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Life satisfaction in Romanian cities on the road from post-communism transition to EU accession

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Abstract. The literature on life satisfaction in transition countries, and in particular on Romania, demonstrated that life satisfaction significantly differs across rural communities and cities of different sizes. The question addressed in this paper is whether these imbalances are stable over time, or instead, they become manifest in the presence of strong divergences in the economic growth rates of different kinds of communities. Results point out that in the period of sharp economic growth led by large urban areas, as the one experienced by Romania on the road to EU accession, rural/urban disparities in life satisfaction widened, favoring cities of intermediate size.

1 Introduction

The interest towards the determinants of life satisfaction largely increased in the last twenty years. An issue only partially explored by the literature, even if it is gaining momentum in recent years (Morrison 2014, Tomaney 2015, Piper 2015), concerns the relationship between urbanization and life satisfaction. This topic is particularly relevant in the case of transition and developing countries, characterized by huge divergences in the economic growth rates of urban and rural areas.

The relevance of geographic location for individual life satisfaction has been clearly demonstrated and persistent differences across space have been highlighted (Oswald, Wu 2010, Glaeser et al. 2016, Morrison 2011). Some works emphasized lower levels of happiness in cities compared to the countryside (Knight, Gunatilaka 2010, Hayo 2007, Sørensen 2014); others instead report no significant relationship between urbanization and well-being (Appleton, Song 2008, Rehdanz, Maddison 2005, Rodríguez-Pose, Maslauskaite 2012). Moreover, some authors indicate that the level of economic development can affect the relationship between urbanization and life satisfaction, and rural areas are at a disadvantage with respect to urban ones especially in poorer countries (Shucksmith et al. 2009, Easterlin et al. 2011, Berry, Okulicz-Kozaryn 2009, 2011, Requena 2015). These analyses have certainly advanced the understanding of spatial variations in life satisfaction and its determinants. However, a relatively neglected issue refers to the temporal dimension of these spatial unbalances, albeit with some exceptions (Ferrara, Nisticò 2015). In fact, it is not clear whether the disparities in life satisfaction are stable over time or they occur only in the presence of relevant gaps in the economic growth rates of urban and rural settings.

The aim of the present paper is to shed some light on these issues by drawing on fresh empirical evidence from Romania. After the end of the communist regime in 1990, Romania experienced a period of deep economic crisis, followed by a fast recovery, leading to the access to the EU in 2007. At the regional level, the growth patterns were highly differentiated. Urban areas always performed better than rural ones; from 2004 on, however, these imbalances widened even more. This was particularly true in the case of the capital city, Bucharest, whose rates of GDP growth outperformed all the other Romanian local economies. The evidence presented in the present paper is, therefore, aimed at understanding when these divergences among rural and urban areas of different size emerged and whether and how they mirrored (or not) on the life satisfaction of the resident population. By doing so, we are able to extend previous analyses on the Romanian case (Lenzi, Perucca 2016b) that highlighted important unbalances in life satisfaction across cities and an important penalty for the capital, Bucharest, in line with the original Easterlin's intuition and recent evidence by Piper (2015). In particular, while keeping the urban level of analysis, in this paper we exploit the longitudinal dimension of the large dataset on Romanian life satisfaction evolution and economic growth trends, in the period 1996-2011, that was not sufficiently examined in previous analyses; neither in cross-country studies, e.g. Okulicz-Kozaryn (2012), Rodríguez-Pose, Maslauskaite (2012), Lenzi, Perucca (2016a), nor in country specific studies, e.g., Andrén, Martinsson (2006), Mariana (2012), Lenzi, Perucca (2016b).

The discussion is organized as follows. In the next section, we discuss the literature on life satisfaction in transition countries and we present some evidence on the regional development patterns in Romania between 1995 and 2010. The third section describes the data set and the methodologies used in the analysis. The fourth section presents our findings, while in the final part we discuss conclusions.

2 Life satisfaction and economic growth in Romanian regions

2.1 Life satisfaction in transition countries: a review of the literature

In recent years, a long stream of research focused on the trends and determinants of individual life satisfaction. The main finding of this body of literature concerns the relationship between economic prosperity and self-reported wellbeing.

In one of the first works devoted to this issue, Easterlin (1995) pointed out two main results. The first one, consistent with the expectations of economic theory, is that richer individuals are happier than poor ones. The second, and counterintuitive, finding is that a further increase in income does not have any significant impact on life satisfaction. This conclusion, referred to as "Easterlin paradox" in the subsequent literature, was confirmed in a number of studies on developed countries, like US and Western European economies (Di Tella, MacCulloch 2008). The fall of the Iron Curtain, followed by a deep economic recession and, some years later, by a fast recovery, created ideal conditions to test whether the Easterlin paradox could be extended also to transition economies. Several works indeed addressed this issue.

From the paper by Blanchflower, Freeman (1997), a common finding of this literature indicates that life satisfaction in post-socialist countries was lower, for the whole period of transition and even at the end of it, than the one observed in developed western economies. Given the abovementioned evidence on the association between self-reported happiness and the absolute level of wealth, this result is consistent with the literature on the US and Western Europe (Lelkes 2006).

The relationship between life satisfaction and income growth patterns in transition economies is, on the other hand, less clear. For example, Sanfey, Teksoz (2007) focused on life satisfaction in a sample of transition countries between 1990 and 2002. Their findings pointed out the simultaneous decline of life satisfaction and GDP in the first years of transition, followed by a steady growth of both indicators in the second stage. As a result, in the early 2000's, almost all countries exhibited levels of self-reported happiness and GDP similar to the pre-transition ones. Evidence supporting the consistency of the association between the rise of life satisfaction and economic growth was found also by Guriev, Zhuravskaya (2009) in their study on 28 post-communist countries. Rodríguez-Pose, Maslauskaite (2012) observed that the increase of life satisfaction over time in Eastern Europe was associated to economic growth only for some countries. Romania was among those. This last finding was confirmed also in the country-study by Andrén, Martinsson (2006). Taken together, these results seem to contradict the Easterlin paradox, at least as transition economies are concerned.

Easterlin et al. (2010), however, claimed that for those countries transitioning from socialism to capitalism, happiness and income go together only in the short term (i.e. for a period of no more than 10 years) while in the long period the Easterlin paradox still holds. Evidence supporting this claim was found by Easterlin, Plagnol (2008) in their analysis on life satisfaction in Eastern and Western Germany, and in a study focused on a set of post-communist countries by Easterlin (2009).

Another element that could help explain the common trajectories of happiness and GDP growth in transition economies is the role of urbanization. A broad amount of literature pointed out that the economic recovery of post-communist counties after the first phase of crisis was led by large urban areas and, in particular, capital cities (Kallioras, Petrakos 2010). Therefore, considering the trend of national GDP as a determinant of life satisfaction could be misleading, since it hides the variety of economic paths followed by different regions within the same country. Post-communist countries represent exemplary cases to test whether the association between urbanization and life satisfaction is likely to be particularly closely related in environments characterized by huge territorial disparities in terms of growth and urban expansion. In fact, urbanization is certainly related to positive externalities on individuals' wellbeing, such as better job opportunities, public services and amenities (Puga 2010), but it also generates agglomeration costs like pollution, congestion and social conflicts (Glaeser, Kahn 2010).

Some of the works summarized above incidentally found evidence of territorial imbalances in life satisfaction across settings marked by a different degree of urbanization. Interestingly, all these findings suggest that people living in rural settings are happier than those living in large cities (Rodríguez-Pose, Maslauskaite 2012). Similarly, Hayo (2007) claimed that residents in Bucharest are consistently less happy than those living in any other type of community. Likewise, Andrén, Martinsson (2006) pointed out that, again on the Romanian case, respondents living in the countryside are more likely to be happy than those in urban areas of any size. Finally, Mariana (2012) pointed out that life satisfaction in Romania mainly depends on the availability of resources satisfying the basic human needs.

More recently, Lenzi, Perucca (2016b) conducted a cross-sectional analysis on life satisfaction in Romanian regions, classified according to their level of urbanization, and found that the life satisfaction of residents in urban communities is higher than the happiness of those living in rural areas, with the sole exception of Bucharest. In this latter case, in fact, urban diseconomies prevail over the positive externalities of agglomeration, leading to lower levels of residents' well-being.

On balance, therefore, the literature has not yet achieved a definitive conclusion about the relationship between transition, urbanization and happiness. Moreover, little is known about the evolution of the relationship between life satisfaction and urbanization over time both in cross-country studies (e.g., Okulicz-Kozaryn 2012, Rodríguez-Pose, Maslauskaite 2012, Lenzi, Perucca 2016a) and in country specific studies (e.g., Andrén, Martinsson 2006, Mariana 2012, Lenzi, Perucca 2016b). The conjecture to be tested in the present paper is, then, that territorial differentials in well-being emerged when the development patterns and urbanization processes of different areas started to diverge. In the case of post-communist countries of Central and Eastern Europe, the most intense territorial divergence between urban and rural settings occurred in the second phase of transition and on the road to EU accession. Romania was not an exception in this respect and the next section will provide empirical evidence of economic growth in Romanian urban and rural regions. The focus on the Romanian case is related to two main reasons. First, this country includes several typologies of urban settlements, from very large cities (Bucharest) to second tier cities (e.g. Timisoara, Cluj), from third tier urban areas (e.g. Piatra Neamt, Arad) to rural communities. Second, survey data on residents' life satisfaction are available for a considerably long time span from 1996 to 2011 (Lenzi, Perucca 2016b)[1].

[1]More details on the data set are available in Section 3.

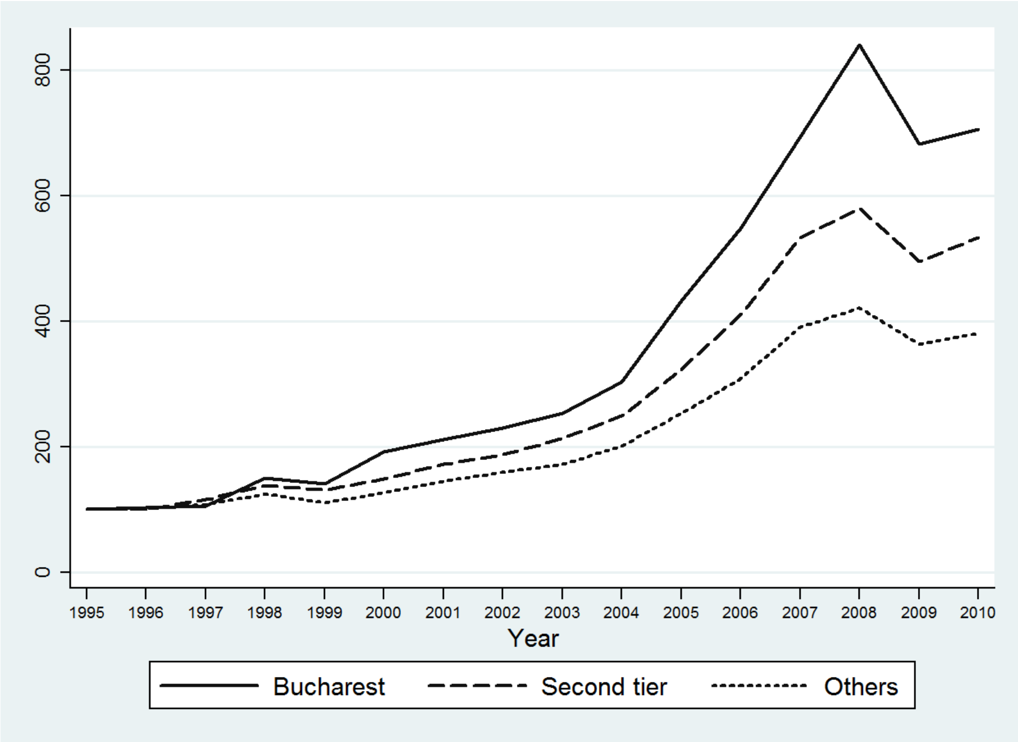

Figure 1: Per capita GDP growth in Romanian regions (1995 = 100)
Source: authors' own elaborations on data from the Romanian Institute of Statistics

2.2 Economic growth in Romanian regions: from the fall of the Iron Curtain to the EU accession

After the fall of the Iron Curtain, Romania experienced, as all the other post-communist countries, a period of strong economic recession. According to the World Bank[2], Romanian per capita GDP in real prices was equal in 1995 to the 85 per cent of its value in 1989. Only in 2003, Romania reached again the pre-transition levels. Within Romania, the growth path was highly differentiated across different typologies of regions.

Figure 1 reports the per capita GDP growth rate of different groups of Romanian NUTS3 regions classified according to the population living in the largest city. Bucharest is a unique case in the national context, with 2.3 (in 1995) million inhabitants living in the urban area. The second category comprehends those regions characterized by the presence of a second tier city, i.e. a city with more than 200,000 residents. Finally, NUTS3 areas including towns with less than 200,000 inhabitants are in the third group.

Figure 1 shows that the first years (1995-1999) were characterized by modest divergences in GDP growth across the three typologies of regions. The gap started to widen from 2000 on, even if, in the short run, it remained relatively moderate. From 2004 on, the year of the accession to the EU of other eight Eastern European countries, the differentials in economic growth for the three groups of regions increased more and more[3]. As a result, the relative weight of urban and rural regions on the overall Romanian economy significantly changed, as shown in Figure 2. In 1995, Bucharest contributed to national GDP for a share of about 15 per cent. Fifteen years later, it accounted for one quarter of the yearly domestic product. In addition, regions dominated by a second tier city experienced a growth of their relative relevance within the country, even if to a lower extent than the capital (from 9.7 to 11.5 per cent). Finally, regions without any large urban areas are marked by a sharp decrease of their share of GDP compared with the

[2]Source: http://data.worldbank.org/indicator/NY.GDP.MKTP.KD

[3]The accession Treaty was signed in April 2005, when both Bulgaria and Romania obtained the status of acceding country. The accession of these countries was initially planned for 2004 but Romania and Bulgaria actually joined the EU in 2007. The European Commission officially considers the 2007 enlargement as part of the 2004 one.

rest of the country, falling from 75.4 per cent in 1995 to 63.4 in 2010. The most intense divergences across these three groups of regions occurred between 2004 and 2008, while relative stability characterized the years of economic crisis (2008-2010).

Lenzi, Perucca (2016a,b) provide complementary evidence about the divergence in life satisfaction across cities of different size but without exploring the temporal dimension of these unbalances and their emergence. The analysis of the present paper, then, tries to supplement previous evidence by advancing an interpretation of the spatial and temporal trends of life satisfaction by taking advantage of the concept of urbanization externalities. In fact, as pointed out in the literature on agglomeration economies (Glaeser 2011), the positive economic externalities generated by large cities in the form of job opportunities and higher income are significantly greater than the ones arising in smaller urban areas. Larger and denser cities tend to show greater productivity and wages, as well as to offer wider opportunities for learning and knowledge exchanges, innovation and creativity. Moreover, public services and amenities that may positively influence life satisfaction (see for reviews Rosenthal, Strange 2004, Puga 2010) tend to be supplied in larger quantities in larger cities. On the other hand, increased city size and population density can show characteristics that can reduce life satisfaction. Land rent is higher (Partridge et al. 2009), and, by consequence, the cost of living (Dijkstra et al. 2013) increases. Environmental problems are exacerbated, such as congestion and pollution (Glaeser, Kahn 2008) and unregulated urban expansion (Glaeser, Kahn 2004), as well as social conflict and malaise (Glaeser, Sacerdote 1999)[4]. Yet, as far as positive and negative externalities grow similarly across different types of urban settings, we may expect a substantially neutral effect of city size on life satisfaction. This may the case of in the years characterized by limited disparities in growth patterns across different urban areas (i.e. between 1995 and 2004). Differently, we may expect that the fast and heterogeneous growth of urban areas on the road to EU accession (from 2004 on), possibly driven by unbalanced positive and negative urbanization externalities, widened the gap in life satisfaction of residents in rural and cities of different size. The next sections try to shed some lights on these possible trends.

3 Data and methods

3.1 Data on life satisfaction in Romania

The empirical analysis draws on a dataset pulling together several Eurobarometer survey waves. Since 1973, these surveys have been conducted on behalf of the European Commission with the aim of monitoring public opinion on multiple issues, such as EU citizens' self-reported well-being.

From 1990 Eurobarometer opinion polls were carried out also in the New Member Countries, initially under the label "Central and Eastern Eurobarometer" (1990-1997) and then as part of the "Candidate Countries Eurobarometer Series" (1998-2004). After the first EU enlargement in May 2004 surveys on CEECs were integrated in the "Standard and Special Eurobarometer Series".

However, the questionnaire wording is not always consistent across different studies. In particular, for Romania, availability and comparability of data is limited to the periods 1996-1998 and 2001-2010[5].

The final dataset has been obtained by pooling different cross sectional studies over time and includes over 24,000 records on subjective well-being at the individual level, together with information on some individual characteristics. The literature largely emphasizes the role played by individual factors on life satisfaction (Frey, Stutzer 2000); consequently, the empirical analysis will consider them as discussed in the next section.

[4] This point is similarly discussed in Lenzi, Perucca (2016b).

[5] More in details, the survey waves employed in the present paper are the following ones. For the period 1996-1998 data come from the collection "Studies from Eastern Europe – Quality of life diagnosis in Romania", edition 1996 (ZA3645), 1997 (ZA3646) and 1998 (ZA3647). Between 2001 and 2003 data are provided by the surveys from the series "Candidate Countries Eurobarometer Series", edition 2001 (ZA3978), 2002 (ZA4153 and ZA3979) and 2003 (ZA3986 and ZA3983). Finally, for the other years data are available from the "Standard and Special Eurobarometer Series", edition 2004 (ZA4229 and ZA4231), 2005 (ZA4411 and ZA4414), 2006 (ZA4506 and ZA4526), 2007 (Z4530 and ZA4565), 2008 (ZA4744 and ZA4819), 2009 (ZA4971, ZA4972 and ZA4973), 2010 (ZA5234, ZA5235 and ZA5449).

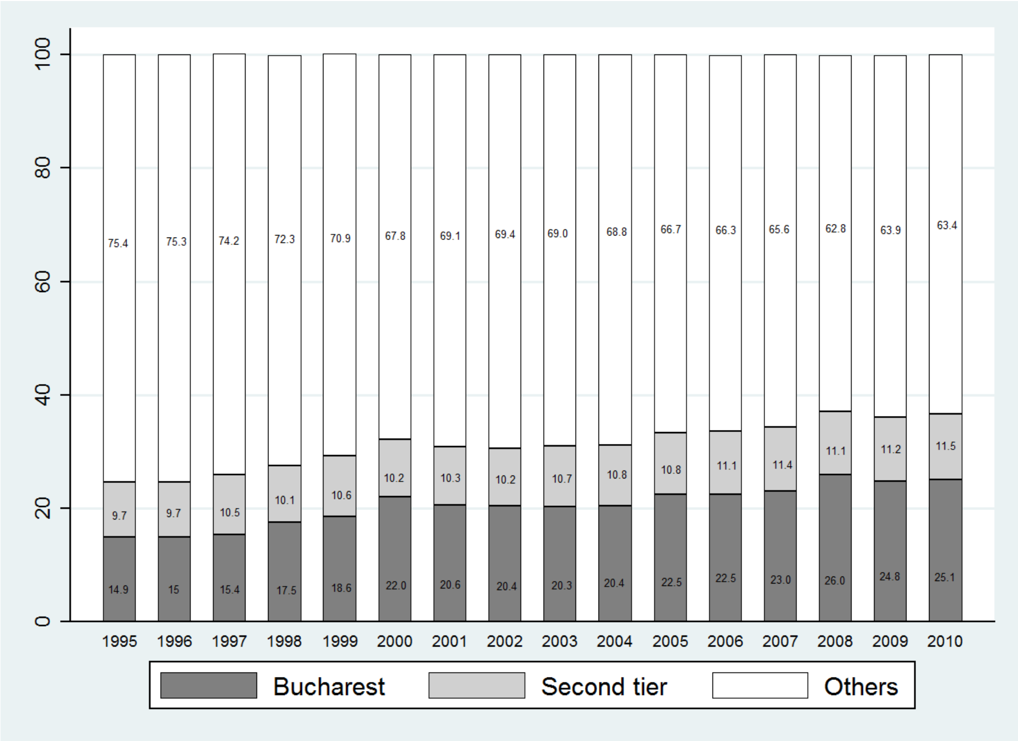

Figure 2: Share of national GDP by different typologies of NUTS3 regions
Source: authors' own elaborations on data retrieved from the Romanian Institute of Statistics

3.2 The empirical model

The empirical model aims at testing the relevance of agglomeration economies on life satisfaction over time while controlling for additional determinants of life satisfaction identified in the literature.

In particular, the effect of city size (i.e. the proxy used for urbanization and agglomeration) on life satisfaction is captured through a set of dummy variables, one for each of the four categories considered. In fact, Eurobarometer surveys ask respondents to indicate the size of the community they live in by choosing from alternative options: less than 100,000 residents (small cities and rural areas), 100,000-200,000 residents (medium cities), more than 200,000 residents (apart from Bucharest, large cities), Bucharest[6]. The answer to this question has been used to capture the possible effects of urbanization generated by the spatial agglomeration of activities and individuals in cities[7].

Besides the dummy variables accounting for city size, the empirical models include several control variables, as suggested by recent reviews on the determinants of life satisfaction (Frey, Stutzer 2000, Dolan et al. 2008, Blanchflower, Oswald 2011). Data availability and comparability across all years considered largely constrained their selection.

At the individual level, the control variables considered are the respondent's age, gender, education, family status, and occupation.[8]. Existing literature indicates some stylized facts about the relationship between individual characteristics and life satisfaction (Dolan et al. 2008, Blanchflower, Oswald 2011). In terms of age, the literature suggests that the relationship between age and happiness is U-shaped (with minimum around

[6]It is worth remarking that in Romania there are several large cities (>200,000 inhabitants) but none of them achieves a population greater than 350,000 whereas Bucharest has a population of about 2 million inhabitants (Source: Romanian National Institute of Statistics, Census 2011).

[7]A fuller discussion of the advantages of this categorization is presented in Lenzi, Perucca (2016b).

[8]In the 1996, 1997, 1998 surveys age was coded into 6 categories. For comparability reasons, therefore, we recoded the continuous age variable available in the other Eurobarometer surveys according to this six-point scale. Additional controls at the individual level, such as vote intention, religion, trust, health were excluded because of the limited comparability of the questionnaires over time.

Table 1: Data description

Name	Description	Source	Year
Community size	Size of the city of the respondent (number of inhabitants): Less than 100,000 inhabitants, 100,000-200,000 inhabitants, more than 200,000 inhabitants (apart from Bucharest), Bucharest; reference category: less than 100,000 inhabitants	Eurobarometer	1996-1998; 2001-2010
Gender	Gender of the respondent; reference category: male	Eurobarometer	1996-1998; 2001-2010
Age	Age of the respondent: coded into six categories, under 20, 21-30, 31-40, 41-50, 51-60, over 60; reference category: under 20	Eurobarometer	1996-1998; 2001-2010
Education	Level of education of the respondent according to the ISCED classification. Low education=ISCED 1-2, medium education=ISCED 3-4, high education =ISCED 5-6; reference category: low education	Eurobarometer	1996-1998; 2001-2010
Occupation	Occupation of the respondent: non-working, student, employed, self-employed; reference category: non-working	Eurobarometer	1996-1998; 2001-2010
Marital status	Marital status of the respondent: single, married, divorced, widowed; reference category: single	Eurobarometer	1996-1998; 2001-2010
Per capita GDP	Per capita GDP in the NUTS2 region of residence	Eurostat	1996-1998; 2001-2010

Source: Adapted from Lenzi, Perucca (2016b)

30-50 years, depending on the study); in fact, younger people tend to be happier than adults are but elder people as well are happier than adults are. The effect of age is captured by six dummy variables each accounting for a different age class (under 20 year old (the reference category in all estimations); 21-30 old; 31-40 old; 41-50 old; 51-60 old; over 60 old). In addition, women are generally more satisfied with their lives than men are[9]. The effect of gender is captured through a dummy variable taking value 1 if the respondent is female and 0 if he is male (which is the reference category in all estimations). Moreover, greater educational levels are associated to higher life satisfaction, especially in lower income countries, despite its effect can be influenced by the introduction of other variables as education often reflects also unobservable traits at the individual level such as motivation, intelligence or family background. The effect of education has been captured by three dummy variables each accounting for a different educational attainment level according to the ISCED classification (ISCED 1-2: low education (the reference category in all estimations); ISCED 3-4: medium education; ISCED 5-6: high education). Empirical evidence also suggests that married people are the happiest and divorced the least happy. The effect of marital status has been captured by four dummy variables each accounting for a different status (married, divorced, widowed, single [the reference category in all estimations]). Finally, being employed is found consistently and significantly associated with higher subjective well-being. The effect of occupation has been captured by four dummy variables each accounting for a different occupational status (non-working, employed, self-employed, student [the reference category in all estimations]).

In absence of data on income at the individual level for all waves, per capita GDP in the respondent's NUTS2 region of residence is used as an alternative proxy. The literature, in fact, reports that income is an important determinant of individual happiness (Easterlin 1995). The effect of income is expected to raise self-reported happiness; however, the relationship between income and happiness can be more complex and a quadratic term is introduced to control for possible decreasing returns detected in some studies, as indicated in the literature (Blanchflower, Oswald 2011)[10].

Table 1 provides a summary of the variables described above and their sources.

[9]The statistical significance of this effect is less stable and frequently vanishes when other control variables are included.

[10]For example, Rodríguez-Pose, Maslauskaite (2012) report that happiness is more influenced by relative income than by absolute income.

Finally, the empirical analysis includes year dummies. Their relevance is particularly high in the present context. First, these variables can control for the evolution over time of nation-wide phenomena in terms of both social and economic institutional conditions, and of macroeconomic factors at national level, as for instance the inflation rate, assumed to be homogeneous across the country. Second, they can account for the deep socio-economic changes that affected Romania in the period considered, most notably the transition from planned to market economy, the preparation for entry and the final accession into the EU, and, lastly, the impact of the financial and public debt crisis, most of which deeply interacted with the operation of urbanization and agglomeration forces. By the use of time dummies we are able to shed further light on the relationship between urbanization, life satisfaction and economic performance. In particular, following the discussion in Section 2, the early years after accession are expected to be characterized by lower levels of life satisfaction, which is instead expected to grow steadily in the years around accession to the European Union, with some decline in the years of the crisis.

The measurement of the dependent variable is based on the Eurobarometer question asking respondents to indicate their level of life satisfaction among four options: very satisfied, rather satisfied, fairly dissatisfied or very dissatisfied. In this paper, self-reported level of satisfaction has dichotomized; the deriving dummy variable takes a value of 1 if the individual is very or rather satisfied and equal to 0 otherwise.

Therefore, the empirical model to be estimated for any individual i in any NUTS2 r is as follows:

$$\begin{aligned} P(\text{Life satisfaction} = 1) \quad = \quad & F(\text{age}_i, \text{gender}_i, \text{marital status}_i, \text{education}_i, \text{occupation}_i, \\ & \text{per capita GDP}_r, \text{city size}_i, \text{year dummy}) \qquad (1) \end{aligned}$$

This model has been estimated by logit. In principle, the ordinal nature of the dependent variable would require the estimation of an ordered model, such as ordered logit or probit. However, the estimation of a binary logit can be defended on the ground of two main arguments. First, ordered models are based on the assumption that the relationship between different categories of the dependent variable is always the same. This hypothesis has been rejected by means of Brant tests implemented on each single variable (as shown in Appendix A.1). Alternatively, multinomial models could be used. The latter, on the other hand, have a less straightforward interpretation since it would produce, in the present empirical study, a set of coefficients for each regressor and make more complex the identification of the overall impact of urban agglomeration on subjective well-being, which is main issue of the paper. Yet, the main conclusions of the analysis are robust to the estimation of ordered logit models (as shown in Appendix A.1), where the probability of satisfaction is measured on a four-item satisfaction scale. Lastly, in all regressions, errors are clustered at both the year and regional (NUTS2) level.

4 Results

Table 2 shows the estimates of Equation 1 and reports adapted results from Lenzi, Perucca (2016b). Individual characteristics largely show the expected sign and significance consistent with stylized facts in the literature, confirming their relevance as determinants of life satisfaction[11]. Given the high consistency of estimates with existing results, the coefficient of individual variables are not displayed with the exception of regional (NUTS2) GDP per capita, our proxy for individual wealth; its influence on life satisfaction follows an inverted U-shaped form suggesting positive though diminishing returns on life satisfaction[12]. More interestingly, the dummy variables accounting for the population size of the residence area are not significant (Table 2, model 2), with the exception of

[11]The full set of individual effects coefficients is available and commented in Appendix A.2.

[12]We are aware that GDP per capita is an indirect proxy for income. Unfortunately, data on income at NUTS2 are available only for a shorter period (i.e. from 2000 onwards). Yet, the simple correlation between GDP per capita and income (computed on those years in which data are available at NUTS2 level) is 0.92 and significant at 1% level. By substituting GDP per capita with income and running regressions on the subsample for which income data are available, findings are qualitatively unchanged. Appendix A.3 reports the results of this robustness check. Therefore, given the high consistency of

Table 2: Life satisfaction and city size

Dependent variable: satisfied/very satisfied = 1	(1)	(2)	(3)
Per capita GDP	0.488***	0.503***	0.477***
	(0.086)	(0.093)	(0.083)
Per capita GDP (square)	-0.022***	-0.023***	-0.021***
	(0.004)	(0.005)	(0.004)
Community size (ref.: less than 100,000 residents)			
100 -200,000 residents		0.106***	0.107***
		(0.036)	(0.034)
>200,000 residents		0.082	
		(0.070)	
>200,000 residents (without Bucharest)			0.130**
			(0.057)
Bucharest			-0.103***
			(0.036)
Year dummies (ref.: 1996)			
1997	-0.196***	-0.197***	-0.195***
	(0.055)	(0.054)	(0.052)
1998	-0.176***	-0.175***	-0.177***
	(0.006)	(0.006)	(0.006)
2001	0.694***	0.693***	0.689***
	(0.074)	(0.076)	(0.073)
2002	0.895***	0.895***	0.892***
	(0.113)	(0.112)	(0.112)
2003	0.607***	0.574***	0.642***
	(0.069)	(0.077)	(0.065)
2004	0.756***	0.760***	0.764***
	(0.091)	(0.091)	(0.089)
2005	0.396***	0.398***	0.396***
	(0.015)	(0.005)	(0.005)
2006	0.378***	0.377***	0.385***
	(0.106)	(0.106)	(0.101)
2007	0.489***	0.486***	0.497***
	(0.087)	(0.087)	(0.077)
2008	0.374***	0.370***	0.383***
	(0.096)	(0.097)	(0.090)
2009	0.396***	0.392***	0.403***
	(0.091)	(0.090)	(0.083)
2010	-0.187***	-0.191***	-0.180***
	(0.059)	(0.059)	(0.048)
Constant	-1.974***	-2.021***	-1.968***
	(0.092)	(0.118)	(0.102)
Individual characteristics	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes
Observations	24,146	24,146	24,146

Standard errors clustered at the year and NUTS2 level in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Source: elaborations on Lenzi, Perucca (2016b)

those living in intermediate towns with 100-200,000 residents, who are more satisfied than residents of other settlement categories, similarly to findings reported by Rodríguez-Pose, Maslauskaite (2012). This result indicate that people living in large cities are as happy as those living in less populated and rural areas. However, on separating out the effect of the capital city (Bucharest) from that of the other large cities, i.e. cities with more than 200,000 inhabitants (Table 2, model 3), the picture becomes more nuanced. In fact, results indicate that people living in these areas are happier than those residing in less populated areas, suggesting the existence of an urban-rural divide in life satisfaction favoring relatively larger cities (with more than 100,000 residents), consistent with findings by Mariana (2012). On the other hand, living in the capital city is detrimental to life satisfaction, consistent with findings by Piper (2015). With the exception of Bucharest, therefore, Romanian people living in larger cities seem happier than the others are.

Possibly, the unexpected result for Bucharest can be read through the concept of agglomeration economies/diseconomies. In particular, the presence of greater congestion costs, pollution, social conflicts, crime rates, labor crowding, living costs and reduced purchasing power can make the capital city less attractive with respect to other large cities in the country. Above a certain threshold, increased population size seems to provide more disadvantages than advantages and agglomeration costs seem to prevail over agglomeration benefits, as may be the case of Bucharest. Finally, coming to the time dummies, life satisfaction has rapidly grown in the years close to accession; this pattern has been rather stable, with a decline in 2010 at the peak of the European financial and public debt crisis. Nonetheless, even during the crisis, life satisfaction was greater than in late 1990s, when the transition phase was not yet completed, as similarly found by Sanfey, Teksoz (2007).

In order to understand better the impact of transition over time and space, we repeated this set of regressions by splitting the sample in two periods. The first one includes the final phase (1995-2004) of post-communist transition. The second period comprehends the years immediately before and after EU accession (2004-2010).

Interestingly, results for the first period (Table 3) indicate that the role of per capita regional GDP for life satisfaction was negligible and the unfolding of positive agglomeration effects was not yet reached. Rather, urbanization economies have a non-significant or even negative effect (in the case of Bucharest and of cities between 100 and 200,000 residents). This can be related to the fact that, in this phase, Romanian cities were not characterized by huge gaps, in terms of economic growth, compared with the countryside. Consequently, the negative urban externalities like the higher costs of living, congestion and pollution, were not fully counterbalanced by the economic benefits specific of urban areas. Interestingly, Bucharest was also the region characterized by the most intense growth of GDP in the period analyzed. To further prove this point, Table 4 shows the results from an Analysis of variance (ANOVA) on both the average level of satisfaction (measured as ratio between satisfied respondents over unsatisfied ones) and the per capita GDP growth rate by different typologies of NUTS3 regions, i.e. the four groups of communities considered above[13]. Interestingly, GDP per capita growth rate in the period considered does not significantly differ across groups of regions of different size, with the exception of Bucharest. Therefore, the economic growth occurred in the capital city was not associated with higher levels of life satisfaction. Instead, after having controlled for individual characteristics and for the overall level of wealth, the pure effect of city size on life satisfaction becomes negative (Table 3)[14].

findings obtained by using the two variables, we opted for the largest temporal coverage and used GDP per capita data.

On a purely theoretical ground, we cannot exclude endogeneity concerns in the form of sorting effects, i.e. satisfied people are more likely to move to happier/wealthier cities. This issue is discussed in depth in the companion paper Lenzi, Perucca (2016b), reporting no substantial evidence of endogeneity and sorting effects, albeit using a different dataset enabling a direct comparison of life satisfaction between natives and migrants. The present dataset, unfortunately, does not allow recording such information in a longitudinal way, even if we are aware that it would add robustness to our findings. In absence of a direct statistical test excluding the presence of endogeneity, however, our estimates are better to be interpreted as robust partial correlation coefficients rather than causally.

[13] NUTS3 regions are classified according to the resident population in their largest city.

[14] Notice that in Table 4 the average level of satisfaction in Bucharest is not significantly lower than in

Table 3: Life satisfaction and city size: 1996-2004

Dependent variable: satisfied/very satisfied = 1	(1)	(2)	(3)
Per capita GDP	-0.137	-0.112	-0.103
	(0.258)	(0.258)	(0.234)
Per capita GDP (square)	0.014	0.013	0.014
	(0.025)	(0.025)	(0.024)
Community size (ref.: less than 10,000 residents)			
100-200,000 residents		-0.100**	-0.099**
		(0.048)	(0.048)
>200,000 residents			-0.028
			(0.075)
>200,000 residents (without Bucharest)		-0.120	
		(0.076)	
Bucharest			-0.236***
			(0.050)
Year dummies (ref.: 1996)			
1997	-0.149***	-0.151***	-0.153***
	(0.032)	(0.041)	(0.046)
1998	-0.214***	-0.212***	-0.213***
	(0.012)	(0.012)	(0.011)
2001	0.542***	0.551***	0.553***
	(0.118)	(0.123)	(0.123)
2002	0.817***	0.820***	0.818***
	(0.118)	(0.122)	(0.122)
2003	0.615***	0.660***	0.693***
	(0.093)	(0.103)	(0.098)
2004	0.931***	0.916***	0.905***
	(0.076)	(0.073)	(0.077)
Constant	-0.532	-0.569	-0.611
	(0.644)	(0.642)	(0.588)
Individual characteristics	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes
Observations	9,935	9,935	9,935

Standard errors clustered at the year and NUTS2 level in parentheses *** p<0.01, ** p<0.05, * p<0.1
Source: authors' own elaborations

On the other hand, results for the second period (Table 5) describe a very different situation. First, life satisfaction begins responding to economic conditions and incentives. Regional (NUTS2) per capita GDP shows a statistically significant and inverted U-shaped effect on life satisfaction (consistent with the literature and Table 1). Second, cities of more than 100,000 inhabitants seem to offer better opportunities and contexts to achieve greater individual life satisfaction with respect to less populated and rural areas. As commented above, Bucharest represents an exception to this pattern and seems characterized by negative agglomeration effects in both periods. The ANOVA results on the average level of satisfaction between 2004 and 2010 and on the change in GDP occurred in the same period are shown in Table 4. Again, as far as GDP per capita growth is concerned, Bucharest outperforms the other groups of regions. In absence of any individual and wealth control, Bucharest is characterized by a level of life satisfaction higher than the one of regions with less than 100,000 inhabitants (Table 4). However, once taking into account all the individual and regional factors described in Table 1, the net effect of the urbanization economies of the capital city appears to be negative (Table 5). Therefore,

the other regions. Nevertheless, in this case we are not accounting for any of the other controls included in Table 3.

Table 4: Per capita GDP growth rate and life satisfaction by different typologies of NUTS3 regions: ANOVA results

1996-2004

	Group means		Pairwise comparisons	
Community size	Δ per capita GDP	Satisfied/ unsatisfied respondents	Δ per capita GDP	Satisfied/ unsatisfied respondents
<100,000	1.083	0.386	Not significant	Not significant
100-200,000	1.094	0.368	Not significant	Not significant
>200,000 (w/o Bucharest)	1.167	0.394	Not significant	Not significant
Bucharest	1.582	0.357	+ [all other groups]	Not significant
F	7.70***	2.14*		

2004-2010

	Group means		Pairwise comparisons	
Community size	Δ per capita GDP	Satisfied/ unsatisfied respondents	Δ per capita GDP	Satisfied/ unsatisfied respondents
<100,000	1.117	0.426	Not significant	-[Bucharest]
100-200,000	1.058	0.532	Not significant	+[<100,000]
>200,000 (w/o Bucharest)	1.169	0.563	Not significant	+[<100,000 and Bucharest]
Bucharest	1.337	0.504	+[<100,000 and 100-200,000]	+[<100,000], -[>200,000 (w/o Bucharest)]
F	4.66***	75.66***		

Source: authors' own elaborations

even if high levels of wealth would lead to a positive payoff in terms of life satisfaction, the purely economic advantages are offset by negative effect on life satisfaction of living in a congested and socially insecure environment.

Finally, we tried to establish a link, if any, between the analysis of the relationship between change in life satisfaction and wealth over time and the main results from the literature on self-reported well-being claiming that economic growth is not associated with significant changes in life satisfaction (Easterlin 1995). In particular, Figure 3 shows the plot of the coefficients of the year dummies reported in Table 3 and Table 5, respectively for the period 1996-2004 and for 2004-2010, associated with the change in per capita GDP that occurred in Romania with respect to the reference years (respectively 1996 and 2004 for the two periods). It is worth noting that between 1996 and 2004 the year dummies and the average growth in per capita GDP follow a very similar pattern, as reported by Sanfey, Teksoz (2007), Guriev, Zhuravskaya (2009), Easterlin et al. (2010). Compared to 1996, the following two years of economic slowdown are associated with a decrease in life satisfaction. The opposite holds for the following years (2001-2004) of economic recovery, even if the differences between the estimated coefficients are, in this case, weakly significant. A different scenario characterizes the second period, between 2004 and 2010. In this case, in fact, the intense economic growth occurred until 2009 is not mirrored by the estimate coefficients of the time dummies. This happens only at the

Table 5: Life satisfaction and city size: 2004-2010

Dependent variable: satisfied/very satisfied = 1	(1)	(2)	(3)
Per capita GDP	0.238***	0.223**	0.278***
	(0.084)	(0.100)	(0.070)
Per capita GDP (square)	-0.015***	-0.016**	-0.014***
	(0.005)	(0.007)	(0.003)
Community size (ref.: less than 100,000 residents)			
100 -200,000 residents		0.186***	0.194***
		(0.067)	(0.069)
>200,000 residents		0.220***	
		(0.068)	
>200,000 residents (without Bucharest)			0.270***
			(0.079)
Bucharest			-0.411*
			(0.229)
Year dummies (ref.: 2004)			
2005	-0.302***	-0.299***	-0.321***
	(0.020)	(0.024)	(0.082)
2006	-0.296***	-0.292***	-0.330***
	(0.056)	(0.055)	(0.060)
2007	-0.124**	-0.113**	-0.174***
	(0.050)	(0.057)	(0.055)
2008	-0.191	-0.173***	-0.260**
	(0.131)	(0.035)	(0.115)
2009	-0.126	-0.103	-0.222***
	(0.080)	(0.089)	(0.051)
2010	-0.761***	-0.745***	-0.838***
	(0.072)	(0.085)	(0.062)
Constant	-0.302***	-0.299***	-0.321***
	(0.020)	(0.024)	(0.082)
Individual characteristics	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes
Observations	16,223	16,223	16,223

Standard errors clustered at the year and NUTS2 level in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Source: authors' own elaborations

beginning of the economic crisis, in 2010, when the reduction in GDP is also associated to a decrease in life satisfaction. These findings seem to support the Easterlin intuition only under some circumstances. In more detail, during periods of economic recession life satisfaction follows the same path of per capita GDP. In phases of economic expansion, on the other hand, the same evidence does not hold.

