of exposure to malaria on height, although only prolonged exposure is statistically significant. The magnitude of the estimated coefficients, however, is very small. To get an idea about the magnitude, let us consider a reduction in malaria mortality from 108.917 in the South to 8.81 in the Center-North, corresponding to a reduction of approximately 91% in the mortality rate. If we consider the estimates in Table 5 as the most reliable and assume an average β coefficient of -0.05, then the increase in the height of the Southern population would be about +0.45% (0.7 centimeters), i.e. sufficient to fill the gap in height between North and South.

These calculations imply that the differences in the incidence of malaria across regions significantly affects spatial health inequality as approximated by conscripts' height.

6 Malaria eradication and health inequality

In the previous section, after accounting for several factors, I have illustrated that spatial disparities in terms of malaria incidence were a major driver of spatial health disparities. In this section, I estimate the effect of malaria eradication on spatial health inequality within and between regions.

Starting with the seminal paper by DiNardo et al. (1996), literature was focused on the impact of policy interventions on the distribution of outcome variables and on its decomposition to assess the most important factors. Recent contributions have particularly refined the use of quantile regressions and prediction decomposition or the evaluation of counterfactual distributions (Chernozhukov et al. 2008, DiNardo et al. 1996, DiNardo, Tobias 2001, Elder et al. 2011, Machado, Mata 2005, Melly 2006). This approach, however, assumes that the treatment affects only some categories, i.e. only some units belonging to some intervals in the distribution. In principle, in the case of malaria, the eradication of the disease in given regions has affected all height intervals, so a quantile regression approach is not feasible, as there is no distinction between treated and control quantiles. To circumvent this problem, and given the characteristics of the dataset, I propose the use of an equation system defined as:

$$height_{hit} = a_{ht} + \alpha_h high_{hi} + \beta_h post_{ht} + \delta_h high_{hi} \times post_{ht} + \epsilon_{hit} \tag{6}$$

where the dependent variable is the share of conscripts with height falling in interval h defined as above, in region i and in year t; α denotes a common trend; $high_{hi}$ is an indicator variable for regions with high mortality; whereas $post_{ht}$ is an indicator for the post-eradication period, i.e. after 1950. Our parameters of interest in system (6) are δ_I as they measure the shift in the distribution after treatment in the regions (i.e. those with high mortality).

According to (6), the counterfactual is defined by the share of conscripts in each interval before and after the treatment in regions with high versus low malaria mortality rates. The system of equations (6) is hence suitable to estimate the changes in the distribution of height through estimates of the movement of the share of conscripts falling in given intervals.

In order to obtain more efficient results, system (6) is estimated though SUR methodology.

We start our analysis with an estimation of the baseline system of equations in (6), the results of which are reported in Table 7. As stated in the previous section, our parameters of interest are those associated with the interaction $high_{hi} \times post_{ht}$, measuring the effect of eradication across height intervals. As documented in the table, the coefficients are significant at 99% across categories, with the sole exception of the interval 174-179 cm. Interestingly, lower categories have negative coefficients, indicating a decreasing share of conscripts falling in those height intervals. The interval 150-154 cm presents a reduction of about 2.8%, whereas the largest drop is in the 155-159 cm interval, with a contraction of 6.3%. Intervals 165-169 cm and 170-174 cm increase by 7.2% and 8.6% respectively. Interestingly enough, the coefficient associated with the highest category, i.e. those taller than 180 cm, has a negative and significant coefficient, indicating a considerable contraction in the domain of the distribution function. The Appendix reports several robustness checks confirming the results.

Overall, our results point to a robust change in the distribution of height of Italian conscripts due to the eradication of endemic malaria with the tails of that distribution becoming thinner; this is especially true of the left one, exhibiting a shift of population towards higher height intervals.

7 Conclusion

An increasing body of social science studies rely on the 'fetal origins hypothesis', according to which in utero, infant, and childhood conditions and shocks can considerably influence adult outcomes. Adult outcomes, in their turn, determine the accumulation and the quality of the human capital of regions and countries, thus influencing economic development.

Table 7: Height distribution change (SUR estimates)

	Intervals							
	<150cm	150-154	155-159	160-164	165-169	170-174	175-179	>180cm
$High_{ir}$	0.820***	3.192***	8.664***	9.086***	-0.879**	-9.579***	-7.719***	-3.590***
	(0.0356)	(0.127)	(0.340)	(0.496)	(0.372)	(0.404)	(0.464)	(0.415)
$Post_{it}$	-0.252***	-1.132***	-4.919***	-11.00***	-9.615***	3.733***	11.13***	12.04***
	(0.0302)	(0.108)	(0.289)	(0.422)	(0.316)	(0.343)	(0.394)	(0.353)
$High_{ir} \times Post_{it}$	-0.736***	-2.798***	-6.320***	-3.023***	7.181***	8.639***	1.282*	-4.214***
	(0.0536)	(0.191)	(0.512)	(0.748)	(0.561)	(0.609)	(0.699)	(0.626)
Constant	0.313***	1.373***	6.469***	18.30***	29.09***	25.51***	13.58***	5.363***
	(0.0195)	(0.0694)	(0.186)	(0.272)	(0.204)	(0.221)	(0.254)	(0.227)
R^2	0.477	0.536	0.604	0.619	0.507	0.521	0.626	0.630
# of Obs.	976	976	976	976	976	976	976	976

Notes: The share of conscripts falling in the interval is the dependent variable for each regression. Significance: ***: p<0.01; **: p<0.05 *: p<0.1.

With the present paper I add to this body of literature by analyzing the experience of Italy.

I particularly focused on the last twelve years of the nineteenth century, examining whether the conscripts born in regions and years with high malaria incidence were on average significantly shorter as adults than those born in years when the incidence was relatively lower.

I used aggregate data at regional level, and found, through both OLS and IV regression estimates, that exposure to malaria during the year of birth (in utero or postnatal exposure according to the quarter of birth) does not significantly influence mean adult height. However, the average level of exposure experienced by conscripts during the first three to five years of life does have a causal and negative effect on height. My estimates suggest that if the South had had the same malaria mortality as the North of Italy, then the difference in conscripts' height would have been almost nonexistent.

Furthermore, by considering cohorts of conscripts born before and after the eradication of malaria in Italian regions, I documented a shift in the distribution of height with an increase in its average and a convergence towards the interval of 164-174 centimeters. This result is suggestive of the redistributive impact of malaria eradication, although some further work on the topic is still needed. The results in the specific case of malaria in Italy point to intra- and interregional redistributive effects of policies addressing issues related to geography of regions. Furthermore, the evidence presented in this study suggests that place-based policies might successfully address spatial health inequality.

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A Appendix: Robustness checks

To test the robustness of the baseline specification results (3), I have run several checks. Firstly, the term $high_{ir} \times post_{it}$ can be confounded with an eventual process of height convergence across cohorts and regions because of a general improvement in living standards. In Table A.1, I present estimates of a version of (3) in which regional GDP per capita is used as a further regressor (the time series are taken from Daniele, Malanima 2007 and are in constant 2002 prices). Notably, all estimates maintain their signs and significance, although the coefficients associated with higher intervals have slightly lower point values with respect to the ones reported in Table 2.

Table A.1: Height distribution change – Robustness checks (SUR estimates)

	Intervals							
	<150cm	150-154	155-159	160-164	165-169	170-174	175-179	>180cm
$High_{ir}$	0.769***	2.915***	7.440***	6.750***	-2.314***	-8.405***	-5.489***	-1.674***
	(0.0388)	(0.137)	(0.340)	(0.427)	(0.291)	(0.420)	(0.373)	(0.255)
$Post_{it}$	-0.160***	-0.705***	-2.885***	-6.157***	-4.587***	3.207***	5.987***	5.289***
	(0.044)	(0.155)	(0.386)	(0.484)	(0.330)	(0.477)	(0.423)	(0.289)
$High_{ir} \times Post_{it}$	-0.736***	-2.771***	-6.290***	-3.427***	6.004***	7.935***	1.910***	-2.613***
	(0.058)	(0.204)	(0.508)	(0.638)	(0.434)	(0.627)	(0.557)	(0.381)
GDP per capita	-0.001***	-0.001***	-0.002***	-0.00511***	-0.004***	0.001***	0.005***	0.006***
	(2.44e-05)	(8.59e-05)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.420***	1.926***	8.949***	23.34***	32.87***	23.59***	8.602***	0.313
	(0.029)	(0.102)	(0.254)	(0.319)	(0.217)	(0.314)	(0.279)	(0.191)
R^2	0.487	0.554	0.662	0.749	0.707	0.561	0.780	0.863
# of Obs.	976	976	976	976	976	976	976	976

Notes: The share of conscripts falling in the interval is the dependent variable for each regression Significance: ***: p<0.01; **: p<0.05 *: p<0.1.

Table A.2: Height distribution change – Excluding treatment cohorts (SUR estimates)

	Intervals							
	<150cm	150-154	155-159	160-164	165-169	170-174	175-179	>180cm
$High_{ir}$	0.769***	2.915***	7.440***	6.750***	-2.314***	-8.405***	-5.489***	-1.674***
	(0.0388)	(0.137)	(0.340)	(0.427)	(0.291)	(0.420)	(0.373)	(0.255)
$Post_{it}$	-0.160***	-0.705***	-2.885***	-6.157***	-4.587***	3.207***	5.987***	5.289***
	(0.0440)	(0.155)	(0.386)	(0.484)	(0.330)	(0.477)	(0.423)	(0.289)
$High_{ir} \times Post_{it}$	-0.736***	-2.771***	-6.290***	-3.427***	6.004***	7.935***	1.910***	-2.613***
	(0.058)	(0.204)	(0.508)	(0.638)	(0.434)	(0.627)	(0.557)	(0.381)
GDP per capita	-0.001***	-0.001***	-0.002***	-0.005***	-0.004***	0.001***	0.005***	0.006***
	(2.44e-05)	(8.59e-05)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.420***	1.926***	8.949***	23.34***	32.87***	23.59***	8.602***	0.313
	(0.029)	(0.102)	(0.254)	(0.319)	(0.217)	(0.314)	(0.279)	(0.191)
R^2	0.487	0.554	0.662	0.749	0.707	0.561	0.780	0.863
# of Obs.	854	854	854	854	854	854	854	854

Notes: The share of conscripts falling in the interval is the dependent variable for each regression. Cohorts of conscripts born between 1945 and 1950 are excluded. Significance: ***: p<0.01; **: p<0.05 *: p<0.1.

Table A.3: Height distribution change – Excluding treatment cohorts and testing for pre-existing trends (SUR estimates)

	Intervals							
	<150cm	150-154	155-159	160-164	165-169	170-174	175-179	>180cm
$High_{ir}$	0.610***	2.316***	5.773***	4.593***	-2.800***	-6.468***	-3.565***	-0.465*
	(0.0388)	(0.135)	(0.329)	(0.411)	(0.309)	(0.412)	(0.357)	(0.249)
$Post_{it}$	-0.241***	-1.008***	-3.729***	-7.250***	-4.834***	4.188***	6.961***	5.901***
	(0.0417)	(0.145)	(0.353)	(0.440)	(0.331)	(0.442)	(0.383)	(0.267)
$High_{ir} \times Post_{it}$	-0.724***	-2.726***	-6.165***	-3.264***	6.041***	7.789***	1.765***	-2.704***
	(0.0540)	(0.188)	(0.458)	(0.571)	(0.429)	(0.574)	(0.497)	(0.346)
GDP per capita	-3.15e-05	-0.001***	-0.001***	-0.0041***	-0.004***	0.001**	0.004***	0.005***
	(2.37e-05)	(8.25e-05)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)
Trend * $High_{ir}$	0.001***	0.001***	0.002***	0.002***	0.001***	-0.002***	-0.002***	-0.001***
	(1.65e-05)	(5.73e-05)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
Constant	0.300***	1.474***	7.689***	21.71***	32.50***	25.05***	10.06***	1.227***
	(0.029)	(0.101)	(0.247)	(0.308)	(0.231)	(0.309)	(0.267)	(0.186)
R^2	0.554	0.620	0.725	0.798	0.713	0.633	0.825	0.887
# of Obs.	854	854	854	854	854	854	854	854

Notes: The share of conscripts falling in the interval is the dependent variable for each regression. Cohorts of conscripts born between 1945 and 1950 are excluded. Significance: ***: p<0.01; **: p<0.05 *: p<0.1.

Regression estimates in Tables A.2 and A.3 report estimates of functions in which the cohorts of individuals born between 1945 and 1950, i.e. during the treatment period, are included. Table A.2 reports estimates in which those cohorts are excluded, and it is quite surprising to see that there is no change in the magnitude of estimated parameters. Finally, the specification, the results of which are in Table A.3, considers a time trend specific to regions with high mortality (i.e. an interaction term between a time trend and height). It is important to note that, in this case, results also do not significantly change from my baseline specification.

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Destination management and sustainable tourism development through the common lens of the Commons

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Abstract. This study combines three interconnected streams in tourism literature: analysis of the utilisation of common pool resources (CPR) in tourism, studies on sustainable tourism development and theoretical contributions to the articulation of roles, missions and strategies of a destination management organisation (DMO). Starting from an integrative literature review, our aim is to explore the symbiotic relationships between these approaches in order to design a conceptual framework for opening new research opportunities. The operational application of such a conceptual model depends on the resources of each destination, the type of tourism dynamics observed, the specific stakeholders involved and the power balance between them. Our objective is to define and to discuss the critical conditions for the integration of sustainable development principles into the strategic role of a DMO through the management of CPR via participatory processes of destination management. An exploratory illustration of this framework for the rural destination of Kushiro-Akan (Hokkaido, Japan) is presented. Policy and managerial implications as well as the needs for further research are discussed.

Key words: common pool resources, destination management organisation (DMO), sustainable development, participatory governance

1 Introduction

Many of the local resources attracting tourists to a destination can be framed as "Common Pool Resources" (CPR), as defined by Ostrom (2008). Although most approaches analysing the relationship between tourism and the preservation as well as appropriation of benefits related to the utilisation of these resources focus on environmental assets (Holden 2005, Moore, Rodger 2010, Pirotta, Lusseau 2015, Heenehan et al. 2015), several authors enlarge the scope of the analysis of CPR in tourism by considering other resources contributing to destination attractiveness (Briassoulis 2002, Bimonte 2008). Adopting a broad perspective, Briassoulis (2015, p. 92) defines the "tourism commons" as "the collection of natural, manmade and socio-cultural resources of host areas and their surrounding regions that are purposefully or inadvertently used in common by tourist and non-tourist activities".

Thus, the adequate management of common resources – both in terms of their protection and also considering the aspects of social justice related to their utilisation – appears crucial for the sustainable development of a destination. In the case of tourism, as

stressed by Butler (1999) or Sharpley (2009), such an approach to sustainability implies a careful use of territorial resources (or the protection and preservation of CPR, as proposed in the literature on the Commons), along with contributions to the improvement of the host communities' socio-economic conditions (or an adequate management of the appropriation of benefits arising from the utilisation of those resources, as formulated in the conceptual approaches to the management of CPR).

Considering the wide range of stakeholders involved in the provision of tourism services as well as the different implications of tourism dynamics for diverse groups within the host communities and their different perceptions regarding the value, utilisation or importance of CPR preservation, participatory processes of tourism management and planning appear to be crucial for sustainable tourism development. In this sense, Briassoulis (2015, p. 92) proposes the concept of "adaptive tourism governance", which is defined as a "multi-level, participatory process of sustainably managing collective affairs under uncertainty in complex tourism socio-ecological systems".

Different streams of literature offer relevant insights for the analysis of these problems: Dietz et al. (2003) or Ostrom (2008) propose this type of participatory governance for the general case of CPR; Briassoulis (2002) or Holden (2005) focus on the specific case of CPR for tourism; institutions like UNESCO (2013) suggest similar processes of stakeholder involvement for the management of cultural heritage; UNWTO (2003, 2007) suggests that DMO should involve all local relevant stakeholders to guarantee sustainable tourism development. In their systematic and comprehensive analysis of multi-stakeholder involvement in tourism management, Waligo et al. (2013) point out the insufficient community participation as a crucial reason for the lack of achievement of sustainable development goals within processes of tourism development. However, this involvement of local stakeholders implies a strong perception of the significance of these mechanisms and institutions (Hall 2019).

Inspired by these contributions, this work aims to develop a symbiotic integration of three different types of interlinked theoretical approaches: the analysis of the utilisation of CPR for tourism purposes; the studies on sustainable tourism development; and the analytical contributions to the definitions of roles, missions and strategies of a destination management organisation (DMO). By focusing on the importance of community-based CPR management, we develop a conceptual approach to the integration of sustainable development principles into the strategic role of a DMO, aiming at identifying and discussing the critical conditions for its implementation. The specific institutional focus on DMOs reflects the suggestion by UNWTO (2007) to assume sustainable development as the main objective of contemporary destination management organisations, while ensuring that potentially implemented collaborative processes correspond to a significant level of decision-making.

By defining and discussing such critical conditions, our framework aims at opening new opportunities for research as well as the application of such a conceptualisation, which depends on the resources of each destination, the type of tourism dynamics observed, the specific stakeholders involved and, among other factors, the power balance between them. As an example, we present an exploratory illustration of the Kushiro-Akan rural destination (Hokkaido, Japan) case, following two extensive studies previously undertaken in this area (Romão et al. 2017, 2018). The concepts and theoretical contributions underlying this analysis are presented in Section 2, considering the concepts of CPR in tourism (2.1), sustainable tourism development (2.2) and DMO (2.3). The integration and synthesis of these approaches are presented in Section 3, proposing a conceptual framework model for destination management. Section 4 offers an illustrative application of this model to the Kushiro-Akan destination, and Section 5 concludes the paper with a discussion of the main results, critical factors for the implementation of such a governance model as well as the limitations of the study and possibilities for further research.

Table 1: Common, destination management and sustainable development

Common Pool Resources			
Problems	Overutilisation and lack of protection	Appropriation of benefits	*Destination management*
Solutions	Sustainable long-term utilisation	Economic growth and social justice	*Sustainable development*

2 Sustainable development and destination management through the common lens of the Commons

The methodology for this analysis incorporates the principles of an integrative literature review (Torraco 2005), combining three different streams of theoretical contributions within a systematic scoping review (Rasoolimanesh et al. 2020) and focusing the literature review on a specific research question, rather than offering a detailed perspective. The novelty of this approach lies in the systematisation as well as the synthesis of different theoretical contributions converging to the question of common resources management in tourism destinations (Section 2). This leads to the definition of a conceptual model for the implementation of institutional solutions addressing this problem (Section 3) and is illustrated by the presentation of an exploratory example in a rural destination in Japan, with diverse resources that can be broadly classified as CPR, where a DMO has been recently implemented (Section 4).

Considering the characteristics of CPR, the problems related to their utilisation in tourism are regarded as challenges for destination management (as represented in the first row of Table 1), whose solutions may contribute to a process of sustainable development (as mentioned in the second row). Thus, the achievement of significant results in terms of the three pillars of sustainable development depends on an adequate management of common resources, which implies the implementation of participatory management processes. The particular aspects of CPR management in the context of tourism development are discussed in Section 2.1, while a more specific focus on recommendations, guidelines and proposals for the utilisation of natural as well as cultural resources is presented in Section 2.2. We conclude by discussing the potential role of DMOs as potential leaders of such a participatory process of CPR management, considering their institutional legitimacy in promoting and coordinating tourism activities, along with the recommendations from UNWTO (2007) regarding their potential leadership within sustainable tourism development processes. The main ideas arising from these different approaches are presented in Table 2, at the end of this Section.

2.1 Common Pool Resources

CPR are characterised by "subtractability" (rivalry among potential users, implying that CPR utilisation by one user may exclude the possibility of their utilisation by others) and "non-excludability" (it is difficult or impossible to limit the access to the resource). Generally, these resources are indivisible, and it is not easy to define their boundaries. Thus, it is difficult to define legitimate users or to exclude others. CPR can be subject to different property regimes (private, public or common), which can change over time. These characteristics are assumed in most of the studies on this topic (Holden 2005).

The levels of "excludability" and "rivalry" may differ for different types of goods. In a pure sense, CPR are characterised by rivalry and non-exclusion, but it is possible to change these conditions: a private beach or the limitation to a certain number of users of natural parks or museums may be seen as generating "exclusion", while eliminating or reducing "rivalry". Musgrave, Musgrave (1973) or Ostrom, Ostrom (1977) define this regime as a "club", implying a certain form of privatisation of resource utilization, while facilitating its management and preservation. For other resources (like air, public security or national defence), there is no "excludability" – they can be utilized by an unlimited number of users and can be classified as "public goods". For our purposes, all

these types of goods are taken into account, once they are no longer a subject to market transactions or regulated by market forces. Moreover, all of them raise the question of the appropriation of benefits, for the tourism sector tends to be highly dominated by large international companies operating in the transportation and accommodation services. The emphasis on the commons is due to the fact that these resources tend to get less attention than public goods in literature on economics and management.

Examples of CPR include natural resources (atmosphere, water, ecosystems, fisheries, forests or wildlife), infrastructure built for collective utilisation (irrigation systems, water distribution and treatment, streets, transportation systems, ports) and immaterial assets shared by a broad community of users (cyberspace, electro-magnetic spectrum, genetic data, traditions, language, knowledge or other creative assets). Once they are not subject to market transactions, their economic value is difficult to measure, even though they are often a source of economic externalities, contributing to the creation and appropriation of value (Scott 2017).

When supporting different recreational or educational activities, along with hospitality services, natural landscapes, monuments or architectural landmarks can also be seen as good tourism-related examples of CPR. In fact, many resources attracting tourists to a destination (culture, nature, landscapes, lifestyles, etc.) can be framed as CPR and can be identified in tourism destinations. Moreover, other resources, facilities or infrastructure with common characteristics can be impacted by tourism dynamics, as observed in detail by Colomb, Navy (2017): local transportation networks; public spaces; public or private services shared between tourists and residents; traditional lifestyles and common forms of life in specific neighbourhoods; or even the collective supply of housing, which is normally subject to planning processes at the local level, having recently become an especially important problem in cities with high tourism demand and the transformation of residential places into tourism accommodation facilities.

Thus, the exploitation of positive externalities related to the existence of common resources may also imply the emergence of negative externalities, with implications for the living conditions of residents. Consequently, diverse types of users have different perceptions about the value of CPR, depending on how they are affected by the externalities (along with aspects related to information, education or cultural values). In the case of tourism, the economic valuation of CPR is also made by users not belonging to the local community, being highly dependent on their individual characteristics (Briassoulis 2002).

Different types of problems related to the utilisation of CPR are identified in the literature (e.g, Briassoulis 2002, Coronado 2014, Nahrath, Bréthaut 2016). On the demand side, the "free-riding" (over-utilisation and appropriation of resources by a limited number of users, eventually leading to the exclusion of others) can lead to resources' degradation or elimination as a consequence of a cumulative non-planned utilisation. On the supply side, the lack of resource preservation as well as of protection may arise (as none of the users has individual responsibility to do it), along with a potentially unequal appropriation of benefits (although the CPR are available for the whole community or are even produced collectively, the appropriation of benefits is private and can be different for various types of users). In fact, transportation and accommodation companies generally get large benefits from the attractiveness of CPR in a destination, not necessarily contributing to their improvement or preservation, while large parts of the local population can be excluded from the benefits of tourism or affected by the presence of tourists and the related negative externalities.

Considering the difficulties and problems with the utilisation, management, preservation, economic valuation and the appropriation of benefits related to these resources (along with the different types of stakeholders using the CPR, with different perceptions about their value), some authors propose general principles for their management. Dietz et al. (2003) summarise these principles, which are depicted in the column titled "CPR" in Table 2 (definition of boundaries; equivalence between benefits of utilisation and preservation costs; implementation of collective-choice arrangements; mobilisation of local communities; and monitoring processes based on quantitative indicators). Generally, these principles (and similar approaches broadly inspired by different formulations proposed by Ostrom, Ostrom 1977, Ostrom 2005, 2008) focus on the utilisation and management

of CPR by communities with "permanent" members. However, in the case of tourism, resources are also used by temporary visitors (the tourists), imposing new challenges for CPR management.

2.2 Management of natural and cultural heritage as commons and tourism resources

Natural resources have attracted travellers for thousands of years, as documented by Graburn (1995) mentioning tourist visits to rural areas of Japan, to enjoy Japanese baths (onsen), at least during the last 3.000 years. Similar movements were observed in the Roman Empire, when thermal baths motivated people to travel, being a central element of daily life. Different types of nature-based tourism emerged since then, including trips to coastal areas (leading to the development of massive forms of tourism in many places), winter sports in mountain areas or, more recently, rural tourism or different types of ecotourism related to recreational and educational activities.

The problematic utilisation of natural resources in tourism has led to different analyses, as written by Meinecke (1929), ORRRC (1962) or Wagar (1964). This type of studies had a strong impulse following the publication of "Our Common Future" (World Commission on Environment and Development 1987) and the generalised acceptance of the concept of sustainable development, which was rather quickly adopted within tourism studies and policy guidelines (Sharpley 2009). In the subsequent years, the importance of protecting these resources (e.g., by defining limits for their utilisation according to their carrying capacity) or their role within strategic processes of destination differentiation, have been widely analysed (Butler 1999, Buhalis 1999, Hassan 2000, Miller, Twining-Ward 2005, Williams, Ponsford 2009). The problems related to climate change reinforced the importance of this discussion (Weaver 2011). Douglas (2014) stresses that the commercialisation of environmental features within tourism markets often raises questions related to excessive use, degradation or destruction, while Coronado (2014) or Nahrath, Bréthaut (2016) focus on the interactions between visitors and host communities.

Heenehan et al. (2015) and Moore, Rodger (2010) use the CPR approach in order to propose a framework model for participatory resource management in places where tourism plays a prominent role, which are especially relevant in the context of our work. Based on the systematisation of principles for CPR management proposed by Ostrom (2005), Heenehan et al. (2015) consider attributes related to resources, users and the interactions between them. This includes the identification of the spatial extent of resources and their predictable use (related to their importance and cost), in order to promote their improvement and monitoring through specific indicators. Participatory management should be based on autonomy, trust and reciprocity, taking previous experiences into consideration. Following a conceptual approach proposed by Agrawal (2001, 2003), Moore, Rodger (2010) discuss the enabling conditions characterising resources, users and the relations between them, taking into account institutional arrangements and their interaction with the resource system, along with aspects related to the external environment. These aspects are framed in Table 2 (columns titled "Enabling conditions" and "Attributes").

Just as natural resources, cultural heritage has attracted visitors for thousands of years. A relevant ancient example is the religious motivation for travel (pilgrimage), but many other material (monuments, architecture, artefacts, etc.) or immaterial (lifestyles, events, local knowledge, etc.) cultural assets have had a significant impact on motivations to travel. The impressive contemporary dynamics observed in urban tourism (UNWTO 2012) are also clearly linked to this kind of motivation (Mazanec 2010, Romão et al. 2015). However, the utilisation of cultural assets in tourism may raise long-term problems, which can be framed within the concept of sustainability. Being subject to different processes of commodification and marketing strategies, the preservation of the integrity, meaning and authenticity of these cultural values requires permanent efforts of protection and regulation, as suggested by different authors (Cohen 1988, Poria et al. 2003, Chambers 2009, Fusco Girard, Nijkamp 2009) and policy institutions (UNWTO 2003, ICOMOS 2008a,b, OECD 2009). Romão (2018) offers a detailed discussion of these aspects.

The policy recommendations proposed by ICOMOS (1999) address the utilisation of common cultural resources in tourism, based on a broad definition of heritage, in-

cluding both natural and cultural aspects: "landscapes, historic places, sites and built environments, as well as bio-diversity, collections, past and continuing cultural practices, knowledge and living experiences. It records and expresses the long processes of historic development, forming the essence of diverse national, regional, indigenous and local identities and is an integral part of modern life". It is assumed that "heritage-based tourism must offer relevant socio-economic benefits for the local communities, while requiring their active participation in the management of heritage resources and tourism dynamics at the local level". This broad focus on landscapes, combining the protection and valorisation of both cultural and natural assets, has been identified in collaborative processes of tourism management involving local communities in Australia (Tolkach et al. 2016) or New Zealand (Grafton 2000), also reinforcing the participation of indigenous communities – even though this did not imply that all the conflicts could be solved or eliminated, as observed by Tribe (2008).

ICOMOS (1999) also defines guidelines for the management of heritage (embedded in the column titled "cultural heritage – ICOMOS" in Table 2), considering the importance of public awareness, the dynamic relationship (and conflicting values) between heritage places and tourism, the need to create a worthwhile visitor experience, the importance of involving host and indigenous communities in the planning processes, the definition of responsible promotion programs, as well as the achievement of benefits for the local communities through job creation and valorisation of local products. Furthermore, when proposing a set of challenges to be addressed while defining a long-term strategy for heritage tourism, UNWTO (2003) also acknowledged the importance of heritage for tourism development and the implications on the implementation of participatory management processes. These principles (integrated into the column "cultural heritage – UNWTO" in Table 2) include: understanding of links between tourism and heritage, definition of heritage-based tourism products, preservation of authenticity, definition of limits of acceptable change, adequate balance between education and entertainment, identification of relevant stakeholders, creation of partnerships, and implementation of participatory mechanisms.

Despite all the recommendations for implementing participatory processes of planning and management, the achievements are far from satisfactory, as observed by Hall (2019), when stressing the importance of combining not only different interests and perspectives, but also diverse types of knowledge coexisting within local communities. These difficulties were also testified by Landorf (2009), when analysing plans for tourism development in World Heritage Sites in the United Kingdom, observing that, despite the existence of a long-term approach and a formal goal-oriented planning process, local communities could not be successfully involved in any of the cases. Furthermore, Coronado (2014) observed that conflicts of interests between different stakeholders involved in two tourism development projects in rural areas of Mexico could not be solved, leading to their commercial failure. Similarly, Jamal, Stronza (2009) identified difficulties when trying to combine traditional and scientific types of knowledge among stakeholders from local communities and international institutions in the management of natural parks in Colombia. Moreover, other economic problems arising from the lack of community involvement were recently observed by Seyfi et al. (2018) in a World Heritage Site in Iran or by Dragouni, Fouseki (2018) in Greece.

2.3 Destination Management Organizations (DMO)

Despite the persistence of conflicts between different interests and perspectives of diverse stakeholders, some rare examples of relatively successful participatory processes of tourism planning and management can be pointed out, like the cases observed in New Zealand (Grafton 2000) or Australia (Tolkach et al. 2016), where local institutional solutions were strongly supported and framed by national policies. Despite these scarce achievements, there is abundant literature on this topic, as exemplified by the early analysis performed by Bramwell, Sharman (1999), emphasising problems related to power imbalances within collaborative processes. More recently, the systematic review proposed by Fyall et al. (2012) identifies different dimensions and typologies for these collaborative processes, also emphasising their limitations and the need for further research. Our study focuses on

collaborative processes of tourism planning and management within a DMO, in order to ensure the policy and institutional legitimacy – and thus the significance – of the network (as defined by Hall 2019).

Generally assuming tasks related to planning, marketing and management of tourism destinations, DMOs may be based on institutions that can integrate the management of CPR into the processes of strategic tourism development. However, it should be noticed that there is no universal definition of DMOs (Pike 2016): their missions, objectives, structures and names can be different, depending on the location. Pike (2016) offers a detailed historical overview of the evolution of DMOs since the end of the 19th century as well as an analysis of the limitations for their actions. Moreover, he points out that they cannot change the reputation or the geographic limits of their locations; they also do not necessarily control the number of visitors and its relation to carrying capacity and have limited (if any) contact with visitors as well as limited control over the attitudes of host communities. DMOs have no control over the different stakeholders' strategies and decisions related to product development, pricing or marketing approaches, as they do not control transportation services, infrastructure or the management of the natural environment and cultural heritage.

DMO are normally dependent on public institutions and/or large private companies, which can raise different types of problems. Public funding (subsidies, grants, provision of services, allocation of taxes, etc.) seems adequate to ensure a power balance between the stakeholders involved, but it implies a strong dependence on policy decisions not controllable by the tourism sector. Funding based on private contributions may be a source of power imbalance between the involved stakeholders, eventually creating a high dependence on a small group of large companies with a dominant position and resulting in difficulties when involving local communities without a direct benefit from tourism (Mason 2016). Considering the importance of a balanced representation of diverse groups with different interests and motivations, a strong share of public financing proves crucial.

DMO can be seen as a coordinator and facilitator of a common strategy, acting as a "coalition of different interests for working towards a common goal, ensuring the viability and integrity of their destination at present and for the future", as suggested by UNWTO (2007). They can operate at different territorial levels, with their actions potentially exerting cumulative impacts on the same destinations, thus implying a clear definition of tasks and complementarities between them. Destination coordination and management, along with the development and management of events and attractions, should be addressed at the local level.

Accordingly, our conceptual model for the integration of CPR management into processes of tourism development focuses on the local level of the destination, which seems more adequate for planning the utilisation of sensitive resources while taking different interests of the diverse stakeholders involved into account. It is assumed that the role of DMO has shifted over time from a promotion-oriented approach driven by short-term economic objectives to a contemporary holistic approach focused on long-term competitiveness, while taking into account the sustainable use of resources as well as the need to manage and solve the potential conflicts between different groups with diverse interests and motivations.

UNWTO (2007) proposes a broad set of guidelines (integrated into the column titled "DMO for SD" in Table 2) addressing the three pillars of sustainable development, which are in accordance with the concerns related to the management of CPR. Such a holistic approach to the role of DMO implies a long-term perspective for the competitiveness of a tourism destination, including the broad range of stakeholders involved in tourism development: policy and regulatory institutions (national and regional governments, economic development agencies, local authorities, authorities responsible for the management of natural parks or cultural facilities, etc.), private companies in different sectors (transport, attractions and events, accommodation, restaurants, leisure services, retail operators, different types of intermediaries, etc.) or different local organisations (local partnerships, business support agencies, education and training organisations, media, NGOs, or organised groups of residents). Involving communities in planning and decision-making processes in order to ensure the achievement of economic benefits from tourism is crucial

for this type of DMO, oriented to the promotion of equitable business through marketing and product development assistance, supported by an assessment of socio-economic, cultural and environmental impacts.

The large number of stakeholders involved, the potential conflicts of interest and the different types of perceptions as well as knowledge coexisting within local communities can constitute obstacles for the efficiency of a DMO, as discussed by Morrison (2019). However, efficiency and value creation are also crucial for the existence and legitimacy of a DMO, as pointed out by Reinhold et al. (2018), when analysing DMOs from the point of view of their business models. The main DMO principles, according to the framework proposed in this work, are presented in the "Value Creation" column of Table 2. They are oriented towards specific interests of the companies operating in tourism businesses (and not towards the broader users of common resources), aiming at ensuring that their interests are taken into account when planning the utilisation of resources as well as marketing products and services. All these aspects, problems and limitations are taken into account in the framework model developed in the next Section.

3 Conceptual framework for participatory tourism destination management

Considering the concepts, concerns and guidelines presented and discussed in the previous Section, Table 2 integrates and synthesises the main principles proposed by each of these approaches, taking into account three key aspects for the implementation of a participatory process of tourism destination management: planning and management (including territorial resources as well as the products and services to be developed); monitoring impacts (socio-economic, cultural and ecological impacts); and stakeholder involvement (forms of participation of the different stakeholders in a destination). The blank spaces in the table emphasise the limitations (or "black holes") of each approach and the need to integrate different theoretical approaches.

The table includes contributions from different streams of literature: column 3 and column 4 refer to principles related to the management of cultural and natural resources, taking into account the guidelines proposed by ICOMOS (1999) and UNWTO (2003); column 5 refers to the recommendations proposed by UNWTO (2007) for the operationalisation of a DMO that integrates sustainable development principles into its mission; column 6 synthesises the main principles for the management of CPR inspired by the work of Ostrom (2005, 2008); columns 7 and 8 present the principles proposed by Moore, Rodger (2010) and Heenehan et al. (2015) for the management of ecological CPR in a context of tourism development. Column 8 integrates principles proposed by Reinhold et al. (2018) for the value added by a DMO.

Taking into account the concerns, proposals and limitations of these contributions, Table 3 represents our conceptual framework for a DMO oriented towards the sustainable development of a tourist destination through a community-based governance model, including the management of CPR. This framework reflects the need to integrate the principles from diverse theoretical perspectives into the diverse stages of action of a DMO (strategic planning, operational planning, management and monitoring), with varied levels of stakeholders' involvement and participation at each stage. This multi-level adaptive framework aims at creating an institutional arrangement combining effective participatory methods for planning and management of common resources utilization (including concerns with their preservation or different valuation of their importance within local communities, along with the importance of monitoring methods), with efficient mechanisms for the development and marketing of competitive tourism products and services that contribute to the sustainable development of a destination, generating socio-economic benefits for local communities.

We also assume that the focus on a long-term strategy for tourism competitiveness implies the definition of a "vision" (as an aspiration) and a mission (what is expected to be achieved and how it can be measured), as defined by Pike (2016), along with his distinction between "goals" (general qualitative statements) and "objectives" (strategic targets, possible to measure through quantitative indicators). Similarly, David (2016) suggests that planning sustainable tourism development implies the definition of a "common vision"

Table 2: Synthesis of principles for a participatory tourism destination management

		Cultural Heritage (ICOMOS)	Cultural Heritage (UNWTO)	DMO for SD (UNWTO)	CPR	Enabling conditions (Moore, Rodger)	Attributes (Heenehan et al)	Value creation (Reinhold et al.)
Planning and Management	**Resource management**	Encouraging public awareness of heritage	Understanding the links between heritage and tourism		Precise definition of boundaries	Identifying resource system characteristics	Defining the spatial extent of resources	Planning the utilization and commercialization of resources
	Product and service development	Ensuring a worthwhile visitor experience; Defining responsible promotion programs	Defining tourism products based on heritage; Balancing education and entertainment	Assisting local marketing and product development; Promoting equitable business		Identifying the relations between resource system and user group characteristics; Defining the external environment	Identifying the predictable use of resources	Planning and marketing of product and services based on local resources
Monitoring Impacts	**Economic impacts**	Providing benefits for the local community		Assessing socio-economic impacts; Maximizing local economic benefits	Assessment of the balance between utilization benefits and preservation costs		Assessing the salience of resources and their (low) discount rate	
	Cultural and ecological impacts	Managing a dynamic relationship between heritage places and tourism	Maintaining authenticity and setting limits of acceptable change; Ensuring cultural dynamism	Respecting social and cultural diversity; Reducing impacts on the environment; Maintaining biodiversity		Defining institutional arrangements considering the resource system	Promoting the feasible improvement of resources	
	Monitoring		Implementing research and monitoring systems		Monitoring processes based on indicators		Defining indicators	Representation of the different interests involved in tourism businesses
Stakeholder involvement	**Participation**	Involving host and indigenous communities	Identifying stakeholders, creating partnerships and establishing participation mechanisms	Ensure communities are involved in and benefit from tourism; Involve local communities in planning and decision making	Mobilization of relevant members; Recognition of rights to organize; Collective-choice arrangements; Mechanisms for conflict resolution and sanctions	Defining institutional arrangements considering user group characteristics	Promoting autonomy and common understanding to create trust and reciprocity; Assuming the importance of prior organizational experience and local leadership	

and a "mission statement" (how that vision can be achieved), the distinction between "goals" (development-driving forces) and "objectives" (specific and quantified targets to reach the goals), as well as the combination between long-term "strategies" (to achieve the objectives) and short-term "tactics" (for immediate achievements). UNWTO (2007) combines long-term vision goals and collectively defined short-term actions for a strategic approach to destination development.

Considering the large number of stakeholders involved in participatory destination management – along with the limitations related to the availability of information – we propose concerted involvement of all the stakeholders during the stages of "strategic planning" (definition of a long-term vision, goals, objectives and targets, with the related policy guidelines, regulations and indicators) and the "evaluation" (comparison between the achievements and the objectives). In both cases, it is crucial that institutions and stakeholders with specialised knowledge in specific fields (managers of ecosystems or cultural services and facilities, cultural agents, marketing strategists, transport planners, business developers, etc.) provide technical information to be shared among all stakeholders, integrated into a strategic plan and translated into quantifiable and measurable indicators for collective assessment. Depending on the size of the destination, the number of stakeholders involved and the funds available, advisory panels for specific topics or domains can be set up (Morrison 2019).

From the point of view of CPR management, it is also crucial that all the rules and conditions for their utilisation, preservation as well as the appropriation of benefits are considered during the phase of strategic planning, in order to reflect a consensual view from all the representatives of local communities. Moreover, these rules and conditions must be followed through the creation of a precise set of indicators, so that all the stakeholders can evaluate the situation of the CPR during the monitoring stage (and ideally, during the other two stages as well).

The other two stages relate to "operational planning" (integration of goals, objectives and targets of the destination into the actions of each involved stakeholder) and "management" (focused on the execution of specific tasks by each stakeholder), being mostly performed at the individual level. The DMO's role during this period mostly lies in coordinating, facilitating, communicating, and eventually contributing to the resolution of conflicts and the performance of specific tasks (marketing or provision of commercial services). DMO can also have an active role in the development and management of digital platforms integrating the diverse tourism services available at the destination.

Considering the importance of CPR for local communities and the need to guarantee an efficient performance of different organizational tasks (including timely decisions and flexible responses to a changing environment, market fluctuations or other occasional disturbances and opportunities), the creation of a specific "committee" (as defined by Morrison 2019) for a regular assessment of the eventual co-production, utilisation and preservation of CPR may be considered. This assessment must take into account the rules and indicators defined within the "Strategic Planning", but not implying collective decisions for the regular utilisation of those resources, as long as they are framed by the strategic guidelines. For other utilisations, however, a revision of the rules based on community consensus may be required.

A crucial aspect of this framework is the definition of objective and quantified indicators during the planning phase, in order to ensure the possibility of a collective assessment of strategic objectives. Following a holistic approach to sustainable development, these indicators should cover the ecological, cultural, social and economic dimensions of tourism dynamics, apart from the utilisation, preservation and appropriation of benefits related to CPR. For the ecological and cultural aspects, indicators related to carrying capacity, number of users, impacts on the degradation of resources or on their protection and valorisation should be considered, along with broader indicators related to pollution, CO2 emissions, biodiversity or cultural diversity. The assessment of social aspects may be based on indicators related to employment, salaries, labor relations, education, poverty, housing or social inequalities. Finally, economic impacts can be assessed on the basis of the number of visitors and overnight stays, expenditures from tourists at the destination, number of jobs and companies created and destroyed, as well as sectorial specialisation or

Table 3: Tasks and stakeholders for participatory destination management organisation

Stage	Strategic planning	Operational planning	Management	Monitoring
Objective	Common vision	Action planning	Execution	Performance evaluation
Tasks	Mission			Assessment
	Goals (driving forces)	Objectives (targets)		Assessment
	Core products and services	Product and service development; Plans for education and training; Plans to support investment and entrepreneurship	Selling products and services; Reservation systems; Information desks; Support services; ICT applications; Events	
	Limits (carrying capacity)	Market research	Brand management; Pricing; Promotional campaigns; Incoming services (receiving tourists)	
	General impacts	Specific impacts		Assessment
	Global indicators	Detailed indicators		Assessment
Stakeholders				
Technical staff at DMO	Technical support	Coordination	Coordination; Service provision	Technical support
Private companies	Discussion Consensus	Planning	Service provision	Assessment; Strategic (re)orientations
Public institutions		Regulation and infrastructures	Service provision	
Community representatives				

evolution of the GDP.

The lack of data and information availability at the destination level is an important obstacle to the implementation of an effective assessment and monitoring system. However, different international institutions have made important efforts to measure different aspects and impacts of tourism dynamics at different territorial levels, including the socio-economic dimensions within Tourism Satellite Accounts (OECD 2000, United Nations 2010) or enlarging the scope of analysis in order to integrate other aspects of sustainable development (UNWTO 2004, European Commission 2006). UNWTO (2016, 2017) is currently developing a "statistical framework for sustainable tourism", aiming at offering guidelines and tools for this kind of assessment.

The integration of local knowledge from the different stakeholders involved into tourism activities appears as a crucial aspect for an effective participatory management process, but also for providing the technical information and data supporting the creation of an effective monitoring system (Hall 2019). Such an information system can benefit from the development of digital platforms, as pointed out by Sigala, Marinidis (2012). Similarly, Boes et al. (2016) claim that a smart destination does not rely only on the technological aspects of digitalisation, but mostly on its utilisation for the implementation of participatory processes of destination management. The next section illustrates the aforementioned principles and guidelines through a case-study in Japan. The main purpose is to discuss whether the conceptual model presented above can serve as a useful operational tool for participatory tourism planning and management in this type of rural destination.

4 Tourism and commons in Kushiro-Akan (East Hokkaido, Japan)

Tourism in the rural region of Kushiro-Akan is based on the natural and cultural features of the region, including hot springs, the authenticity of the Japanese onsen tradition, natural parks and other ecological sites, museums and other cultural as well as educational

facilities (including the cultural heritage related to the indigenous Ainu communities). Apart from the traditional hospitality services (accommodation and restaurants), these resources can be broadly defined as CPR, thus justifying participatory management. The main characteristics of each of these resources are briefly described below, concluding with some observations on existing tourism management organisations.

Kushiro City has 169.000 inhabitants (March 2019), with a low density (124 persons per km2). 210 accommodation facilities (33 "conventional" hotels and 174 ryokans) with 7484 rooms (3760 in "conventional" hotels, with an average of 114 rooms per facility; and 3578 in ryokans, corresponding to 21 rooms per facility) were registered in 2015. According to Akan Tourism Association (2018), 609.000 tourists visited the area in 2017 (20% being Japanese guests). Most foreign visitors came from Taiwan (50%), China (20%) and Hong Kong (9%). Despite its relatively small size, Kushiro-Akan incorporates the main areas of 2 of the 6 national parks in Hokkaido: Kushiro-Shitsugen, comprising Japan's largest marsh, the Kushiro Marsh (designated a Ramsar site), a habitat for diverse flora and fauna (including the red-crowned crane, a National Special Natural Monument); and Akan-Mashu National Park, including the Akan (the mountainous areas around Lake Akan and Lake Onneto) and the Mashu (around the lakes Mashu and Kussharo) areas. The region has 10 natural and scenic spots classified as interesting for tourists, one zoo, one aquarium, eight museums and three other cultural facilities, along with one ski resort and three golf courses. Moreover, this area features the "Ainu village", where traditional aspects of the Hokkaido indigenous group's culture can be explored.

In a broad sense, the territorial resources that can be classified as CPR are: the hot springs supporting the supply of the Japanese bath tradition (onsen), a unique experience with potentially positive impacts on users' health and wellness; the natural (parks and other scenic elements) and cultural (museums and other facilities) resources accessible to the visitors for different types of activities; and the unique resources (traditional products, crafts, music, dance or lifestyles) related to the presence of Ainu communities.

4.1 Onsen (hot springs)

The onsen (traditional Japanese bath) is based on the water properties of the Japanese hot springs and is associated with wellness, relaxation or meditation activities. Although some springs flow in open spaces (with free public access), they are generally integrated into accommodation facilities (hotels, which may follow the traditional Japanese ryokan type of accommodation). As a compensation for the community, the Municipalities charge a tax (approximately €1.2) for each person using the bath. This tax is included in the accommodation cost (for hotel guests) or is paid as an entrance fee. Landowners require a permit from the prefectural government for the exploitation of the hot springs, based on an application evaluated by a screening committee. Quality controls based on national laws defining the thermal characteristics (chemical composition and temperature of the springs) are performed before the license is given and also during the exploitation phase.

The spatial extent of this resource is clearly delimited, while its quantity and quality are highly predictable. The privatisation of the resource through a license for its exploitation can potentially increase its protection, since there is a specific stakeholder responsible for its maintenance as well as a public institution controlling its quality and quantity. The community is then compensated for the privatisation of the resource through a municipal tax. However, part of the revenue obtained with this tax is invested in the creation and maintenance of tourism events and infrastructure, thus offering a new advantage for the hospitality companies.

This process is potentially conflictive within a community, for a particular entity (a hotel) can take advantage of the resource's privatisation. Whether the compensation paid to the local authorities is fair or not, once there is a direct negotiation and regulation with the City Council, it is no longer a matter of discussion within communities. The supply of accommodation services is as an externality to the exploitation and utilisation of these thermal waters, and hotels offering onsen services normally charge higher prices. Moreover, at least in the Kushiro-Akan destination, dinners are generally included in the accommodation cost, thus constraining the opportunities for the development of restaurant services in the area. In this sense, the private appropriation of the hot springs

contributes to the achievement of a dominant position, not only in the provision of accommodation, but also in other tourism-related services. Thus, the achievement of positive results within the social dimensions of sustainable development (generating and spreading economic benefits for the local populations) clearly depends on the negotiation and implementation of appropriate processes of resource management.

4.2 Natural and cultural resources

The particular ecosystems of the region offer diverse opportunities for recreational and educational nature-based activities. These resources are clearly identified, delimitated and protected, being managed by public institutions which regulate their utilisation for commercial purposes. Activities undertaken in this area usually include boat trips (on the Akan Lake), bird watching and hiking. However, the number of visitors s activities in natural areas (below 2.000 per year) is extremely low in comparison with the number of users of ski resorts (more than 200.000 per year), which seem to be the most significant attraction of the region.

Apart from the boat trips on the Akan Lake (with boarding places located very close to accommodation facilities), these nature-based activities do not seem adequately integrated into the local tourism dynamics, with low level of service development and low economic impacts. In this sense, the current utilisation of the resources does not lead to any of the potentially negative implications (free-riding or lack of protection). Instead, it seems that their use can be widened in order to generate socio-economic benefits for the local communities. Clearly, transportation and mobility services, along with information for non-Japanese travellers could contribute to diversify the attractions and services currently enjoyed at the destination. Moreover, there is no available statistical information related to the utilisation of these ecological resources (jobs created, amount of revenue generated, etc.), implying that the potential socio-economic impacts of these tourism-related activities cannot be effectively assessed.

Similarly, the utilisation of local museums and cultural facilities for international tourists also seems far from its full potential. Despite the emphasis on education and recreation (mostly related to local ecosystems and cultural heritage) at the facilities and in services they provide, their integration into tourism dynamics (through the creation of routes, packages of services, etc.) is not properly addressed. Furthermore, the information available to non-Japanese travellers is insufficient. It appears that a larger involvement of the institutions in charge of these facilities and services within the local tourism management organisations would contribute to the diversification of tourism services in the area, as well as result in higher socio-economic benefits for the local community through job creation.

In the case of these common resources, a management process oriented towards sustainable development should include local communities in order to increase the potential economic benefits, create opportunities for small companies to develop new services (interpretation, guided tours, ICT, food and drinks, etc.), generate jobs (social dimension), and limit the use of sensitive resources (environmental aspects).

4.3 Ainu traditional heritage

The Ainu are the indigenous people who have lived mainly in the northern part of the Japanese archipelago before the arrival of Japanese inhabitants in the late 19th century. They have their own spoken language and distinctive culture. In the late 19th century, after the Meiji Restoration, Ezochi /Ainu Mosir was renamed “Hokkaido”. The Meiji government had direct control over the region and promoted an institutional unification, introducing the modern land ownership system. Besides, a large scale of immigration from the main island of Japan and the so-called “cultural enlightment movement” (which banned practicing Ainu customs) were carried out. These measures inflicted decisive damage on all aspects of the Ainu culture and livelihoods, implying the assimilation of Ainu into the Japanese culture (Advisory Council for Future Ainu Policy 2009).

In April 2019, the Japanese government enacted a new law recognising the Ainu ethnic minority as indigenous people of Japan for the first time in history. This new law expands

Table 4: Existing tourism management organisations in Kushiro-Akan

Territorial level	Prefecture	Multi local		Local
Denomination	Hokkaido Tourism Organization	Kushiro Tourism & Convention Association	The road to the general Institute of East Hokkaido natural beauty DMO	Akan Tourism Association & Community Development Organization
Related policy institutions	National Government, Prefectural Government	City Councils (Kushiro City and Teshikaga Town)	City Councils (6 cities and 9 towns including Kushiro and Teshikaga)	City council
Legal type	Public interest incorporated association	General incorporated association	General incorporated association	Incorporated non-profit organisation
Mission and tasks	Territorial and sectorial planning and coordination; Tourism planning and related policies	Promotion; Surveys and human resource development; Information centers and shops	Promotion & Marketing of tourism; Tourism planning	Tourism planning; Marketing; Promotion
Staff	41 persons	20 persons	4 persons	10 persons
Representative	Former President of private company (bank)	President of private company (environmental services)	President of private company (hotel)	President of private company (tourism)

measures to promote, not only the Ainu culture, but also related economic activities, including tourism. A national Ainu museum and park will open in 2020 in the Hokkaido town of Shiraoi, which is expected to be a national centre for the revitalisation of Ainu culture. Ahead of this project, the "Council for the Ainu culture excursion trail" was established in 2017, involving Ainu organisations as well as travel and advertisement agencies, aiming at the creation of a cultural route between Shiraoi and the satellite cities of Hakodate, Biratori, Sapporo, Asahikawa and Akan (the "Yukar Road"). Featuring one of the most famous tourist attractions related to Ainu culture since World War II (the Marimo festival, created in 1950), Akan is a leading player in this project. Akan is also home to an Ainu village since the late 1950s, where Ainu residents opened craftwork shops and studios, along with hosting traditional dance performances, integrating their culture into tourism circuits in Akan (Saito 1999). Though Akan became a popular tourist destination, the Ainu community is facing several remaining challenges, such as competing with the Ainu crafts made outside Hokkaido or an insufficient mobilisation of Ainu culture as a tourism resource (Akibe 2010). In 2018, the Akan Tourism Association set up and launched new projects for the integration of Ainu heritage into tourism dynamics, involving representatives of the Ainu communities as consulting members.

The local processes for the sustainable development of tourism should be geared towards the active participation of these communities in destination planning and management, as in countries with populations of similar characteristics, like New Zealand or Australia. Such an involvement would allow these communities to have a more active participation in the tourism industry through the production of traditional goods as well as the development of new cultural, educational and recreational services based on their heritage, thus contributing to the economic and social dimensions of sustainable development.

4.4 Tourism-related organisations

Table 4 presents the characteristics of the tourism-related organisations operating in Kushiro-Akan.

The Hokkaido Tourism Organization, including representatives from the National and Prefectural governments, is responsible for framing tourism dynamics within regional development strategies, taking national policies into account. With a smaller territorial scale, the Kushiro Tourism & Convention Association involves the neighbouring municipalities of Kushiro City and Teshikaga Town, being responsible for promotional initiatives and the

management of tourism information centres, along with human resource development and implementation of surveys. Another multi-local organisation, the "Road to East Hokkaido Natural Beauty", was established in 2018 to cover almost all of Eastern Hokkaido.

At the local level, the Akan Tourism Association & Community Development Organization appears most suitable for the management of natural and cultural resources within tourism development processes (according to general objectives defined in table 1), along with the integration and participation of local stakeholders, including Ainu communities (assuming the structure, processes and tasks proposed in Table 3). The purpose of this brief analysis is to test whether and how this structure corresponds to the conceptual model we proposed.

The organisation has been created, promoted and financed by the City Council in partnership with a very small number of large companies of the tourism sector, officially aiming at community development. However, the strategic plan supporting its activity is mostly focused on short-term marketing actions (until 2020), rather than a long-term comprehensive approach to sustainable development (Akan Tourism Association 2018). Moreover, the quantified objectives presented and the indicators proposed for performance assessment are exclusively oriented towards the tourism business, not towards a broader perspective of community or sustainable development.

In terms of organisation, there is a strong hegemony of three major companies operating in the area (accommodation, transport and marketing), which allocate human resources for the performance of the technical tasks of the DMO, while taking full responsibility for the decision-making process. However, efforts to involve stakeholders related to the management of natural and cultural resources and the Ainu communities, through processes of consultancy aiming at the achievement of a general consensus, have been made. Questions related to the appropriation of benefits arising from the externalities created by the privatisation of hot springs (which are concentrated in very large accommodation companies) are not addressed by the DMO. Similarly, there is no participatory decision making related to establishing limits for the utilisation of resources or the discussion of potential negative ecological, cultural, social and economic impacts. The indigenous Ainu communities particularly lack representation in the decision-making processes, and their specific knowledge and cultural heritage are not effectively used for the creation of unique and differentiated tourism products in the region. Similarly, there are no companies owned or managed by members of the Ainu communities providing tourism products or services.

When comparing the local DMO with our conceptual proposal, crucial differences, relating to the type of local stakeholders' involvement, become evident: although all the relevant entities in the tourism sector are consulted during the planning process, the final decisions are made by a few large stakeholders, which are in charge of the development of the future vision and its translation into goals, along with the identification of core products, services and potential markets. This reflects the focus on marketing issues, aiming at the reinforcement of the destination's attractiveness, rather than a process of sustainable development with broader objectives and indicators.

5 Conclusion

By pointing out the problems and obstacles for the creation of a local DMO promoting a tourism destination's sustainable development while ensuring active participation of local stakeholders in the processes of planning, managing and monitoring tourism activities and CPR, our conceptual model proposes a large participatory process for the stages of strategic planning and monitoring, combined with decentralised operational planning and management. From the point of view of the management of the commons, such an organisation would imply the articulation of rules for the utilisation and appropriation of related benefits during the stage of strategic planning, implying the definition of a broad and precise set of indicators for collective monitoring. Moreover, a specific committee focused on CPR management could be assigned to monitor their utilisation during subsequent stages. The effectiveness of this type of structure depends on technical information to be provided by specialised experts in different fields in a way that it can be

shared among all involved stakeholders. Specific information and indicators are required for the assessment of the undertaken strategies, which often poses a difficulty at the local level. The work currently undertaken by institutions like UNWTO (2016), to define a set of local indicators for sustainable tourism development, may help create and consolidate participatory process of local tourism development.

However, the implementation of a concrete DMO with these purposes and principles depends on the characteristics of each destination. Different types of resources determining attractiveness, diverse levels of tourism development and positions in the life cycle of the destinations, different traditions and grades of organisation of local communities, as well as the types of support from public institutions may impose different constraints and open different opportunities for such a participatory management process in each destination. In this sense, further research is required in order to evaluate how such a process can be implemented in each place. The amount and diversity of stakeholders to be involved, along with the need to ensure enough stable financial resources and a well-balanced decision-making structure constitute important difficulties for their implementation. On the other hand, the creation of other types of organisations, without political legitimacy to coordinate or plan tourism activities, would surely result in strong difficulties when mobilizing local stakeholders.

The exploratory application of our conceptual model to a specific destination highlights the potential advantages of such a participatory tourism management structure, while pointing out the differences regarding the existing DMO. In this case, the activities of the organisation are mostly dependent on the initiative of large private companies, with potential negative implications on the diversification of services based on endogenous resources. The privatisation of common resources that ensures their protection also promotes a concentration of benefits in a small number of large companies. Since the number of visitors to the most sensitive areas (like natural parks) is relatively low, there are not significant problems of overutilisation or degradation of resources. However, it is clear that the economic potentials of natural and cultural resources are not fully exploited. The involvement of the Ainu communities is particularly very limited. Moreover, the DMO under investigation does not specify broad objectives and indicators for the three pillars of sustainable development, focusing exclusively on marketing goals. Although most of the tasks proposed in our conceptual model are performed by this DMO (except the monitoring process, which is very limited), there is a very weak representation of local stakeholders, limited to three large (and complementary) companies. These companies also provide the technical staff to the organisation, assuming all the tasks, while the participation of other local stakeholders is only possible through consultation processes, without formal involvement in decision-making processes.

In our view, the structure and operational framework of the said DMO clearly exemplify the difficulties of implementing an organisation based on the conceptualisation presented in this work. However, it is also clear that crucial aspects related to the utilisation of common sensitive resources, distribution of benefits among local communities or, in a broad sense, the potential achievements related to the three pillars of sustainable development, are not sufficiently addressed by the existing tourism development strategies for the area. In fact, despite the recommendations from UNWTO (2007) most of the existing DMOs do not assume large forms of local stakeholders' representation, with different interests and motivations regarding tourism dynamics. In general terms, they involve a coalition of public authorities and private companies, with limited participation of representatives of other types of groups of interest within the local population. From our analysis, the critical factors for overcoming this problem are:

- identification of legitimate representatives of different interests;
- potential high number of representatives, implying difficulties in achieving consensual solutions;
- adequate power balance between the stakeholders involved;
- stable and adequate financial contributions, not leading to power imbalances;

- possibility to share and understand different forms of knowledge;
- achievement of a common vision;
- definition of clear objectives, measures and indicators;
- definitions of clear rules and regulations;
- policy legitimacy and possibility of the decisions' enforcement;
- broad culture of participation;
- ability to generate efficient and timely decisions.

Clearly, the challenges raised by contemporary tourism dynamics and their implications for local resources and communities justify the integration of sustainable development goals and broad participatory processes involving local stakeholders into formal destination management organisations. However, it is not possible to achieve ths without significant challenges and obstacles, which may be different in each place, depending on local path-dependent processes of cultural, economic, institutional and political evolutions. Our work resulted in the design of an operational framework for the analysis and creation of such organisations in specific tourist destinations, taking their specific characteristics into account.

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Linking the Performance of Entrepreneurial Universities to Technoparks and University Characteristics in Turkey

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Abstract. Universities' third mission of knowledge commercialization imposes them a core role towards becoming entrepreneurial universities in the triple helix interacting with the government and industry. Entrepreneurial universities have crucial functions of providing entrepreneurial support infrastructure for innovation and engaging in the regional economy. Technoparks, in that sense, form an essential channel for universities to disseminate and commercialize the knowledge considering their geographical proximity and facilitating mechanisms. Measuring the performances of entrepreneurial universities and technoparks in quantitative metrics have been initiated by different government agencies in Turkey, which resulted in two different indices. The Most Entrepreneurial and Innovative University Index and the Performance Index for Technoparks track performances annually. Using the data provided by the two indices, this study explores how the technoparks' performance can be linked to the universities' scores in entrepreneurship and innovation, along with some university-specific characteristics and their interactions. The geographical proximity provided by the technoparks contributes to the performance of entrepreneurial universities. While the increasing university size has a negative effect on university entrepreneurial scores, the socio-economic development factor of the region positively contributes to the scores. Young universities are also found to benefit more from the large share of the graduate students of their student composition on university entrepreneurship and innovation scores.

Key words: Entrepreneurial universities in Turkey, technoparks, knowledge commercialization, geographical proximity, regional innovation

1 Introduction

Universities play a fundamental role in regional innovation and economic growth (Gunasekara 2006, Power, Malmberg 2008, Rasmussen et al. 2006) beyond their traditional missions of teaching and research that they were identified with so long in the history. The third mission of universities, contributing to the knowledge society, has its roots seeded in the pioneering work of Clark (1983). In his conceptual tool of the triangle of coordination, Clark (1983) views the place of universities from a broader perspective within the interactions of academic oligarchy, state authority, and market. This notion of

interactions was later developed into the notion of the triple helix by Etzkowitz, Leydesdorff (1995). Even the triple helix model has further been transformed into the quadruple and quintuple models to incorporate the society's and environment's role (Carayannis, Campbell 2010). The government plays a key role in the interaction of the university and industry where the linear model of innovation based on the long-term contribution of the knowledge disseminated from the university to the economy is no longer the only option. Universities contribute to knowledge-based economic development via a spiral model of innovation commercializing and capitalizing the knowledge in both short and long terms (Etzkowitz, Leydesdorff 1995, Leydesdorff, Etzkowitz 1996).

Studying the ten to fifteen years of transformative developments in the five European institutions, Clark (1998) argues that universities are forced to change by the enormous demand overload surpassing their capacities, which they respond to transforming themselves into entrepreneurial universities. The notion of the entrepreneurial university is closely linked to the universities' third mission of evolving with new perspectives on technology transfer and commercialization and expanding to undertake a more direct role in regional development and innovation (Rasmussen et al. 2006). Etzkowitz (2004) punctuates the new mission of the entrepreneurial university acting as an economic entity interacting with the users of knowledge in capitalizing the knowledge.

The acceptance of knowledge commercialization as a third mission first came onto the development agenda in the U.S. in the 1980s and later spread to European countries in the 1990s (Baycan, Stough 2013, Charles, Howells 1992, van Geenhuizen 2010). While the first wave of knowledge commercialization in the 1980s was recognized by the establishment of traditional science parks where collaboration with existing industry emerged, the second wave in the 1990s saw a stronger focus on patenting/licensing and spinoffs as well as an increased involvement by students in commercialization (Rasmussen et al. 2006).

The third mission of engaging with the community (Rubens, Spiragelli 2017) is essential in getting the most out of all the stakeholders in the interacting spheres of the university, industry, and government. The engagement with the industry could take different forms, such as formal contracting, sponsoring research, transferring key personnel into employment, or access to university facilities (Monck et al. 1988, Quintas et al. 1992). Science and technology parks form another significant mechanism in engaging businesses with the academic knowledge on-site, which could have important regional implications (Lindelöf, Löfsten 2002). The geographical proximity provided by science parks could facilitate the transfer of knowledge, interactive learning, and innovation (Albahari et al. 2017).

The emergence of science and technology parks initiated a debate on how property-based actions improve the economic and innovation performance of the university, industry, and the region (Link, Scott 2007). In the prior literature, scholars study how the science and technology park characteristics such as size, age, sectorial specialization, and geographical area affect the park tenants' innovation performance (Albahari et al. 2017, 2018, Liberati et al. 2016). Firms that are smaller in size benefit more from being located in science and technology parks on innovation performance (Huang et al. 2012). Besides, firms' innovation performance improves when the firms are located in less technologically developed areas or very new or longer established parks (Albahari et al. 2018).

Different terminology is used for technology parks in the literature. It is more common to use the term science park in Europe, the research park in the U.S., and the technology park (i.e., technopark) in Asia (Eckhardt, Shane 2003, Link, Scott 2007). While science, research, and technology parks are used interchangeably in the literature, we choose to use the term technopark within the context of our study. According to the legislation passed in 2001 in Turkey, technoparks are referred to as technology development zones representing the sites where academic, economic, and social structures are integrated and established within the close vicinity of the university, high-technology institute, or R&D center for which they operate (General Directorate of Legislation Development 2001). Technoparks maintain companies that develop technology or software, carry out activities to transform a technological invention into commercial products, and use high or new technologies benefiting from the resources of the university or high-technology institute that they operate for.

On the other hand, entrepreneurial universities have come onto the agenda of the Higher Education Council of Turkey as well, and several programs, including regional development-oriented mission differentiation and specialization of Turkish universities, have been initiated recently. Two indices have been developed by the government agencies to track the performance of the entrepreneurial universities and the technoparks: the Most Entrepreneurial and Innovative University Index and the Performance Index for Technoparks. Universities that are smaller in size embrace the third mission differently in contributing to the regional economy and innovation (Rubens, Spiragelli 2017). Not all the universities get the expected benefits of the close geographical proximity of the technoparks. This study aims to understand how technoparks can be linked to the success of entrepreneurial universities from a regional perspective using the most recent data of the two indices. In understanding the link between the two, we also consider the effects of specific characteristics such as technopark age, university age, university size, the graduate program composition, and the socio-economic development index of the region.

In analyzing the third role of universities, Gunasekara (2006) highlights the variation in universities' performance of fulfilling the third mission in different regions. From the perspective of the Turkish regional innovation system, this study offers insights to regional policymakers, universities, and firms. Technoparks, with their proximity to universities, can help them to build entrepreneurial capacities and contribute to their innovation performances. However, other factors also promote entrepreneurial university performance a great deal. Young universities can benefit more from being research-oriented via investing in advanced degrees for more graduate-level students.

The rest of the paper is organized as follows. Section 2 investigates the geographical embeddedness of entrepreneurial universities, explicitly referring to the literature to understand how entrepreneurial universities commercialize knowledge and contribute to regional development via its linkages to technoparks. Section 3 describes the data and presents the empirical analyses of the research model. Section 4 offers a general discussion of the critical factors of the most entrepreneurial and innovative universities with concluding remarks and recommendations for future researches.

2 Linking Entrepreneurial Universities to Technoparks

The need for universities to transform themselves into a more entrepreneurial structure leads to the development of new kinds of relationships, governance systems, and a university-industry-public relations model. The model referred to as the triple helix (Etzkowitz, Leydesdorff 1995) indeed goes back to the pioneering study of Clark (1983) and visualizes the university as one of the main actors of the three – university, state, and the market – interacting with each other. Having high interactions with industry and government, entrepreneurial universities play an essential role in the process of knowledge commercialization and can contribute significantly to regional development.

The university dedicated to achieving the primary missions of teaching and research is needed to handle the new mission via the triple-helix or so-called partnership model carrying out the academic capabilities and resources outside the academic environment (Rubens, Spiragelli 2017). The universities undertaking the new mission are referred to as entrepreneurial universities resulting in an academic revolution in the field of higher education (Clark 1998, Etzkowitz 1983).

In fulfilling the third mission, entrepreneurial universities undertake new roles as

1. trainer (supply of skilled young graduates);
2. innovator (commercialization of academic knowledge);
3. partner (provision of technical know-how);
4. regional talent magnet (attractiveness of the region to talented academics and entrepreneurs);
5. facilitator (between private and public sectors) (Betts, Lee 2004).

In dealing with the new roles to become more entrepreneurial, universities face many challenges, from the perception of entrepreneurship and developing a shared institutional vision and consensus, to an organizational transformation or strong links with

commercialization and income generation rather than education (Hannon 2013). However, the greatest challenge is how universities create effective environments for developing entrepreneurial capacities. Technoparks form a key channel in creating and enhancing the entrepreneurial capacities of the universities, in which there is a need to understand further how entrepreneurial universities are linked to technoparks.

2.1 Entrepreneurial Universities and Knowledge Commercialization

Three steps are defined towards an entrepreneurial university:

1. "the ability to set a strategic direction";
2. "a commitment to seeing that the knowledge developed within the university is put to use";
3. "the encouragement of start-ups based upon technologies that do not find a fit within existing firms" (Clark 1998, Etzkowitz 2016).

Therefore, universities develop their organizational capacities to work with firms, to transfer technologies, and to respond to societal changes. This proactive role that the universities take over leads to enhancing the innovation capabilities of the region where they are located. As a provider of human talent, entrepreneurial universities function as a seed-bed of new firms in the knowledge economy (Etzkowitz et al. 2000, Rasmussen et al. 2006).

An entrepreneurial university can be seen as "a university that develops a comprehensive internal system for the commodification and commercialization of knowledge" (Jacob et al. 2003, p. 1556). While undertaking the new role of knowledge commercialization opens up opportunities for the universities, it brings its own challenges. On the one hand, universities deal with increasing the extent of commercialization and finding ways to improve the economic contribution. On the other hand, they need to balance the commercialization and the other core activities (Rasmussen et al. 2006). To promote knowledge commercialization, universities go through various formal and informal initiatives. Building the infrastructure, such as establishing offices of patenting and licensing and incubator facilities for supporting new ventures, is one step that many universities take to become entrepreneurial universities (Rasmussen et al. 2006). Besides, legislation and policies are made at country levels to facilitate the commercialization of university research. However, infrastructure and policies are not sufficient for creating a culture of entrepreneurship, and making the individuals desire entrepreneurial activities is another important part of the knowledge commercialization.

Via the viewpoint of a researcher, Nilsson et al. (2010) explore why and how researchers engage in the commercialization process. Researchers desire to be academic entrepreneurs in alignment with the changing role of the university perceived in society as contributing to innovation and economic development as Nilsson et al. (2010) elaborates on. An academic entrepreneur is a university scientist, mostly a professor, sometimes a doctoral student or a post-doctoral researcher who establishes a company to commercialize the results of his/her research. Teaching at different universities, conducting consulting activities (Goldfarb, Henrekson 2003), conducting research projects (Louis et al. 1989), participating in patenting and licensing activities (Siegel et al. 2004), and founding new companies are considered academic entrepreneurship. The concept of academic entrepreneurship, illustrated by the activities that universities have carried out to contribute to commercialization in the regions they are in, has changed considerably in recent years. As a result of this change, universities are approaching the concept of academic entrepreneurship more strategically, and more stakeholders are involved (Siegel, Wright 2015). The supportive infrastructure that the university has and being located in a region where there are companies in need and capability to work with form the essential determinants of engaging in knowledge commercialization (Jensen, Thursby 2016, Melese 2006, Nilsson et al. 2010, Shane, Stuart 2002). The network links and trust between the researchers and industrial actors also affect knowledge commercialization (Nilsson et al. 2010).

In answering the question of how researchers transfer knowledge, Bercovitz, Feldmann (2006) conceptualize four different modes of knowledge transfer that are sponsored research,

licenses, hiring of students particularly those working on sponsored projects, and spinoff firms. In addition to these, there are other informal mechanisms such as serendipity (Nilsson et al. 2010). In a similar vein, governance structures can also be described on a continuum where on one end, the knowledge can be commercialized and transferred through a Technology Transfer Office (TTO) , and establishing a new organization with an entrepreneurial structure on the other (Bengtsson et al. 2009).

Using these structures, in the past years, universities have reached wider regions surrounding themselves by offering new programs and closer relationships with the business world (Boucher et al. 2003, Bramwell, Wolfe 2008, Duch-Brown et al. 2011, Goldstein, Renault 2004, Hudson 2006, Lazzeretti, Tavoletti 2005). Thus, the commercialization of knowledge has begun to be seen as an important stimulus of economic growth, particularly of development capability and boosting the economic performance of the regions (Agrawal 2001, Baycan, Stough 2013, Bok 2003, Etzkowitz 1990, 2002, Kochetkov et al. 2017, Litan et al. 2008, Viale, Etzkowitz 2010).

2.2 Geographical Embeddedness of Entrepreneurial Universities

The entrepreneurial potential of a regional university is determined by its engagement in a regional economic system (Kochetkov et al. 2017). An entrepreneurial university cannot be thought independent of its environment. As a key player in the regional economy, the entrepreneurial university needs to be evaluated from the point of its geographical embeddedness to the other players in the triple helix.

Agglomeration economies deal with the aggregation of various activities and different players in clusters, which is closely related to knowledge externalities. The cost of transmitting tacit knowledge increases with distance, supporting the argument that knowledge spillovers are geographically bounded (Audretsch 2002). When knowledge transfer is taking place, geographical proximity is crucial in exploiting the knowledge spillovers. Geographical proximity is linked to interactive learning and innovation as a facilitator of coordination and control in the prior literature of economic geography (Boschma 2005). There are four other dimensions of proximity identified in the literature – cognitive, organizational, social, and institutional – that need to be evaluated with geographical proximity (Torre, Gilly 2000). Boschma (2005) argues that geographical proximity is needed for better performance; however, it is not sufficient since geographical proximity facilitates interactive learning through other dimensions of proximity.

The geography of innovation activity matters more in industries where new knowledge is a crucial ingredient (Audretsch, Feldmann 2007). In considering the production and dissemination of new knowledge, spatial proximity plays a role in the transfer of knowledge between the university and the domestic industry, which does not happen to occur internationally (Kuttim 2016). According to the "university spillover thesis", the innovative activities of local entrepreneurial firms are positively affected by the knowledge spillovers from universities (Audretsch et al. 2012). While this effect is heterogeneous, which is likely to depend on the region and the university characteristics, the indirect and less tangible effects can be greater than the visualized. Classifying the entrepreneurial universities into three groups – potentially entrepreneurial, adaptive entrepreneurial, and ideal – Budyldina (2018) argues that entrepreneurial universities contribute to the region in terms of human capital attraction and detention, entrepreneurial capital, networking, and many other formal and informal means.

Entrepreneurial universities contribute and engage differently depending on their core strengths and modes of engagements, as there is no one-size-fits-all model (Benneworth et al. 2016, Sánchez-Barrioluengo 2014). While some contribute more towards commercialization activities such as producing spinoffs, others regionally engage with collaborative research, consulting, and contract research (Sánchez-Barrioluengo, Benneworth 2019).

Recent studies demonstrate that the implementation of the third mission at smaller universities generally promotes a much more regional or local approach to economic development (Rubens, Spiragelli 2017). The larger university ecosystem has been shown to have a significant impact on technology transfer while playing a critical role in providing resources and enhancing the competencies of faculty and students (Boh et al. 2016). University entrepreneurship ecosystems may differ according to their focus on internal

versus external resources and connections. While some universities create a very structured network, others develop more organic entrepreneurship ecosystems, and other universities focus both internally and externally on creating connections and drawing in resources (Boh et al. 2016).

2.3 Entrepreneurial Universities and Technoparks

Dalmarco et al. (2018, p. 102) propose five distinct characteristics of entrepreneurial universities that are

1. having an entrepreneurial perspective,
2. developing external links,
3. giving access to university resources,
4. providing entrepreneurial support infrastructure for innovation,
5. carrying out scientific research.

While all are crucial for universities to develop entrepreneurial capabilities to support the third mission of knowledge commercialization and socio-economic development, we particularly focus on the fourth characteristic of innovation arrangement.

Technoparks form an important channel for universities to disseminate knowledge, especially considering their geographical proximity to universities to facilitate this process. In considering the triple-helix model, technology parks undertake a coordinating role among the various actors of research and development to collaborate and interact with each other (Jongwanich et al. 2014). Clustering firms within its body also triggers learning and innovation via reduced transaction costs of inter-firm activities (Fan, Scott 2003, Jongwanich et al. 2014). Science and technology parks form an essential means of commercializing knowledge for entrepreneurial universities.

Firms that reside in science parks are found to be associated with higher intangible outputs from innovative cooperation within the science and technology parks (Vásquez-Urriago et al. 2016). Science park firms having higher cooperation and links with universities (Löfsten, Lindelöf 2003, Malairaja, Zawdie 2008), might get more benefit from being located near and linked to the universities (Díez-Vial, Montoro-Sánchez 2016, Lindelöf, Löfsten 2002, Löfsten, Lindelöf 2003, Vásquez-Urriago et al. 2016).

3 Research Model and Empirical Analyses

Drawing attention to the rise of entrepreneurial universities in Turkey, we explore the contribution of being linked with a technopark, and the university and region-specific characteristics on the dependent most Entrepreneurial and Innovative Universities Index (EIUI) scores of the selected sample. We test the effects of variables including the university age, university size, the composition of the graduate (i.e., Masters and doctorate levels) students, the rankings of the technoparks, technopark age, and the socio-economic development index of the city on the dependent EIUI using a multiple regression model.

3.1 Data and Variables

3.1.1 The Most Entrepreneurial and Innovative Universities Index

'Entrepreneurial University of the Year' in the U.K.; 'Top Schools for Entrepreneurship' in the U.S.A., 'The Most Entrepreneurial and Innovative Universities Index' in Turkey are some of the measurement tools for ranking the most entrepreneurial universities. In Turkey, the Scientific and Technological Research Council of Turkey (TUBITAK) initiated an index to measure the 50 most entrepreneurial and innovative universities annually. Classifying universities according to their entrepreneurship levels is a new concept in Turkey that has found an important place on the agendas of various stakeholders, including university management executives, policymakers, academics, and students since its introduction in 2012 by TUBITAK. Ranking the performances of universities over the years aims to foster the competitiveness based on entrepreneurial and innovativeness activities among Turkish

universities. The most entrepreneurial and innovative universities index (i.e., EIUI) is composed of four criteria and several indicators, as given in Table A.1 in the Appendix.

The data for indicators are provided by several institutions, as illustrated in the last column of Table A.1, including the Ministry of Industry and Technology, TUBITAK, Council of Higher Education, Turkish Patent and Trademark Office, and Small and Medium Enterprises Development Organization of Turkey. Nineteen different indicators reflect the four main criteria that are listed in the first column of Table A.1. Some indicators count the number of scientific papers, citations, and doctoral graduates to assess the research performance in a typical university ranking index, such as U.K.'s Times Higher Education (THE) rankings or Quacquarelli Symonds' (Q.S.) World University Rankings. Some other indicators focus on companies owned or partnered by graduates or students, similar to the Princeton Review's annual rankings of top universities for entrepreneurship. TUBITAK's EIUI also includes other indicators mainly focusing on the innovativeness of the university measuring the number of patent and utility model applications, and the R&D and innovation projects carried out by university, industry, and international cooperation.

Ranking the universities according to the indicators given in Table A.1 in the year 2018 results in Table A.2 in the Appendix. The total scores range between 29.63 and 93.16, where the average total score is 53.29. When the scores for each criterion is normalized to 100, the average scores are calculated as 56.34, 47.53, 60.19, and 47.63 for CSTR, IPR, CI, and ECC, respectively. The average criterion-based scores indicate that universities get lower scores in both Intellectual Property Pool and Economic Contribution and Commercialization measures (i.e., 47.53 and 47.63) relative to the other components. While the universities overall seem to be competent in scientific and technological research, transforming these assets into tangible outputs such as the number of patents or firms established by the students, graduates or academics appear to be low as compared to the other criteria of entrepreneurship and innovation. We also notice the change in the positions of the universities when the universities in the list are re-ranked according to the individual subcriterion components. Although the scores are totaled and weighed over subcomponents as shown in the last column of Table A.2, the breakdown of the total scores across subcomponents provides a good overview of the strong and weak areas in the path to becoming a more innovative and entrepreneurial university for all universities.

3.1.2 The Performance Index for Technoparks

The Bayh-Dole Act of 1980 in the U.S. had been designed and employed to facilitate the technology transfer from the universities to the industry, stimulating the patenting and licensing activities of American universities (Mowery et al. 2001). Similar actions also took place in Europe and all around the world to create and promote entrepreneurial universities (Kirby 2006). In Turkey, several initiatives were also taken on the path to developing entrepreneurial universities. The Turkish Government passed legislation to establish 85 technoparks within the country in 2001. Seventy-one of these planned eighty-five technoparks were established, and they are active as of 2020. The technoparks are also called technology development zones with geographical locations, as shown in Figure 1. Technoparks are targeted to be made attractive to entrepreneurs with the support and incentives provided by the government (Cansiz 2017).

As of October 2020, 6,119 firms operate at these technoparks. 322 of these are foreign firms or have foreign partners, 1,289 of them have academic partners. These firms completed 37,605 projects, with 10,484 more in progress. Various intellectual and industrial property rights have been granted at these technoparks (Table 1).

While the numbers of intellectual and industrial property, as shown in Table 1, reflect the success and performance of these technoparks, establishing a comprehensive performance index for technoparks or science parks is not an easy task. As an example, Bigliardi et al. (2006) identify several areas of performance, including economic and financial aspects, human resources, and technical-scientific productivity, as well as international and inter-regional relationship development in measuring the success of science parks. Berbegal-Mirabent et al. (2019) draw attention to how the objectives and strategies of a science park might affect its performance, such that focusing on a few

Figure 1: Technoparks in Turkey: Red and yellow circles denote the active and inactive technoparks, respectively

Table 1: Intellectual and Industry Property at Technoparks

Intellectual and Industry Property	Count
Number of patent registrations (National/International)	1,239
Number of patent applications (in progress)	2,793
Number of utility model registrations	431
Number of utility model applications (in progress)	261
Number of industrial design registrations	181
Number of industrial design applications (in progress)	122
Software copyright (acquired)	419

Source: https://btgm.sanayi.gov.tr

relevant components in mission statements might result in higher performance.

In Turkey, the Ministry of Industry and Technology developed an index to measure the performances of technoparks, which we refer to as the Technopark Performance Index (TPI) within the context of this study. The index is employed every year starting from 2011 and monitors the performances of technoparks relative to each other over the years. Thus, the Ministry aims to provide the necessary support to technoparks in achieving its target R&D and innovation levels by revealing their strong and weak areas of performance and relative positions among all technoparks. Tracking the performance of technoparks via the index also gives direction to decisionmakers in drawing future strategies for the growth of the universities and the overall economy. The proximity of technoparks to universities is shown to positively affect university growth by shifting academic research from basic to applied (Link, Scott 2003). Technoparks' performance, on the other hand, bolsters economic diversity and jobs (Dabrowska 2011). The policymakers can align the interests of both the university and the technopark in the direction of specialized fields with the highest performance.

The index is composed of 25 different indicators targeting to measure three main criteria of performance – Inputs, Activities, and Outputs – as shown in Table A.3 in the Appendix. The subcriteria of the Inputs are measures of Financing, Incentives, and Infrastructure, where they are altogether weighed as 16.67%. Activities are formed of five different subcriteria that are R&D Activities, Incubation Activities, Technology Transfer & Collaboration, Institutionalization, Sustainability and Developing Ecosystems, and Technology Product Investment. Activities have the highest weight, with 51% on the overall score of performance. Lastly, the criterion Outputs consists of indicators measuring three subcomponents that are R&D Outputs, Intellectual Property, R&D Impact, and Internationalization with a weight of 32.33% on the overall performance score.

The performances of technoparks are ranked according to their scores as measured by

Figure 2: The geographical distribution of the 34 technoparks that are used in empirical analyses

Table 2: Descriptive Statistics and the Correlation Matrix of the Model Variables

	EIUI	TPI	Technopark Age	University Age	University Size	Log GradStudent	SEGE
EIUI	1						
TPI	-0.631**	1					
Technopark Age	0.485**	-.547**	1				
University Age	0.425*	-.360*	0.301	1			
University Size	-0.297	0.098	-0.126	0.395*	1		
LogGradStudent	0.397*	-0.334	0.269	0.992**	0.465**	1	
SEGE	0.739**	-0.349*	0.159	0.321	-0.202	0.336	1
Mean	56.94	22.71	11.76	39.76	10.53	8.60	1.69
Std. Dev.	18.44	14.29	3.89	17.95	0.72	0.83	1.43
Min.	31.69	1	4	12	8.55	6.52	-0.53
Max.	93.16	49	17	85	11.36	9.96	4.05

*, ** Correlation is significant at the 0.05 and 0.01 level (2-tailed).

the performance indicators given in Table A.3. The rankings of all technoparks in the year 2018, the same as the year that EIUI was measured, are provided in Table A.4 in the Appendix. The date of establishment and the associated university are also given. The oldest technopark in the rankings was established in 2001, and there are a few technoparks established every other year between 2001 and 2015.

3.2 Empirical Analyses

When two indices are merged, 34 technoparks in the list of TPI are found to be associated with a single university in the list of EIUI in the same year, 2018. Thus, the dataset for the analyses is composed of these 34 universities. The universities are scattered around the country in 22 different cities. There exist more than one university-technopark couple in only three cities. There are 6, 5, and 4 universities in the cities Istanbul, Ankara, and Izmir, respectively. The distribution of the 34 technoparks across the country is shown in Figure 2.

The best performing universities data are supported with additional data on variables such as the age of technopark, the age of the university, the total number of students, the ratio of graduate students to all students, and the socio-economic development index that are obtained from the Council of Higher Education and the Ministry of Industry and Technology. The descriptive statistics and the correlation matrix of all variables are presented in Table 2.

The average age of the technoparks is 11.76, where the minimum and maximum age is 4 and 17, respectively. On the other hand, the average age of universities is 39.76, where the oldest and youngest universities are 85 and 12 years old. The average score of

EIUI is 56.94 ranging in the interval between 31.69 and 93.16. We use the total number of students as a proxy for the university size; thus, this variable is constructed as the natural logarithm of the total number of students. Because of the large deviations in the total number of students and the ratio of graduate students to all students, we employ the logarithm of these variables and present the descriptive statistics for the transformed variables in Table 2. The average for the total number of students is found to be 44,778, where the smallest size university has 5,172, and the largest size university has 85,520 students. The average ratio of graduate students, including students that are at both masters and doctorate levels to all students, is 0.16, which changes in the range between 0.06 and 0.33. Lastly, the variable SEGE represents the development of the region related to social, economic, cultural, and environmental issues. SEGE scores are calculated annually. For our analyses, we use 2017 scores, which is the closest year to 2018. SEGE scores of the cities that the university-technopark couple reside in change between -0.53 and 4.05, which corresponds to cities Istanbul and Erzurum, respectively.

We run two different regression models to test the effects of the explanatory variables described in Table 2 on the dependent EIUI. The first model is the main effects model where we test the direct effects of the rank TPI, the age of technopark, the age of university, size of the university, the graduate student composition, and the SEGE on EIUI. The establishment and growth of graduate programs offering education in higher degrees and producing scientific knowledge take time. Thus, to test how these two variables, i.e., graduate student composition and the university-age, interact on the dependent EIUI, we add the two variables' multiplication to the first model. This gives us the second model, where we refer to the interaction effects model with the newly included interaction term. The parameter estimates of the ordinary least-squares regression models for both are presented in Table 3.

The high adjusted coefficients of multiple determination for both models highlight the good fit of the models to the data. In the main effects model, TPI, university size, and SEGE are found to significantly affect the entrepreneurship and innovation related scores of the universities. The coefficient for TPI is negative and significant, pointing to the importance of climbing up in the technopark rankings on the scores of universities being more entrepreneurial and innovative. The university size, on the other hand, is found to have a reverse effect on EIUI. The negative and significant coefficient of university size indicates that smaller universities obtain higher scores of EIUI. SEGE is the third variable for which its effects are significant, implying the higher the SEGE scores of the city, the higher the scores of EIUI. The ages of the technopark and the university are found not to have any significant effects on EIUI.

While the university's composition of graduate students does not appear to be significant in the main effects model, the interaction effects of the ratio of graduate students to all students with the university age happen to be significant when both variables are present in the model. The direct effects of the ratio of graduate students to all are positive and significant. The larger the share of the graduate students (that are at master's and Ph.D. levels) to all students, the higher the university obtains a score as measured by EIUI. However, its interaction with the university age is negatively significant, revealing that the younger universities benefit more from the higher composition of graduate students among all students. The significant effects of TPI, the university size, and SEGE remain the same considering the direction of effects in the second model.

4 Discussions and Concluding Remarks

Entrepreneurial universities have emerged via the second academic revolution, which transformed the traditional university missions of teaching and research into new missions of economic and social development (Etzkowitz 2003). For so long, universities have transformed and organized their functions to translate the knowledge they produce into the economic activities that benefit the regions in which they reside (Clark 1998). The university arranges the innovation activities providing an entrepreneurial structure in the form of technology transfer offices, incubators, and technoparks (Dalmarco et al. 2018). Technoparks function as a key mechanism in the triple helix of university, industry, and

Table 3: Parameter Estimates for the Dependent most Entrepreneurial and Innovative Universities Index

	Main Effects Model		Interaction Effects Model	
	Unstd. Coeff.	Std. Coeff.	Unstd. Coeff.	Std. Coeff.
Intercept	116.865		43.060	
TPI	-0.366	-0.283 (0.016)*	-0.336	-0.260 (0.019)
Technopark Age	0.680	0.143 (0.192)	0.582	0.123 (0.234)
University Age	0.127	0.124 (0.327)	2.618	2.548 (0.030)
University Size	-13.983	-0.544 (0.017)	-12.279	-0.478 (0.026)
LogGradStudent	8.582	0.388 (0.102)	14.504	0.656 (0.013)
University Age× LogGradStudent			-0.272	-2.653 (0.037)
SEGE	5.163	0.401 (0.002)	6.354	0.493 (0.000)
Adj. R^2	0.757		0.787	

*p-values are given in parentheses

government in creating and strengthening the entrepreneurial capacities of the university and the region. The extant literature has focused on the issues linking technoparks to knowledge spillovers to firms (Díez-Vial, Fernández-Olmos 2015, Montoro-Sánchez et al. 2011); however, how universities benefit from the proximity of technoparks is an area which requires further questioning. We explore the link between entrepreneurial universities and technoparks from a regional perspective considering the university region-specific factors.

The most entrepreneurial and innovative universities index is an initiative that was developed by the government in Turkey and has been successful in creating a competitive environment amongst the universities towards realizing the third mission. While the performance of the entrepreneurial universities has been measured for more than eight years now, there is little known about which ways the universities benefit in the path towards being more entrepreneurial. We empirically analyze a cross-section of the most recent data on the two indices of EIUI and TPI to understand which specific characteristics play a role in the increasing performances of the entrepreneurial universities.

Our findings highlight the importance of the performance of the technopark the university is linked to the university's scores on entrepreneurship and innovativeness. The higher the rankings in technopark performance, the more the university achieves in entrepreneurship and innovation. This finding may look like the expected outcome when one thinks of the connection between the activities and outputs measured in technoparks rankings to the collaboration, economic contribution, and commercialization dimensions in entrepreneurial universities rankings. However, in combining the two indices, the universities that are associated with 16 of technoparks out of the best 50 are not placed in the most entrepreneurial universities list. While our findings reveal the link between the two based on empirical evidence, there are certainly other characteristics that promote the entrepreneurial levels of universities.