5 Conclusions

This paper has explored the evolution of life satisfaction over time and across space in Romania in the period 1996-2010. In so doing, the paper has extended previous analyses on the subject (Lenzi, Perucca 2016b) by underlining that the relationship between transition, life satisfaction and urbanization is far from straightforward and the original Easterlin intuition cannot be translated uniformly in a spatial setting. Moreover, our findings suggest that the temporal dimension plays a relevant role as well. Our results, in fact, seem to support the Easterlin intuition and the hypothesized trade-off between economic growth and individual well-being only under some circumstances. In particular, the analysis highlights that the economic growth benefits deriving from transition have been reaped especially by the largest, capital city at detriment, however, of people's

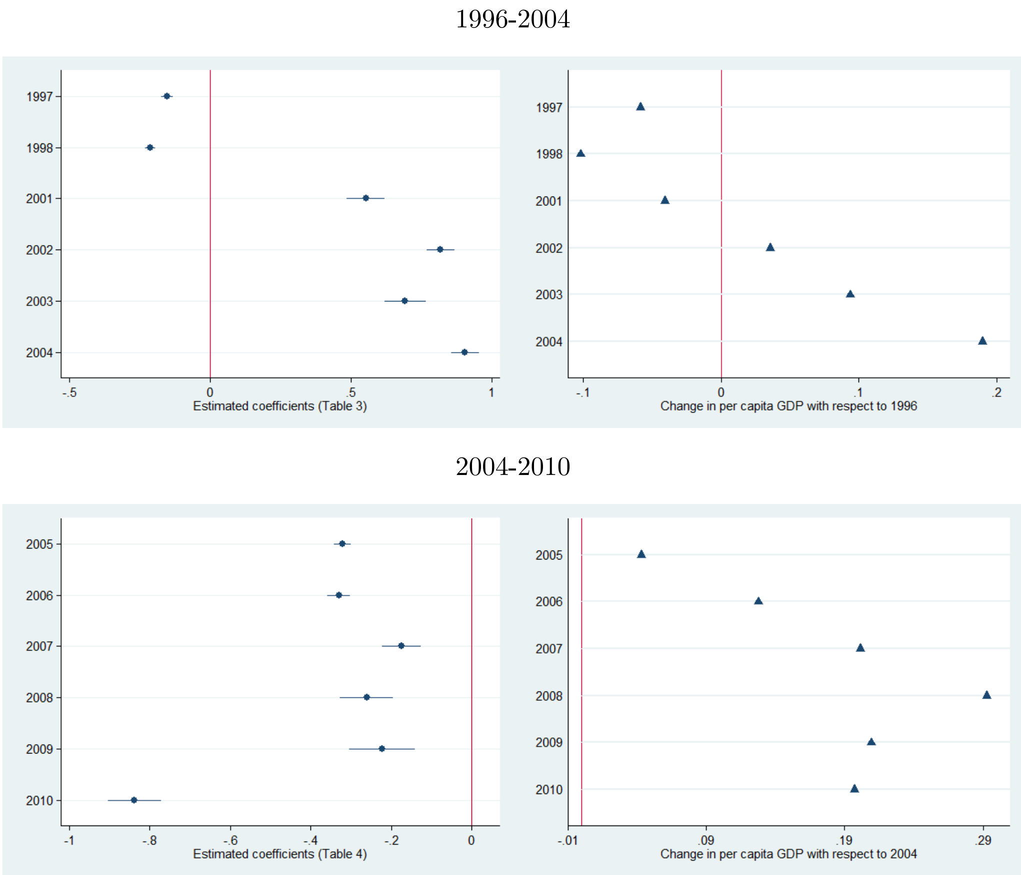

Figure 3: Estimated coefficients and change in per capita GDP over time
Source: authors' own elaborations

well-being. In this case, GDP growth was accompanied by increasing disparities in terms of economic standards with respect to residents of other types of settings, thus translating in the end, into worse well-being prospects. Yet, this conclusion does not apply to medium-large cities. In these cases, instead, economic growth was not characterized by disparities as large as in the case of Bucharest and in the end teamed with increasing life satisfaction. Moreover, in periods of economic recession life satisfaction follows the same path of per capita GDP whilst the same evidence does not hold in periods of economic expansion.

Importantly, our findings seems to suggest that the hypothesized trade-off between economic growth and well-being is not spatially neutral and that under some circumstance there are opportunities to make the two objectives matching. The achievement of such a virtuous combination between growth and well-being (i.e., competitiveness and cohesion, as it could be rephrased in the EU policy jargon) primarily depends on limited (or at least not diverging) wealth and growth gaps. If this is the case, cities and the related agglomeration benefits could actually translate in enhanced individual life satisfaction.

Our analysis certainly presents limitations in terms of geographical extension (and consequent generalization of results) as the analysis covers only one country; nonetheless, these limitations can turn into important opportunities to enlarge the research on this topic. One interesting and promising avenue of investigation concerns a deeper understanding of the interaction between spatial and temporal reach of direct and indirect urbanization effects on the individual well-being of residents of cities of different size across the EU space. We hope to extend our future research in this direction.

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A Appendix

A.1 Appendix A. Ordered logistic results

Table A.1 reports the results from an ordered logistic regression on the four level of life satisfaction, employing the same specification of model (3), Table 2. The interpretation of the coefficients and their significance are consistent with those discussed in the main paper (see Table 2 and Table A.2). Nevertheless, the Brant test rejected the hypothesis on the validity of the parallel regression assumption (Table A.1) for several variables making the binomial logit model more suitable for the empirical analysis of this paper.

Table A.1: Life satisfaction, individual and regional characteristics: ordered logit results

Dependent variable: level of satisfaction (1-4)	(3)	Brant test (chi2)
Gender: female	-0.036	8.91**
	(0.025)	
Age: 21-30	-0.339***	3.16
	(0.047)	
Age: 31-40	-0.488***	4.37o
	(0.037)	
Age: 41-50	-0.636***	11.25***
	(0.040)	
Age: 51-60	-0.570***	9.25***
	(0.060)	
Age: over 60	-0.472***	5.80*
	(0.077)	
Education: medium level	-0.014	13.56***
	(0.040)	
Education: high level	0.471***	2.72
	(0.064)	
Occupation: employed	0.546***	22.28***
	(0.030)	
Occupation: self employed	0.545***	0.27
	(0.041)	
Occupation: student	0.728***	13.03***
	(0.115)	
Marital status: widowed	-0.329***	0.67
	(0.056)	
Marital status: divorced	-0.421***	0.42
	(0.072)	
Marital status: married	0.096***	4.62*
	(0.037)	
Per capita GDP	0.433***	8.99**
	(0.086)	
Per capita GDP (square)	-0.020***	12.23***
	(0.005)	
Community size (ref.: less than 10,000 residents)		
100 -200,000 residents	0.103*	3.61
	(0.053)	
>200,000 residents (without Bucharest)	0.120*	4.18o
	(0.062)	
Bucharest	-0.027	8.91**
	(0.020)	
Year dummies	Yes	
Regional dummies	Yes	
Constant cut 1	0.006	
	(0.203)	
Constant cut 2	1.902***	
	(0.157)	
Constant cut 3	4.850***	
	(0.178)	
Observations	24,146	

Standard errors clustered at the year and NUTS2 level in parentheses; *** p <0.01, ** <0.05, * p <0.1, o p <0.15
Reference categories: under 21 (age), low level (education), non-working (occupation), single (marital status), less than 100,000 residents (community size).

A.2 Life satisfaction and individual characteristics of the respondents

As discussed in Section 3.2, life satisfaction was regressed on a set of individual characteristics. Results are reported in Table A.2. The three models in Table A.2 differ according to the typology of regional controls included (Table 2). Among other things, our findings indicate that younger people are happier than older people, with a U-shaped effect: people aged between 51-60 are happier than those aged between 41-50, and people aged over 60 are even happier than those aged between 31-40. Highly educated people are also happier with respect to those with low educational attainment. Employed, self-employed and students are more satisfied than people that do not work. Married people are also happier than singles, whereas divorcees and widows/widowers are less satisfied than singles. Finally, females do not appear to be happier than males. These effects are consistent across all models displayed in Tables 3 to 5. It is important to remember that the interpretation of these individual effects has to be done in relative terms with respect to the reference cases (mentioned in the note to Table A.2). As to the age effect, in particular, the coefficient of the dummy variables indicate that the effect of age is U-shaped, with a minimum around 40–50 years. Dolan et al. (2008) as well as Blanchflower, Oswald (2011) report that generally the minimum is between 30 and 50, depending on the study. Moreover, Dolan et al. (2008) indicate that, even if women tend to be happier than men are, the statistical significance of its effect frequently disappears when other controls are inserted.

Table A.2: Life satisfaction and individual characteristics of the respondents

Dependent variable: satisfied/very satisfied = 1	(1)	(2)	(3)
Gender: female	-0.012	-0.014	-0.013
	(0.028)	(0.028)	(0.028)
Age: 21-30	-0.304***	-0.310***	-0.313***
	(0.036)	(0.042)	(0.040)
Age: 31-40	-0.422	-0.426	-0.426
	(.)	(.)	(.)
Age: 41-50	-0.574***	-0.578***	-0.583***
	(0.077)	(0.078)	(0.078)
Age: 51-60	-0.558***	-0.562***	-0.565***
	(0.046)	(0.047)	(0.046)
Age: over 60	-0.373***	-0.375***	-0.377***
	(0.095)	(0.095)	(0.094)
Education: medium level	-0.076	-0.081	-0.076
	(0.050)	(0.051)	(0.050)
Education: high level	0.492***	0.472***	0.477***
	(0.079)	(0.080)	(0.081)
Occupation: employed	0.536***	0.530***	0.523***
	(0.045)	(0.044)	(0.043)
Occupation: self employed	0.540***	0.547***	0.551***
	(0.064)	(0.065)	(0.064)
Occupation: student	0.726***	0.720***	0.709***
	(0.085)	(0.092)	(0.087)
Marital status: widowed	-0.306***	-0.304***	-0.303***
	(0.096)	(0.097)	(0.098)
Marital status: divorced	-0.423***	-0.426***	-0.427***
	(0.064)	(0.066)	(0.066)
Marital status: married	0.101***	0.104***	0.106***
	(0.021)	(0.020)	(0.023)
Constant	-3.184***	-3.296***	-3.049***
	(0.338)	(0.389)	(0.320)
GDP per capita	Yes	Yes	Yes
Community size	No	Yes	Yes
Year dummies	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes
Observations	24,146	24,146	24,146

Standard errors clustered at the year and NUTS2 level in parentheses; *** p <0.01, ** p <0.05, * p <0.1
Reference categories: under 21 (age), low level (education), non-working (occupation), single (marital status).

A.3 Life satisfaction and the role of regional income per capita

Table A.3: Life satisfaction and the role of regional income per capita

Dependent variable: satisfied/very satisfied = 1	(1)	(2)	(3)
Net disposable income	0.038**	0.034	0.049***
	(0.018)	(0.021)	(0.013)
Net disposable income (square)	-0.000**	-0.000*	-0.000***
	(0.000)	(0.000)	(0.000)
Community size (ref: less than 100,000 residents)			
100 -200,000 residents		0.185***	0.194***
		(0.066)	(0.066)
>200,000 residents		0.185***	
		(0.060)	
>200,000 residents (without Bucharest)			0.265***
			(0.078)
Bucharest			-0.394*
			(0.205)
Constant	-0.863***	-1.505***	-1.432***
	(0.068)	(0.384)	(0.445)
Individual characteristics	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Observations	16,223	16,223	16,223

Standard errors clustered at the year and NUTS2 level in parentheses. *** p <0.01, ** p <0.05, * p <0.1

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Tree-based approaches for understanding growth patterns in the European regions*

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Abstract. We run an empirical analysis to understand the main drivers of economic growth in the European Union (EU) regions in the past decade. The analysis maintains the traditional factors of growth used in the literature on regional growth – stage of development, population agglomeration, transport infrastructure, human capital, labor market and research and innovation – and incorporates the institutional quality and two variables which reflect the macroeconomic conditions in which the regions operate. Given the scarcity of reliable and comparable regional data at the EU level, the starting point of the analysis was devoted to build reliable and consistent panel data on potential factors of growth. Two non-parametric, decision-tree techniques, randomized Classification and Regression Tree and Multivariate Adaptive Regression Splines, are employed for their ability to address data complexities such as non-linearity and interaction effects, which are generally a challenge for more traditional statistical procedures such as linear regression. Results show that the dependence of growth rates on the factors included is clearly non-linear with important factor interactions. This means that growth is determined by the simultaneous presence of multiple stimulus factors rather than the presence of a single area of excellence. Results also confirm the critical importance of the macroeconomic framework together with human capital as major drivers of economic growth. This is overall in line with most of the economic literature, which has persistently underlined the major role of these factors on economic growth but with the novelty that the macroeconomic conditions are here incorporated. Human capital also has an important role, with low-skilled labor supply having a higher detrimental effect than the conducive one of high-skilled labor supply. Other important factors are the quality of governance for most developed economies and, in line with the neoclassical growth theory, the stage of development in particular for less developed economies. The evidence given by the model about the impact of other factors on economic growth such as those on the quality of infrastructure or the level of innovation is more limited and inconclusive.
The analysis conclusions support the reinforcement of the EU economic governance and the conditionality mechanisms set in the new architecture of the EU regional funds

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2014-2020 whose rationale is that the effectiveness of the expenditure is conditional to good institutional quality and sound economic policies.

Key words: Regional economic growth, European Union regions, non-parametric statistics, decision trees, multivariate adaptive regression splines.

1 Introduction

Understanding what triggers economic growth is difficult and controversial (Cristelli et al. 2015). Factors of growth form a complex system where identifying causality is not trivial as contradictions arise where variables are positively associated at some times but appear unrelated or even negatively associated depending on the system state. Such state-dependent behavior is an earmark of complex nonlinear systems and creates problems when fitting models to observational data (Sugihara et al. 2012). Proper methodologies are in need.

The focus of the paper is to identify the main determinants of economic growth in the European Union (EU) regions in the most recent years. The analysis covers the 2003-2013 period and includes as many indicators as possible at the regional, NUTS2 level[1] for all the regions of the 28 EU Member States. The interest is in the NUTS2 geographical level as being the main territorial level for the application of EU regional policies. Socio-economic data availability at the regional level in the EU is unfortunately limited. Two reasons determined the time period spanned by the analysis: first, the availability of reliable and comparable data at the regional level and, second, the inclusion of all the EU28 Member States. Given that the last, big EU enlargement took place in 2004 and that the set of explanatory indicators are one year time lagged with respect to the dependent, we set the starting year at 2003. The ending year is the one with the most recent data on regional GVA growth rates at the time of the analysis.

A variety of empirical studies are available in the econometric literature which explore the effectiveness of European and national policies in stimulating economic growth. They are mostly based on linear regression with growth rate as the response and a set of (sometimes non-linearly transformed) explanatory factors which can include interactions and/or spatial effects. Some relevant examples are discussed in (Rodríguez-Pose, Fratesi 2004, Dall'erba, Le Gallo 2008, Ramajo et al. 2008, Rodríguez-Pose, Garcilazo 2013). These approaches are all model-based with strong underlying assumptions. From the methodological point of view, our analysis differs from most of the studies on economic growth by being non-parametric: we employ data-driven approaches that learn nonlinearities and interactions directly from the data without the need to explicitly model them (Grömping 2009). Two non-parametric statistical methods, Classification and Regression Trees – CART – and Multivariate Adaptive Regression Splines – MARS, are employed in a complementary way. A huge literature is available on the two techniques that have been introduced respectively by the seminal works of (Breiman et al. 1984) and (Friedman 1991). Both techniques belong to the wide family of decision tree techniques, with MARS being the evolution of CART. In the past two decades or so, CART and MARS have been used in a wide range of applications from astronomy (Weir et al. 1995) to biology (Leathwick et al. 2005), from finance (Mezrich 1994) to medicine (Austin 2007), showing their versatility and usefulness. To our knowledge, though, the employment of decision-tree techniques to econometrics and, in particular to the study of economic growth is very limited and specific. An early contribution in this vein uses CART to explore nonlinearities in the process of cross-country output growth (Durlauf, Johnson 1995), while a more recent example can be found in (Curtis, Kokotos 2009) for tourism-based regional development. Varian (2014) recently advocated the use of these techniques as they 'may allow for more effective ways to model complex relationships'. This is exactly why we use them.

[1] The NUTS classification (Nomenclature des Unités Territoriales Statistiques) is a hierarchical system that the European Statistical Office – EUROSTAT – employs for dividing the economic territory of the EU for the collection, development and harmonization of European regional statistics, for socio-economic analyses of the regions and for framing EU regional policies.

The paper is structured as follows: Section 2 provides the description of the two non-parametric techniques employed to identify the main determinants of regional growth while the theoretical framework and the data used is detailed in Section 3. Results are discussed in Section 4 and Section 5 summarizes main results in the European Union context.

2 Methods

For understanding the main determinants of growth we want to capture all the possible non-linearities and interactions that may be, and usually are, present in datasets of this kind. To this aim two non-parametric, data-driven techniques, randomized CART and MARS, are employed.

CART and MARS are tree-based regression techniques which solve the problem of fitting a response y to a set of predictors (explanatory factors) $\mathbf{x} \in \mathcal{R}^n$ from observed data in high dimensions. Methods based on polynomial approximation are generally unsuccessful due to the instability of the polynomial for high n. Methods which locally approximate y in a neighborhood of a point $\mathbf{x}$ are also unsuccessful in high dimensions due to the 'curse of dimensionality', that is too many observations are necessary to get a reliable approximation of the response y (De Veaux et al. 1993). CART and its successor MARS have been designed to overcome these limitations. Their common starting point is a tree-based regression.

2.1 Randomized CART

CARTs are classification-type techniques where the dependent y and the factors $\mathbf{x}$ can be categorical, either nominal or ordinal, or continuous (Breiman et al. 1984, Hastie et al. 2001). Many statistical methods are available for analyzing classification-type problems. Regression approaches, such as logistic regression (Agresti 1990), or classification approaches, such as linear discriminant analysis (Mardia, Kent 1979), play an important role but are both linear and parametric. Although attractively simple, traditional parametric linear models may fail in empirical analysis as in real life effects are most often non linear and highly interactive (Hastie et al. 2001).

Non parametric methods are more flexible and provide a powerful approximation for any type of relationships among any type of variables. Being non-parametric, they do not rely on any explicit or implicit assumptions on the data structure, meaning that linearity or monotonicity of the relationship between the dependent variable and factors are not required. This makes tree-based techniques particularly suitable for empirical analyses as non-linearity is ubiquitous in the socio-economic science.

CART is the most popular tree-based method. It is a stepwise top-down algorithm performing binary splits of the starting population P into smaller and smaller sub-populations less impure than the parent population. Impurity levels are based on the dependent variable y whose type determines the impurity measure to be adopted. The Gini index, G, is used here: G is a non-negative real number with 0 representing perfect purity (Breiman et al. 1984). It is easy to compute, more sensitive to changes in node probabilities and has a twofold meaning: misclassification rate and node variance. At each step one explanatory factor at a time is analyzed and the one which mostly decreases the impurity level of the parent population is selected. When a certain stopping rule is achieved, terminal sub-populations are called leaves. The starting node comprising the whole population is the root. Other tree algorithms allow for multiway splits instead of binary ones but they are generally not recommended (Hastie et al. 2001).

To avoid overfitting trees should be optimized. This can be done either by fixing the minimum number of observations in each leaf or by using the cost-complexity approach, which is a way to cope with trade-off between tree size (number of leaves) and its goodness of fit (Breiman et al. 1984). The choice is here to set the minimum leaf size because we are more interested in having non-irrelevant terminal sub-populations rather than having the best possible tree. Different minimum leaf sizes have been tested with robust results.

After one (optimal) tree is set-up, a class of the response category is assigned to each leaf according to the so called plurality rule: each node is classified into one class k of the categorical response y ($k = 1, \dots K$) if k the most frequent class of that node. The goodness of fit of the tree can be measured via the misclassification rate (MR) that can be estimated in various ways. The most common one is the re-substitution estimate of MR, defined as the proportion of misclassified cases (Breiman et al. 1984). If the data set is large enough, the validation process can be undertaken with either split-sample or cross-validation misclassification rates. In the split-sample case, the tree is generated using a training sample and the misclassification rate is computed on the remaining sample, called the validation sample. In cross-validation, the sample is divided into a number of sub-samples, usually 10-20, and the tree is generated excluding one sub-sample at a time. The split-sample approach is employed here to estimate MR for each tree, with the training set including 90% of the sample points, randomly selected (the remaining points are included in the validation set).

In general results from different randomized sample splits differ from each other. In order to get stable results, 1000 different 90%/10% randomized splits are computed and average results together with their estimated confidence intervals are provided.

Explanatory factors are ranked according on their use in the final tree. Different metrics can be used, from the simple count of the number of times a factor is used for splitting to more sophisticated measures based on the purity level improvements in all the splits where the factor is used. Apart from the count of splits, which is a naive variable importance measure, the other options are almost equivalent unless the set of predictors includes interval-scale and categorical variables or when categorical predictors are measured with different number of categories (Strobl et al. 2007). The sum of squared errors (SSE) is here used as variable importance measure (SAS 2014) and, given that predictors are all measured on an interval scale, this choice is not going to substantially affect the results. The SSE for a classification tree is defined as the sum across all the leaves Λ of the square of the number of misclassified observations in each leaf $\lambda_i, \; i = 1, \dots \Lambda$:

$$SSE = \sum_{\lambda=1}^{\Lambda} \sum_{k=1}^{K} \left(N_\lambda - N_\lambda^k \right)^2 \tag{1}$$

where N_λ is the number of observations in leaf λ predicted to be in category k and N_λ^k is the number of observations in λ in category k.

The SSE-based importance of factor x_i, $IMP_{(SSE)}(x_i)$, normalized with respect to the maximum factor importance is then defined as:

$$IMP_{SSE}(x_i) = \frac{\left(\sum_m^M \Delta_m \right)^{0.5}}{\max_{x_i} \left\{ IMP_{(SSE)}(x_i) \right\}} \tag{2}$$

where M is the total number of nodes in the tree and Δ_m is the change in SSE at node m.

CART is not without limitations. First, it has difficulties in describing smoothly varying responses. Indeed, the sharp nature of the splits in CART generates discontinuities at the edge of each data sub-region produced by the split. Secondly, the splits are all dependent from another split. This induces a model with high-order interactions among predictors and makes it difficult to interpret results. Thirdly, large sample sizes, typically of the order of magnitude of 10^3, are usually needed to provide stable results[2].

2.2 Multivariate Adaptive Regression Splines

MARS is a successor of CART (Friedman 1991). Similarly to CART, it is non-linear and 'almost' non-parametric. MARS cannot be considered completely non-parametric for at least two reasons: it transforms predictors with specific functional forms (the 'basis') and estimates the model with an ordinary least square regression of the transformed predictors. Being empirical and very flexible, it nevertheless preserves many advantages

[2] Sample sizes required to obtain stable results always depend on the complexity of the relationships to be uncovered. Please consider this indication just as a rule of thumb.

of non-parametric techniques (De Veaux et al. 1993). MARS attempts to remedy the limitations of CART relieving the split discontinuity by means of piece-wise linear splitting functions and reducing the interaction order, because subsequent splits are not necessarily dependent on previous splits.

While decision trees use step functions to model the dependent, MARS uses piecewise linear functions, called basis. This makes it more effective in dealing with model non-linearities and smoothly varying responses (De Veaux et al. 1993, Deichmann et al. 2002). By adding the basis, MARS is capable of uncovering non-linear relationships and interaction effects. In the classical MARS model explanatory factors can be either categorical or continuous while the dependent is continuous. Binary variables can be used as response if the model is run in binary mode with the logistic regression MARS.

The algorithm consists of a two-step analysis that firstly builds a collection of functions called 'basis' – Bs – and automatically selects the best regression model based on a selection of basis functions and their interactions. Bs are piece-wise linear transformations of the explanatory factors $\mathbf{x} = x_1, x_2, \ldots, x_n$ and are used to represent the information contained in one or more x_i. Bs are defined as:

$$B(x_i, \tau) = \max\{0, x_i - \tau\} + \max\{0, \tau - x_i\} \tag{3}$$

where τ is an inflection point along the range of a given predictor x_i, the 'knot' of the basis. More than one knot τ may be used for the same predictor. A MARS model is built using a subset of all such possible piecewise linear functions. Smoother curves can be used as well by allowing for higher order terms in the functional form of Bs, like quadratic or cubic terms. The simplest version of MARS using piecewise linear splines is adopted because it keeps the model simple while giving enough degrees of freedom for fitting the data, like for example through higher-order interactions. Products of Bs can be included in the model to account for different order interactions. Contrary to CART, in MARS the maximum number of interactions allowed is a parameter of the model chosen by the analyst. It is then possible to have full control on the model complexity, in terms of number of interactions allowed. Optimal combinations of basis are used to estimate a least-square model with the Bs as new independent variables.

To determine the optimal number of terms in the model the generalized cross-validation GCV criterion is employed. GCV is the average of the squared residuals times a penalty to take into account the model complexity, in terms of number of basis functions included. The algorithm then involves a backward stage which eliminates Bs that unnecessarily complicate the model. Parsimony on the number of basis entering the model has indeed the desirable effects of limiting spurious interaction effects caused by collinearity, an ever present problem when modeling observational data, while facilitating interpretation. To reinforce parsimony, an additional penalty factor γ can be introduced to reduce the model improvement for any new variable that is introduced at each iteration of the model forward selection. Commonly used values for γ lie between 0 (no penalty on complexity) to 0.15 (high penalty on complexity)[3].

The importance of a variable in the model is computed on the basis of GCV. For variable ranking, GCV is computed with and without each variable in the model and the difference is computed. These differences are then normalized into a 0 (not important) to 100 (most important) scale.

An interesting feature of MARS is the possibility to get graphical representation of the modeled relationships between the dependent and the transformed predictors x_i, model components. The contribution to the response of individual explanatory factors can be shown explicitly, enabling local interpretation of the underlying model (De Veaux et al. 1993).

From our perspective, one of the advantages of MARS over CART is that smaller sample sizes are necessary with MARS, generally of the order of 10^2. In the seminal work by Friedman (1991), the accuracy of different MARS models is assessed using sample sizes going from 50, considered as a small sample, to 200. Another important advantage of MARS is the possibility of better understanding the impact of the predictors on the

[3] For more details on MARS technicalities see Friedman (1991).

response variable in terms of order of interactions and type of non-linear relations. The case study on regional growth will help in elucidating these points.

3 Understanding regional economic growth

3.1 Theoretical framework

The theoretical framework of the analysis starts from the Solow-type growth framework to control for the regional initial GVA per capita as a proxy for its initial capital endowment (Solow 1956, Barro, Sala-i-Martin 1992). But this is only the basic model because it assumes that all the regions feature the same structural characteristics, which is clearly an implausible assumption. Other explanatory factors are then included in the model. Following the main literature contributions and data availability across the EU regions, the regional factors included go from human and physical capital to population density, from levels of employment to the quality of institutions (Mankiw et al. 1992, Rodrik et al. 2004, Kwok, Tadesse 2006, Crescenzi, Rodríguez-Pose 2008, Mohl, Hagen 2010, Rodríguez-Pose 2013, Rodríguez-Pose, Garcilazo 2013, Pescatori et al. 2014).

Two macroeconomic variables are also added with the aim of capturing the impact of debt, both public and private, which is currently considered as a major constraint to economic growth. The quick accumulation of both private and public debt in the Member States with the poorest trends in economic development over the last 10-15 years, the significant correlation of regional development trends with national trends in the EU and the low attention paid to these factors in analysis of regional development in the EU explains the inclusion of these factors

3.2 Data

The empirical analysis uses panel data from 2003 to 2013 available or estimated for the EU regions at the NUTS2 level. Please note that the attribute 'regional' is used as synonymous of 'NUTS2 level' hereafter. The selected time period allowed for including the highest possible number of indicators at the regional level and to carry out an analysis of all the regions in the 28 EU Member States. The task is in general particularly demanding due to the scarcity of reliable and comparable data at the EU level and the complex interaction between the factors of growth.

As described in Sections 2.1 and 2.2, the statistical models chosen for the analysis are both non-parametric: they let the data speak without superimposing any assumptions. This means that preliminary data-handling becomes even more than usual an essential ingredient for reliable results.

Limiting the analysis time span to a decade (2003-2013) allowed us to include a relatively rich set of basic indicators from official sources (Eurostat, World Bank, World Economic Forum, Quality of Government Institute).

As the global financial and economic crisis hit almost worldwide in 2008, the period under analysis captures both pre- and post-crisis years. In the EU the crisis emerged in 2008 and unfolded over the following years revealing long-term problems especially in southern countries. The presence of a structural breakpoint in GVA growth has been statistically tested using the Analysis of Variance – ANOVA (Moore 2004) on every two consecutive growth periods (3-year average periods). Significant differences with p-values < 0.001, are found between the periods $2006-2008; 2007-2009$ and $2007-2009; 2008-2010$. That said, the authors think neither that the crisis substantially changed the main drivers of growth nor that there is the need to split the analysis into the pre- and post-crisis. The reason for this is both economical and statistical. Some economists (Botta 2014, Constantinescu et al. 2015) defend that what we are seeing is not just a cyclical downturn but the result of many macroeconomic and structural imbalances built over time. Consequently, we cannot assume that the crisis is just cyclical and believe that both the European and the global economy will return to its previous levels without major costs. The 2008 events unveiled some major economic imbalances that were underlying the significant economic growth observed in some Member States already before 2008. The fast increase in consumption and investment happened in parallel with a significant increase in access to credit and indebtedness of those economies. This is reflected by the negative current account deficits, the deterioration of their International investment positions and/or the increasing levels of Government debt. From the statistical perspective, the drivers of growth are likely to be the same both before and after the crisis, even assuming that an after-crisis is already in place. In the post-crisis period the drivers' effect on growth is likely to be amplified. Instead of hampering the statistical analysis, the inclusion of pre- and post-crisis years highlights the positive and negative effects on growth helping in identifying most and least resilient regions. In this sense the crisis "statistically helped" in separating the signal from the noise. For these reasons, we did not consider the crisis as a structural break in the time series but fully incorporated it into the analysis with the entire 2003-2013 period considered as a whole.

The dependent variable y is based on real growth rates of regional gross value added – GVA – per capita. To allow for a time lag and to smooth out sharp changes in yearly growth rates, y at year t is computed as the geometric mean of y in the following 3 years $(y_{t+1}, \ldots, y_{t+3})$. Real growth rates of GVA are available in EUROSTAT at the regional level for most of the EU member states. For some countries the time series of GVA real growths are not available or not complete at the regional level. In these cases growth rates have been estimated on the basis GVA series by economic activity according to EU NACE codes ('Nomenclature Generale des Activites Economiques', revision 2).

The set of explanatory variables is described in the following:

Stage of development GVA per capita in constant prices is chosen to describe the stage of economic development of the regions. According to the neo-classical growth theory (Solow 1956) the growth rate of poor economies is higher than that of more developed economies and, consequently, their income per head (or equivalent) would catch up with that of richer economies. The level of GVA per capita are therefore expected to be one of the most important growth factors. GVA per capita values used in the analysis are computed from the reference year and are consistent with the GVA per capita growths in constant price used for the response y.

Urban areas The level of agglomeration is included in order to test whether more agglomerated regions perform better as advocated by the new economic geographers (Krugman 1998). The shares of people living in metropolitan areas or commuting belts are included as a proxy for the presence of dense urban areas. Cities commuting belts follow the definition of Functional Urban Areas according to the methodology jointly developed by the Organization for Economic Co-operation and Development (OECD) and the European Commission (Dijkstra, Poelman 2012). The year of reference of this indicator is 2006 as time series are not available so far. It is worth noting that this is a very slow moving indicator. Given the context of the analysis, it is expected to play the role of a static control variable more than a dynamic factor of growth[4].

Road infrastructure The road infrastructure indicator depends both on the availability of roads and the spatial distribution of the population. It does not simply measure the number or density of road kilometers but takes into account the population density of the areas connected by the road network. The level of road infrastructure is then a 'potential accessibility' indicator based on the assumption that the attraction of a destination increases with size, represented by population, and declines with distance, travel time or costs. The indicator is estimated by EC-DG for Regional and Urban Policy on the basis of results of the project described in (Stelder 2013). It is available for one year only, 2012. In a similar vein as for the Urban areas indicator, an indicator of this type serves here more as a static control variable than as a dynamic factor of growth.

Quality of governance Institutions have been recently emphasized as playing a key role in explaining the causes of economic growth/stagnation (Rodrik et al. 2004, Kwok, Tadesse 2006, Rodríguez-Pose 2013). Recent analyses at the regional level in the EU

[4]The limited time span of the analysis and the fact the no time series is available for this indicator makes its role differ from the others explanatory factors

uncovered an important sub-national dimension that can partly explain the observed within-country divergences in economic performance (Charron et al. 2012, Charron, Lapuente 2013, Rodríguez-Pose 2013). It is then important to include in the analysis a measure of quality of governance at the regional level. The regional data used in the paper is computed on the basis of the regional Quality of Government index – QoG – by the University of Gothenburg (Charron et al. 2014) and a composite index of national indicators yearly published by the World Bank and the World Economic Forum. The regional values of the QoG index are used to compute the regional/national ratio of the perceived quality of institutions within each country. These ratios are then applied to the national aggregated index computed from the World Bank and the World Economic Forum selection of indicators for the whole period under analysis. This national index is based on a total of 14 indicators, 6 coming from the World Bank-Worldwide Governance database and 8 from the World Economic Forum-Global Competitiveness Index database[5]. This approach allowed us to set up a time series of an indicator measuring the quality of institutions at the regional level.

Macroeconomic conditions Two indicators which provide a proxy for the macroeconomic context of the regions are included in the analysis: the *Net foreign position* – NFP – and *Government debt*. NFP is measured with the Net International Investment Position indicator available in EUROSTAT at the national level as the difference between national assets and liabilities of the country with respect to the rest of the world, expressed as a percentage of national Gross Domestic Product, GDP. The indicator records the net financial position of the domestic sectors of the economy versus the rest of the world, as the share of GDP. It is frequently used in economic analysis and research focusing on external vulnerability of countries and the risk of crises (DG ECFIN 2012). NFP is also highly correlated with the level of indebtedness of the households and the financial sector. Typically, highly negative values of net foreign position result from persistently high current account deficits and this is why the indicator is used as a measure of country vulnerability: the lower (or more negative) its values, the more vulnerable the country. The government debt, available in EUROSTAT as percentage of national GDP, is the second macroeconomic indicator included in the analysis. The relation between economic growth and government indebtedness is still an open and controversial issue, especially regarding the minimum level where government debt starts to be significantly detrimental to economic growth (Pescatori et al. 2014). However, the importance of public debt as one of the factors of growth is not disputable, especially for the time period of the analysis. Both indicators, NFP and government debt, are available at the country level only. A straightforward regionalization method is adopted that firstly redistributes the national value across the regions according to their population share, and secondly normalizes the regional values as shares of regional GDP. The approach is simpler than the one employed for the quality of governance but its rational is clear: it assumes that the level of national government debt, for instance, is distributed across the regions according to their population and their GDP. This can be seen as a rescaling procedure rewarding highly productive regions (where few people produce a high GDP) and, symmetrically, penalizes those with high population levels and low GDP that are assigned a higher debt share. This implicitly assumes that these regions (with low GDP and high population) are more affected by a deteriorated macroeconomic environment because more vulnerable.

Human capital Two human capital related indicators are included in the analysis, namely *lowly-* and *highly-educated workforce*. They are available at the regional level in EUROSTAT and are defined respectively as: 1. share population aged 25-64

[5]Selected indicators from the World Bank: 1. Voice & Accountability, 2. Political stability, 3. Government effectiveness, 4. Regulatory quality, 5. Rule of law, 6. Control of corruption. Selected indicators from the World Economic Forum: 7. Property rights, 8. Intellectual property protection, 9. Efficiency of the legal framework in settling disputes, 10. Efficiency of the legal framework in challenging regulations, 11. Transparency of government in policy making, 12. Business costs of crime and violence, 13. Organized Crime, 14. Reliability of police services.

with at most secondary education attainment and 2. share of population aged 25-64 with completed tertiary education.

Labour market Similarly to the human capital component, the labor market is described by two classical indicators available in EUROSTAT at the regional level: *long-term unemployment* and *employment* rates. The former is the 12-month or more unemployment rates as % of active population; the latter is the percentage of employed persons aged 20-64 with respect to the population cohort 20-64.

Research & Innovation As a proxy for the research and innovation potential of a region a composite index is computed from seven indicators available in EUROSTAT at the regional level: 1. Total patent applications, 2. Core creative class employment, 3. Knowledge workers, 4. Total intramural R&D expenditures, 5. Human resources in science and technology, 6. High-tech patents and 7. ICT patents.

All the explanatory factors listed above are included in the analysis at the NUTS2 level and for the time period 2003-2010. As aforementioned, the only exceptions are Urban areas and Road infrastructure that refer to the years 2006 and 2012 respectively. Descriptive statistics are shown in Table A.1 of the Appendix for all the factors of growth included in the analysis. Statistics are separately computed for the EU28, EU15 and EU13 groups of countries.

4 Results

Randomized CART and MARS are used in a complementary way to understand data on regional growth in the EU as a whole (EU28), with a sample size of 2144 observations (268 regions x 8 years). The EU is an interesting mix of Member States with a long EU membership (EU15) and ones which joined the EU after 2004 (EU13)[6]. Is it meaningful to consider the two groups all together? The t-test (Mood et al. 1974) carried out for all the variables in the analysis shows indeed a significant difference between the two groups (with p-values always < 0.0001). The EU13 averages are always significantly lower than the EU15 ones, apart from growth rate and long-term unemployment. The EU13 group indeed grows faster than the EU15 and has higher average levels of long-term unemployment.

Given t-test results, the EU28 scenario is integrated, when feasible, with additional analyses carried out separately for the EU15 group and the EU13 one. The sample size of the two groups of countries is 1680 and 464 respectively. This does not allow for getting reliable results from CART for the EU13 case. CART results are then discussed only for the EU28 and the EU15 scenarios. MARS is instead run for the three groups and provides some insights into the different mechanisms of growth across different areas.

All the analyses are run using SAS® ver. 9.4.

4.1 Randomized CART

The dependent variable y used in all the simulations is the real regional GVA per capita growth rate. For CART analysis y is categorized into three classes based on yearly quartiles: low growth rate if $y < P_{25\%}$; intermediate if $P_{25\%} \leq y < P_{75\%}$; high if $y \geq P_{75\%}$. The purpose is in fact to identify the most important factors driving high or low regional growth. A sensitivity analysis has been carried out to assess the robustness of results with respect to different types of categorization: 4 classes, with thresholds $\{P_{25\%}, P_{50\%}, P_{75\%}\}$, and 5 classes, with thresholds $\{P_{20\%}, P_{40\%}, P_{60\%}, P_{80\%}\}$. Variable importance ranking is stable for both the EU28 and the EU15 scenarios,especially for the most important factors (See Table A.2 in the Appendix for results).

Table 1 shows the parameters used in the randomized CART analysis. Two different analyzes are carried out: one for the EU as a whole (EU28) and one for the EU15 group.

[6]EU15 includes: Belgium, Denmark, Germany, Ireland, Greece, Spain, France, Italy, Luxembourg, Netherlands, Austria, Portugal, Finland, Sweden and United Kingdom; EU13 includes: Bulgaria, Czech Republic, Estonia, Croatia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Romania, Slovenia and Slovakia.

Table 1: Parameters used for the CART analysis

CART parameters	Selected option
Dependent variable	Real GVA growth rate categorized into three classes: *low* if below $P_{25\%}$ *medium* if between $P_{25\%}$ and $P_{75\%}$ *high* if above $P_{75\%}$
Type of split	Binary
Criterion	Gini index
Pruning	none
Limit on the leaf dimension	Yes minimum number of observations = 20
Cross-validation	Yes sample partition into 90% (training) and 10% (validation)
Randomization	Yes 1000 randomized $90 \div 10$ partitions
variable importance criterion	*SSE*

Main results are shown in Table 2. The two randomized CARTs are characterized by average misclassification rates *MR* of 0.29 and 0.32 respectively for the EU28 and EU15 case. As expected, the average accuracy of the models improves with larger sample sizes. Factors are reordered according to the normalized variable importance IMP_{SSE}, as defined in (2). IMP_{SSE} and vary between 0 (no importance) and 1 (highest importance). Estimated standard deviation for the mean, coefficient of variation and lower and upper limits of the 95% confidence intervals for the mean are also shown in Table 2. A factor is considered having an important effect on growth if $IMP_{SSE} \geq 0.6$, a medium effect if $0.2 \leq IMP_{SSE} < 0.6$ and non-relevant effect if $IMP_{SSE} < 0.2$.

The two cases share some common features, as some variables remain important or unimportant in both cases, but interesting specificities can be identified. The share of poorly educated workforce and the Net foreign position are the two most important factors in both cases. The former is negatively (partially) correlated with growth rate (Table 3), meaning that the growth rate is higher where the share of poorly educated people is lower; the latter is positively (partially) correlated with growth rate, showing that the lower the vulnerability level of the region, measured by the Net foreign position, the higher its growth rate (Table 3). The stage of development is the third most relevant factor for the EU28, with negative orientation which conforms to the neoclassical theory of growth. However the stage of development becomes a medium-impact factor for the EU15 group, with the Quality of Governance being the third most important growth factor. The EU15 group includes all the most developed economies and the role of institutions assumes more importance. This is the effect of the interdependency between different factors of growth. The quality of governance is unlikely to have a purely autonomous effect on economic growth; it rather interacts with other factors to play a role in relative terms. Institutions remain silent till a certain level of level of development is reached, above which they start to make the difference and become more important than other basic aspects like the initial regional endowment. Accordingly, the Quality of Governance is not detected as important by MARS in the least developed economies of the EU13 group (Section 4.2). The two least important factors are in both cases the share of Employment and Research and Innovation, all the others being medium-impact factors. It is interesting to note that Government debt has a higher, negative effect for the EU15 model.

In results interpretation it is important to remember that the analysis is not capable of capturing factors' impact on long-term growth, due to the limited time-span of the

Table 2: CART results: Variable ranking based on their average normalized importance(from 1000 randomized CARTS)

Factor	EU28 model Mean	Average $MR = 0.29$ Std Dev	CoV $\left(\frac{\sigma}{\mu} \cdot 100\right)$	CI for Mean lower 95%	CI for Mean upper 95%
Lowly educated workforce	1.00	0.00	0.01	1.00	1.00
Net foreign position	0.83	0.08	9.14	0.82	0.83
Stage of development	0.66	0.07	10.37	0.65	0.66
Quality of governance	0.37	0.07	18.60	0.37	0.37
Urban areas	0.35	0.10	28.60	0.34	0.35
Long-term unemployment	0.25	0.10	39.31	0.25	0.26
Road infrastructure	0.24	0.08	34.16	0.24	0.25
Government debt	0.24	0.10	39.84	0.23	0.25
Highly educated workforce	0.17	0.12	70.29	0.16	0.18
Employment	0.12	0.11	91.02	0.11	0.12
Research and Innovation	0.09	0.09	96.64	0.09	0.10
Factor	**EU15 model Mean**	**Average $MR = 0.32$ Std Dev**	**CoV $\left(\frac{\sigma}{\mu} \cdot 100\right)$**	**CI for Mean lower 95%**	**CI for Mean upper 95%**
Net foreign position	0.98	0.04	3.97	0.98	0.98
Lowly educated workforce	0.98	0.03	3.41	0.97	0.98
Quality of governance	0.46	0.08	18.26	0.46	0.47
Government debt	0.35	0.09	25.99	0.34	0.35
Stage of development	0.32	0.10	32.63	0.31	0.32
Urban areas	0.30	0.09	30.54	0.30	0.31
Long-term unemployment	0.23	0.13	57.26	0.23	0.24
Road infrastructure	0.22	0.12	55.95	0.21	0.23
Research and Innovation	0.20	0.14	68.28	0.19	0.21
Employment	0.20	0.13	64.90	0.19	0.20
Highly educated workforce	0.18	0.13	72.54	0.17	0.18

available regional data time series.

4.2 Multivariate Adaptive Regression Splines

Table 4 compares the accuracy of different MARS models for the EU28, the EU15 and the EU13. In all the cases the penalty γ is set to 0.05 which corresponds to a moderate penalty (Section 2.2). The goodness of fit of the models, measured by GCV and adjusted R^2, generally increases as higher-order interactions are included. A simple additive model is not suitable to investigate growth patterns as interacting effects are important elements of the analysis. Nevertheless, third or higher-order models do not substantially increase the model accuracy so second-order models are considered as the best ones (only third-order interaction models are shown in Table 4). R^2 values are overall pretty low, ranging from a minimum of 0.39, for the EU15-additive model, to a maximum of 0.62, for the second and third-order interactive model for the EU13. This means that the noise-to-signal ratio is high and, consequently, the margin of error cannot be considered as negligible. Any interpretation of results must then be tempered by these considerations. The EU15 accuracy is the lowest one among the three, well below 50% of variance accounted for, and for this reason this model has been discarded from further analysis.