University size happens to be a significant characteristic that inversely contributes to the university's ranking of entrepreneurship and innovativeness. Measuring the university size in the total number of students enrolled, we find that the smaller the size of the university, the more the university performs in entrepreneurship and innovation. The most entrepreneurial universities in the U.S., according to the Princeton Review's annual evaluation between 2015 and 2018, reveal that the average number of students enrolled at

these universities is approximately 27,500, which are considered to be small universities (Özer et al. 2019). Rubens, Spiragelli (2017) argue that small universities adopt a more regional approach in achieving the third mission. Universities that are smaller in size are, in general, more agile and could respond to the changes faster as compared to the massively scaled universities where the management can be more complex.

Two other university-specific characteristics are found to interact with each other, which makes the interpretation more interesting, considering the context of the study. The direct effects for the student composition measured as the relative ratio of the graduate students to all students and the university age are found to be positively significant in the interaction effects model. However, their joint effect is significantly negative, indicating that younger universities benefit more from the higher composition of graduate students among all students. The other factors, including technoparks' rankings, university size, and socio-economic development index, continue to remain in the model with the same direction in their effects as before. The high graduate student ratio points to the better research productivity, which the prior literature identifies as a quality of research universities in their contributions to local knowledge spillovers and entrepreneurship activities (Smith, Bagchi-Sen 2012). Our findings suggest that this effect could be more viable for younger universities, which implies the role of small specialized universities in regional development and innovation.

Measuring the performances of entrepreneurial universities in quantitative metrics has been new for regional economies. Considering the universities' battle for bringing about the third mission, our study offers different avenues for future thinking of the university-technopark links in regional innovation and entrepreneurship. Our analyses are cross-sectional since the methodology of the rankings has changed as of 2018, which limits the number of periods to study. However, future studies can extend the analyses to longitudinal ones within different regional contexts. Besides, future case studies will help to provide an in-depth understanding of how entrepreneurial universities benefit from being associated with technoparks. Having access to information on some regional characteristics such as human capital of the region, industrial infrastructure of the region, R&D investments, and other regional development measures could take the analyses to a higher state.

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A Appendix: Data for the Most Entrepreneur and Innovative Universities Index and Technopark Performance Index

Table A.1: The Criteria and Indicators of the Most Entrepreneur and Innovative Universities Index

Criterion	Weight	Indicators	Data Sources
Competency in Scientific and Technological Research (CSTR)	23.75%	1) Number of scientific papers 2) Citations 3) Number of projects received from R&D and innovation support programs 4) Amount of funds received from R&D and innovation support programs 5) Number of national and international science awards 6) Number of doctoral graduates	TUBITAK, the Ministry of Industry and Technology, the Council of Higher Education, Turkish Academy of Sciences, Technology Development Foundation of Turkey
Intellectual Property Pool (IPR)	18.75%	7) Number of patent applications 8) Number of patent documents 9) Number of utility model/number of industrial design documents 10) Number of international patent applications	Turkish Patent Office, the Council of Higher Education, Universities
Collaboration and Interaction (CI)	28.75%	11) Number of R&D and innovation projects carried out by university-industry 12) Amount of funds received from R&D and innovation projects carried out by university-industry cooperation 13) Number of R&D and innovation projects made with international cooperation 14) Amount of funds obtained from international R&D and innovation collaborations 15) Number of academic staff/ students in circulation	TUBITAK, the Ministry of Industry and Technology, the Council of Higher Education, Technology Development Foundation of Turkey, Universities, Ministry of Foreign Affairs Directorate for European Union Affairs cooperation
Economic Contribution and Commercialization (ECC)	28.75%	16) Number of active firms that are owned or partnered by academics in technoparks and incubation centers 17) Number of active firms that are owned or partnered by university students or graduates in the last five years in technoparks and incubation centers 18) Number of people employed by firms that are owned or partnered by academics in technoparks and incubators 19) Number of patents / utility models / industrial designs licensed	The Ministry of Industry and Technology, the Council of Higher Education, Small and Medium Enterprises Development Organization of Turkey, Universities, TUBITAK, Turkish Patent Office

Source: Created based on information at https://www.tubitak.gov.tr/

Table A.2: 2018 Rankings of Universities according to the most Entrepreneurial and Innovative Universities Index

Rank	University	CSTR	IPR	CI	ECC	Total
1	Middle East Technical University	23.63	16.24	28.54	24.75	93.16
2	Istanbul Technical University	21.93	15.89	27.59	24.75	90.16
3	Sabancı University	18.08	15.16	27.9	24.36	85.49
4	Bilkent University	21.3	14.02	26.05	23.05	84.42
5	Boğaziçi University	20.55	15.46	28.06	19.26	83.33
6	Yıldız Technical University	17.18	17.54	24.1	22.58	81.4
7	Gebze Technical University	18.18	9.93	24.64	25.07	77.82
8	Hacettepe University	20.18	12.51	24.44	18.8	75.93
9	Izmir Institute of Technology	20.99	9.3	24.93	20.42	75.64
10	Ege University	18.37	10.29	25	17	70.66
11	Koç University	18.64	13.65	27.13	9.46	68.87
12	Istanbul University	17.47	14.09	19.47	16.1	67.13
13	Gazi University	18.07	10.69	19.3	18.74	66.8
14	Özyeğin University	13.85	11.88	20.71	18.99	65.44
15	TOBB Economics and Technology University	14.43	12.8	17.31	17.26	61.8
16	Dokuz Eylül University	17.31	7.3	21.3	15.67	61.58
17	Erciyes University	15.87	7.03	18.73	19.77	61.4
18	Ankara University	18.77	5.44	22.06	13.63	59.9
19	Selçuk University	14.97	13.58	15.64	13.72	57.91
20	Anadolu University	11.54	10.4	16.16	18.89	56.99
21	Sakarya University	12.1	9.76	15.34	18.55	55.74
22	Uludağ University	11.52	11	16.74	15.27	54.53
23	Gaziantep University	12.65	14.9	12.93	11.15	51.63
24	Akdeniz University	13.92	8.45	18.85	9.89	51.11
25	Kocaeli University	10.22	4.72	17.1	18.1	50.13
26	Atılım University	10.21	5.37	14.91	17.14	47.63
27	Çukurova University	14.43	5.88	16.42	8.74	45.47
28	Abdullah Gül University	11.04	8.92	17.3	7.57	44.82
29	Istanbul Medipol University	9.94	11.24	16.69	6.59	44.46
30	Süleyman Demirel University	13.63	7.18	11.4	11.15	43.36
31	Yeditepe University	11.74	15.73	15.82	0	43.29
32	Pamukkale University	10.09	7.18	12.29	13	42.56
33	Marmara University	14.85	5.04	17.88	3.97	41.73
34	Atatürk University	16.75	6.29	11.01	6.94	41
35	Karadeniz Technical University	12.83	3.8	13.39	10.81	40.83
36	Fırat University	10.94	5.38	9.43	14.77	40.52
37	İzmir Economy University	6.43	10.07	14.23	8.97	39.7
38	Yaşar University	7.96	5.98	13.35	11.23	38.53
39	Çankaya University	8.79	6.39	11.75	10.88	37.81
40	Mersin University	9.44	4.01	12.1	9.98	35.53
41	Eskişehir Osmangazi University	11.8	3.53	10.43	8.84	34.6
42	Hasan Kalyoncu University	4.49	11.25	5.87	12.58	34.19
43	Niğde Ömer Halisdemir University	8.41	3.71	13.69	8.33	34.14
44	Bahçeşehir University	8.61	1.95	14.05	9.36	33.97
45	Acıbadem Mehmet Ali Aydınlar University	6.79	3.61	17.87	4.82	33.09
46	Başkent University	6.18	4.92	7.68	13.8	32.59
47	Düzce University	7.06	5.46	12.54	7.17	32.23
48	Çanakkale Onsekiz Mart University	9.56	2.67	13.03	6.88	32.15
49	Tekirdağ Namık Kemal University	7.14	3.18	8.49	12.88	31.69
50	İstanbul Şehir University	8.2	4.82	13.6	3	29.63

Source: https://www.tubitak.gov.tr/

CSTR: Competency in Scientific and Technological Research; *IPR*: Intellectual Property Pool; *CI*: Collaboration and Interaction; *ECC*: Economic Contribution and Commercialization

Table A.3: Main and Sub-criteria of the Technopark Performance Index

Main Criterion	Sub-criterion	Percentage (%)	Indicators
Inputs	Financing, Incentives, and Infrastructure	16.67	1) Supports provided to the managing company 2) Occupancy level 3) The exemption provided to firms 4) Expenditures made by the managing company
Activities	R&D Activities	14	5) R&D staff 6) R&D expenditures 7) R&D projects
	Incubation Activities	9	8) Incubation service 9) Incubation employment
	Technology Transfer & Collaboration	13	10) Knowledge and technology transfer 11) Collaboration between firms 12) International R&D collaborations
	Institutionalization, Sustainability and Developing Ecosystems	12	13) Capacity building activity 14) Services provided by the managing company 15) Clustering activities 16) Overseas activities
	Technological Product Investment	3	17) Investor activities 18) Commercialization activities
Outputs	R&D Outputs	6.67	19) Project outputs 20) Incubation service outputs
	Intellectual Property	5.99	21) Patents 22) Utility models 23) Designs
	R&D Impact and Internationalization	19.67	24) Export 25) R&D revenues

Source: Created based on information at https://www.btgm.sanayi.gov.tr/

Table A.4: 2018 Rankings of Technoparks according to their TPI

Rank	Technopark	Date of Establishment	Associated University
1	Yıldız Technical University Technopark	2003	Yıldız Technical University
2	Middle East Technical University Technopark	2001	Middle East Technical University
3	Istanbul Technical University Arı Technopark	2003	Istanbul Technical University
4	Ankara Technopark	2002	Bilkent University
5	Mersin Technopark	2005	Mersin University
6	Istanbul Technopark	2009	Istanbul Commerce University
7	Erciyes University Technopark	2004	Erciyes University
8	Batı Akdeniz Technopark	2004	Akdeniz University
9	Izmir Technopark	2002	Izmir Institute of Technology
10	TUBITAK-Marmara Research Center Technopark	2001	TUBİTAK-TTGV
11	Ankara University Technopark	2006	Ankara University
12	Gazi Technopark	2007	Gazi University
13	Trabzon Technopark	2004	Karadeniz Technical University
14	Sakarya University Technopark	2008	Sakarya University
15	Samsun Technopark	2009	Ondokuz Mayıs University
16	Hacettepe University Technopark	2003	Hacettepe University
17	Istanbul University Technopark	2003	Istanbul University
18	Ege Technopark	2014	Ege University
19	Ankara Technopark	2014	Yıldırım Beyazıt University
20	GOSB Technopark	2002	Sabancı University
21	Celal Bayar University Technopark	2012	Celal Bayar University
22	Namık Kemal University Technopark	2011	Tekirdağ Namık Kemal University
23	Gaziantep Technopark	2006	Gaziantep University
24	Selçuk University Technopark	2003	Selçuk University
25	Dokuz Eylül Technopark	2013	Dokuz Eylül University
26	Ulutek Technopark	2005	Bursa Uludağ University
27	Konya Technopark	2015	Selçuk, Necmettin Erbakan, Aksaray Karamanoğlu Mehmet Bey, KTO Karatay Universities
28	Fırat Technopark	2007	Fırat University
29	Erzurum Technopark	2005	Atatürk University
30	Boğaziçi University Technopark	2009	Boğaziçi University
31	Tokat Technopark	2008	Gaziosmanpaşa University
32	Cumhuriyet Technopark	2007	Cumhuriyet University
33	Kocaeli University Technopark	2003	Kocaeli University
34	Pamukkale University Technopark	2007	Pamukkale University
35	Eskişehir Technopark	2003	Anadolu University
36	Kırıkkale University Technopark	2013	Kırıkkale University
37	Kahramanmaraş Technopark	2011	Sütçü İmam University
38	İzmir Science Technopark	2012	İzmir Economy University
39	Düzce Technopark	2010	Düzce University
40	Çukurova Technopark	2004	Çukurova University
41	Trakya University Edirne Technopark	2008	Trakya University
42	Yüzüncü Yıl University Technopark	2012	Yüzüncü Yıl University
43	Malatya Technopark	2009	İnönü University
44	Çanakkale Technopark	2011	Çanakkale Onsekiz Mart University
45	Göller Region Technopark	2005	Süleyman Demirel University
46	Bolu Technopark	2009	Abant İzzet Baysal University
47	Afyon Uşak Zafer Technopark	2015	Afyon Kocatepe, Uşak Universities
48	Niğde Ömer Halisdemir University Technopark	2013	Niğde Ömer Halisdemir University
49	Marmara University Technopark	2014	Marmara University
50	Dicle University Technopark	2007	Dicle University

Source: Created based on information at https://www.btgm.sanayi.gov.tr/

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Analysing Higher Educational Institutions' role in fulfilling their Third Mission

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Abstract. The transitional process happening in higher educational institutions tend to underscore initiatives aimed at positioning these institutions as hubs of knowledge production and transfers capable of influencing regional development. Nonetheless, the literature has failed to capture the extent to which these institutions have embraced their third mission of impacting regional development, thus calling for a broader range of approaches in examining the roles of these institutions. To fill this gap, this study evaluates the various ways higher educational institutions have embraced their third mission of contributing to the development management activities of regions. We sourced data from 164 higher education institutions (HEIs) located across the United Kingdom, employing the propensity score matching estimation model to estimate the average treatment effects (ATE) of various interventions. The results demonstrate additionality effects of HEIs on graduate support, attracting inward investment, R&D collaborations and network facilitation. Surprisingly, our results show HEIs as playing an insignificant role in supporting SMEs, and knowledge exchanges. The main implication of this is that adopting initiatives that proved successful in specific universities to other higher educational settings remains a challenge.

Key words: Propensity scores matching, regional development, higher education institutions, knowledge transfers, third mission, United Kingdom

1 Introduction

Interest in research exploring the contributions of higher education institutions (HEIs) to economic growth, regional development, and as agents of social change has soared in recent decades (Kempton 2019). This new role of HEIs in driving regional growth and development denotes an embracing of the novel third mission alongside the traditional (pedagogical) and second (research) duties (Sánchez-Barrioluengo, Benneworth 2019). Higher educational institutions (universities and public research laboratories) have long played central roles in national and regional innovation systems (Carayannis et al. 2018, Asheim 2019). They have also been pivotal in knowledge production and dissemination (Fischer et al. 2019). Traditionally, HEIs have contributed to regional and national economies by new knowledge production through basic applied research (Sengupta, Ray 2017), while contributing to the overall workforce by educating new generations of scientists (Trippl et al. 2015).

In recent times policy makers expect universities to move beyond the supply of human capital, to playing an active role in regional development (Nicolescu 2018). The role of universities in the regional economy has been reinforced by the triple helix framework (Frondizi et al. 2019). This has supported and exemplified the conviction that the research capabilities of regional institutions such as universities can be leveraged to contribute to regional development (Rodríguez-Pose 2013). Regional development refers to concerted efforts undertaken by policy makers to develop certain parts of a country socioeconomically. Regional development is therefore not just assessed by the number of jobs created or incomes, but other general subcomponents such as creativity and innovation in the region (Bærenholdt 2009, Pike et al. 2016). Regional institutions like universities can be the main drivers of such creativity and innovation. Regional development must not be confused with territorial development which is a subset term used to refer to a cohesive multi-sector development limited to a specific part of a territory that relies on the expertise of regional institutions like universities (Bran et al. 2018). This enhanced and deeper role of universities in regional development is strongly reflected in recent strategies and policies at the European level such as Europe 2020 and flagship initiatives like the innovation union. Although universities have long been important actors in regional innovation systems, implementation of the smart specialization policy has amplified and entrenched this role (Carayannis et al. 2018).

Smart specialization affords universities new opportunities to intensify and expand their contributions to regional development and innovations (McCann, Ortega-Argilés 2015). It puts universities at the core of their regions, with an expectation to forge new collaborations with local and regional authorities, industries, and civil society for win-win benefits (Kempton 2015). According to Foray et al. (2012), "universities have a crucial role to play in creating knowledge and translating it into innovative products and services, in cooperation with research centers and businesses. Successful mobilization of the resources of universities can have a strong and positive effect on the achievement of comprehensive regional strategies".

According to Gunasekara (2006), universities can play two central roles to enhance regional and territorial development. A generative role relates to the direct promotion of growth opportunities through knowledge capitalization and entrepreneurial discovery activities such as the formation of spin-offs, and active participation on industrial boards. They can in tandem evaluate pitfalls in regional innovation environments and take the initiative in organizing networks for the development of regional innovation strategies. In addition, universities can influence regional institutions and the advancement of social capacity through fostering regional collaborations and institutional capacity building, in-house training activities as well as mediating between regional, national, and international actors (Gunasekara 2006).

Similarly, Kempton et al. (2013) have proposed seven possible areas through which universities can engage in regional development and smart specialization strategy. First, they can help to outline regional strategies by carrying out a thorough assessment of the region's capabilities, knowledge assets and competencies. Secondly, through academic research, universities contribute to the local knowledge base and its subsequent transformation into innovative products and services. Additionally, they can weigh into the regional entrepreneurial unearthing process through global awareness and collaborations across regional boundaries. Universities can in addition aid in fostering the social relations that underpin regional innovation systems, and lastly, they can contribute to regional institutional leadership and smart specialization governance.

Furthermore, universities can provide professional research expertise that can bridge national and international knowledge networks. Universities can also contribute to regional development through demand-side knowledge transfer and absorptive capacity development through new business formation (spin offs), graduate start-ups and graduate placements, all of which are aimed at boosting numbers of active collaborators with local industries. The potential incapsulated in a region's innovative activities are based on two main capacities: the ability to entice good ideas or information from elsewhere (absorptive capacity) and the ability to utilize absorbed knowledge to generate and develop new products or services (development capacity). Universities also contribute to the supply of

regional human capital through teaching programs such as lifelong learning and graduate and post graduate courses (Kempton et al. 2013).

Considerable attention has been given to the concept of socially engaged universities (including other higher educational establishments) in recent years (Klofsten et al. 2019). The literature contends that academic engagement and contributions to regional growth and development in the United Kingdom and the USA has increased over time (Degl'Innocenti et al. 2019). Yet fewer studies have been devoted to understanding the various ways higher educational institutions contribute to socioeconomic development or the social impact they have on their respective regions. Some caveats remain, however, in understanding which aspects of socioeconomic and regional development universities and other higher educational institutions are making impacts. The primary aim of this study is to assess the various ways universities and other higher educational institutions in the United Kingdom contribute to fulfilling their third mission of promoting regional development. This study intends to deepen the understanding of the experience of the United Kingdom's higher educational institutions' academic engagement in regional development in a hypothesis-based study. This study contributes to and fulfils the theories of knowledge transfers and regional development. These theories assume that academic knowledge and technologies can be transferred within regional actors (networks) to boost regional innovations, capacities, and development.

This article is arranged as follows; the following section (Section 2) focuses on the theoretical and empirical literature exploring the relationships between higher educational institutions' contributions to regional development. The third Section elaborates on the empirical methodology, the source of data and the variables employed in the model. Section 4 is devoted to reporting the findings of the econometric model specifications. Section 5 provides an in-depth discussion of the results in relation to existing literature. Section 6 concludes this paper with implications and suggestions for future research.

2 Theoretical background

This research is based on the triple helix theory that presupposes that universities are no longer just in the business of producing graduates and industry-worthy personnel each year, but also actively engaged in the creation, sharing, dissemination and application of knowledge for the purposes of regional growth, and eventually, development. This theoretical framework is strongly reliant on the perception that universities are not just thinkers but applicants and users of knowledge creation from interactions with other stakeholders and even employees themselves (Amin, Goddard 2018). The triple helix model places emphasis on the proactive roles played by regional actors like higher educational institutions in the knowledge society (Ranga, Etzkowitz 2013).

The academic environment has undergone disparate structural revolutions that have overhauled the roles of higher educational institutions in the economy. The first academic revolution can be traced to the 1930s (Schmitz et al. 2017), and is known for the tendency of universities to conduct research alongside the conventional mission of teaching (Etzkowitz, Dzisah 2015), however this did not encourage academic collaborations and engagements. The second and third academic revolutions that took place in the 1980s (Clark 2015) transformed and paved way for the direct engagement of universities in the economy. This led to the emergence of entrepreneurial scientists and universities (Altbach et al. 2019). HEIs have contributed to economies through novel knowledge production via their basic applied research. Recently, policy makers demand universities move beyond knowledge production, to playing active roles in regional development with their research capabilities (Nicolescu 2018).

Traditionally, universities have been known as 'hubs' of intrinsic and theoretical knowledge, endowing students with limitless potential. Furthermore, with such inherent potential, consistent interaction and knowledge sharing consciously creates cognitive thoughts and ideas that actively morphs into practical knowledge for use by these universities. Research on knowledge sharing in 230 United Kingdom universities shows that these universities possess an intrinsic knowledge culture, but their culture is self-centered and to some extent self-serving (Fullwood et al. 2019), presenting knowledge

management challenges. However, universities could fail in achieving their objective of knowledge exchange for a myriad of reasons. For example, firms in the region may not be endowed with the resources needed to absorb the knowledge on offer (Qiu et al. 2017). In addition, universities that try to foster a transfer of knowledge, may also have difficulties impacting their own regional economies (Youtie, Shapira 2008), likely due to resource limitations or outright performance inefficiency. Nevertheless, we believe that, when maximized, knowledge exchange can help to facilitate the development management initiatives of both higher educational institutions and their regions. Hence, we hypothesize that:

> *H1*: Knowledge exchange has a significant positive impact on development management activities of higher educational institution in the region.

Furthermore, closely related to their most prominent role of producing graduates, universities are also known for providing material and immaterial support for their graduates in the form of financial awards and even start up support. Most research underscores the role higher education institutions play in determining the possibilities of individual graduates being self-employed or creating their ventures (Honig 2004). A growing body of policy evidence suggests a positive association between the extent of a cohort's entrepreneurialism and the performance of regional and national economies as the number of HEIs using their initiatives to stimulate graduate enterprise and entrepreneurship increases (Fischer et al. 2019, Marzocchi et al. 2019). We believe that the organizational capabilities and resources of a university, and the knowledge generated through research affect the entrepreneurial competences of graduate entrepreneurs, and influence the capacity of universities to generate student ventures and assist with social development of the region. This is widely supported by the literature (Marzocchi et al. 2019, Anderson, Stejskal 2019). In this regard we hypothesize that:

> *H2*: Graduate support is significantly and positively influential to development management activities of higher educational institutions in the regions.

Furthermore, inputs aside, investment inflows have been shown to be directly connected to an improvement in human development and regional research output performance. A stream of investors can commit funds in support of universities' research and development agendas (Reiter, Steensma 2010). University-industry linkages, their reputational strength, and technology clusters appear to be key factors in attracting investment from foreign nationals, though Teirlinck, Spithoven (2012) may have found the contrary. Most authors believe investments do not run a sequential route to ensuring development in the regions. This is due to various barriers such as political structures, administrative capacity and the inefficiency of these investments that could easily hinder their transmission into proper social interventions and development of the region concerned. Nevertheless, we believe a consistent stream of funds coupled with proper allocation will facilitate value creation for established ventures (Rodríguez-Pose, Fratesi 2004, Mohl, Hagen 2010) and essentially assist development management activities in the regions. Hence, we also hypothesize that:

> *H3*: Inward investment has a significant and positive impact on development management activities of higher educational institutions in the region.

Research and development collaborations have also largely been discussed by most researchers as having a significant impact on educational institutions (Aldieri et al. 2018, Bischoff et al. 2018). Nosenko et al. (2018) researched such collaborations in the context of the cloud-based society. The study found the use of cloud-based resources needs to be more systematic, to be organized into a united system, and to be consciously and purposely oriented at pedagogical aims. They opined that there is a current need for the upgrading of ICT skills of educational personnel, especially those engaged in providing educational systems with emerging ICT. Considering the broad engagement of academic researchers in collaboration with other research institutions, we believe that the reputational enhancement of their institutions and an extension of these institutions' capacity for knowledge transmission should help develop the regional development activities of academic institutions (Klofsten et al. 2019). Hence, we hypothesize that:

H4: Research and development collaborations positively and significantly influence development management activities of higher educational institutions in the regions.

Furthermore, according to the endogenous theory, human capital forms a central element of the growth theory and can be described as an enabling factor of innovation (Gomez 2011). As imperative as personnel is to the growth of productivity, it is crucial to acquire the right fit for the needed roles (Moreland 2013, Pather 2014). In this context, we presuppose that efforts of educational institutions to fulfill these needs will create a deepened effort to recreate and innovatively shape the learning structure of higher institutions. Additionally, by developing institutional collaboration opportunities like contests, scientific hubs, and international networks, we believe this will further strengthen the talent and skill growth of these higher educational institutions. Hence, we hypothesise that:

H5: Higher education institutions facilitated networks can positively and significantly impact the development management of regions.

3 Data and Methodological approach

The empirical analysis is based on a cross-sectional dataset from the Higher Education Business and Community Interaction Survey (HE-BCI). The HE-BCI Survey is obligatory for all higher education providers in the United Kingdom (Wales, Scotland, Northern Ireland and England). The HE-BCI Survey collects data for evaluating the volume and direction of collaborations between UK higher education providers and industries and the general community (Marzocchi et al. 2019). The survey collects information on the third mission of higher educational institutions by investigating the various ways they contribute to their regional economies. The survey also provides data on capacities and strategies of HE providers, and financial data on their third-stream activities related to the usage, production, application and utilization of knowledge and other HE provider capabilities outside academic environments. The survey consists of two parts, the first part requires HEI to answer and provide information related to their engagement strategies and competences and their ability to work with other organizations. The second part pertains to HEIs activities in areas such as contract (collaborative) research, their engagements and services to businesses and communities, development and regeneration plans, intellectual property, and other cultural and social engagements with communities. We used datasets spanning four academic years, specifically the 2014/15 academic year to the 2018/19 academic year. The final sample used for the empirical model specification consisted of all the 164 higher educational institutions that filled and return these questions in the time period.

For the model specification, this paper involved a two-stage analysis. In the first stage, we employed a binary logistic regression to estimate the probability of a binary outcome based on one or more covariates (Archer, Lemeshow 2006). The binary logistic regression model applies the techniques of multiple regression analyses to research situations in which the outcome variable is categorical (Sperandei 2014). We used the logit regression model and cross-sectional data to examine variations in the university's development contributions based on the changes in the predictor variables. The model assumes that the dependent variable is a linear function of the independent variables and the logit transformation of the dependent variable having an error term that is not normally distributed and denoted by (ϵ_i). We analyze the probability that universities would contribute to their regions through several ways, and we assume that these associations are not a linear function and hence, we the assumed the relationship mathematically as

$$\text{Logit}(P) = \log(P/1-P) = \log(p) - \log(1-P) \tag{1}$$

Where:

Logit (P) = the logit (log of the odds ratio)

P = The probability of implementing development activities

1-P = the probability of not implementing development activities

We provide the reduced form of the Logit model equation as,

$$\mathrm{DM}_i = \alpha + \beta_i X_i + \epsilon_i \tag{2}$$

Where:

DMi$_i$ = Higher educational institution' Development Management activities

$\boldsymbol{\alpha}$ = intercept

$\boldsymbol{\beta}_i$ = slope coefficient of each of the explanatory variables

$\boldsymbol{X}_i$ = Coefficients of the covariates

$\boldsymbol{\epsilon}_i$ = The error term

In the second stage, we use the propensity score matching technique to examine the additionality effect of the social impacts of universities engagements. The propensity score matching technique is used to estimate the average treatment effects of an activity, policy, treatment and other interventions, by reporting the covariates that envisage receiving the treatment (Abadie, Imbens 2016). We modelled the outcome variable as development management, and the treatment dependent variables as the various ways universities contribute to social development. This approach helped us to control and eliminate all potential confounding factors (Diamond, Sekhon 2013).

Table 1: Description statistics of the dependent and independent variables

Variable	Variable description	Mean	VIF
Knowledge exchange	1 if HEIs share knowledge with regional partners, 0 otherwise	0.931	1.12
SMEs support	1if HEIs provides facilities, equipment, consultancy, services to SMEs, 0 otherwise	0.879	1.56
Graduate support	1 if HEIs support graduate entrepreneurship, 0 otherwise	0.881	1.10
Incubator support	1 if HEIs provide services to start-ups to improve their commercial success, 0 otherwise	0.700	1.46
Attracting investment	1 if the HEIs bring investment to the region, 0 otherwise	0.628	1.25
R&D collaborations	1 if the HEIs engage in R&D collaborations with other regional bodies, 0 otherwise	0.817	1.12
Attracting nonlocals	1 if HEIs attract nonlocal population, 0 otherwise	0.804	1.14
Regional development	1 if HEI help their regions affected by socioeconomic and environmental decline to rebuild, 0 otherwise	0.743	1.21
Managing development	1 if HEI manage any wealth creation and social development activities, 0 otherwise	0.665	—
Facilitating networks	1 if HEI promote networking activities, 0 otherwise	0.798	1.24
Meeting reg. skills	1 if HEI knowledge contribute to skills development challenges, 0 otherwise	0.847	1.30

Source: Authors' calculations, *Note*: VIF = Variance Inflation Factor

4 Results

Before commencing with the results and discussion, it is pertinent to briefly discuss the descriptive statistics and correlation of variables used in the empirical model. The results of the Variance Inflation Factor (VIF) in Table 1 show that the correlations between

Table 2: Results of Wald test of exogeneity

Variables	Coefficients	Standard error	$P > \|z\|$
Incubator support	1.133	0.792	0.152
Meeting reg. skills	0.323	0.222	0.147
Knowledge exchange	1.157	0.437	0.008**
SMEs support	-0.236	0.443	0.595
Graduate support	0.997	0.292	0.001***
Attracting investment	0.744	0.252	0.003***
Constant	-2.826	0.473	0.000***
Model summary			
N		164	
Wald chi^2		129.28	
Prob $>chi^2$		0.000***	
Endogenous variable		Incubator support	
Instruments		All variables not found in this model were instrumented	

Source: Own calculation. $***= p < .001$, $**= p < .01$, $*= p < .005$.
Wald test of exogeneity: $chi^2 = 3.23$, prob $> chi^2$: 0.0722

the dependent and explanatory variables are low, hence the sample does not suffer from potential collinearity issues. The mean results of the descriptive statistics in Table 1 show that universities in the United Kingdom play key roles in contributing to regional development management. The results suggest the presence of relatively high levels of academic engagement activities across United Kingdom universities and other higher educational institutions. The degree of knowledge exchange among these institutions was strongly noticeable in the sample. About 93% reported to have exchanged knowledge in diverse forms with other regional actors. Support for SMEs is also relatively high, with the average value for this variable at 88%. Beside their contributions to knowledge creation and dissemination, they also attracted inward investment to their regions, with 63% of the sampled population contributing in this regard. The presence of these higher educational institutions also helped to attract non-local residents potentially resulting in a trickle-down effect on regional development. Institutional collaborations are also very high among the sample population (82%). These collaborations could result in innovations that could spur regional development and management. Approximately 70% of the higher educational institutions have incubator support systems with funding to acquire new skills and expertise to help start-ups to succeed in regions or international markets.

The figures also show that about 85% of these higher educational institutions meet the regional skill needs of their catchment areas. With regards to facilitating networks, about 80% of the sampled higher educational institutions reported carrying out these activities. On the question of having strategies in place that promote the management of regional development by these institutions, 66% of institutions declared that they have strategies in place that contribute to the development management of their regions. About 80% of these higher educational institutions also declared that they attracted residents who are non-locals to these regions who could be either students, faculty or other workers. The community development agenda was also very prominent among higher educational institutions in the United Kingdom, about 74% of the sample reported that they contributed directly or indirectly in this regard.

The econometric model estimation aims to describe the expected effects of the predictors on the dependent variable, as shown in Table 3. As noted previously, we believe that higher educational institutions having regional development strategies will strengthen their incubator related activities and help to alleviate regional skill deficits. We anticipate that this could result in a reverse causality problem with potentially negative impact on our results. We therefore tested further which of the variables considered endogenous

Table 3: Results of the logit regression analysis

Variables	Coef.	Std. Err	z	$P > z$	Hypotheses
Facilitating networks	1.116	0.387	2.88	0.004**	*H5*-Supported
Graduate support	1.604	0.491	3.26	0.001***	*H2*-Supported
Inward investments attracting	1.165	0.272	4.28	0.000***	*H3*-Supported
R&D collaborations	1.461	0.292	5.00	0.000***	*H4*-Supported
Attracting nonlocal students	0.592	0.298	1.98	0.047*	*H1*-Supported
Regional development	1.501	0.263	5.70	0.000***	
Meeting regional skill needs	0.248	0.375	0.66	0.508	
Incubator support	0.453	0.316	1.43	0.151	
Knowledge exchange	0.805	0.718	1.12	0.262	
Supporting SMEs	0.209	0.501	0.42	0.677	
Model fit statistics					
Number of obs.			164		
Log pseudolikelihood			-232.13854		
Wald $chi^2(10)$			205.05		
Prob > chi^2			0.0000***		
McFadden Pseudo R^2			0.4433		

Source: Own calculations.

Note: *** Parameter significant at 99 % level, ** significant at 95 % level, * significant at 90 % level.

can be tested for exogeneity. The Wald test of exogeneity considers whether the null hypothesis of exogeneity is confirmed by our data (see Monfardini, Radice 2008). We ran an instrumental Variable (IV) probit model using Newey's two-step estimation to test for potential endogeneity in our data. We used the provision of incubator support activities of these higher educational institutions as an endogenous variable and the existence of development management strategies as the dependent variable. All the remaining variables were instrumented. The Wald test results show that Chi^2 (3.23), Prob > Chi^2 = 0.072. (see results in Table 2). The result is insignificant at the 95% confidence interval; ergo, we accept the null hypothesis. Hence, our variables are not contaminated with any potential endogeneity problems. The results show that there is no need for instrumental variable model estimations because the estimates of the binary logistic model are efficient and consistent.

An initial assessment of the logit model in Table 3 suggests that the predictive power is 44% as per the value of the McFadden Pseudo R^2 statistics. The results show that six of the variables demonstrated to have a positive and statistically significant relationships. The results show that there is a positive and statistically significant relationship between graduate support and higher educational institutions development management ($\beta = 1.604$, $p < 0.001$). This supports hypothesis *H2*. This signifies that higher educational institutions likely contribute to supporting graduates in diverse ways.

Furthermore, the relationship in hypothesis *H3* is also supported. We found a positive and statistically significant correlation between attracting inward investments to development management of higher educational activities ($\beta = 1.165$, $p < 0.001$). R&D collaborations also demonstrated a positive and statistically significant relationship ($\beta = 1.461$, $p < 0.001$). This means that hypothesis *H4* is also supported showing that HEIs are consequential on R&D outcomes. The positive high value of the coefficient 1.461 demonstrates there is a high probability that higher educational institutions in the United Kingdom contribute to regional development when they collaborate with other regional actors such as industries and governments. A positive and statistically significant relationship between attracting non-local students to regions and higher educational institutions development management activities is also evident ($\beta = 0.592$, $p < 0.047$), meaning it is probable that higher educational institutions can attract non-local residents to regions of the universities, and this can contribute to regional development. The results show that there is also a positive and statistically significant relationship between regional

development and development management, as seen from the high coefficient ($\beta = 1.501$, $p < 0.001$). Lastly, we found that there exists a positive and statistically significant association between facilitating networks and higher educational institutions development management ($\beta = 1.116$, $p < 0.004$). Our hypothesis *H5* is also confirmed. This means that higher educational institutions can facilitate networks, and this can positively contribute to regional development. However, four of the remaining variables were all not statistically significant at the 0.05 significance levels ($\beta = 0.805$, $p > 0.262$, $\beta = 0.209$, $p > 0.677$, $\beta = 0.453$, $p > 0.151$, $\beta = 0.248$, $p > 0.508$ respectively). Subsequently, the low values of the coefficients and the non-significant p-values indicate that the expected relationships are non-existent as anticipated. The surprising result means that it is not probable that knowledge exchanged by higher educational institutions could contribute to their development management activities. The results also show a low probability of small and medium-sized enterprises (SMEs) in the United Kingdom collaborating with higher educational institutions for knowledge and innovations.

We have established the causal relationships between the constructs. Although we believe that the binary logit model is not a biased estimator, it can be easily contaminated by the presence of confounding variables which can lead to unreliable and misleading results. This bias can result from either errors in the measurement instrument or the data collection approach. To overcome the issues of confounding, we used the propensity score matching technique to moderate the bias effect of any confounding variable (Baser 2006). Propensity score matching is a class of treatment effect analysis widely used in evaluation research to calculate average treatment effects (Caliendo, Kopeinig 2008). It is a quasi-experimental technique that allows a researcher to construct a non-natural control group by matching individually treated items with the controlled units of comparable attributes. The propensity score matching calculates the probability that universities will participate in development management activities based on observed qualities. The propensity score matching compares treated items to untreated items based on their fully calculated randomized propensity scores. The ATE determines the difference in mean of the outcomes among units allocated to the treatment and those assigned as the control. The average treatment effect can be calculated from the propensity scores by comparing the mean outcomes for both the treated and untreated component (Blundell, Dias 2002). The propensity score is used to calculate the probability that a variable with certain characteristics will be allocated to a treatment group. The scores help to eliminate selection bias by balancing independent variables between the control group and the treated group. We modelled our outcome variables as higher educational institutions development contributions while the treatment dependent variables were the various ways HEIs contribute to socioeconomic development. The teffects psmatch was estimated using the default values option. All variables included in the estimation of the preferred treatment assignment are shown in Tables 1 and 3. The results of the average treatment effects (ATE) of the population are presented in Table 4. The results show that five of the covariates; graduate support, attracting inward investments, R&D collaborations, regional development and network facilitations have positive and statistically significant correlations with the development management policies or programs of higher educational institutions. The results demonstrate that all these variables produce a positive and additional impact on HEI development management activities, which could have a potential impact on regional development.

5 Discussions

Universities have become pivotal in regional development due to the spill over effects of the knowledge they produce and disseminate from their campuses (Trippl et al. 2015). Most universities in recent times have tried to adjust and position themselves better to embrace their third mission which is making significant contributions to regional development. This recent trend reflects the fact that most universities are tying their existing traditional duties to a new role of direct engagement with other stakeholders like industries, and regional and national governments. Nonetheless, there exist some fundamental gaps in our understanding of the social impacts of these universities. In the United Kingdom,

Table 4: Average treatment effects of HEI contributions to development

Variables	Coef.	Std. Err	z	$P > z$
Knowledge exchange	-0.141	0.333	-0.42	0.673
Supporting SMEs	-0.126	0.412	-0.31	0.760
Graduate support	0.118	0.030	3.99	0.000***
Incubator support	0.078	0.061	1.28	0.199
Attracting inward investments	0.186	0.055	3.36	0.001***
R&D collaborations	0.494	0.030	16.64	0.000***
Attracting non-local students	-0.005	0.031	-0.17	0.864
Regional development	0.125	0.050	2.50	0.012**
Meeting regional skill needs	0.086	0.064	1.35	0.176
Facilitating networks	0.567	0.042	13.41	0.000***
Model summary				
Number of obs.	164			
Estimator	Propensity-score matching			

Source: Own calculations.

Note: *** Parameter significant at 99 % level, ** significant at 95 % level, * significant at 90 % level.

universities are documented as contributing to regional development, but our knowledge as to which aspect of regional development they make this impact upon remains very limited. With this in mind, we carried out an econometric analysis of which aspects higher educational institutions in the United Kingdom are likely to make a social impact. In this regard, our results show that higher educational institutions play additional roles in providing graduate support to assist with their regional development agenda. As seen from the ATE results, graduate support contributes on average 12 percentage points to the development management programs of higher educational institutions. Through the various levers of support available to graduate students, they can gain valuable knowledge that they can then use to contribute to the development of their regions after completion of their studies. The results are supported by a similar study by Smith, Beasley (2011) and Salomaa (2019) conducted in the United Kingdom. They found that the University of Lincoln has developed several graduate entrepreneurship activities and services to support the regional economy to retain graduates. These initiatives could equip graduates with the entrepreneurial skills they need to establish businesses or render services that can spur growth in the regional economy.

Simple initiatives aimed at increasing regional development and entrepreneurial prospects are shown to be ineffective in this regard. HEIs supporting the development of the private sector especially micro, small and medium-sized enterprises (MSMEs), did not demonstrate a contribution to increased entrepreneurship and regional development. Many young graduates dream of establishing their own businesses but lack proper business experience to be potential entrepreneurs, and in response, HEIs provide support to these potential entrepreneurs through business advice, mentoring and information on obtaining financial support. Our results did not identify any strong justification for HEIs involvement in this initiative. Many higher educational institutions have developed incubator support to promote enterprises and spin-off ventures, with the growth of these entities potentially contributing significant benefits to regional growth (Voisey et al. 2013). However, our results showed that the provision of incubator support by these universities did not provide any significant additionality effect to their regional development initiatives. Our results shouldn't be interpreted as demonstrating that proper incubator support provided by HEIs is insignificant, but rather that the level of support might need to be increased. These results show that the studied higher educational institutions are not effective in providing these support initiatives to benefit firms' growth and innovations. The results of our analysis differ from previous studies such as Soetanto, Jack (2016) that concluded that universities in the United Kingdom are proactive in incubation and entrepreneurial support such as networking, and that these initiatives have a positive effect on the performance of SMES and spin-offs alike.

Similar results are also found for the variable of meeting regional skill needs; no evidence was found that HEIs regional development programs or policies helped to meet regional skill needs. This result mean that HEIs role in contributing to meeting a region's skill needs is insignificant, and that these programs and initiatives aimed at meeting the regional skills needs did not produce any additionality effects on regional development management. This result may indicate that these HEIs do not have regionally oriented courses or educational programs that might contribute to regional development and growth directly. The curriculum and course contents might not have the necessary domestic regional focus, and if so, would be unlikely to meet the regional skills need. This finding is contrary to that presented in the findings of Eriksson, Forslund (2014) where universities were proven to significantly contribute to the regional skills composition needs and therefore university induced knowledge spill overs to meet the regional skills needs.

In addition, these results show that higher educational institutions have a positive impact on attracting inward investments into their regions and catchment areas. This is a positive result, as the attraction of students, faculty and other non-academic staff to these regions contributes to an increase in the population of these regions and can subsequently influence investment decisions of central and regional governments (Guerrero et al. 2014). Within this context, higher educational institutions serve as hubs that can attract inward investment to their regions. The prestige and the status of a university can be a significant contributor to its ability to attract investment opportunities (Cattaneo et al. 2019). The results of the ATE show that, by fostering inward investments, universities create an additionality effect of contributing to regional development. Attracting inward investments contributes to higher educational institutions' regional development policies. HEIs in the United Kingdom attract about 19 percentage points of investment to their respective regions. These investments can significantly contribute to spurring regional growth and development. These results mean that, in the absence of these higher educational institutions, the studied regions wouldn't have attracted such inward investments. Despite our significant result, it however differs from the conclusions of previous studies by La Torre et al. (2019), which concluded that HEIs in the UK do not attract investment as a means of contributing to local regional development. This is because these institutions are not traditionally profitable economic entities. Although we cannot dispute the fact that research conducted by HEIs is shown to contribute to regional economies, the research investment they attract can also have spillover effects, which can help spur regional growth and development.

From the results analysis, it is evident that higher educational institutions' R&D collaborations with other regional stakeholders like industries and governments is positively associated with their regional development management. As described in the literature (see Benneworth, Fitjar 2019) these regional engagements enable HEIs to act as problem solvers by finding lasting solutions to regional problems. The literature suggests that a positive association between HEIs research productivity and its subsequent spillovers may significantly contribute to regional growth (Bonaccorsi 2017). This can improve existing problems, because they will conduct research and come up with sustainable solutions. The ATE results also demonstrate that R&D collaborations of HEIs have the highest coefficient (0.494). This means that the R&D collaborations of HEIs with other partners increase the propensities of improving their contributions to regional development management on average by 50 percentage points more than HEIs without these collaborations. This can be interpreted as showing that R&D collaborations undertaken by HEIs can create additionality impacts on regional development. In the United Kingdom, evidence of the impact that R&D collaborations of HEIs have on regional development is scant.

Contextualizing the results further to a regional development perspective, we have shown that HEIs are contributing to the development of their regions. This regional development mission produces a significant and positive role in the overall development management agenda of these HEIs. The results of the ATE show that the impact HEIs have on regional development intensifies when they are involved in direct community engagements and activities. HEIs that have policies in place, and engage in activities, at the community level, are more likely to improve their contributions to regional development by on average 13 percentage points. Furthermore, the absence of these engagements

reduces the likelihood of contributing to regional development, and this reduces the role of HEIs in development management by 87 percentage points. One aspect in which HEIs fulfil regional expectations can be through organizing training courses for the regions at large and offering trainings on how to develop small and medium-sized enterprises (SMEs). HEIs offer regional courses that can be used to cater for the respective region's needs, and their theoretical models can also be directly useful for regional development. Also, knowledge from HEIs play a crucial role in producing knowledge needed for regional development. Our result is supported by a related study by Klofsten et al. (2019), which finds that universities, especially entrepreneurial-focused ones, encourage changes that benefit the entire community and region where they are located.

Our results demonstrate that HEIs contribute significantly towards facilitating networks, pointing to a positive relationship between this variable and the contributions of HEIs to regional development management. HEIs bring people together in their catchment regions and facilitate networks which serve as a mobilizing force for regional development (Rutten, Boekema 2007). The ATE results show that network facilitation has the highest coefficient (0.567), meaning that it is the variable that has the highest likelihood to improve or significantly impact HEIs' regional development commitments. These networks promoted by HEIs usually bring regional experts to a single platform, where they can deliberate on aspects or sectors, they can work on to ensure regional development. HEIs that have policies and activities in place geared toward networking are likely to improve their regional development contributions by 57 percentage points more than HEIs without these initiatives. Some HEIs occasionally form networks that bring alumni who have flourished professionally back to their regions to become key figureheads and networkers. These HEI-initiated networks can pool together a wealth of talents and expertise that work towards solving immediate regional development challenges. The tacit knowledge and ideas shared from these networks and relationships promoted by HEIs can be transmuted into innovative ideas and policies that can contribute to regional growth.

6 Concluding remarks

This study was oriented towards addressing the third mission of universities as an active contributor to regional development efforts. We built our empirical analysis to evaluate the socioeconomic and additionality impacts of higher educational institutions' support and contributions to regional development and tested the variables that span these areas. We addressed HEIs' effectiveness in activities and initiatives that are anticipated to exert influences on their propensities to contribute to local and regional development. The set of hypotheses tested revealed that support for graduates, attracting inward investments, attracting university research and development collaborations, attracting non-local students, the development of the community, supportive knowledge networks, and efforts to meet regional skill needs, all strongly significantly contribute to higher education institutions regional development and management activities.

Theoretically, this research adds to the existing knowledge and literature on the role academia plays in regional development. This study fills a gap in the literature which had previously only lightly touched on the recurring contributions of academic institutions to regional development efforts. Practically, the results provide regional decision makers an understanding of the actual significance of both the socio-economic as well as academic roles universities occupy in the efforts to create regional value for all inhabitants. Having an understanding of the relative as well as actual contribution, this eases their task of deciding on sensitive areas to invest or provide support to create a multiplier effect on the economic impact of the regions concerned and the nation as a whole.

The main limitation of the study relates to the dataset used, which makes it difficult to use this study for generalization purposes. Though the sampling strategy focused on all higher educational institutions in the United Kingdom, the data was limited and did not shed enough light on certain characteristics of these institutions, for example: the size and scope of these institutions, the characteristics of a region such as its degree of specialization and innovativeness, and the existence, size, and role of specific intermediary organizations like technology transfer offices (TTOs) and the regional distributions of

these institutions. These characteristics could have broadened our understanding of the pivotal contributions these HEIs make in the regional innovation ecosystem. We suggest future research to incorporate these variables to build upon this study to deepen knowledge and understanding of the commitment HEIs to their third missions.

Disclosure statement

The authors do not have any potential conflict of financial, professional and personal interests relating to the contents described in this research.

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The Efficiency of Tourism Sector in EU Mediterranean Coastal Regions: The Effects of Seasonality and Spatiality of Demand

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Abstract. The present paper studies the effects of seasonality and spatiality of tourist flows on the regional performance of tourism sector. The empirical analysis is conducted for 36 coastal North Mediterranean EU NUTS II regions, for the period 2010-2016. Performance is estimated under the concept of efficiency under a Data Envelopment Analysis methodology and the relationship of efficiency with seasonality, spatiality, and some other contextual factors is estimated with a double bootstrap method. The empirical analysis demonstrates that a typical linear function seems to be inappropriate to describe the relationships of these tourism features, as an N-shaped relationship between performance and seasonality and a U-shaped relationship for performance and spatiality were found.

1 Introduction

Coastal destinations have seen tourism as a strong competitive advantage that may form the cornerstone for economic development. This is because tourism may create opportunities, especially concerning income and employment (Apostolopoulos et al. 2002, Gossling et al. 2018), with strong positive externalities and multiplicative effects. Utilizing a wide range of marine natural resources, coastal destinations attract tourists, mainly, through the development of the "sea, sun and sand" (henceforth: "3s") model (Hall 2001). The "3s" model embodies a couple of key features (Bramwell 2004, Batista e Silva et al. 2018): seasonality (i.e., the temporal concentration of tourism flows in the summer season), and spatiality (i.e., the spatial concentration of tourism flows on adjacent-to-the-sea areas).

Seasonality is a well-covered topic in scientific literature. According to Baum, Lundtorp (2001) 'seasonality is widely seen as a "problem" to be "tackled" at a policy, marketing and operational level' (p. 2). This is because, under the presence of seasonality, the full potential of tourism as catalyst of development cannot be exploited by destinations. This is due to the underutilization of resources (in the low demand season) and the severe fluctuation of revenues (between low and high season) as seasonality shortens the operational period in which tourism entrepreneurs generate their revenue, thus adding pressure for generating the revenue of a whole year only in a short period. Under these conditions, long term employment cannot be generated, and investors may seem reluctant in driving funds to tourism operations. Finally, there are also environmental implications, as the high flows of tourists in limited time and the overutilization of resources associated with them impose serious threats on the local ecosystems (Baum, Lundtorp 2001, Butler 2001). Nevertheless, in places facing high tourism flows, the existence of seasonality could

be considered a relieving factor because it allows local ecosystems to recover within the low season (Butler 2001).

Spatiality, in contrast, is an under-studied topic in scientific literature. Some sporadic studies (Lau et al. 2017, Niavis 2020) developed ways to measure the phenomenon at a macro spatial scale, thus allowing for the comparison of the phenomenon among a capable number of regions. The vast majority of studies, however, focus on micro spatial scales (i.e., individual regions or cities), despite the existence of corresponding analytical tools.

The present paper studies the effects of seasonality and spatiality of tourist flows on the regional performance of tourism sector. Essentially, the paper seeks to provide clear-cut, empirically-based, answers indicating whether, and to what extent, temporal and spatial concentrations of tourism flows improve or harm the regional performance of the tourism sector. To this end, the paper focuses on one particular aspect of performance: efficiency. The paper employs the Data Envelopment Analysis (DEA), which has been an effective method for assessing the performance of destinations in a comparative context. Although there are papers applying DEA to measure regional tourism efficiency (see among others Assaf, Josiassen 2016, Cuccia et al. 2017), this kind of efficiency has not hitherto been used as a means to model the nexus between performance and the temporal and spatial concentration of tourism flows. This is because the few past papers that assessed the efficiency of destinations by incorporating seasonality and spatiality measures have a priori considered the two phenomena as undesirable outputs of the tourism operation (Bosetti et al. 2007, Niavis 2020). This paper differs in the sense that it does not make any a priori assumptions regarding the effect of seasonality and spatiality on regional tourism efficiency, hence allowing this to be revealed by the empirical analysis.

The analysis is conducted for 36 coastal North Mediterranean EU NUTS II regions, for the period 2010-2016. The Mediterranean Sea basin provides a fertile ground for such an analysis, given that, despite the particularities of the tourism sector, the corresponding destinations mostly experience tourism-led development. Moreover, the Mediterranean destinations have long suffered from the negative effects and externalities of the mass "3s" tourism model, and many of them have implemented initiatives to decentralize the tourism flows, on both temporal and spatial terms (Fernandez-Morales 2003). Therefore, the results of the paper could be extremely important not only for the particular areas under consideration but also for other areas facing similar spatiotemporal pressures.

The paper proceeds as follows. The next section provides a concise review of the literature dealing with the performance-seasonality-spatiality nexus. The third section presents the methodological steps of the paper. The penultimate section provides the results of the empirical analysis on the coastal Mediterranean regions. The last section offers the conclusions.

2 Literature Review

In tourism-related literature, performance is tightly connected to the concept of competitiveness. Competitiveness could be viewed by two different approaches. The first approach builds on the work of Smith and Ricardo on the comparative advantage concept and puts a premium on the factors that enable a tourism actor, call it an enterprise, destination region, or a country to sustain among competition. The second approach builds mostly on the work of Porter on the theory of competitive advantage and views the issue of competitiveness on a rather managerial perspective (Croes, Kubickova 2013). Competitiveness is important as it shapes the potential of tourism actors to provide the most beneficial results on society (Mazanec, Ring 2011).

As competitiveness is a relative and multidimensional concept, scholars have long sought to conceptualize and operationalize the measurement of actors' performance in sustaining competition (Mazanec, Ring 2011, Crouch, Ritchie 2012). Therefore, performance, as a concept, is open to various definitions which are merely affected by the very conceptualization of competitiveness (Sainaghi et al. 2017). Many conceptual and empirical frameworks have been developed to measure the performance of tourism actors either according to their potential or their outcomes (Croes, Kubickova 2013). When competitiveness focuses on the potential of actors, different qualitative and quantitative

indices are used in order to assess the comparative performance of tourism actors (Firgo, Fritz 2017). Cost, prices, abundance of infrastructure, and resources (human, natural, and cultural), as well as quality of services are used as proxies for measuring competitiveness when this approach is chosen (Hanafiah, Zulkifly 2019). On the other hand, when competitiveness is approached from the results' perspective, the terms of productivity and efficiency acquire a significant role in measuring performance (Hanafiah, Zulkifly 2019). This is because productivity, as a ratio of outputs to inputs, provides a solid basis for measuring the achievements of tourism actors and is tightly connected with the overall impact of tourism-related activities to society (Croes, Kubickova 2013). Profits, revenues, arrivals, nights stayed, and tourists' satisfaction are the outputs that lie at the core of this research stream and are compared with the inputs utilized in order for them to be achieved (Croes, Kubickova 2013, de la Peña et al. 2019, Hanafiah, Zulkifly 2019). When productivity is measured in a comparative context among various actors then an estimation of efficiency could be extracted by signifying the maximum possible realized output at each input level or the minimum possible use of inputs for certain levels of output (Coelli et al. 2005).

As the present paper follows the logic of the results-oriented performance, the rest of the literature review will focus on this stream of studies. Despite the fact that results-oriented performance is a, rather clearly, defined concept, a large diversity still exists in the relevant literature concerning the selection of subjects to be evaluated (such as firms, destinations, managers, and policy-makers) and the objects to conduct the evaluation (such as total nights, arrivals, profits, capacity, and occupancy) (Assaf, Josiassen 2016). Large variability is also observed in the methods employed for measuring performance. The measurement of actors' achievements can be extracted by simple ratios – synthetic indices, regression analyses – and frontier methods such as the DEA and Stochastic Frontier Analysis (SFA) (Sigala 2004, Croes, Kubickova 2013, Hanafiah, Zulkifly 2019). The selection of the method depends on the goals of each study. When productivity is assessed, indices such as Total Factor Productivity are adequate for extracting results. In addition, when efficiency is evaluated, DEA could be considered as a sound method for extracting results, considering its wide application in the tourism domain (Assaf, Josiassen 2016, Cuccia et al. 2017). Therefore, when conducting reviews of studies on the assessment of the effect of phenomena such as seasonality and spatiality on the performance of the tourism sector, the previous considerations should be considered. This is because different conclusions regarding the type of the nexus of the aforementioned phenomena could be extracted by studies that are based on different conceptions of performance as well as on different subjects and objects of performance measurement.

Considering the seasonality-performance nexus, it is unexpected that, despite the general consensus regarding the importance of seasonality on tourism destinations performance, there is only a limited number of studies which provide empirical evidence in a cross-regional context. More precisely, Ortega, Chicon (2013) assess the performance of the accommodation sector of the Spanish regions in terms of labor productivity and find that seasonality has no effect. Saito, Romao (2018), studying the exact same sample of Spanish regions conclude that seasonality negatively affects the performance of the accommodation sector. However, when there are substantial peaks of the tourism flows, some regions may also benefit from a concentrated temporal distribution of flows. This finding could be considered contradictory and, perhaps, it could be attributed to the adopted assumption of a linear relationship between performance and seasonality. Both of the aforementioned studies focus on the productivity dimension in order to quantify the regional performance of the tourism sector. More precisely, in order to extract a labor productivity measure, Ortega, Chicon (2013) use the ratio of output to labor, whilst Saito, Romao (2018) use the more holistic total factor productivity approach. Ortega, Chicon (2013) estimate seasonality through the Gini index, taking as an estimation base the monthly overnight stays of each region. Saito, Romao (2018) perform the same kind of analysis, estimating, additionally, the Coefficient of Variation metric. Finally, the effect of seasonality on performance is modeled through regression analysis in both papers. Particularly, Ortega, Chicon (2013) test on a panel dataset, covering the period 1997-2004, one basic Ordinary Least Squares regression and one with regression Instrumental Variables

to control for endogeneity. Saito, Romao (2018) test on a time-series dataset, covering the period 2001-2014, one regression to extract total factor productivity and one regression to estimate the effect of seasonality on total factor productivity.

Concerning the spatiality-performance nexus, the literature lacks empirical evidence on the nexus with performance in a cross-regional context. Even though it includes some empirical measures of spatiality across regions, incorporating metrics such as the Gini index (Wen, Sinha 2009, Li et al. 2015, Papatheodorou, Arvanitis 2014), it does not use these measures as means to explain the fluctuation of performance across the considered regions. The relationship between spatiality and tourism performance may be detected among studies with a focus on the impacts of agglomeration economies, and particularly of localization economies, on the tourism sector. The term "agglomeration economies" describes the advantages of costs or quality generated by concentrating inputs, population, firms, and collective agents at a point in space (Capone, Boix 2008). Agglomeration economies may take the form of either localization (Marshall 1890, Arrow 1962, Romer 1986) or urbanization economies (Jacobs 1969). The former type of agglomeration economies arises from intra-industry spillovers, whereas the latter arises from inter-industry spillovers. As noted by Henderson (1997), the type of agglomeration economies (whether localization or urbanization economies) for an industry has implications for regional development. If agglomeration economies take the form of localization economies, then areas specialize in one export activity and/or closely-related activities. As it has been aptly put by Thompson (1956) "nothing could seem more certain, deductively, than a close causal relationship between local industry mix and the cyclical instability of that area" (p. 16). In the same vein, Fatás (1997) explains that "regions display cycles where their level of economic activity fluctuates relative to other regions" (p. 744) and identifies the differences in the industry-mix (comparing to the other regions) and the regional policy effects as asymmetry determinants. Thus, concerning the stream of studies that focus on the relationship between spatiality and tourism performance, sectors – and, consequently, the corresponding regions – may benefit by their own geographical concentration (Beaudry, Schiffauerova 2009), and, particularly, by production enhancements and heightened demand (Chung, Kalnins 2001).

Considering the agglomeration effects on tourism performance, a large diversity of results exists, regarding the direction and strength of the effects and depending on the dimension performance considered. Such a diversity highlights the complexity of the relationship between performance and agglomeration. Chung, Kalnins (2001) studying the Texas lodging industry, find that agglomeration affects the profitability (revenue per available room ratio) of hotels. The effect is positive for smaller hotels that operate close to larger ones but negative for medium- and large-sized hotels. Canina et al. (2005), also, observe a dual effect of agglomeration, finding that profitability is enhanced for the hotels of the lower-end categories, due to differentiation spillovers, whilst profitability is lower for highly-differentiated luxury hotels that co-exist with firms of low-cost strategic orientation. Chan et al. (2012) assess the nexus of agglomeration and performance in Taiwan, figuring out that agglomeration reduces profitability and improves labor productivity. Marco-Lajara et al. (2016), studying the hotel sector of the Mediterranean coastal part of Spain, extract some contradicting results, regarding the effect of agglomeration on hotels performance, finding that concentration harms income and, at the same time, reduces the costs for the hotels operating within tourism districts.

The present paper differentiates from the above literature in many aspects. On the investigation of the nexus between seasonality and performance, the present paper adds to the relevant literature by examining the effect of seasonality on tourism efficiency of regions, complementing the studies that focus merely on the productivity dimension of performance. Moreover, different functional forms of the relationship between seasonality and efficiency are tested, questioning the linear approximation of the past papers. On the investigation of the nexus between spatiality and performance, the present paper adopts a perspective that draws more from the regional science rather from the pure tourism-oriented discipline. The focus of the past papers on agglomeration was to reveal the ways concentration impacts on the performance of tourism enterprises. Conversely, the aim of the present paper is to assess the effect of the concentrated pattern of tourism

development not on individual firms or firms' classes operating within agglomerations but on the performance of the sector as a whole against the sectors of other regions. That is, the question of the present paper is whether spatial concentration benefits the corresponding regions or not.

3 Methodological Framework and Variables Specification

The empirical analysis is conducted for 36 coastal North Mediterranean EU NUTS II regions, for the period 2010-2016. The NUTS II spatial level is preferred since, according to the definitions of Eurostat (2019b), it is the territorial level typically used for the application of regional policies. Although NUTS II regions normally include more than one tourism destination, they are institutionally relevant in order to address policy questions related to the integration of tourism dynamics into broader resource management or economic development policies (Romao et al. 2017). Indeed, despite the existence of the rather diversified tourism products being developed within the regions, these still encompass a common characteristic, which is their sea borders, which allow for the development of coastal tourism. The latter is the dominant type of tourism for coastal regions. The study of Batista e Silva et al. (2018) reflects this ascertainment, indicating that for the vast majority of coastal regions, summer is the peak season.

Towards studying the nexus between performance and the temporal and spatial concentration of tourism flows, the paper starts from the quantification of the considered phenomena. Particularly, for the measurement of performance, the method of DEA is selected. DEA is among the most-used efficiency estimation methods. Given a set of Decision Making Units (DMUs) utilizing some inputs to produce some outputs, DEA uses the linear combinations of the observations of the sample to construct a technology (or maximum efficiency) frontier. The distance of all DMUs from the frontier is used to compute their technical efficiency (Barros 2005, Cooper et al. 2011). Since DEA is based on real observations, it provides feasible targets for the inefficient DMUs. Moreover, it provides targets that are consistent with the very scope of benchmarking, which renders DMUs capable of realizing their improvement potential (Sigala 2004), since all DMUs are compared against the technology frontier.

In order to set a basic DEA model, it is assumed that there are n destinations using m inputs and producing s outputs. Furthermore, $x_{ij} > 0$ expresses the amount of input i used by destination j, and $y_{rj} > 0$ expresses the amount of output r produced for destination j. Under these assumptions, the efficiency for a destination o results from the solution of model 1:

$$
\begin{aligned}
\mathit{Effi}^* \quad &= \quad \max_{o} \mathit{Effi}_o \qquad (1)\\
\text{s.t.} \quad &\sum_{j=1}^{n} x_{ij}\lambda_j \leq x_{io}, \quad i = 1, 2, \ldots, m\\
&\sum_{j=1}^{n} y_{rj}\lambda_j \geq \mathit{Effi} y_{ro}, \quad r = 1, 2, \ldots, s\\
&\lambda_j \geq 0 \quad j = 1, 2, \ldots, n
\end{aligned}
$$

where *Effi* is the efficiency score, λ_j are the weights that destination j assigns to destination o, in order to construct its efficient reference set, and the mark * expresses the optimized model (Zhu 2014). Model (1) has an output orientation, implying that each destination is evaluated according to its ability to achieve the largest output with the current level of inputs. This complies with the relevant literature, where output-oriented models have, mostly, been adopted (Assaf, Josiassen 2016), thus, marking that it is more rational for a destination to try to expand its demand than to shift its capacity into lower levels.

A major limitation of DEA is that it provides scores without any statistical properties. In order to overcome this weakness, Simar, Wilson (1998) proposed a simple bootstrapping method in order to obtain confidence intervals, within which the true efficiency of each individual DMU occurs, for the obtained scores. In addition, when environmental variables

are incorporated into analysis, Simar, Wilson (2007) proposed two algorithms that can be used in order to extract consistent estimation of the effect of variables on the efficiency of DMUs. In the first algorithm, scores are extracted from the basic DEA models and the effect of environmental variables is estimated with a bootstrapped truncated regression. In the second algorithm, the effect of environmental variables is incorporated into the estimation of the scores of DMUs through a double bootstrapped truncated regression. By this way, the algorithm returns both bias-corrected DEA scores and the effect of environmental variables. In the present study, the second algorithm will be used in order to compute the efficiency scores of the considered regions and to estimate the effect of seasonality, spatiality, and of some contextual environmental variables on the efficiency of regions. To do so, the "simarwilson" command of the STATA statistical software is used with 1000 bootstrap replications (Badunenko, Tauchmann 2018).

In addition, the type of returns to scale of the DEA models should be, also, decided. DEA models could be set in order to accommodate, both Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS). The estimation of efficiency under a CRS assumption accommodates both the pure technical and the scale efficiency of DMUs, whilst under the VRS assumption only the technical efficiency is computed (Cooper et al. 2011). The selection of the model type is up to the researchers and their good knowledge about the reference technology of the DMUs under consideration. In the tourism domain, and specifically in the applications of DEA on destinations' efficiency, prior research includes both type of models (Assaf, Josiassen 2016). Therefore, in the present paper both models are estimated, and their results are discussed in a comparative context.

A critical parameter for the extraction of the performance measurement is the selection of outputs and inputs to be incorporated in the DEA model. Most of the previous works rely on the total bed-nights in order to measure the output of the accommodation sector (Cuccia et al. 2017). Especially in studies employing DEA to assess efficiency at a subnational spatial level, monetary measures of the tourist activities output are, still, absent. This is due to the fact that tourism statistics are mostly available at the national level. Therefore, previous research provided only a partial picture of the tourism sector achievements. To fill this gap, the present paper considers two outputs of the accommodation sector. The first is the total annual bed-nights (TBN) and the second, a monetary measure of the average daily expenditures of foreign tourists (ADE). By doing so, the destinations are assessed not only on their efficiency to fill in their supply, but also on their ability to do that in the most favorable context for the regional economy. For the ADE variable, a very demanding effort involved selecting data from various sources of the countries considered in the analysis. The main sources for extracting the ADE data were the border surveys, mainly conducted by the National Banks of the considered countries. As it was difficult to disaggregate the total expenditures into various categories, due to categories-setting inconsistencies, the total expenditure of foreign tourists was considered, after subtracting any expenses for international transport, where applicable[1]. This measure provides a good approximation of the wider economic benefits of tourism than those that are strictly connected to the accommodation domain. The variable has been normalized considering the Purchasing Power Parity of the countries and in respect to the EU average (Eurostat 2020). For the inputs, the present paper incorporates measures of both capital and labor production factors. The variable of capital production function is expressed as the available Total Beds Capacity (TBC), and labor production function as the Total Labor Capacity (TLC) considering the total number of employees at the accommodation sector at each region. The data for the TBN, the TBC, and the TLC variables are obtained from Eurostat (2019a,c,e).

The Seasonality index (SI) and the Spatiality index (SPI) are constructed in a similar manner, as, for both variables, the Shannon's entropy index (Theil 1967) is utilized. The entropy index expresses the level of disorder according to which a set of observations are distributed. The basis for estimating the seasonal uniformity is the total bed-nights observed over the twelve months of the year, whilst the basis for estimating the spatial

[1]The variable is constructed by foreign tourists' expenditures for Accommodation, Food and beverages, Local transport and renting transport equipment, Cultural, sport and leisure services and Other items (shopping etc.).

uniformity index is the total-bed nights observed over NUTS III divisions per region (Eurostat 2019b)[2]. The Shannon's entropy index, is defined by the negative logarithm of a variable's probability mass function (P) (Theil 1967) and is presented in Equation (2):

$$H = -\sum_{i=1}^{N} P_i \ln P_i \tag{2}$$

The observed entropy $\hat{H}$ is calculated by Equation (3), assuming that each month or sub-division poses s_i share of the total bed-nights:

$$\hat{H} = -\sum_{i=1}^{N} s_i \ln s_i \tag{3}$$

The SI and SPI are computed by the ratio presented in Equation (4):

$$\mathrm{NH} = \frac{\hat{H}}{\hat{H}_{\max}} \tag{4}$$

which is defined as the ratio of the observed ($\hat{H}$) to the maximum entropy ($\hat{H}_{\max} = \ln n$) of a region (Cowell 2000). Larger values of the variables denote greater seasonal and spatial uniformity, whilst the corresponding lower values denote a concentration of flows in seasonal and spatial terms. It should be noted that the SPI may not fully depict the tourists' concentration at the considered regions, as it only provides a measure of the flows' dispersion among the NUTS III sub-regions. This is because regions of the same size may be divided into different numbers of sub-regions and therefore a region consisting of a rather large number of divisions may present lower concentration levels than a region of similar size and flows but less divisions. To overcome this difficulty, more detailed data for the concentration of tourists at the destination and not at the NUTS III level could be very useful. Unfortunately, this type of data is not available from official sources and therefore one should rely on other sources such as online user generated content, dedicated surveys, and mobile data providers. Considering the large scale of the present analysis, covering six countries, those data could not become available and thus the NUTS III basis is adapted as the best alternative way for measuring spatiality. The data for estimating the indicators are extracted from the National Statistics Offices or the National Tourism Authorities of the considered countries.

Having extracted the measures of the three phenomena (i.e., performance, seasonality, and spatiality), their relationship is modeled through regression analysis. The Effi index is set as the dependent variable and the SI and SPI as the independent ones. Following the specification suggested by Simar, Wilson (2007), the double bootstrap algorithm will be used to extract the coefficients of the independent variables.

In order to capture the temporal trends and the spatial heterogeneity across the observations, some additional variables are included in the model. More precisely, year dummies, with reference to 2010, are incorporated in order to capture any time trends of the efficiency. Moreover, country dummies, with reference to Greece, are included in order to account for any differences resulting from the different environments under which the various destinations are operating. Four additional variables are incorporated into the analysis in order to capture the effect of various contextual factors on the efficiency of the regions. The first variable (INS) regards the type of the regions and whether they are insular or not. Insular destinations are among the most attractive places for summer vacation but insularity may put some constraints on the potential of destinations to accommodate large flows of tourists due to connectivity issues which are amplified in the low-season periods (Papatheodorou 2001, Agius et al. 2020). Insularity is quantified by a dummy variable which takes the value 1 for insular regions and 0 for non-insular ones. The second variable is for population density. More urbanized areas may find it easier to

[2]Since Cyprus and Illes Balears are not divided in NUTS III regions, a customized division has been followed in order for them to be included in the analysis. More precisely, Illes Balears was divided into three sub-regions, corresponding to the three main islands (Mallorca, Minorca, and Ibiza-Formentera), and Cyprus has been divided to five sub-regions corresponding to the districts of the Republic of Cyprus.

attract tourists year-round due to enhanced pull capacity for different types of tourism (Niavis 2020). The variable DENS is constructed as the ratio of residents to 1 km^2 and it is extracted by Eurostat (2019d). The third variable quantifies the mix (MIX) of flows, domestic or international, evolving at each region. The MIX variable is incorporated into the estimations as the ratio of domestic overnight stays to total overnights stays and seeks to capture what type of tourism market favor the most the destinations under consideration. The data for the variable are extracted from Eurostat (2019a). Finally, the last variable measures the specialization (SPEC) level of regions in tourism activities and captures any heterogeneity potentially arising from higher productivity levels of the more tourism-oriented regional economies. The data for the variable are extracted from the Structural Business Statistics indicators of Eurostat (2019e).

In contrast with the past empirical studies on the relationship of performance and seasonality, which assumed a linear relationship between performance and seasonality, in the present paper, the type of relationship is not presumed since the final functional relationship is configured using a stepwise approach. The same stands true for all the variables of the model. The pairwise correlations of the remaining variables are found to be quite moderate (< 0.67) and, thus, their insertion in the model can be considered as not causing any bias on the estimations. This is also reflected by the fact that the value of all Variance Inflation Factors (VIF) does not exceed the critical threshold of 10 (Dormann et al. 2013). Therefore, Equation (5) represents the final configuration of the model:

$$\begin{aligned} Effi_{ij} \quad = \quad & \beta_0 + \beta_{DES} DES_i + \beta_{DFR} DFR_i + \beta_{DIT} DIT_i + \beta_{DMT} DMT_i + \\ & \beta_{CY} DCY_i + \beta_{D2011} D2011_i + \beta_{D2012} D2012_i + \beta_{D2013} D2013_i + \\ & \beta_{D2014} D2014_i + \beta_{D2015} D2015_i + \beta_{D2016} D2016_i + \beta_{SI} SI_i + \beta_{SI^2} SI_i^2 + \\ & \beta_{SI^3} SI_i^3 + \beta_{SPI} SPI_i + \beta_{SPI^2} SPI_i^2 + \beta_{INS} INS_i + \beta_{DENS} DENS_i + \\ & \beta_{MIX} MIX_i + \beta_{SPEC} SPEC_i \quad i = 1, 2, \ldots, N\text{regions}, j = \text{crs}, \text{vrs} \end{aligned} \tag{5}$$

where,

Effi The efficiency scores of each region, as extracted by the application of the W-DEA analysis

DES, *DFR*, *DIT*, *DMT*, *DCY* The country dummies with reference to Greece

$SD_{2011-2016}$ The year dummies with reference to 2010

SI The seasonality index scores

SPI The spatiality index scores

INS A dummy variable taking the value 1 for insular regions and 0 otherwise

DENS The population density of the regions

MIX The proportion of domestic bed-nights to total bed-nights for each region

SPEC The specialization of regions in tourism related activities (based on employment)

β The regression parameters to be estimated

ϵ The error term

4 Results and Discussion

The 36 coastal North Mediterranean EU NUTS II regions under consideration[3] are located in 6 Mediterranean EU countries and are presented in the bottom of Table 1. Table

[3]The Croatian coastal region Jadranska Hrvatska is not included in the analysis because official data for seasonality have become available only after 2015.

Table 1: The descriptive statistics of the DEA variables and the bias corrected efficiency scores

Statistics	Variables					
	TBC	TLC	TBN	ADE	Effi_{CRS}	Effi_{VRS}
Mean	111115	13,198	13,608,642	75.178	1.709	1.443
St. Dev	93,547	11,264	13,860,830	19.605	0.464	0.291
Min	5,956	573	271,525	33.757	1.015	1.013
Max	358,169	52,093	59,000,000	127.124	3.262	2.225
Min Region	Molise	Molise	Molise	Molise	Malta	Malta
Max Region	Illes	Cataluña	Illes Balears	Illes Balears	Sterea Ellada	Anatoliki Makedonia, Thraki

Source: Elaboration from Eurostat (2019a,c,e) and National Statistic Authorities or Tourism Organizations of the considered countries

Note: **Total** (NUTS – II) Regions: 36; *Spain* (4): Cataluña, Comunidad Valenciana, Illes Balears, Andalucia; *France* (3): Occitanie, Provence-Alpes-Côte d'Azur, Corse; *Italy* (15): Liguria, Veneto, Friuli-Venezia Giulia, Emilia-Romagna, Toscana, Marche, Lazio, Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria, Sicilia, Sardegna; *Greece* (12): Anatoliki Makedonia, Thraki, Kentriki Makedonia, Ipeiros, Thessalia, Ionia Nisia, Dytiki Ellada, Sterea Ellada, Peloponnisos, Attiki, Voreio Aigaio, Notio Aigaio, Kriti; *Malta* (1); *Cyprus* (1);

1 also includes the basic descriptive statistics for the variables of the DEA model and the bias-corrected DEA scores under both returns to scale specifications. The lowest scale of activity is observed over the rather small region of Molise, as it accounts for the minimum values of all four variables of the DEA models. The highest activity is observed over the Balearic Islands as the region presents the highest number of overnights stays while accounting for the highest average daily expenses of the foreign tourists. The mean efficiency score is estimated at 1.709 under CRS and 1.443 under the VRS specification. The CRS model comes up with higher inefficiency than the VRS, as it also accommodates the scale differences among regions. The most efficient region is Malta under both models, while the least efficient regions, under both models, are Greek; Sterea Ellada under the CRS model, and Anatoliki Makedonia and Thraki under the VRS one. This result signifies how the scale parameter might have harmed the efficiency of Sterea Ellada whose rank clearly improved when the pure technical efficiency is estimated through the VRS model.

The independent variables incorporated into the bootstrapped truncated regression are presented in Table 2. The mean value of the seasonality index is estimated at 0.894, while the mean value of spatiality at 0.773. The two indices present substantial differences on their standard deviation values, with the latter showing larger variability. The larger variability is observed by examining the range of the two indices, which is substantially larger for the spatiality index. On the individual records of the regions, Ionia Nisia presents the highest seasonal concentration and Attiki presents the most diverse allocation of flows across the twelve months. Malta is the region with the most spatially concentrated flows of tourists and Corse is the region with the most spatially balanced tourism flows. The DENS variable presents a large variability as the St. Dev value exceeds this of the mean. On average, the Mediterranean regions present a population density of 196 residents per km2 with the highest density observed in Malta and the lowest in the Greek region of Sterea Ellada. In addition, the mean of the MIX variable denotes that, on average, the regions of the Mediterranean present a balanced mix of domestic and foreign tourism, as expressed by the total bed-nights. Nevertheless, there are remarkable differences across regions. The share of domestic bed-nights hardly exceeds the 4% in Malta, whilst it reaches the 90% in the Italian region of Molise. Finally, the tourism activities account, on average, for the 5% of the regional employment. The highest tourism specialization is found in the insular region of Notio Aigaio where more than 27% of the local employment jobs concern those of the accommodation sector, and the lowest specialization in the Attiki region with a tally of about 1%.

The longitudinal variability of values of four indices for the years 2010-2016 is presented

Table 2: The descriptive statistics of the independent variables of the double bootstrapped truncated regression

Statistics	Variables				
	seasonal	spatial	density	mix	specialization
Mean	0.894	0.773	196.035	0.501	0.041
St. Dev	0.075	0.174	262.697	0.258	0.042
Min	0.716	0.218	35.900	0.039	0.011
Max	0.997	0.990	1450.200	0.913	0.272
Min Region	Ionia Nisia	Malta	Sterea Ellada	Malta	Attiki
Max Region	Attiki	Corse	Malta	Molise	Notio Aigaio

Source: Elaboration from Eurostat (2019a,c,e) and National Statistic Authorities or Tourism Organizations of the considered countries

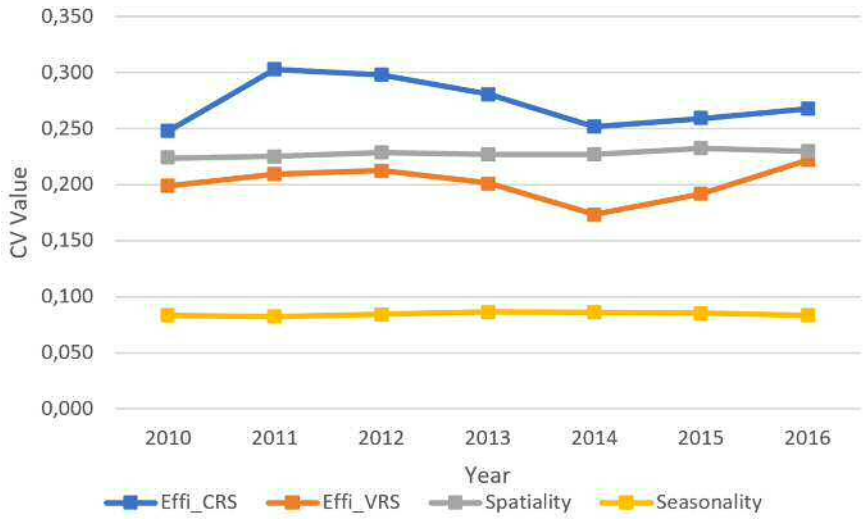

Figure 1: Annual Coefficient of Variation (CV) values for the indices of efficiency, spatiality, and seasonality across Mediterranean regions (2010-2016)
Source: Elaboration from Eurostat (2019a,c,e) and National Statistic Authorities or Tourism Organizations of the considered countries

in Figure 1. The CV values show that the highest dispersion is observed on the EffiCRS scores and the lowest on seasonality. On the one hand, this result signifies that there are very low variations in the seasonal dispersion of tourists across the coastal regions of the Mediterranean. On the other hand, the higher efficiency and spatiality variations portray that the utilization of resources and the diffusion of flows at the inner parts of the regions could be seen as more significant differentiation factors for the way that the tourism phenomenon evolves in the Mediterranean region. As far as the trends are concerned, the variation of efficiency scores shows a peak during the 2011-2012 period and it decreases in the following years, just to show trend upward again after 2014. This upward trend makes the variation of the EffiVRS scores reach the spatiality index in 2016. Finally, the changes of the annual seasonality and spatiality scores variability should be considered as only marginal if not zero.

The results of the application of Simar, Wilson (2007) for the two efficiency indices are presented in Table 3. In total, 252 observations were used to conduct the regression analysis. The values of the Wald Test (440.83 for the first model and 358.94 for the second model) exceed the critical value of the chi-square distribution for 20 degrees of freedom (df), thus the null hypothesis, that the models' variables have no effect on the dependent variable, is rejected for both models at a significance level of (< 0.01). As for the statistically significant coefficients, their signs remain the same under both specifications except for the ones estimated for the ISL and DENS variables. In addition, there are

Table 3: Results of the EffiCRS and EffiVRS bootstrapped truncated regression models

Coefficient	EffiCRS Model (1)		EffiVRS Model (2)	
	Estimation	Significance Level	Estimation	Significance Level
β_0	-167.071	0.01	-122.076	0.01
β_{DES}	-1.256	0.01	-0.688	0.01
β_{DFR}	-1.230	0.01	-0.465	0.01
β_{DIT}	-0.597	0.01	-0.368	0.01
β_{DCY}	-0.622	0.01	-0.282	0.05
β_{DMT}	-1.360	0.05	-1.124	0.05
β_{2011}	0.003	NS	-0.038	NS
β_{2012}	0.087	NS	0.001	NS
β_{2013}	0.051	NS	-0.063	NS
β_{2014}	-0.022	NS	-0.108	0.05
β_{2015}	-0.001	NS	-0.100	0.05
β_{2016}	0.016	NS	-0.056	NS
β_{SI}	580.613	0.01	418.083	0.01
β_{SI^2}	-667.406	0.01	-469.673	0.01
β_{SI^3}	254.818	0.01	174.347	0.01
β_{SPI}	2.532	0.05	1.926	0.05
β_{SPI^2}	-1.890	0.01	-1.254	0.05
β_{ISL}	0.144	0.10	-0.106	0.05
β_{DEN}	-0.001	0.05	0.001	NS
β_{MIX}	1.305	0.01	0.477	0.01
β_{SPEC}	1.823	0.01	-0.615	NS

Source: Elaboration from Eurostat (2019a,c,e) and National Statistic Authorities or Tourism Organizations of the considered countries

some minor differences regarding the magnitude of the estimated coefficients and their statistical significance. More precisely, β_{D2014} and β_{D2015} are found to be statistically significant only under the VRS efficiency specification. The exact opposite estimation is found for the β_{DEN} and β_{SPEC} as they were only found statistically significant under the CRS specification. Finally, some differences on the estimated significance levels are found for the coefficients β_{DCY}, β_{SPI^2} and β_{ISL}. In essence, the models produce similar results, especially for the seasonality and spatiality indices, facilitating, in this way, the common interpretation of the estimated coefficients and the drawing of more robust conclusions.

At the country level, the estimated coefficients of the countries' dummy variables, which are all statistically significant at least at the (< 0.05) level, signify that the Greek regions suffer from inefficient resources' management when compared to the regions of the other countries. Greek destinations suffer from both scale and managerial inefficiencies as they fail to fill up their capacity and trigger an adequate spending of the foreign tourists in comparison with other parts of the Mediterranean. Considering the value of the coefficients, the largest gap is observed between the Greek destinations and Malta. Therefore, for the Greek case there seems to be some disfavoring conditions, either at the policy or at the social environment, which do not allow the various destinations to attain a satisfactory management level. Regarding the year dummy variables, the results signify that little variability is observed in the efficiency of the Mediterranean throughout years, since no statistically significant estimation is extracted for the respective dummy variables in the CRS model. On the other hand, some variability is observed on the VRS model since the statistically significant estimations for the 2014 and 2015 dummies show that in these years, destinations operated, on average, more efficiently than they did in 2010. This finding signifies that when the scale factor is omitted from the estimations, pure managerial efficiency may be more sensitive to the effect of the external environment.

In addition, the statistically significant estimation of the seasonality coefficients reveals that efficiency and seasonality are related with an N-shaped curve. This finding portrays that seasonality has mixed effects on the performance of the accommodation sector. In

order to estimate the turning points and to better define the functional relationship of the two variables, the average marginal effects of the SI on efficiency scores of over 1, are first evaluated using the "margins" Stata command (Badunenko, Tauchmann 2018). After obtaining the marginal effects, the two turning points are, approximately, computed using the estimated coefficients by the Equation (6) (Plassmann, Khanna 2007):

$$\mathrm{TP}_{1,2} = \frac{-\beta_{SI^2} \pm (\beta_{SI^2}^2 - 3\beta_{SI}\beta_{SI^3})}{3\beta_{SI^3}} \tag{6}$$

The two turning points for the SI variable are 0.82 and 0.93 under the CRS efficiency specification and 0.81 and 0.98 under the VRS efficiency specification. Within the zone of the lowest values of the SI (SI < 0.82 or 0.81), where substantial peaks of flows are observed, performance is affected negatively, since the imbalance of tourism overnight stays among the high and low season is such that causes severe under-utilization of resources in the latter. To put it simply, it is hard for these regions to fill up the high capacity needed for coping with the relatively high demand of summer during the remaining months. Moreover, destinations that are based only on seasonal tourism find it difficult to keep a standard level of prices all year round and thus the lowering of prices to lure demand on the lowest seasons may harm the overall tourism spending. Since the ADE variable incorporates other tourism expenses, the present result may also highlight the inability of one peak season destinations to provide added value services in the mild and low seasons, as well. On the other side, as the seasonality phenomenon becomes smoother (0.79 < SI < 0.89 or 0.81 < SI < 0.98), destinations' performance seems to be favored. This is the case where the imbalances among the peak and low months become lower, thus, leading to less under-utilization of resources in the latter period and better performance in tourism receipts. In these destinations, seasonality is under control and is welcomed as a means for reversing the possible losses of the low months. Finally, as seasonality tends to its lowest levels (SI > 0.89 or 0.98), its effect on performance is becoming negative again. Destinations with this type of seasonality are dealing with the challenge of filling up their capacity in a year-round basis without any push of increased flows in a month or season of the year that would increase the total annual utilization of their resources and the achievement of high room prices and receipts from added value services. Finally, a comment should be made about the interesting finding of the different turning points resulting from the two different efficiency specifications. The distance between the two turning points is wider under the VRS efficiency specification, also including the respective range of CRS turning points. This result signifies that seasonality favors the pure managerial efficiency of destinations the most, and to a lesser extent, the overall efficiency including the scale factor.

Considering the comparative basis on which the performance assessment has been realized in the present paper, the general finding of the performance-seasonality analysis is that the latter can be a competitive advantage for the destinations with coastal tourism. This finding contradicts the finding of Ortega, Chicon (2013), who found no relationship between performance and seasonality. Nevertheless, it should be noted that a direct comparison is not feasible because the paper of Ortega, Chicon (2013) approached performance through labor productivity, which is more easily adjusted to seasonal fluctuations (Saito, Romao 2018) and, therefore, it cannot depict the total performance gains or losses due to seasonality.

In addition, the paper validates only partially the findings of Saito, Romao (2018), who observe that, although seasonality is, in general, negatively related to the regional performance, the performance losses could still be offset by increased demand in the peak season. The empirical model of the present paper takes the analysis a step further by defining zones of seasonality that affect performance in a varying way. Therefore, the paper validates that seasonal peaks may turn up as beneficial for the destinations, but only below a certain threshold. Nevertheless, the direct comparison of these findings should be treated with caution because the present paper focuses only on coastal regions, the variables quantifying seasonality are different and, finally, the functional form of the relationship is polynomial in the present study and linear in the study of Saito, Romao (2018).

As for the SPI variable, the estimations of both the linear and quadratic coefficients are statistically significant at the (< 0.05) level at least but yield different signs. More precisely, the sign of the linear term is positive, whilst the sign of the quadratic term is negative, thus, denoting that performance and spatiality are linked through an inverse U-shaped curve. This type of relationship is validated by both models. This finding portrays that for the lower values of SPI, where concentration of flows is higher, the inefficiency tends to be increasing. After a point, the effect of spatiality is inversed, thus, denoting that regions, which manage to achieve a rather equal diffusion of flows across their sub-divisions, are operating more efficiently. The turning point of the curve is extracted, after obtaining the average marginal effects of the variables, by (7) (Plassmann, Khanna 2007):

$$\frac{\beta_{SPI}}{2\beta_{SPI^2}} \tag{7}$$

For the present sample, the turning point is estimated at 0.67 for the CRS model and 0.76 for the VRS case, which are slightly lower than the mean value of the observations (0.77). The finding denotes that it is to the greatest benefit of regions to diffuse the tourism flows on all their sub-divisions, as a means for utilizing better their capacity and increase tourists' spending. This is because the high spatial concentration of tourist flows in popular destinations of a region is not able to offset the possible under-utilization of resources occurring at the less popular destinations. Moreover, the lack of an adequate number of popular destinations in a region may lower tourism expenses due to low demand for a series of services such as transportation within the region, booking of excursions, and car rental. To put the results in perspective with the past research on agglomeration-performance nexus, the paper shows that at a regional scale agglomeration is beneficial for performance only in very polarized regions where a large variety of services can be provided on site. As polarization decreases, so does the efficiency until the regions shift toward a better spatially balanced model where efficiency seems to improve.

Moreover, the estimation of the INS variable coefficient shows that insularity has a dual effect on the efficiency of regions. More precisely, insularity is found to have a negative effect on the CRS efficiency and a positive effect on VRS efficiency. This finding shows that connectivity issues might impede destinations to fill up their capacity, but when the scale factor is omitted, insular regions seem to operate rather more efficiently than their terrestrial competitors. In addition, the DENS coefficient has a negative sign and thus it favors the efficiency of regions. This relationship is found significant only for the CRS case, which is something reasonable as more urbanized regions are favored by large number of tourists' flows and thus acquire a competitive advantage in scale terms. Furthermore, the estimated coefficient for the MIX variable is positive and statistically significant at the (< 0.01) level. This result indicates that foreign tourism is the driver of performance for the coastal Mediterranean regions, since the regions where domestic tourism acquires a large proportion of the total nights present higher levels of inefficiency. This inefficiency arises both from the inability to fill up the supply of beds and from the reduced spending of foreign tourists as destinations whose target market is the domestic population may not have the capacity to develop added value services for foreigners. Therefore, strategies for performance improvement should consider that destinations should be able to attract non-domestic tourism in order to achieve larger efficiency gains. Finally, the SPEC variable was found to have an effect only on the CRS efficiency of the regions and according to the estimated sign it seems that regions which are highly specialized in tourism activities are found to perform less efficiently than the others. This is a quite unexpected finding and maybe should be attributed to the fact that for the Mediterranean region, the higher specialization is found for the islands. Therefore, specialized regions tend to suffer from their inability to maintain a rather stable flow of tourists all year round and therefore are struggling to cover their existing capacity. When the scale factor is omitted (VRS model) this effect is not so strong. Overall, in a Mediterranean context the most favored destinations are those that can combine urban and coastal tourism so as to achieve high occupancy rates and rather high levels of spending.