The second-order EU28 model is able to account for 50% of the variance (Table 4). The three most important factors are Net foreign position, Stage of development and share of Lowly educated workforce (Table 5). These are the same as the ones identified by CART analysis for the EU-28 model, even if with a different order of importance (Table

Table 3: Partial correlation coefficients between real GVA growth rate and its explanatory factors (*p*-values in brackets)

	Stage of dev.	**Urban areas**	**Road infr.**
EU28	-0.195	0.011	-0.041
	(<**0.0001**)	(0.628)	(0.066)
EU15	-0.128	0.000	-0.044
	(<**0.0001**)	(0.9980)	(0.0774)

	Quality of gov.	**Net foreign position**	**Government debt**
EU28	0.040	0.288	-0.323
	(0.0681)	(<**0.0001**)	(<**0.0001**)
EU15	0.122	0.257	-0.180
	(<**0.0001**)	(<**0.0001**)	(<**0.0001**)

	Lowly ed. workforce	**Highly ed. workforce**	**Long-term unempl.**
EU28	-0.143	-0.134	0.113
	(<**0.0001**)	(<**0.0001**)	(<**0.0001**)
EU15	-0.052	-0.148	0.043
	(0.0381)	(<**0.0001**)	(0.084)

	Employment	**Research and Innovation**
EU28	-0.092	0.074
	(<**0.0001**)	(**0.0008**)
EU15	-0.118	0.071
	(<**0.0001**)	(**0.0045**)

2). To get further insight into the relationships between growth and its factors, Figure 1 shows the contribution to the prediction, which is the estimated growth rate, of the four most important factors in the additive model[7]. For the Net foreign position factor, which is used as a proxy for the level of vulnerability or resilience of the region (Lau et al. 2003), the dependence is positive when net foreign position tends to the balanced level from negative values. After this level, the factor does not influence growth rate any longer as the curve almost levels off (Figure 1a). The dependence of growth rate on the stage of development is in line with the neoclassical growth theory, as in the CART case: at the increase of the stage of development, the economic growth rate slows down. The pace is however different: the decrease of growth rate is steeper for low levels and slower for higher levels of development (Figure 1b). The dependence of growth rate on the share of Lowly educated workforce is instead somewhat surprising at least in the right-hand side of the curve with higher shares of lowly educated people positively associated with growth rate (Figure 1c). A possible explanation can be found in the effects of interaction between Lowly educated workforce and other important factors, as can be seen in Table 4. It is also true that in poor economies, with a low-tech job environment, lowly educated people boost the first stage of the economy. This assumption would nevertheless need further investigation. Government debt shows instead an interesting relationship with growth rate with an almost neutral effect up to a certain level of debt, around 130% of GDP, above which growth rate decreases steeply as debt increases (Figure 1d). Even if some of the components show interesting and conceptually reasonable relationships with growth, any interpretations must be taken with caution, given the relative low level of accuracy of the model. Also, the existence of collinearity among the explanatory factors generally causes problems in the interpretation of results (Friedman 1991).

The EU13 model reaches the highest accuracy, explaining 62% of the variance and Table 5 lists the most important factors. The most important factor of growth is the Net foreign position with a positive effect on growth rate as for the EU28 model (Figure 2a).

[7] For interpretation purposes only the additive model components are shown.

Table 4: Comparison of different MARS models and their interacting factors

Model	*GCV* based R^2	Adj. R^2	Relevant interactions
EU28 additive	0.44	0.45	none
EU28 second-order	0.48	0.50	Stage of dev. – Lowly ed. workforce Stage of dev. – Net foreign position Net foreign position – Gov. debt Net foreign position – Long-term unempl. Net foreign position – Lowly ed. workforce Lowly ed. workforce – Highly ed. workforce
EU28 third-order	0.49	0.50	Net foreign position – Gov. debt Net foreign position – Long-term unempl. Stage of dev. – Lowly ed. workforce Net foreign position – Lowly ed. workforce – Stage of dev. Net foreign position – Gov. debt – Employment Net foreign position – Gov. debt – Highly ed. workforce
EU15 additive	0.39	0.39	none
EU15 second-order	0.39	0.42	Net foreign position – Quality of governance Net foreign position – Long-term unempl. Net foreign position – Road infrastructure Lowly ed. workforce – Highly ed. workforce Stage of dev. – Gov. debt
EU15 third-order	0.42	0.43	Net foreign position – Quality of Governance Net foreign position – Employment Net foreign position – Lowly ed. workforce Stage of dev. – Quality of Governance Net foreign position – Lowly ed. workforce – Quality of gov. Net foreign position – Lowly ed. workforce – Employment Net foreign position – Stage of dev. – Quality of gov.
EU13 additive	0.51	0.56	none
EU13 second-order	0.56	0.62	Net foreign position – Stage of dev. Net foreign position – Highly ed. workforce Net foreign position – Lowly ed. workforce Highly ed. workforce – Urban areas Long-term unemployment – Gov. debt
EU13 third-order	0.56	0.62	Net foreign position – Stage of dev. Net foreign position – Highly ed. workforce Net foreign position – Lowly ed. workforce Long-term unemployment – Gov. debt Highly ed. workforce – Urban areas

The shape of the curve is however different, only slightly increasing for low and negative values and a steep increase as the Net foreign position reaches the parity (zero level). Having a highly educated workforce is important in this case with a constant and positive effect (Figure 2b). Long-term unemployment is an important factor for the EU13 case but with a surprising positive effect (Figure 2c). Apart from model accuracy considerations, this may be due to the interaction of long-term unemployment with other important factors as can be seen in Table 4. The stage of development is important for the EU13 group as well but to a lesser extent than in the EU28 case as its normalized importance is 38% against the 54% for EU28 (Table 5). In both cases the higher the GVA levels the lower the growth rate, with a minor anomaly in the EU13 case for very low GVA values (Figure 2d).

Finally, Government debt is only slightly less important than the stage of development, in the EU13 case and its relationships with growth is the opposite as that of the EU28 case, with a positive effect until values of around 25% of the GDP above which the effect levels off (Figure 3). This is in line with the assumption that there is a certain level of government debt beyond which economic growth starts to be impeded.

Table 5: Second-order MARS models: important variables for the EU28 and the EU13 models

Model	Variable	Number of Basis	Normalized importance
EU28	Net foreign position	8	100.00
	Stage of development	6	54.07
	Lowly ed. workforce	9	38.66
	Government debt	1	13.19
	Long-term unemployment	1	9.51
	Highly ed. workforce	2	6.61
	Quality of Governance	2	5.97
EU13	Net foreign position	8	100.00
	Highly ed. workforce	5	67.35
	Long-term unemployment	4	62.66
	Stage of development	2	38.32
	Government debt	1	34.01
	Urban areas	1	21.28
	Lowly ed. workforce	2	6.69

5 Conclusive remarks

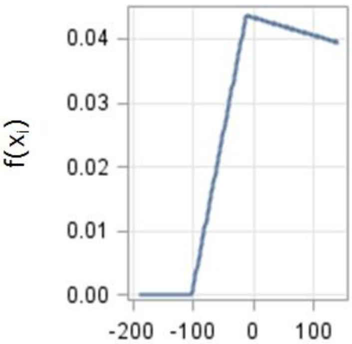
In the search of the main determinants of regional economic growth, in our view this paper features some novelties.

First it employs non-parametric, data-driven statistical models as an alternative to more classical regression techniques. They are more suitable to deal with complex data which feature non-linearities and interaction effects and proved to be rather informative with respect to the type of relationships between growth and its main factors.

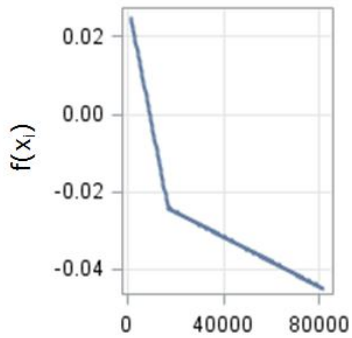
Second, it reaches the regional, sub-national level across the whole EU. Reaching the regional level proved to be particularly demanding due to scarcity of reliable and comparable regional data at the EU level. A large part of the analysis has been then devoted to the building of comparable panel data but longer time series and richer datasets would be needed to overcome the short-run perspective of the analysis and the omission of important factors of growth.

Third, the analysis maintains the traditional factors used in the literature on growth but also incorporates the institutional quality and two variables which aim to reflect the macroeconomic conditions in which the regions operate.

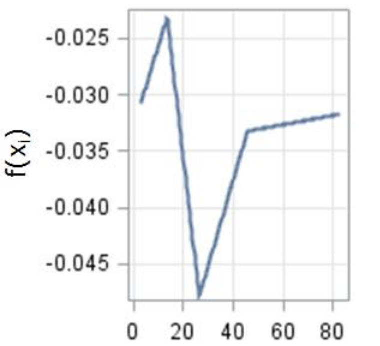
The main results of the analysis can be summarized as follows. Macroeconomic conditions are found to be important to explain the economic growth of regions. They are typically national variables and have been here broken down the regional level with a straightforward approach based on regional population shares. The macroeconomic framework has been generally ignored in the analysis of regional growth trends and convergence, traditionally focused on factors of production (typically infrastructure and education) and the drivers behind Total Factor Productivity (quality of institutions, technological progress, research and innovation). The economic crisis has however shown that the macroeconomic conditions of the economies in which European regions operate are critical and our results actually show the importance of macroeconomic factors in explaining regional growth. The macroeconomic framework is approximated by two variables of the Scoreboard of Indicators of the Macroeconomic Imbalances Procedure, the Net International Investment Position and the Government Debt. While they are highly correlated to other variables such as the current account balance, private sector debt or the financial sector liabilities, other important variables such as the unit labor costs or the export market shares are not captured. The net foreign position is intended to capture the degree of vulnerability (negative values) or resilience (positive values) of the national economy in which the region operates. Government debt is also a very



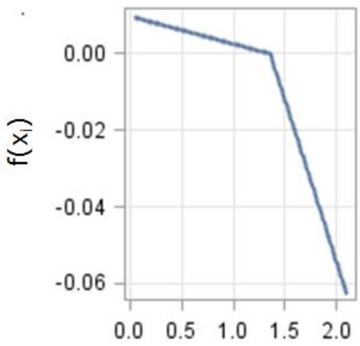
(a) Net foreign position component



(b) Stage of development component



(c) Lowly educated workforce component

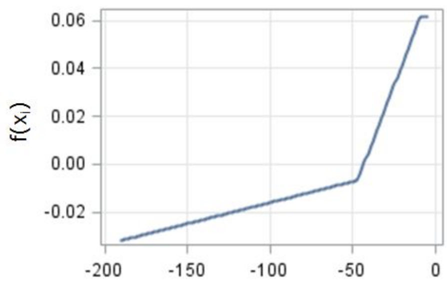


(d) Government debt component

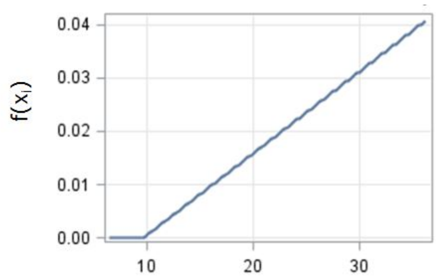
Figure 1: MARS EU28 additive model: dependence of growth on the main four factors, as detected by the model.

relevant indicator of vulnerability of a Member State and its capability to deal with economic crisis and asymmetric shocks. The crisis has shown that the adverse effects of the uncertainties regarding the sustainability of the Government debt spreads to the whole economy through a contraction of the financing supply by the market and an increase in the risk premium faced by public and private operators. What we observe is that positive levels of net foreign position are always fostering growth while for government debt the picture is more diverse. Results suggest that there are good debt levels which have a positive effect on growth (see the EU13 scenario). However, above a certain threshold, around 130% of GDP, debt has a clear counteracting effect. A high level of general government debt is therefore a problem 'per se' and its consequences cannot be compensated by a low level of private debt. Further discussion and investigation may be required to improve the availability of regional statistics on macroeconomic variables, to analyze the impact of the macroeconomic framework on regional economic growth.

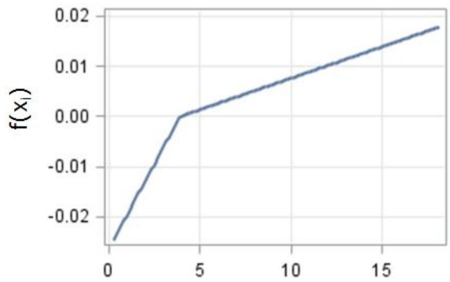
Human capital is another relevant factor driving economic growth of the EU regions. The paper confirms the wide consensus of the economic literature about the major importance of human capital for economic growth, in line with a number of studies (Solow 1956, Mankiw et al. 1992, Lucas 1988, Barro 1989). Human capital is measured at both ends of the scale, in terms of lowly and highly educated people of working age. The analysis interestingly indicates that higher shares of poorly educated people are more detrimental than lower shares of highly educated ones, as also highlighted by a recent study at the regional level in OECD countries (OECD 2012). Human capital is likely to be transmitted into higher economic growth through higher productivity of the labor force but also through technological progress, increasing therefore the Total Factor Productivity of countries and regions. The importance of the institutional quality is also confirmed by the analysis, fully in line with a vast number of economic analyses such as in (Knack, Keefer 1995, Acemoglu et al. 2003, Rodrik et al. 2004) which have identified the quality



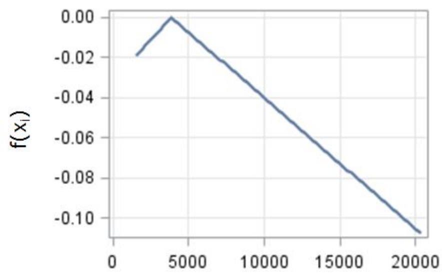
(a) Net foreign position component



(b) Highly educated workforce component



(c) Long-term unemployment component



(d) Stage of development component

Figure 2: MARS EU13 additive model: dependence of growth on the main four factors, as detected by the model.

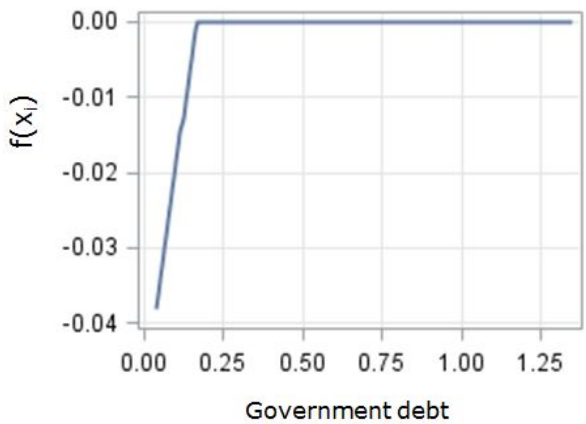


Figure 3: MARS EU13 additive model: dependence of growth on Government debt, as detected by the model.

of institutions as a major explanatory factor of growth and regional disparities. Good institutions may lead to higher economic growth through a higher productivity of the factors of production, lower rent-seeking behaviors, more room for technological progress and innovation, lower administrative costs and corruption, etc. There has been however a wide debate on the literature on what does institutional quality mean and what the most relevant indicators that capture this notion are. This paper uses the Quality of Government Index, published twice (in 2010 and 2013) by the University of Gothenburg, to regionalize a longer time series of well-known governance indicators by the World Bank and the World Economic Forum.

Finally, the evidence given by the model about the impact of other factors on economic growth such as those on the population agglomeration, infrastructure or the level of innovation is more limited and inconclusive. As striking as it may seem, these findings are however in line with what was found in a recent OECD analysis on regional growth

(OECD 2012). It is beyond the purpose of this paper to dig into why these factors are detected as non-influential. One of reasons is surely related to the comparatively short-term perspective of the analysis due to data availability constraints. An interesting explanation of the little support for the link between innovative activities and growth at the regional level – *the innovative puzzle* – is for example provided in the recent OECD analysis just mentioned (OECD 2012).

The conclusions of the paper underpin the rationale behind the reinforcement of the European economic governance and the conditionality mechanisms set in the new architecture of the EU regional funds 2014-2020. In 2011 the European institutions adopted a new economic surveillance procedure for the prevention and correction of macroeconomic imbalances which strengthens the economic surveillance powers at the EU level. The reason behind is the recognition that significant factors influencing economic performance and stability had overall been ignored by the EU economic surveillance, which was limited to the monitoring of the fiscal and budgetary positions of Member States until the advent of the economic crisis. The allocation of regional funds is now made conditional to (i) compliance with a number of ex-ante conditionalities which aim to ensure a minimum level of framework conditions related to institutional quality and to (ii) compliance with the fiscal and macroeconomic procedures enshrined in the EU primary and secondary legislation. The rationale behind this conditionality is that the effectiveness of the expenditure is reinforced by good institutional quality and sound economic policies as suggested by the results of this study.

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A Appendix

Table A.1: Descriptive statistics of indicators included in the analysis

GVA per capita

year	Country group	Average	SD	Min	Max
2003	EU_13	5036	3137	1498	15838
	EU_15	21537	7072	9462	66904
2003 Total		17966	9354	1498	66904
2004	EU_13	5283	3235	1564	16672
	EU_15	22017	7177	9511	68453
2004 Total		18396	9493	1564	68453
2005	EU_13	5525	3424	1583	17564
	EU_15	22324	7486	9583	73020
2005 Total		18688	9711	1583	73020
2006	EU_13	5851	3599	1649	18570
	EU_15	22913	7664	9714	74094
2006 Total		19221	9909	1649	74094
2007	EU_13	6171	3823	1754	20023
	EU_15	23468	8005	10063	78926
2007 Total		19725	10204	1754	78926
2008	EU_13	6386	3878	1814	20334
	EU_15	23426	8134	10152	81903
2008 Total		19739	10215	1814	81903
2009	EU_13	6078	3646	1720	18882
	EU_15	22387	7629	9847	75123
2009 Total		18857	9674	1720	75123
2010	EU_13	6193	3737	1661	19464
	EU_15	22754	7969	10109	76813
2010 Total		19170	9964	1661	76813

Urban Areas

year	Country group	Average	SD	Min	Max
2006	EU_13	32	29	0	100
	EU_15	42	33	0	100

Road infrastructure

year	Country group	Average	SD	Min	Max
2012	EU_13	48	26	7	115
	EU_15	105	81	1	311

Quality of governance*

year	Country group	Average	SD	Min	Max
2003	EU_13	-1.14	0.83	-2.94	0.32
	EU_15	0.33	0.72	-1.85	2.87
2003 Total		0.01	0.96	-2.94	2.87
2004	EU_13	-1.23	0.75	-2.87	0.11
	EU_15	0.41	0.75	-1.87	2.95
2004 Total		0.06	1.01	-2.87	2.95
2005	EU_13	-1.17	0.76	-2.83	0.04
	EU_15	0.32	0.73	-1.94	2.73
2005 Total		0.00	0.96	-2.83	2.73
2006	EU_13	-1.17	0.74	-2.64	0.13
	EU_15	0.33	0.81	-1.98	2.60
2006 Total		0.01	1.01	-2.64	2.60
2007	EU_13	-1.25	0.69	-2.67	0.23
	EU_15	0.47	0.87	-2.14	2.66
2007 Total		0.10	1.09	-2.67	2.66
2008	EU_13	-1.17	0.64	-2.63	0.33
	EU_15	0.33	0.84	-2.17	2.63
2008 Total		0.00	1.01	-2.63	2.63
2009	EU_13	-1.13	0.59	-2.66	0.24
	EU_15	0.15	0.86	-2.30	2.51
2009 Total		-0.13	0.97	-2.66	2.51
2010	EU_13	-1.03	0.58	-2.63	0.23
	EU_15	0.22	0.87	-2.26	2.52
2010 Total		-0.05	0.96	-2.63	2.52

* Note: the Quality of governance index is by construction expressed in z-scores

Net foreign position* (regionalized)

year	Country group	Average	SD	Min	Max
2003	EU_13	-39.8	27.7	-120.4	38.9
	EU_15	-12.9	27.1	-79.9	140.3
2003 Total		-18.7	29.4	-120.4	140.3
2004	EU_13	-43.9	30.1	-130.3	39.4
	EU_15	-15.6	29.0	-91.9	113.1
2004 Total		-21.7	31.5	-130.3	113.1
2005	EU_13	-49.1	33.3	-147.1	36.0
	EU_15	-14.7	34.8	-106.9	127.8
2005 Total		-22.1	37.3	-147.1	127.8
2006	EU_13	-56.6	36.9	-161.3	37.8
	EU_15	-17.0	40.1	-120.1	131.6
2006 Total		-25.5	42.7	-161.3	131.6
2007	EU_13	-65.6	37.8	-167.1	17.7
	EU_15	-19.7	42.5	-134.5	95.5
2007 Total		-29.6	45.6	-167.1	95.5
2008	EU_13	-72.5	38.3	-169.7	2.6
	EU_15	-16.2	41.7	-120.3	100.1
2008 Total		-28.4	47.1	-169.7	100.1
2009	EU_13	-79.8	41.9	-190.9	12.6
	EU_15	-17.6	50.7	-138.5	86.7
2009 Total		-31.1	55.3	-190.9	86.7
2010	EU_13	-81.5	39.2	-186.0	8.1
	EU_15	-17.1	51.9	-139.1	98.0
2010 Total		-31.1	56.1	-186.0	98.0

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Government debt (regionalized)					
year	*Country group*	*Average*	*SD*	*Min*	*Max*
2003	**EU_13**	0.42	0.19	0.06	0.87
	EU_15	0.69	0.29	0.06	1.67
2003 Total		0.64	0.29	0.06	1.67
2004	**EU_13**	0.45	0.21	0.05	0.93
	EU_15	0.70	0.29	0.06	1.64
2004 Total		0.64	0.29	0.05	1.64
2005	**EU_13**	0.42	0.22	0.05	0.94
	EU_15	0.71	0.30	0.06	1.67
2005 Total		0.65	0.31	0.05	1.67
2006	**EU_13**	0.42	0.25	0.04	1.09
	EU_15	0.70	0.31	0.07	1.68
2006 Total		0.64	0.32	0.04	1.68
2007	**EU_13**	0.40	0.25	0.04	1.06
	EU_15	0.67	0.31	0.07	1.63
2007 Total		0.62	0.32	0.04	1.63
2008	**EU_13**	0.37	0.25	0.05	1.10
	EU_15	0.72	0.32	0.14	1.68
2008 Total		0.64	0.33	0.05	1.68
2009	**EU_13**	0.49	0.29	0.07	1.35
	EU_15	0.85	0.33	0.16	1.85
2009 Total		0.77	0.35	0.07	1.85
2010	**EU_13**	0.52	0.28	0.07	1.34
	EU_15	0.93	0.36	0.20	2.10
2010 Total		0.84	0.38	0.07	2.10

Lowly educated workforce					
year	*Country group*	*Average*	*SD*	*Min*	*Max*
2003	**EU_13**	22.4	11.0	5.6	80.2
	EU_15	35.5	16.8	3.8	84.7
2003 Total		32.7	16.6	3.8	84.7
2004	**EU_13**	21.5	10.7	5.1	76.4
	EU_15	34.2	16.2	3.5	82.8
2004 Total		31.4	16.0	3.5	82.8
2005	**EU_13**	20.4	10.6	4.5	74.8
	EU_15	33.2	15.4	3.6	81.3
2005 Total		30.4	15.4	3.6	81.3
2006	**EU_13**	19.2	10.1	4.6	73.5
	EU_15	32.7	15.1	3.8	80.8
2006 Total		29.8	15.3	3.8	80.8
2007	**EU_13**	18.5	10.0	4.3	73.4
	EU_15	32.1	15.1	3.4	81.4
2007 Total		29.2	15.2	3.4	81.4
2008	**EU_13**	17.9	10.0	4.4	72.2
	EU_15	31.4	15.0	3.0	82.0
2008 Total		28.5	15.1	3.0	82.0
2009	**EU_13**	17.3	9.9	4.2	69.2
	EU_15	30.6	14.8	4.0	79.6
2009 Total		27.7	14.9	4.0	79.6
2010	**EU_13**	16.7	9.8	3.3	67.0
	EU_15	29.8	14.6	3.6	78.4
2010 Total		27.0	14.7	3.3	78.4

Highly educated workforce					
year	*Country group*	*Average*	*SD*	*Min*	*Max*
2003	**EU_13**	14.6	5.8	6.5	30.1
	EU_15	22.3	7.7	6.1	43.0
2003 Total		20.6	8.0	6.1	43.0
2004	**EU_13**	15.5	5.9	6.8	31.1
	EU_15	23.5	7.6	6.6	43.8
2004 Total		21.8	8.0	6.6	43.8
2005	**EU_13**	16.2	6.0	7.5	33.2
	EU_15	23.9	7.8	7.7	45.5
2005 Total		22.3	8.1	7.5	45.5
2006	**EU_13**	16.8	6.1	8.0	33.2
	EU_15	24.4	7.8	8.2	45.8
2006 Total		22.8	8.1	8.0	45.8
2007	**EU_13**	17.3	6.4	7.3	33.3
	EU_15	24.8	8.0	7.4	47.6
2007 Total		23.2	8.3	7.3	47.6
2008	**EU_13**	18.1	6.6	6.8	34.5
	EU_15	25.4	7.9	7.2	48.3
2008 Total		23.8	8.2	6.8	48.3
2009	**EU_13**	19.0	6.6	8.4	36.1
	EU_15	26.3	8.2	8.2	51.5
2009 Total		24.7	8.5	8.2	51.5
2010	**EU_13**	19.9	6.8	9.0	35.7
	EU_15	27.0	8.5	9.9	53.1
2010 Total		25.4	8.6	9.0	53.1

Long-term unemployment					
year	*Country group*	*Average*	*SD*	*Min*	*Max*
2003	**EU_13**	6.9	4.1	1.0	16.8
	EU_15	3.1	2.8	0.1	15.4
2003 Total		3.9	3.5	0.1	16.8
2004	**EU_13**	6.6	3.7	1.2	17.4
	EU_15	3.2	2.8	0.3	13.8
2004 Total		4.0	3.3	0.3	17.4
2005	**EU_13**	6.4	3.7	1.2	18.1
	EU_15	3.3	2.8	0.3	13.4
2005 Total		4.0	3.2	0.3	18.1
2006	**EU_13**	5.5	3.0	0.9	15.9
	EU_15	3.1	2.5	0.3	12.0
2006 Total		3.6	2.8	0.3	15.9
2007	**EU_13**	4.1	2.2	0.7	11.8
	EU_15	2.7	2.2	0.3	11.1
2007 Total		3.0	2.3	0.3	11.8
2008	**EU_13**	3.0	1.9	0.5	9.6
	EU_15	2.5	2.0	0.1	9.4
2008 Total		2.6	2.0	0.1	9.6
2009	**EU_13**	3.1	1.8	0.4	8.8
	EU_15	2.8	1.9	0.3	11.7
2009 Total		2.9	1.9	0.3	11.7
2010	**EU_13**	4.3	2.4	0.2	12.3
	EU_15	3.5	2.3	0.2	12.2
2010 Total		3.7	2.4	0.2	12.3

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Employment

year	*Country group*	*Average*	*SD*	*Min*	*Max*
2003	**EU_13**	62.6	6.7	51.2	77.0
	EU_15	69.4	7.0	46.1	86.5
2003 Total		67.9	7.5	46.1	86.5
2004	**EU_13**	62.7	6.5	50.7	75.9
	EU_15	69.4	6.6	47.8	81.9
2004 Total		67.9	7.1	47.8	81.9
2005	**EU_13**	63.2	6.2	53.9	76.9
	EU_15	70.2	6.4	48.1	82.1
2005 Total		68.7	7.0	48.1	82.1
2006	**EU_13**	64.6	6.0	54.5	77.2
	EU_15	70.9	6.3	48.3	82.5
2006 Total		69.6	6.8	48.3	82.5
2007	**EU_13**	66.0	5.7	55.9	77.2
	EU_15	71.7	6.4	47.9	86.7
2007 Total		70.5	6.7	47.9	86.7
2008	**EU_13**	66.9	5.7	54.7	78.0
	EU_15	72.1	6.6	46.4	88.8
2008 Total		71.0	6.8	46.4	88.8
2009	**EU_13**	65.5	5.1	53.2	76.9
	EU_15	71.0	6.9	44.8	84.0
2009 Total		69.8	6.9	44.8	84.0
2010	**EU_13**	64.5	4.8	53.7	76.0
	EU_15	70.6	7.0	43.7	83.3
2010 Total		69.3	7.1	43.7	83.3

Innovation index*

year	*Country group*	*Average*	*SD*	*Min*	*Max*
2003	**EU_13**	-0.86	0.53	-1.67	1.09
	EU_15	-0.03	0.79	-1.87	2.43
2003 Total		-0.21	0.82	-1.87	2.43
2004	**EU_13**	-0.81	0.54	-1.65	1.22
	EU_15	0.08	0.78	-1.79	2.62
2004 Total		-0.11	0.82	-1.79	2.62
2005	**EU_13**	-0.74	0.59	-1.70	1.36
	EU_15	0.13	0.79	-1.64	2.78
2005 Total		-0.06	0.83	-1.70	2.78
2006	**EU_13**	-0.67	0.60	-1.51	1.43
	EU_15	0.19	0.79	-1.59	2.80
2006 Total		0.00	0.83	-1.59	2.80
2007	**EU_13**	-0.65	0.55	-1.39	1.34
	EU_15	0.19	0.79	-1.45	2.75
2007 Total		0.01	0.82	-1.45	2.75
2008	**EU_13**	-0.56	0.64	-1.52	1.56
	EU_15	0.24	0.80	-1.67	3.03
2008 Total		0.06	0.84	-1.67	3.03
2009	**EU_13**	-0.53	0.57	-1.36	1.28
	EU_15	0.28	0.81	-1.33	2.79
2009 Total		0.10	0.83	-1.36	2.79
2010	**EU_13**	-0.36	0.88	-1.51	2.73
	EU_15	0.37	0.93	-1.53	3.08
2010 Total		0.21	0.96	-1.53	3.08

* Note: the Innovation index is by construction expressed in z-scores

3-year average of annual real GVA per capita growth

3-y average period	*Country group*	*Average*	*SD*	*Min*	*Max*
2004_2006	**EU_13**	1.052	0.022	1.013	1.111
	EU_15	1.021	0.011	0.987	1.064
2004_2006 Total		1.027	0.019	0.987	1.111
2005_2007	**EU_13**	1.051	0.026	1.002	1.110
	EU_15	1.021	0.012	0.974	1.062
2005_2007 Total		1.027	0.021	0.974	1.110
2006_2008	**EU_13**	1.051	0.025	1.004	1.113
	EU_15	1.015	0.013	0.971	1.044
2006_2008 Total		1.023	0.022	0.971	1.113
2007_2009	**EU_13**	1.016	0.026	0.956	1.068
	EU_15	0.992	0.013	0.961	1.027
2007_2009 Total		0.997	0.019	0.956	1.068
2008_2010	**EU_13**	1.003	0.023	0.950	1.041
	EU_15	0.989	0.016	0.947	1.048
2008_2010 Total		0.992	0.019	0.947	1.048
2009_2011	**EU_13**	1.000	0.021	0.966	1.038
	EU_15	0.992	0.019	0.918	1.038
2009_2011 Total		0.994	0.019	0.918	1.038
2010_2012	**EU_13**	1.021	0.022	0.974	1.059
	EU_15	1.006	0.029	0.907	1.089
2010_2012 Total		1.009	0.028	0.907	1.089
2011-2013	**EU_13**	1.029	0.023	0.964	1.085
	EU_15	1.003	0.030	0.892	1.076
2011-2013 Total		1.009	0.031	0.892	1.085

Table A.2: CART robustness analysis for the EU28 (left column) and the EU15 (right column) scenarios

	EU28 scenario				EU15 scenario			
	3 classes (thresholds= P25%, P75%)				3 classes (thresholds= P25%, P75%)			
	Mean	Lower 95% CI	Upper 95% CI	Rank	Mean	Lower 95% CI	Upper 95% CI	Rank
Stage of development	0.66	0.65	0.66	3	0.32	0.31	0.32	5
Urban areas	0.35	0.34	0.35	5	0.30	0.30	0.31	6
Net foreign position	0.83	0.82	0.83	2	0.98	0.98	0.98	1
Governmt debt	0.24	0.23	0.25	8	0.35	0.34	0.35	4
Transport infrastructure	0.24	0.24	0.25	7	0.22	0.21	0.23	8
Quality of governance	0.37	0.37	0.37	4	0.46	0.46	0.47	3
Lowly educated workforce	1.00	1.00	1.00	1	0.98	0.97	0.98	2
Highly educated workforce	0.17	0.16	0.18	9	0.18	0.17	0.18	11
Long-term unemployment	0.25	0.25	0.26	6	0.23	0.23	0.24	7
Employment	0.12	0.11	0.12	10	0.20	0.19	0.20	10
Research and Innovation	0.09	0.09	0.10	11	0.20	0.19	0.21	9
MR	0.29				0.32			
	4 classes (thresholds=P25%, P50%, P75%)				4 classes (thresholds=P25%, P50%, P75%)			
	Mean	Lower 95% CI	Upper 95% CI	Rank	Mean	Lower 95% CI	Upper 95% CI	Rank
Stage of development	0.48	0.48	0.49	3	0.15	0.15	0.16	10
Urban areas	0.22	0.22	0.22	8	0.26	0.25	0.27	9
Net foreign position	0.63	0.63	0.63	2	0.95	0.94	0.95	2
Governmt debt	0.39	0.39	0.40	5	0.48	0.47	0.49	4
Transport infrastructure	0.19	0.18	0.19	10	0.32	0.32	0.33	6
Quality of governance	0.43	0.43	0.44	4	0.66	0.65	0.66	3
Lowly educated workforce	1.00	.	.	1	0.99	0.99	0.99	1
Highly educated workforce	0.26	0.26	0.26	7	0.30	0.29	0.30	7
Long-term unemployment	0.28	0.28	0.29	6	0.38	0.38	0.39	5
Employment	0.19	0.18	0.19	9	0.29	0.29	0.30	8
Research and Innovation	0.13	0.13	0.14	11	0.10	0.09	0.11	11
MR	0.39				0.42			
	5 classes (thresholds=P20%, P40%, P60%, P80%)				5 classes (thresholds=P20%, P40%, P60%, P80%)			
	Mean	Lower 95% CI	Upper 95% CI	Rank	Mean	Lower 95% CI	Upper 95% CI	Rank
Stage of development	0.56	0.55	0.57	3	0.20	0.19	0.21	10
Urban areas	0.19	0.18	0.20	10	0.31	0.30	0.31	8
Net foreign position	0.67	0.66	0.68	2	0.94	0.93	0.94	2
Governmt debt	0.38	0.38	0.39	5	0.54	0.53	0.55	4
Transport infrastructure	0.20	0.20	0.21	8	0.32	0.31	0.32	7
Quality of governance	0.56	0.55	0.56	4	0.71	0.71	0.72	3
Lowly educated workforce	1.00	.	.	1	0.99	0.99	0.99	1
Highly educated workforce	0.31	0.30	0.32	6	0.44	0.43	0.44	5
Long-term unemployment	0.24	0.24	0.25	7	0.36	0.35	0.36	6
Employment	0.20	0.19	0.20	9	0.26	0.26	0.27	9
Research and Innovation	0.16	0.15	0.17	11	0.14	0.13	0.15	11
MR	0.45				0.48			

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Cities and Inequality*

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Abstract. We propose an innovative methodology to measure inequality between cities. If an even distribution of amenities across cities is assumed to increase the average well-being in a given country, inequality between cities can be evaluated through a multidimensional index of the Atkinson (1970) type. This index is shown to be decomposable into the sum of inequality indices computed on the marginal distributions of the amenities across cities, plus a residual term accounting for their correlation. We apply this methodology to assess inequality between Italian cities in terms of the distribution of public infrastructures, local services, economic and environmental conditions.

JEL classification: R11, R12, R23

Key words: Inequality, inequality aversion, social welfare, city

1 Introduction

Recent literature has shown that excessive inequality produces negative effects not only for disadvantaged individuals but also for a whole community. The State of the World's Cities Report by UN-Habitat (2008) established an international alert line corresponding to a Gini coefficient[1] value of 0.4. Several African and Latin American cities exhibit a value of Gini coefficient above this threshold[2]. High income inequality can have drastic consequences of economic, social, and political nature, such as lack of investment, protests and riots, and civil conflicts. In addition, high inequality may lead to the weak functioning of labor markets, inadequate investments in public services, or institutional and structural failures in income redistribution (UN-Habitat 2008)[3]. Given the importance of having an

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[1]The Gini coefficient is a measure of inequality varying from 0 (every individual received an equal share of income, then there is perfect equality) to 1 (one individual receives all the income, then there is perfect inequality).

[2]See UN-Habitat (2010) and Brambilla et al. (2015) for a world's selected city-ranking by Gini index for the year 2010.

[3]Brambilla et al. (2015) provide a deeper discussion on why excessive inequality can be harmful for a community.

even distribution of resources, or at most moderate levels of inequality, to the normal functioning of a community, in this paper we focus on inequality across cities because we are witnessing a dramatic increase of people living in urban areas over the last 60 years. According to United Nations and World Health Organization projections, while less than one-third of the world's population lived in cities in 1950, about two thirds of humanity is expected to live in urban areas by 2030 (UN-Habitat 2008, WHO-UN Habitat 2016). Local facilities and public goods available at the city-level may have an impact on individual well-being. As a result, there has been a growing interest on complementing income measures with the value of public goods and services that are available at the municipality, provincial, or regional level (Aaberge et al. 2010). Following a multidimensional approach, we consider inequality in terms of urban disparities, i.e. provincial capitals rather than in terms of differences across individuals. We propose an innovative methodology, which relies on the assumption that an even distribution of local goods and services across cities increases the average level of well-being in a given country. Due to the spatial nature of such goods and services, not all individuals in a society are equally exposed to the same quantities and qualities of them. Location choices are also driven by preferences for local public goods so even though these goods are not marketable, their impact on individual utility is capitalized in housing and labor markets. The hedonic approach is used to obtain a monetary evaluation of local public goods, named amenities, and defined as location specific characteristics with positive or negative effects on household's utility (Bartik, Smith 1987). People living in different cities face different amenities, and this generates inequalities across individuals in the level of welfare they locally perceive. The link between welfare and inequality in a multidimensional setting is captured by the Abul Naga, Geoffard (2006) index. We extend their methodology by endogenously determining the parameters of the index through a hedonic model referred to the housing and labor markets.

We employ our methodology to assess inequality between 103 Italian provincial (NUTS-3) capitals on the basis of a set of localized goods, such as public infrastructure, local services, economic, and environmental conditions. The proposed methodology allows to disentangle not only the effect of the distribution of each amenity on overall inequality, but also the effect of the joint distribution of amenities in determining overall inequality across cities.

The multidimensional inequality index turns out to display a value indicating that there are significant disparities between cities, mainly due to differences in the availability of services and infrastructure, in particular health services, economic conditions, transport infrastructure, and educational services. Environmental conditions and cultural amenities play a minor role in determining the overall level of inequality.

The paper is organized as follows. In Section 2 we present the theoretical framework by deriving the multidimensional inequality index from a social evaluation function having specific properties. Section 3 describes the data. Section 4 presents the results. Section 5 concludes the paper.

2 Framework

This section first shows how to obtain the multidimensional inequality index (Section 2.1). Then the Rosen (1979) and Roback (1982) model is briefly reviewed to show how implicit prices of amenities are determined (Section 2.2). Implicit prices are needed to endogenously determine the value of the multidimensional inequality index parameters.

2.1 Assessing multidimensional inequality

To derive the multidimensional inequality index, we proceed in two steps. First, we introduce a function measuring the level of well-being in a given city, provided by a bundle of k amenities[4]. Second, we aggregate the levels of well-being specific to each city in the simplest way, i.e. by considering their mean.

[4] Albeit well-being usually refers to individuals, we use this term instead of "livability" since the latter is unusual in economic literature. We also avoid using "quality of life", which usually refers to city rankings based on the monetary value of a selected bundle of amenities.

Let us consider n cities, indexed by $i = 1, \dots, n$. Each city is endowed with k amenities, which are all strictly positive. The quantities owned by city i are denoted by the vector $\boldsymbol{z}_i = (z_{i1}, \dots, z_{ij}, \dots, z_{ik}) \in R^k_{++}$.

We assume that an increasing and concave function $w(\boldsymbol{z}_i)$ measures the social evaluation of well-being in city i, as a function of the available amenities, and we define the average evaluation function among the n cities as $W(\boldsymbol{z}_1, \dots \boldsymbol{z}_n) = \frac{1}{n}\sum_{i=1}^{n} w(\boldsymbol{z}_i)$. The monotonicity of $w(\cdot)$ implies that an increase in the quantity of any amenity in any city results to be socially desirable. The concavity of $w(\cdot)$ implies inequality aversion, that is, it would be socially desirable having a homogeneous level of amenities across cities, rather than cities exhibiting huge disparities in terms of public goods, services, and infrastructure. Under the assumption of inequality aversion, society is willing to renounce a share of amenities to obtain an equitable distribution of them across cities. The higher inequality aversion, the higher the share society is willing to renounce. This idea was initially introduced in the risk literature by Pratt (1964) through the concept of "certainty equivalent", which is the amount of money a decision maker is willing to pay to undertake a risky decision. It is a function of the risk attitude of the decision maker. Atkinson (1970) imported in inequality and welfare measurement the notion of certainty equivalent by defining the analogous concept of "equally distributed equivalent income", which is the amount of income that, if equally distributed across individuals, would enable the society to reach the same level of welfare as the actual (unequal) distribution of incomes. The equally distributed equivalent income has been extended to the multidimensional case by Tsui (1995, 1999) (see also Gajdos, Weymark 2005, Abul Naga, Geoffard 2006; Weymark 2006 for a survey). In this paper, we transpose these concepts in comparing well-being among cities. More precisely, we define the vector of equally distributed equivalent amenities as the quantity of amenities that, if equally distributed across the n cities, guarantee the same average well-being as the (unequal) current amenity distribution.

Figure 1 shows the simple case with two cities: a and b, and two amenities: z_1 and z_2. We assume cities a and b are endowed with the bundles $Z_a = (Z_{1a}, Z_{2a})$ and $Z_b = (Z_{1b}, Z_{2b})$, respectively. The distribution of two amenities is unequal since city a has a greater quantity of amenity 2 and a lower quantity of amenity 1, compared with city b.

Let us define $Z_m = (Z_{1m}, Z_{2m})$ the mean bundle, containing the average quantity of each amenity, that is $Z_{1m} = (Z_{1a} + Z_{1b})/2$ and $Z_{2m} = (Z_{2a} + Z_{2b})/2$.

Jensen's inequality[5] implies that the level of social well-being would be higher if a and b were endowed with the same bundle of amenities Z_m rather than with their actual bundles Z_a and Z_b. In formal terms,

$$2W(Z_m) > W(Z_a) + W(Z_b). \tag{1}$$

By continuity and monotonicity of $W(\cdot)$, starting from (1) it is possible to find a positive scaling factor $\theta < 1$, such that the bundle $\theta Z_m = (\theta Z_{1m}, \theta Z_{2m})$ satisfies $2W(\theta Z_m) = W(Z_a) + W(Z_b)$. The vector θZ_m contains the equally distributed equivalent amenities mentioned above, which guarantee the same average level of well-being provided by the actual (unequal) amenity distribution across cities.

Abul Naga, Geoffard (2006) provide an axiomatic characterization of θ as an index of relative equality and its complement to one $(1-\theta)$ as a (relative) index of inequality. While a formal presentation of their framework goes beyond the scope of this paper, we point out the assumptions needed to formulate the multidimensional inequality index $(1-\theta)$, such that it can be used to measure inequality between cities. The social evaluation function is assumed to take a Cobb-Douglas form, $w(\boldsymbol{z}_i) = \prod_{j=1}^{k} z_{ij}^{\sigma_j}$. The parameter σ_j captures the aversion to an unequal distribution of amenity - across cities. In Section 2.1 we further discuss the role of this parameter in the setup and present the methodological strategy to determine the value of σ associated with each amenity.

[5] Jensen's inequality (Jensen 1906) states that for any strictly concave function u defined on a random variable X with expected value $E(x)$, we get $u(E(x)) > E(u(x))$. In social welfare theory, this means that, for any concave individual utility, the average welfare of an egalitarian distribution is always higher than the average welfare obtained through any other distribution of the same total amount of resources. In the example above Jensen's inequality refers to the distribution of urban amenities across cities a and b.

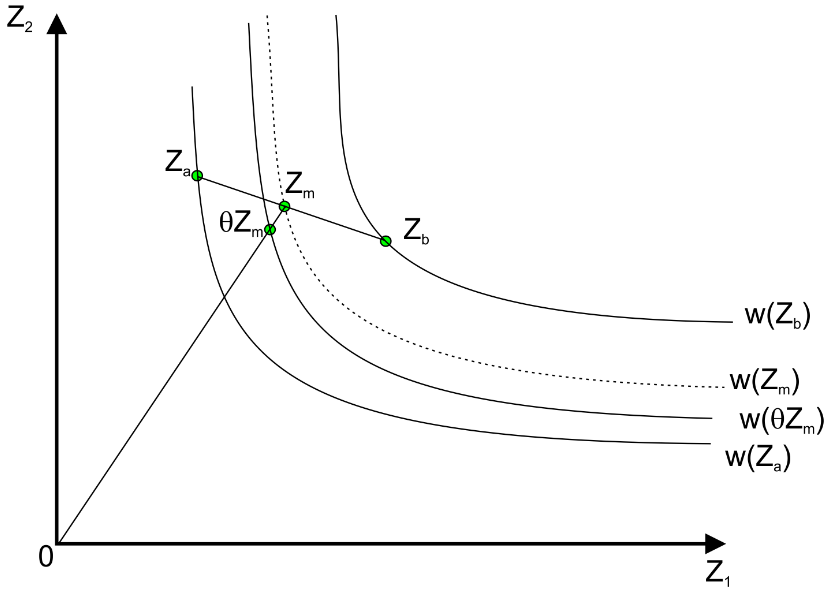

Figure 1: The equally distributed equivalent amount of amenities

The equality index θ has been shown to be decomposable into k indexes, one for amenity, related to the marginal distribution of amenities, and a residual term based on the dependence structure between amenities. In formal terms,

$$(\sum_{j=1}^{k} \sigma_j) \ln \theta = \sum_{k=1}^{k} \sigma_j \ln \gamma_j + \ln \rho \tag{2}$$

where γ_j, with $j01, \ldots, k$ are k unidimensional indices of the Atkinson (1970) type, i.e. $\gamma_j = \frac{1}{\bar{z_j}} \left[\frac{1}{n} \sum_{i=1}^{n} z_{ij}^{\sigma_j}\right]^{\frac{1}{\sigma_j}}$; ρ is an interaction term equal to[6] $\rho = \frac{n^{k-1} \sum_{i=1}^{n} (\prod_{j=1}^{k} z_{ij}^{\sigma_j})}{\prod_{j=1}^{k} (\sum_{i=1}^{n} z_{ij}^{\sigma_j})}$.

The complement to 1 of γ_j, i.e. $1 - \gamma_j$, is the Atkinson index of inequality for amenity j. Notice that the value of parameters σ_j determines not only the degree of inequality aversion in the evaluation function $w(\cdot)$, but also the weight assigned to amenity j in the θ decomposition (1). In multidimensional inequality literature, equal weights are usually assumed for the different attributes under exam, as in the Human Development Index, as well as in studies by other institutions and scholars such as Becker et al. (2005) and Croci Angelini, Michelangeli (2012). In this paper, we follow Brambilla et al. (2013) to endogenously determine the values of σ_j. They are set to their respective weight on the monetary assessment of the amenity bundle with sample average quantities. The monetary value of amenities, denoted by p_j, with $j = 1, \ldots, k$, is determined on the basis of hedonic regressions based on the housing prices individuals are willing to pay and the wages they are willing to accept to locate in a given city. More precisely, σ_j, with $j = 1, \ldots, k$, is defined as:

$$\sigma_j = \frac{1 - \varepsilon_j}{k - 1} \tag{3}$$

where

$$\varepsilon_j = \frac{p_j \bar{z_j}}{\sum_{l=1}^{k} p_l \bar{z_l}} \tag{4}$$

Each parameter ε_j is set to be equal to the ratio between the estimated value of the average quantity of the amenity j and the value of all amenities. The methodology implicitly assumes that the higher the contribution of amenity j in determining the

[6] See Brambilla, Peluso (2010).

amenity bundle value, the more intense is the aversion for its uneven distribution across cities, the lower will be the value of σ_j.

In the next section, we determine the implicit prices of amenities, p_j, by referring to the hedonic spatial equilibrium model, developed by Rosen (1979) and Roback (1982), which explain the optimal location choice of agents, i.e. consumers and firms.

It is worth mentioning that implicit or shadow prices of amenities could be computed using alternative approaches. For example, Veneri, Murtin (2016), in order to compute multidimensional living standards among OECD regions, use the life satisfaction approach to estimate the shadow price of three dimensions of well-being: income, jobs, and health outcomes.

2.2 *Determining the implicit value of amenities*

Rosen (1979) considers household and business location decisions in order to maximize utility and to minimize costs, respectively. Household choices depend on the wage that one can earn living in a given city and the cost of living approximated by the cost of housing services. Households with a preference for amenity-rich cities will move to those cities, which are also the more expensive, and will be willing to earn lower wages to enjoy the higher (lower) level of amenities (disamenities). Conversely, household living in low-amenity cities will be compensated with higher wages and lower housing prices. In equilibrium, no-one has an incentive to move, since the relocation costs are higher than the utility gains generated by moving. The representative household experiences the same level of utility in all cities, and unit production costs are equal to the unit production price. Roback (1982) extends the model in a general equilibrium setting, by considering the housing market in addition to the labor market, since the two markets are interconnected and both contribute to determine the implicit price of amenities. The implicit price is given by the sum of the housing price differential and the negative of the wage price differential.

The model is empirically implemented by estimating two separate equations for the log of housing prices and wages:

$$\ln v_{hit} = \beta_0 + \beta_1 X_{hit} + \beta_2 Z_{it} + \eta_{hit} \quad (5)$$

$$\ln w_{mit} = \delta_0 + \delta_1 Y_{mit} + \delta_2 Z_{it} + \zeta_{mit} \quad (6)$$

where v_{hit} is the real price of housing unit h in city i at time t; X_{hit} is a vector of housing characteristics; Z_{it} is a vector of amenities in city i; w_{mit} is the real wage of individual m in city i at time t; Y_{mit} is a vector of individual characteristics; $\eta_{hit} \sim N(0;\sigma^2_\eta)$ and $\zeta_{mit} \sim N(0;\sigma^2_\zeta)$.

The implicit price of amenity z_j is given by

$$p_j = \frac{\partial v}{\partial z_j} - \frac{\partial w}{\partial z_j}. \quad (7)$$

3 Data

We use our methodology to assess inequality between 103 provincial capitals observed in the period 2001-2010. We consider six amenities: cultural infrastructure, educational and health services, transport infrastructure; economic and environmental conditions (Table A.1 in the Appendix sets out the list of amenities with their sources). Cultural conditions, educational services and health services are measured each by an index provided by GuglielmoTagliacarne Institute at the provincial level in 2004. These three indices are used as proxy for services at the city-level. Each of these indices is set to 100 for the Italian average. Cultural conditions are measured by an index of cultural infrastructure accounting for museums, theatres, cinemas, libraries, gyms. The index for educational services combines information about the number of schools of all levels, public and private; the number of classrooms per school; presence of building facilities, such as recreation and gym facilities, library and computer lab facilities; the number of teachers. The index

Table 1: Summary statistics of amenity variables

Variable	Mean	Std. Dev.	Min.	Max.	Unit of observation	Year
Cultural infrastructure	126.11	71.89	18.90	504.17	Province	2004
Educational services	113.47	41.34	24.06	325.32	Province	2004
Health services	121.75	56.90	26.59	287.19	Province	2004
Transport	105.29	26.88	47.00	161.00	Municipality	2006
Employment rate	90.33	7.39	68.61	97.23	Municipality	2010
Air quality	9.96	3.12	0.00	18.00	Municipality	2004

for health services aggregates statistical information about the number of doctors at all levels, the number of nurses and other auxiliary personnel, the number of hospital beds, and the number and types of medical devices. Transport infrastructure is measured by a multimodal index that considers accessibility by air, train and car. The index is at the city level and is set equal to 100 for the European average. It is provided for the year 2006 by European Observation Network for Territorial Development and Cohesion (ESPON) project. The employment rate serves as proxy for economic conditions. The rate is at the city level for the year 2010, and it is provided by the Italian National Institute of Statistics (ISTAT). Environmental conditions are represented by the air quality in terms of reduced number of polluting agents in the air. The variable for air quality was constructed setting the maximum number of air-polluting observed in our sample equal to zero and associating increasing integer values with the decreasing number of air-polluting agents. The numbers of polluting agents are at the city level, refer to 2004 and were from ISTAT. Table 1 presents summary statistics of amenity variables.

The 103 provincial capitals of our sample have on average a higher endowment of cultural infrastructure, followed by health and educational services. The indicator for cultural infrastructure shows the largest variability, according the standard deviation, followed by health and educational services.

For the housing and labor markets, we use the same data set of Colombo et al. (2014) used to measure quality of life in the 103 cities. Housing market data are from the Real Estate Observatory of the Italian Ministry of Finance, and refer to individual house transactions in the 103 Italian provincial capitals between 2004 and 2010. In addition to sale prices, the dataset provides a detailed description of housing characteristics, such as total floor area, number of bathrooms, floor level, number of garages, location (center, semi center, suburb), and location (center, semi-center, suburbs).

Labor market data are from the Italian National Social Security Institute (INPS) for years 2001 and 2002 and were provided by Fondazione Rodolfo De Benedetti. The dataset provides information on the private sector employees' annual earnings, the level of occupation, whether the job is full-time or part-time, contract length, province of work, and sector of economic activity. Personal and demographic characteristics include gender, age, nationality, and province of residence. Housing prices and wages are measured at constant 2004 prices. As mentioned in Colombo et al. (2014), the difference in the timing of the data between wages and housing prices is due to data availability. However considering that we are using only data on dependent employment (entrepreneurs and self-employed are not included) the cross-sectional variation across cities is relatively stable over time, and the actualization procedure applied to the data should account for the possible concerns on this issue[7].

[7] We computed the times-series and cross-sectional variation of housing prices and wages. It turns out that the latter is much larger than the former for both variables. For housing prices, the proportion of between variation is about 90 per cent and the proportion of within variation is about 10 per cent. For wages, the proportion of between variation is about 97 per cent and within variation is about 3 per cent.

Table 2: Amenity hedonic prices and multidimensional inequality index decomposed in the six unidimensional inequality indices plus an interaction term

Variable	Hedonic price* p_j	Parameter measuring inequality aversion** σ_j	Univariate inequality index $1-\gamma_j$
Cultural infrastructure	7	0.1956	0.4104
Education	122	0.1310	0.2482
Health services	91	0.1448	0.3270
Transport	76	0.1601	0.2560
Employment rate	68	0.1694	0.2783
Air quality	21	0.1989	0.2309
Interaction term $\rho = \frac{n^{k-1}\sum_{i=1}^{n}(\prod_{j=1}^{k} z_{ij}^{\sigma_j})}{\prod_{j=1}^{k}(\sum_{i=1}^{n} z_{ij}^{\sigma_j})}$		1.3860	
Multidimensional Inequality Index $I = 1-\theta$		0.3121	

*The implicit price is the marginal willingness to pay (in Euro at constant 2004 prices) associated with a one-standard deviation in the corresponding amenity.

**Higher values of σ_j imply lower levels of inequality aversion.

4 Results

Equations (5) and (6) are estimated by OLS and the results are reported in Table A.1 and A.2, respectively, in the Appendix. Robust standard errors are used with clustering at city level in order to allow for within-city correlation. The covariates used in model (5) account for about 72 per cent of the variance of the logarithm of housing prices, while the marginal explanatory power of local amenities is about 7%. Model (6) explains 61 per cent of the variability of the logarithm of wages, while the marginal explanatory power of local amenities is about 1.8%. The amenity coefficients are jointly statistically significant in the two models ($F = 15.01$, p <0.00 for the housing price equation; $F = 37.46$, p <0.00 for the wage equation).

Full implicit prices for local amenities are shown in Table 2, column 2. The implicit price of amenity z_j is given by (7). To calculate the first derivative, the estimated expected housing price and wage are obtained by (5) and (6), respectively. However, since the empirical specification for the housing price regression and wage regression are log-linear, the relation between the normal and the lognormal distribution has to be taken into account to derive appropriate estimates. The following results from the normal distribution are used. If Y is a normally distributed random variable with expected value μ and variance σ^2, $P = \exp(Y)$ is lognormally distributed with expected value equal to $\exp(\mu + \sigma^2/2)$. Hence, the expected values of housing price and wages have been obtained by plugging in the estimated values in the previous formulas.

The implicit price of a given amenity can be interpreted as the monetary amount, expressed in Euro at constant 2004 prices, households would be willing to pay annually for a one-standard deviation change in that amenity. Increasing the index for educational services by one-standard deviation is valued €122, while the implicit prices associated with health services and cultural infrastructure are €91 and €7, respectively. The weakness of the influence of culture on housing and labor markets is common in hedonic studies on Milan and other Italian cities (for instance Colombo et al. 2014, Brambilla et al. 2013). This is a puzzling result demanding a deeper investigation. The estimated marginal willingness to pay for increasing the employment rate by one-standard deviation is €68. Increasing the ESPON index for transport infrastructure by one-standard deviation is valued €76. A marginal improvement in air quality is valued €21.

The amenity estimated implicit prices and the city average quantities are used to

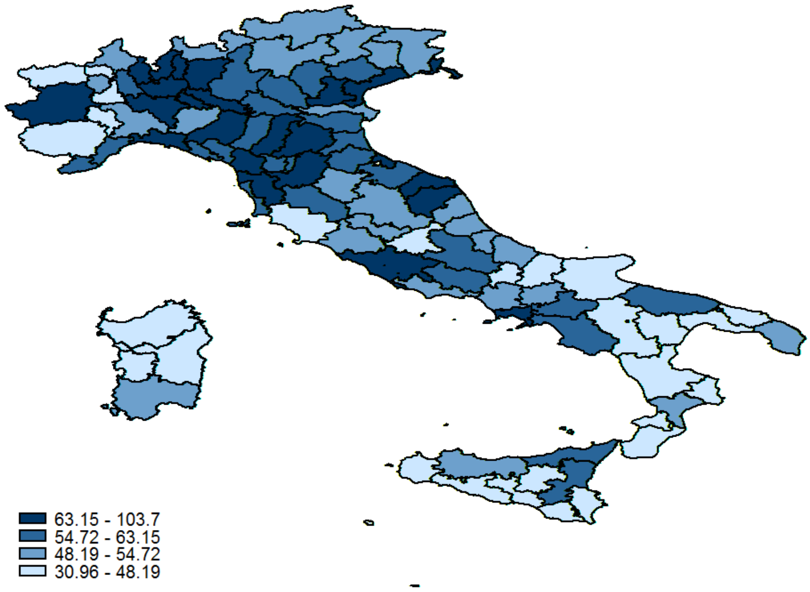

Figure 2: Distribution of W values across cities

estimate the vector of parameters $\boldsymbol{\sigma} = (\sigma_1, \ldots, \sigma_k)$ according to equations (5) and (6). We recall that their values, reported in Table 2, column 3, determine the level of inequality aversion and the weight of each amenity in the θ decomposition, given by equation (2). The higher σ_j, with $j = 1, \ldots, k$, the lower aversion to an unequal distribution of amenity j across cities, and the lower the value of the unidimensional inequality index for this amenity , i.e. $1 - \gamma_j$. The highest degree of inequality aversion is for educational and health services, followed by transport infrastructure and economic conditions, represented by the employment rate. Inequality aversion is lower for air quality and cultural amenities.

The last column of Table 2 shows the unidimensional inequality index of the Atkinson (1970) type, $1 - \gamma_j$. It is lower for air quality and becomes progressively higher for educational services, transport infrastructure, employment rate, health services and cultural infrastructure.

As mentioned in Section 2, ρ measures the effect on inequality due to the interdependence relationship between amenities. If ρ equals one, there is no joint effect of amenities on the multidimensional inequality index; if ρ is less than 1, the joint effects tend to magnify, while if ρ is more than 1, they offset each other. Table 2 shows a value for ρ higher than 1 implying that the joint effect of amenities contributes to the decrease of inequality across cities.

Finally, the multidimensional inequality index (3) turns out to be equal to 0.3121.

To sum up, overall inequality is mainly due to educational and health services, transport infrastructure, and economic conditions because of the higher inequality aversion and the higher value of the unidimensional inequality index for the variables associated with these four amenities. Air quality and cultural infrastructure play a minor role in determining the overall degree of inequality either because the unidimensional inequality index and the degree of inequality aversion are low, as for air quality, or because the inequality aversion and the weight of the variable are low, as for cultural amenities.

We use the estimated values for $\boldsymbol{\sigma} = (\sigma_1, \ldots, \sigma_k)$ to calculate the values of the evaluation function $W = \frac{1}{n} \prod_{j=1}^{k} z_{ij}^{\sigma_j}$ specified in Section 2, which gives the level of well-being individuals enjoy from the endowment of the six amenities specific to each city. Table 3 reports the city-ranking for the value function W, and Figure 2 shows the geographic distribution of W values across Italian cities. Looking at the map, a clear North-South divide can be observed. A clustering of high scores can be observed for cities in the Lombardy and Veneto regions. Cities in the South generally display relatively lower values of W, with clustering of low scores in the cities of Molise, Sardinia and Basilicata. Looking at the city size, well-being is generally higher in large cities (Rome,

Table 3: City ranking according to W values

City	W	City	W	City	W	City	W
Trieste	103.65	Forli	62.62	Biella	54.62	Asti	47.96
Firenze	97.28	Vicenza	62.58	Ascoli Piceno	54.57	Reggio Calabria	47.33
Roma	88.56	Brescia	61.95	Rovigo	54.08	Cosenza	46.81
Milano	85.48	Pistoia	61.59	Chieti	53.90	Vibo Valentia	45.56
Padova	81.92	Bari	61.17	Palermo	53.68	Sassari	45.51
Pisa	81.35	Novara	60.82	Viterbo	53.40	Ragusa	45.29
Napoli	80.36	Verona	60.43	Lecce	53.36	Cuneo	44.84
Varese	76.02	Livorno	60.20	Pescara	53.13	Trapani	44.41
Pavia	74.84	Prato	59.84	Cagliari	52.88	Campobasso	43.31
Bologna	73.20	Imperia	59.73	Caserta	52.49	Vercelli	43.01
Gorizia	72.88	La Spezia	59.62	Latina	52.09	Taranto	42.91
Lucca	70.29	Savona	59.41	Benevento	52.05	Isernia	42.23
Rimini	69.62	Massa	59.24	Udine	51.47	Oristano	41.93
Ancona	69.41	Catania	58.44	Pordenone	50.71	Aosta	41.80
Venezia	69.06	Ravenna	58.30	Alessandria	50.54	Siracusa	41.75
Torino	69.01	Mantova	58.25	Verbania	50.35	Potenza	41.17
Cremona	68.79	Ferrara	57.58	Trento	50.20	Rieti	40.41
Modena	68.22	Avellino	57.38	Bolzano	49.97	Foggia	39.05
Bergamo	67.01	Frosinone	57.29	Piacenza	49.73	Agrigento	37.24
Como	66.23	Treviso	56.68	Belluno	49.61	Crotone	36.50
Macerata	65.57	Siena	56.67	Teramo	49.35	Caltanissetta	36.19
Lecco	65.13	Salerno	56.45	Catanzaro	49.00	Grosseto	36.11
Genova	64.70	Messina	55.63	Sondrio	48.79	Enna	35.34
Lodi	63.88	L'Aquila	55.19	Arezzo	48.30	Matera	33.10
Parma	63.17	Reggio Emilia	54.80	Terni	48.23	Nuoro	30.95
Pesaro	63.14	Perugia	54.71	Brindisi	48.19		

Table 4: Ranking of Italian regions by W

Region	W	Region	W
Lazio	85.10	Umbria	52.70
Friuli Venezia Giulia	78.57	Abruzzo	52.44
Lombardy	76.87	Sicily	51.66
Campania	73.97	Apulia	50.71
Tuscany	70.47	Trentino Alto Adige	50.09
Veneto	66.97	Sardinia	47.03
Emilia Romagna	65.14	Calabria	45.99
Marche	64.17	Molise	42.99
Liguria	63.46	Aosta Valley	41.80
Piedmont	63.16	Basilicata	37.43

Milan, Naples) or medium-sized cities (Trieste, Firenze, Padua, Pisa).

The North-South divide is also evident if we aggregate the results for W by region, as shown in Table 4. The value of W corresponds to the average of provincial values by region, weighted by population size. The first ten regions with a higher value of W are located in the Center-North, with the exception of Lazio and Campania. The last ten are in Southern Italy, with the exception of Trentino Alto Adige and Aosta Valley.

Ferrara, Nisticò (2013) find similar results by measuring well-being at the regional level over about the same period of our analysis, from 1998 to 2008, using two composite indexes: the Augmented Human Development Index (AHDI), which is an adapted version of the Human Development Index for developed countries; the Well-Being Index (WBI), which extends the AHDI, by considering three important dimensions of well-being, i.e. equal opportunities as regards gender and age in the labor market, the ability to innovate and compete in the market, the quality of the socio-institutional context. The two rankings determined according to the values of AHDI and WBI show a sharp demarcation between the Center-North and Southern regions, which is less marked in the WBI ranking.

Finally, we compare the ranking of 103 Italian provinces based on well-being with the ranking of the same provinces based on per-capita GDP.[8] The Spearman's rank correlation coefficient, equal to 0.5888 ($P > |t| = 0.0000$), indicates a statistically significant positive relationship between these two measures. This means that our analysis is consistent with a unidimensional analysis based only on a measure of income. The advantage of a multidimensional approach is that it provides relevant insights about the factors underlying urban disparities.

5 Conclusion

A huge and multidisciplinary literature has analyzed the distribution of the main factors affecting people well-being across different communities (country, region, urban area). Traditional studies focus on income or wealth distribution. Some recent attempts consider other factors influencing well-being in addition to income. For example, Aaberge et al. (2013) take into account public service provision, such as health insurance or education. This paper is the first attempt to focus on inequality between cities, by setting a multidimensional framework. The multidimensional index we propose allows, on one hand, to separate the effect of different amenities, which contribute to determine the overall degree of inequality, and, on the other hand, to consider the joint effect of all amenities on the overall inequality. Moreover, our methodology allows the determination of some important aspects from a policy maker's point of view, such as the degree of inequality aversion specific to each amenity, and the weight of each amenity.

The methodology has been applied to measure inequality between the main Italian cities referring to six important factors. Our results show that to decrease inequality between cities, improving efficiency and equalizing opportunities and life-chances, policies favoring a more even availability of educational and health services, transport infrastructure and employment opportunities should be promoted. In this perspective, our methodology could be applied for simulating the effects of changes in the provision of local public goods on inequality. This constitutes a promising avenue for future research.

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A Appendix

Table A.1: Description and sources of amenity variables

Variable	Description	Source
Cultural infrastructure	Index of cultural infrastructure. Italian average = 100	Istituto Tagliacarne http://istitutotagliacarne.it
Educational services	Index of educational services. Italian average = 100	Istituto Tagliacarne http://istitutotagliacarne.it
Health services	Index of health services. Italian average = 100	Istituto Tagliacarne http://istitutotagliacarne.it
Transport	Multimodal accessibility index (train, air, car). European average = 100	ESPON http://espon.eu
Employment rate	Percentage rate	ISTAT
Air quality	Reduced number of polluting agents in the air	ISTAT

Table A.2: Estimation results for the housing price equation

Variable	Coefficient (Std. Err.)
Cultural infrastructure	0.00028 ***
	(0.00004)
Educational services	0.0035 **
	(0.0010)
Health services	0.0019 ***
	(0.00042)
Transport	0.0036 ***
	(0.00038)
Employment rate	0.0062 **
	(0.0027)
Air quality	0.00096 *
	(0.0004)
Total floor area (log)	0.8595 ***
	(0.02794)
Second bathroom	0.0596 ***
	(0.0069)
Third bathroom or more	0.0042 ***
	(0.00042)
To be renewed	-0.116 ***
	(0.0142)
Heating	0.0147 ***
	(0.0013)
2nd floor or higher	0.0183 ***
	(0.0012)
Parking	0.0723 ***
	(0.0080)
Elevator	0.0647 ***
	(0,0118)
Ln(age)	-0.0074 *
	(0.0039)
Location: central	0.1163 ***
	(0.0068)
Location: semi-central	0,0637 ***
	(0.0049)
Year 2005	0.0305 ***
	(0.0012)
Year 2006	0.0687 ***
	(0.0137)
Year 2007	0.0895 ***
	(0.01772)
Year 2008	0.0976 ***
	(0.0186)
Year 2009	0.1035 ***
	(0.01877)
Year 2010	0.1145 ***
	(0.0179)
R^2	0.8011
Adjusted R^2	0.8002
Number of observations	150,622

Significance levels are denoted with *** (1%), ** (5%), and * (10%)

Table A.3: Estimation results for the wage equation

Variable	Coefficient (Std.Err.)
Cultural infrastructure	-0.000043 *
	(0.00002)
Educational services	-0.0021 **
	(0.0010)
Health services	-0.00106 *
	(0.00068)
Transport	-0.00076 *
	(0.00039)
Employment rate	-0.0011 **
	(0.00056)
Air quality	-0.00091 *
	(0.0006)
Sex	0.1993 ***
	(0.0015)
Age	0.0307 ***
	(0.0005)
Age squared	-0.0002 ***
	(0.000006)
Country of birth: Asia	-0.1224 ***
	(0.0078)
Country of birth: Africa	-0.1292 ***
	(0.0048)
Country of birth: South America	-0.1053 ***
	(0.0034)
Executives	1.5548 ***
	(0.0076)
Managers and white collars	0.4641 ***
	(0.0038)
Agriculture	0.4958 ***
	(0.0107)
Electricity	0.3670 ***
	(0.0097)
Chemistry	0.3428 ***
	(0.0094)
Metalworking	0.2840 ***
	(0.0095) ***
Food, textile, wood	0.2289 ***
	(0.0096)
Building materials	0.2440 ***
	(0.0094)
Commerce and services	0.2919 ***
	(0.0098)
Transport and communications	0.3460 ***
	(0.0095)
Credit insurance	0.2636 ***
	(0.0096)
Firm size	0.0002 ***
	(0.0001)
Year 2002	0.0195 ***
	(0.0012)
Intercept	6.1977 ***
	(0.0635)
R^2	0.6140
Adjusted R^2	0.6089
Number of observations	165,917

Significance levels are denoted with *** (1%), ** (5%), and * (10%)

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Regional Science in a time of uncertainty*

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Abstract. This paper uses state-of-the-art modelling techniques to simulate possible outcomes for employment across Europe's regions. The model demonstrates the importance of cross-regional spillovers, and these are an integral part of the simulations. These illustrate what would happen if the current austerity programme remains in force, or possible outcomes if there is a return to pre-2007 'boom' conditions. Given that region-specific intervention is a possibility, it is suggested that the methodology of Regional Science is ideally suited to a role of monitoring impacts spilling over to other regions. The paper concludes by emphasising the uncertainty associated with regional prediction and simulation, and highlights the need for a range of possible outcomes.

Key words: spatial econometrics, dynamic spatial panel model, simulation, European regional employment

1 Introduction

I have given this paper the title 'Regional Science in a time of uncertainty' because that is what it appears to be, very much a time of uncertainty. Uncertainty is always with us, but what I mean is the future is more uncertain than usual. There are multiple unanticipated and threatening shocks to our economic, social, and environmental systems. For example, global climate change appears to be upon us right now, so what is the future especially for the world's poorest people, living at the margins of existence? The after-effects of the 2007 shock to the global economy are still very much with us. In an era of very low demand, Central Banks are running out of policy options. We are moving into an era of experimental and unconventional fixes, such as negative interest rates. But these could have dangerous, unanticipated consequences. Also the upheavals in the Middle East are now being manifest as unforeseen mass migrations. Closer to home, the vote to exit the UK from the EU was based on a referendum dominated by claims and counterclaims about the effects of Brexit. Now the UK has voted to leave, the true consequences remain uncertain.

How does Regional Science come into it? We as regional scientists are motivated by a scientific perspective. That means we typically build models that help us make sense of the reality embodied in observable data. These models help us sort out, as best we can, causes and consequences at a 'regional' level, where region is a broadly defined concept. Our data relates to space and time, so we observe nations, regions and cities evolving over time.

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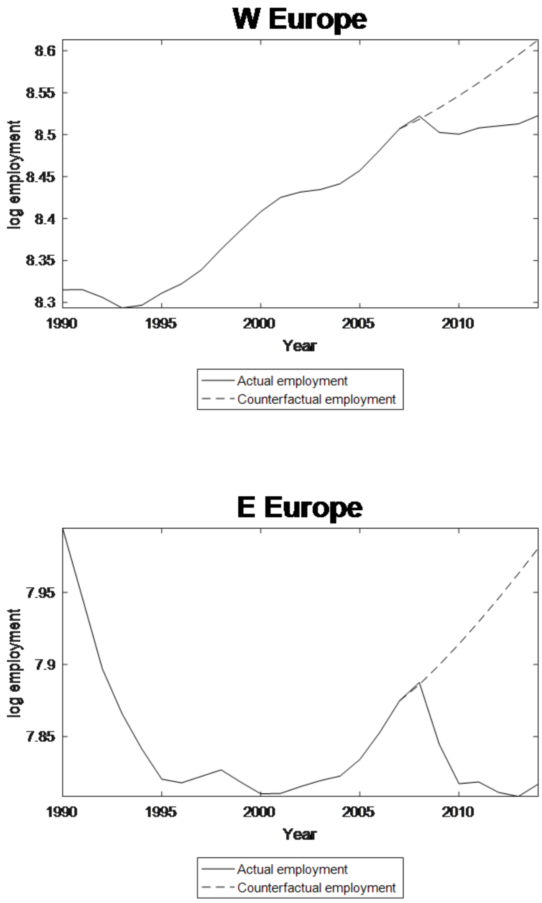


Figure 1: The implications of demand deficit

One big advantage, probably the hallmark of the scientific approach, is the ability to use our models to predict. We might attempt to predict what will happen in the future, or simulate what could, might or should happen in the future, in other words, counterfactual analysis.

I want to focus on the impact of the global economic shock of 2007. Nine years after the event, we are still a long way from what we would consider normality. Global and European demand has fallen and remains persistently low despite Central Banks' efforts. Because of this persistence, two years ago the European Central Bank became the world's first major central bank to adopt negative interest rates, a policy also followed by Denmark, Switzerland, Sweden, and Japan. Besides negative interest rates, we are also seeing Government and Corporate Bonds with negative yields.

Figure 1 shows what happened to employment across European OECD economies. It also shows the counterfactual, what I think would have happened had the shock not occurred. Evidently, in Western Europe at least, we remain a long way from normality.

2 Model specification

Clearly what the counterfactual is based on is crucial to our interpretation. For a counterfactual, we need a model, preferably driven by theory. My underlying theory has strong post-Keynesian flavour. In other words, the theoretical basis of my analysis is the so-called Verdoorn's Law (Verdoorn 1949), linking productivity to output and capital stock. This can be written with employment as the dependent variable, and elaborated by introducing temporal and spatial spillovers.

Temporal spillovers mean that employment evolves with a memory, the level of employment this year depends in part on its level last year. This we envisage captures market imperfections which cause employment change to react to the previous change in the drivers of employment. For example, it may take time for extra labour to be fully assimilated into the working practices and technology of employers, or for new capital stock to function effectively.

With spatial spillovers, we assume that the employment level in a given region is not independent of its level in other regions with which there is strong economic interdependence. Economic interdependence is assumed to depend on trade between regions, and is captured by a (time constant) N by N interconnectivity matrix W_N, where the N refers to N regions. This interregional connectivity matrix is estimated interregional trade which is based essentially on parameters derived from a model of international trade, following the methodology given in Fingleton et al. (2015), which has its basis in disaggregation methods for time series given by Chow, Lin (1971). The matrix is standardised, as is typical in spatial econometric models, so that each row of W_N consists of export shares from a given region to all other regions. Given W_N, the model specification is

$$\begin{aligned} \ln E_t &= \gamma \ln E_{t-1} + \rho_1 W_N \ln E_t + \beta_1 \ln Q_t + \beta_2 \ln K_t + \epsilon_t \\ \epsilon_t &= u_{it} - \rho_2 m_{Ni} u_t \\ u_{it} &= \mu_i + \nu_{it} \end{aligned} \quad (1)$$

In equation (1), $\ln E_t$ is a vector denoting the level of employment at time t in $N = 255$ NUTS 2 regions of the European Union. The level of employment at time t depends on its previous level at time $t-1$, with the strength of this memory effect determined by the parameter γ. It also depends on the contemporaneous employment in other regions weighted by trade-shares as embodied in W_N, with parameter ρ_1 determining the strength of this interregional spillover effect. The within-region drivers of employment are the levels of output and capital stock within each region, denoted by Q_t and K_t, with parameters β_1 and β_2 respectively.

Unobservable effects are captured by the error term ϵ_t. The error term is compound, with a time invariant component μ_i representing the net effect of regional heterogeneity, for example the effect of time-invariant features such as geology, climate, and natural vegetation. In the short term, these vary across space but not across time. In addition we have an idiosyncratic component ν_{it} capturing the remaining unobservable effects, varying across both time (t) and space (i).

In our model, the error term is also spatially dependent. In his case we use the N by N connectivity matrix M_N which is a matrix of 1s and 0s denoting whether or not regions are contiguous, subsequently row standardised so that rows sum to 1. Assume for example that geology in one region is similar to geology in nearby (contiguous) regions. If adjacent regions have a similar legacy of coal mining, then the effects on economic structure, society and environment, and consequently employment will tend to be similar.

To capture this localised spillover involving the errors, we invoke a moving average spatial autocorrelation process for the errors, as introduced into the panel data literature in Fingleton (2008). This is distinct from the spatial autoregressive process for the direct effect of employment. In the latter, a local change has effects throughout the system of regions, rather than being confined locally as under moving averages. There is an advantage in specifying a moving average spatial error process, because it absorbs local spillovers. Otherwise we might need to consider the spatial lags of right hand side variables, namely $W_N \ln E_{t-1}$, $W_N \ln Q_t$ and $W_N \ln K_t$. Incidentally, the estimates produced by such a dynamic spatial Durbin model (see Elhorst 2014) in this instance violate the conditions necessary for model stability.

3 Estimation

What I have briefly described is a dynamic spatial panel model. Further details of the estimation of similar models, but with spatial autoregressive errors rather than spatial

Table 1: Parameter Estimates

variable	para-meter	Exogenous $\boldsymbol{x}_{1t}$, $\boldsymbol{x}_{2t}$ param. est.	std. err.	t ratio	Endogenous $\boldsymbol{x}_{1t}$, $\boldsymbol{x}_{2t}$ param. est.	std. err.	t ratio
$\boldsymbol{y}_{t-1} = \ln \boldsymbol{E}_{t-1}$	γ	0.6261	0.01035	60.48	0.5222	0.03309	15.78
$\boldsymbol{W}_N \boldsymbol{y}_t = \boldsymbol{W}_N \ln \boldsymbol{E}_t$	ρ_1	0.2068	0.01588	13.02	0.3702	0.05675	6.52
$\boldsymbol{x}_{1t} = \ln \boldsymbol{Q}_t$	β_1	0.1390	0.005201	26.72	0.1042	0.02032	5.13
$\boldsymbol{x}_{2t} = \ln \boldsymbol{K}_t$	β_2	0.01542	0.0009967	15.48	0.01502	0.004759	3.16
	ρ_2	-0.3431			-0.2864		
	σ_μ^2	0.5283			0.5870		
	σ_ν^2	0.0008			0.0007		

moving average errors, are given by Baltagi et al. (2014) and Fingleton et al. (2015). Evidence of consistency of the model with moving average errors is given in Baltagi et al. (2015). To save space I am skipping over the detail of how I estimate this model, which is detailed in these papers, but simply giving the outcome, based on data for the 255 NUTS2 regions for the years 2000 to 2007. As described in Baltagi et al. (2014), estimation is in the spirit of Arellano, Bond (1991), mixing spatial and non-spatial instruments together with a GMM estimator for spatially dependent moving average errors. The estimator with exogenous regressors and a spatial moving average error process works well, as shown by Monte-Carlo experiments (Baltagi et al. 2015). However in this paper we assume endogeneity for all right hand side variables, not simply for the temporal and spatial lags. Bond (2002) gives an accessible description of the methodology, but essentially it involves using a subset of the instrumental variables which are sufficiently lagged in time to avoid correlation with the errors, as is required for instruments. This is important in the case of the Verdoorn law, as detailed below. Because of the reduction in the number of instruments, the estimates differ from what one would obtain if an assumption of exogeneity was made for output and capital. Table 1 shows the differences.

Table 1 shows that there are significant temporal and spatial spillover effects, and that the levels of output and capital are also significant determinants of the level of employment. Note that the negative estimate of coefficient ρ_2 for the moving averages spatial dependence indicates positive dependence.

The question of which variables were endogenous or exogenous was the subject of a lively debate in some of the earlier Verdoorn law literature, as is evident in the exchange between Kaldor (1975) and Rowthorn (1975b,a), since it is unclear whether output can realistically be treated as exogenous to employment. Assuming endogeneity for all right hand side variables, which is the more conservative stance, does make a difference. It restricts the instrumental variables that can be used, and thus impacts point estimates and increases standard errors, but not so much that the variables become insignificant.

Note that the coefficients for output and capital are positive and significant, but of course we should look at the true derivatives, not the point estimates (Le Sage, Pace 2009, Elhorst 2014). In particular it is noteworthy that the total effect of output on employment in the short run, equal to the direct plus indirect effect, is about 0.17. It appears that in the short run there are increasing returns to scale. However in the long run, the total effect of a persistent 1% increase in output is a 0.97% increase in employment. This suggests that in the long run increasing returns to scale, with higher productivity induced by higher output, is almost wiped out by the spillover effects embodied in our model.

4 Prediction

The prediction equation, given in the standard literature, is

$$\ln \hat{E}_t = \hat{B}_N^{-1} \left[\hat{\gamma} \ln \hat{E}_{t-1} + \hat{\beta}_1 \ln \tilde{Q}_t + \hat{\beta}_2 \ln \tilde{K}_t + \hat{H}_N \bar{\mu} \right] \quad (2)$$

This is solved recursively. In our case we start with 2008 and predict employment up to 2020. Of course the predictions are based on many assumptions. One is that the parameter estimates will remain the same. Second I will assume for the moment that connectivity between regions, resulting in the spillovers, will also remain the same over the prediction period. So the matrices $\hat{B}_N$ and $\hat{H}_N$, which take care of the spatial autoregressive process and a spatial moving average process for the errors, are based on the same trade-based connectivity matrix W_N and on the standardised contiguity M_N as used for estimation. But this is optional, and we could make different assumptions about interregional connectivity for the future.

5 Austerity and Boom scenarios

But for now I will focus on different assumed paths for each region's output and capital. What could happen to these variables? Let us say that the current policy regime continues, involving monetary policy, quantitative easing, and fiscal policy. Monetary policy in many countries takes the form of low or negative interest rates. Negative interest rates penalize saving, with the hope of stimulating demand. Negative interest rates are not so unreal as a policy option, indeed the European Central Bank already imposes negative interest rates for the Euro area, but currently these only apply to deposits by commercial banks, discouraging them from holding excess cash, and have not, as yet, been passed on to consumers by commercial banks.

Quantitative easing, where a Central Bank creates new money to buy financial assets, like government and corporate bonds, aims to get to a target inflation level of 2%, and is also designed to bring demand back and thus increase employment.

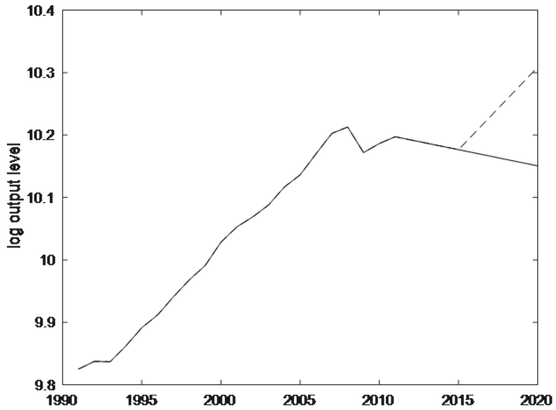
I also assume a continuation of current fiscal policy, in the form of a commitment to a balanced budget and therefore the taxation and spending policies imposed over recent years. For the UK, for example, the target remains a balanced budget, with the ultimate goal a surplus for public finances.

Nevertheless, despite negative interest rates and quantitative easing, we are experiencing continuing austerity. Under a so-called 'austerity scenario', the counterfactual path is for every region to maintain its post-2007 downward path for output and for capital. In contrast, under what I call the 'boom scenario' we assume that each region's economy reverts to its 1999-2007 growth rate from 2015. Figure 2 gives the aggregate paths for employment driver's output and capital stock, summing the region-specific paths over 255 regions.

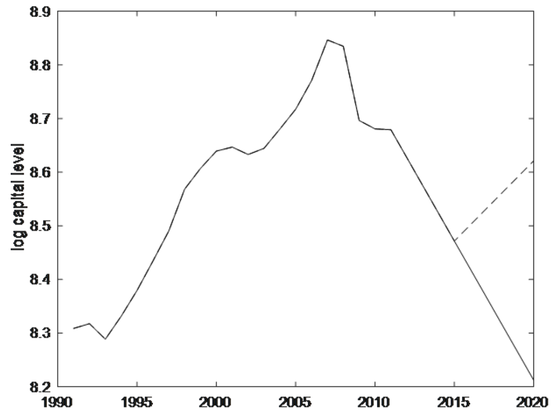
The downward path under austerity is evident. In contrast we see the upward path under the alternative boom scenario, which is based on each region's output and capital stock trajectory over the period 1999-2007. During these years, output grew at approximately 2.7% pa taking the mean across the EU regions, while capital stock grew at approximately 3% pa. Under the boom scenario we assume that each region's economy reverts to its 1999-2007 growth rate from 2015.

Figure 3 shows the outcomes for employment, giving employment in 2020 relative to 2007 under the austerity scenario. The prospects of continuing austerity is for employment levels in many regions to remain at or below the 2007 level. Figure 4 shows the boom scenario outcome for employment, showing what would happen to employment as a result of the drivers of employment growing at the pre-crisis rate. It shows that by 2020 employment would have reached the 2007 levels or above across all regions. This is good, if it could be achieved. But the recovery would be quite heterogeneous, ranging from about 15% to 20% above the 2007 level in the most buoyant regions, to parity with the 2007 level in the least buoyant. In reality a resurgence of growth of this magnitude, if achievable, would not be the ideal solution with regard to regional equity. While such rapid growth would help eliminate the employment crisis in many regions, especially in Southern Europe, the heterogeneous outcomes could lead to overheating, congestion and inflationary pressures in other regions.