5 Conclusions

The present paper studies the effects of seasonality and spatiality of tourist flows on the regional performance of tourism sector. The empirical analysis is conducted for 36 coastal North Mediterranean EU NUTS II regions, for the period 2010-2016, and is based on a triplet of quantitative indices and on a double bootstrapped truncated regression. As far as seasonality is concerned, the empirical application of the proposed methodological framework shows that seasonality and performance are linked with a rather complex relationship. This relationship is portrayed with an N-shaped curve, which shows that the general question "is seasonality desired by the accommodation sector" should be better replaced by the question "how much seasonality is desired by the accommodation sector". Therefore, future studies on the nexus of performance and seasonality should avoid the adoption of a linear relationship assumption. Moreover, the paper sheds light on spatiality, whose effect on destinations performance has remained rather under-studied up to now. The results of the empirical analysis show a U-shaped relationship between performance and spatiality. This means that the uncontrolled spatial concentration of flows could pose severe threats on the ability of destinations to perform efficiently and to achieve a satisfactory utilization of their resources. Moreover, performance is affected by geographical and structural characteristics, which should be considered when conducting comparative evaluations of performance.

The findings of the paper come up with several policy implications towards the improvement of the performance of coastal destinations. The analysis shows that performance hardly changes in the short-run. The same stands true for seasonality and spatiality. Therefore, a constant effort should be made by regional and tourism authorities in order for substantial improvements to take place. Although seasonality has been at the spot of nearly all strategic plans of tourism, the efforts to be made on its confrontation should aim at bringing the destinations to levels of seasonality which correspond to those being met at the middle zone of the N-shaped relationship curve.

Moreover, from a regional development perspective, it is critical for strategic planning to aim at the reduction of the uncontrolled spatial concentration of flows. Therefore, actions aiming at the diversification of the tourism product, as a means for confronting seasonality, should consider that larger imbalances could be generated if diversification takes place only in specific areas of a region. This is because destinations of the same region, that formerly operated as complementary, may turn up to be competitive if diversification in one area eliminates the competitive advantage of another. This fact may be considered as a natural process, within the frame of the destinations' lifecycle and the competitive market of tourism, but, under a regional development perspective, it may compromise the targets of the balanced economic development and efficient use of resources within the regions and, furthermore, the competitive position of regions as economic entities.

Furthermore, the balance of foreign and domestic tourist flows has a significant role in shaping the ability of destinations to perform efficiently. Places which attract more foreign tourists find it easier to fill in their capacity and benefit from higher foreign tourists spending. The way that the monetary output was incorporated into the present estimations excluded the domain tourists' expenditures due to a lack of data. Therefore, if some destinations manage to accommodate domestic tourists with the same rate of expenditures as this of foreign then they can offset the deficit of international demand. Nevertheless, this is hardly the case in Mediterranean, as the foreigners' spending is usually higher than this of the residents. Therefore, a double challenge arises for the more domestic-oriented destinations as they need not only to attract more international flows but also to improve their tourism offer and to develop added value services in order to achieve more average daily spending from the existing flows of foreign tourists.

The findings of the present paper signify that the complexity of the tourism phenomenon requires tailor-made, focused, empirical approaches in order to decompose the latent relationships between the multiple dimensions of tourism. To this end, the present paper sheds light to one of the possible impacts of seasonality and spatiality, which has to do with the effect of the phenomena on the performance of the accommodation

sector. Such a decomposition approach may help authorities to develop more efficient monitoring tools than those of simple indicators, which may provide an assessment of seasonality and capacity utilization but ignore the impacts of the former on the latter (i.e., European Tourism Indicators System). Therefore, more sophisticated models of sustainability assessment may be developed if the interactions among the dimensions of tourism under consideration can be modeled.

The present results mainly concern developed countries and regions, where coastal tourism is the dominant form of tourism. Therefore, additional research should follow in order to test the relationships of seasonality, spatiality, and performance in other types of tourism and areas. Finally, since spatiality and seasonality are phenomena, which can be altered only in the long-run, the extension of the period of analysis, adopted by the present paper, may offer more comprehensive assessments of their impacts.

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The bias of avoiding spatial dynamic panel models A tale of two research teams*

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Abstract. Many questions in urban and regional economics can be characterized as including both a spatial and a time dimension. However, often one of these dimensions is neglected in empirical work. This paper highlights the danger of methodological inertia, investigating the effect of neglecting the spatial or the time dimension when in fact both are important. A tale of two research teams, one living in a purely dynamic and the other in a purely spatial world of thinking, sets the scene. Because the research teams' choices to omit a dimension change the assumed optimal estimation strategies, the issue is more difficult to analyze than a typical omitted variables problem. First, the bias of omitting a relevant dimension is approximated analytically. Second, Monte Carlo simulations show that the neglected dimension projects onto the other, with potentially disastrous results. Interestingly, dynamic models are bound to overestimate autoregressive behavior whenever the spatial dimension is important. The same holds true for the opposite case. An application using the well-known, openly available cigarette demand data supports these findings.

Keywords: Spatial dynamic panel data Monte Carlo simulation Spatial interaction Dynamic model Omitted variable bias

JEL: C13 C23 R10

1 Introduction

In regional economics, it has long been understood that units of observation may not be considered independent from one another across space, often associated with Tobler's first law of geography. The beauty of one house may increase the perceived beauty of neighboring houses. A region may be forced to decrease local tax rates because its close-by regions chose to decrease theirs in order to retain its tax base. One region's negative employment shock may not only increase local unemployment but also unemployment in neighboring regions due to the mobile workers. From early influential contributions like Cliff, Ord (1972), a formidable spatial econometric literature has grown. Kelejian, Piras (2017) offer an extensive overview.

Economists are also aware about the dynamics of economic processes. The notion that the state of a variable in some period depends on the state in the previous period plays a major role in many fields. In general, any partial adjustment process may be seen as a

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motivation. A classic example is the convergence literature, where the contribution of Islam (1995) is among the early ones to exploit panel data. Most readers have likely dealt with issues in estimating dynamic models themselves. This notion has too led to a massive body of econometric tools that enable researchers to use panel data to investigate dynamic processes. For example, sophisticated methods that deal with incidental parameter problems that come with short-in-time panel data have evolved and found widespread use. Hsiao (2014) offers a comprehensive overview of econometric methods for (dynamic) panel data. In the current discourse, generalized method of moments (GMM) approaches in the line of Arellano, Bond (1991) and Blundell, Bond (1998) are widely used, but have received considerable criticism about their suitability in empirical applications. While these GMM methods tend to suffer from instrument proliferation and are likely to break down when facing non-random initial observations or in proximity of unit roots, they remain popular due to their availability and the possibility to exploit internal and external instruments (Roodman 2009).

With the increasing availability of geo-referenced panel data, methods that take into account dependence over time and space have emerged. These methods are relatively new to the market, and have hardly been used in regional economics, at least in relative terms. Even if applied, dynamic models tend to be the main estimation methodology, while spatial dynamic models appear to be used mainly to assess robustness. It seems that spatial dynamic applications are more data-driven than formally theoretically justified. However, there are some exceptions worth mentioning that expanded more 'traditional' approaches to include spatial and dynamic properties. For example, Elhorst et al. (2013) investigate spatial diffusion of financial liberalization among countries using a spatial dynamic approach similar to the one discussed below. Expanding the famous Blanchard-Katz labor market model, Vega, Elhorst (2014) find highly significant spillover effects applying a spatial dynamic Durbin model. Similarly, Rios (2017) report significant indirect effects of employment growth with respect to unemployment rates among European NUTS 2 regions, which appear sizable especially in the long-run. One of the traditional motivations of (cross-sectional) spatial econometric approaches are house prices. Including a spatial time lag in a panel smooth transition regression model, Pijnenburg (2017) reports significant heterogeneity in spatial dependence. As a last example, Wanzenböck, Piribauer (2018) investigate R&D networks across NUTS 2 regions, highlighting strong spatial and dynamic effects in the course of a spatial Durbin model.

The aim of this study is to raise awareness about the problems research can encounter by neglecting dependence in either space or time from an econometric point of view. In order to meet this goal, the remainder of this paper builds on a tale of two research teams, where one team is located in a purely dynamic and the other in a purely spatial world of thinking. Both teams are handed the same data and each tries to explain the process as they see fit.

A few words of caution are in order. Even though the points made here are closely related to the typical omitted variables argument, the specific issues to be dealt with are a little different. An omitted variable usually does not change the optimal estimation strategy. Here, the preferred estimation methods of both teams will abstract from the optimal one. In fact, both teams aim for a suitable estimator *given* their beliefs about the underlying data generating process (DGP). Hence, 'Team Dynamic' fits a dynamic model, while 'Team Spatial' fits a (static) spatial panel model. Still, the mistakes made by both teams may be categorized as an omitted variable problem. However, they are more severe because they change the estimation method and, hence, the conceptualization of the DGP. In fact, both teams will make systematic errors in explaining the dynamics of the process. The question this paper tries to answer is whether the remaining dimension may still be estimated in an unbiased manner. In particular, is Team Dynamic able to estimate time dependence accurately? Is Team Spatial able to infer on spatial dependence without bias? The answer to both questions is *no*. In fact, it is possible to determine the direction of each bias.

As a first step, approximations of the mistakes made by both teams are derived analytically. The results show that the autoregressive parameter is overestimated in absolute terms whenever there is spatial dependence. Consequently, marginal effects of

covariates may also be severely biased, as discussed in Section 5. The other way around, results are less clear, but point in the same direction. Note that in the course of this paper, the term autoregressive always refers to the time dimension.

These approximations are put to the test using a Monte Carlo simulation. The results confirm the expectations and show potentially drastic outcomes. Lastly, a brief application using the openly available 'Baltagi cigarette demand' data (Baltagi, Li 2004) supports the findings.

2 A spatial dynamic process

As laid out in the introduction, the task is to infer the bias of omitting the time or spatial dimension. Naturally, there are multiple ways to include both types of dependence in a DGP that serves as a starting point. Leaning on Yu et al. (2008) and the examples stated before, assume a DGP that incorporates dependence over time as well as space in a seemingly separated manner. Specifically, define

$$Y_{nt} = \gamma_0 Y_{n,t-1} + \lambda_0 W_n Y_{nt} + X_{nt}\beta_0 + c_{n0} + d_{t0} l_n + V_{nt}, \tag{1}$$

where Y_{nt} is the $n \times 1$ vector of the outcome variable at time t that depends on its time lag $Y_{n,t-1}$, its contemporaneous spatial lag $W_n Y_{nt}$, an exogenous time-varying variable X_{nt}, and region specific fixed effects $\mathbf{c}_{n0}$ (all $n \times 1$). Further, the model includes a time-fixed effect given by a scalar term d_{t0} multiplied with the size-n vector of ones, l_n, and a $n \times 1$ vector of *i.i.d.* error terms V_{nt} with mean zero and variance σ_0^2. Scalars γ_0, λ_0, and β_0 are the coefficients of interest. The restriction to one exogenous variable X_{nt} is for notational convenience only. The $n \times n$ spatial weights matrix W_n is assumed non-stochastic and with diagonal values of zero. The common notion is that the more influence unit i has on another unit j, the larger the weight w_{ij}. As usual, let W_n be constant over time. For the following approximations it is useful to assume maximum-row-normalization, which preserves the symmetry of W_n. Note that whether one assumes local or global spillovers depends on the assumed DGP and how it translates into marginal effects, not the spatial weights matrix. Equation (1) implies the presence of global spillovers.

It has to be noted that the bulk – all except one – of the studies mentioned in the introduction as already applying spatial dynamic approaches use a spatial dynamic Durbin model (SDD), which would include a spatial time lag as well as a spatial lag of the covariate. This is motivated by LeSage, Pace (2009) for empirical applications due to preferable behavior in the presence of omitted variables or spatially correlated residuals, and Elhorst (2012) suggests a general-to-specific model selection approach where the Durbin model represents the most general approach.[1] For the ease of the argument, however, it is preferable to stick to seemingly 'separated' dimensions while noting that the DGP described in (1) is nested in a SDD model.

In the following, cases with negative time dependence are disregarded due to their near nonexistence in (regional) economics. Small samples in terms of the time dimension may require bias reduction procedures Team Dynamic and Team Spatial. In order to focus on the research question at hand, let us assume that the data provided to the teams has time dimension T large enough, such that this issue can too be disregarded.

Because explicit solutions of the biases are not available, either because of the presence of global spillovers or the estimation procedure, approximations are presented. The conclusion is that the direction of the bias can be determined, and that it can be approximated fairly simply.

Usually, exogenous variables are not of much interest in specifying DGPs, since the property of being exogenous suffices for proper estimation. Key to the derivations that follow in the next section is strict exogeneity of the covariate, implying that innovations in the DGP of the covariate are uncorrelated with contemporaneous and past innovations in the DGP of the dependent variable. Albeit not discussed in the literature, there is no reason to assume spatial behavior in the dependent variable but to deny it to the

[1] It is worth mentioning that the evolution of spatial dynamic panel models is still progressing. For example, Shi, Lee (2017) extend spatial dynamic panel models with interactive fixed effects, that is, different factor loadings of unobserved time-effects that may affect groups of units heterogeneously.

covariate. In fact, strict exogeneity is bound to break down if the covariate itself follows a dynamic DGP. The interested reader is relegated to Appendix D, where the case of a full spatial dynamic DGP of the covariate is investigated, after reading the following sections.

Lee, Yu (2010b) provide limited evidence on the effect of omitted time- and spatial-terms based on Monte Carlo simulations for spatial dynamic panel data models. Their focus, however, is on comparing the performance of ML estimation with respect to different types of panel transformations. Omitting the spatial lag leads to a potentially large bias in the estimated coefficient of the time lag and vice versa, while estimated coefficients of exogenous variables appear unaffected. In the following, the argument is formalized and the impact on marginal effects of the covariate is analyzed.

3 The tale

Before telling the tale of the two research teams – Team Dynamic and Team Spatial – it has to be stressed again that the analytical derivations of the estimates presented in this section are approximations, based on the first two elements of the Neumann series representation of $A_n = (I_n - \lambda_0 W_n)^{-1} = \sum_{k=0}^{\infty} (\lambda_0 W_n)^k$ with the usual constraint $|\lambda_0| < 1$, where I_n denotes an identity matrix of size n. This approximation is especially precise for low to moderate values of λ_0, as the share of A_n explained by the first two terms $I + \lambda_0 W_n$ equals $1 - \lambda_0^2$. As mentioned in the beginning, both research teams are handed the same data with the goal to explain the DGP as best as possible, thereby abstracting from usual omitted variable problems. While equally investigating the difference between estimated and true parameters and marginal effects by inserting the DGP in the estimate, the *estimator* is the not the one that would fit the DGP optimally.

Team Dynamic misreads the data, or is misguided by theory, such that the assumed DGP is purely dynamic. This implies that λ_0 is wrongly set to zero. A typical problem with dynamic panels is that the within-estimator is biased due to the correlation of the error terms and lagged dependent variable. This bias is of the order $O(1/T)$ (Nickell 1981). Therefore, the strategy is to take first differences, indicated by a bar. In the sense of Anderson, Hsiao (1982) and Arellano, Bover (1995), Team Dynamic may apply a two-stage least squares approach in which the endogenous lag of the first difference of the dependent variable ($\bar{Y}_-$) is instrumented by earlier lags to avoid the bias caused by taking first differences. Regardless of which of these moment estimators is applied, the estimation will be of the form

$$\boldsymbol{\phi}_{TD} = \left(\bar{\Gamma}' P_Z \bar{\Gamma}\right)^{-1} \bar{\Gamma}' P_Z \bar{Y}, \tag{2}$$

where the estimated parameters of Team Dynamic (TD) are collected in $\boldsymbol{\phi}_{TD} = (\gamma_{TD}, \beta_{TD})'$, $\bar{\Gamma} = \left[\bar{Y}_-, \bar{X}\right]$, and P_Z is the projection matrix of the instruments chosen by Team Dynamic. As already mentioned, let us assume that the time dimension is large. Hence, the Nickell problem may be disregarded such that using $P_Z = I_{nT}$ yields a sufficiently consistent estimator given the belief of Team Dynamic (Hsiao 2014). Using $W = I_T \otimes W_n$ and inserting the first-differenced reduced form of (1), the parameter bias of neglecting the spatial dimension is approximated by (see Appendix A)

$$\begin{aligned} \operatorname{plim}\left[\boldsymbol{\phi}_{TD} - \boldsymbol{\phi}_0\right] &\approx \lambda_0 \left(\tilde{\Gamma}'\tilde{\Gamma}\right)^{-1} \tilde{\Gamma}' W \tilde{\Gamma} \boldsymbol{\phi}_0 \\ &\approx \lambda_0 \left(\tilde{\Gamma}'\tilde{\Gamma}\right)^{-1} \left(\tilde{\Gamma}'\tilde{\Gamma} \odot \mathbf{M}\right) \boldsymbol{\phi}_0, \end{aligned} \tag{3}$$

where $\tilde{\Gamma} = P_Z \bar{\Gamma}$ and $\phi_0 = (\gamma_0, \beta_0)'$ captures the true parameter values.[2] The symmetric matrix $\mathbf{M}$ captures spatial correlation in the fashion of Moran's I. The off-diagonal values of $\mathbf{M}$ tend to zero as long as the covariate X remains exogenous, justifying the search for (quasi-) random assignments of covariates in the literature. In principle, one can also assume a non-spatial DGP for $\tilde{X} = P_Z \bar{X}$. The important characteristic, as in any dynamic model, is the strict exogeneity. Appendix A offers detailed derivations.

[2] Note that, in general, $\tilde{\Gamma}' W \bar{\Gamma} \neq \tilde{\Gamma}' W \tilde{\Gamma}$ even when P_Z and W are symmetric.

Because $\left(\tilde{\Gamma}'\tilde{\Gamma}\right)^{-1}$ is a concentration matrix, the elements η_{ij} are negative partial covariances, and diagonal elements η_i correspond to inverse residual variances of regressing all but one components of $\tilde{\Gamma}$ on the component of the corresponding row/column (Cox, Wermuth 1996). Under strict exogeneity, as spelled out, for example, in equation (D.4), these off-diagonal values will be zero unless the innovations in the DGP of $\tilde{X}$ are autocorrelated. The more complex case in which the covariate is not strictly exogenous is derived in Appendix A, equation (A.4), showing that potential 'cross-effects' might blur the main bias term as presented here. This case is further discussed in Section 5 and Appendix D.

Given these arguments, the approximated bias in both coefficients is easily derived as

$$\operatorname{plim}\left(\boldsymbol{\phi}_{TD} - \boldsymbol{\phi}_0\right) \approx \lambda_0 \begin{bmatrix} \gamma_0 \eta_{\tilde{Y}_-} \sigma^2_{\tilde{Y}_-} m_{\tilde{Y}_-} \\ \beta_0 \eta_{\tilde{X}} \sigma^2_{\tilde{X}} m_{\tilde{X}} \end{bmatrix}, \tag{4}$$

where σ^2 indicates a variance, $m_{\tilde{Y}_-} = \tilde{Y}_-' W \tilde{Y}_- / \tilde{Y}_-' \tilde{Y}_-$ is Moran's I of $\tilde{Y}_-$, $m_{\tilde{X}}$ similarly represents Moran's I of the covariate, and in accordance to above notation, $\tilde{Y}_- = P_Z \bar{Y}_-$. Hence, the sign of the bias of each coefficient, additionally to its own sign, depends on λ_0 and the spatial dependence in its corresponding DGP. As shown in Appendix B, the sign of $m_{\tilde{Y}_-}$ in (3) is determined solely by λ_0 under the common assumption $|\lambda_0|, |\gamma_0| \leq 1$. This consequence is that Team Dynamic will always overestimate the true value of γ_0 in absolute terms and give too much weight to the time dimension whenever the spatial dimension is important. In cases where time dependence is already large, Team Dynamic will become more likely to report non-stationarity when in fact the DGP may be stationary.

Note that the measure of spatial dependence in the covariate, $m_{\tilde{X}}$, is based on the spatial structure defined in the true DGP, W_n, by construction. As long as $m_{\tilde{X}} = \tilde{X}' W \tilde{X} / \tilde{X}' \tilde{X}$ is nil, the coefficient estimate β_{TD} will not be affected. In any other case, the sign of the bias is given by the sign of the product of λ_0 and β_0 or in short: $sgn(\beta_{TD} - \beta_0) = sgn(\lambda_0 \beta_0)$. Therefore, this distortion changes on a case-by-case basis. As usual, whenever the spatial lag is unimportant ($\lambda_0 = 0$), spatial heterogeneity in explanatory variables will not lead to biased estimates, as (3) clarifies.

Interestingly, these results are in line with evidence of omitting spatial lag terms in cross-sectional and non-dynamic panel models. Regarding the cross section, Pace, LeSage (2008) report that the coefficient estimate of the covariate will show an asymptotic bias when the spatial lag term is neglected if there is spatial dependence in both, the covariate as well as the regressand. The authors further report that this bias is increasing in either spatial dependence. Noticably, the results regarding panel models reported in Franzese Jr, Hays (2007) follow suit, and show the same pattern regardless of cross-sectional size or the number of observed periods. Appendix D, where the covariate is allowed to exhibit spatial and time dependence, shows that this is also the case here, as illustrated in Table D.3. Effects on marginal effects are further investigated in Section 5.

Team Spatial is confident that the data represents a spatial-autoregressive process and believes $\gamma_0 = 0$. Here, fixed-effects are concentrated out by a usual within-transformation and a tilde indicates this transformation. For practical purposes, one may consider the transformation proposed in Lee, Yu (2010a), which does not create time dependence in the disturbances. The bias of neglecting the time dimension is approximated analytically by comparing the likelihood estimators of a full model, indicated by superscripted '0', and the model chosen by Team Spatial, indicated by 'TS', as derived in Appendix A. Given the strict exogeneity assumption on X, the quasi maximum likelihood (QML) estimate is

Table 1: Bias directions

dependence		team	
space (λ_0)	*time* (γ_0)	*dynamic*	*spatial*
+	+	overestimates time	unclear
-	+	overestimates time	underestimates space

Note: Spatial and time dependence in the data generating process and bias of each research team – Team Dynamic estimating a dynamic panel model, and Team Spatial estimating a static spatial panel model, while the true model is a spatial dynamic panel model.

given by (Yu et al. 2008)

$$\lambda_{TS} \approx \frac{\sigma^2_{\tilde{Y}} - m_{\tilde{Y},\tilde{X}} \frac{\sigma^2_{\tilde{X},\tilde{Y}}}{\sigma^2_{\tilde{X}}}}{\sigma^2_{\tilde{Y}} m^{W^2}_{\tilde{Y}} + \frac{1}{nT}\mathrm{tr}(W^2) - \frac{\sigma^2_{\tilde{X},\tilde{Y}}}{\sigma^2_{\tilde{X}}}(m_{\tilde{Y},\tilde{X}})^2} \tag{5}$$

$$\beta_{TS} \approx \left(\sigma_{\tilde{X},\tilde{Y}}\left(1 - m_{\tilde{X},\tilde{Y}}\lambda_{TS}\right)\right)/\sigma^2_{\tilde{X}}, \tag{6}$$

where $m_{\tilde{Y},\tilde{X}} = m_{\tilde{X},\tilde{Y}} = \tilde{Y}'W\tilde{X}/\tilde{Y}'\tilde{X}$ and $m^{W^2}_{\tilde{Y}} = \tilde{Y}'W^2\tilde{Y}/\tilde{Y}'\tilde{Y}$. Denoting β_{TS} as a function of the estimate of the spatial parameter clarifies that whenever the spatial parameter is biased, then so is β_{TS}. Because inserting the reduced form DGP into equations (5) and (6) as in an omitted variable analysis does not seem constructive, another angle is pursued. To see the fault in neglecting the time dimension, consider the QML estimator $\hat{\lambda}^0_{QML}$ of the full model:

$$\lambda^0_{QML} \approx \frac{m_{\tilde{Y}}\sigma^2_{\tilde{Y}} - m_{\tilde{X},\tilde{Y}}\frac{\sigma^2_{\tilde{Y},\tilde{X}}}{\sigma^2_{\tilde{X}}} - m_{\tilde{Y},\tilde{Y}_-}\frac{\sigma^2_{\tilde{Y},\tilde{Y}_{-1}}}{\sigma^2_{\tilde{Y}}}}{\sigma^2_{\tilde{Y}} m^{W^2}_{\tilde{Y}} + \frac{1}{nT}\mathrm{tr}(W^2) - \frac{\sigma^2_{\tilde{Y},\tilde{X}}}{\sigma^2_{\tilde{X}}}(m_{\tilde{Y},\tilde{X}})^2 - (m_{\tilde{Y},\tilde{Y}_-})^2}, \tag{7}$$

where $m_{\tilde{Y},\tilde{Y}_-} = \tilde{Y}'W\tilde{Y}_-/\tilde{Y}'\tilde{Y}_-$ is defined accordingly. Note that the estimate β^0_{QML} is determined equally in the full model by inserting equation (7) into (6). If there is no co-variation between contemporary and time-lagged values, the two estimates coincide. If there is co-variation, estimates differ. While the difference in the nominator of eqs. (5) and (7) depends on the sign of the dependence, it is negative in the denominator. Hence, the sign of $\lambda_{TS} - \lambda^0_{QML}$ is not entirely clear. Whether the estimate suffers from upward or downward bias hinges on $m_{\tilde{Y},\tilde{Y}_-}$, which reflects spatial correlation between the contemporary and time-lagged values of the dependent variable which again only depends on λ_0. The direction of the bias is only clear in cases where the nominator increases.

Table 1 summarizes the findings so far. Because all analytical derivations are based on the approximation $A_n \approx I_n + \lambda_0 W_n$, the next section attempts to confirm the expectations built here by means of a Monte Carlo simulation. In other words, the tale of the two research teams will be told many times. Note that the approximation of the spatial multiplier is not used at any other stage of the manuscript unless explicitly stated otherwise.

4 Monte Carlo simulation

There is little reason to expect finding explosive spatial dynamic processes in economic reality, at least on the regional level. Therefore, Monte Carlo simulations apply to stable DGPs. The condition is that the absolute eigenvalues of $A_n\gamma_0$ need to be smaller than unity (Lee, Yu 2010b). Applying the first-order approximation of the matrix inverse to the reduced form of (1), the condition simplifies to $1 > |\gamma_0|\cdot(1 + |\lambda_0|)$. Because it is not feasible to cover the whole set of parameters that obey this restriction, a subset of combinations as described in Table 2 is used. The underlying spatial structure is

Table 2: Parameter combinations.

team	λ_0, step size	γ_0, step size	combinations
dynamic	[-0.60; 0.60], 0.15	[0; 0.80], 0.05	144
spatial	[-0.60; 0.60], 0.05	[0; 0.80], 0.20	125

Note: Parameter combinations of the simulated data generating process as given in equation (1) used for the corresponding calculation of the bias in parameters and marginal effects of the corresponding research team. λ_0 denotes spatial dependence, γ_0 represents time dependence.

given by 35 Austrian NUTS 3 regions. A smaller number of regions is preferable from a computational point of view, as the spatial weights matrix is increasing quadratically in the number of regions. The spatial weights matrix is based on the road distance between the central cities of each NUTS 3 region. Most frequently researchers use either inverse distance measures or contiguity schemes. Given that user-friendly packages to calculate distances accurately for a larger number of connections without cost exist for most statistics programs, distance appears a more natural approach. Using a maximum-row normalized spatial weights matrix based on these inverse distance measures, the DGP is simulated for 30 periods according to equation (1). Pre-estimation periods ensure independence of spurious existence or absence of spatial correlation through randomly assigned start values (Lee, Yu 2010a). Periods 31 to 60 are handed to the research teams.

Team Dynamic uses a GMM procedure in the spirit of Arellano, Bover (1995) provided in the *xtabond2* package for Stata (Roodman 2006). As discussed above, Team Spatial uses a QML approach based on Lee, Yu (2010a), provided in the *xsmle* package for Stata (Belotti et al. 2017).

X_{nt} is strictly exogenous and the coefficient β_0 is set to 0.75. As expected, β_{TD} is largely unaffected by omitting uncorrelated terms by virtue of its strict exogeneity. As indicated by equation (6) the bias in the coefficient estimate of Team Spatial (β_{TS}) increases with the bias in λ_{TS}.[3]

Since we are interested in the interplay of λ_0 and γ_0, simulations are run for different parameter combinations, summarized in table 2. Each combination is simulated 500 times. Hence, results are based on 134,500 runs. Due to the large amount of information, results are summarized graphically in figures 1 and 2.

In general, the expectations formed in the former section find strong support. Simulation results for Team Dynamic are in line with table 1. However, with negative spatial dependence, the bias in estimating the autoregressive parameter is smaller compared to cases with positive spatial dependence. Still, both situations show that the autoregressive parameter is overestimated for every combination of λ_0 and γ_0, and high values of autocorrelation are disproportionately vulnerable to neglecting the spatial dimension, as the bias appears to explode at a range of $\lambda_0 \approx 0.65$. This is an alarming result given that many dynamic processes in regional economics show high levels of autocorrelation.

Figure 2 describes the bias of Team Spatial in estimating λ_{TS}. As discussed in the previous section, an underestimation in the case of negative spatial dependence (and positive time dependence) could be expected, and finds support in the simulation results. Notably, this overestimation in absolute terms pertains to the case of positive spatial dependence, implying that the importance of space will always be overstated. As before, this bias is larger the more important the omitted dimension is. In many (regional) economic investigations the time dependence is large, and the results here make clear that the importance of spillovers is likely to be overstated in cases where the 'within-dynamics' are not accounted for. It has to be stressed that accounting for potentially spatial heterogeneous (time-invariant) fixed effects does not help to counter this problem. Anselin, Arribas-Bel (2013), looking into the ability of 'spatial fixed effects' to control for spatial dependence in cross-sectional models, conclude that such spatial fixed effects

[3]Graphs included in the supplementary material. The do.-files for running the simulations in Stata are provided as supplementary material. A shape-file containing Austrian NUTS3 regions can be found, for example, at https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data

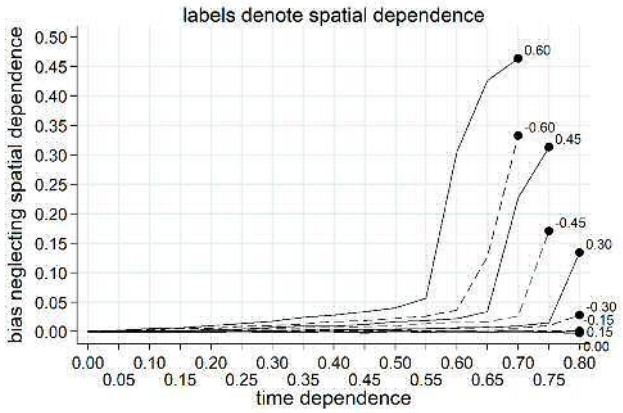

Figure 1: Bias of Team Dynamic neglecting the spatial dimension. The vertical axis describes $\gamma_{TD} - \gamma_0$, the horizontal axis depicts γ_0. Labels denote spatial dependence in the DGP (λ_0).

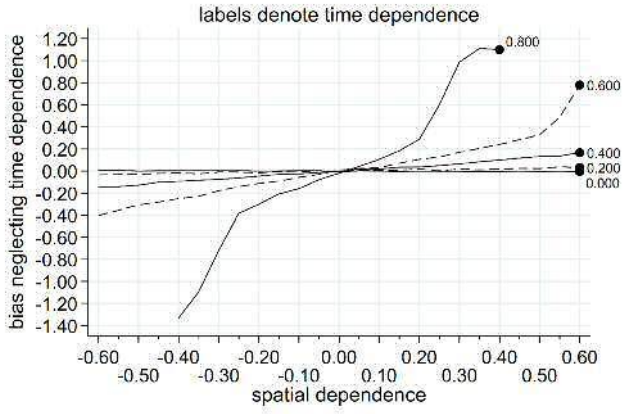

Figure 2: Bias of Team Spatial neglecting the time dimension. The vertical axis describes $\lambda_{TS} - \lambda_0$, the horizontal axis depicts λ_0. Labels denote spatial dependence in the DGP (γ_0).

might only filter out spatial dependence if there is no distance decay, implying group-wise dependencies. This argument may be extended to a panel set up, where such spatial-fixed effects would fall in line with panel-fixed effects. Hence, unless the true DGP features such group-wise structures, fixed effects do not suffice to account for spatial dependence.

Considerable effort has been given to (mis-)specification issues in spatial econometrics, and also in order to find empirical strategies to identify the underlying date generating processes (Florax et al. 2003, Anselin 2002, for example). As noted by Anselin (2010), typically one cannot differentiate between spatial heterogeneity and spatial dependence, an issue summarized as the inverse problem, closely related to Manski's reflection problem. Stressing these difficulties more rigorously, Gibbons, Overman (2012) suggest different strategies. First, one should aim at exploiting quasi-experimental set ups to pinpoint sources of exogenous variation. More importantly, the authors suggest using a reduced form spatial lag of X (SLX) approach to capture spatial dependence. This is a strategy that Team Dynamic might use, seeing that testing for spatial correlation in their residuals will most likely reject the null of no correlation. Graph E.2 demonstrates that this strategy does not relieve Team Dynamic of their bias completely, but attenuates it to a certain degree. Certainly, the extent to which WX is a 'good' replacement of WY in a reduced form depends on the explanatory power of the exogenous variable in determining Y.

In order to rule out that the results may be driven by the particular shape of Austria,

with a large longitudinal stretch (from 9.6 to 16.95 degrees) compared to latitudinal (from 46.53 to 48.82 degrees), the exercise is repeated using German NUTS 2 regions (see Figure E.1). Results of this robustness check are presented in Appendix E.

It can be expected that one will not find significant differences in marginal effects when comparing two estimates where one is based on maximum-row normalization and one is based on row-normalization, for example. While maximum-row normalization is used for representative convenience, row-normalization is the much-preferred specification in the literature. As LeSage, Pace (2014) argue, the correlation between spatial lag terms, for example W_nY_{nt}, based on two such spatial weights matrices that are themselves based on the same geographical information is shown to be very high. Therefore, it appears unlikely that any of the results, especially in terms of marginal effects of the covariate, differ due to the exact specification of W_n. Figure E.5 as well as Figure E.6 in Appendix E present simulation results using a row-normalized version of W_n, showing that this argument is indeed valid.

5 The marginal effect of the covariate

What if, instead of specifying the importance of time or space, the real interest lies in eliciting the effect of the covariate X? It does not suffice to compare parameter estimates, as both research teams assume different impact channels compared to the true DGP. In a similar vain, LeSage, Pace (2018) or Debarsy et al. (2012) argue that marginal effects should be the main target when comparing spatial econometric approaches in Monte Carlo studies, mainly because they are non-linear combinations of estimated parameters and often the main focus in applied research.[4] In order to elicit the respective marginal effects, differences in the assumed DGP need to be accounted for. In short, Team Spatial will not be able to differentiate between short- and long-run effects, and Team Dynamic will be unable to estimate indirect effects, the importance of feedback, and total effects. Therefore, it appears most appropriate to compare marginal effects of both teams with the corresponding correct ones.

The true marginal effects can be separated into direct, indirect, and total, and short-run or contemporaneous versus long-run or equilibrium effects. Regarding the short-run, they are based on the product of the coefficient and the spatial multiplier matrix:

$$\mathbf{y}_x^0 = \frac{\partial Y_{nt}}{\partial X_{nt}} = \beta_0 \left(I_n - \lambda_0 W_n\right)^{-1} \tag{8}$$

The direct marginal effect is calculated as the average diagonal element of $\mathbf{y}_x^0$ and the indirect effect is the average row sum of $\mathbf{y}_x^0$ excluding the diagonal element. The total effect follows as the sum of direct and indirect effects (LeSage, Pace 2009). Long-run or equilibrium effects are calculated accordingly using

$$\mathbf{y}_x^{0*} = \frac{\beta_0}{1-\gamma_0} \left(I_n - \varphi_0 W_n\right)^{-1}, \tag{9}$$

where $\varphi_0 = \lambda_0/(1-\gamma_0)$.

As discussed above, Team Dynamic is able to estimate β_0 without bias as long as $m_{\tilde{X}}$ is nil. Even though this assumption is unlikely to hold using observational data, it represents a case in which the covariate is assigned (quasi-)randomly. Because the team blocks out spatial interaction, it is only able to estimate a direct effect without any potential feedback captured in the spatial multiplier. Hence, the marginal short-run effect y_x^{TD} is simply β_{TS}. As such, one might expect an overestimation in the case of negative spatial dependence, and an underestimation otherwise, and that Team Dynamic is close to estimating the true direct effects as long as this feedback is small, implying $(1/n) \cdot \text{diag}(\mathbf{y}_x^0) l_n \approx \beta_0$ using the approximation of the spatial multiplier. As noted above, this approximation is more accurate for low to moderate values of λ_0. Formally, the bias

[4] It has to be noted that the focus of the authors' contribution is the precision of different estimation techniques in estimating marginal effects of covariates, instead of parameter estimates that have been the focus of earlier studies.

Table 3: Bias of marginal direct short- and long-run effects of Team Dynamic.

λ_0 \ γ_0	0.2	0.4	0.6	0.8
	PANEL A: DIRECT SHORT-RUN EFFECT			
-0.3	-0.005	-0.006	-0.004	0.000
0	-0.008	-0.008	-0.007	-0.006
0.3	-0.005	-0.005	-0.006	0.018
	PANEL B: DIRECT LONG-RUN EFFECT			
-0.3	0.001	0.001	0.005	0.108
0	0.000	-0.001	0.000	0.021
0.3	0.000	0.004	0.001	0.726

Note: Bias of Team Dynamic relative to corresponding marginal effects in the true model. λ_0 denotes spatial dependence, γ_0 represents time dependence.

of the marginal direct short-run effect is given by

$$y_x^{TD} - \frac{1}{n} l_n' \left(\text{diag}(\mathbf{y}_x^0)\right) l_n = \beta_{TD} - \frac{1}{n} l_n \left(\text{diag}\left(I_n' - \lambda_0 W_n\right)^{-1}\right) l_n \beta_0$$
$$= (\beta_{TD} - \beta_0) - \beta_0 \frac{1}{n} \sum_{k=1}^{\infty} l_n' \text{diag}(\lambda_0 W_n)^k l_n, \tag{10}$$

where the first term $(\beta_{TD} - \beta_0)$ may be labeled 'coefficient bias' and the latter term may accordingly be called the 'feedback bias'. Hence, even the coefficient estimate is unbiased, the feedback bias will lead Team Dynamic to a false marginal effect. With respect to long-run effects, the upward bias of Team Dynamic comes into play. Similarly to the short-run, the bias in the long-run direct effect can be separated into a coefficient bias and a feedback bias, where the autoregressive parameter enters directly. Formally, we get

$$y_x^{TD*} - \frac{1}{n} l_n' \left(\text{diag}(\mathbf{y}_x^{0*})\right) l_n =$$
$$\left(\frac{\beta_{TD}}{1-\gamma_{TD}} - \frac{\beta_0}{1-\gamma_0}\right) - \frac{\beta_0}{1-\gamma_0} \frac{1}{n} \sum_{k=1}^{\infty} l_n' \text{diag}(\frac{\lambda_0}{1-\gamma_0} W_n)^k l_n, \tag{11}$$

where $y_x^{TD*} = \beta_{TD}/(1-\gamma_{TD})$. In principle, the overestimation of the time-autoregressive parameter might counteract the absence of feedback channels. Hence, it might be possible that Team Dynamic gets close to the direct long-run effects, even though working with a misspecified model. On the other hand, given that spatial dependence is large enough such that the estimated autoregressive parameter is close to unity, unreasonably large or even perverted effects might result.

Table 3 clarifies that marginal direct short-run effects can indeed be estimated fairly well for moderate values of spatial dependence. Only for cases with positive spatial dependence and high autocorrelation the relative bias surpasses the 1% mark. Panel B displays the relative bias of marginal direct long-run effects, and shows a similar picture as figure 1. Because the bias in the short-run coefficient is quite small, most of the bias in the long-run coefficient is carried by the bias in the autoregressive parameter. As mentioned before, this bias is larger the larger the autoregressive component and the larger the spatial component. Indeed, the last column in panel B shows that the bias is substantial for negative spatial dependence, and becomes even larger with $\lambda_0 > 0$. In the extreme, the direct long-run effect has an average upward bias of approximately 73%.

Team Spatial can estimate direct, indirect and total marginal effects, but cannot differentiate between the short- and the long-run and will interpret marginal effects as equilibrium, hence long-run, effects. The bias in either marginal effect is based on the

Table 4: Bias of marginal direct and indirect long-run effects of Team Spatial

λ_0 / γ_0	-0.5	-0.25	0	0.25	0.5
	DIRECT LONG-RUN EFFECT				
0	-0.038	-0.038	-0.039	-0.039	-0.039
0.6	-0.652	-0.642	-0.639	-0.641	-0.673
	INDIRECT LONG-RUN EFFECT				
0	0.026	0.065	-0.004	-0.089	-0.053
0.6	-0.749	-0.824	0.038	-0.644	-0.833

Note: Bias of Team Spatial relative to the corresponding marginal effects in the true model. Column three ($\lambda_0 = 0$) of indirect long-run effects measures absolute bias because the true effect is nil. λ_0 denotes spatial dependence, γ_0 represents time dependence.

difference

$$\begin{aligned}\mathbf{y}_x^{TS} - \mathbf{y}_x^{0*} &= (I_n - \lambda_{TS} W_n)^{-1} \beta_{TS} - \frac{\beta_0}{1-\gamma_0} (I_n - \varphi_0 W_n)^{-1} \\ &= (\beta_{TS} - \frac{1}{1-\gamma_0}\beta_0) + \sum_{k=1}^{\infty} W_n^k \left(\lambda_{TS}^k \beta_{TS} - \lambda_0^k/(1-\gamma_0)^{k+1}\beta_0\right), \qquad (12)\end{aligned}$$

showing three potential sources. These are differences between the estimated spatial parameter λ_{TS} and the true one, differences between the estimated coefficient of the covariate β_{TS} and the true one, and the omission of the autoregressive component γ. Equation (6) clarifies that a random assignment of the covariate such that $m_{\tilde{X},\tilde{Y}}$ is nil will lead to an unbiased estimate β_{TS}. Similar to the argument for Team Dynamic, (quasi-) random assignment across space appears crucial. However, the omission of the autoregressive component will not relieve Team Spatial of its inability to measure correct direct, indirect, or total effects. The overestimation of the spatial parameter in absolute terms increases in λ_0 as shown in Figure 2, however, equation (12) shows that this might off-set the bias to a certain degree. The bias can be expected to be small for low levels of time dependence. Interestingly, LeSage, Pace (2018) mention that cases where the estimates of β and λ are negatively correlated may mitigate the bias in the marginal effect. On the other hand, they may also be aggravated (p.22). However, even with unbiased estimation, both direct and indirect long-run effects are likely downwardly biased because Team Spatial neglects the autoregressive multiplier $(1/1(-\gamma_0))$ entirely, which the overestimation of λ_{TS} is unlikely to make up for assuming typical parameter values. Table 4 presents simulation results for a situation with no autoregressive component and with a parameter γ_0 of 0.6. In line with the results of figure 2, the bias is larger when λ_0 is greater in absolute value.

To sum this section up, it has to be stressed that (quasi-) random assignment of the covariate turns out to be a central requirement for both teams. Only then, Team Dynamic will have a proper estimate of the direct short-run effect, but will likely overestimate the long-run effect given that the autoregressive parameter is bound to be overestimated. Team Spatial, even though possibly able to get a proper estimate of the coefficient of the covariate, will suffer from neglecting the autoregressive multiplier $(1/(1-\gamma_0))$.

6 Application: Cigarette demand

The openly available cigarette demand data used in Baltagi, Li (2004) for all landlocked US states is a standard data set that is frequently used to illustrate issues in spatial, dynamic, or spatial dynamic estimation methods, as in Kelejian, Piras (2017) or Debarsy et al. (2012), who demonstrate the interpretation and calculation of marginal effects in space-time models in the short- and long-run. It covers 30 years of cigarette sales per capita, the average price per pack, and the average income per capita. The spatial weights matrix used for this illustration is given by a queen-contiguity scheme. Thereby, cigarette sales are hypothesized to depend on the average price P per pack, the average price in

neighboring states, and the average income as exogenous determinants (Debarsy et al. 2012, Elhorst 2014, Kelejian, Piras 2017). Referring to the tale in Section 3, table (5) presents the estimation results of Team Dynamic, Team Spatial, and of a 'full' specification according to the DGP assumed in equation (1). The estimation of the full model is carried out using the estimator of Yu et al. (2008), which has already been used in previous Sections. The fixed effects specification can be expected to work well given that the data is available for the years 1963 to 1992. Recently, Jin et al. (2020) propose a quasi-maximum likelihood estimator in first differences for panels with a short time horizon that would potentially be vulnerable to the incidental parameter problem, which would otherwise represent a viable alternative estimator of the full model.

The observations that can be drawn are in line with the expectations formed above. With a large autoregressive component, the spatial lag is highly overestimated when the former component is neglected, as a comparison of columns three ('Team Spatial') and four ('full model') shows. Indeed, while remaining highly significant in the full specification, Team Spatial is bound to overestimate the spatial lag parameter fourfold. Further, with a small spatial component, the potential bias in estimating the time component is small. Both estimators of Team Dynamic are very close to the full model in terms of the autoregressive parameter.

With respect to the covariates, parameter estimates themselves are not meaningful. Rather, marginal effects as discussed in section 5 need to be compared. In order to illustrate this comparison, estimated marginal effects of the average price are presented in panel 2 of Table 5. For Team Dynamic, it can be seen that both short-run and long-run (direct) effects are similar to those of the fully specified model. This is unsurprising given that the spatial component is small such that the autoregressive parameter can be estimated fairly well and the spatial multiplier is small. Because Team Spatial misses the autoregressive component in calculating long-run effects, neither the direct nor the indirect effect are similar to those in the full specification and are underestimated quite substantially. The indirect effect even shows the opposite sign, pointing towards the structural misspecification.

Regarding the observations made above, it seems quite unlikely that $m_{\tilde{X},\tilde{Y}}$ is zero in this setting such that the bias of the spatial-autoregressive parameter is transferred to the coefficient of the average price per pack. Team Spatial interprets marginal effects as long-run elasticities by construction and consequently underestimates them.