In practice, the policy of negative interest rates by the ECB is not having much effect on growth, and we should not rely on negative interest rates because of the several disadvantages. For example, such a policy could lead to dangerous asset price bubbles, for instance in real estate markets, and destabilize banks as customers choose to stash money



(a) output



(b) capital

Figure 2: Alternative ‘boom’ and ‘austerity’ scenarios

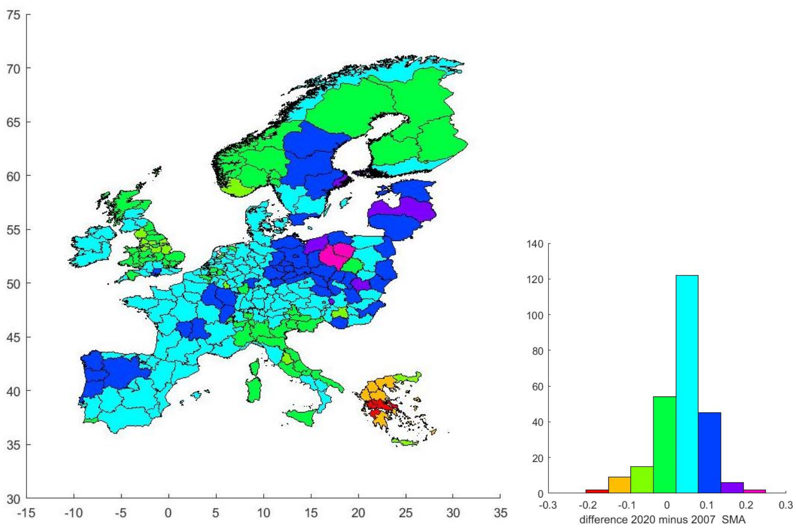


Figure 3: Austerity : employment in 2020 relative to 2007

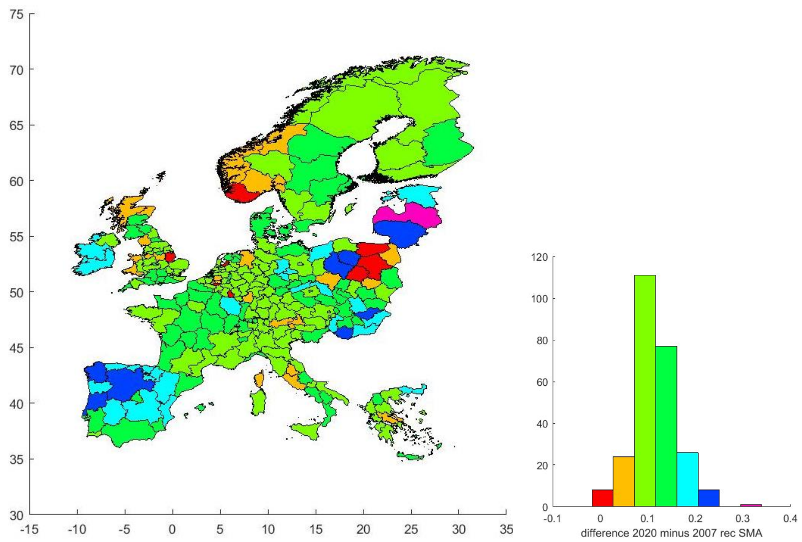


Figure 4: Boom : employment in 2020 relative to 2007

in safes or under the mattress! Such a policy could also disadvantage certain regions, since according to Benoît Cœuré, Member of the Executive Board of the ECB, 'in the euro area, ... the negative interest rate policy has distributional consequences across banks located in different jurisdictions,' because different banks in different jurisdictions might have different capacities to shield borrowers from negative interest rates.

Instead, direct region-specific intervention is necessary in order to alleviate the severe problems of demand-deficit regions. One option, seriously considered in some circles, and not ruled out by ECB President Mario Draghi, is to use what Milton Friedman described as 'helicopter money'. Conceptually, a helicopter hovers over a region with demand deficit, and drops money directly to individuals, bypassing financial and corporate sectors and going straight to lower and middle income consumers. This would introduce money directly into the income stream, rather than indirectly via negative interest rates working through the banking system. More realistically, this could take the form of regionally specific tax rebates, funded by either printing money or cheap Government borrowing. In this way one could boost demand in deficit regions. Likewise extra Government spending on infrastructure such as roads, bridges, ports, and railroads would ensure extra money is put into circulation. This should be targeted on deficit regions, in order to boost employment and eliminate deflationary tendencies. With borrowing cheap, this would not cost much.

There is one important caveat however. The concept of regional spillovers is well known in Regional Science, and it is likely that intervention targeted in deficit regions will naturally spill over to all regions, and so weaken the desired impact. But in Regional Science we have the tools to be able to estimate and monitor the magnitude, spatial and temporal extent of these leakages to other regions, and so in this way we could provide a valuable service to policy makers in helping them understand the fuller consequences of their actions.

6 Conclusion

To sum up, my counterfactual projections are based on a typical Regional Science model; dependence across time and across space is embedded within the model. It does however have a couple of novel features. First it embodies a spatial moving average error process, and this has the virtue of accounting for local spillovers among the unmodelled variables which are contained within the errors. Otherwise a more complex model, with spatial lags of the right hand side variables would possibly be needed to capture these local spillovers. Secondly, model estimation treats the right hand side variables as endogenous, since output and capital could depend on the level of employment, as well as determine it.

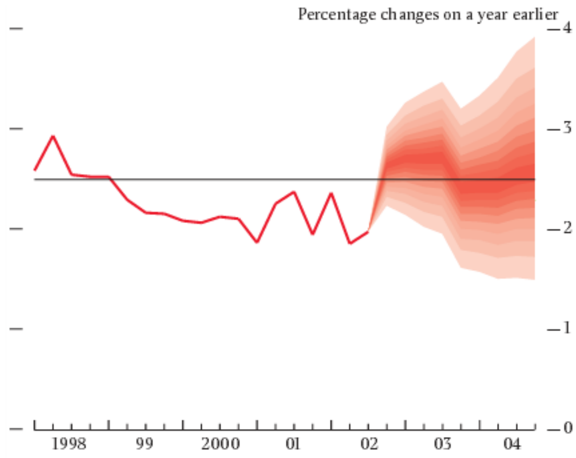


Figure 5: Bank of England Fan chart

Estimation occurs up to the point at which the 2007 shock occurred, and the parameter estimates obtained form the basis of the projections under austerity and boom scenarios. Of course the projections can be open to question because the model on which they are based can be questioned, and the relationships which held in the historical past, can they be assumed to be valid for the future? Further analysis could explore the robustness of the projections to different assumptions. Ideally our forecasts should be as probability distributions rather than single point forecasts, as exemplified in the Bank of England fan chart in Figure 5. These would emphasise our uncertainty regarding the future, but it is not total uncertainty. In such a way, we can reduce the uncertainty we have about the future, and knowing what might happen under particular assumptions is to me preferable to total uncertainty. To conclude, Regional Science in a time of uncertainty is alive and well and it has an important role to play in helping us to reduce the uncertainty with which we all have to live.

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Identifying Clusters of Regions in the European South, based on their Economics, Social and Environmental Characteristics

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Abstract. Regional development has been the focal point of both academics and decision makers in the central and local governments of many European countries. Identifying the key problems that regions face and considering how their solutions could be effectively used as a basis for planning their development process, are essential in order to improve their conditions. The growth of a region depends on its ability to attract and retain both business units and the right blend of people to run them. In this context, we introduced a variable which is referred to as the image of a region and quantifies its attractiveness. A region's image depends on a variety of factors, economic, social, and environmental, some of which are common for all potential movers and some specific for particular groups, and expresses its current state of development and its future prospects. The paper examines a number of south European countries and focuses on their NUTS 2 level regions. Its objective is to estimate the image values of those regions and to group them into different clusters on the basis of the characteristics used to define their image. The results are presented and discussed.

JEL classification: C02, C65, Q01, R58

Key words: Regional Development, Region's Image, Cluster Analysis, South European Regions

1 Introduction

For many years regional development has been linked to economic prosperity but this attitude has been gradually changing. Many societies underwent very deep and far reaching changes which have led to the need for redefining the concept of development and have brought up the concept of sustainability. This refers to the capability of a region to satisfy the needs of the present without, however, jeopardizing the right of the future generations to meet their own expectations. Measuring sustainable development is not an easy task as it requires overcoming the simple unidimensional economic description of human activities and incorporating social and environmental dimensions as well. It also requires novel techniques which could benchmark performance, identify cases of growth and recession on the aforementioned dimensions of development, and pinpoint the best practices. Furthermore, new tools should be developed which could lead to more objective, robust, and reliable decision making.

In Angelis, Dimaki (2011) the nature of the functions of a region as a socioeconomic unit has been discussed in detail. Every region carries out a number of functions; economic, social, and environmental (Kotler et al. 1999, Boschma, Lambooy 1999). The relative importance of those functions has not remained constant over time. Initially the economic function was the dominant, but gradually the social started gaining in importance. Recently the environmental function emerged as the third pole of development. Furthermore, the region's functions are not always compatible; on the contrary the idea of a conflict between the economic, on one hand, and the social and environmental, on the other, is widespread in literature (Llewellyn 1996, Lovering 2001, Bristow 2005).

The process of business and residential location has been presented in detail in Angelis, Dimaki (2011). The development of a region depends on its power to attract business activities and the right blend of people to run them (Malecki 2004, Bristow 2005). Business location has been traditionally dependent on economic factors, such as easy access, availability of land, labor and capital, and infrastructure. Lately, however, a number of social and environmental factors have gained in importance. Similarly, residential location has been traditionally dependent on a set of employment related factors, such as availability/quality of jobs and level of salaries. Over the last years, however, this set has been enriched by other factors, such as quality of life, housing availability/quality, and educational services (Burgess 1982, Bristow 2010). Moreover, a set of "attraction" factors seem to be common for both business units and employees. This set comprises of healthy economy, easy access, reliable infrastructure, good living conditions, and social amenities. The choice of location by a group of prospective movers (i.e. business or employees) seems to consist of two steps. The first step leads to a short list of candidate locations, which satisfy a set of basic criteria common to all groups, while the second step leads to the best choice for the particular group (Malecki 2004). The paper presents the concept of a region's image, a composite measure of the region's overall trend towards sustainable development, which encompasses two dimensions: economic and social, and suggests ways for its measurement. Image, as defined in Angelis, Dimaki (2011), has two distinct characteristics. It allows for possible discontinuities in the development of a region and it uses methods and techniques, which can tackle them.

Following this brief introduction, Section 2 presents and discusses the concept of a region's image, as a measure of its ability to attract business activities and the right blend of people to run them and goes on to refine it by introducing the concepts of Basic and Specific Image. The Basic Image, which we will focus on in this paper, is defined as a function of two potentially conflicting indicators, Economic and Social, each depending on a number of factors expressing the region's economic and social profile, respectively. Section 3 presents the general model of a region's Basic Image. Based on evidence provided in the authors' earlier works that a region's Basic Image may exhibit nonlinear behavior, it has been modeled in terms of Catastrophe Theory (the general mathematical theory of discontinuous behavior resulting from continuous underlying forces) and indeed as a Cusp Catastrophe. Section 4 adapts the general model presented in the previous section to the case of the four south European countries under study, namely Greece, Italy, Portugal, and Spain. This adaptation was needed since data availability for all four countries was, in certain cases, limited and this determined, to a large extent, the quantification of the regions' two indicators and eventually of their Basic Image. The variables chosen are stated, their selection is justified, their measurement, aggregation and normalization methods are presented, and their conversion into the two Indicators and finally into the region's Basic Image is outlined. Section 5 focuses on the sixty NUTS 2 level regions of the four countries under study, calculates, in the way described in the previous section, their Economic and the Social Indicator values, and finally uses the proposed model to estimate their Basic Image values. The results are presented and discussed. Section 6 goes on to the clustering of all sixty regions on the basis of their economic and social characteristics which have been used for the quantification of their Economic and Social Indicators, respectively, and comments on the findings. Section 7 summarizes the overall results and discusses potential policy implications while Section 8 presents the conclusions and suggests areas for further research.

2 The concept of a region's image

The development of a region, as already mentioned, depends on its ability to "attract" and "keep" healthy businesses and competent human resources to run them. This ability is a function of the region's image. This term has been used over time in different ways. Many researchers consider it as a sum of beliefs, ideas, and impressions, or as the total impression an entity makes on the mind of people, which exerts an influence on the way they perceive it and react to it (Dowling 1998, Dichter 1985). Marketing researchers, in particular, refer to place images and make a distinction between projected and received images (Kotler et al. 1993). The former can be seen as ideas and impressions available for the receivers' assessment and transmitted to them through various communication channels. The latter, on the other hand, are shaped by the interaction of the "projected" images and the particular needs, motivation, prior knowledge, experience, and personal characteristics of every receiver. In this way every receiver creates its own personal image (Ashworth, Voogd 1990, Gartner 1993, Bramwell, Rawding 1996). The concept of a region's Image or, in other words, of its power to pull and retain businesses and employees appears in literature as a variable under different names, like "attractiveness", "competitiveness", and "quality of life". In most of the cases, it is expressed as a composite indicator referring to specific groups of potential movers (business units or residents/employees) or specific aspects of the region's function (economic, social, and environmental) (Dijkstra et al. 2010, Lagas et al. 2015, Annoni, Kozovska 2010). Furthermore, multivariate analysis has been used to evaluate the regions' performance (del Campo et al. 2008, Morais, Camanho 2011). This paper defines image in a different way that is as a function of objectively measured factors affecting the movement of both business activities and employees. Obviously, a region's image may be improved through marketing and promotion but only temporarily. The only lasting improvement is the "real" and objective endorsement of the region's image attributes which increases its competitiveness and makes it a "sticky place" for business and people (Markusen 1996, Malecki 2004). Since a region's image is received by many groups of potential movers with varying characteristics, wishes, and priorities, it is obvious that each of those groups perceive it in a different way. Hence we can say that, effectively, a region does not have an image but multiple images (Dowling 1998). On the basis of all those mentioned so far we may say that a region "transmits" its image, which is perceived and assessed by its receivers, and is accordingly classified as attractive or non-attractive. At this point someone may argue that since the receivers belong to different groups with distinct characteristics their assessment of the same region's image would vary (Kotler et al. 1999, Bryson et al. 2007). This is a reasonable argument but, on the other hand, the available evidence shows that all those receiving the region's image have a set of common basic criteria which should be satisfied if the region is to be considered, by any of them, as a potential final choice. (Kotler et al. 1999, Schneider, White 2004). In order to bridge those two seemingly opposing views, the concept of a region's image has been refined by introducing the concepts of Basic and Specific Image. The Basic Image expresses the extent to which a region meets the criteria common to all its receivers and hence it may enter their shortlist of potential final choices. The Specific Image, as perceived by a particular group of movers, expresses the degree to which the region will be the final choice for the members of this group.

The rest of the paper will concentrate on a region's Basic Image, a rather abstract concept which expresses the actual state of the region. A physically realizable measure for the Basic Image is difficult to find; what may be measured more easily is the net change of a region's population and industrial stock during each time period. Such a change, however, is of very little importance as a measure of the real state of the region. The perception and reaction times to any change in the state of a region's Basic Image are different for the various groups of potential movers and are particularly long for certain vulnerable minorities, without any real choice of the place to live and work. Hence, the measurable changes of the region's population and industrial stock may be generally considered as the delayed and considerably smoothed consequence of changes in the Basic

Image. The novelty and the main advantage of a region's Basic Image is that it gives an early warning of any potential problems and at the same time helps the decision makers to detect the causes and the symptoms of those problems. An early and correct diagnosis of a problem is perhaps the biggest step towards its solution. In the case of regional development, however, the seeds of decay are usually planted during a period of prosperity and no action is taken to prevent them until it is too late. Ironically, the very state of being an attractive place may unleash forces that ultimately unravel the attractiveness of a place. Many places experience a period of growth, followed by a period of decline, and the fluctuations may be repeated several times. Therefore, a monitoring device, which will alert us at the first sight of danger, is a tool of great importance. By keeping a region's Basic Image attractive, we may argue that in spite of any fluctuations in the various specific factors and/or of any unforeseen external adversities, the region may retain its overall attractiveness, redirect its strategy and finally overcome the difficulties. If, on the other hand, its Basic Image becomes non-attractive, the region enters a vicious circle of fall and decline.

On the basis of all those mentioned so far, a region's Basic Image may be expressed as a number of factors classified into two groups depending on whether they refer to the economic or the social/environmental function of the region. The factors of the first group, properly measured and scaled, give a measure of the i^{th} region's economic profile known as its Economic Indicator (IND_i^1). Similarly, the factors of the second group give a measure of the i^{th} region's socio-environmental profile, known as its Social Indicator (IND_i^2). Hence, the Basic Image is a function of its Economic and Social Indicators i.e. $Basic\ Image = \phi(IND_i^1, IND_i^2)$. The expression of the Basic Image as a function of those two Indicators is not accidental; on the contrary, it is consistent with the concept of a region as a socio-economic unit. The main advantage of such an expression is that it may be used to underline and, eventually, describe the potential conflict between the economic and social functions of a region in the course of development (Llewellyn 1996, Lovering 2001, Bristow 2005). The factors to be included in each group as well as their measurement, aggregation, and normalization methods will be presented in Section 4. Concluding this section it should be mentioned that the growth of a region may be expressed in both absolute and relative terms. For the purposes of this work we are interested in the latter case or, in other words, in the development of a given region with respect to the "typical" region (Angelis, Dimaki 2011). This is a fictitious region representative of the regions under study, in the sense that the values of its indicators are the average of the respective indicator values of all those regions. Hence all the factors comprising the Basic Image of a given region will be expressed in relative terms in comparison to the corresponding values of the "typical" region.

3 Modeling a region's Basic Image

Having defined a region's Basic Image as a function of two indicators, the next step will be to get a first idea of the shape of its graph. Obviously, the higher/lower the value of each or both indicators, the higher/lower the value of the Basic Image and consequently the higher/lower the region's attraction. On the contrary, when the values of the two indicators follow opposite trends, no clear conclusions may be drawn for the value of the region's Basic Image; hence the region may be alternating from attractive to non-attractive and sudden changes in the value of its Basic Image may be expected. The latter statement is obviously more important as it indicates that the graph under consideration could be discontinuous. Furthermore, evidence has been provided (Angelis, Dimaki 2011) that the mechanism generating a region's Basic Image may be modelled in terms of Catastrophe Theory and indeed as a Cusp Catastrophe (Thom 1975, Zeeman 1973, Gilmore 1993, Poston, Stewart 2012), since it possesses all the required properties. Catastrophe theory was developed and popularized in the early 1970's. After a period of criticism, it is now well established and widely applied (Rosser 2007). Today, the theory is very much alive and numerous nonlinear phenomena that exhibit discontinuous jumps in behavior have been modeled by using the theory, for instance in chemistry (e.g. Wales 2001), in physics (e.g. Aerts et al. 2003), in psychology (e.g. van der Mass et al. 2003) in clinical studies (e.g. Smerz, Guastello 2008) and in the social sciences (e.g. Smith et al. 2005, Dou, Ghose 2006, Huang 2008, Bełej, Kulesza 2013). Returning to the present case, the value x_i, $i = 1, \ldots, n$, of the i^{th} region's Basic Image at a given time is deduced as a solution of the Basic Image equation:

$$x_i^3 - Bx_i - A = 0 \tag{1}$$

with,

$$\begin{cases} A = m(IND_i^1 - IND_0^1) + (IND_i^2 - IND_0^2) \\ B = (IND_i^1 - IND_0^1) - m(IND_i^2 - IND_0^2) \end{cases} \text{if } m \leq 1$$

and

$$\begin{cases} A = m(IND_i^1 - IND_0^1) + (1/m)(IND_i^2 - IND_0^2) \\ B = (1/m)(IND_i^1 - IND_0^1) - (IND_i^2 - IND_0^2) \end{cases} \text{if } m > 1$$

where:

IND_i^1: The Economic Indicator for the i^{th} region;

IND_i^2: The Social Indicator for the i^{th} region;

IND_0^1: The Economic Indicator for the "typical" region;

IND_0^2: The Social Indicator for the "typical" region; and

m: expresses the relative weights attached to each of the two indicators in defining the Basic Image.

It is noted that the Economic and Social Indicators values of all regions lie in the interval [0,1] while their respective Basic Image values in the interval [-1,+1]. Furthermore, the Economic and Social Indicators of the typical region are calculated as the average of the respective indicators' values of all regions under study while its Basic Image value is zero (Angelis, Dimaki 2011). Hence, a region with positive Basic Image value is attractive and potentially a final choice for some group of prospective movers. Finally, for the purposes of the present work, the relative weights attached to each of the two indicators are equal, and hence $m = 1$.

Going a step further we can say that each indicator may be expressed as the geometric mean of several sub-indicators, each one depending on a number of factors among those affecting the region's Basic Image. The use of geometric mean is justified by the fact that each of them is considered to be critically important for this indicator's value. Consequently,

$$IND_i^h = \sqrt[m]{\prod_{j=1}^{m} SbI_{ij}^h} \qquad h = 1, 2, \quad i = 1, \ldots, n$$

where IND_i^h denotes the h^{th} indicator of the region i and SbI_{ij}^h denotes the j^{th} sub-indicator of the region i which is related to the indicator h. Each sub-indicator SbI_{ij}^h is defined as a nonlinear function of a respective relative index RI_{ij}^h, which in turn, is a function of all variables, measured or estimated, affecting the sub-indicator and may be defined in the following two ways:

- The values of all variables, expressed in relative terms with respect to the typical region, are used to obtain directly the relative index RI_{ij}^h, $h = 1, 2$, $i = 1, \ldots, m$.
- The variables are grouped into various sets, depending on the particular component of the sub-indicator they affect. The values of all variables belonging to a specific set, expressed in relative terms with respect to the typical region, are used to obtain directly the respective relative sub-indices RSI_{ijk}^h, $h = 1, 2$, $i = 1, \ldots, n$,

$j = 1, \ldots, m$, $k = 1, \ldots, r$. Finally, those sub-indices are combined so as to give the corresponding relative index:

$$RI_{ij}^{h} = \frac{\sum_{k=1}^{r} w_k RSI_{ijk}^{h}}{\sum_{k=1}^{r} w_k}; \qquad h = 1, 2, \quad i = 1, \ldots, n, \quad j = 1, \ldots, m$$

where, w_k, $k = 1, \ldots, r$ are weights indicating the relative importance attached to each sub-index in defining the respective relative index.

By normalizing the relative index RI_{ij}^{h}, the sub-indicator SbI_{ij}^{h} is obtained. The normalisation is needed in order to ensure that:

- All sub-indicators have the same range. For the purposes of this work, all sub-indicators have the same range value, namely [0, 2]; hence, the range of their product is [0, 2^n] and, consequently, the range of IND_i^h, $h = 1, 2$, $i = 1, \ldots, n$ is also [0, 2]. In certain cases, however, the dominance of a particular sub-indicator needs to be emphasized. This may be done by increasing its range. In such a case, the range of the remaining sub-indicators must be modified, so that the range of their product remains the same i.e. [0,2^n].
- The effect of changes in the values of variables on the respective sub-indicators follows the same pattern for all sub-indicators.

4 The proposed model for the case of the south European regions

Having presented the model for the estimation of a region's Basic Image, we will now proceed with its adaptation to this particular case. As already mentioned, this adaptation was needed since data availability for all four countries was, in certain cases, limited and this determined, to a large extent, the quantification of the regions' two indicators and eventually of their Basic Image. Let us start with the Economic Indicator which, as already mentioned in Section 2, should depend on factors related to the economic function of a region. For the purposes of this particular case, three factors will be considered, namely the region's level of economic development, the emphasis placed on research and development, and its accessibility to large centers. Each of them is expressed through a respective sub-indicator. The three factors and the corresponding sub-indicators are presented below.

Economic Development: The level of the economic development and financial robustness of a region seems to affect the locational choices of both business units and employees and it is measured in different ways. In this particular case, it is quantified through an appropriate sub-indicator. The Economic Development sub-indicator of the i^{th} region, (SbI_{i1}^{1}), is a nonlinear transformation of the Relative Economic Development index (RI_{i1}^{1}), which is defined as the region's gross domestic product per capita, expressed in relative terms.

Research and Development: While the region's GDP is an indication of its current financial status, the emphasis placed by the region on research and development is an indication of its future prospects, in the sense of its readiness to adapt to the changing conditions of the dynamic business environment. In this particular case, the region's emphasis on research and development is quantified through the Research and Development sub-indicator (SbI_{i2}^{1}). It is a nonlinear transformation of the Relative Research and Development index which is defined as the i^{th} region's expenditure on R&D as percentage of its GDP, expressed in relative terms.

Accessibility: Easy access to large centers seems to be one of the factors that both businesses and employees take into account when deciding to move into or out of a region. The concept of "easy access" appears in literature under different names such as accessibility, proximity, or connectivity and is measured in different ways. In this paper, it appears as "accessibility" and it is quantified through the

Location sub-indicator of the i^{th} region, (SbI^1_{i3}). It is a nonlinear transformation of the Relative Location index (RI^1_{i3}), which expresses the region's relative position with respect to the various influence centers. Every region is generally surrounded by more than one influence centers. Hence, the Relative Location index expresses the total influence exerted on region i by all influence centers. In other words, the Relative Location index is the sum of r Relative Location sub-indices (RSI^1_{i3k}), $k = 1, \ldots, r$, each one expressing the influence exerted on the i^{th} region by the respective influence center k. Hence,

$$RI^1_{i3} = \sum_{k=1}^{r} RSI^1_{i3k}; \qquad i = 1, \ldots, n$$

Furthermore, each of the Relative Location sub-indices is a function of:

- The influence center's size, as defined by its Gross Domestic Product, expressed in relative terms.
- The region's accessibility to the given influence center, which depends on the cost of transporting a unit quantity between the i^{th} region and the given influence center, expressed in relative terms and the degree of a region's spatial discontinuity, as defined by the transport modes available and their transportation capacity, expressed in relative terms.

Having completed the presentation of the factors/sub-indicators affecting the i^{th} region's Economic Indicator, we will now proceed with the Social Indicator which is considered as a function of four factors; health services, educational conditions, poverty, and environmental conditions, expressed through the respective sub-indicators. The four factors and the respective sub-indicators are presented below.

Health Services: The level of the region's health services is one of the main factors affecting directly the employees' locational choices and indirectly the employers' decisions. The level of health services provided may be measured in different ways and in this particular case is quantified through an appropriate sub-indicator. The Health Services sub-indicator (SbI^2_{i1}) is a nonlinear transformation of the Relative Health Services index which is defined as the i^{th} region's health personnel per inhabitant as expressed in relative terms.

Educational Conditions: The level of educational conditions is also among the factors exerting a strong direct influence on the employees' locational decisions and, at the same time, an equally strong indirect influence on the business units' decisions. Many different ways have been used for its measurement and in this particular case it is quantified through the Educational Conditions sub-indicator (SbI^2_{i2}). It is a nonlinear transformation of the Relative Educational Conditions Index which is defined as the i^{th} region's ratio of population with secondary and tertiary education, expressed in relative terms.

Poverty: The GDP/capita used for the quantification of the i^{th} region's Economic Development sub-indicator certainly gives an aggregate and overall view of its financial status. Such an aggregate measure, nevertheless, may hide inequalities and, in certain extreme cases, may distort the picture. The level of poverty in the region gives an indication of the equity in income distribution. This may be measured in different ways and in this particular case is quantified through an appropriate sub-indicator. The Poverty sub-indicator (SbI^2_{i3}) of the i^{th} region is a nonlinear transformation of the Relative Poverty Index of the i^{th} region which is defined as the region's population at risk of poverty and social exclusion, expressed in relative terms.

Environmental Conditions: As mentioned in the introduction, every region performs three main functions: economic, social, and environmental with the latter gaining in importance recently. Hence, although environment does not appear as a distinct

Table 1: The Economic Indicator of region i

$IND_i^1 = \sqrt[3]{\prod_{j=1}^{3} SbI_{ij}^1}, \qquad i = 1, \ldots, n$	
IND_i^1	The Economic Indicator of region $i = 1, \ldots, n$
SbI_{i1}^1	The Economic Development sub-indicator of region i. The transformed data used are based on the GDP per inhabitant.
SbI_{i2}^1	The Research & Development sub-indicator of region i. The transformed data used are based on the R&D expenditure as percent of GDP.
SbI_{i3}^1	The Accessibility sub-indicator of region i. The transformed data used are based on the distance from the large influence centers and modes of transport available (land, sea, air).

Table 2: The Social Indicator of region i

$IND_i^2 = \sqrt[4]{\prod_{j=1}^{4} SbI_{ij}^2}, \qquad i = 1, \ldots, n$	
IND_i^2	The Social Indicator of region $i = 1, \ldots, n$
SbI_{i1}^2	The Health Services sub-indicator of region i. The transformed data used are based on the health personnel per 100,000 inhabitants.
SbI_{i2}^2	The Education Conditions sub-indicator of region i. The transformed data used are based on the population with upper secondary or tertiary education attainment.
SbI_{i3}^2	The Poverty sub-indicator of region i. The transformed data used are based on people at risk of poverty or social exclusion.
SbI_{i4}^2	The Environmental sub-indicator of region i. The transformed data used are based on the environmental protection expenditure as percent of GDP.

dimension in this case, we have included it as a component in the Social Indicator. Environmental conditions may be measured in different ways and in this particular case are quantified through the Environmental Conditions sub-indicator (SbI_{i4}^2), a nonlinear transformation of the Relative Environmental Conditions Index which is defined as the region's expenditure on environmental protection as percentage of its GDP, expressed in relative terms. At this point, it should be mentioned that, as part of their ongoing research, the authors have been experimenting with removing the environmental conditions from the Social Indicator and introducing a new third Environmental Indicator based exclusively on environment-related factors. In this case, the Basic Image may be defined as a function of three indicators Economic, Social, and Environmental and modeled in terms of a Butterfly Catastrophe (Angelis et al. 2013).

On the basis of all the above, the Economic and Social Indicators for the case of the south European regions may be expressed as shown in Tables 1 and 2, respectively. A clear overview of the variables affecting a region's development and their conversion, through relative indices and sub-indicators into indicators and finally into the region's Basic Image, is given in Table 3.

We have so far used a number of factors to define a region's Economic and Social Indicators and hence its Basic Image. However, one may argue that a number of important factors such as unemployment rates, labor quality and availability, salaries, and financial incentives have been left out. This is a plausible argument but it should be reiterated that the Basic Image, as defined, measures the degree to which the region satisfies the criteria that are common for all potential movers and hence it should be a function of factors affecting, almost to the same extent, both business units and employees. Important factors which have been left out and seem to affect primarily some of the groups of potential movers will be used for the estimation of the respective Specific Images. In this respect, employment rates, and level of salaries as well as housing quality and availability may be

Table 3: Variables affecting region's i development and their conversion into its Economic and Social Indicators

INDICATORS, INDICES AND VARIABLES CONCERNING REGION			
Indicators of region i	Sub-indicators of region i	Relative Indices of region i	Variables
Economic Indicator (IND_i^1)	Economic Development sub-indicator (SbI_{i1}^1)	Relative Economic Development index (RI_{i1}^1)	Gross Domestic Product, Population
	Research and Development sub-indicator (SbI_{i2}^1)	Relative Research and Development index (RI_{i2}^1)	Expenditure on R&D, Population
	Accessibility sub-indicator (SbI_{i3}^1)	Relative Accessibility index (RI_{i3}^1)	Size of Influence Centers, Distance/Cost from Influence Centers
Social Indicator (IND_i^2)	Health Services sub-indicator (SbI_{i1}^2)	Relative Health Services index (RI_{i1}^2)	Health Personnel, Population
	Education Conditions sub-indicator (SbI_{i2}^2)	Relative Education Conditions index (RI_{i2}^2)	Population with upper secondary and tertiary education, Population
	Poverty sub-indicator (SbI_{i3}^2)	Relative Poverty index (RI_{i3}^2)	Population at risk of poverty or social exclusion, Population
	Environmental Conditions sub-indicator (SbI_{i4}^2)	Relative Environmental Conditions index (RI_{i4}^2)	Expenditure on Environment, GDP

used for the estimation of the residents' Specific Image whereas labor quality/availability and financial incentives may be used for the calculation of the business activities' Specific Image. It must be reiterated that the Specific Image of a given region, as perceived by a group of potential movers, measures the degree to which movers belonging to that particular group consider the region as their best final choice. The Specific Image however, although a function of selected factors, appealing mainly to the members of that group, is primarily a function of the region's Basic Image. Maintaining and improving a region's Basic Image is not an easy task. However, all efforts to improve the conditions, through the improvement of Specific Image factors have limited and temporary effect and the only effective and long lasting solution is the improvement of the Basic Image factors (Angelis et al. 2015).

5 Estimating the Basic Image values of the south European regions

The methodology presented in the previous sections, has been used for the estimation of the Economic Indicator, the Social Indicator, and the Basic Image values of the NUTS 2 level regions of four south European countries namely, in alphabetical order, Greece, Italy, Portugal and Spain, for 2012. Those countries have in total sixty regions distributed among them as shown in Table 4. The required data have been drawn from the official site of Eurostat. For each of the sixty regions under study the primary data have been successively converted, as described in Section 4 and Table 3, into relative indices and sub-indicators and eventually (according to Tables 1 and 2) into the Economic and Social indicators. The Economic and Social indicators of the "typical" region have been also calculated and found to be 0.495 and 0.485 respectively. The values of each region's indicators together with the typical region's respective indicators have, in turn, been used for the calculation of the coefficients A and B of equation (1), whose solution has given the region's Basic Image values. The results are summarized in Tables A.1 and A.2 of the Appendix. Table A.1 contains the values of the Economic and Social Indicators for the south European regions for the year under study which are also graphically depicted

Table 4: Number of regions per country

Countries	# of regions
Spain	19
Italy	21
Greece	13
Portugal	7
TOTAL	60

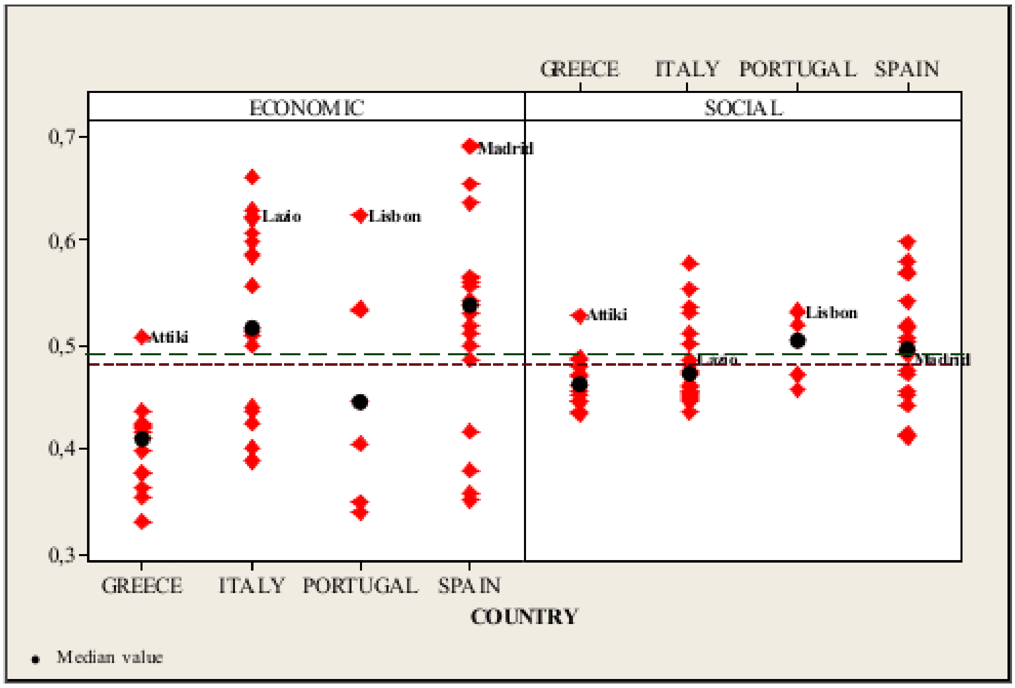

Figure 1: The Economic and Social Indicators of the 60 south European regions

in the Figures A.1 and A.2 of the Appendix. Table A.2 presents the values of the Basic Image for all south European regions and for the year under study. As a reminder, the "typical" region's Basic Image value is zero.

The Economic Indicator values of the Spanish and Italian regions range from about 0.35 to 0.70 (Figure 1). This wide range shows strong regional heterogeneity but the small gaps between successive regions indicate the lack of a dominating region. Moreover, the regions seem to be assembled in three distinct groups. Portugal's regions exhibit a similar range of Economic Indicator values but also a distinct gap between the leading capital region and all the rest as well as small but sizeable gaps between the successive regions. The Economic Indicator values of the Greek regions extend over a narrower range (0.35-0.50) but the large gap between the leading capital region and all the rest indicates its clear dominance. Furthermore, more than 50% of the regions in Spain and Italy have Economic Indicators' values greater than 0.495, which is the value of the typical region's Economic Indicator (denoted by the upper dotted line in Figure 1); whereas in Greece and Portugal this occurs only in one and two regions, respectively. The corresponding median values are shown in Figure 1. Finally, the capital regions in all four countries have high Economic Indicators values: the highest values in Greece and Portugal, the second highest in Spain, and third highest in Italy.

The Social Indicator values of the Spanish and Italian regions range from about 0.40 to 0.60, without any discontinuities between them (Figure 1). On the contrary, the Social Indicator values of the Greek and Portuguese regions extend over a narrower range (0.45-0.55) but with a noticeable gap between the leading region (or regions) and all the

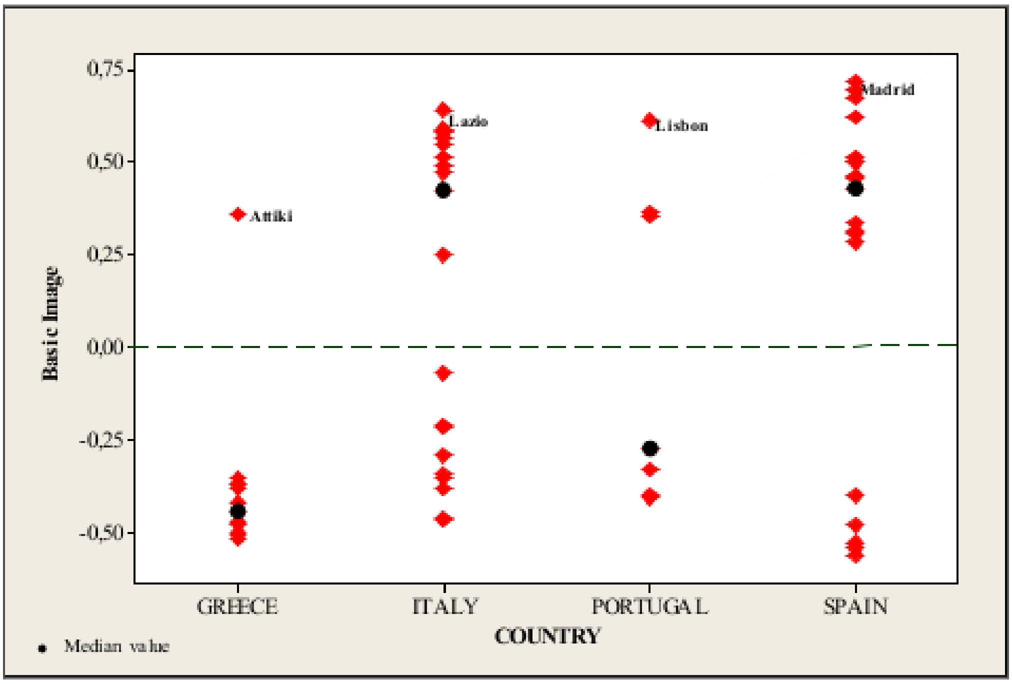

Figure 2: The Basic Image of the 60 south European regions

rest. More than 50% of the regions in Spain and Portugal have Social Indicator values greater than 0.485, which is the value of the typical region's Social Indicator (denoted by the lower dotted line in Figure 1). The respective ratios in Italy and Greece are about 35% and 25%. The corresponding median values are shown in Figure 1. Finally, the capital regions have the highest Social Indicators values in Greece and Portugal but considerably lower in Italy and Spain (Figure 1). At this point it should be noted that the range of the Social Indicator's values in all countries is narrower than the respective range of Economic Indicator. This is an interesting but easily explainable observation. The three factors comprising the Economic Indicator move, in most of the cases, in the same direction. In other words, regions with high economic activity usually combine high accessibility, good financial conditions, and investment in R&D whereas a region with low economic activity faces the opposite situation. This leads to extreme values, both high and low, for the Economic Indicators thus widening their range. On the contrary, the four factors comprising the Social Indicator move in different directions. In most of the cases, regions with high economic growth exhibit improved health services and educational conditions but low poverty and environmental conditions, and the opposite happens in regions with low economic activity. This leads to a smaller gap between the leading and lagging regions with respect to the Social Indicator and to a narrower range of their values.

The Basic Image values of Spanish, Italian and Portuguese regions extend over a wide range from about -0.55 to 0.70 indicating a strong regional heterogeneity (Figure 2). Moreover, in all three countries the regions seem to be assembled in two distinct groups separated by a big gap. It should also be noted that Portugal exhibits a smaller range of values and in contrast to the other two countries a dominance of the capital region. Finally, the Basic Image values of the Greek regions extend over a narrower range from about -0.50 to 0.35 and the large gap between the capital region and the rest indicates the dominance of this region. Furthermore, more than 60% of the regions in Spain and Italy have positive Basic Image values (the typical regions' Basic Image value is zero and it is denoted by the dotted line in Figure 2). The respective percentage for Portugal is about 40% whereas in Greece only the capital region exhibits positive Basic Image. The corresponding median values are shown in Figure 2. Finally, the capital regions in all four countries have high Basic Image value; the highest values in Greece and Portugal,

Table 5: Classification of the south European regions according to their Basic Image value

The Basic Image lies in the interval:	Regions per country				Total
	Greece	Italy	Portugal	Spain	
$[-1.0, -0.5)$	3	–	–	3	6
$[-0.5, 0)$	9	9	4	2	23
$[0, 0.5)$	1	4	2	7	15
$[0.5, 1)$	–	8	1	7	16
Total	13	21	7	19	60

the second highest in Italy and Spain.

The Basic Image values of all sixty south European regions, which may be found in Table A.6 of the Appendix, are summarized in Table 5 and graphically depicted in Figure 3. A final comment on the Basic Image results may be that our model seems to underestimate the values of all island regions. This is due to the fact that the negative impact of spatial discontinuity has been built into our model's Economic Indicator, thus reducing its value and hence the Basic Image value in the case of island regions. A second run of the model with a relaxed Economic Indicator, taking into account only the distance of the regions from the main influence centers and not their geographical discontinuity, improves the Basic Image values of island regions, but not significantly. This happens because most of the islands in the four countries under study are located far from large influence centers and this keeps their accessibility at low level despite the spatial discontinuity relaxation. However, most of the island regions focus on the attraction of business activities for which unfavorable location is not necessarily a handicap. Tourism is such an activity, for which distance, isolation and geographical discontinuity may not be a problem, but on the contrary, in certain cases a strong comparative advantage. Hence, the current model must be modified for the case of island regions.