Table C.1 in Appendix (C) discusses some further possible modeling choices of both research teams. Team Spatial may argue that time-fixed effects already capture the time dimension. Given that state-fixed effects account for differences in levels, time-fixed effects would 'catch' average dynamics. Compared to the column (3) in table 5, not including time-fixed effects indeed induces a larger estimate of the spatial lag parameter, as column (1) illustrates. On the other hand, Team Dynamic might follow up on the argument of Gibbons, Overman (2012) and use a reduced-form spatial lag of X model. As shown in column (2), this approach appears to work reasonably well in this case, as both the autoregressive and the coefficient of the price are almost identical to those in the full specification. Note that the SLX specification allows calculating direct and indirect effects, albeit assuming local spillovers that do not account for potential feedback loops. Alternatively, Team Dynamic might simply run a dynamic spatial error model (SEM) as proposed by Su, Yang (2015).[5] As discussed in LeSage, Pace (2009), if covariates are the source of spatial heterogeneity, the corresponding dynamic SEM can be rewritten as a dynamic spatial Durbin model, in which case the results are naturally very similar to those reported in column (4) in Table 5.[6]

7 Conclusions

In a time when geo-referenced data becomes more available and stretches across longer time periods, researchers are able to account for dependencies in both dimensions, space and time. The aim of this study is to give insights to the problems one can expect if

[5] Unfortunately, this estimator is not implemented in statistical software.

[6] The author thanks an anonymous reviewer for these remarks.

Table 5: Empirical illustration; dependent variable: log consumption per capita

	Team Dynamic		Team Spatial	*full model*
	(1) fixed effects	(2) bias corrected	(3) QML	(4) QML
Panel 1: estimated parameters				
time lag	0.832***	0.862***		0.867***
	(32.60)	(58.55)		(24.63)
spatial lag			0.210***	0.049***
			(9.24)	(2.88)
price	-0.296***	-0.277***	-1.001***	-0.264***
	(-8.50)	(-11.96)	(-9.05)	(-4.95)
income	0.114***	0.101***	0.467***	0.090***
	(3.06)	(3.81)	(4.17)	(3.73)
W · price	0.084	0.086**	0.096	0.159**
	(1.64)	(2.48)	(0.59)	(2.17)
R^2	0.86		0.68	0.90
Panel 2: marginal effect of price				
short run:				
direct	-0.296***	-0.277***		-0.262***
	(72.25)	(143.04)		(146.23)
indirect				0.152***
				(12.81)
total				-0.110**
				(5.80)
long run:				
direct	-1.765***	-2.004***	-1.006***	-1.942***
	(39.80)	(88.82)	(848.22)	(129.16)
indirect			-0.144**	0.685
			(4.24)	(2.61)
total			-1.150***	-1.257**
			(197.25)	(6.39)

Observations: 1334 (N=46, T=29). Column 'fixed effects' follows a least squares dummy variable estimation. Column 'bias corrected' indicates the dynamic panel bias correction advocated by Kiviet (1995). Columns 'QML' and 'QML full' present results of a (dynamic) fixed effects spatial autoregressive model as outlined in Yu et al. (2008), where the latter applies a bias correction. Robust t-statistics in parentheses in panel 'estimated parameters'. Test statistics in panel 'marginal effects' are all of Wald-type for matters of comparability. All specifications include year-fixed effects. Data can be downloaded, for example, at spatial-panels.com/software. All variables in logs. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

either one dimension is neglected. In order to illustrate the issue at hand, a tale of two research teams is told, each one being agnostic of one dimension. The results show that the neglected dimension projects onto the other, thereby biasing coefficient estimates, and subsequently tests, marginal effects, and predictions. Neither purely dynamic nor purely (static) spatial estimation approaches are able to estimate 'their side' of the data appropriately. Analytical approximations combined with simulation results show that the direction of these biases in spatial- and time-autoregressive parameters can be determined. Even though signs are correctly estimated, the importance of the remaining dimension is overstated. Investigations of spatial dynamic processes that neglect space are likely to report slower convergence speeds, are more likely to 'find' unit roots when in fact processes are stable, and will show severely biased long-run effects. These results are amplified for positive spatial dependence. These biases further work their way through to marginal effects of covariates, which are shown to be equally affected.

Likewise, estimates of spatial dependence without considering time can be severely biased upwards in absolute terms. In these cases, the role of spillovers is likely to be overestimated. Because partial adjustment is ruled out when the time dimension is denied, marginal effects are bound to be underestimated given that autocorrelation is large. Both cases offer a wide range of research questions that may be reassessed considering these pitfalls. A short application to real data supports these findings. While the sizes of simulated biases are conditional on the spatial structure and weights matrix, the signs are robust. Figures E.3 and E.4 in Appendix E display qualitatively identical simulation

results of Team Dynamic and Team Spatial using German NUTS 2 regions as underlying spatial structure. Further, Figures E.5 and E.6 clarify that the result is not dependent on the normalization of the spatial weights matrix.

In terms of methodological recommendations, several aspects are worth noting. First of all, practitioners should have sound theoretical foundations that would exclude either partial adjustment or spatial interaction. More often, practitioners have used dynamic rather than spatial models. In that sense, tests for spatial residual correlation should be done routinely in regional and urban economics applications to check for the presence of any kind of spatial interaction. Of course, this also holds for non-dynamic applications. Likewise, spatial panel applications should routinely check for autoregressive residuals by the same argument. Coming back to the argument of Gibbons, Overman (2012) and the reflection issue, a reduced form spatial dynamic approach might be preferred. As in most issues regarding identification, sources of exogenous variation are most crucial. In the words of the tale of Team Dynamic and Team Spatial, as so often, it would be beneficial for all to put their heads together.

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Appendix

A Approximation of biases

Team Dynamic runs two-stage least squares on first differences. The bias is determined by inserting the reduced form DGP for $\bar{y}$:

$$\boldsymbol{\phi}_{TD} - \phi_0 = \left(\tilde{\Gamma}'\tilde{\Gamma}\right)^{-1}\tilde{\Gamma}'\left[\left(I_{nT} - \lambda_0 W\right)^{-1}\left(\tilde{\Gamma}\phi_0 + \tilde{V}\right)\right] - \phi_0 \tag{A.1}$$

This is the point where the approximation of the spatial multiplier enters. Multiplying out and exogenous residual terms yields the desired result of equation (3). Under strict exogeneity and assuming well-behaved innovations $A_{nT} = \left(I_{nT} - \lambda_0(I_T \otimes W_n)\right)^{-1} \approx I_{nT} + \lambda_0 W$ as well as $P_Z = I_{nT}$,

$$\boldsymbol{\phi}_{TD} - \boldsymbol{\phi}_0 = \lambda_0\left(\tilde{\Gamma}'\tilde{\Gamma}\right)^{-1}\tilde{\Gamma}' W\tilde{\Gamma}\boldsymbol{\phi}_0 \tag{A.2}$$

With K right-hand side variables ($k = 1$ indicating the time lag, $k = 2$ the first exogenous variable, and so on), one gets

$$\mathbf{Q} \equiv \left(\tilde{\Gamma}'\tilde{\Gamma}\right)^{-1}\left[\tilde{\Gamma}'\tilde{\Gamma} \odot \mathbf{M}\right] = \begin{bmatrix} \sum_{j=1}^{K}\eta_{1j}\sigma_{j1}m_{j1} & \dots & \sum_{j=1}^{K}\eta_{1j}\sigma_{jk}m_{jk} \\ \sum_{j=1}^{K}\eta_{2j}\sigma_{j2}m_{j2} & \dots & \sum_{j=1}^{K}\eta_{2j}\sigma_{jk}m_{jk} \\ \vdots & \vdots & \vdots \\ \sum_{j=1}^{K}\eta_{Kj}\sigma_{j1}m_{j1} & \dots & \sum_{j=1}^{K}\eta_{Kj}\sigma_{jK}m_{jK} \end{bmatrix} \tag{A.3}$$

where σ_{ij} (η_{ij}) is the row i, column j element in $\tilde{\Gamma}'\tilde{\Gamma}$ ($(\tilde{\Gamma}'\tilde{\Gamma})^{-1}$). Hence, the approximated bias is given as

$$\text{plim}(\hat{\boldsymbol{\phi}} - \boldsymbol{\phi}_0) \approx \lambda_0\mathbf{Q}\boldsymbol{\phi}_0 = \lambda_0\begin{bmatrix} \sum_{k=1}^{K}\phi_{0,k}\sum_{j=1}^{K}\eta_{1j}\sigma_{jk}m_{jk} \\ \vdots \\ \sum_{k=1}^{K}\phi_{0,k}\sum_{j=1}^{K}\eta_{Kj}\sigma_{jk}m_{jk} \end{bmatrix} \tag{A.4}$$

Team Spatial estimates a spatial autoregressive model by QML. First consider a correctly specified model with first order conditions (Yu et al. 2008)

$$\tilde{\Gamma}'\tilde{V} = 0 \tag{A.5}$$

$$\tilde{Y}'W\tilde{V} - \text{tr}(G) = 0 \tag{A.6}$$

$$\tilde{V}'\tilde{V} = 0, \tag{A.7}$$

where $\tilde{\Gamma} = \left(\tilde{Y}_{-}, \tilde{X}\right)$, $\tilde{V} = (I - \lambda_0 W)\tilde{Y} - \tilde{\Gamma}\delta_0 = \tilde{Y} - \lambda_0 W\tilde{Y} - \tilde{\Gamma}\delta_0$, $G = W(I_{nT} - \lambda_0 W)^{-1}$, and $\delta_0 = \begin{bmatrix}\gamma_0 & \beta_0\end{bmatrix}'$. These conditions follow from the concentrated (within) likelihood function indicated by a tilde. The system of equations can easily be solved analytically by using the approximation of the spatial multiplier matrix in calculating the trace of G.

$$\text{tr}(G) = \text{tr}\left(W\left(I - \lambda_0 W\right)^{-1}\right) \approx \text{tr}\left(W\left(I + \lambda_0 W\right)\right) \approx \lambda_0\text{tr}(W^2). \tag{A.8}$$

Condition (A.7) yields and estimate of the error variance and is not important for the approximation of the bias. The problem thus boils down to solving the linear equation system given by conditions (A.5) and (A.6):

$$\begin{bmatrix} \tilde{Y}_{-}'W\tilde{Y} & \tilde{Y}_{-}'\tilde{Y}_{-} & \tilde{Y}_{-}'\tilde{X} \\ \tilde{X}'W\tilde{Y} & \tilde{X}'\tilde{Y}_{-} & \tilde{X}'\tilde{X} \\ \tilde{Y}'W^2\tilde{Y} + \text{tr}(W^2) & \tilde{Y}'W\tilde{Y}_{-} & \tilde{Y}'W\tilde{X} \end{bmatrix}\begin{bmatrix}\hat{\lambda} \\ \hat{\gamma} \\ \hat{\beta}\end{bmatrix} \approx \begin{bmatrix} \tilde{Y}_{-}'\tilde{Y} \\ \tilde{X}'\tilde{Y} \\ \tilde{Y}'W\tilde{Y} \end{bmatrix} \tag{A.9}$$

Since all variables are demeaned, one can rewrite the problem in terms of (co-)variances, reflecting the notion of variance decomposition. According to the DGP defined above,

$\text{plim}(X'Y_-) = 0$. The resulting estimates are thus

$$\hat{\lambda}^0_{QML} \approx \frac{m_{\tilde{Y}}\sigma^2_{\tilde{Y}} - m_{\tilde{X},\tilde{Y}}\frac{\sigma^2_{\tilde{Y},\tilde{X}}}{\sigma^2_{\tilde{X}}} - m_{\tilde{Y},\tilde{Y}_-}\frac{\sigma^2_{\tilde{Y},\tilde{Y}_{-1}}}{\sigma^2_{\tilde{Y}}}}{\sigma^2_{\tilde{Y}}m^{W^2}_{\tilde{Y}} + \frac{1}{nT}\text{tr}(W^2) - \frac{\sigma^2_{\tilde{Y},\tilde{X}}}{\sigma^2_{\tilde{X}}}(m_{\tilde{Y},\tilde{X}})^2 - (m_{\tilde{Y},\tilde{Y}_-})^2} \tag{A.10}$$

$$\beta^0_{QML} \approx \frac{\sigma_{\tilde{Y},\tilde{X}}\left(1 - \hat{\lambda}^0_{QML}m_{\tilde{X},\tilde{Y}}\right)}{\sigma^2_{\tilde{X}}} \tag{A.11}$$

$$\gamma^0_{QML} = \frac{\sigma_{\tilde{Y},\tilde{Y}_{-1}}\left(1 - \hat{\lambda}^0_{QML}m_{\tilde{Y},\tilde{Y}_-}\right)}{\sigma^2_{\tilde{Y}}} \tag{A.12}$$

Team Spatial uses the same QML estimator under the assumption that $\gamma_0 = 0$. Hence the system of equations is given by

$$\begin{bmatrix} \tilde{X}'W\tilde{Y} & \tilde{X}'\tilde{X} \\ \tilde{Y}'W^2\tilde{Y} + \text{tr}(W^2) & \tilde{Y}'W\tilde{X} \end{bmatrix} \begin{bmatrix} \lambda_0 \\ \beta_0 \end{bmatrix} \approx \begin{bmatrix} \tilde{X}'\tilde{Y} \\ \tilde{Y}'W\tilde{Y} \end{bmatrix} \tag{A.13}$$

The solution follows immediately as

$$\lambda_{TS} = \frac{\sigma^2_{\tilde{Y}}m_{\tilde{Y}} - m_{\tilde{Y},\tilde{X}}\frac{\sigma^2_{\tilde{X},\tilde{Y}}}{\sigma^2_{\tilde{X}}}}{\sigma^2_{\tilde{Y}}m^{W^2}_{\tilde{Y}} + \frac{1}{nT}\text{tr}(W^2) - \frac{\sigma^2_{\tilde{X},\tilde{Y}}}{\sigma^2_{\tilde{X}}}(m_{\tilde{Y},\tilde{X}})^2} \tag{A.14}$$

$$\beta_{TS} = \frac{\sigma_{\tilde{X},\tilde{Y}}\left(1 - m_{\tilde{X},\tilde{Y}}\lambda_{TS}\right)}{\sigma^2_{\tilde{X}}} \tag{A.15}$$

The result in equation (5) follows for $\sigma^2_{\tilde{Y}} = 1$.

B The sign of Moran's I

The MA(∞) representation of the DPG is given by

$$Y_{nt} = \gamma_0^t A_n^t Y_{n0} + \sum_{\tau=0}^{t} \gamma_0^\tau A_n^{\tau+1}\left(X_{n,t-\tau}\beta_0 + V_{n,t-\tau}\right) \tag{B.1}$$

For $\gamma_0 < 1$, the first term will vanish. Moran's I of the sample is the sum of the yearly values (divided by the square sum of the sample). For period t:

$$\begin{aligned} Y'_{nt}W_nY_{nt} = &\left(\sum_{\tau=0}^{t} \gamma_0^\tau A_n^{\tau+1}\left(X_{n,t-\tau}\beta_0 + V_{n,t-\tau}\right)\right)' W_n \\ &\left(\sum_{\tau=0}^{t} \gamma_0^\tau A_n^{\tau+1}\left(X_{n,t-\tau}\beta_0 + V_{n,t-\tau}\right)\right) \end{aligned} \tag{B.2}$$

assuming that cross-time values are nil we can rewrite

$$\begin{aligned} Y'_{nt}W_nY_{nt} = &\sum_{\tau=0}^{t} \gamma_0^{2\tau}\left(\beta_0^2 X'_{n,t-\tau}\left(A_n^{\tau+1}\right)'W_nA_n^{\tau+1}X_{n,t-\tau}\right. \\ &\left. + V'_{n,t-\tau}\left(A_n^{\tau+1}\right)'W_nA_n^{\tau+1}V_{n,t-\tau}\right) = \sum_{\tau=0}^{t} \gamma_0^{2\tau}\mathcal{M}_\tau \end{aligned} \tag{B.3}$$

Hence, $\text{plim}(Y'_{nt}W_nY_{nt}) = \text{plim}\sum_{\tau=0}^{t}\gamma_0^{2\tau}\mathcal{M}_\tau$ and γ_0 and β_0 cannot influence the sign. Using the approximation of the spatial multiplier matrices for the DGPs of Y and X, for

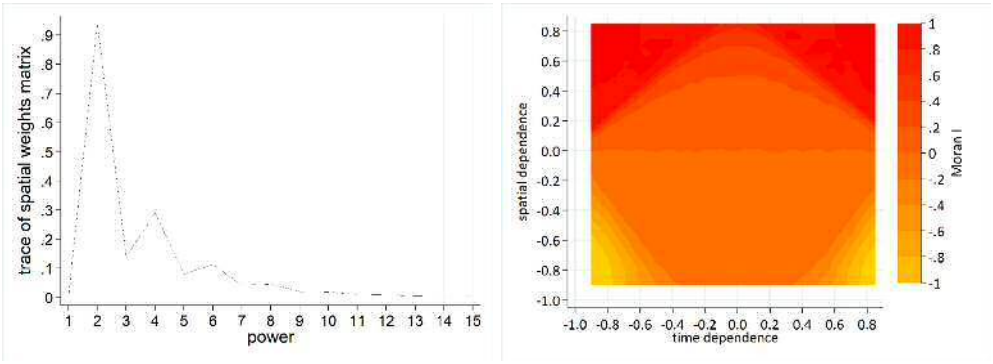

Figure B.1: Trace of powers of the spatial weights matrix (left) and simulated Moran's I values (right).

$\tau = 0$ it follows:

$$\begin{aligned}\mathcal{M}_0 \approx \beta_0^2 \big[&\sigma_\varepsilon \alpha_0 \left(2\mathrm{tr}(W_n^2) + \alpha_0 \mathrm{tr}(W_n^3)\right) + \\ &+ 2\lambda_0 \left(\sigma_\varepsilon^2 \alpha_0 \left(2\mathrm{tr}(W_n^3) + \alpha_0 \mathrm{tr}(W_n^4)\right) + \sigma_\varepsilon^2 \mathrm{tr}(W_n^2)\right) \\ &+ \lambda_0^2 \left(\sigma_\varepsilon^2 \alpha_0 \left(2\mathrm{tr}(W_n^4) + \alpha_0 \mathrm{tr}(W_n^5)\right) + \sigma_\varepsilon^2 \mathrm{tr}(W_n^3)\right)\big] \\ &+ \lambda_0 \sigma^2 \left(2\mathrm{tr}(W_2) + \lambda_0 \mathrm{tr}(W_n^3)\right)\end{aligned} \tag{B.4}$$

Evidently, it is difficult to get more insight by investigating the terms $\mathcal{M}_\tau$ in approximation. For $\alpha_0 = 0$, the term is greatly simplified to

$$\mathcal{M}_0 \approx \lambda_0 \sigma_\varepsilon^2 \beta_0^2 \left(2\mathrm{tr}(W_n^2) + \lambda_0 \mathrm{tr}(W_n^3)\right) + \lambda_0 \sigma^2 \left(2\mathrm{tr}(W_n^2) + \lambda_0 \mathrm{tr}(W_n^3)\right) \tag{B.5}$$

The symmetry of W_n implies $\mathrm{tr}(W_n^k) = \sum_{i=1}^n e_i^k$, where e_i is an eigenvalue of W_n. Since all eigenvalues are within the unit circle, $\max\limits_{k \ \epsilon \ N} \mathrm{tr}(W_n^k) = \mathrm{tr}(W_n^2)$ (figure B.1, left). Even though one might assume that $\mathcal{M}_0$ dominates and that by $2\mathrm{tr}(W_n^2) + \lambda_0 \mathrm{tr}(W^3) > 0$ the sign is determined by λ_0, figure B.1 (right) confirms that indeed the sign of λ_0 determines the sign of Moran's I.

C Cigarette Demand: Further Specifications

Table C.1: Empirical illustration – Alternative specifications; dependent variable: log consumption

	Team Spatial	Team Dynamic			*full model*
	(1) LSDV	(2) No Space	(3) DSLX	(4) DSEM	(5)
Panel 1: estimated parameters					
time lag		0.858**	0.861***	0.865***	0.867***
		(57.33)	(58.42)	(65.04)	(24.63)
spatial lag	0.321***			0.049***	
	(11.06)			(2.88)	
price	-0.938***	-0.270***	-0.278***	-0.266***	-0.264***
	(-24.02)	(-11.72)	(-12.20)	(-13.19)	(-4.95)
income	0.348***	0.092***	0.109**	0.100***	0.090***
	(17.85)	(3.55)	(3.15)	(4.16)	(3.73)
W · price	0.476***		0.083**	0.170**	0.159**
	(10.33)		(2.34)	(3.66)	(2.17)
W · income			-0.020	-0.022	
			(-0.49)	(-0.87)	
spatial time lag				-0.015	
				(-0.29)	
Panel 2: marginal effect of log price					
short-run direct		-0.270***	-0.278***	-0.262***	-0.262***
		(-11.72)	(-12.20)	(-11.48)	(-12.09)
short-run indirect			0.083**	0.160***	0.152***
			(2.34)	(3.49)	(12.81)
long-run direct	-0.965***	-1.900***	-1.992***	-1.931***	-1.942***
	(-22.91)	(9.35)	(9.64)	(-9.59)	(-11.36)
long-run indirect	-0.420***		0.594**	0.610	0.685
	(-7.22)		(2.32)	(0.98)	(1.62)
time-fixed effects	No	Yes	Yes	Yes	Yes

Observations: 1334 (N=46, T=29). Robust t-statistics in parentheses in both panels. Test statistics in panel 'marginal effects' are all of Wald-type for matters of comparability. All specifications except column (1) include year-fixed effects. Column (1) estimates a least squares dummy variable model, outputs in columns (2) and (3) based on dynamic panel bias correction advocated by Kiviet (1995). Column (4) would ideally be estimated in the line of Su, Yang (2015), which is unfortunately not implemented in any (known to the author) statistics program. Results in column(4) replicated from Elhorst (2014) (p.114). Columns (4) and (5) use the estimator proposed by Yu et al. (2008). All variables in logs. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

D Spatial dynamic covariate

Let X_{nt} be generated as

$$X_{nt} = \psi_0 X_{n,t-1} + \alpha_0 W_n X_{nt} + \varepsilon_{nt} = (I_n - \alpha_0 W_n)^{-1} (\psi_0 X_{n,t-1} + \varepsilon_{nt}), \tag{D.1}$$

where ε_{nt} are independently and identically distributed random draws, α_0 represents spatial dependence, and parameter ψ_0 represents autocorrelation. Because all derivations above are conditional on within-transformed data, it is reasonable to assume a DGP like this for the transformed covariate. The assumption that there is a common spatial weights matrix W_n that reflects spatial linkages is most frequently used, in applied as well as theoretical work. In this section, we stick to this tradition. In principle one would be able to define different weight matrices for the spatial lag of the dependent variable and the DGP of the covariate. Besides having to bear additional notational burden of different weight matrices, there is very good reason to rely on one representation of space. As LeSage, Pace (2014) argue, spatial weights matrices are likely highly positively correlated.

Similar the equation (B.1), one can characterize the DGP of the covariate equally as

$$\begin{aligned} X_{nt} &= \psi_0^t A_{x,n}^t X_{n,0} + \sum_{\tau=0}^{t} \psi_0^\tau A_{x,n}^{\tau+1} \varepsilon_{n,t-\tau} \\ A_{x,n} &= (I_n - \alpha_0 W_n)^{-1} \end{aligned} \tag{D.2}$$

implying that the state of the covariate depends on its initial or start values, the start values of all other units, and all past residual terms, own and of all other units. For $\psi_0 < 1$, the first term will disappear. This gives rise to the same result as in Appendix B, stating that, indeed, α_0 governs the sign of spatial correlation of X.

Two additional parameters and the reduced form DGP of X greatly increase the difficulty in deriving approximations of the bias of the teams. For example, the approximated bias of Team Dynamic, as given in equation (A.4), in a set up with one covariate is given by

$$\text{plim}(\hat{\boldsymbol{\phi}} - \boldsymbol{\phi}_0) \approx \lambda_0 \mathbf{Q} \boldsymbol{\phi}_0 = \lambda_0 \begin{bmatrix} \gamma_0 \left(\eta_{\tilde{Y}_-} \sigma^2_{\tilde{Y}_-} m_{\tilde{Y}_-} \right) + \beta_0 \left(\eta_{\tilde{X},\tilde{Y}_-} \sigma_{\tilde{X},\tilde{Y}_-} m_{\tilde{X},\tilde{Y}_-} \right) \\ \gamma_0 \left(\eta_{\tilde{X},\tilde{Y}_-} \sigma_{\tilde{X},\tilde{Y}_-} m_{\tilde{X},\tilde{Y}_-} \right) + \beta_0 \left(\eta_{\tilde{X}} \sigma^2_{\tilde{X}} m_{\tilde{X}} \right) \end{bmatrix} \tag{D.3}$$

Whereas term $m_{\tilde{X},\tilde{Y}_-}$ can be considered nil in the case of random assignment, this is not the case in this setting, as all random draws $\varepsilon_{n,0}$ to $\varepsilon_{n,t-1}$ affect both $\tilde{X}$ as well as $\tilde{Y}_-$. This implies further that $\tilde{X}_{nt}$ and $\tilde{Y}_{n,t-1}$ are in fact collinear, rendering $\eta_{\tilde{X},\tilde{Y}_-}$ and $\sigma_{\tilde{X},\tilde{Y}_-}$ nonzero. Hence, it appears quite unpromising to pursue further approximations, as potentially all parameters $(\gamma_0, \lambda_0, \alpha_0, \psi_0, \beta_0)$ may play a direct or indirect role in determining the bias in either estimate of Team Dynamic. The same argument can be applied to the approximated bias of Team Spatial.

In cases where $\psi_0 = 0$, equations (1) and (D.1) imply that the off-diagonal values of $\mathbf{M}$ $(m_{i,\neq i})$ tend to zero as long as innovations ε are not autocorrelated. Formally, the condition is given by

$$\text{plim} \left(\left[(I - \lambda_0 W)^{-1} (I - \alpha_0 W)^{-1} \varepsilon_{n,t-1} \right]' (I - \alpha_0 W)^{-1} \varepsilon_{nt} \right) = 0, \tag{D.4}$$

which holds by the *i.i.d.* assumption.

Simulation results of several possible cases are presented in the tables below, with results as discussed in the following two paragraphs.

Autoregressive Parameters The main conclusions remain for both teams. Team Dynamic will overestimate γ_0, and more so the larger spatial dependence (λ_0) in absolute value. Comparing positive and negative values of spatial dependence, the bias is smaller at the latter. For lower values of γ_0, autocorrelation in the covariate $(\psi_0 > 0)$ appears to

aggravate this bias, and also spatial depedence in the covariate (α_0) has a positive impact on the bias. This is shown in in Table D.2.

Regarding Team Spatial, Table D.5 reveals that the bias in estimating λ_0 is, as above, increasing in γ_0 in absolute terms conditional on α_0 and ψ_0. For a given parameterization of the DGP of Y_{nt}, interesting insights appear, however. First, the bias in increasing in ψ_0. Thus, it is possible that the sign of the bias may even change sign, even though this possibility seems confined to cases where the DGP of the dependent variable itself is highly autocorrelated. Similar to Team Dynamic, spatial dependence in the covariate seems to positively affect this bias. It has to be stressed, however, that the main effect is determined by λ_0 and γ_0 for both teams.

Marginal effect of the covariate As in the main text, Team Dynamic is able to measure direct long- and short-run effects *without* feedback, while Team Spatial interprets marginal effects as equilibrium effects without considering the time dimension. Because team *dynamic* misses feedback effects, it could be expected that the short-run marginal effect is more prone to underestimation the larger the potential for such feedbacks, indicated by large values of λ_0. This is indeed the case, and seems to be more pronounced the larger the autocorrelation (ψ_0) in the covariate. However, results show a slight overestimation for $\psi_0 = 0$ at high values of autocorrelation and positive spatial dependence in the dependent variable, as shown in Table D.3. The effect of α_0 seems limited, but suggest a shift of the bias, where the direction is given by the sign of λ_0

As in the main text, the balance between missing feedbacks and an overestimation of the auotregressive parameter plays a crucial role in the long-run. Table D.4 presents the result for varying parameter constellations in the DGP of the covariate, and shows that this interplay is influenced significantly. For example, while the long-run direct effect is slightly underestimated for $\gamma_0 = 0.4$, $\lambda_0 = 0.6$, $\alpha_0 = -0.3$, it turns out to be *over*estimated when α_0 is nil or positive. Autocorrelation in the covariate aggrevates the bias in either case.

Team spatial is most likely to underestimate equilibrium effects of the covariate due to the omission of the time dimension, and this finds strong support in Table D.6 and Table D.7. In the case of direct marginal effects in Table D.6, one can conclude that spatial correlation in the covariate has no visible effect on the bias, while autocorrelation $\psi_0 > 0$ of the covariate tends to dampen this bias mildly. Regarding indirect effects, as presented in Table D.7, this result remains unchanged with the exception that the sign of α_0 determines the sign of the bias when the DGP of the dependent variable in fact features no spatial dependence.

Table D.2: Bias of Team Dynamic – autoregressive parameter.

ψ_0 →		0			0.3			0.6		
α_0 →		-0.3	0	0.3	-0.3	0	0.3	-0.3	0	0.3
γ_0	λ_0									
0.00	-0.60	0.000	0.001	0.000	0.006	0.002	0.000	0.013	0.007	0.004
0.00	-0.30	0.001	-0.002	0.001	0.003	0.001	0.001	0.003	0.003	-0.001
0.00	0.00	0.000	0.000	-0.001	0.000	0.001	0.000	0.000	0.000	0.000
0.00	0.30	0.000	0.000	-0.001	-0.001	0.002	0.001	0.002	0.002	0.006
0.00	0.60	0.002	0.002	0.000	0.001	0.004	0.009	0.001	0.008	0.025
0.40	-0.60	0.021	0.016	0.011	0.027	0.020	0.016	0.049	0.028	0.018
0.40	-0.30	0.006	0.001	0.000	0.008	0.004	0.002	0.013	0.005	0.000
0.40	0.00	0.000	0.001	-0.001	0.000	0.001	0.000	0.001	-0.002	0.000
0.40	0.30	-0.001	0.003	0.004	0.001	0.006	0.007	0.002	0.010	0.017
0.40	0.60	0.020	0.027	0.035	0.021	0.032	0.051	0.029	0.049	0.098
0.80	-0.30	0.031	0.032	0.031	0.033	0.029	0.027	0.045	0.027	0.019
0.80	0.00	0.002	0.001	0.002	0.001	0.002	0.001	0.001	0.001	0.001
0.80	0.30	0.140	0.144	0.141	0.132	0.121	0.131	0.119	0.113	0.117

Note: Bias of the estimated autoregressive parameter γ_{TD} of Team Dynamic relative to the corresponding parameter in the true model. λ_0 and γ_0 represent spatial and time dependence in the DPG of the dependent variable Y, α_0 and ψ_0 represent spatial and time dependence in the DPG of the covariate X. Bias in absolute terms whenever $\gamma_0 = 0$.

Table D.3: Bias of Team Dynamic – direct short-run marginal effect of covariate.

ψ_0 →		0			0.3			0.6		
α_0 →		-0.3	0	0.3	-0.3	0	0.3	-0.3	0	0.3
γ_0	λ_0									
0.00	-0.60	0.010	0.000	-0.010	0.011	0.000	-0.012	0.009	-0.002	-0.020
0.00	-0.30	0.005	0.000	-0.003	0.007	0.001	-0.008	0.003	0.000	-0.007
0.00	0.00	0.000	0.001	0.003	-0.001	0.000	0.000	0.000	0.000	0.001
0.00	0.30	-0.003	0.000	0.005	-0.004	-0.001	0.008	-0.008	-0.002	0.005
0.00	0.60	-0.013	-0.001	0.018	-0.014	-0.002	0.016	-0.015	-0.005	0.009
0.40	-0.60	0.012	-0.001	-0.010	0.007	-0.003	-0.018	-0.005	-0.013	-0.028
0.40	-0.30	0.005	0.000	-0.004	0.003	0.000	-0.006	0.004	-0.001	-0.009
0.40	0.00	-0.001	0.001	-0.001	-0.002	-0.002	0.001	0.000	0.000	0.000
0.40	0.30	-0.004	-0.001	0.006	-0.006	-0.001	0.005	-0.011	-0.005	0.006
0.40	0.60	-0.011	0.001	0.016	-0.018	-0.005	0.008	-0.032	-0.024	-0.022
0.80	-0.30	0.007	0.006	0.001	0.005	-0.001	-0.009	-0.014	-0.014	-0.027
0.80	0.00	0.002	0.000	0.002	0.001	-0.001	0.002	-0.002	0.001	0.001
0.80	0.30	0.020	0.022	0.028	-0.019	-0.014	-0.007	-0.082	-0.068	-0.057

Note: Bias of the estimated direct short-run effect of Team Dynamic relative to the one in the true model. λ_0 and γ_0 represent spatial and time dependence in the DPG of the dependent variable Y, α_0 and ψ_0 represent spatial and time dependence in the DPG of the covariate X.

Table D.4: Bias of Team Dynamic – Long-run marginal effect of covariate.

ψ_0 →		0			0.3			0.6		
α_0 →		-0.3	0	0.3	-0.3	0	0.3	-0.3	0	0.3
γ_0	λ_0									
0.00	-0.60	0.011	0.002	-0.009	0.017	0.002	-0.012	0.022	0.005	-0.016
0.00	-0.30	0.006	-0.001	-0.002	0.010	0.002	-0.007	0.006	0.003	-0.007
0.00	0.00	0.000	0.001	0.002	0.000	0.001	0.000	-0.001	0.001	0.001
0.00	0.30	-0.003	0.000	0.003	-0.005	0.001	0.010	-0.007	0.000	0.011
0.00	0.60	-0.011	0.001	0.018	-0.013	0.003	0.025	-0.014	0.003	0.036
0.40	-0.60	0.028	0.006	-0.012	0.033	0.010	-0.012	0.062	0.014	-0.019
0.40	-0.30	0.011	-0.001	-0.007	0.013	0.003	-0.006	0.022	0.004	-0.013
0.40	0.00	0.000	0.002	-0.002	-0.001	0.000	0.001	0.002	-0.002	0.001
0.40	0.30	-0.009	0.000	0.009	-0.010	0.004	0.012	-0.012	0.008	0.031
0.40	0.60	-0.011	0.013	0.044	-0.017	0.014	0.065	-0.017	0.029	0.138
0.80	-0.30	0.099	0.106	0.101	0.100	0.069	0.043	0.170	0.024	-0.035
0.80	0.00	0.017	0.008	0.017	0.006	0.010	0.011	0.005	0.009	0.005
0.80	0.30	0.691	0.655	1.506	0.008	-0.107	0.054	-0.507	-0.511	-0.460

Note: Bias of the estimated direct long-run effect of Team Dynamic relative to the one in the true model. λ_0 and γ_0 represent spatial and time dependence in the DPG of the dependent variable Y, α_0 and ψ_0 represent spatial and time dependence in the DPG of the covariate X.

Table D.5: Bias of Team Spatial – spatial-autoregressive parameter.

ψ_0 →		0			0.3			0.6		
α_0 →		-0.3	0	0.3	-0.3	0	0.3	-0.3	0	0.3
γ_0	λ_0									
0.00	-0.60	0.018	-0.003	0.006	-0.006	0.007	0.013	0.005	0.003	0.003
0.00	-0.30	0.003	-0.004	-0.001	-0.007	0.000	0.007	-0.005	-0.001	-0.007
0.00	0.00	-0.006	0.008	-0.008	-0.006	-0.007	0.004	0.002	-0.003	-0.005
0.00	0.30	-0.003	-0.008	-0.006	-0.011	0.000	-0.006	-0.003	-0.001	-0.003
0.00	0.60	-0.010	-0.005	-0.008	-0.006	-0.003	-0.008	-0.015	-0.006	-0.011
0.40	-0.60	-0.194	-0.153	-0.094	-0.267	-0.202	-0.133	-0.363	-0.260	-0.149
0.40	-0.30	-0.114	-0.062	-0.026	-0.173	-0.102	-0.007	-0.251	-0.122	-0.012
0.40	0.00	-0.047	-0.006	0.051	-0.088	-0.003	0.079	-0.129	-0.010	0.113
0.40	0.30	0.015	0.069	0.116	0.021	0.079	0.167	0.002	0.121	0.247
0.40	0.60	0.119	0.167	0.203	0.147	0.209	0.271	0.182	0.261	0.367
0.80	-0.30	-0.737	-0.708	-0.648	-0.786	-0.653	-0.583	-0.928	-0.670	-0.384
0.80	0.00	-0.199	-0.063	0.140	-0.259	-0.013	0.241	-0.399	-0.015	0.405
0.80	0.30	0.981	1.004	1.006	0.956	0.922	0.985	0.914	0.931	0.964

Note: Bias of the estimated spatial-autoregressive parameter λ_{TS} of Team Dynamic relative to the corresponding parameter in the true model. λ_0 and γ_0 represent spatial and time dependence in the DPG of the dependent variable Y, α_0 and ψ_0 represent spatial and time dependence in the DPG of the covariate X. Bias in absolute terms whenever $\lambda_0 = 0$.

Table D.6: Bias of Team Spatial – marginal direct long-run effect.

ψ_0 →		0			0.3			0.6		
α_0 →		-0.3	0	0.3	-0.3	0	0.3	-0.3	0	0.3
γ_0	λ_0									
0.00	-0.60	0.000	0.000	0.000	0.000	0.000	-0.001	0.001	0.002	-0.001
0.00	-0.30	0.000	0.001	0.002	0.002	0.000	-0.002	-0.002	0.001	0.001
0.00	0.00	0.000	0.000	0.002	-0.001	0.000	0.000	-0.001	0.000	0.000
0.00	0.30	0.002	0.000	-0.001	0.001	-0.001	0.002	-0.001	-0.001	0.000
0.00	0.60	-0.003	-0.003	0.003	-0.003	-0.001	0.000	0.000	-0.001	-0.002
0.40	-0.60	-0.426	-0.425	-0.424	-0.351	-0.350	-0.349	-0.249	-0.250	-0.251
0.40	-0.30	-0.416	-0.416	-0.415	-0.343	-0.341	-0.339	-0.240	-0.240	-0.244
0.40	0.00	-0.415	-0.414	-0.414	-0.338	-0.340	-0.340	-0.240	-0.242	-0.241
0.40	0.30	-0.416	-0.415	-0.417	-0.341	-0.340	-0.341	-0.244	-0.242	-0.243
0.40	0.60	-0.431	-0.430	-0.431	-0.356	-0.355	-0.355	-0.258	-0.258	-0.254
0.80	-0.30	-0.842	-0.841	-0.839	-0.801	-0.800	-0.796	-0.720	-0.721	-0.720
0.80	0.00	-0.824	-0.823	-0.823	-0.778	-0.777	-0.778	-0.692	-0.689	-0.689
0.80	0.30	-0.975	-0.975	-0.975	-0.969	-0.970	-0.970	-0.957	-0.958	-0.959

Note: Bias of the estimated direct long-run effect of Team Spatial relative to the one in the true model. λ_0 and γ_0 represent spatial and time dependence in the DPG of the dependent variable Y, α_0 and ψ_0 represent spatial and time dependence in the DPG of the covariate X.

Table D.7: Bias of Team Spatial – marginal indirect long-run effect.

ψ_0 →		0			0.3			0.6		
α_0 →		-0.3	0	0.3	-0.3	0	0.3	-0.3	0	0.3
γ_0	λ_0									
0.00	-0.60	-0.027	0.005	-0.009	0.009	-0.011	-0.021	-0.006	-0.002	-0.005
0.00	-0.30	-0.011	0.012	0.004	0.024	0.000	-0.022	0.012	0.006	0.022
0.00	0.00	-0.001	0.002	-0.002	-0.001	-0.001	0.001	0.000	-0.001	-0.001
0.00	0.30	-0.008	-0.029	-0.024	-0.040	0.000	-0.021	-0.012	-0.004	-0.012
0.00	0.60	-0.025	-0.014	-0.014	-0.017	-0.008	-0.017	-0.033	-0.013	-0.026
0.40	-0.60	-0.534	-0.556	-0.585	-0.430	-0.468	-0.509	-0.274	-0.346	-0.423
0.40	-0.30	-0.507	-0.565	-0.604	-0.375	-0.459	-0.577	-0.172	-0.348	-0.508
0.40	0.00	-0.009	-0.001	0.010	-0.019	-0.001	0.018	-0.032	-0.003	0.030
0.40	0.30	-0.661	-0.592	-0.532	-0.609	-0.525	-0.394	-0.581	-0.384	-0.153
0.40	0.60	-0.672	-0.639	-0.614	-0.608	-0.557	-0.500	-0.517	-0.436	-0.302
0.80	-0.30	-0.896	-0.898	-0.903	-0.864	-0.879	-0.885	-0.783	-0.828	-0.874
0.80	0.00	-0.034	-0.011	0.026	-0.054	-0.003	0.059	-0.113	-0.005	0.147
0.80	0.30	-0.995	-0.994	-0.994	-0.994	-0.995	-0.993	-0.992	-0.992	-0.992

Note: Bias of the estimated indirect long-run effect of Team Spatial relative to the one in the true model. λ_0 and γ_0 represent spatial and time dependence in the DPG of the dependent variable Y, α_0 and ψ_0 represent spatial and time dependence in the DPG of the covariate X.

E Additional graphs and simulation results

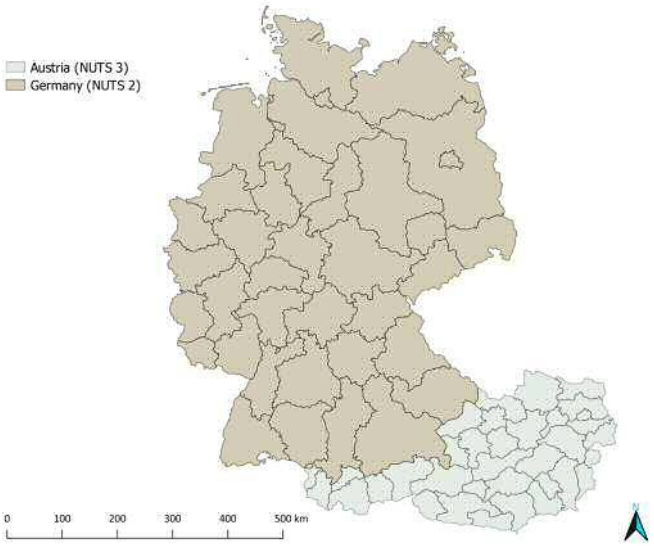

Figure E.1: NUTS regions used in the simulation.

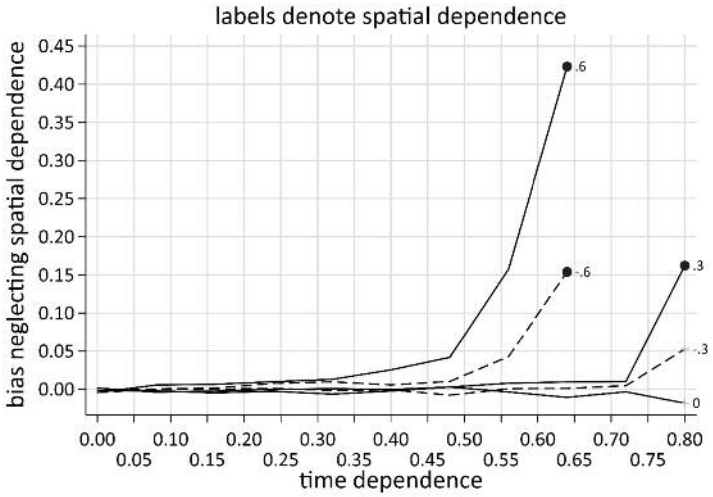

Figure E.2: Bias of Team Dynamic neglecting the spatial dimension, but applying a spatial lag of X specification. The vertical axis describes $\gamma_{TD} - \gamma_0$, the horizontal axis depicts γ_0. Labels denote spatial dependence in the DGP (λ_0).

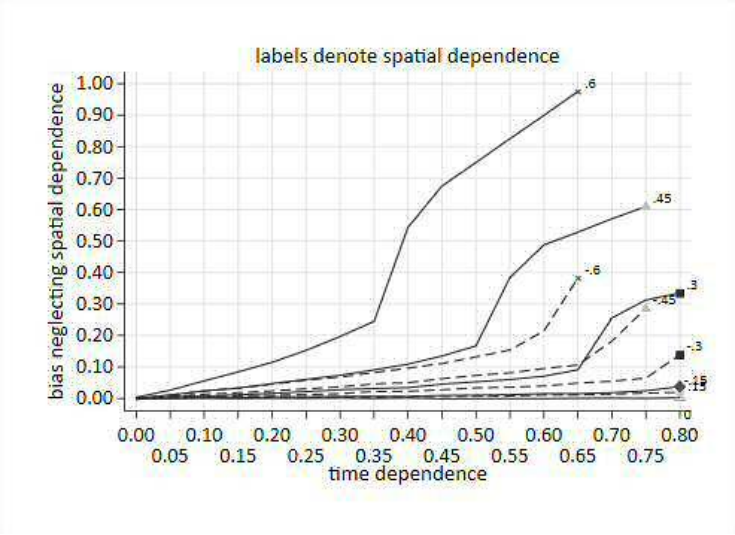

Figure E.3: Bias of Team Dynamic neglecting the spatial dimension. The vertical axis describes $\gamma_{TD} - \gamma_0$, the horizontal axis depicts γ_0. Labels denote spatial dependence in the DGP (λ_0). Based on German NUTS 2 regions.

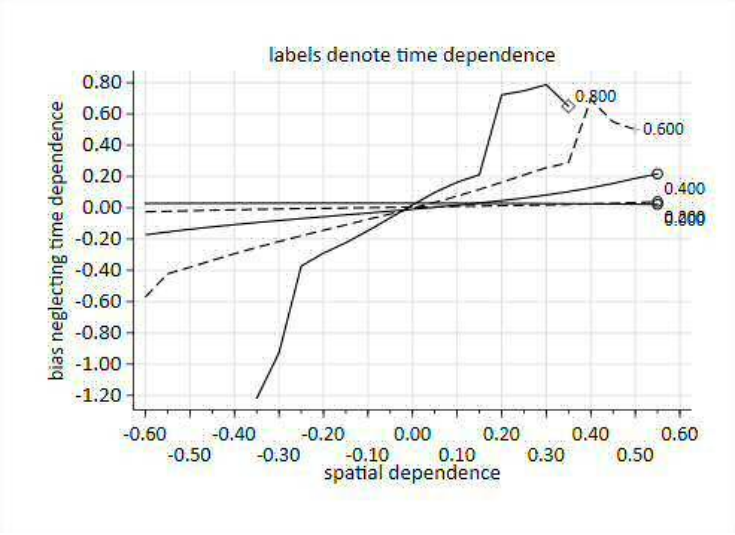

Figure E.4: Bias of Team Spatial neglecting the time dimension. The vertical axis describes $\lambda_{TS} - \lambda_0$, the horizontal axis depicts λ_0. Labels denote spatial dependence in the DGP (γ_0). Based on German NUTS 2 regions.