Looking at the similarities between the patterns of the Economic Indicator and the Basic Image values, one may argue that there is no reason of calculating a region's Basic Image if we know that a high Economic Indicator (or even a high GDP) leads to a high positive Basic Image. The answer to that is very simple. A high Economic Indicator leads to a positive Basic Image only if the Social Indicator exceeds a given value. A drop of the Social Indicator (which in many cases may be the outcome of an excessive and uncontrolled increase of the region's economic growth) below a given threshold may lead to a sudden jump in the value of the Basic Image, which however, will be realized much later and as a smooth change. This is due to the long and different times needed by the members of each group of potential movers to perceive changes in a region's Basic Image value and react to them, which naturally leads to a smooth and delayed aggregate behavior. A closer and more careful look at the Economic Indicator and the Basic Image values for Greece and Portugal confirms this argument. In the case of Portugal, the better overall Social Indicators of its regions, as compared to Greece, leads to an improvement of the Basic Image values of some of its lagging regions and hence a closer gap between them and the leading regions in comparison with the gap of their respective Economic Indicator values. On the contrary, in the case of Greece, the low values of its regions' Social Indicators cannot have any positive effect on their Basic Image values thus widening their gap, as compared to the gap of the respective Economic Indicator values. A similar reasoning may explain the differentiation of the pattern of the Basic Image values for Spanish and Italian regions with respect to their Economic Indicator values. On the basis of all the above it could be said that the great importance of calculating both indicators and the Basic Image is to have an overall view of the region's development, get, through the Basic Image, an early warning of any potential dangers, identify, through the respective indicators and sub-indicators, the causes of these potential dangers and finally take the necessary measures to overcome the problems thus maintaining and improving the Basic Image.

Concluding this section we will refer to the robustness of our model and to its sensitivity

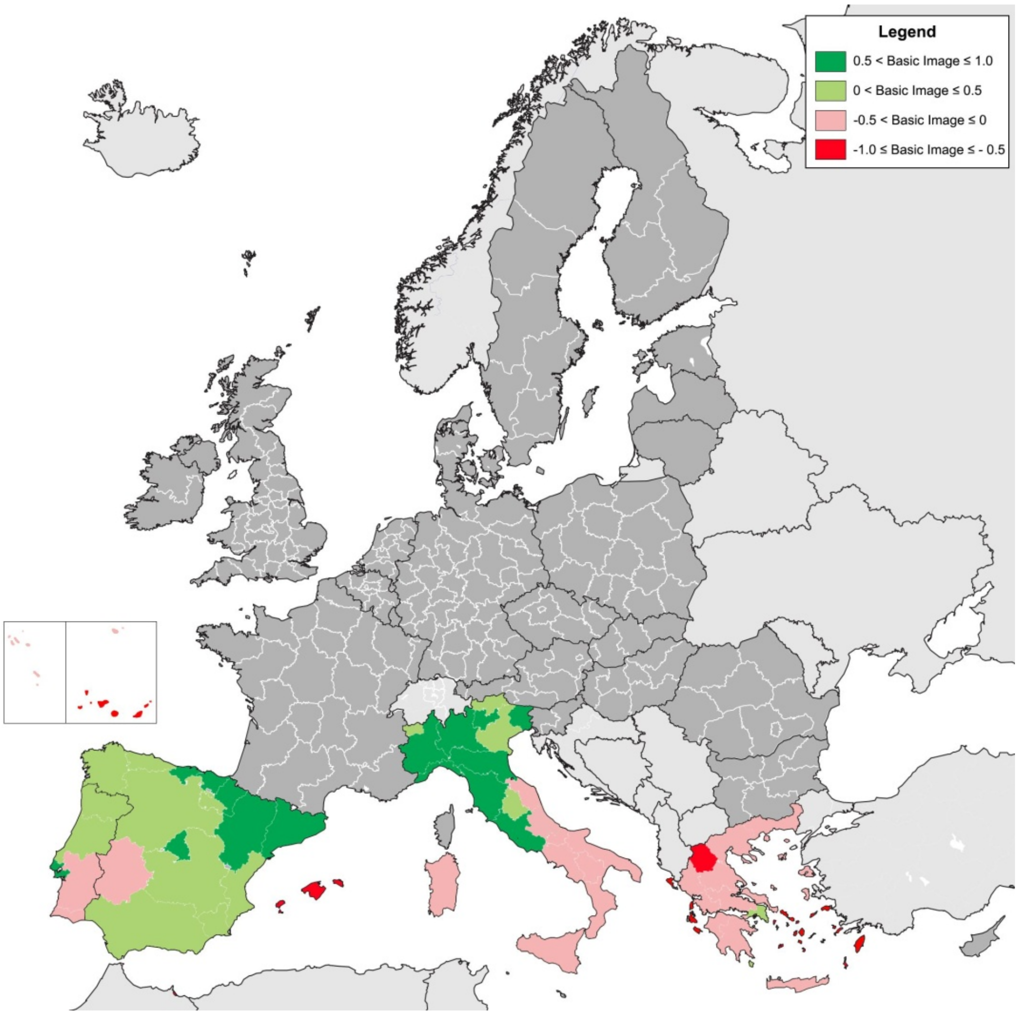

Figure 3: Classification of the south European regions according to their Basic Image value

to any changes in the selection and measuring of the variables affecting a region's Basic Image. The building of composite indicators involves a series of steps and decisions, most of which are arbitrary. Such decisions concern, among other things, the selection of the variables used as well as of the methods of weighting, aggregating, and normalizing the data. Hence, sensitivity analysis is needed in order to assess the extent to which those decisions might affect the values of those indicators, the model results, and hence, the conclusions drawn on the basis of those results.

In the context of this paper, three types of sensitivity analysis have been carried out (Charron et al. 2015, Dijkstra et al. 2010, Lagas et al. 2015). In the first case, a fourth factor expressing the Quality of Government has been added to the Economic Indicator, thus making it a function of four sub-indicators. In the second case, the environmental factor has been removed from the Social Indicator, thus making it a function of three sub-indicators (Charron et al. 2014, 2015). Finally, in the third case, the Accessibility Sub-indicator has been relaxed by taking into account only the distance of the regions from the main influence centers and not their geographical discontinuity. In each case, the values of the modified indicators have been re-estimated and the model was applied in order to estimate the regions' Basic Image values. The results obtained in all cases indicate the robustness of the model and its limited sensitivity to the changes described. Obviously there are some variations in certain values but no significant changes in the overall trends and no switches in the regions' Basic Image signs. An indicative comparative view of the Basic Image values as given by the base model (using a three factor Economic Indicator) and the test model, where a fourth factor (Quality of Government) has been added, is presented in Figure 4.

6 Identifying the economic and social profiles of the south European regions

Having calculated the Basic Image values of all the 60 regions under study we will now go on to their clustering on the basis of their economic and social characteristics which have been used for the quantification of their Economic and Social Indicators, respectively. To that end the Hierarchical Clustering method was initially used to determine, through a dendrogram, the number of emerging clusters and was followed by the *k*-means method which assigned the regions in the various clusters. Finally, the means of selected economic characteristics were compared in order to identify differences between clusters.

6.1 The economic profile of the south European regions

Let us start with the economic profile of the regions under study. Following the first two steps described above, the regions may be classified according to their economic characteristics into three clusters EC1, EC2 and EC3 (Figure A.3). The findings are summarized in Table A.3 and graphically depicted in Figure 5.

In order to identify the differences between the three clusters, the following hypotheses were tested:

H0: There is no difference in the means of the economic characteristics of the regions belonging to clusters EC1, EC2, EC3.

H1: There is difference in the means of the economic characteristics of the regions belonging to clusters EC1, EC2, EC3.

Based on Table 6 (summary report) and Figure 6 the following conclusions may be drawn:

- Cluster EC1 contains 13 regions (i.e. 21.7%). These are regions with very good economic profile, as the mean values of all relevant variables are considerably higher than the respective overall mean values. Furthermore, the dispersion of those variables' values is low in the case of Economic Development (5.7%) and higher in the case of Research & Development and Accessibility (10.6% and 10.2% respectively).

- Cluster EC2 contains 22 regions (i.e. 36.7%). These are regions with average economic profile, as the mean values of all variables expressing this profile, are only marginally higher than the respective overall mean values. Furthermore, the dispersion of those variables' values is high in the case of Economic Development (16.0%) and lower in the case of Research & Development and Accessibility (13.8% and 10.2% respectively).

- Cluster EC3 contains the remaining 25 regions (i.e. 41.6%). These are regions with poor economic profile, as the mean values of all variables expressing this profile, are lower than the respective overall mean values. Furthermore, the dispersion of those variables' values is low in the case of Economic Development (8.2%) and much higher in the case of Research & Development and Accessibility (18.5% and 20.0% respectively).

This classification shows the clear superiority of cluster EC1 over the clusters EC2 and EC3 and the superiority of cluster EC2 over the cluster EC3. The cross tabulation (by country) leads to Table 7.

As we can see from Table 7 and Figure 5, the clusters EC1 and EC2 (i.e. the clusters of regions with average and high economic profile), contain 35 regions or 58% of the total number or regions in all four countries. Most of the regions of Spain (78.9%) and Italy (71.05%), over half of the regions of Portugal (57.1%) but only one in Greece (7.7%) and no island regions, in any of the countries, belong to this group. Furthermore, in all four

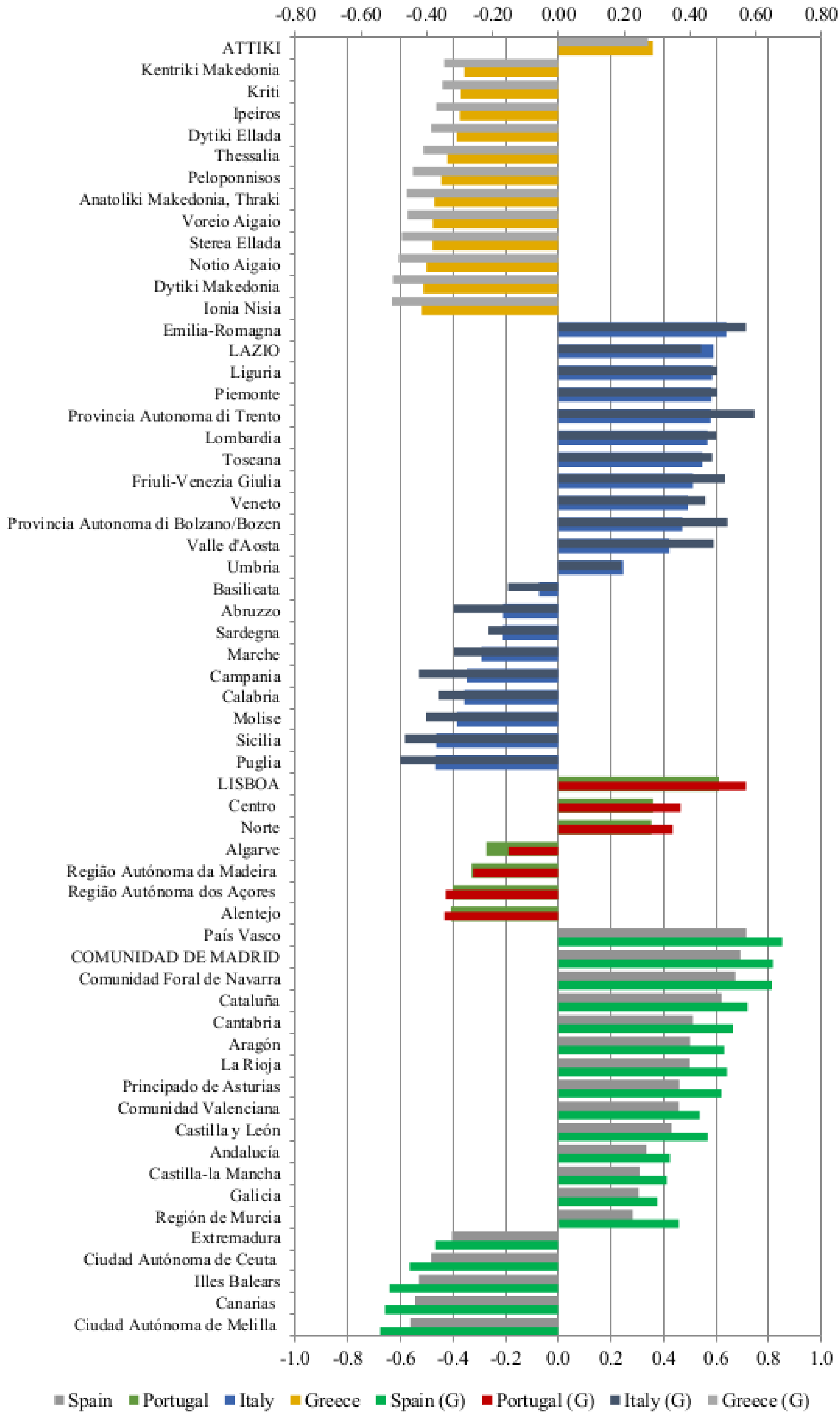

Figure 4: Basic Image values given by the model when using a three and a four-factor Economic Indicator respectively. The latter values are denoted by (G)

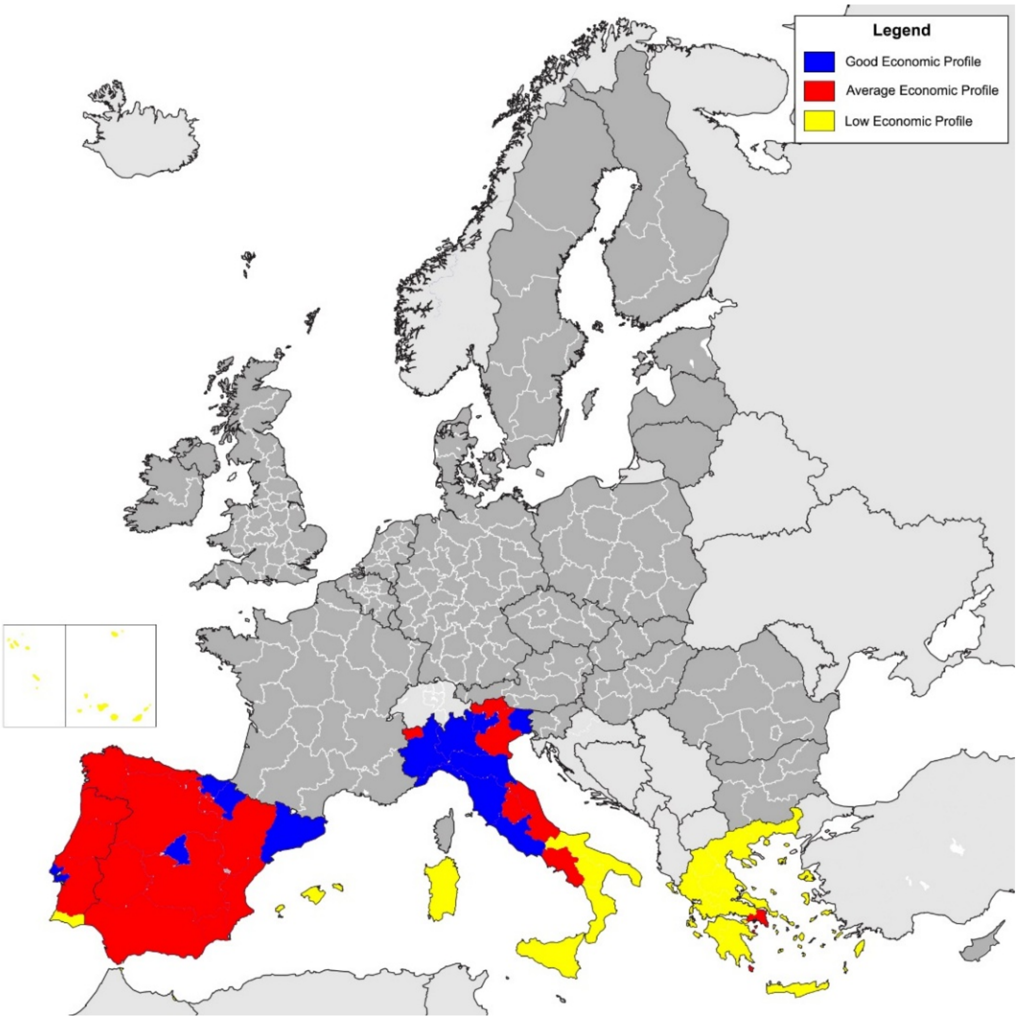

Figure 5: Clustering based on the regions' economic characteristics

countries most of the regions with high economic profile are located around the respective capital regions or other big cities. Moreover, in Spain and Italy most of those regions are located in the northern part of the country. These findings reflect the high economic activity and good economic prospects of Spain and Italy as compared to the other two countries. Portugal shows an ongoing process to improve its economic profile while Greece exhibits an almost negligible activity. Furthermore they seem to confirm the momentum of the capital regions and the north-south division in the bigger countries.

6.2 The social profile of the south European regions

Moving on the regions' social profile and, using the same method, we can see that according to their social characteristics the regions under study may be classified into two clusters S1 and S2 (Figure A.2). Cluster S1 contains 23 regions (i.e. 36.7%) with higher than average Health and Education sub-indicators, but lower than average Poverty and Environmental sub-indicators. Cluster S2 contains 38 regions (i.e. 63.3%) with higher than average Poverty and Environmental sub-indicators, but lower than average Health and Education sub-indicators. As we can see, this classification does not show any clear superiority of one cluster over the other. To clarify this situation, the clustering procedure was repeated twice on the basis of the regions Health/Education and Poverty/Environmental characteristics respectively.

According to their Health and Education characteristics the regions are classified into two clusters SC1 and SC2. The findings are summarized in Table A.4 and graphically

Table 6: Summary Report of the clustering based on the regions' economic characteristics

Cluster		Economic Development sub-indicator	R&D sub-indicator	Accessibility sub-indicator
EC1	Mean	1.1985	1.4077	1.2269
	N	13	13	13
	Std. Dev.	.06878	.14934	.12466
EC2	Mean	1.0095	1.0227	1.1564
	N	22	22	22
	Std. Dev.	.16188	.14065	.11745
EC3	Mean	.8836	.7512	.7520
	N	25	25	25
	Std. Dev.	.07210	.13860	.15033
Total	Mean	.9980	.9930	1.0032
	N	60	60	60
	Std. Dev.	.16387	.28703	.25254

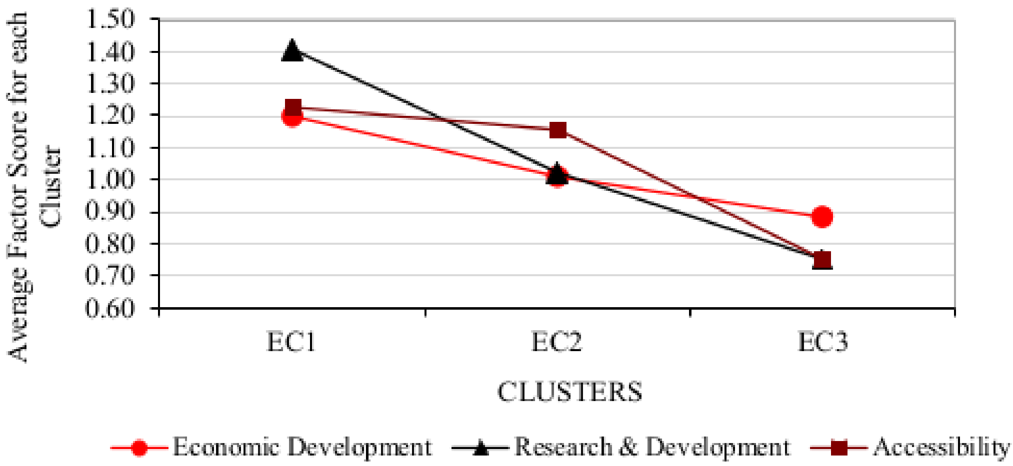

Figure 6: Cluster centers

Table 7: Regions per country. Clustering based on the regions' economic characteristics

Clusters	Regions per country				Total
	Greece	Italy	Portugal	Spain	
EC1	–	8	1	4	13
EC2	1	7	3	11	22
EC3	12	6	3	4	25
Total	13	21	7	19	60

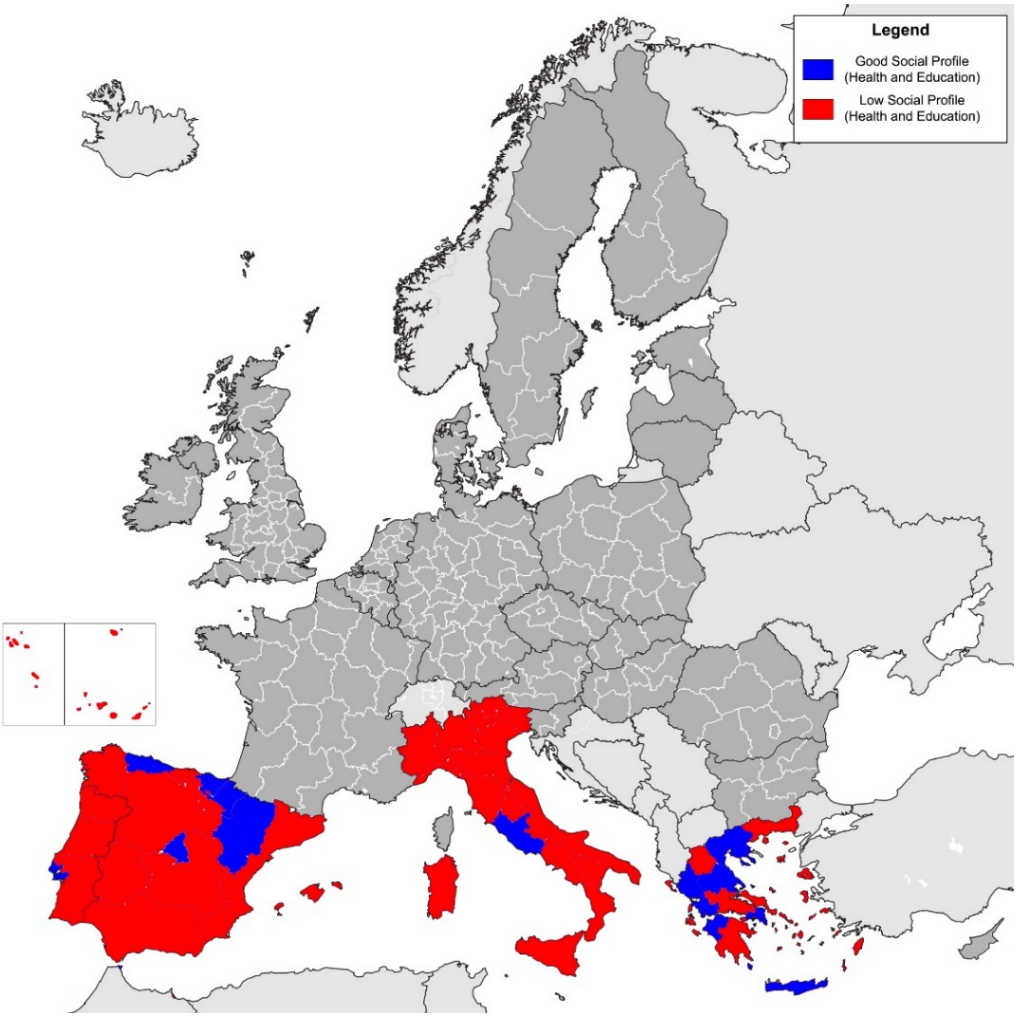

Figure 7: Clustering based on the regions' health and education characteristics

depicted in Figure 7.

In order to identify the differences between the two clusters, the following hypotheses were tested:

H0: There is no difference in the means of the health and education characteristics of the regions belonging to clusters SC1, SC2.

H1: There is difference in the means of the health and education characteristics of the regions belonging to clusters SC1, SC2.

Based on the summary report given in Table 8, the following conclusions may be drawn:

- Cluster SC1 contains 46 regions (i.e. 76.7%). These are regions with lower than average Health Services and Education Conditions sub-indicators. Furthermore, the dispersion of those variables' values is low in the case of both Health Services and Education Conditions (9.4% and 10.0% respectively).

- Cluster SC2 contains 14 regions (i.e. 23.3%). These are regions with higher than average Health and Education sub-indicators. Furthermore, the dispersion of those variables' values is low in the case of Education Conditions (8.4%) but higher in the case of Health Services (13.1%).

The cross tabulation (by country) leads to Table 9.

Table 8: Summary Report of the clustering based on the regions' health and education characteristics

Cluster		Health Services sub-indicator	Education Conditions sub-indicator
SC1	Mean	.9250	.9793
	N	46	46
	Std. Dev.	.08697	.09756
SC2	Mean	1.2257	1.0707
	N	14	14
	Std. Dev.	.16066	.09025
Total	Mean	.9952	1.0007
	N	60	60
	Std. Dev.	.16705	.10282

Table 9: Regions per country. Clustering based on the regions' health and education characteristics

Clusters	Regions per country				Total
	Greece	Italy	Portugal	Spain	
SC1	7	20	6	13	46
SC2	6	1	1	6	14
Total	13	21	7	19	60

As we can see from Table 9 and Figure 7, the cluster SC2 (i.e. the cluster of regions with better than average health and education sub-indicators), contains 14 regions or 23.3% of the total number of regions in all four countries. Almost half of the regions of Greece (46.2%), many of the regions of Spain (31.6%), few of the regions of Portugal (14.3%), one of the regions of Italy (4.8%), and no island regions (apart from Crete in Greece) belong to this cluster. Moreover, in all four countries the regions around the respective capitals belong to this cluster. Finally, apart from the capital regions, all other regions belonging to this cluster are located in the northern and more industrialized part of the respective countries. These findings reflect the ability of capital regions and regions with high economic activity to attract a larger number of educated people and provide better education and health facilities to their inhabitants. According to their poverty and environmental characteristics the regions are classified into two clusters SC3 and SC4. The findings are summarized in Table A.5 and graphically depicted in Figure 8.

In order to identify the differences between the two clusters, the following hypotheses were tested:

H0: There is no difference in the means of the poverty and environmental characteristics of the regions belonging to clusters SC3, SC4.

H1: There is difference in the means of the poverty and environmental characteristics of the regions belonging to clusters SC3, SC4.

Based on the summary report given in Table 10, the following conclusions may be drawn:

- Cluster SC3 contains 40 regions (i.e. 66.7%). Those are regions with lower than average Poverty and Environmental Conditions sub-indicators. Furthermore, the dispersion of those variables' values is very low in the case of Poverty (7.7%) but very high in the case of Environmental Conditions (18.1%).

- Cluster SC4 contains 20 regions (i.e. 33.3%). Those are regions with higher than average Poverty and Environmental Conditions sub-indicators. Furthermore, the

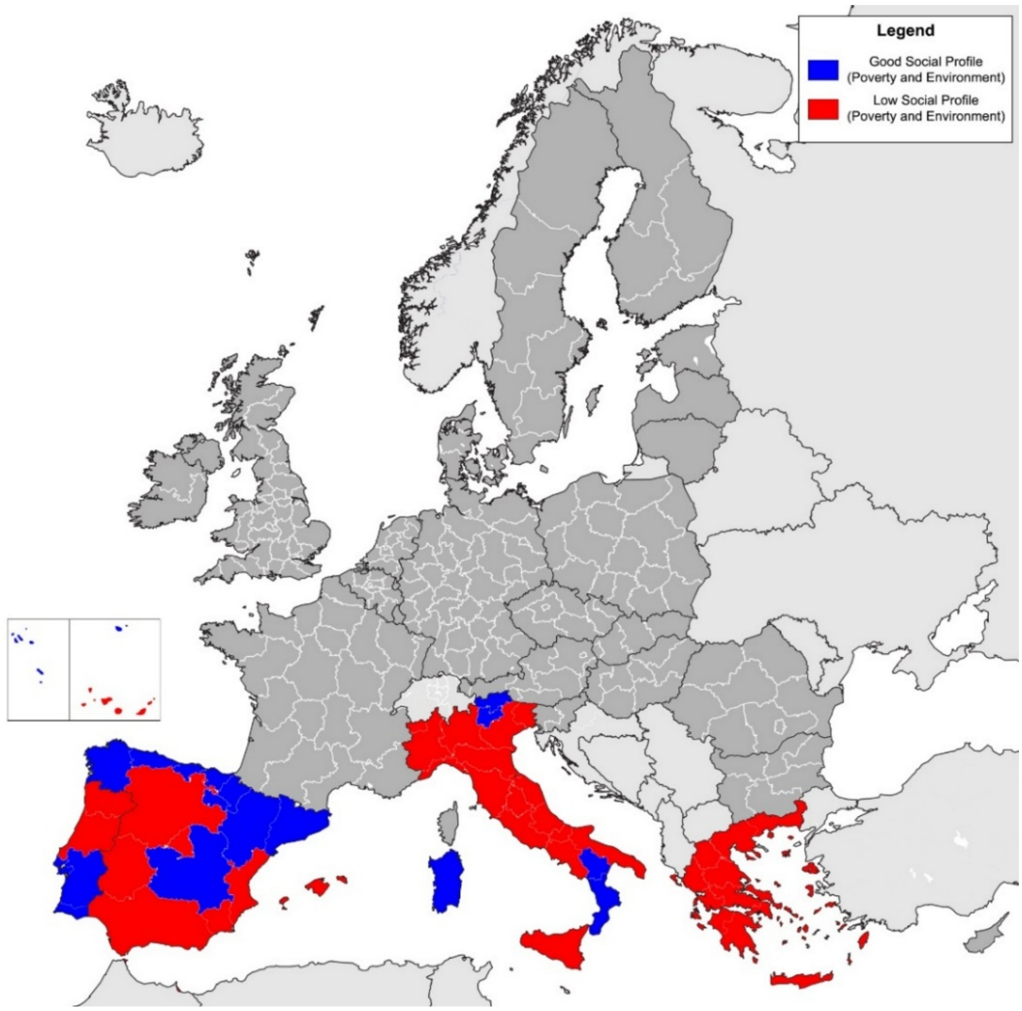

Figure 8: Clustering based on the regions' poverty and environmental characteristics

dispersion of those variables' values is very low in the case of Poverty (7.2%) but very high in the case of Environmental Conditions (20.8%).

- The cross tabulation (by country) leads to Table 11.

As we can see from Table 11 and Figure 8, the cluster SC4 (i.e. the cluster of regions with higher than average poverty and environmental sub-indicators) contains 20 regions (i.e. 33.3%) of the total number of regions in all four countries. Most of the regions of Portugal (71.4%), almost half of the regions of Spain (47.4%), many of the regions of Italy (28.6%), but no Greek regions belong to this cluster. Moreover, in all four countries the regions around the respective capitals do not belong to this cluster. Finally, in Spain and Italy most of these regions are located in the southern part of the countries. These findings reflect up to some extent the failure of the highly industrialized regions to offset the environmental degradation but also the low poverty and social exclusion rates of the smaller and largely self-sustainable communities. Concluding, it is worth noticing that there are only 5 regions in all countries (4 in Spain and 1 in Portugal) with better than average values in all four social sub-indicators.

7 Discussion of the results – Policy implications

The previous two sections looked at the NUTS 2 regions of the four south European countries under study. In particular, the former estimated the Economic Indicator, Social Indicator and Basic Image values for all their regions while the latter went on to the

Table 10: Summary Report of the clustering based on the regions' poverty and environmental characteristics

Cluster		Poverty sub-indicator	Environmental Conditions sub-indicator
SC3	Mean	.9835	.7460
	N	40	40
	Std. Dev.	.07550	.13466
SC4	Mean	1.0370	1.3575
	N	20	20
	Std. Dev.	.07491	.28228
Total	Mean	1.0013	.9498
	N	60	60
	Std. Dev.	.07888	.34950

Table 11: Regions per country. Clustering based on the regions' poverty and environmental characteristics

Clusters	Regions per country				Total
	Greece	Italy	Portugal	Spain	
SC3	13	15	2	10	40
SC4	–	6	5	9	20
Total	13	21	7	19	60

clustering of those regions based on the economic and social characteristics which had been used for the estimation of their Basic Image. The four countries under study may be naturally divided into two groups, the first comprising of Spain and Italy, the bigger and more industrialized countries and the second, including Greece and Portugal, the small and less developed countries. The results confirm to a large extent this subdivision. However, it should be noted that, in some cases, Portugal seems to behave more like the two bigger countries rather than like Greece.

Based on the results of Section 5, we can say that most of the regions of Spain and Italy have high Economic Indicator values which cover a wider range thus indicating a rather strong regional heterogeneity and a lack of a dominant region. A similar range of values may be found in Portugal but with a smaller percentage of regions with high Economic Indicator and a clear gap between the leading capital region and all the rest. The presence of a dominant region is even more emphatic in Greece where the range of Economic Indicator values is much narrower and the percentage of regions with high Economic Indicator values very small. Furthermore, almost 50% of the regions of Spain and Portugal and 35% of the regions of Italy have high Social Indicator values while the respective percentage for Greece is much lower. Moreover, the Social Indicator values in all four countries extend over a narrower range, as compared to the Economic Indicator values for the reasons explained. Finally, the Basic Image values in all four countries follow a trend similar to that of the Economic Indicators. An important point, however, is the reinforcement of the gap between leading and lagging regions as a result of the described interplay between Industrial and Social Indicator values.

Moving on to the results of Section 6, it can be said that, regarding the economic characteristics (Section 6.1), almost 80% of the regions of Spain and Italy, over 50% of the regions of Portugal but only one region in Greece belong to the high economic activity cluster. These findings reflect the better economic conditions and prospects of Spain and Italy but also Portugal's effort to improve its status and Greece's almost negligible economic activity. Furthermore, the location of the regions within each country seems to confirm the momentum of the capital regions and the north-south division, especially in the big countries. Regarding the social characteristics (Section 6.2), the picture is more complex. Greece and Spain belong to the good health and education services cluster with Portugal and Italy to trail, whereas Portugal and Spain perform better in limiting poverty and preserving the environment, followed by Italy and Greece. Furthermore, the location of the leading and lagging regions within each country seems to confirm the ability of the capital and large regions in general to provide better health and education services and their failure to offset the environmental deterioration caused by extensive and uncontrolled industrialization but also to limit poverty and social exclusion.

The results obtained in the previous two sections may act as the basis for policy decisions. The Basic Image has been structured in such a way as to allow the researcher to detect inner changes in the region's attractiveness but also their causes. Going backwards from the Basic Image, through indicators, sub indicators, indices and sub-indices to the variables, one can identify the real causes of the Basic Image changes. Hence, the Basic Image may prove a very useful managerial tool for both regional authorities at both national and European level and business firms. The regional authorities may use the Basic Image in order to monitor the development of the various regions, get an early warning of any potential problems they may face and take the necessary measures to prevent them. The business firms on the other hand, may use the Basic Image in order to follow the development of various regions, assess their potential for future growth and take the proper location and investment decisions. Furthermore, a deeper analysis of the strengths, weaknesses, and potential prospects of the members of each one of the clusters which have been identified may lead to the drawing of policies, at a national or European level, especially designed, for the regions of each cluster.

8 Conclusions – Suggestions for further research

Sustainability expresses the capability of a country to satisfy the requirements of the present generation while securing, at the same time, the satisfaction of all the future generations' needs. Measuring sustainable development requires overcoming the simple one-dimensional approach of human activities and incorporating into them the social and environmental dimensions. Furthermore, new methods are needed which could benchmark performance, identify cases of fast and slow regional development and pinpoint best practices. Finally new techniques should be introduced leading to more objective, robust, and reliable decision making.

The first part of this paper, introduced the concept of a regions' Basic Image as a measure expressing a region's attractiveness and overall progress towards sustainable development. Furthermore, it presented a methodology for the estimation of a region's Basic Image. The second part used this methodology for the estimation of the Basic Image values of the NUTS 2 regions of four south European countries, namely Spain, Italy, Greece and Portugal for the year 2012 and went on to the clustering of those regions based on their economic and social characteristics.

The application gave very interesting results for the regions, within each country but also across the four countries, which were presented and discussed in the previous section. Furthermore, a number of areas of further research have been identified. A first area would be to elaborate on the definition of the regions' Economic and Social Indicators by introducing new variables as well as new data measuring, aggregation, and normalization methods and assess their impact on the changes in the Basic Image values of the regions and their clustering. A second thought would be to adjust this general model for the island regions along the lines already described. A third idea would be, as already mentioned in Section 4, to introduce a third indicator, thus expressing the Basic Image as a function of three indicators: Economic, Social, and Environmental. In such a case, the Basic Image could be modeled as a Butterfly Catastrophe. Finally, since the estimation of a region's Basic Image at a point in time gives a "snapshot" view of its development, a more interesting exercise would be to estimate it for a number of years, identify the Basic Image trend and design a policy, so as to bring it at a desired "optimum" orbit, giving at the same time an indication of the cost of its implementation.

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A Appendix

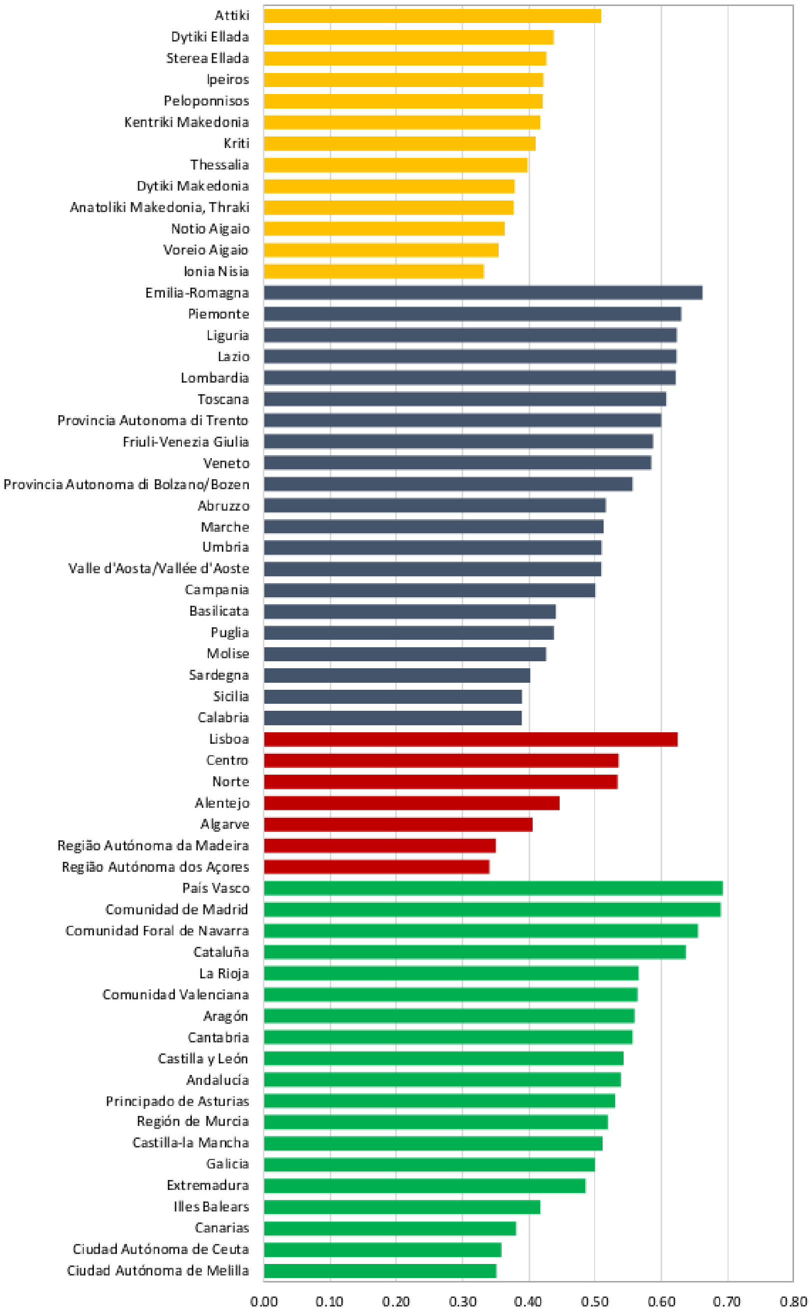

Figure A.1: The Economic Indicator of the south European regions

Table A.1: The values of the Economic and the Social Indicators of the south European regions

Region	Economic Indicator	Social Indicator
GREECE		
Anatoliki Makedonia, Thraki	0.377	0.457
ATTIKI*	0.509	0.528
Dytiki Ellada	0.437	0.470
Dytiki Makedonia	0.379	0.434
Ionia Nisia	0.332	0.445
Ipeiros	0.422	0.480
Kentriki Makedonia	0.417	0.489
Kriti	0.410	0.487
Notio Aigaio	0.363	0.446
Peloponnisos	0.421	0.453
Sterea Ellada	0.427	0.436
Thessalia	0.398	0.473
Voreio Aigaio	0.355	0.462
ITALY		
Abruzzo	0.516	0.463
Basilicata	0.441	0.532
Calabria	0.389	0.502
Campania	0.501	0.451
Emilia-Romagna	0.662	0.453
Friuli-Venezia Giulia	0.588	0.474
LAZIO*	0.623	0.487
Liguria	0.624	0.477
Lombardia	0.622	0.448
Marche	0.513	0.456
Molise	0.426	0.475
Piemonte	0.630	0.446
Provincia Autonoma di Bolzano/Bozen	0.557	0.512
Provincia Autonoma di Trento	0.600	0.554
Puglia	0.438	0.437
Sardegna	0.402	0.538
Sicilia	0.390	0.456
Toscana	0.608	0.461
Umbria	0.510	0.481
Valle d'Aosta	0.510	0.580
Veneto	0.585	0.455
PORTUGAL		
Alentejo	0.447	0.457
Algarve	0.406	0.520
Centro	0.535	0.473
LISBOA*	0.625	0.533
Norte	0.534	0.472
Região Autónoma da Madeira	0.351	0.531
Região Autónoma dos Açores	0.341	0.505
SPAIN		
Andalucía	0.539	0.453
Aragón	0.560	0.541
Canarias	0.381	0.416
Cantabria	0.557	0.569
Castilla y León	0.543	0.503
Castilla-la Mancha	0.511	0.497
Cataluña	0.637	0.507
Ciudad Autónoma de Ceuta	0.358	0.457
Ciudad Autónoma de Melilla	0.351	0.412
COMUNIDAD DE MADRID*	0.690	0.491
Comunidad Foral de Navarra	0.656	0.599
Comunidad Valenciana	0.564	0.477
Extremadura	0.486	0.442
Galicia	0.500	0.516
Illes Balears	0.417	0.412
La Rioja	0.566	0.520
País Vasco	0.693	0.581
Principado de Asturias	0.530	0.571
Región de Murcia	0.519	0.473

* Capital region

Table A.2: The Basic Image values of the south European regions

Region	Basic Image
GREECE	
Anatoliki Makedonia, Thraki	-0.471
ATTIKI*	0.360
Dytiki Ellada	-0.385
Dytiki Makedonia	-0.512
Ionia Nisia	-0.518
Ipeiros	-0.375
Kentriki Makedonia	-0.356
Kriti	-0.371
Notio Aigaio	-0.500
Peloponnisos	-0.444
Sterea Ellada	-0.477
Thessalia	-0.420
Voreio Aigaio	-0.476
ITALY	
Abruzzo	-0.210
Basilicata	-0.073
Calabria	-0.356
Campania	-0.347
Emilia-Romagna	0.641
Friuli-Venezia Giulia	0.513
LAZIO*	0.590
Liguria	0.586
Lombardia	0.568
Marche	-0.291
Molise	-0.384
Piemonte	0.583
Provincia Autonoma di Bolzano/Bozen	0.472
Provincia Autonoma di Trento	0.580
Puglia	-0.467
Sardegna	-0.212
Sicilia	-0.463
Toscana	0.548
Umbria	0.248
Valle d'Aosta	0.423
Veneto	0.493
PORTUGAL	
Alentejo	-0.408
Algarve	-0.272
Centro	0.361
LISBOA*	0.611
Norte	0.355
Região Autónoma da Madeira	-0.329
Região Autónoma dos Açores	-0.401
SPAIN	
Andalucía	0.335
Aragón	0.501
Canarias	-0.543
Cantabria	0.512
Castilla y León	0.430
Castilla-la Mancha	0.309
Cataluña	0.621
Ciudad Autónoma de Ceuta	-0.483
Ciudad Autónoma de Melilla	-0.562
COMMUNIDAD DE MADRID*	0.693
Comunidad Foral de Navarra	0.674
Comunidad Valenciana	0.459
Extremadura	-0.404
Galicia	0.305
Illes Balears	-0.530
La Rioja	0.498
País Vasco	0.716
Principado de Asturias	0.461
Región de Murcia	0.283