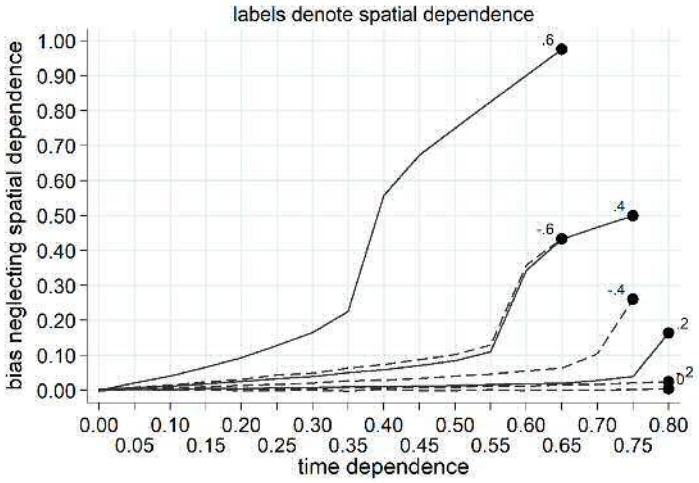

Figure E.5: Bias of Team Dynamic neglecting the spatial dimension. The vertical axis describes $\gamma_{TD} - \gamma_0$, the horizontal axis depicts γ_0. Labels denote spatial dependence in the DGP (λ_0). Based on row-normalized spatial weights matrix.

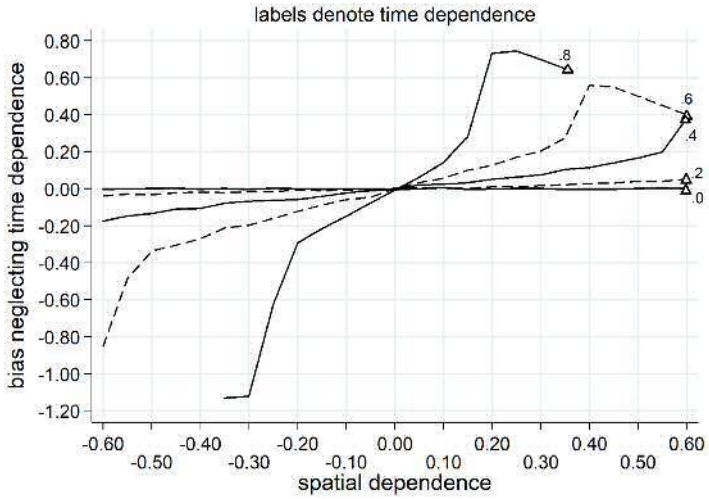

Figure E.6: Bias of Team Spatial neglecting the time dimension. The vertical axis describes $\lambda_{TS} - \lambda_0$, the horizontal axis depicts λ_0. Labels denote spatial dependence in the DGP (γ_0). Based on row-normalized spatial weights matrix.

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The Importance of Location Factors in Determining Land Prices: The Evidence from Bratislava's Hinterland

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Abstract. Bratislava, the capital city of Slovakia, is currently experiencing a period of intensive suburbanisation, which in turn creates demand pressures and increases the price of urban land located in its hinterland. This paper investigates several locational factors, which likely significantly influence the demand for land plots and modulate 'price-maker' conditions. Based on the population sample of 102 units, the results indicate that built-in infrastructure facilities on land under analysis, advanced transport connectivity in municipalities, and various amenities in the municipality cadastre tend to elevate land prices significantly. Moreover, the factor of distance from the city of Bratislava plays a major role in household location, which was identified by the apparent decreasing rent gradient pattern.

JEL classification: R11, R14, R31

Key words: land economics, rent gradient, suburbanization, bid-rent function

1 Introduction

In the last decades, Slovakia's core settlements are facing an ongoing process of suburbanisation, which establishes a network of small municipalities interconnected by a population of commuters. Rising demand for land and competition among dwellers compels municipalities to access new construction areas, which in turn places upward pressure on land prices.

The study's objective is to examine the dynamics of building land prices across various suburbs of Bratislava, the capital of Slovakia. According to preliminary data, building land prices in the Bratislava region far exceed prices for building land located in the rest of Slovakia. We propose that the main cause is the spatial proximity of Bratislava, to which all municipalities located in its catchment area are strongly connected.

As a basic reference model, we will utilise Alonso's Model (1964), considering a monocentric city with a central business district (CBD) to which all economic activities are connected. We will make a slight modification of the original model by focusing only on those land plots located in suburban zones and transitive-rural areas located behind Bratislava. Using empirical data on vacant land plots assigned for construction, we estimate the land plots' rent gradient at various distances from the Bratislava city. Considering distance and other variables assists us to assemble several distinct models

expressing the location factors that are likely driving bidding market prices for land plots in municipalities around Bratislava city.

Although location theories are generally well explored (Blažek, Uhlíř 2011), land economics is not sufficiently explored in Slovakian conditions. There are a number of studies devoted to suburbanisation processes in the Bratislava hinterlands, but mostly their topics of concern are subsequent demographic and urban morphological changes (Bezák 2006, Falťan 2019, Falťan, Pašiak 2004, Novotný, Pregi 2017, Podolák, Šveda 2014, Šveda 2016, Šveda et al. 2016, Šveda, Pazúr 2018).

The city of Bratislava holds a significantly more prominent political and economic position relative to the rest of Slovakia. Regional disparities measured as a difference in real GDP per capita between the wealthiest and poorest regions are immense. In 2017 the Bratislava region recorded €53,778/capita; however, the Presov region was at just €13,861/capita, more than 75% lower. Furthermore, the Bratislava region is the only Slovakian region that exceeds the EU average. The region's relative macroeconomic performance reached 180% of the EU average in 2017. There are similar regional differences in other variables like labour productivity or household incomes. Concerning other real assets, the median of total real assets ranges from €44,300 in the Banska Bystrica region to €92,200 in Bratislava and reaches €61,800 per average household at the national level (National Bank of Slovakia 2019, Messner, Zavadil 2014).

The aforementioned differences are also reflected in housing prices or building land prices. According to 2020 National Bank of Slovakia (NBS) data, in absolute values, the average price of apartments in €/m^2 of floor area is highest in the Bratislava region (€2,360/m^2) and lowest in the Nitra region (€988/m^2), while the national average is €1,792/m^2. However, house prices are considerably lower, with the national average at €1,336/m^2. Building land prices are highest in the Bratislava region (€158.63/m^2) and lowest in the Nitra region (€33.76/m^2), with the national average at €74.82/m^2 and a considerable standard deviation of 107.58 (National Bank of Slovakia 2020, Dluhoš 2017).

2 The Theoretical framework

2.1 Historical Approach to the Land and Location Economics

The term rent is a common word for which economists assign a specialised meaning. In their day-to-day use of this term, most people think of the payments made to property owners to use their land and buildings; however, this term has evolved over centuries to denote slightly different things (Samuelson, Nordhaus 2005, Mankiw 2009). Samuelson, Nordhaus (2005) consider rent or net economic rent to be a price for land use or other production inputs, whose supply is fixed. Thus, rent is what is paid for the use of factors of production with a fixed supply. Mankiw (2009) distinguishes two different prices: the cost of acquisition and rent price. The cost of acquisition of land or capital is an amount that an agent pays for time indefinite possession of a factor of production. The rent price is an amount that is needed to pay for using the factor of production for a definite length of time. McConnell et al. (2009) highlight rent differences based on physical factors; the location of land itself may be just as important in explaining differences in rent. Other things equal, renters will pay more for a unit of land that is strategically located with respect to materials, transportation, labour, and customers than they will for a unit of land whose location is distant from these things.

The theory of land rent, being a rather complicated economic category, has an established methodological basis developed by representatives of the classical school of political economy. In that era, land rent had been seen through the lens of its products related to agricultural fertility (Ricardo 1817, Smith 1776, Mill 1848). Smith (1776) perceived rent as the price paid for land use, which is naturally the highest that the tenant can afford to pay considering the land's characteristics. The rent charged for land is frequently no more than what represents a reasonable profit or interest for the stock laid out by the landlord upon its improvement (Smith 1776). Ricardo (1817) refers to land rent in relation to compensation paid to the land owner for use of its original and indestructible powers (Ricardo 1817).

Location theories are considered as predecessors to regional development theories. They stem from a neoclassical foundation, and their goal is to establish factors affecting the location of economic activities, and to explain the spatial distribution of economic activities (Blažek, Uhlíř 2011). The importance of the location concept in early literature sources has been traditionally linked with distance. The oldest literature dedicated to understanding interrelationships between location and transport includes von Thünen (1826), Launhardt (1882, 1885), Weber (1929), Palander (1935), Lösch (1954), Dean (1938), Hoover (1937), Dunn (1954), Greenhut (1956), Isard (1956) and Lefeber (1958) who have contributed to the element of general location theory that also implicitly accounts for transport costs (Isard et al. 1998, Bertuglia et al. 2013).

Location models differ according to their hypotheses on the spatial structure of demand and supply, which reflect the aims that the models pursue. Some models aim to interpret firms' location choices on the assumption of punctiform final and raw materials markets with given locations. Other models seek to identify the market areas of firms, that is, the division of a spatial market among producers (Weber 1929, Greenhut 1956). Location equilibrium is determined by a logic of profit maximisation whereby each producer controls its market area (Lösch 1954, Hotelling 1929). Finally, location theory analyses the economic and spatial mechanisms that regulate the size of territorial agglomerations, functional specialisation, and territorial distribution (Christaller 1933, Lösch 1954). These models put forward a more complex and general theory of location and the structure of the underlying economic relations that account for the existence of diverse territorial agglomerations within a framework of general spatial equilibrium (Capello, Nijkamp 2009).

Ideas about economic relations between the space and structures were first pioneered by von Thünen (1826) through an example of agricultural use. He demonstrated how economic forces contribute to the evolution of regional differences in land use. Besides traditional factors like quality and soil fertility, the land's geographical position or location plays a substantial role in different use of the land (Maier, Tödling 1995). The location rent represents the maximum payment that farmers could afford to pay to the landowner. On a given condition, location rent represents potential profit, independent from institutional factors (Maier, Tödtling 1997). In other words, the land rent is residual, as it equals the difference between the cost resulting from the production and transportation of the product at the 'marginal site,' which is equal to the product's return, and the costs that have to be incurred at the place currently under consideration (Fischer 2011).

No two such gradients are identical. The level and the structure of transfer costs naturally influence the slope and rent gradients' shape. When the transfer is costly, the ceiling rent for any given kind of use drops off rapidly with increasing distance; but along a route of cheap transfer, the corresponding rent gradient is relatively flat. An accentuated concavity of the gradients characterises the latter; i.e., ceiling rents fall off rapidly with increasing distance from the market as long as the distance is short, but less and less rapidly as longer hauls are involved. Finally, the gradient slope will differ according to the amount and transferability of the product produced per unit of land, which is not the same as the intensity. The process that yields a large volume of output per unit of land, particularly if it is expensive to distribute, has relatively steep rent gradients. Conversely, for land uses producing small amounts of easily transferable products per unit of land, the rent gradient is flat (Hoover 1948).

The basic urban model focusing on the fundamental trade-off between accessibility and space in residential choice was developed by Alonso (1964), Mills (1967) and Muth (1969). Considering a monocentric city with a prespecified centre, called a central business district (CBD), where all jobs are located. In this context, the only spatial characteristic of a location is its distance to the CBD (Fujita, Thisse 2002). Alonso (1964) reinterpreted the Thünen model by using households' location within the urban area. The trade-off theory is based on the perception that each household is willing to spend some amount of money on housing as a fraction of its income in a given market condition. The optimal locality of the household is determined by expenditures, which depend on location decisions. A minimum of total costs represents the optimal locality

as a sum of transport costs, which are rising outwardly from CBD, and rental costs, which in turn are declining outwardly from CBD (Maier, Řezáč 1997, Maier, Tödtling 1997, Brakman et al. 2003). The role of transport costs and land value leads to a key concept in classical urban economics, the bid-rent curve (or bid-rent function). The bid-rent is the maximum rent that a potential user is willing to pay for a site or location. Each potential user of land has a bid-rent curve (or function), which relates the user's bid-rent to the location of the land site, showing in particular how the bid-rent changes as a function of the user's distance from some central point. The central point is the point at which the transportation costs are minimised for that use, the point at which the bid-rent or residual value is maximised (Geltner et al. 2014). The nature of diminishing rent gradients with rising distance from the CBD have been widely confirmed in a number of studies (Glumac et al. 2019, Colwell, Munneke 1997, Abelson 1997, Atack, Margo 1998). However, there were also some inconclusive (Heikkila et al. 1989), mixed, and also contradictory results (Shimizu, Nishimura 2007, Plaut, Plaut 2003).

2.2 Value of location in the land price determination

Real estate can be purchased or leased within any sub-national region at a great range of prices or rents. Price increases with the land's suitability for construction, the public services available to it (public water, drainage sewers, sanitary sewers, electric power, natural gas service, etc.), proximity to the transportation network of all modes, and proximity to transportation and employment nodes (urban and suburban commercial cores, superhighway interchanges) (Harrington, Warf 2002). Competition for land plays an important locational role in areas where activities tend to concentrate for any reason. Locations with good soil, climate, access to other areas, and areas suitable for agglomeration under local external economies' influence are in demand. The price of land, which is our best measure of the intensity of demand and competition for land, varies with quality and access, and rises abruptly to high peaks in urban areas (Hoover, Giarratani 2020). The primary determinant of the cost of land is its accessibility. Transport costs (the measure of accessibility) determine parcels' location rent at different distances from the city. Thus, because land downtown is the most accessible, it is the most expensive; in most cities, costs decline exponentially away from the city centre (Stutz, Warf 2012).

A complex set of factors impacts the choice of residential location. Extensive analysis of modelling the choice of residential location via a multinomial logit model is provided by McFadden (1978) and McFadden (1973), Quigley (1976), and Lerman (1975). McFadden (1978) asserts that an economically rational consumer will choose a residential locality by weighing the attributes of each available alternative – accessibility of workplace, shopping, and schools; quality of neighbourhood life, taxes, and travel costs; and dwelling characteristics, such as age, number of rooms type of appliances – and by choosing an alternative that maximises utility. Lerman (1975) describes the household location decision model using factors like locational attributes, transportation level of service to work, spatial opportunities, and the household's socioeconomic characteristics. Household choice among eighteen types of residential housing in a metropolitan area is shown to vary according to a household's income and size (Quigley 1976).

Three main theories are used to explain private-sector housing location: travel-cost minimisation, the travel-cost / housing-cost trade-off, and maximum housing expenditure. Of the three theories, the second is the most widely accepted and, for this reason, has become the most developed theory of residential location. It essentially states that, given an opportunity, a perfectly mobile household would move to a plot where it can satisfy its spatial requirements while paying acceptable transport costs (Phe, Wakely 2000). Bayoh et al. (2006) show empirical evidence that rising incomes, lifecycle effects, residential filtering, transportation changes, and employment decentralisation are likely factors driving suburbanisation in which changes in these conditions make suburban locations more attractive to city residents.

Schirmer et al. (2014) propose a four-tier classification of location variables:

- The built environment, defined by geometrics and volumes of spatial objects, including buildings, parcels, blocks, and connecting networks (both road and public transport networks).
- Socioeconomic environment, which describes various aspects of society: population size, income level, ethnic distribution, age, and education level. These variables are usually available at a certain aggregation level, such as neighbourhood, postal district, census block, or grid cell.
- Points of interest provide functions relevant to the public. For instance, the city centre within the CBD, or a hospital.
- Accessibility is the product of interest points and a transport network. As such, it contains a transport component and land-use component.

Kim et al. (2005) identified a trade-off process between transport and amenities, in that individuals prefer residential locations with a combination of shorter commuting time, lower transport costs, lower density, and higher quality of schools. Among other factors influencing the location of residential construction, Rietveld, Wagtedonk (2004) found the accessibility of workplaces, distance to railway stations, and, to a lesser extent, the accessibility of nature, surface water, and recreational areas. Similar conclusions were found by Naess (2006), Manivannan, Somasundaram (2014), and Yan (2020). Zrobek et al. (2015) based on a social survey, performed a more exhaustive search for the factors which likely influence residential location choice. Among the considered factors, price became the most important factor in the buyer's residential property choice. It was followed by 'quiet neighbourhood' and 'sense of security'. High scenic value, was regarded as a moderately important factor. The other natural features, such as the proximity of water bodies, air quality and undeveloped space, were regarded as not important.

When discussing land plot evaluation or real estate in general, we might speak about hedonic pricing models, which are widely used for this purpose (Saphores, Li 2012, Brander, Koetse 2011, Glumac et al. 2019, Mirkatouli et al. 2018). The analysis of hedonic markets in a perfectly competitive setting was pioneered by Rosen (1974). His hedonic model characterises markets for heterogeneous goods (or amenities) that implicitly price out attributes that characterise the goods (or factors or amenities) (Ekeland et al. 2004).

There are a number of techniques for estimating the hedonic pricing of real estate properties. Hannonen (2008) generally distinguishes three approaches to estimation: (1) parametrically, (2) semiparametrically, and (3) nonparametrically. Parametric modelling represents the classical approach in hedonic modelling, which is theory-laden because pre-specified functional forms are used in the analysis. Nonparametric techniques are on the other hand, data-driven, very flexible tools, and semiparametric techniques combine features from parametric and nonparametric approaches.

Among the parametric approaches, mainly ordinary least square regression (OLS), spatial autoregressive, and geographically weighted regression models were deployed to model hedonic real estate prices/rents, like Löchl, Axhausen (2010), Zrobek et al. (2014), Ahlfeldt (2008), Shimizu, Nishimura (2007), Farber, Yeates (2006). Nonparametric approaches include area-to-point Kriging and local regression estimation methods which mostly model effects of location on objects of study (for instance property prices) (Clapp 2003, McMillen 2001, Yoo, Kyriakidis 2009). Combes et al. (2018) developed a new methodology to estimate urban costs' elasticity using French data. In an extensive analysis, they investigated, among other topics, specific distance gradients for land prices in several French cities. Using the data panel approach by applying a non-linear econometric model, they provide estimates for land values in French urban areas. Among the results useful for our analysis, they found that the land price tends to rise with road access, basic utilities, and vacant land, and fall with rising distance. While distance gradients differ across urban areas they are in most cases negative. Land price gradients are in general much steeper than house price gradients.

2.3 *Current Situation of the Housing Market in Bratislava's Hinterlands*

The rapid development of the housing market since the turn of the century is likely to be the primary cause of suburbanisation in Slovakia. The most important factors were the growth of GDP, real incomes, FDI inflow and government policy reforms on a national and local level (Špirková 2008, Golej et al. 2016, Drachal 2013).

Falťan (2019) argues that the first signs of modern suburbanisation in Slovakia are visible in an area of Bratislava city and its hinterland beginning in the 1980s. Its character, architectural or social, was significantly affected by the urbanisation process with a strong dependence on the city of Bratislava. A commonly visible pattern is the transformation of gardening colonies located on the city periphery on permanent habituated objects. This trend has reportedly shifted to city suburbs or the countryside and gradually to other Slovakian cities.

Most authors attribute internal migration as the leading cause of ongoing suburbanisation tendencies in Bratislava's hinterlands (Falťan, Pašiak 2004, Bezák 2006, Podolák, Šveda 2014, 2019). Falťan, Pašiak (2004) characterise urban development in Slovakia after 1990 as typical in the transformation of urban and rural settlements, in human potential, in the economic base, and in its internal structures and relations. Bezák (2006) distinguishes four types of internal migration, in Slovakia on the perceived axis of the urban-rural dichotomy. During the 1980s, emigration from the countryside to cities was a decisive part of migration flows, while after 1990 counter-urbanisation tendencies had prevailed. Migration between the cities and the countryside is also seen over this period. Podolák, Šveda (2019) show that municipalities in the hinterland of Bratislava city are most active in the country with regards to ongoing suburbanisation. Two components play a crucial role in this trend – natural birth rate and migration balance. While the natural birth rate has been, in general, very low, sometimes negative, a strongly positive migration balance has ensured a net increase.

Šveda et al. (2016) provided deeper insights into the structural elements of suburbanisation occurring in Bratislava's hinterlands. They identified seven suburban types of municipalities located in the hinterland of Bratislava city; (i) Type 1 – Large-scale development in the suburban ring, (ii) Type 2 – Intensive development in an agricultural landscape, (iii) Type 3 – Intensive development in vineyards, (iv) Type 4 – Development driven by Hungarian in-migration, (v) Type 5 – Development in a natural environment, (vi) Type 6 – Second-home development on the Danube riverside, (vii) Type 7 – Development in rural periphery. The main classification attributes were migration, dwelling construction, income, residential prices, and land use. According to the conclusions, better-educated and well-off social groups are the primary agents of suburbanisation. Furthermore, these people prefer localities in the city's vicinity, which leads to higher prices and rents of real estate in these municipalities. In turn, people with primary and secondary education are more likely to move to more distant residential areas.

Housing prices in the Slovak Republic have seen phenomenal growth since 2002, outpacing house price growth in most other OECD countries. However, house price growth has been quite divergent across the country. The highest levels of price growth have predominantly been seen in the West of the country, which outpaced the rest of the country by 21% since 2005 for Bratislava, 32% for Trenčín and 14% for Trnava (Hüfner 2009, Cár 2018). Housing prices in Slovakia are being determined by demand-side factors such as social-demographic (population features), social-economic (income), social-politics (national savings, access to loans, interest rates). Relevant supply side factors include: territorial and legal (housing support, the supply of building plots, local zoning policy, others), and economical-technical (financial capital, number of apartments and others) (Cár 2009).

There is the evidence that the value of constructed dwellings and built-up areas is highest in the immediate hinterland of Bratislava city and gradually decreases towards the periphery (Šveda, Pazúr 2018, Šveda 2011, 2014). A relevant factor is the 'urban-rural continuum', in which the effects of suburbanisation decreases with increasing distance from the city (Slavík et al. 2011, Novotný, Pregi 2017).

In most cases, the final bid prices for land plots are determined by the market – a result of supply and demand. However, there are some cases when the market fails to

determine the 'true' intrinsic value of a land plot. In the Slovakian context, real estate (asset) values might be appraised through the following approaches (Ilavský et al. 2012).

- Market value
- Market value on the public market
- General value (applied in Slovakia)

Ordinance no.492/2004 Coll. (Secretary of Justice of the Slovak Republic 2004) on the property's general value adjusts methods for determining the value of tangible assets like land, buildings, and others. It authorises the appraiser to use three possible approaches:

1. Comparative approach
2. Income capitalisation approach
3. Location differentiation approach

3 Data and Methodology

For this paper, we use the classical approach, which should, at best and in the simplest form, model causal relations between land plot prices and a subset of location factors based on a population sample. We will not consider either spatial dependency or spatial heterogeneity among the population sample, although it would be corrected for autocorrelation if detected. For this purpose, we intend to use several multiple regression models. All proposed models are based on the cross-sectional data collected in the spring of 2020, from a database of several web portals of real estate agencies, aiming at mediating the acquisition and sale of real estate. The population sample represents vacant land plots designated for construction in nominal prices.

It should be noted that this price represents the anticipated price for the land plot and does not represent the final price as a result of the real transaction. The real price paid for the land is disclosed in the transaction agreement, which is not public. However, this shortcoming should be ignored, as asked prices still reflect the prevailing market situation. Every land price advertised by real estate agencies are the result of the due diligence process performed by an agency. However, every agency uses a slightly different approach when setting the real estate value. Nonetheless, it is assumed that the price still overwhelmingly captures an 'intrinsic' value of the real estate property.

Initially, we estimate the following cross-sectional regression model with ordinary least squares, taking into account several location factors. The general model can be specified as:

$$y_i = \alpha_1 + \alpha_2 EN_{2i} + \alpha_3 T_{3i} + \alpha_4 A_{4i} + \beta_1 X_{1i} + \beta_2 X_{2i} + u_i \tag{1}$$

where y_i is the price of the land plot in m^2, EN_{2i} is a dummy variable expressing the influence of engineer networks (electricity, gas, water, sewer) present in the land plot, T_{3i} is a dummy variable expressing the location factor of transport connectivity present in the municipality cadastre (railway, highway connection, etc.); A_{4i} is a dummy variable expressing the presence of the amenity in the municipality. In this case, several types of amenities were considered; natural – forest, river or pond, historical – castle, or manor house, and specialised services – sport facilities, tourism facilities, etc. We have given each variable equal weighting. In the case of the dummy variable EN, which assesses the impact of engineer networks present on the land plot, the variable is 1 – if all networks are found on the land plot (sewer, electricity and gas) and 0 – if not. If at least one network on the plot is missing, the statistical unit was not considered in the sample.

Among the quantitative variables, X_{1i} is a 'development fee', which represents a construction tax per m^2 of the built-up area claimed by the municipality, and X_{2i} is a municipality's distance from the CBD of Bratislava city in km.

The total population sample consists of $n = 102$ units. The explanatory variable X_1, 'development fee', was adopted by Act no. 447/2015 on local fees for the development Coll., in 2015 (Slovak Republic 2015), thereby introducing the instrument regulating developers' activity in settlements. The municipality sets the amount of the fee according

to the law. The amount of the fee is calculated as a product of the fee rate in €and the floor area of the house in m^2. In the first model, we will estimate the parameters based on the population sample, taking the general model, including all dummy variables.

Next, we shift attention to measuring the impact of distance from the city of Bratislava, thereby CBD, on prices of land plots in various municipalities located in the Bratislava hinterland. Based on theoretical and empirical sources, we intend to modify the regression function as:

$$y_i = \alpha_i e^{\beta_2 X_{2i}} \tag{2}$$

Where y_i is a price for the land plot and X_{2i} is the physical distance of land plot i from Bratislava city in kilometres. The metric physical distances were collected separately per each land plot via the google maps application, measuring the physical (travel) distance from the Bratislava centre (pedestrian zone) to the land plot located in each municipality according to its unique zip code. Finally, we will incorporate an exclusive dummy variable model (ANOVA), distributing the population sample to the predefined bands based on rising distance from the CBD. The distance bands were set according the univariate clustering algorithm using the XLSTAT program, setting following distance bands behind the Bratislava's urban perimeter:

Band 1: 0 – 13,5 km
Band 2: 13,51 – 22,8 km
Band 3: 22,81 – 32,2 km
Band 4: >32,2 km

The Model can be specified as:

$$y_i = \beta_0 D_{i1} + \beta_1 D_{i2} + \beta_2 D_{i3} + \beta_3 D_{i4} + u_i \tag{3}$$

4 Results

Figure 1 shows a map of the Bratislava region and an overview of the study using the geographic information system (GIS) ArcMap 10.5.1. The red dot marks Bratislava city. There are municipalities located in several concentric rings around Bratislava city representing chosen distance bands. The fourth distance band is not represented by a ring. The shape of the rings is intentional, as it embodies superior statistical properties (Wong, Lee 2005). Land plots located in municipalities within and outside of the rings are the object of this research. They were picked at random based on the underlying data.

Table 1 shows the estimation results according to Model 1. The control variables are shown in €/m^2, as specified in Model 1.

According to the model, all control variables have shown a statistically significant effect on the dependent variable (the price of the land per m^2) except the Development fee. Interestingly, according to the model, with rising unit distance, land price per m^2 declines by €0.433/m^2 on average, the presence of engineer networks on the land increases the price by €0.208/m^2, the presence of transportation facilities within the municipality cadastre increases the price by €0.117/m^2 and the presence of amenities in the municipality increases the price by €0.249/m^2.

In general, the model could be considered adequate. The coefficient of determination R^2 shows an above-average value, and parameter F became highly significant. Possible spatial autocorrelation, measured by the Durbin-Watson statistic, shows only scant effect, and heteroscedasticity of the sample, according to the Breusch-Pagan test, is not detected. Therefore, according to the test presented in Table A.1, there is no issues of multicollinearity in the model (See Table A.1 of the Appendix).

Table 2 shows results of the effect of distance on the price of land plots. Considering the nonlinear relation between the dependent and independent variable and comparing various functional forms, the exponential regression model yielded most desirable qualitative features.

Figure 1: The Bratislava region

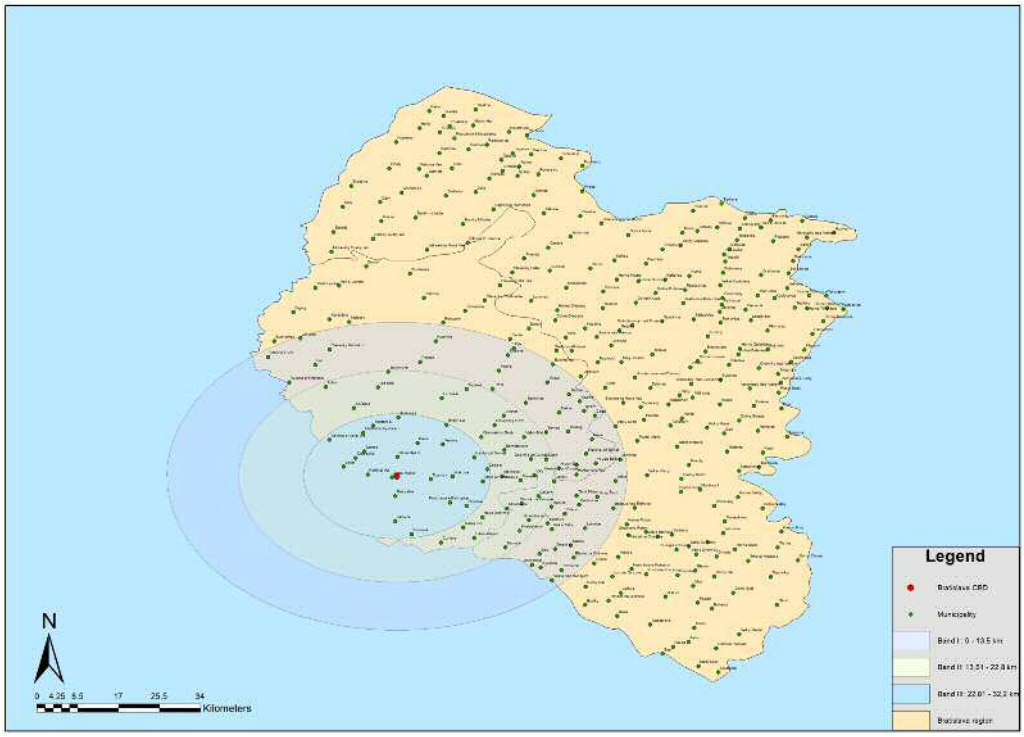

Table 1: General estimation results (Model 1)

Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)
Intercept	5.751	0.280	20.549	<0.0001	5.195	6.306
Development fee	0.032	0.034	0.936	0.352	-0.036	0.100
Distance	-0.433	0.067	-6.490	<0.0001	-0.565	-0.300
E. networks	0.208	0.057	3.657	0.000	0.095	0.321
Transportation	0.117	0.057	2.061	0.042	0.004	0.230
Amenity	0.249	0.060	4.119	<0.0001	0.129	0.369
R^2	0.580					
Adjusted R^2	0.558					
DW	1.773					
F	26.463					
Pr > F	<0.0001					

Table 2: General estimation results (Model 2)

Source	Value	Standard error	Lower bound (95%)	Upper bound (95%)
Intercept	208.828	15.132	178.807	238.849
Distance	-0.024	0.003	-0.030	-0.018

Table 3: General estimation results (Model 3)

Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)
Dist. 1	182.736	10.822	16.885	<0.0001	161.259	204.212
Dist. 2	-54.286	12.496	-4.344	<0.0001	-79.085	-29.487
Dist. 3	-85.827	12.339	-6.956	<0.0001	-110.313	-61.340
Dist. 4	-98.310	12.100	-8.125	<0.0001	-122.321	-74.298
R^2	0.452					

According to Model 2, distance could be considered a critical factor in determining a suitable housing location, with a profound impact on the land plot price. The results imply that increasing the distance by one km from the CBD of Bratislava city may decrease the land plot price by 2.4% per €/m^2 on average. The model has good properties, and based on the test results, we can rule out possible autocorrelation or heteroscedasticity (Provided in appendix, Table A.2).

Finally, we assembled Model 3, estimating different land price gradients in various distances from the CBD. Distance boundaries were set using a univariate clustering algorithm, which seeks to maximise the classes' homogeneity due to minimising the sum of the within-class variance. The main comparing factor is Band 1. The left part of the table shows absolute differences in land prices in €/m^2 in among the distance bands.

Table 3 shows the variation in prices for land plots located in municipalities in different distance bands from Bratislava city. The model shows a decreasing rent gradient with increasing distance from the CBD, which is in line with the theory. According to the proposed model, price in €/m^2 of the land plots located in the second distance band (13,51 – 22,8 km) is about 29,7% less compared to the first distance band (0 – 13,5 km); in the case of the third distance band (22,81 – 32,2 km); it is 54,2% less, and in the case of the fourth distance band (>32,2 km) it is 67,4% less than the price in the first band, on average. In the case of the fourth distance band, we considered the width of the band only up to 10 km, as through empirical inspection we detected a sudden increase in land prices. A possible cause might be the spatial proximity of Trnava city, the capital city of the Trnava region on the NUTS 3 level. Centrifugal effects of Trnava city may be present which would therefore distort the sample.

All coefficients are highly significant and the model, in general, is adequate. Moreover, possible autocorrelation or heteroscedasticity was not detected (See Appendix, Table A.3).

Figure 2 shows a relation between the distance in km and price in €/m^2 for the land plot in the Bratislava region. The negative pattern of the scatterplot shows an apparent decrease in land prices when the distance increases.

5 Conclusions

The paper's primary objective was to examine the spatial variation of urban land prices in municipalities located in Bratislava's hinterland. The examination was primarily based on selected location factors, with a likely effect on land prices. Secondly, the factor of physical distance was assessed separately. Considering a monocentric city with a central business district (CBD) located in the centre, we used multiple regression as a primary method of research, combining quantitative and qualitative (dummy) search variables. The research results have shown a statistically significant impact of searched variables on urban land prices in various municipalities located in Bratislava's hinterland. Notably, the presence of alternative transport modes (railway or highway most notably) and built-in engineer networks on land plots have confirmed a sizeable impact on land prices. The presence of engineer networks on the land plot significantly elevates land prices. However, it was considered that land was fully equipped with all engineer networks (water,

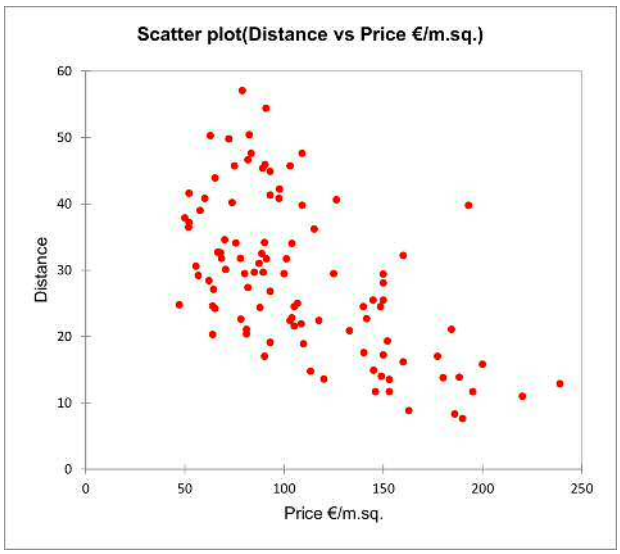

Figure 2: Scatterplot mapping distance vs price for land plots in Bratislava region

energy, sewer). The effect of partially built networks is likely to be only minor. For the proprietor, built-in networks represent a significant reduction of costs, accelerating zoning and building procedures and thus making the land ready for building upon. Physical access to land plots also means important savings for the proprietor. Moreover, the spatial proximity of superior transport networks (like motorways or railways) to land likely represents a significant advantage for the proprietor when performing daily activities like commuting to work or for services in terms of time savings. The presence of local amenities nearby to land plots showed a significant price increase. With regards to higher aesthetic values, such localities give an impression of exclusivity for the proprietor and thus are in greater demand.

Similar conclusions were found by Ilavský et al. (2012), Harrington, Warf (2002), Rietveld, Wagtedonk (2004), Naess (2006) and Combes et al. (2018). Moreover, newly introduced land policy instruments aiming to regulate demand for new land plots have been shown to raise prices but so far fail to stem demand for the land plots. However, this factor hasn't become statistically significant. The reason might be that application of this is an exclusive competency of the municipality and thus the decision about fee rate is fully decentralised. It could be reasoned that municipalities are not perfectly informed about the fee rates in other municipalities, or that some municipalities hesitate to apply steep rates because they are afraid of stifling the influx of new citizens moving to the municipality.

The influence of physical access and distance to the land from Bratislava city is shown as statistically significant. For this purpose, we used the nonlinear method of regression in coherence with earlier theoretical knowledge and empirical findings (Stutz, Warf 2012, Zrobek et al. 2014, Hannonen 2008, Ahlfeldt 2008, Wang 2009). The results have confirmed a decreasing rent gradient with increasing distance from the CBD. Similar conclusions have been found by Glumac et al. (2019), Shimizu, Nishimura (2007), Combes et al. (2018).

This study is far from exhaustive; the analysis could therefore be extended to include other cities, varying by size and locations to reflect other geographical and social conditions. This study provides another piece of evidence showing that progressively rising rent gradients move inwardly to the city. The results also suggest that differences in price/rents of real assets mentioned by Cár (2018), Dluhoš (2017), Messner, Zavadil (2014), and National Bank of Slovakia (2020) between the Bratislava region and rest of Slovakia are primarily caused by the unique position of Bratislava city.

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A Appendix:

Table A.1: Heteroscedasticity and multicollinearity tests of Model 1 results

Breusch-Pagan test:		Multicollinearity statistics:		
			Tolerance	VIF
LM (Observed value)	2.372	Development fee	0.802	1.247
LM (Critical value)	11.070	Distance	0.713	1.402
DF	5	E. networks	0.928	1.078
p-value (Two-tailed)	0.796	Transportation	0.802	1.246
alpha	0.05	Amenity	0.932	1.073

Table A.2: Heteroscedasticity and autocorrelation tests of Model 2 results

White test:		Durbin-Watson test:	
LM (Observed value)	1.203	DW	1.806
LM (Critical value)	5.991	rho	0.093
DF	2	p-value (one-tailed)	0.277
p-value (Two-tailed)	0.548	alpha	0.050

Table A.3: Heteroscedasticity test of Model 3 results

White test:	
LM (Observed value)	1.203
LM (Critical value)	5.991
DF	2
p-value (Two-tailed)	0.548
alpha	0.05

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The determinants of Covid-19 mortality rates across Europe: Assessing the role of demographic and socio-economic factors during the first wave of the pandemic

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Abstract. The aim of this paper is to examine empirically the impact of the demographic structure and socio-economic environment on the Covid-19 mortality rate across 29 European countries. The analysis is based on empirical data recorded cumulatively from 15th February 2020 until 26th May 2020, thus covering 'the first wave of the pandemic'. Results indicate that, although countries with a higher degree of population ageing are anticipated to be more vulnerable to Covid-19, this study provides evidence that population ageing contributes only marginally to Covid-19 death rates across Europe. The degree of urbanization, the level of economic development, and the state of health care systems, seem to better explain patterns of interstate mortality rates. The analysis provides important policy implications since it underlines the importance of urbanization and socio-economic conditions in the accelerating incidence of casualties, and it signifies the importance of health care systems for the protection of people and places from the pandemic.

Key words: Covid-19, mortality rates, Europe, population ageing, urbanization, ANOVA, Bayesian BYM spatial model

1 Introduction

Over the past few months, the scientific community's interest has been focused largely on the Covid-19 pandemic, which is spreading rapidly in almost all parts of the world. Researchers from different scientific fields have approached the issue from various angles, but in all instances there is a common goal, to understand the behaviour of the virus, to formulate methods and policies to control its spread and to find the right treatment.

However, the pandemic of Covid-19 is a very recent phenomenon, which is still in progress. Thus, scientific knowledge about the disease is imperfect and the statistical documentation limited. The numbers of documented events (deaths, cases) vary widely across and within countries. So far, estimations of the eventual impact on the population and on the spread of the disease rely largely on mathematical and statistical models which are formulated on an assortment of assumptions (Fauci et al. 2020, Georgiou 2020). Empirical research has led to some sound findings, revealing that people suffering from certain underlying conditions such as cardiovascular and respiratory diseases, neoplasms and diabetes face an elevated risk of an adverse outcome (Chen et al. 2020, Guan et al.

2020, Halvatsiotis et al. 2020). It is also pointed out that the elderly comprise the most vulnerable group of the population as they often have a less favourable clinical picture than younger people, and once infected they usually have lower chances of survival (Ioannidis et al. 2020). Statistical observations deriving from a wide range of countries demonstrate that deaths from Covid-19 are concentrated mostly among older people (Dowd et al. 2020). The implication of this finding is that demographic ageing may result in structural changes in the demo-pathology of the population that should be taken into account by the health and socioeconomic policy makers. Most European populations already exhibit an age-structure with a large number of older people, while national population projections indicate that demographic ageing will continue; therefore, in the short and medium term, the demographic aspects of the pandemic must not be ignored.

The actual number of cases and deaths due to the virus is not known; however, it can be argued that Covid-19 mortality data may be a more reliable means of analyzing the impact of the disease than statistics on confirmed Covid-19 cases. Of course, mortality reflects the incidence of the disease, the adequacy of the health system as well as practices of reporting, but mortality data, although potentially undercounted, may serve as a more tangible approach for assessing the effects of the disease.

Given that older people are more vulnerable to Covid-19, the demographic structure and ageing of the population could be considered as significant determinants of the mortality rates from Covid-19. However, the fact that the Covid-19 mortality rate disproportionally affects older people does not necessarily imply that the higher the degree of population ageing the higher are the risks for the society as a whole. In order to capture the incidence of the disease and the outcomes on mortality rates, additional factors such as urbanization and the socio-economic environment should be taken into consideration.

Socio-economic determinants are important contributing factors to the incidence and fatalities from the pandemic. Poverty, deprivation and job insecurity are important issues in poorer countries and more deprived populations within countries, cities and regions. Environmental degradation and pollution, poor education, employment insecurity, conditions of built environment, and access to care are factors unequally distributed across regions, that influence the population health in Europe (Marmot et al. 2012, Santana et al. 2017, Mitsakou et al. 2019). The health consequences of the economic crisis induced by Covid-19 are likely to be similarly, unequally distributed, exacerbating heath inequalities. Health inequalities will probably increase during the pandemic (Bambra et al. 2020).

In this context, the aim of this study is twofold; first, to explore the demographic dimension of the pandemic with respect to age structure effects; more specifically we aim to examine whether populations experiencing a high degree of ageing tend to exhibit higher mortality rates due to Covid-19 and vice versa. Second, we further explore the demographic structure along with socio-economic determinants in order to test how they affect the mortality rates of the disease. To address our research questions, we employ recent statistical information from 29 European countries and we apply well established demographic, econometric and statistical techniques.

The analysis refers to the first wave of the pandemic and has some important merits. First, it provides an initial accounting of the mortality rates and the determinants of the pandemic across Europe. Second, this provides the baseline data which allow us to follow the evolution of the disease and to provide comparisons with subsequent waves. Third it serves as a basis for policy measures for better responses and preventive policies in response to future pandemics. Fourth, this analysis provides useful insights concerning Covid-19 which could enrich interdisciplinary dialogue across fields such as demography, economics, epidemiological studies, and health policy. Finally, it could be utilized for scientific discussion regarding the spread of disease that goes beyond the Covid-19 pandemic.

The paper is structured as follows. Following the introduction, section 2 provides a concise literature review regarding the demographic and socio-economic determinants of the pandemic. Section 3 presents data sources and methods of analysis for the estimation of the significance of the age structure on Covid-19 mortality rates. Section 4 presents and discusses the empirical results. Section 5 provides a Bayesian model for analysing Covid-19 mortality rates. Section 6 summarizes the findings, codifies policy proposals and sketches the framework for the expansion/extension of this work.

2 Literature review

The issue of the spread of the pandemic has attracted the attention of scientists, international organizations, citizens and governments across the globe. Epidemiological episodes and the spread of epidemiological diseases is not at all a new issue. Historically, on numerous occasions, humankind has faced similar outbreaks of diseases and a fair number of analyses have been the subject of scientific investigation (Carillo, Jappelli 2020, Jordà et al. 2020, Percoco 2016). However, under the current circumstances of economic globalization, the high degree of concentration of people and economic activities in large cities and urban agglomerations, the soaring income inequalities as well as the highly developed means of transportation and communication have made this disease unique in world health history. This disease could undermine: fundamental aspects of the organization of economic activity; social interaction and participation in the social processes; social activities and possibly personal life, and psychological health. Today, a vaccine has been used for the protection against Covid-19. However, during the first wave of the pandemic the absence of a medication or a vaccine to limit the spread, to protect against and eventually to cure Covid-19 make this disease a distinct case in world history. The shock was exogenous and global (Faggian 2020). However, it had an asymmetrical impact across countries, social groups and individuals. Demography and spatial statistical analysis and spatial epidemiology constitute scientific disciplines that have explicitly contributed to the analysis of diseases. Demography has provided some important insights regarding the spread and the consequences of Covid-19. Demographic ageing has been quite an important issue for Europe in recent decades. The ageing of the population exerts pressures on the pension systems and on the health-care systems, and it requires actions to support the everyday life of elderly people. Covid-19 brings an additional risk to elderly people and to societies. The lives of elderly people are at high risk: the mortality rate is higher among this category and the incidence of Covid-19 peaks in areas where elderly people are concentrated such as old-age homes. The higher vulnerability of older people to Covid-19 is a well-documented statistical fact. As a result, the age structure of a society and the vulnerability of populations, along with other socio-economic conditions that prevail in a society, should be examined in scientific research (ECDC 2020).