* Capital region

Table A.3: Clustering based on the economic characteristics of the south European regions

Cluster	Country	Region
EC1	Spain	País Vasco, Comunidad de Madrid, Comunidad Foral de Navarra, Cataluña
	Italy	Emilia-Romagna, Piemonte, Liguria, Lazio, Lombardia, Toscana, Provincia Autonoma di Trento, Friuli-Venezia Giulia
	Portugal	Lisboa
EC2	Spain	La Rioja, Comunidad Valenciana, Aragón, Cantabria, Castilla y León, Andalucía, Principado de Asturias, Región de Murcia, Castilla-la Mancha, Galicia, Extremadura
	Italy	Veneto, Provincia Autonoma di Bolzano/Bozen, Abruzzo, Marche, Umbria, Valle d'Aosta, Campania
	Greece	Attiki
	Portugal	Centro, Norte, Alentejo
EC3	Spain	Illes Balears, Canarias, Ciudad Autónoma de Ceuta, Ciudad Autónoma de Melilla
	Italy	Basilicata, Puglia, Molise, Sardegna, Sicilia, Calabria
	Greece	Dytiki Ellada, Sterea Ellada, Ipeiros, Peloponnisos, Kentriki Makedonia, Kriti, Thessalia, Dytiki Makedonia, Anatoliki Makedonia - Thraki, Notio Aigaio, Voreio Aigaio, Ionia Nisia
	Portugal	Algarve, Região Autónoma da Madeira, Região Autónoma dos Açores

Table A.4: Clustering based on Health and Education characteristics of the south European regions

Cluster	Country	Region
SC1	Spain	Andalucía, Canarias, Cantabria, Castilla y León, Castilla-la Mancha, Cataluña, Ciudad Autónoma de Melilla, Comunidad Valenciana, Extremadura, Galicia, Illes Balears, La Rioja, Región de Murcia
	Italy	Abruzzo, Basilicata, Calabria, Campania, Emilia-Romagna, Friuli-Venezia Giulia, Liguria, Lombardia, Marche, Molise, Piemonte, Provincia Autonoma di Bolzano/Bozen, Provincia Autonoma di Trento, Puglia, Sardegna, Sicilia, Toscana, Umbria, Valle d'Aosta, Veneto
	Greece	Anatoliki Makedonia - Thraki, Dytiki Makedonia, Ionia Nisia, Notio Aigaio, Peloponnisos, Sterea Ellada, Voreio Aigaio
	Portugal	Alentejo, Algarve, Centro, Norte, Região Autónoma da Madeira, Região Autónoma dos Açores
SC2	Spain	Aragón, Ciudad Autónoma de Ceuta, Comunidad de Madrid, Comunidad Foral de Navarra, País Vasco, Principado de Asturias
	Italy	Lazio
	Greece	Attiki, Dytiki Ellada, Ipeiros, Kentriki Makedonia, Kriti, Thessalia
	Portugal	Lisboa

Table A.5: Clustering based on Poverty and Environmental characteristics of the south European regions

Cluster	Country	Region
SC3	Spain	Andalucía, Canarias, Castilla y León, Ciudad Autónoma de Ceuta, Ciudad Autónoma de Melilla, Comunidad de Madrid, Comunidad Valenciana, Extremadura, Illes Balears, Región de Murcia
	Italy	Abruzzo, Campania, Emilia-Romagna, Friuli-Venezia Giulia, Lazio, Liguria, Lombardia, Marche, Molise, Piemonte, Puglia, Sicilia, Toscana, Umbria, Veneto
	Greece	Anatoliki Makedonia - Thraki, Attiki, Dytiki Ellada, Dytiki Makedonia, Ionia Nisia, Ipeiros, Kentriki Makedonia, Kriti, Notio Aigaio, Peloponnisos, Sterea Ellada, Thessalia, Voreio Aigaio
	Portugal	Centro, Norte
SC4	Spain	Aragón, Cantabria, Castilla-la Mancha, Cataluña, Comunidad Foral de Navarra, Galicia, La Rioja, País Vasco, Principado de Asturias
	Italy	Basilicata, Calabria, Provincia Autonoma di Bolzano/Bozen, Provincia Autonoma di Trento, Sardegna, Valle d'Aosta
	Portugal	Alentejo, Algarve, Lisboa, Região Autónoma da Madeira, Região Autónoma dos Açores

Table A.6: Overall classification of the south European regions based on their Basic Image

Interval	Country	Region
$[-1.0, -0.5)$	Spain	Canarias, Ciudad Autónoma de Melilla, Illes Balears
	Greece	Dytiki Makedonia, Ionia Nisia, Notio Aigaio
$[-0.5, 0)$	Spain	Extremadura, Ciudad Autónoma de Ceuta
	Italy	Basilicata, Calabria, Campania, Marche, Molise, Puglia, Sardegna, Sicilia
	Greece	Kentriki Makedonia, Kriti, Ipeiros, Dytiki Ellada, Thessalia, Peloponnisos, Anatoliki Makedonia - Thraki, Voreio Aigaio, Sterea Ellada
	Portugal	Algarve, Região Autónoma da Madeira, Região Autónoma dos Açores, Alentejo
$[0, 0.5)$	Spain	Andalucía, Castilla-la Mancha, Castilla y León, Comunidad Valenciana, Galicia, Principado de Asturias, Región de Murcia
	Italy	Abruzzo, Provincia Autonoma di Bolzano/Bozen, Umbria, Valle d'Aosta, Veneto
	Greece	ATTIKI
	Portugal	Centro, Norte
$[0.5, 1.0)$	Spain	Aragón, Cantabria, Cataluña, COMUNIDAD DE MADRID, Comunidad Foral de Navarra, La Rioja, País Vasco
	Italy	Emilia-Romagna, Friuli-Venezia Giulia, LAZIO, Liguria, Lombardia, Piemonte, Provincia Autonoma di Trento, Toscana
	Portugal	LISBOA

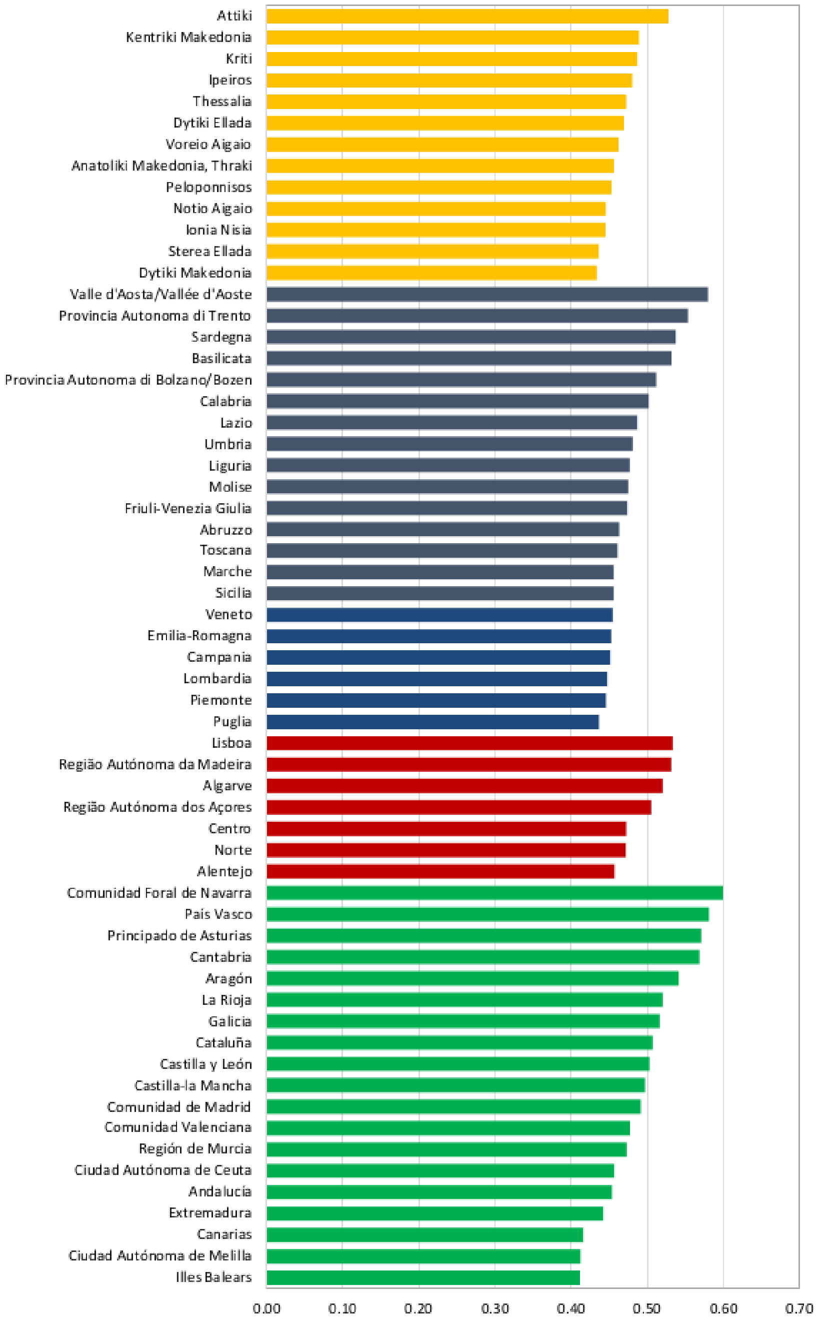

Figure A.2: The Social Indicator of the south European regions

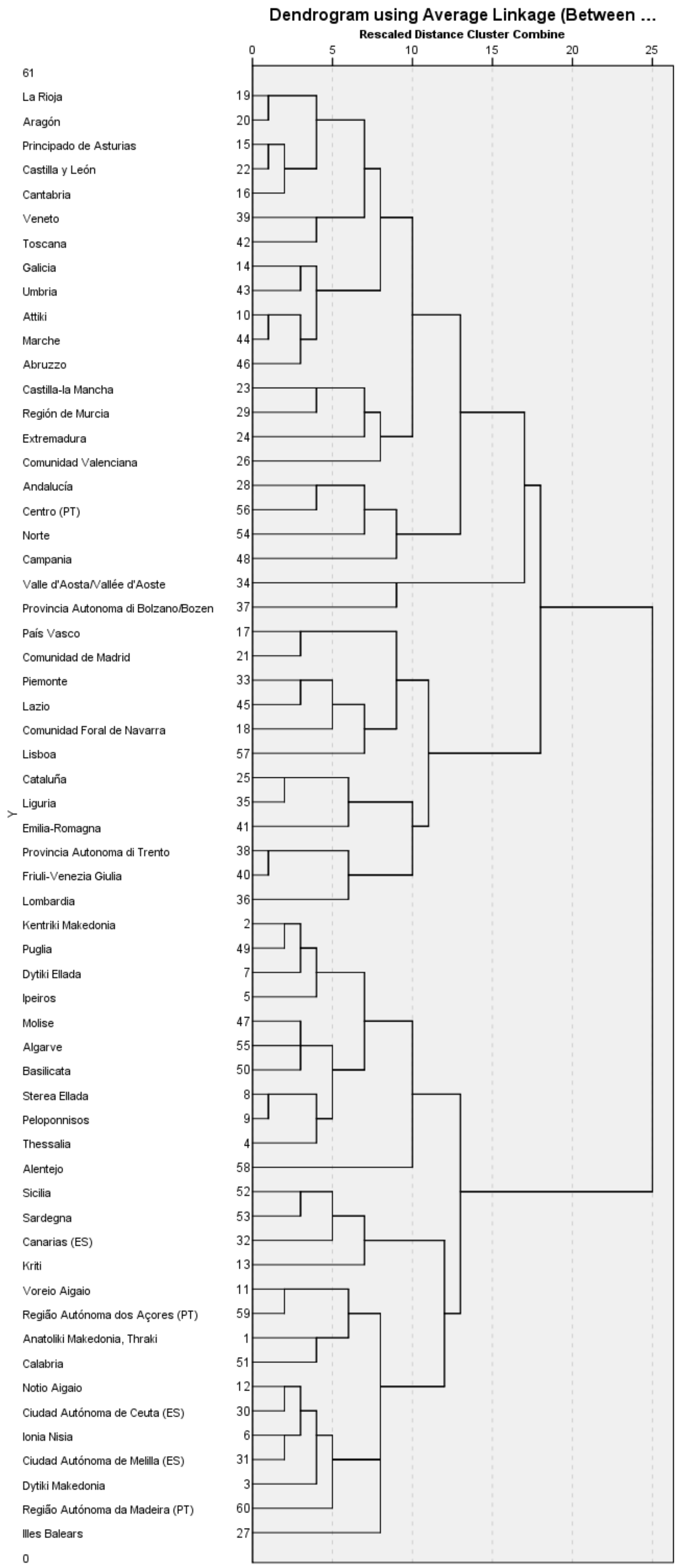

Figure A.3: Dendrogram based on the economic characteristics of the south European regions

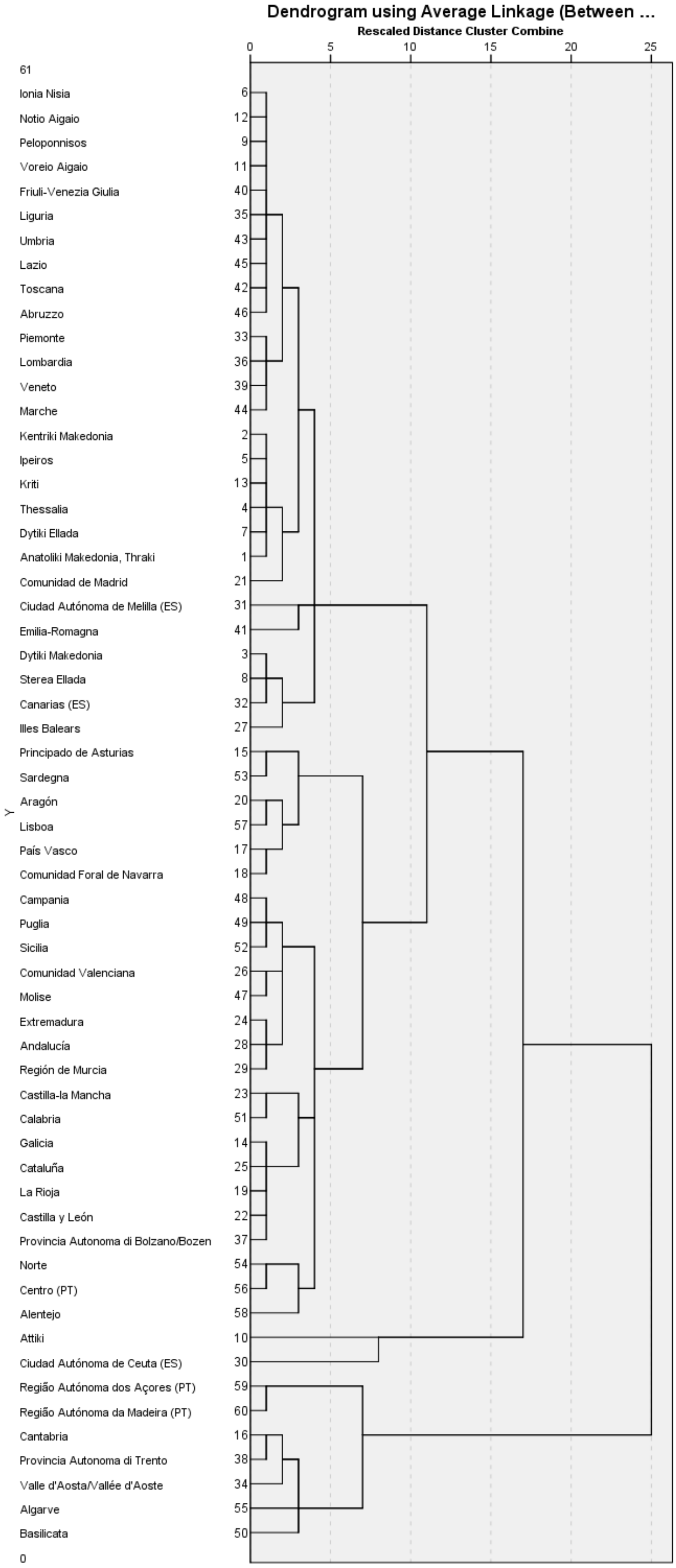

Figure A.4: Dendrogram based on the social characteristics of the south European regions

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Pride in the city*

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Abstract. Urban pride is an individual and collective response to living in a given city. Unlike other emotions such as life satisfaction or happiness with which it is weakly positively correlated, pride involves stake holding; to be proud of something requires having an investment in its success emotionally, financially or culturally.

For this study I specify a multilevel model based on responses to a five category survey question which asks residents how proud they are in the 'look and feel of their city'. Responses to the 2008 survey are distributed over almost 6000 residents across 12 cities in New Zealand. Although the primary variation is among individuals, urban pride also varies by city and I show how differences in urban context affect the way different types of stake holding temper urban pride.

JEL classification: R19, R590, I390, H890

Key words: Pride, urban pride, civic pride, city, social identity, multilevel model, New Zealand, Quality of Life Survey

> *Pride is an emotion that has profound economic consequences and indeed consequences for all areas of human activity* (Boulding 1987, pp. 15–16)

1 Introduction

Almost thirty years ago Kenneth E. Boulding proposed a link between power, planning, and pride in a paper entitled, '*The economics of pride and shame*' (Boulding 1987).

*Successive drafts of this paper have been presented over the last four years and I wish to acknowledge the feedback received. An initial presentation was made on 23 August 2012 to the Geography, Environmental and Development Studies Seminar series at Victoria University of Wellington, a year later on 10th October, 2013 to the National Institute of Demographic and Economic Analysis (NIDEA) at the University of Waikato. A later version was presented to the Department of Geography, University of Otago on 2nd October, 2014. The case study was also used as an application of multilevel modelling in a keynote address to the Oceania Stata User Group Meeting in Sydney, on 28 September, 2016 under the title 'Multilevel estimation of contextual effects'.

Several people have commented on earlier drafts. Professor Jacques Poot, University of Waikato, made constructive comments on an earlier manuscript. Dr Michael Thomas, Faculty of Spatial Sciences, University of Groningen, made a number of valuable suggestions on the model, some of which I have adopted and others of which I will address in subsequent work. Dr Tom Collins, School of Geography, University of Leeds whose work on civic pride I drew on in the literature review was kind enough to read the penultimate manuscript and he made several points which I've now included in the paper. I also wish to acknowledge the literature review on this topic initially undertaken by Robert Nairn as part of his honours research essay in 2010. Finally, I wish to thank the three anonymous referees whose comments have strengthened the paper. As usual the responsibility for any errors remain mine.

Economists, he observed, simply assume that preferences are given but in practice our preferences are strongly determined by our identity which depends very much on the community we live in.

This same relationship was recognised by New Zealand's Wellington Regional Council when it wrote,

> *Despite the limitations in being able to monitor our progress regionally, it is known that residents with a strong sense of pride and a sense of community are key to building strong, socially sustainable and connected communities. These people will act as advocates for their region and promote the positive aspects their region has to offer and contribute to improving their neighbourhood* (Wellington Regional Council 2011, p. 35)

Notwithstanding the frequent appearance of the term pride in the urban and regional planning discourse very little attention has been paid to the role of urban pride; how it forms in individuals, how it is distributed among residents within and between cities, and above all how it is used in decision making. This lacunae exists in spite of the increasing attention being paid to the way emotion motivates behaviour in general (Davidson et al. 2007), collectively (Sullivan 2014b, von Scheve, Ismer 2013), and within individuals (Lea, Webley 1997)[1].

At the same time it is important to differentiate pride from a number of other emotions that are receiving attention, such as life satisfaction and happiness. Pride is unique among the emotions in the way it is tied to stake holding for one only feels pride (or shame) in people, events, or places in which one has a stake, through investment, ownership, or membership.

In this paper I ask three questions. To what extent does urban pride reflects the stake people have in their city? What is the relative role of the city and the individual in the measure of pride? And what characteristics of the city influence the way urban pride responds to stake holding? Each of these questions is addressed by analysing responses to a unique question on urban pride asked in the 2008 New Zealand Quality of Life Survey.

The paper makes four contributions to the urban and regional literature. Firstly, it introduces urban pride as a distinct emotion expressed by most respondents in their city. Secondly, the paper identifies and tests for the several types of urban stake holding. Thirdly, it shows how levels of urban pride vary across residents and cities. And fourthly, it explores the way characteristics of the city can modify the impact of stake holding on urban pride.

1.1 Outline

The paper is in eight sections. Section 2 gathers the scattered literature on pride in support of its defining characteristics and draws a working distinction between *civic* pride and *urban* pride. Section 3 introduces the New Zealand Quality of Life Survey. The idea of interacting characteristics of the city with attributes of the individual is integral to the multilevel model introduced in Section 4. The random intercepts model is estimated in Section 5, selected measures of city context are introduced in Section 6, and the multilevel model itself is estimated in Section 7. The paper concludes in Section 8.

2 Pride

Pride is not simply another measure of wellbeing - it is an emotion that results from having a stake in someone, something, or some place. For example: 'I am proud of *my* performance', 'I am proud *we* won gold at the Olympics', or, 'I am proud of *my* city'[2]. The opposite of pride is shame, which also depends on stake holding, as in 'I am ashamed of my performance, my country or my city'.

[1] Despite the attention emotions receive in the Davidson et al. (2007) collection, pride as such is not given any attention and this appears to also be the case in papers published so far in the journal Emotion, Space and Society, with the possible exception of Bennett (2013).

[2] As Rosenblatt (1988) points out, one may admire (and envy) a stranger's achievements, but one is not 'proud of' a stranger.

The essential point about pride is that it is based on a prior belief that one has played a role or made a difference in generating the phenomena, event, or condition of interest, even if only in a secondary or peripheral way. Most followers of sports teams feel they contribute simply by being a fan and they are proud of that contribution. Most citizens of countries feel some degree of pride in their country simply because they are born with the right to permanent residence.

Research on pride is scattered over four quite different literatures and each has implications for how we might think about the pride we express in our cities. The psychology literature addresses the way pride regulates individual behaviour (Reissland 1994, Rosenblatt 1988). The social identity literature considers the association between pride and group membership and a growing body of work in economics considers the way pride is associated with departures from rational behaviour. Political scientists focus their attention on the pride we exhibit in our country, on national pride.

In psychology, pride has been characterised as an attitude and an expression of personal self-esteem, and is referred to as a 'social emotion' (Haidt 2003). The feeling of pride is something that we absorb socially from a young age because pride is closely linked with identity formation (Reissland 1994). Beginning with the development of self-concept as a child, we learn how to associate actions with positive self-esteem and we gain a sense of identity in order to interact socially (Tracy, Robins 2004, 2007).

Tajfel, Turner (1979) show that the groups we belong to are an important source of pride and that much of our self-esteem arises from membership of collectives. Building on this literature, Rosenblatt (1988) shows that individuals who form a group share the same ego ideal and thus identify with one another: "The assertion of a group affiliation appears necessary to make some of the status 'rub off'." (Rosenblatt 1988, p. 69). Membership of a collective can also help create a sense of self awareness. As Sullivan points out, "At some level, there is an understanding that the events in question are concerned with 'us' and celebrate 'our' achievements, values, standards or goals, which implicitly or explicitly constructs or imagines an 'other'" (Sullivan 2014b, p. 1–2).

Economists have explored the role of pride as an example of behaviour which departs from the 'rational'. For example, personal pride might inhibit an unemployed person from accepting the dole, or encourage others to work harder for no additional remuneration. Pride is also relevant in understanding conformism in consumer behaviour (Wilcox et al. 2011).

One of the collectives in which pride has long been associated is the nation, the "positive affect that the public feels towards their country" (Smith, Kim 2006, p. 127). National pride involves admiration and stake-holding as well as, "the feeling that one has some kind of share in an achievement or admirable quality" (Evans, Kelley 2002, p. 303). Fabrykant, Magun (2015) go on to make a useful distinction between pride based on objective and normative criteria[3]. National pride has been characterised as imagined kinship through shared acceptance of political institutions and norms (Ha, Jang 2015)[4].

The nation and the city are both spatially bound collectives but they differ over the role of choice. Most people do not have a choice of country, whereas it is rare not to have a choice of city therein. Investing in the city is therefore discretionary in a way it is not with the country[5]. This may be one of the reasons why, "the 'sentiment of urban pride' is becoming more and more popular and widespread as a form of identity that often dominates the national one" (Bell, de Shalit 2011, Pachenkov 2014, p. 368). It is

[3]They argue that rational national pride requires some objective grounds to believe in a nation's perfection, and normative national pride is not so strongly related to objective achievements and therefore can be more easily manipulated. The practical implication of this difference stems from the fact that in their search for objectively grounded national pride people would be eager to foster country achievements and their maintenance of normatively imposed pride requires in many cases just reliably protected wishful thinking (Fabrykant, Magun 2015). Elements of this argument may well apply to cities, but a more sophisticated question on urban pride than the one available for this paper would be required to test its applicability.

[4]The degree to which national pride originates from 'civic' versus 'ethnic identity' is still a matter of debate within this literature and the results depend partly on whether individuals are being compared across countries (Reeskens, Wright 2011).

[5]For this very same reason however there is a need to pay closer attention to issues of endogeneity in the study of urban pride compared to national pride.

also one of the reasons for the growing attention being paid to city branding (Sevin 2014, Zenker, Rutter 2014).

2.1 Urban pride

There are three main reasons why scholars have begun to pay attention to urban pride. The first has been to identify 'soft' returns as complements to the financial returns to investment. The focus here is on the degree to which local investments enhance pride in the region or country (think most recently of the Olympics in Rio de Janeiro, or London four years earlier)[6]. A second reason is to better understand ways of fostering urban pride (Trueman et al. 2004), notably through city promotion (Anttiroiko 2015). Both these literatures focus primarily on the aggregate or collective consequences of urban pride rather than the way pride is distributed across city residents themselves.

A third reason has been to understand how pride has been invoked in support of urban redevelopment. Williams (1995), for example, has shown how the term urban pride has been used in the United Kingdom to promote a realignment of urban regeneration policy based on public-private sector partnerships[7]. He argues that so-called City Pride experiments of the early 1990s were only superficially about city pride and were more about procurement and delivery of resources for the development of property[8]. As such, city pride has been used as a smokescreen for a much narrower set of interests, public and private (Randall 1995)[9].

In a more recent paper, Collins (2016) considers the way in which cities promote and defend local identity and autonomy through the evocation of 'civic pride'. The contrast between Collin's perspective and the one I take below invites a distinction between *civic* pride as the term is used by various urban leaders and spokespersons, and what I introduce here as *urban* pride, the pride expressed by individual residents in their city. According to this distinction, civic pride refers to pride packaged from the 'top' by city leaders and urban pride to pride expressed from 'below', by individual residents.

Defined in this way civic pride and urban pride represent different perspectives and are likely to be measured and analysed in different ways. For example, Collins applies a discourse analysis to recent urban documents and local media as a way of examining how civic pride is mobilised and promoted within and beyond the city. By contrast, my paper is concerned with how and why urban pride is expressed by individuals and the relative effect of the city on those relationships. I apply a statistical model in order to understand the implied multilevel variance.

One of the possibilities that emerges from the identification of these two types of pride, civic and urban, is that the view from the 'top', may not be highly correlated with the view from the 'below'. One of the reasons for this disjuncture is statistical: civic pride is a packaged average based largely on anecdote whereas urban pride is a distribution based on a representative sample of city residents. The latter can range from very high levels of urban pride expressed by residents who are passionate about their city through to quite

[6] There is also evidence that international sporting success can be captured in higher subjective wellbeing (Pawlowski et al. 2014) even if the effect is short lived (Cummins 2009). The propagation of urban pride via the Sydney Olympics also appears to have been successful because, "Regardless of socio-economic divisions within Sydney, the anticipatory effect of hosting an Olympics united residents in feelings of achievement, civic pride and community" (Waitt 2001). The united Germany's quest for the FIFA world cup is another example (Sullivan 2014b,a) (Sullivan, 2014a, 2014b). The collective pride in that responsibility promoted subjective wellbeing and accelerated the convergence of East Germans' preferences towards those of West Germans (Sussmuth et al. 2010).

[7] The City Pride initiative was announced in November 1993 with Birmingham, London and Manchester being challenged to prepare a 'City Prospectus' in "an attempt to provide a coherent vision involving the cultural assimilation of local 'partners' and 'stakeholders', and competitive resource targeting beyond existing bidding mechanisms" (Williams 1995).

[8] The policy was more directly aimed at collective co-ordination of investment and local service provision with a focus on, "sustainable development, and the need to increase integration between land uses and the activities of the various actors in order to improve the quality of urban life" (Williams 1995).

[9] From Randall's perspective the City Pride movement in the UK in 1990s was, "a property rather than people-led vision of urban development with its implicit, if unsubstantiated, faith in its supposed spin-offs percolating downwards to benefit all social layers . . . .it is exclusionary, allowing participation only to those who can afford the entry price" (Randall 1995, p. 43).

negative views expressed by those who are actively hostile. As I show below, the actual variance is quite wide, complex, and in need of understanding.

2.2 Hypotheses

The broad hypothesis of this paper is that the level of urban pride returned by city residents is a function of their individual and collective stake in the city. Without stake holding there is no urban pride and I propose four types: emotional, financial, cultural, and civic stakeholding. Although these respective stakes can operate independently they can also be reinforcing such as when the emotional and cultural combine, or the financial and civic join forces.

The first form of stake holding is the '*emotional*', the way people *feel* about the city and what it means to them personally. This form of sentimental attachment takes time to develop and deepen and for this reason it is positively associated with the duration of residence. Those residents whose families have grown up in the city and whose friends continue to live there have a major stake in their continuing presence in the city. The 2011 earthquake in Christchurch, New Zealand was a salient reminder of the emotional cost to residents who experienced their city being removed from under them.

The second form of stake holding is '*financial*'. Prime candidates are home owners and those in full-time employment who have the means to invest locally. Their livelihood is tied materially to the fortunes of the city. By extension, those who find it difficult to get an economic foothold in the city are likely to have a lower stake which is expected to be reflected in lower levels of urban pride.

The third type of stake holding I term '*cultural*' and involves those whose sense of collective (as opposed to personal) identity is linked to the way the city meets their cultural needs. Their initial support is tied to the sharing of their location with others like them and their pride in their city largely reflects what living in the city means to them in identity terms.

The fourth type of stake holding I refer to as '*civic*' for it refers to the level of engagement people have with the leadership, administration, and general running of the city.

There have been very few attempts to actually measure and quantify urban pride. Some initial steps were made in response to a perceived reduction in community belonging associated with the restructuring of cities and towns in the United Kingdom (e.g. Wood 2006)[10]. The restructuring of the New Zealand economy in the 1980s and 1990s prompted a similar response when local governments realised that evidence on quality of local life and wellbeing was needed if they were to make credible cases for devolution. The result was the introduction of an on-going survey aimed at capturing the quality of urban life in the late 1990s, the New Zealand Quality of Life Survey[11].

[10]Few surveys have asked about pride of any kind. An exception is the World Value Survey (WVS), which includes a question about the 'degree of pride in your work' and 'pride in your nationality'. The International Social Survey Programme (ISSP) National Identity modules come close. They ask 'How close – how emotionally attached – do you feel to ... your town or city' (Kelly 1998). However such a question does not capture pride as a distinct emotion. Both surveys are also administered in New Zealand and the responses have been explored by the author (but not reported here) and offer support for the conclusions drawn on the basis of the New Zealand Quality of Life Survey. The closest the New Zealand General Social Survey comes is a question on satisfaction with services.

[11]Details of the New Zealand Quality of Life Project may be found in http://www.qualityoflifeproject.-govt.nz/. In addition to being followed by descriptive reports after each round, the Quality of Life Survey has also been used as the evidence base for several research publications. The first used the 2004 sample to study inter-city variations in subjective wellbeing (Morrison 2007), and was later extended to include measures of accessibility using the 2006 survey (Morrison 2011). In a later study, local economists merged the 2006 and 2008 Quality of Life Surveys in order to assess the role of home ownership on social capital (Roskruge et al. 2013). These last three papers did not formally recognise the theoretical and methodological implications of the fact that sampled individuals were grouped within cities (or by neighbourhoods within cities) and hence that the micro-economic behaviour and attitudes of individuals might vary depending on the particular geographic context in which they lived. The first to attempt to measure context effects using the Quality of Life survey were local psychologists interested in how people's 'sense of community' varied across individuals and neighbourhoods (Sengupta et al. 2013). The focus of their study however was the neighbourhood, not the city.

1. Rodney 2. North Shore 3. Waitakere 4. Auckland 5. Manukau 6. Hamilton
7. Tauranga 8. Porirua 9. Hutt 10. Wellington 11. Christchurch 12. Dunedin
Note: Although Rodney is a district rather than a city, I retain the survey's own description of it as a city.
Source: Quality of Life Team (2009)

Figure 1: The location of the twelve cities included in the Quality of Life project. New Zealand, 2008

3 The Quality of Life Survey

The Quality of Life Survey is a multi-agency research project designed to explore quality of life issues every two years in a selection of New Zealand cities[12]. The 2008 survey was a partnership between twelve New Zealand City Councils and the Ministry of Social Development. The survey captures New Zealand residents' perceptions of their quality of life, health and wellbeing, crime and safety, community, culture and social networks, city council decision making processes, environment, public transport, lifestyle, and work and study[13].

The 2008 survey was not the latest available at the time of writing. It was selected for this particular study because a subsequent amalgamation of the four previously separate Auckland cities to form a new unitary authority reduced the number of urban areas from 12 to 8 thus reducing the range of cities which could be included[14]. The locations of the twelve cities covered in the 2008 survey are shown in Figure 1.

The twelve cities include almost 59 percent of the country's total population. The largest city, as of the 2006 census, was Auckland City (404.6 thousand), followed by Christchurch (348.4), Manukau (329), and North Shore (205.6). The smallest was Porirua City (48.5). As Figure 1 shows, eight of the twelve cities were located in either the Auckland or Wellington Metropolitan areas.

[12] This account draws on Quality of Life Team (2009, p. 4).

[13] A probabilistic sample of the population of approximately 500 aged 15 years or older was drawn from each city. The 2008 survey involved Computer Assisted Telephone Interviews (CATI) conducted with n=8,155 (including 1,500 residents from outside the twelve cities who were aged 15 years and older). Quotas were set for ethnicity, age, location and gender. Respondents were selected randomly from the Electoral Roll and a pre-notification letter was sent to potential respondents, who were contacted by phone for the interviewing. Fieldwork was conducted between 16 July and 28 October 2008. The average duration of the interviews was 20.3 minutes and the final response rate was 37 percent.

[14] Auckland Council became a unitary authority in November, 2010 when the Auckland regional council area and seven territorial authority areas amalgamated Rodney district, North Shore city, Waitakere city, Auckland city, Manukau city, Papakura district, and Franklin district.

Table 1: Responses to the statement "I feel a sense of pride in the way [my city] looks and feels". Twelve New Zealand cities, 2008

Response	Frequency	Percent	Cumulative Percent
Strongly disagree	98	1.5	1.5
Disagree	443	6.6	8.0
Neutral	1,786	26.5	34.6
Agree	3,068	45.6	80.1
Strongly agree	1,341	19.9	100
Total	**6,736**	**100.0**	

Source: Quality of Life Survey, 2008.
Note: Excludes 21 respondents who did not know.

Each city is divided into electoral wards which are a contiguous areal groupings of relatively similar neighbourhoods. The four large cities in Auckland are divided into three to six wards each, Wellington City into five wards and Christchurch into seven. The total number of wards over the 12 cities is 59[15]. The average number of sampled individuals per ward is 103 although they range in size from a minimum sample of 2 to a maximum of 230 people. Some individuals were not able to be assigned to wards thus reducing the usable sample size when wards are analysed from 6117 to 6093[16].

3.1 Measuring urban pride

The measure of urban pride used in this paper are the responses to the following question: "On a scale of one to five where one is strongly disagree and five is strongly agree, rate your agreement with the statement, '*I feel a sense of pride in the way [my city] looks and feels*'."[17]

The general tendency was for New Zealand city dwellers to return at least some level of pride in their city. The responses tabulated in Table 1 show that almost 63 percent (45.2 + 19.9) felt positively about 'how their city looked and felt'. Over one quarter were ambivalent in that they neither agreed nor disagreed, and fewer than 10 percent (7.7) did *not* feel a sense of urban pride as defined.

The urban pride question generates responses on an ordinal scale. While methods of analysing such responses are well developed (Hosmer, Lemeshow 2000, McKelvey, Zovoina 1975) it is now common for quantitative analysis of related wellbeing questions to assume a cardinal level of measurement (Ferrer-i Carbonell, Frijters 2004). The estimated coefficients are much easier to interpret and accord very closely with the relative magnitudes estimated by the ordinal logit model (Kristoffersen 2010)[18].

[15] Boundary maps of the electoral wards laid over standard Google street maps may be found in: https://koordinates.com/layer/2159-nz-electoral-wards-2011-yearly-pattern/

[16] Since multilevel analysis involves two or more levels, questions are often asked about optimal sample sizes. Hox (2002) mentions Kreft's 30/30 rule, which suggests 30 groups with at least 30 individuals in each. This could be sufficient for the estimation of the regression coefficients but inadequate for other purposes. If it is cross-level interactions that are of interest, Hox recommends the 50/20 rule: 50 groups with 20 or more in each group. If there is strong interest in the random part, the advice is 100 groups with a minimum of ten in each: http://essedunet.nsd.uib.no/cms/topics/multilevel/ch3/5.html. A slightly different take is offered by Rabe-Hesketh, Skrondal (2008, p. 62): "It is often said that the random-effects approach should only be used if there is a sufficient number of clusters in the sample, typically more than 10 or 20. However, if a random-effects approach is used merely to make appropriate inferences regarding β, a smaller number of clusters may suffice. Regarding cluster sizes, these should be large in the fixed-effects approach if the α_j are of interest. However, in random-effects models, it is only required that there are a good number of clusters of size 2 or more. It does not matter if there are also 'clusters' of size 1".

[17] Administration of four validity tests – content, retest, criterion and construct validity – confirmed that the pride question was sufficiently robust to be modelled. The urban pride question produced similar distributions when it was asked in in 2004, 2006, 2010 and again in 2012.

[18] Decisions to report the OLS results from Likert scales are now routine (see for example Helliwell, Putnam 2004, p. 1438).

Treating urban pride as a continuous measure yields a mean 3.71 on the 1-5 scale (SD=0.87). The highest average level of pride, 4.12, was reported by residents of Wellington City (the country's capital), and the lowest were returned by residents in the City of Manukau, 3.33, located within the wider Auckland region. The intermediate levels of urban pride in descending order were the cities of North Shore 3.90, Dunedin 3.87, Tauranga, and Hamilton, 3.83 Christchurch 3.82, Waitakere, 3.62 Lower Hutt, 3.61 Porirua, 3.57 Rodney, 3.56 and Auckland, 3.48.

In summary, the New Zealand Quality of Life survey has provided the research community with an opportunity to explore the distribution of urban pride across the country's cities. Urban pride is captured in a single measure which asks respondents to declare how strongly they agree they feel a sense of pride in the way their city looks and feels. Following common practice in studies of subjective wellbeing, I treat the ordinal responses as cardinal and will now model this variation as a function of individual stake holding and city characteristics[19].

4 The two level model

Most studies of emotional response apply the conventional OLS 'total' regression model to the relationship between the outcome y and arguments X in order to estimate the *fixed* parameters α and β, where i refers to the individual[20].

$$\boldsymbol{y}_i = \alpha_0 + \beta X_i + \boldsymbol{\epsilon}_i \tag{1}$$

In such a model the random or allowed-to-vary element is captured by $\boldsymbol{\epsilon}$, the mean or expected value of which is assumed to be zero. An accompanying assumption is that there is constant variability in $\boldsymbol{\epsilon}_i$ and no autocorrelation. The assumption is necessary if the variance of the error term is to be characterised by a single parameter σ^2_ϵ.[21]

The application of equation (1) would fail to address two integral features of urban pride: that pride is likely to be contagious *within* the city, as well as being responsive to differences *between* cities. The presence of contagion and inter-city differences violates the i.i.d assumptions of the OLS regression model implicit in $\boldsymbol{\epsilon}$ and renders the occurrence of type 1 errors more likely (Kreft, du Leeuw 2006, Rabe-Hesketh, Skrondal 2008).

A more suitable model would allow average levels of urban pride to vary across cities so that the average level of urban pride in the j^{th} city is the sum of the city-wide average, α_0, plus a varying difference $\boldsymbol{u}_j$.[22]. The fixed intercept, α_0, would represent the average level of urban pride across all the cities and the variance, σ^2_μ, would measure the inter-city variability about the average[23].

$$a_{0j} = \alpha_0 + \boldsymbol{u}_j \tag{2}$$

Combining the micro equation of (1) and the macro equation of (2) produces the two-level mixed model of equation (3).[24]

$$\boldsymbol{y}_{ij} = \alpha_0 + \beta x_{ij} + (\boldsymbol{u}_j + \boldsymbol{\epsilon}_{ij}) \tag{3}$$

An initial step in applying this random intercepts model is to estimate the proportion of the variance attributable to differences among individuals at one level and cities at the other. In this null model,

[19] Multilevel models are used to estimate context effects – in this case the marginal and cross-level effect of the city (context) on urban pride. Two useful introductions to the method are Luke's study of voting behaviour in the USA (Luke 2004) and Jones et al. (1992) for the UK.

[20] I follow Kreft, du Leeuw (2006, p. 22) in writing random variables in bold, $\boldsymbol{y}_i$ and $\boldsymbol{\epsilon}_i$.

[21] The following account draws on two particularly clear introductions to multilevel models in two fields, geography and public health (Jones 1991, Subramanian et al. 2003).

[22] Although I introduce a layer between the individual and city, the ward variation turns out to simply be a composition effect. Therefore the three level model will not be continued into the multilevel model and j will continue to refer to the city level.

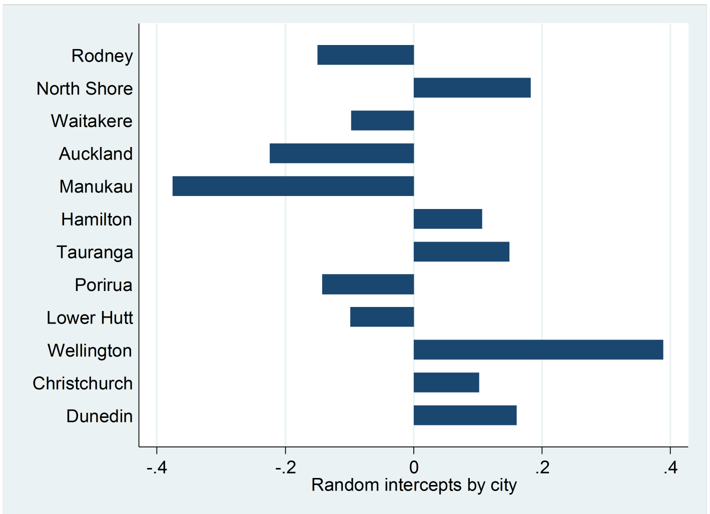
[23] If this equation was used to estimate the relationship between urban pride and the level of stake holding the effect of the city itself would be subsumed within the error term $\boldsymbol{\epsilon}_i$ and go unrecognised as such. By contrast, the random intercepts model (equation 3) allows this inter-city heterogeneity to be recognised.