The level of urbanization is also an important determinant for the incidence and spread of the pandemic. Empirical analyses have demonstrated that the impacts of the current Covid-19 crisis alone will be vast, as well as spatially uneven. Given the high concentration of both population and economic activities in cities, these are often hotspots of Covid-19 infections (Sharifi, Khavarian-Garmsir 2020). Other factors being equal, for the first wave of the pandemic the incidence of Covid-19 is higher in urban areas compared to the semi-urban and rural areas of countries. Indeed, there are some who advocate a rediscovery of rurality as a reaction to the pandemic (Cotella, Vitale Brovarone 2020).

The social mix of the population is another important factor. The most deprived parts of the population tend to be more vulnerable to the disease. The UK Office of National Statistics (ONS) released the March–April 2020 data for England and Wales which revealed that Covid-19-related death rates in the most deprived areas are more than double those in the less deprived (Dodds et al. 2020, p. 289). Income inequality reflects different mortality rates in the USA. Mortality rate of the less well-off Black and Latino people, is twice that of White people (Wade 2020).

The level of economic development of an area is also factor that serves as an important determinant for explaining the incidence and spread of the disease. Spatial analysis for Italy provides statistical evidence that the level of economic development of regions is positively correlated with the incidence of Covid-19 (Ghose, Cartone 2020). The highest positive spatial correlation in the Northern provinces stresses the link between economic development and Covid-19. LISA indicators confirm that the most economically developed areas in the country are more likely to be affected by Covid-19. Ascani et al. (2020) corroborate these findings providing further statistical evidence that the striking spatial unevenness of Covid-19 suggests that the infection hits core economic locations harder.

Furthermore, empirical analysis for Germany highlights spatial patterns of the disease.

First, there was a regional outbreak in Western Germany centred around the Heinsberg district. Second, tourists returned to their home regions carrying the infection. Third, the spread of the disease took place through specific events (Kuebart, Stabler 2020).

Burlina, Rodríguez-Pose (2020) have shown that highly connected regions, in colder and dryer climates, with high air pollution levels, and relatively poorly endowed health systems witnessed the highest incidence of excess mortality.

These unprecedented conditions have made state intervention even more urgent. The intensity of state intervention has become obvious across the globe. National health systems have played an important role in the health care policy. European countries and others, including the United States, are now choosing to inject large sums of money in order to kick-start economics, resume business, and maintain good polling for the ruling parties. The EU recovery plan constitutes an initiative in this line of action (European Council 2020). The OECD has so far produced comprehensive briefings on policy responses including the topics of cities (OECD 2020a), rural development (OECD 2020b), as well as the territorial and multilevel governance (OECD 2020c).

This paper focuses on European countries. This aggregate level of analysis provides an initial approach to the European space which is characterised by a high degree of integration and interaction, and where geography and the socioeconomic environment are significant diversification factors.

3 Examining demographic factors: Data sources and methods of analysis

3.1 Data and data sources

Data that have been utilised for this analysis can be grouped into two main categories. The first category focuses on the data of deaths from Covid-19, while the second includes demographic and socio-economic variables. The statistical data regarding deaths from Covid-19 have been collected from various official sources (see Table A.1 in the Appendix).

For the purposes of the study, we used numbers of deaths recorded cumulatively until May 26, 2020. The comprehensive databases we used include 32 European populations (EU members, EEA countries as well as Switzerland and UK). Three countries (Iceland, Liechtenstein, and Malta) exhibit very small numbers of deaths (<15) and high relative standard errors (>25%); thus, they are excluded from our study as in such instances the results derived are unreliable (NCHS 1999, Klein et al. 2002). Hence, the present analysis focuses on 29 national populations. For 18 of these countries, the available statistical material refers to the total number of deaths (all ages, both sexes combined). Classification of deaths by age is available only for eleven European countries: Austria; Denmark; France; Germany; Greece; Italy; Netherlands; Norway; Spain; Switzerland; and Portugal. This provides a valuable piece of information which allows application of demographic age-standardisation techniques (see below).

The first Covid-19 death in Europe was reported on February 15, 2020 in France. By February 21, nine countries had reported cases: Belgium (1); Finland (1); France (12); Germany (16); Italy (3); Russia (2); Spain (2); Sweden (1); and the UK (9) (Spiteri et al. 2020). In the EU/EEA and the UK, 121 cases and three deaths had been reported as of February 23. The rate of infection and deaths rapidly expanded across Europe. In Greece for example, the first case was diagnosed on February the 26 and only a month later, on March the 23 there were 695 confirmed cases and 17 deaths. Nation-wide restrictions on the freedom of movement were imposed at that time.

Furthermore, the dataset includes demographic and socio-economic data. Information on the population by age (January 1, 2020), as well as on selected socioeconomic indicators used in the analysis, was obtained from Eurostat official site (see Table A.1). These data include Population, Gross Domestic Product per capita (ppp-adjusted), Number of Hospital Beds per 100,000 population, Life Expectancy at Birth and percent of Urban Population. The variables used in this analysis are presented in the Appendix Table A.2.

3.2 Variables and methods of analysis

Combining the basic statistical information (total numbers of deaths and cases due to Covid-19) with the relevant population data, we calculated three broad (crude) measures:

Death Rate (DR) defined as number of deaths per 100,000 population;

Incidence Rate (IR) referring to number of cases per 100,000 population;

Fatality Rate (FR) expressing number of deaths per 1,000 cases.

It is well known, however, that crude demographic rates are affected by the age-structure of the study populations; hence, for comparative purposes we computed standardised indices to eliminate age affects (Siegel, Swanson 2004). Two types of standardisation procedures are employed:

First, for the eleven European countries for which statistics on deaths from Covid-19 by age are available, we computed standardised death rates (DSDR) directly, choosing the average age composition of the eleven populations under consideration as the more appropriate reference age structure rather than the average European standard age-distribution, which encompasses populations excluded from the present analysis.

Second, for the 29 populations under investigation we calculated Standardised Mortality Ratios (SMR) using the age-specific death rates (of Covid-19) of the Italian population as the reference mortality schedule. The SMRs are expressed per 100 and compare the national figures of the study populations to the mortality levels of Italy. Multiplying the SMRs (per unit) by the observed death rate of the standard population (Italy) we obtain the corresponding indirectly standardised death rates (ISDR).

To explore the potential association between death rates and demographic and socioeconomic factors, we applied a linear correlation analysis as well as a one-way analysis of variance (ANOVA). The factors of interest considered include the proportions of the elderly population (ages 65+, 70+, 80+), the percentage of the urban population, the per capita Gross Domestic Product (ppp-adjusted) and the number of hospital beds per 100,000 population. The statistical analysis was performed using SPSS version 24.

4 Results: ageing and Covid-19 death incidence

Table 1 presents the data used in the analysis considering up-to-date outcomes due to Covid-19 reported cumulatively until May 26. Cases and, particularly, deaths show large variations across European countries. Numbers of deaths range from 17 (Cyprus) to 36914 (UK) exhibiting a relative dispersion of 193%. Numbers of cases range from 937 (Cyprus) to 261184 (UK); the relative dispersion is 164%. The average death rate (DR) is about 18 deaths per 100,000 people, the average incidence rate (IR) 210 cases per 100,000 population while the average fatality rate (FT) is 71 deaths per 1000 cases.

Empirical research indicates that mortality risk due to Covid-19 is greatly concentrated in the older age ranges, mainly at the ages of 70, 80 and older. This finding often leads to the assumption that countries exhibiting higher proportions of older persons in the population are expected to experience higher death rates from the disease. To test this hypothesis, we apply four different approaches.

First, we computed correlation coefficients between ageing indicators (the percentages of the population aged 65, 70 and 80 years or more) and the Covid-19 rates. We also calculated the correlation coefficients between these indicators and the general economic conditions of the countries, based on the per capita gross product, the availability of hospital infrastructure (hospital beds per 100,000 inhabitants) and the percentage of the urban population as it reflects, to some extent, the concentration and density of the population. The correlation matrix is presented in Table 2. The correlation coefficients between incident rates and the ageing measures are inconsistent; for death and fatality rates they are very low and trivial, though they point in the expected direction for persons aged 70+ and 80+. Nevertheless, there is a palpable and noteworthy association between death and incidence rates and the proportions of the urban population while it seems that good hospital infrastructure plays a favourable role. It may be interesting to note that the associations and the impact of the proportion of the urban population, GDP

Table 1: Data used in the analysis and basic descriptive statistics (26/5/2020) and indirectly standardised death rates

Country	cases	deaths	death rate	incidence rate	fatality rate	Pop 65+ (%)	Pop 70+ (%)	Pop 80+ (%)	e(o)	GDP	Urban (%)	Beds	ISDR
Austria	16459	641	7.20	185	39	19.0	13.9	5.3	81.8	128	57	737	9.1
Belgium	57342	9312	81.06	499	162	19.2	13.8	5.7	81.7	118	98	566	100.3
Bulgaria	2433	130	1.87	35	53	21.6	15.0	4.9	75.0	51	76	745	2.4
Croatia	2244	100	2.47	55	45	21.1	14.5	5.5	78.2	63	58	554	3.1
Cyprus	937	17	1.92	106	18	16.3	11.2	3.7	82.9	90	67	340	3.1
Czechia	9004	317	2.97	84	35	20.0	13.6	4.1	79.1	91	74	663	4.1
Denmark	11387	563	9.64	195	49	19.8	14.3	4.7	81.0	129	88	261	12.7
Estonia	1824	65	4.90	137	36	20.1	14.3	5.9	78.5	82	68	469	6
Finland	6599	308	5.57	119	47	22.3	15.8	5.7	81.8	112	86	328	6.4
France	145279	28432	42.31	216	196	20.4	14.6	6.1	82.9	104	82	598	49.1
Germany	179002	8302	9.98	215	46	21.8	15.9	6.8	81.0	123	76	800	10.8
Greece	2882	172	1.61	27	60	22.3	16.6	7.2	81.9	69	85	421	1.7
Hungary	3771	499	5.12	39	132	19.9	13.3	4.5	76.2	71	72	702	7
Ireland	24698	1606	32.49	500	65	14.4	9.9	3.4	82.3	191	63	296	57.8
Italy	230158	32877	54.58	382	143	23.2	17.4	7.4	83.4	97	69	318	54.6
Latvia	1049	22	1.15	55	21	20.6	14.8	5.8	75.1	69	69	557	1.4
Lithuania	1635	63	2.28	59	39	20.1	14.5	5.9	76.0	81	71	656	2.7
Luxembourg	3993	110	17.58	638	28	14.6	10.2	4.1	82.3	263	88	466	28.8
Netherlands	45445	5830	33.62	262	128	19.6	13.8	4.7	81.9	130	92	332	44.4
Norway	8352	235	4.38	156	28	17.5	12.4	4.3	82.8	153	70	360	6.3
Poland	21631	1007	2.65	57	47	18.2	11.8	4.4	77.7	71	60	662	3.8
Portugal	30788	1330	12.96	300	43	22.2	16.1	6.6	81.5	77	66	339	14.2
Romania	18283	1197	6.21	95	65	19.0	12.7	4.8	75.3	66	55	689	8.5

Continued on the next page ...

Table 1: Data used in the analysis and basic descriptive statistics (26/5/2020) and indirectly standardised death rates (*continued*)

Country	cases	deaths	death rate	incidence rate	fatality rate	Pop 65+ (%)	Pop 70+ (%)	Pop 80+ (%)	e(o)	GDP	Urban (%)	Beds	ISDR
Slovakia	1511	28	0.51	28	19	16.6	10.5	3.3	77.4	74	54	582	0.9
Slovenia	1469	106	5.09	71	72	20.4	13.9	5.5	81.5	88	55	450	6.3
Spain	235400	26834	57.03	500	114	19.7	14.5	6.1	83.5	91	80	297	66.8
Sweden	33843	4029	38.93	327	119	19.9	14.7	5.2	82.6	121	88	222	49.0
Switzerland	30601	1645	19.11	356	54	18.7	13.7	5.3	83.8	156	78	453	24.4
UK	261184	36914	55.02	389	141	18.5	13.5	5.0	81.3	106	88	254	72.8

Statistics	cases	deaths	death rate	incidence rate	fatality rate	Pop 65+ (%)	Pop 70+ (%)	Pop 80+ (%)	e(o)	GDP	Urban (%)	Beds	ISDR
min	937	17	0.5	27.0	18.1	14.4	9.9	3.3	75.0	51.0	54.0	222	0.9
max	261184	36914	81.1	638.2	195.7	23.2	17.4	7.4	83.8	263.0	98.0	800	100.3
range	260247	36897	80.6	611.2	177.6	8.7	7.4	4.0	8.8	212.0	44.0	578	99.4
mean	47904	5610	17.9	209.9	70.5	19.6	13.8	5.2	80.4	105.7	73.6	487	22.7
std. dev.	78753	10817	21.8	173.2	48.6	2.1	1.8	1.0	2.8	44.2	12.4	173	26.9
CV (%)	164	193	121	83	69	11	13	20	3	42	17	35	119

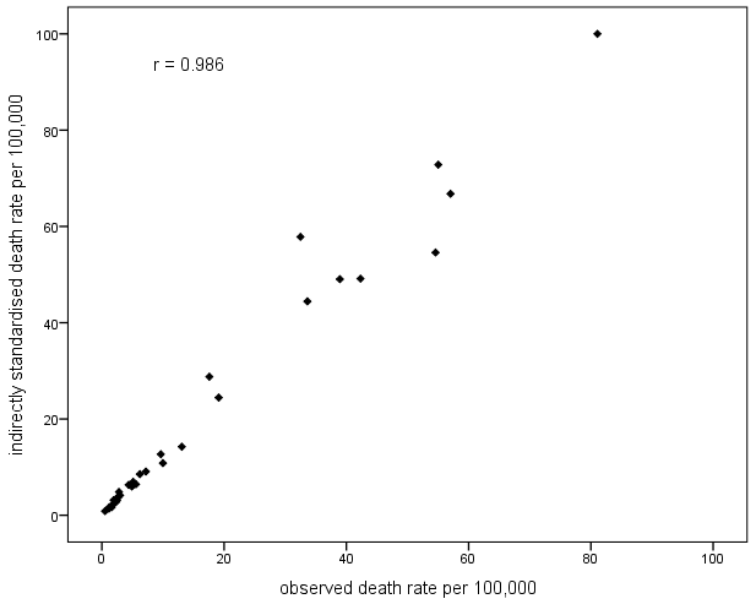

Figure 1: Association between observed death rate and standardised death rate using the indirect method of standardisation: data 26-5-2020

per capita and hospital infrastructure are clearer with respect to incidence rates. One explanation might be that countries with relatively higher levels of economic development are usually characterized by higher trade openness, interactions and connections with the international community. It seems that the spread of Covid-19 puts into question openness, internationalization and globalization. Covid-19 is following the paths of international connections and integration.

Second, in order to eliminate age structure effects and to increase the validity of our results, we calculated indirectly standardized death rates and we examined the association between observed and indirectly standardised death rates. Table 1 presents the computational results. Compared to Italy (standard population), Belgium, Spain and the UK exhibit higher mortality, however the overall association between observed and adjusted death rates is positive and very strong implying that ageing effects do not seem to be present (Figure 1).

Third, a direct comparison of the observed death rates with demographic ageing indicators across countries at different stages of the disease progression that have adopted different policies of social distancing and have different health systems and capabilities may be naive. To overcome to some extent these incompatibilities, it may be more appropriate to compare countries with roughly similar levels of mortality. Hence, we divided our sample into three sub-groups reflecting low, medium and high mortality rates (<5, 6-19 and 20+ deaths per 100000 population, respectively) and we applied one-way ANOVA to examine if the differences in mean population ageing indicators between the three groups differ considerably. The results of the statistical analysis are presented in Table 3 and confirm that the mean proportions of populations aged 65, 70 or 80 or more do not in fact differ across mortality levels (p-values 0.863, 0.936 and 0.661, respectively).

Fourth, we applied direct standardisation for countries where the relevant information was available, as this demographic technique perhaps more accurately clarifies the potential connection between observed death rates and population ageing. The results of our computations are presented in Figure 2. The pattern of the observed and standardised rates across countries is consistent; the association between observed and directly standardised death rates is very high (r = 0.986) implying that the age differentials do not seem to have an effect on the mortality rates.

Table 2: Correlation matrix of variables of interest (2-tailed p-values in parenthesis): data 26/5/2020

	Death rate	Incidence rate	Fatality rate	Pop 65+ (%)	Pop 70+ (%)	Pop 80+ (%)	e0	GDP	Urban % (%)	Beds
Death rate	1									
Incidence rate	0.762** (0.000)	1								
Fatality rate	0.807** (0.000)	0.387* (0.038)	1							
Pop 65+ (%)	-0.019 (0.923)	-0.349 (0.064)	0.216 (0.260)	1						
Pop 70+ (%)	0.118 (0.541)	-0.160 (0.407)	0.262 (0.169)	0.962** (0.000)	1					
Pop 80+ (%)	0.238 (0.214)	0.030 (0.877)	0.295 (0.120)	0.815** (0.000)	0.894** (0.000)	1				
e0	0.513** (0.004)	0.632** (0.000)	0.304 (0.109)	-0.117 (0.545)	0.069 (0.721)	0.170 (0.378)	1			
GDP	0.252 (0.187)	0.724** (0.000)	-0.025 (0.897)	-0.594** (0.001)	-0.436* (0.018)	-0.300 (0.114)	0.566** (0.001)	1		
Urban (%)	0.545** (0.002)	0.475** (0.009)	0.476** (0.009)	0.120 (0.536)	0.250 (0.190)	0.191 (0.321)	0.396* (0.034)	0.354 (0.060)	1	
Beds	-0.391* (0.036)	-0.464* (0.011)	-0.177 (0.357)	0.116 (0.549)	-0.025 (0.896)	0.004 (0.985)	-0.633** (0.000)	-0.310 (0.101)	-0.360 (0.055)	1

** Significant at the 0.01 level (2-tailed)

* Significant at the 0.05 level (2-tailed)

Table 3: One-Way Analysis of Variance examining differences in mean ageing indicators by low, medium and high levels of death rates due to Covid-19: 26-5-2020

(A) Descriptive statistics

		N	Mean	Std. Dev.	Std. Error
Pop 65+ (%)	death rate 0 - 5	14	19.8	1.9	0.5
	death rate 6 - 19	7	19.3	2.5	0.9
	death rate 20 +	8	19.4	2.4	0.9
	Total	29	19.6	2.1	0.4
Pop 70+ (%)	death rate 0 - 5	14	13.7	1.7	0.5
	death rate 6 - 19	7	13.9	2.0	0.8
	death rate 20 +	8	14.0	2.0	0.7
	Total	29	13.8	1.8	0.3
Pop 80+ (%)	death rate 0 - 5	14	5.0	1.0	0.3
	death rate 6 - 19	7	5.4	1.0	0.4
	death rate 20 +	8	5.5	1.2	0.4
	Total	29	5.2	1.0	0.2

(B) ANOVA: F-test

		Sum of Squares	df	Mean Square	F	Sig.
Pop 65+ (%)	Between Groups	1.447	2	0.723	0.148	0.863
	Within Groups	127.125	26	4.889		
	Total	128.572	28			
Pop 70+ (%)	Between Groups	0.470	2	0.235	0.066	0.936
	Within Groups	92.568	26	3.560		
	Total	93.039	28			
Pop 80+ (%)	Between Groups	0.964	2	0.482	0.421	0.661
	Within Groups	29.738	26	1.144		
	Total	30.702	28			

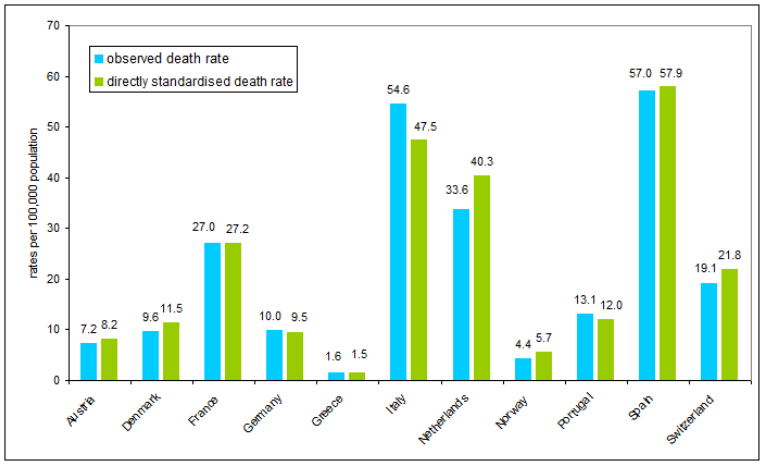

Figure 2: Observed and directly standardised death rates on the basis on the average population age-structure of the countries under investigation: data 26-5-2020

5 Modeling Covid-19 mortality rates: a Bayesian BYM spatial model

5.1 *Presentation of the Model*

In recent years, epidemiology has used Bayesian models widely (Greenland 2006). Quite frequently, the spatial and/or the temporal framework of the epidemiological data upgrades the Bayesian approach into a very efficient strategy for a plethora of epidemiological studies (Diggle, Ribeiro 2007, Jewell et al. 2009, Blangiardo et al. 2013).

In order to further analyse the risk of Covid-19 mortality rate, we employ a spatial econometric epidemiological model that explains the mortality rates integrating a number of covariates. Therefore, in the following section we have a dual goal: on the one hand to smooth the Standardized Mortality Ratios (SMRs) with the Hierarchical Bayesian method; and on the other hand to fit the Besag-York Mollie (BYM) spatial model with a view of estimating relative risk while quantifying the effect of a set of covariates (Mollié 1996, Morris et al. 2019).

The BYM model incorporates two types of effects: spatial and non-spatial: a spatially structured effect and an unstructured random effect. Rigorously, we assume that the observed counts, O_i, are conditionally independently Poisson distributed (Moraga 2019):

Model based approaches enable us to incorporate covariates and borrow information from neighbouring countries to improve local estimates, resulting in the smoothing of extreme values based on small sample size. We take the following equation:

$$O_i \sim \text{Poisson}(E_i\theta_i) \qquad i = 1, \ldots, n \tag{1}$$

where E_i is the expected count and θ_i is the relative risk in area i. The logarithm of θ_i is expressed as:

$$\log(\theta_i) = \boldsymbol{d_i}\boldsymbol{\beta} + u_i + v_i \tag{2}$$

$\boldsymbol{d_i} = (1, d_{i1}, \ldots, d_{ip})$ is the vector of the intercept and p covariates corresponding to area i, and $\boldsymbol{\beta} = (\beta_0, \beta_1, \ldots, \beta_p)$ denotes the coefficient vector.

The error term u_i is modeled with a CAR distribution $u_i|u_{-i} \sim N(\bar{u}_{\delta_i}, \frac{\sigma_u^2}{n_{\delta_i}})$ where $\bar{u}_{\delta_i} = \frac{\sum_{j\in\delta_i} u_j}{n_{\delta_i}}$, δ_i, and n_{δ_i} represent the set of neighbors and the number of neighbors of area i respectively. v_i is modeled as identically distributed normal variables with zero mean and variance σ_v^2, namely, $v_i \sim N(0, \sigma_v^2)$.

For the analysis, R statistical software was used. Inferences for Bayesian Hierarchical models were approximated by Integrated Nested Laplace approximation (INLA) with R-INLA package (Rue et al. 2018).

5.2 *Empirical application*

We employ a spatial epidemiology model in order to estimate the disease risk due to Covid-19 in 29 European countries during the first wave of the pandemic. Following equation 1 as the dependent variable, we use observed deaths per country (O_i) which are conditionally independently Poisson distributed with expected deaths (E_i) and θ_i the relative risk for each country. Equation 2 allows us to include a set of covariates in our model in order to quantify the effect and incorporate this information into relative risk estimates. Five variables are examined as covariates in our spatial econometric model, Gross Domestic Product (GDP), ageing indicators (the percentages of the population aged 70 and 80 years or more), the availability of hospital infrastructure (hospital beds per 100,000 inhabitants) and the percentage of population living in an urban context. Our analysis comprises the mean posterior, the standard deviation and the 95% credible intervals of the relative risks which represent the 2.5 and 97.5 percentiles respectively. Additionally, with the purpose of interpreting the relative risk in our model, we construct an additional column where we calculate the factor increase, $\exp(\beta_j)$, keeping all other covariates constant. Finally, in order to compare the different Bayesian models we use the Watanabe Akaike information Criterion (WAIC) (Watanabe 2010).

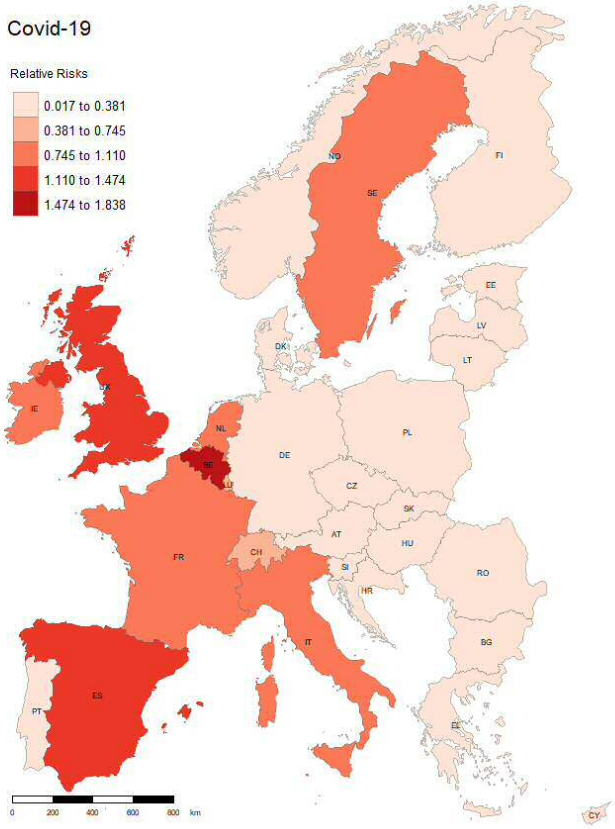

Figure 3: Mapping Covid-19 relative risk across European countries

5.3 Mapping the evidence

Figures 3 and 4 illustrate the output of the BYM model regarding the relative mortality risk, considering Italy as a baseline. As Italy exhibits the highest mortality rate, the probability of death is estimated based on Italy=1: higher values denote higher mortality rates and vice versa.

Figures 3 and 4 indicate that there is a geographical pattern in mortality rates. Countries on the left part of the map show higher probability rates than countries on the right. Belgium, Spain, UK and Ireland show the greatest values above the baseline. France, Slovenia and the Netherlands are a little below the baseline. Conversely, a large number of countries including Germany and Denmark from the North, Greece and Portugal from the South and a large number of former Eastern European countries exhibit rates below that of Italy and well below the baseline. This demonstrates the spatial heterogeneity of mortality rates across Europe.

5.4 The results

The application of the spatial epidemiology model provides some interesting results which are presented in Table 4. These could be summarized as follows:

First, in all models the coefficient of the variable URBAN is positive, indicating that urbanization is an important explanatory factor for the probability of the mortality rate and overall increases Covid-19 risk.

Second, in all models, the variable BEDS is negatively associated with the probability of mortality indicating an inverse relationship between hospital beds and Covid-19 risk. This is achieved taking into account the observed deaths from Covid-19, the expected number of deaths but also a set of covariates. The greater the bed availability per 100,000 population, the lower the Covid-19 mortality risk. This signifies the importance of sound health care systems to efficiently tackle the negative impacts of the pandemic.

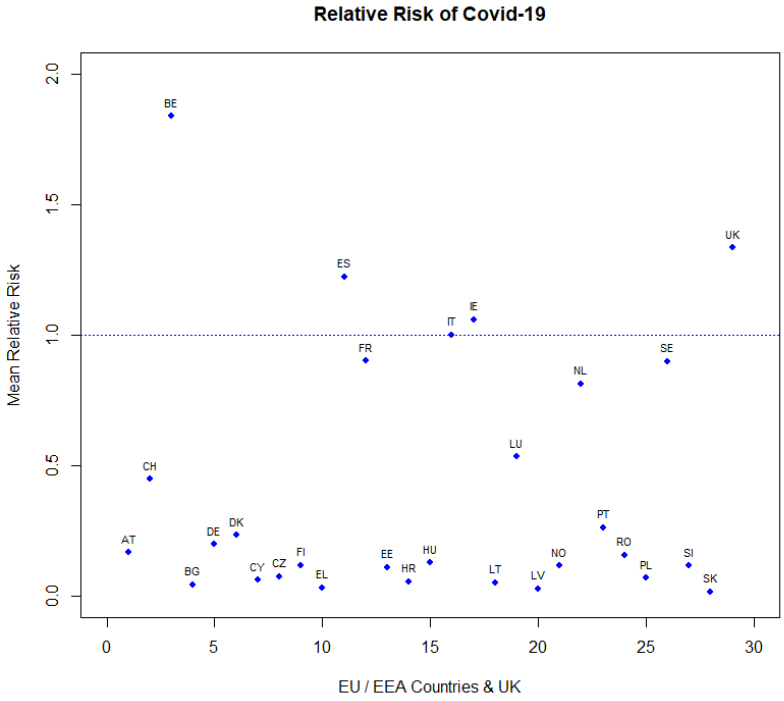

Figure 4: Covid-19 relative risk across European countries

Third, where the explanatory factor of GDP is taken into account, its coefficient was positive, suggesting that countries with greater GDP tend to have greater Covid-19 risk. The higher the market size and the level of development, the higher the risks. This finding corroborates the literature that the most advanced and open economies are more vulnerable to Covid-19 (Sorci et al. 2020). Developed economies are expected to be more affected in 2020 than developing economies, at -5.8 per cent and -2.1 per cent, respectively (United Nations 2020, p. 13). Since GDP and urbanization show a high level of correlation in the data, they are inserted separately in the analysis.

Fourth, the coefficient of variable P80 is positive, indicating that there is a higher risk of mortality for people above 80 years of age.

Finally, in line with WAIC criterion, the best model is model 3 which has the lowest value and therefore the highest explanatory power of those that are presented (Table 4).

Figure 4 presents all the posterior distributions of covariates P70, GDP, Urban and Beds. On the one hand, covariates GDP and Urban display positive distribution of values for the coefficients indicating an increase in Covid-19 risk. On the other hand, the posterior distribution of the coefficient of Beds is mainly negative, demonstrating this inverse relationship between Beds and Covid-19 risk.

6 Conclusions and discussion

The Covid-19 pandemic is a new phenomenon that has been ongoing for one year. Empirical studies from various countries reveal that older people are at a higher risk of developing the disease than younger people. Furthermore, not only are the majority of cases concentrated in older ages but elderly people have a much higher risk of a fatal outcome. These findings often lead to the assumption that countries with high proportions of aged population would tend to exhibit higher death rates from Covid-19.

However, our results based on recent cross-sectional data from 29 European countries, referring to what now is termed 'the first wave of the pandemic', do not agree with the standpoint expressed in the literature, that the population age structure may explain notable variations in fatality or death rates across countries (Dowd et al. 2020). Although a correlation is apparent between death rates and proportions of persons aged 70 or more,

Table 4: Besag-York-Mollié model using Bayesian Hierarchical smoothing on SMRs

Covariates	Mean	S.d.	2.5%	97.5%	Exp(Mean)
		Model 1:			
P70+	-0.059	0.122	-0.301	0.183	0.943
Urban	0.047	0.019	0.009	0.085	1.048
Beds	-0.002	0.054	-0.005	0.000	0.998
Constant	-3.179	2.156	-7.450	1.076	
Marginal log-likelihood	-271.02				
WAIC	292.64				
		Model 2:			
P80+	0.084	0.211	-0.332	0.500	1.088
Urban	0.043	0.019	0.005	0.081	1.044
Beds	-0.002	0.001	-0.005	0.000	0.998
Constant	-4.101	1.896	-7.854	-0.359	
Marginal log-likelihood	-270.52				
WAIC	292.58				
		Model 3:			
P70+	0.111	0.141	-0.169	0.391	1.117
GDP	0.013	0.006	0.001	0.025	1.013
Urban	0.028	0.020	-0.013	0.068	1.028
Beds	-0.002	0.001	-0.004	0.001	0.998
Constant	-5.711	2.372	-10.411	-1.031	
Marginal log-likelihood	-277.38				
WAIC	292.47				
		Model 4:			
P80+	0.282	0.210	-0.134	0.698	1.326
GDP	0.013	0.005	0.002	0.023	1.013
Urban	0.027	0.019	-0.010	0.064	1.027
Beds	-0.002	0.001	-0.004	0.001	0.998
Constant	-5.576	1.847	-9.235	-5.571	
Marginal log-likelihood	-276.34				
WAIC	292.48				

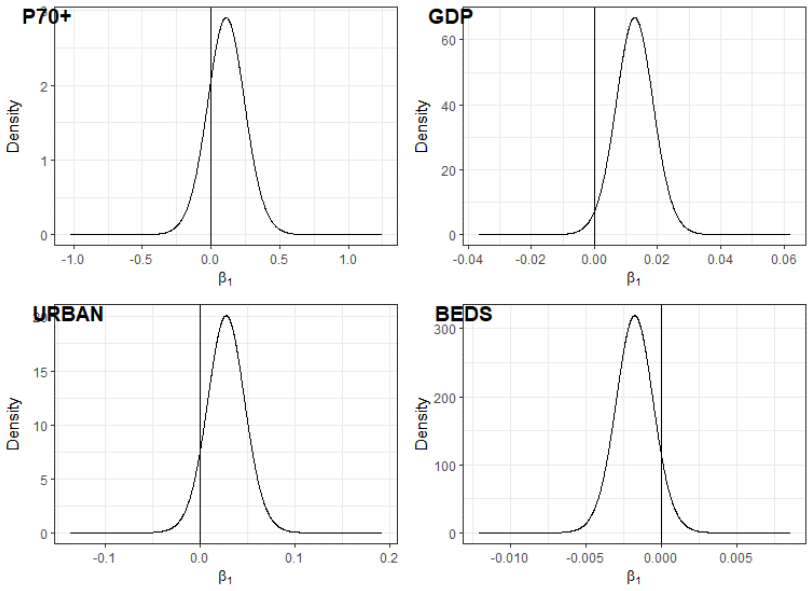

Figure 5: Posterior Distribution of the coefficient of covariatest

and, especially, 80 or more, the associations are small in magnitude. Several factors contribute to this discrepancy. First, the degree of ageing does not differ substantially between European countries; hence, the standardization methodology used in this study did not result in sizeable differences. Second, it may be still too early to confirm the effects and the interrelationships of the disease with the structural characteristics of the population. As the Covid-19 pandemic is still under way additional deaths are recorded every day and more statistical material is collected globally. Comparisons may be inconsistent because different countries are at different stages of the epidemic while additionally, they employ different social and health policies to protect their citizens. Third, differential reporting of Covid-19 deaths (and of cases) adds to the confusion. There is evidence that, at present, there is a significant under-reporting of deaths from Covid-19, particularly in developing countries, while different definitions and practices are employed by different countries (for instance, in the UK, only deaths occurring in hospitals are registered; in Sweden deaths occurring in nursing homes are not recorded). Furthermore, even accurate identification of Covid-19 deaths is a difficult task. Additionally, in many instances, it is mainly some cities or regions that have been disproportionally affected by the virus compared with the rest of the country (e.g. in Sweden Stockholm, in Greece mostly Athens, etc.).

Analysis has shown that explanations on high fatality rates of Covid-19 for elderly people don't necessarily imply high fatality rates for aging societies. Moving from the individual determinants of fatality to societal fatality rates, the determinants are changing significantly. It is not only age that matters. It is the socio economic environment and the broader conditions that affect vulnerability to Covid-19.

Furthermore, our analysis has unveiled the issue that socio-economic variables exert a significant impact on the incidence of and fatalities from Covid-19. Testing for socio-economic and demographic factors, the Bayesian Besag-York Mollie (BYM) spatial model provides some interesting results which we present below.

First, the level of urbanization of a country is a significant determinant of death rates from Covid-19. The level of urbanization proxies the market size along with the level of interaction and interconnections. The higher the level of interactions, the higher the risk of the disease. This risk is caused by the large number of those affected vis-a-vis the limits of the health system. As a result this observation signifies the role of health systems and corroborates previous findings in the literature of epidemiological studies (Neiderud 2015). At the same time the more deprived populations within urban areas are more vulnerable to fatality rates (Wade 2020).

Second, the level of economic development emerges as a significant factor for the spread of the disease. The level of economic development proxies the openness and the international connectedness of the economy. The higher the connections through trade and transport, the higher the risks from the disease. According to Sorci et al. (2020), GDP per capita was positively associated with the levels of fatality rates in Europe. Similarly, Hamidi et al. (2020) identified connectivity as a risk factor for COVID-19 in the US, while Burlina, Rodríguez-Pose (2020) show that highly connected regions witnessed the highest incidence of excess mortality.

The 'first wave of the pandemic' made evident that Covid-19 challenges the two fundamental trends/issues of the contemporary global economic system: globalization and urbanization. This could mean that factors which were clear advantages for the economic development in the past (such as agglomeration and interactions) might operate differently in the context and aftermath of Covid-19 (Bailey et al. 2020).

Third, the number of beds, which proxies the quality of health system, plays a significant role in protection from the disease. The higher the standards of the health system, the greater the protection of people from the disease. This finding corroborates with the results of Sorci et al. (2020) who demonstrated that fatality rates in the EU countries were negatively associated with the number of hospital beds per 1000 inhabitants.

The present pandemic is raising fundamental questions about what makes a community, a population and a nation resilient and sustainable to external shocks (Psycharis et al. 2014). As a result, this analysis highlights some interesting challenges and policy implications for the future.

First, this disease questions the pace of urbanization and the functioning of urban systems. The international trend towards urbanization witnessed in recent years is anticipated to be affected or even halted by the recent spread of the pandemic. In addition, the organization of everyday life and the economic activities within cities has changed drastically. It is very early to predict the long term consequences. However, it is certain that these trends introduce another factor that should be taken into consideration in urban development and urban policy in the future.

Second, the Covid-9 pandemic questions the pace of globalisation. The world appears to be becoming less globalized as the pandemic persists (United Nations 2020).

Third, these trends place into question: the specialization of the economy; the organization of production; and location choices. More remote and rural areas may provide safer and healthier types of economic activity and choices for residence. Although it is still early, the location choices of people and enterprises may be affected by the spread of the disease. Will people move to peripheral areas? It is very early and would be premature to make such a prediction. However, the balance between centrifugal or centripetal forces that operate and determine the location choices of people and enterprises will probably change and the underlying forces will be reshuffled in the post-Covid-19 period.

Fourth, the pandemic threatens the inclusiveness of societies. Historically, pandemics have hit minorities and people at the bottom of the socioeconomic ladder disproportionately (Wade 2020). During the pandemic the most vulnerable populations have been hit the hardest (United Nations 2020, p. 111). Inequality, one of the major issues in contemporary societies, will probably deteriorate further.

Fifth, the spread of the pandemic requires the improvement of public health care systems. An unequal distribution of resources or the uneven delivery of healthcare could incur harmful effects on people across and within regions. The structure of health systems is a vital condition for the wellbeing of people and the proper functioning of the economy. Thus, a more active role of states in upgrading the health systems is a fundamental factor in modern public policy.

Finally, the European Union has launched the Recovery Fund for the support of the economy and society. It seems that the disease is leading to a reconstruction of the priorities and the means of cohesion policy. This may transform the cohesion policy and the functioning of public policy as we knew it in the pre-Covid-19 era.

This study also opens some new directions for future work.

We believe that a robust age-specific analysis of the mortality from Covid-19 cannot be performed at this time. Such studies will be much more reliable and fruitful later on, when governments relax the restrictive measures already taken. There may also be more recurrent waves of the disease. No clear conclusions can be drawn yet with respect to the correlation between demographic dimensions and the levels of mortality due to the virus. It is however a fact that the Covid-19 pandemic has already led most countries into a major economic recession. The adverse effects of this crisis could impact public health care service capabilities and efficiency, adding a further future complication to the estimation of the association of demographic factors with Covid-19 mortality.

Nevertheless, one of the interesting outcomes of the present analysis is that higher rates of the disease are associated with higher levels of economic development and urbanization. These factors could offer a partial explanation of the patterns and the spread of disease. The most developed countries are usually those with greater trade openness and frequent interactions on a global scale.. Furthermore, empirical studies have shown that in urban areas, certain population groups tend to advance the transmission of pathogens and provide suitable conditions for the manifestation of infectious disease (Neiderud 2015). At the same time Covid-19 places an unequal burden on more deprived populations (Wade 2020). Therefore, Covid-19 requires a place-specific and people-centered implementation of public policy (Bag et al. 2020). This constitutes an important challenge for public policy in the current circumstances. A closer analysis of the association of urbanization with the spread of and fatalities from the disease, the impact of income level and spatial segregation on the spread of the disease, as well as analyses on smaller geographical scales constitute fruitful avenues for future research.

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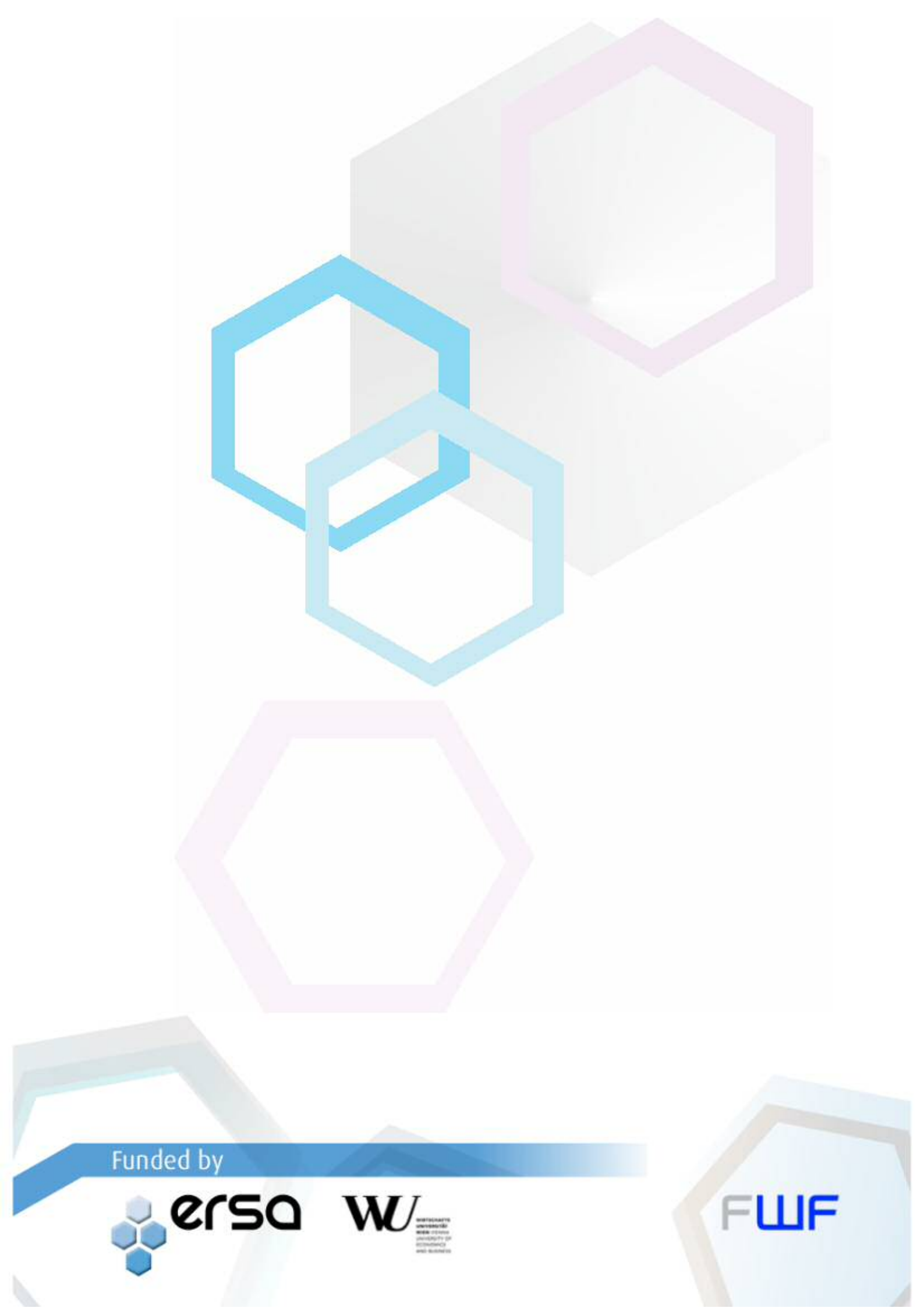
A Appendix:

Table A.1: Data sources

Country and material	Source of data
Deaths and cases of Covid-19	
Deaths by age	
Austria, Denmark, France, Germany, The Netherlands, Norway, Spain, Portugal	Institut National D' Etudes Démographiques (IDED) https://dc-covid.site.ined.fr/en/
Greece	Greek National Public Health Organisation (EODY) https://eody.gov.gr/en/covid-19/
Italy	Instituto Superiori di Sanita (epicentre) https://www.epicentro.iss.it/coronavirus/sars-cov-2-sorveglianza-dati
Switzerland	Switzerland's Federal Office of Public Health https://www.bag.admin.ch/bag/en/home/krankheiten/ausbrueche-epidemien-pandemien/aktuelle-ausbrueche-epidemien/novel-cov/situation-schweiz-und-international.html#1867597016
Total deaths and cases (all ages)	
EU countries, EEA (European Economic Area) countries U.K.	European Center for Disease Prevention & Control (ECDC) for the EU / EEA https://www.ecdc.europa.eu/en/cases-2019-ncov-eueea
Socio-economic and demographic data and indices	
Population size and structure (1.1.2020); Life expectancy at birth (both sexes, last available year); Percent urban population (2017); Hospital beds per 100,000 population (2017); Gross Domestic Product per capita in 2018 (ppp-adjusted)	https://ec.europa.eu/eurostat/data/database

Table A.2: Variable definition and variable name

Variable	Definition
(death rate):	deaths of covid-19 per 100000 population
(incidence rate):	cases of covid-19 per 100000 population
(fatality rate):	deaths of covid-19 per 1000cases
Pop (65+) %:	percentage of population aged 65 or higher
Pop (70+) %:	percentage of population aged 70 or higher
Pop (80+) %:	percentage of population aged 80 or higher
e(o):	life expectancy at birth (latest data)
GDP:	Gross Domestic Product per capita ppp adjusted (2018)
Urban (%):	percentage of urban population (latest data)
Beds:	Hospital beds per 100,000 inhabitants
ISDR:	Indirectly Standardised Death Rates per 100000 population



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