[24] There is of course also an implicit variable here multiplied by α_0, x_0 which is a vector of ones

Table 2: Intra-class correlation coefficients: cities, wards, cities and wards. New Zealand 2008

Levels	**ICC**	**SE**	**95% confidence interval**	
Cities	0.06	0.02	0.03	0.12
Wards	0.07	0.01	0.05	0.11
Cities/Wards	0.06	0.02	0.02	0.12
Wards/Cities	0.07	0.02	0.03	0.13

Source: Quality of Life Survey, 2008.



Source: Quality of Life Survey, 2008.

Figure 2: Inter-city variation in urban pride: predicted random intercepts by city. New Zealand 2008.

$$\boldsymbol{y}_{ij} = \alpha_0 + (\boldsymbol{u}_j + \boldsymbol{\epsilon}_{ij}) \tag{4}$$

where the proportion of the variance attributable to individuals is

$$\frac{\sigma_\epsilon^2}{\sigma_\epsilon^2 + \sigma_\mu^2}$$

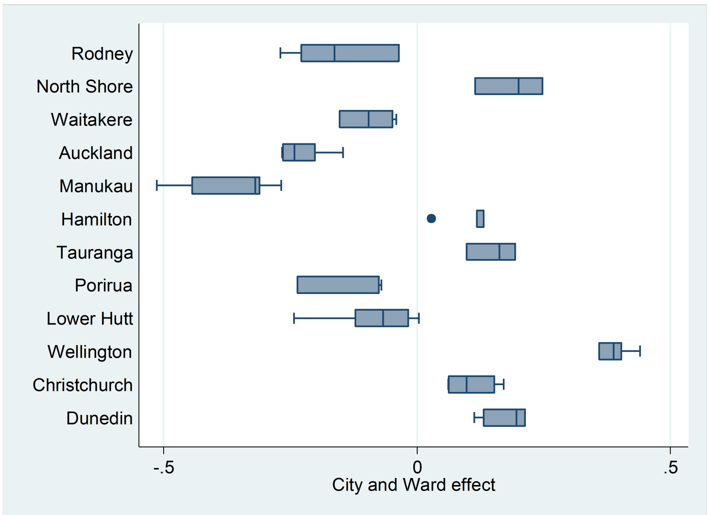
and the variation across cities is

$$\frac{\sigma_\mu^2}{\sigma_\epsilon^2 + \sigma_\mu^2}$$

which is referred to as the *intra-class correlation* (ICC).

In this application, the intra-class correlation is a measure of the degree to which individuals share the experiences of living in the same city. If the correlation is greater than zero then there is a case for applying a random coefficients model and its extension as a multilevel model. The presumption in such a step is that the differences we see in the level of urban pride from one city to another is not due simply to differences in the levels of stake holding by individual residents (the *composition* effect) but arise in part from differences among the cities themselves (the *context* effect).

An intra-class correlation coefficient of 5.7 percent implies that differences in levels of urban pride across the 12 cities account for nearly 6 percent of the variance in urban pride (Table 2). The rest, 94 percent, is due to the differences among individuals. A similar partitioning of the variance applies if clustering is confined to the 59 wards, however since



Source: Quality of Life Survey, 2008.

Figure 3: Ward to ward variation in urban pride within cities: predicted random intercepts by wards within cities. New Zealand 2008.

wards are nested within cities, both variances are reduced slightly when they are both included; to 5.5 and 6.6 percent, respectively[25].

In summary, since urban pride varies both within and between cities as a possible result of both contagion and intercity differences, the standard OLS regression model is better replaced by one which treats the city as a random variable.

5 A random intercepts model

The random intercept model of equation (4) implies a different intercept term for each city, $\alpha + \mu_j$; $j = 1, \ldots, 12$. These terms are not estimated directly but we can use linear unbiased predictions (BLUPS) of their random effects as shown in Figure 2. At one extreme, the City of Manukau has a prediction one half a standard deviation lower than the grand mean, and Wellington City almost half a standard deviation higher. These differences in the average level of urban pride across the twelve New Zealand cities are immediately recognised by New Zealand audiences (often with a smile).

Recognising that average levels of urban pride vary across New Zealand cities does not in itself address the fact that urban pride may vary within cities. We can identify variation both within and between cities by adding the neighbourhood intercept term $\boldsymbol{u}_*$ to equation (3), that is, $\boldsymbol{u}_j + \boldsymbol{u}_* + \boldsymbol{\epsilon}_{ij}$. Ward random effects are not calculated directly either but we can overlay their best linear unbiased predictions as in Figure 3. The median in each box reflects the city random intercepts while the length of the boxes (and the outliers) indicates the degree of inter-ward variation within each city.

As Figure 3 shows, the inter-ward variation in urban pride varies noticeably from one city to another, being relatively wide in Rodney and Manukau and Porirua and comparatively narrow in Wellington and Auckland.

5.1 Differences among residents

As expected, urban pride varies across cities. It also appears that levels of urban pride vary by ward. We now turn to the third possible source of variation – differences among individuals themselves.

Nine separate sources of individual stake holding along with two controls are listed under the four headings in Table 3 together with their respective means and standard

[25] Similar magnitudes are obtained when pride is represented as a binary variable, i.e. when 1 is set to either Strongly Agreeing with the pride statement or Agreeing and Strongly Agreeing.

Table 3: Measures of stake holding and controls used in the modelling of urban pride. New Zealand, 2008

Variable	Description	Mean	Std Dev
Controls			
Female	Female	0.53	0.50
Health	Health good or very good	0.61	0.49
Emotional stakes			
Duration	Resident in city 10 years +	0.70	0.46
Community	Sense of community	0.55	0.50
Financial stakes			
Owner	Home owner	0.62	0.49
Not employed	Not employed	0.26	0.44
Enough	Income meets everyday needs	0.87	0.34
Cultural stake			
Minority	Non-European	0.23	0.42
Civic stakes			
Safe	Feel safe in central city	0.63	0.48
Clean	No rubbish noticed	0.49	0.50
Council	Councidence in Council decisions	0.46	0.50

Source: Quality of Life Survey, 2008.
Note: The relevant survey questions are listed in the Appendix.

deviation. Each is a binary variable coded so that the expected sign is positively correlated with urban pride. The emotional stake in the city is represented by two variables. The first is duration of residence and we learn that over 70 percent of residents had lived in their city for a decade or more. Notwithstanding this long average association with the city, only 55.3 percent felt their neighbourhood offered them a sense of community.

Three measures are designed to capture residents' financial stake in the city: home-ownership (62 percent)[26], employment (over three quarters) and nearly 87 percent said they had enough money to live on[27]. Having a cultural stake in the city is represented by a single variable, membership of a minority ethnic group, collected here under the term non-European (23 percent)[28]. Three measures were used to identify civic stake holding: whether the respondent felt safe or very safe in their city centre during the day (63.4%), whether they identified litter and rubbish lying on the street (49.3%), and whether they agreed that 'the council makes decisions that are in the best interests of their city' (45.5 %)[29]. The two controls in Table 3 reveal a slight majority of women in the sample (52.8%), and a population where nearly 61 percent of respondents are in Good or Very Good Health.

[26]The exact definition of home ownership affects the strength of the relationship between ownership and pride, the tighter or more literal definition the stronger the link. See the Appendix for the definitions used.

[27]This subjective measure of economic prosperity has been selected for two reasons. Firstly, although income (at both the individual and household level) is collected by the survey, the response rates are unacceptably low. Secondly, when people report their perceived ability to cope financially they implicitly consider the local costs of living and these vary from one city to another.

[28]The term European is ambiguous in the New Zealand context for various reasons including the widespread presence of dual ethnicity. In this survey around seven percent of respondents reported dual ethnicity (mainly Maori and European). They have been included here as European as have those identifying as 'Kiwi' or New Zealander.

[29]The base population implied by Table 3 (where all the arguments take zero values) identifies European men in relatively poorer health who have lived in the city for less than a decade, who do not feel a sense of community, who are not owners but are employed and have enough money. This group typically feels less than safe in their central city, notice rubbish less and feel the council does not act in the city's best interests.

Table 4: Correlation matrix of urban pride arguments. New Zealand, 2008

		1	2	3	4	5	6	7	8	9	10
1	Female	1.00									
2	Health	0.04	1.00								
3	Duration	0.04	-0.01	1.00							
4	Community	***0.04***	0.04	0.03	1.00						
5	Owner	0.04	0.01	***0.06***	***0.09***	1.00					
6	Not employed	***0.12***	***-0.10***	***0.05***	***0.08***	-0.02	1.00				
7	Enough	0.01	***0.10***	0.04	0.01	***0.10***	***-0.07***	1.00			
8	Minority	-0.04	***-0.11***	***-0.14***	***0.06***	***-0.18***	***-0.06***	***-0.10***	1.00		
9	Safe	***-0.06***	***0.12***	0.00	0.01	***-0.05***	0.02	0.04	***-0.08***	1.00	
10	Clean	-0.03	0.02	***-0.05***	***0.04***	0.02	0.00	0.02	0.01	***0.11***	1.00
11	Council	0.00	0.03	***-0.05***	***0.09***	***-0.13***	0.03	0.02	***0.10***	***0.07***	***0.09***

Source: Quality of Life Survey, 2008.
Number of observations: Min 5957 to Max 6093.

5.2 *The correlation matrix*

The pairwise correlation matrix of the 11 variables listed above is reproduced in Table 4. Although the variance inflation factor was low at 1.05 and tolerances were all over 0.9, almost half the pairwise correlations were statistically significant ($p \leq 0.05$ in bold italics)[30].

The connections implied by this correlation matrix are instructive. Reading the statistically significant correlations by column shows that women (column 1) were more likely to feel a sense of community in their neighbourhood, were less likely to be employed, and felt less safe within the city centre during the day. From column 2 we learn that good health was associated with being employed, having enough money, being defined as European, and feeling safe. Column 3, duration, identifies those who lived in the city for a decade. They are more likely to be home owners, less likely to be employed or identify as a minority. They are also more likely to be critical of the city in terms of its cleanliness and the extent to which the council represents the interests of the majority.

Feeling a sense of community (column 4) is positively correlated with home ownership, not being employed, being a minority, seeing the city as clean, and feeling positive about council. Home ownership (column 5), is associated with having enough money and not being a minority, but also not feeling safe in the city centre or agreeing that council works in the best interests of the majority. Not being employed (column 6) is negatively associated with having enough money and not identifying with minority status. Having enough money (column 7) is a characteristic of minorities, as is feeling very safe in the city centre, but feeling less positive about council decisions. Identification with a minority is negatively correlated with feeling safe in the central city but positively associated with approval of council. Those who feel safe in the city also view the city as clean and have a positive view of council (column 9). Appreciating a clean city and viewing council positively are positively correlated (column 10).

The results of applying the random intercepts model (equation 3) are presented in Table 5. The results only include city random effects because the inter-ward intra-class correlation dropped to almost zero. In other words, ward to ward differences in urban pride were due almost entirely to population composition effects rather than to unique contexts characteristic of the wards themselves[31]. Cities, rather than wards within them, are the primary object of city pride as the city pride question itself implies.

The first point to note from the fixed effects estimates in Table 5 is that urban pride is most strongly associated with civic stake holding, and with the confidence people have that their council works in their best interests. Those supporting Council have a mean

[30] The Šidák correction used here takes multiple comparisons into account.

[31] In many applications of the multilevel model adding successive attributes of individuals absorbs some of the variance that occurs between level 2 groups. The variability in the ICC that takes place when variables are added can reflect an incomplete specification of the level 1 effects model.

Table 5: The distribution of urban pride. Stake holding fixed effects and city random effects. New Zealand, 2008

Variable	Description	Coef.	Std Err.	z	P > |z|
	FIXED EFFECTS				
Controls					
Female	Female	0.10	0.02	4.91	0.00
Health	Health good or very good	0.06	0.21	3.01	0.00
Emotional stakes					
Duration	Resident in city for 10 years or more	0.11	0.02	4.78	0.00
Community	Sense of community	0.24	0.02	11.22	0.00
Financial stakes					
Owner	Home owner	0.08	0.08	3.80	0.00
Not employed	Not employed	0.06	0.02	2.45	0.01
Enough	Income meets everyday needs	0.10	0.03	3.17	0.00
Cultural stakes					
Minority	Non-European	0.20	0.03	7.44	0.00
Civic stakes					
Safe	Feel safe in the central city	0.21	0.02	9.37	0.00
Clean	No rubbish noticed	0.23	0.02	11.20	0.00
Council	Confidence in council decisions	0.37	0.02	17.68	0.00
Constant		2.80	0.07	37.36	0.00
	RANDOM EFFECTS				
Cities	Constant	0.04	0.02		
	Residual	0.61	0.01		
Number of cases		5867			
Log likelihood		-6897.12			
LR vs linear model test		348.72			
Wald chi, pr=0		982.88			
Degrees of freedom		14			
AIC		13822.23			
Intraclass correlation		0.07			

Source: Quality of Life Survey, 2008.
Note: Estimates from the MIXED model, Stata14.

level of urban pride which is over one third (0.37%) of a unit higher than the rest of the population on the 1-5 urban pride scale. Those who feel a sense of community, see a clean city, and feel safe in its centre have a mean pride between a fifth and a quarter of a unit higher than the base population. Being non-European has a similar effect (0.20).

Having lived in the city for a decade or more has a weaker but still positive effect on urban pride, as does being female and being in good health. Having enough money to meet every day needs and being a homeowner are less important but still positive, increasing urban pride by at 0.10 and 0.08 of a unit, respectively. Being in retirement (most of those not employed) also contributes (0.06).

The model with covariates is a clear improvement over the null model with cities alone. In the absence of a clear equivalent of the r-squared statistic, R^2, I use the Akaike Information Criterion (AIC) $(-2\log(\text{likelihood}) + 2k)$, where k is the number of model parameters and $-2\log(\text{likelihood})$ is the deviance statistic. The difference between the null model and the model reported in Table 5 in AIC terms is 1901 = 15723-13822.

In summary, when it comes to accounting for the way urban pride varies over the population, the measures introduced to represent stake holding clearly matter. Urban

Table 6: Selected characteristics of the twelve New Zealand cities.

City	Pride	Population('000)	Affluence	European	Council
Rodney District	3.56	89.56	0.10	0.95	0.30
North Shore City	3.90	205.61	0.13	0.77	0.44
Waitakere City	3.62	186.44	0.07	0.67	0.48
Auckland City	3.48	404.66	0.14	0.62	0.40
Manukau City	3.33	323.97	0.07	0.46	0.51
Hamilton City	3.83	129.25	0.07	0.76	0.57
Tauranga City	3.87	103.64	0.06	0.88	0.40
Porirua City	3.57	48.55	0.10	0.66	0.51
Lower Hutt City	3.61	86.93	0.09	0.75	0.47
Wellington City	4.12	179.47	0.17	0.81	0.50
Christchurch City	3.82	348.44	0.07	0.88	0.41
Dunedin City	3.88	118.68	0.05	0.92	0.46

Source: Census of Population and Dwellings, 2006 and Quality of Life Survey, 2008.

pride is most sensitive to the degree to which council is recognised as listening to the people, a result which highlights the role of city leadership (Boezeman, Ellemers 2014). Feeling a sense of community, appreciating a clean city, and feeling safe in the city centre all contribute to a sense of urban pride as does being a member of an ethnic minority. Having a financial stake in the city (having enough income and being a homeowner) also matters but not to the degree anticipated.

6 City context

The results I have summarised from Table 5 suggest that urban pride reflects a sense of collective achievement rather than personal success. We might ask in addition whether cities themselves raise or lower urban pride. In the absence of an empirical literature on urban pride, I start with four relatively generic attributes of the city: its population size, its level of affluence, the share of Europeans in the population, and the confidence people have in its civic leadership. It is possible to think of a range of other measures such as the quality of the environment, but these will remain as suggested refinements only.

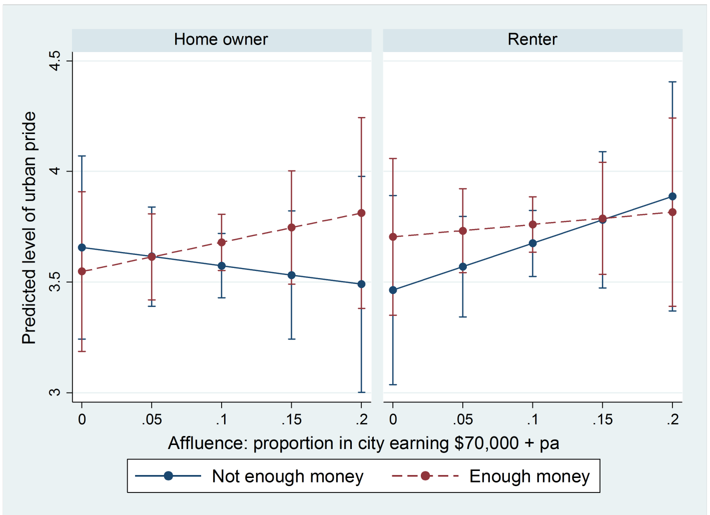
The distributions of the city's four characteristics are shown in Table 6 along with the average level of pride in each city. The population figure is drawn from the nearest population census (2006) as are the proportion of individuals with pre-tax incomes of over $70,000 per annum, and the proportion of Europeans in the city. The fourth variable, civic engagement, is aggregated from the sample responses.

The fixed effects coefficients at the individual level remained remarkably stable when each of these city level measures is added to the model singly or together. The exception is the variable 'minority' whose influence on urban pride drops as a result of the high concentration of the minority population in the two cities of Manukau and Porirua.

While the difference between the cities themselves may not account for much of the variance in urban pride, the contexts they represent may still condition the marginal effect of individual attributes. This tempering turns out to be the principle role of the city when it comes to understanding urban pride.

7 The multilevel model

Urban pride is a two-way street because it reflects attributes of both the residents *and* the characteristics of the city. However, while New Zealand cities do differ in size and composition, their differences appear to have little influence in raising or lowering urban pride. Rather, the role of the characteristics of the city is to modify the way particular forms of stake holding raise or lower urban pride.



Source: Quality of Life Survey, 2008 and Census of Population and Dwellings, 2006.
Note: With the same fixed and random effects as in Table 5 adding the interaction of enough x owner x affluence term yields a coefficient of -3.72 and a standard error of 1.91 and a z of -1.95 and $p > (z)$ of 0.052. The 95% confidence intervals are plotted.

Figure 4: The effect of 'not having enough money' on urban pride in more affluent cities by housing tenure. New Zealand, 2008

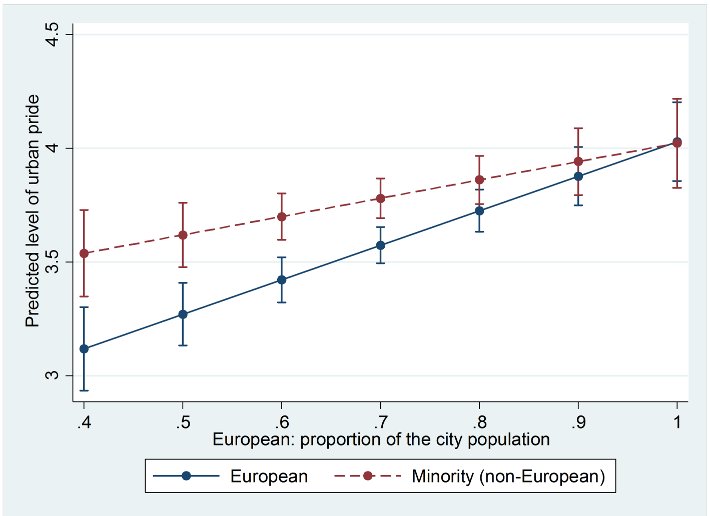
I illustrate this last point by showing that the negative effect on urban pride of not having enough money has greater effect in more affluent cities, that the level of urban pride exhibited by minorities rises as their share of the population increases, and that duration of residence modifies the way city-wide support of the local city council affects urban pride. These do not exhaust the possible interactions between individuals and their city of course, but they do indicate the way the city can influence the level of urban pride people express.

7.1 The influence of context on financial stake holding

The motivation for the first of these illustrations is the possible role of relativities. The argument here is that it is not just financial wellbeing that moderates one's pride in the city but one's *relative* position. Recall from Table 6, that affluence at the city level is measured as the proportion of the 2006 census population who earn more than $70,000 per annum (before tax). The range across New Zealand cities is quite wide, from a low of five percent in Dunedin City through to 17 percent in the capital, Wellington City. The testable proposition is that not having enough money 'to meet every day needs' may have a greater negative effect on urban pride in more affluent cities because it is associated with lower relative rank, over and above the pride reducing effects of material deprivation itself. The secondary argument is that this relationship will vary with homeownership.

I have already shown that, as a characteristic of the city, affluence (a level 2 variable) plays a very limited role in raising or lowering urban pride. However, when having enough money (a level 1 variable) is interacted with city affluence separately for owners and renters, renters without enough money (typically younger residents) return higher levels of urban pride in cities which are more affluent. This result is apparent in the solid line in the right panel of Figure 4. By contrast, homeowners without enough money (typically older residents) return lower levels of urban pride in more affluent cities (solid line, left panel of Figure 4).

By contrast, renters and owners who say they *have* enough money to meet daily needs both return higher levels of urban pride in more affluent cities (the dashed lines in Figure 4) with city affluence having a more marked influence on homeowners' urban pride. The results presented in both panels of Figure 4 are plausible in light of the role I have attributed to stake holding.



Source: Quality of Life Survey, 2008 and Census of Population and Dwellings, 2006.
Note: With the fixed effects of Table 5 in the model, the addition of the cross-level term (minority x European) is $\beta = -0.710$ (SE=0.19; z= -3.74).

Figure 5: The positive impact of minority status on urban pride falls as the proportion of Europeans in the city rises. New Zealand, 2008

7.2 Context influences on cultural stake holding

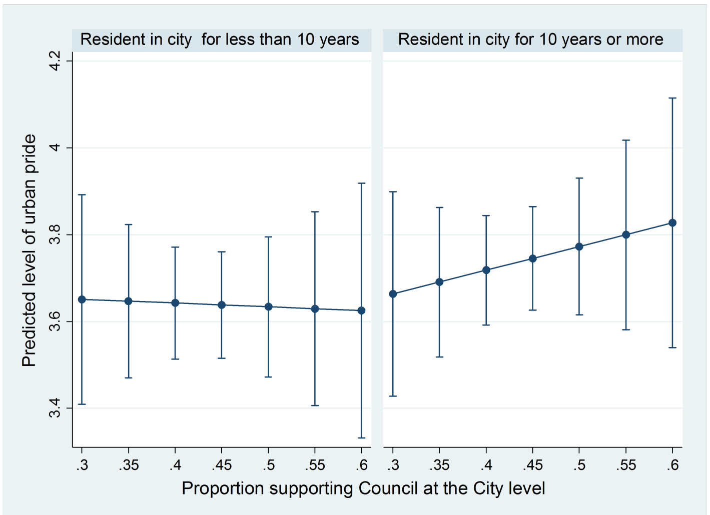
My second illustration addresses the impact minority ethnic status has on urban pride. My expectation was that minorities would return higher levels of pride in cities the larger their share of the population because the relative size of the minority groups have been shown to contribute to both a greater sense of identity and collective strength (Tyler, Blader 2001, p. 209–210). My expectation in the case of non-Europeans living in New Zealand cities therefore was that their sense of identity would diminish as their share of the population fell and this would be reflected in the level of pride they expressed in their city. The evidence in this case rests on the interaction of the level 2 variable 'European' and the level 1 variable 'minority'.

Figure 5 offers support for the minority 'share' hypothesis. The fixed effects results of Table 5 have minorities returning higher levels of urban pride than the European majority. Introducing a city x minority cross-level effect reveals how much urban pride rises as the proportion of Europeans in the city increases. This rise is much slower in the case of minorities (dashed line) and the urban pride converges when the proportion of Europeans in the city approaches its maximum. In other words, while members of ethnic minorities in New Zealand return higher levels of urban pride than the much larger number of Europeans, any such difference falls as the proportion of Europeans rises, reflecting an expected diminution in the social and cultural identity of non-Europeans.

7.3 Does the urban pride effect of support for Councils vary with duration of residence?

A third possible factor influencing urban pride is duration of residence. However, discerning this interaction is more complicated because the relationship could conceivably be two-way. The length of residence in a city could be a function of as well as an influence on pride: being proud of the city may encourage staying, and those who are not particularly proud of their city may be more likely to leave. The endogeneity present in this relationship renders my investigation of this relationship quite exploratory.

Those who see City Councils acting in the interests of the majority return higher levels of urban pride (as I showed in Table 5). However it is possible that this relationship is affected by how long people have lived in the city. The available duration of residence variable only separates those who are relatively new to the city, from those who have lived there for more than a decade. (Finer partitions beyond the decade offered little



Source: Quality of Life Survey, 2008.
Note: The estimate of the Council x duration interaction term is $\beta = 0.631$ (se= 0.32), z = 1.97.

Figure 6: The estimated relationship between urban pride and city wide support for Council: longer vs. shorter term residents. New Zealand, 2008

further insight).

Figure 6, which interacts duration of residence with the proportion of the city supporting Council, suggests that the positive relationship between urban pride and the city's confidence in its council only applies to the longer term residents. The pride experienced by relative new comers in their city appears unaffected by the confidence the city has in its council. The 95% confidence intervals are relatively wide in this case but with the fixed effects of Table 5 in the model the interaction between the level 1 variable duration and the level 2 variable Council is statistically significant.

To summarise Section 7, when it comes to statistically accounting for the variance in the pride we express in our cities, city characteristics themselves account for relatively little. Most of the variance in urban pride comes down to the stake individuals have in their city. Having said that, exactly *how* people's stake in the city affects their level of urban pride is influenced by the characteristics of the city. Being able to demonstrate this contingency and the way in which city context modifies the effect of stake holding on urban pride is one of the primary findings of this paper, and the main reason for reporting the multilevel model.

8 Conclusions

Collins' recent study of pride in British cities suggested that, "civic pride has been under-theorised in geography and that the emotional meanings of pride need to be better understood" (Collins 2016, p. 185). I agree, and in response, I have drawn a distinction between *civic* pride as promulgated by city leaders and the emotion expressed by individual residents themselves which I have termed '*urban* pride'. Such a contrast is designed to expose the difference between city spokespersons claiming citizens are proud of their city and individuals who are free to express their own personal level of urban pride. The later has the value of demonstrating the way different levels of urban pride are distributed both within and between cities.

Civic pride in the sense above is a dimension of self-esteem which city politicians and planners go to great lengths to foster among their citizens. In practice however, most cities are content simply to anecdote civic pride when it suits, and few make a serious attempt to actually measure the level of urban pride empirically. New Zealand cities may have been an exception in this respect by ensuring that their Quality of Life Survey actually included a question on the pride their residents have in their city.

In this paper I have sketched in a theory of urban pride based on stake holding as it applies to the city. I identified four primary sources: the stake holding that accrues through emotional attachment to the city, financial investment in the city, cultural affiliation and civic engagement. I then specified a multilevel model in order to empirically test the relative influence of such stake holding on urban pride. By drawing on a large random sample from twelve cities in an otherwise relatively homogeneous country like New Zealand, I have been able to assess the degree to which the stake individuals have in the city influences how proud they feel.

As a result of the Urban Consortium funding a large sample of nearly 6000 residents in 2008, I have been able to show that certain types of stake holding have more influence than others. After controlling for gender and self-assessed health, individuals positively disposed towards their council, who felt safe and saw their city as clean and well maintained were more likely to declare such pride. This is also true of those who felt a sense of community. I also learned that, other things equal, those who owned their dwelling and who felt they earned enough to meet every day needs also enjoyed higher levels of urban pride. When it came to emotional stake holding, I was able to show that ethnic minorities return higher levels of urban pride as their share of the city population increased.

I went into this project expecting that the identified characteristics of cities themselves would have a major influence on the level of urban pride citizens report. This was not the case. Most of the measurable variance turned out to be due to individual stake holding. By explicitly testing for city x individual interaction (cross level effects) estimates from the multilevel model revealed that city characteristics *conditioned* the way individual stakes in the city influenced urban pride. They revealed how the negative effect on urban pride of not having enough money is more marked in more affluent cities, how the higher levels of urban pride exhibited by minorities increased as their share of the population in the city rose, and how duration of residence affects the way aggregate support of city councils conditioned citizens level of urban pride.

Although broader than Kenneth Boulding's proposition on stake holding, the above findings are consistent with his argument on pride and shame (Boulding 1987). At the same time my analysis has rested on a single definition of urban pride – pride in the 'look and feel of your city'. There are many other ways of asking about urban pride and if and when they are applied we may discover other ways in which stake holding alters the pride we hold in our cities.

Measures of urban pride have been argued to be among the 'soft' returns that accrue to accumulated investment in the city. If city leaders are tempted to use such 'soft' measures alongside the standard financial measures, then we need to know a great deal more about what people mean by urban pride, what generates the emotion, how it takes root and among whom, in what circumstances, and in what kinds of cities. As we have learned from the burgeoning literature on subjective wellbeing, investments in the community are unlikely to carry the force of change unless their returns can be measured (Stiglitz et al. 2009). So far, urban pride has remained a largely unmeasured response to our feelings toward our city and as such remains an unexploited barometer of the distributional consequences of public and private investment.

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A Appendix: Level 1 variables

The survey questions asked are as follows. The underlined responses are coded 1, the rest as zero.

Health Q29: In general how would you rate your health? Poor, fair, good, Very good, Excellent

Duration Q8: How many years have you lived in this city? Less than 1, 1-2, 2-5, 5-10, 10 years or more

Community-sense Q37: R2. I feel a sense of community with others in my local neighbourhood: Strongly agree, Disagree, Neither, Agree, Strongly Agree.

Owner Q57: Who owns the residence you live in? You own this house/flat/apartment, You jointly own this house/flat/apartment with other people, a family trust owns this house/flat/apartment, parents/other family members or partner own this house/flat/apartment, a private landlord who is not related to you owns this. . . ., a local authority or city councils owns. . . ., Housing New Zealand owns . . . .. Other State landlord owns. . .

Employment Q24: Which of the following best describes your current employment status? By employed I mean you undertake work for pay, profit or other income, or do any work in a family business without pay. Employed fulltime (for 30 or more hours per week), employed part time (for less than 30 hours per week), Not in paid employment and looking for work, not in paid employment and not looking for work (e.g. full-time parent, retired persons).

Enough Q35: Which of the following best describes how well your total income meets your everyday needs for things such as accommodation, food, clothing and other necessities? Have more than enough money, enough money, just enough money, not enough money.

Minority Q1: Can you please tell me which ethnic group or groups you belong to? European, Maori, Samoan (and other non-European).

SafeCC Q13: R4: Now thinking about issues of crime and safety, using a four point scale ranging from very unsafe, a bit unsafe, fairly safe to very safe, please tell me how safe or unsafe you would feel in the following situations. In your city centre during the day.

No rubbish Q17: R1.. Have any of the following been a problem in your city over the last twelve months? Rubbish or little lying on the streets: yes, no, don't know.

Conf_council Q21r3: Thinking about your local City or District Council. On a scale of one to five, where one is strongly disagree and [four is agree] and five is strongly agree, how would you rate the following: R3. Overall, I have confidence that the council makes decisions that are in the best interests of my city or district.

Source: Quality of Life Team, 2009

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The Role of Institutional Environment in International Trade: The Case of Spanish Regions*

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Abstract. We move beyond the nation-state as the unit of analysis and use subnational spatial variation to study the effect of the institutional environment on international trade. Additionally, we address the heterogeneous effect of trade agreements on different regions within a country. Employing a gravity model approach, we use a region-to-country dataset to estimate the determinants of Spanish regional exports and we apply quantile regressions for panel data. We find that better institutional quality of trade agreements leads to an increase in both the intensive and the extensive margins of trade. The institutional quality of trade agreements exerts a differential effect on regional exports at different locations within a country, although differences across Spanish regions seem to be larger for the intensive margin than for the extensive margin. However, we do find a common trend: for the relatively more important exporting regions the institutional quality of trade agreements is less relevant for trade margins. Therefore, our results posit that subnational spatial variation should be added to the analysis of the determinants of international trade flows.

JEL classification: F14, F15, F55, R10

Key words: Trade Agreements; Institutional Environment; Trade Flows; Regions; Gravity Equation; Quantile Regression

1 Introduction

In this research we analyse the role of supranational standard-setting and regulation institutions, i.e. the institutional quality of regional integration agreements, in international trade. More specifically, our interest is in determining whether the increase in regional exports is due to maintaining and enhancing trade relations over time or to the appearance of new markets. Therefore, we study the determinants of the so-called intensive margin (IM) and extensive margin (EM) of trade (Márquez-Ramos et al. 2015). To do so, we

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employ a gravity framework, which is generally considered the workhorse of international trade analyses, focusing on regional exports from a single country (Spain). The notion "regional" has both a subnational (e.g. Valencian Community) and a supranational meaning (e.g. in regional trade agreements) as "regional trade" can be trade flows from a specific community or within a trade agreement. In this paper we refer to the subnational meaning of the notion "regional".

Since the time of Spain's economic integration into the European Union (EU), and since 1986 into the European Economic Community (EEC), there were a number of trade agreements (TAs) with third countries that were signed. For example the Barcelona Process or the Euro-Mediterranean Partnership, which was set up in 1995, as well as bilateral trade agreements with countries in other geographical areas such as Mexico, South Africa and Chile. Additionally, following the accession of new countries to the union there are now 28 EU member states.

It is worth mentioning that a key empirical challenge in assessing the effect of TAs on international trade flows is identification (Márquez-Ramos 2016b). We require exogenous variation in TAs, however it is well known that the TA variable is an endogenous regressor in the conventional gravity approach, i.e. country-to-country (see, for example, Baier et al. 2014).

Using available regional trade statistics for Spain allows us to use panel data and instrumental variables (IV) to test whether TA institutional quality is endogenous. Additionally, we apply quantile regressions (QR) for panel data, which has two identification advantages (Figueiredo et al. 2016). First, QR estimation of log-linear gravity models is robust with respect to heteroskedasticity bias (Santos-Silva, Tenreyro 2006). Second, quantile estimation identifies the effect of TA institutional quality across the entire trade flow distribution. Additionally, this is a suitable methodology to analyse whether the effect of TA institutional quality is heterogeneous at different locations within a country.

This research makes two main contributions to the literature. First, it analyses the effect of TA institutional quality on international trade in a region-to-country dataset and in contrast to mainstream research, we then examine the institutional quality of TAs (Kohl et al. 2013) rather than their creation per se (Cipollina, Salvatici 2010, Head, Mayer 2014). Second, it addresses the importance of dealing with within-country heterogeneity in a gravity framework when analysing the factors behind the variation in the IM and in the EM of trade.

We start the next section by discussing the background of the gravity model and trade margins and formulating our main hypotheses. The third section presents our data and variables as well as the analytical model used in our analyses, while the fourth section details the obtained results. Finally, the last section concludes and provides a discussion of several important caveats to our results, including the fact that the effect of TA institutional quality differs by region within a country.

2 Background and Hypotheses

There are two main streams of literature that explore the relationship between TAs, the margins of trade and the gravity framework. First, a series of papers analysing the effect of TAs on trade flows considers the endogeneity problem of TAs in the gravity approach at country level (see for example Baldwin, Taglioni 2006, Baier et al. 2014). TA variables correlate with the error term, as there is an omitted variable bias due to the multilateral resistance terms, or MRT (Anderson, van Wincoop 2003). At country-level, the most commonly-used solution for solving the endogeneity problem of TA variables is to include country-pair and country-time dummies to control for unobserved effects.

In a recent paper, Márquez-Ramos (2016b) proposes the use of regional trade statistics (region-to-country) as an alternative to country-to-country trade statistics in order to analyse the effect of regional integration on trade flows ("regionalising with regionalism"). When using trade statistics at region-to-country level, introducing the full array of dummies at country level in the gravity equation is not free of cost and it has the shortcoming that it does not allow the analyst to distinguish the effect of those determinants that are collinear with the introduced dummies, as is the case with key determinants such as TAs or distance (see the discussion about within-country discontinuity in economic space by Beugelsdijk, Mudambi 2013).

Second, a series of empirical studies has concentrated on the effect of trade liberalisation on the margins of trade, although there is no consensus in the literature about how to measure trade margins and what methodology to use. For instance, Baier et al. (2014) and Márquez-Ramos et al. (2015) adopted the intensive versus extensive decomposition proposed by Hummels, Klenow (2005), while Bensassi et al. (2012) based their approach on the decomposition of trade proposed by Hillberry, Hummels (2008). These studies define the EM at sector-product level although it can be defined at different levels of aggregation such as firm or country level (Santos-Silva et al. 2014).

In addition to trade literature, international business literature has also shown the importance of distinguishing between these two margins: the EM refers to the discrete trade decision, while the IM relates to the continuous amount of trade (Beugelsdijk, Mudambi 2013). For the EM we can therefore distinguish between the appearance of trade in new products and in new markets. Although recent gravity literature has mainly focused on product diversification (Bensassi et al. 2012, Baier et al. 2014, Márquez-Ramos et al. 2015), the EM in the pure sense of the term can be defined as those exports that provide new market entrants, while the IM in the pure sense is a result of continued growth in existing exporters' sales to the same destinations (Florensa et al. 2015). Thus, in the present paper we focus on international diversification while acknowledging that there might be a trade-off between product diversification and international diversification due to limited resources (Meyer et al. 2011).

Turning to our hypotheses, we expect that TAs (and more specifically, their institutional quality) can boost exports, but the effect may differ by region within the boundaries of a single country. The two main hypotheses tested in the empirical analysis of this research are:

Hypothesis 1: Better institutional quality of TAs leads to an increase in regional exports.

Hypothesis 2: The institutional quality of TAs exerts a differential effect on regional exports at different locations within a country.

In addition to the two main hypotheses presented above, we test a third hypothesis that makes a distinction between the EM and the IM of trade. It reads as follows:

Hypothesis 3: The institutional quality of TAs exerts a differential effect on the extensive and on the intensive margins at different locations within a country.

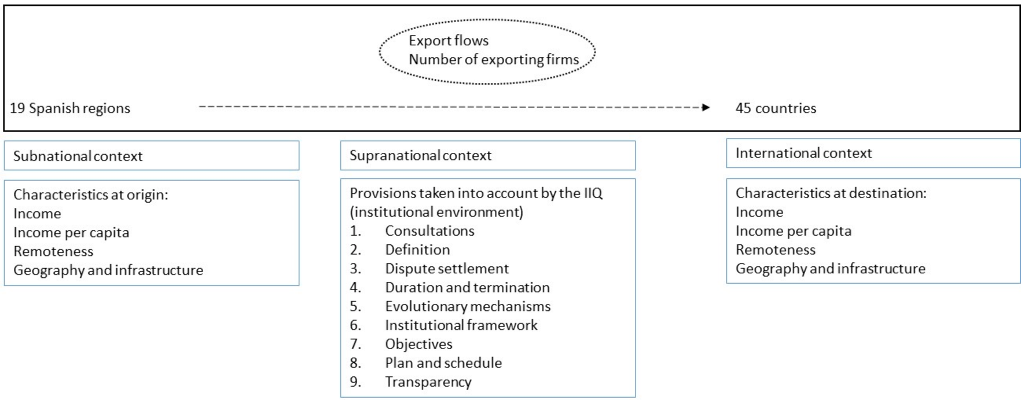
3 Methodology

3.1 Data and variables

In this paper, we use the dataset provided by Márquez-Ramos (2016a), who uses a sample of exports from the 19 Spanish regions to 45 destination countries over the period 2000-2008. These importing countries are: Algeria, Argentina, Australia, Austria, Bangladesh, Belgium, Brazil, Canada, Chile, China, Colombia, the Czech Republic, Denmark, Egypt, Finland, France, Germany, Greece, Hong Kong, India, Indonesia, Ireland, Italy, Japan, Jordan, Lebanon, Malaysia, Morocco, Mexico, the Netherlands, New Zealand, Pakistan, Poland, Portugal, Singapore, South Africa, South Korea, Sweden, Thailand, Tunisia, Turkey, the United Kingdom, the United States, Venezuela and Vietnam.

Characteristics of origins (Spanish regions) and destinations (countries) are taken into account following the gravity theory; MRT are captured using remoteness variables (see the discussion provided by Márquez-Ramos 2016a, pages 333-334). The dataset that we use includes data on bilateral export flows (in terms of value, i.e. the IM) and on a number of explanatory variables that we require in the present research: namely income, income per capita, distance, language, border and coastal dummies, remoteness, and port infrastructure variables.

Additionally, we measure the EM as the number of firms that export to the selected destinations, by region. To do so, we use the Spanish Datacomex – Estadísticas del Comercio Exterior (Foreign Trade Statistics, available at http://datacomex.comercio.es).



Source: Own elaboration

Figure 1: The role of institutional environment in international trade: subnational, supranational and international contexts

We base our analysis on the data provided by Kohl et al. (2013) regarding the institutional quality of TAs in which the EU is involved over the period 2000-2008. The index that reflects an agreement's institutional quality – the index of institutional quality, or IIQ – measures a TA's depth as a function of the number of provisions that are included. The provisions relate to consultations, definition, dispute settlement, duration and termination, evolutionary mechanisms, institutional framework, objectives, plan and schedule, and transparency. The IIQ allows us to examine specific characteristics of a TA that might have a crucial influence on increases in regional exports. It is calculated as the sum of the legally enforceable provisions that are included for each TA divided by the total number of possible provisions, i.e. nine. Appendix B.1 provides a description of these provisions and three clarifications to the notion "institutional quality of trade agreements". The IIQ variable to be included in the regression analysis equals zero when there is not a TA with country j in year t (see Table B.3 in Appendix B.1 for frequencies and TAs involved). Table A.1 in Appendix A shows the descriptive statistics of the dataset.

The subnational context interacts with the supranational context (the EU negotiates TAs as a regional trading bloc) by means of the IIQ, as the institutional quality of TAs might exert a differential effect on the EM and the IM at different locations within a country. Figure 1 summarises the set of variables and interactions taken into account in the empirical analysis.

3.2 Analysis

The present study offers two types of analyses. First, we present a descriptive analysis to illustrate graphically the importance of the variation in export data from different regions within a country. Second, we employ regression analysis to examine the determinants of those regional exports. In particular, we use pooled ordinary least squares (OLS), IV and QR.

In the first part of the regression analysis (pooled OLS and IV) we take into account three excluded instruments, these are the three exogenous variables that are excluded from the gravity equation: 1) the rule of law at country level 2) the interaction between the importance of maritime transport for a Spanish region and the knowledge about trading partners and 3) the quality of government at the regional level. Appendix B.2 details the logic underlying the choice of these instruments.

We proceed as follows. Our first exercise is to test whether our excluded instruments correlate with TA institutional quality. As the first condition for valid instruments is relevance, the excluded instruments should be related to the endogenous explanatory variable, i.e. TA institutional quality. Next we assume that the instruments do not correlate with omitted factors that explain regional exports in a gravity approach. This is because we control for all factors included in international trade models that aim to explain the determinants of international trade flows. This assumption is related to the second condition for valid instruments, which is exogeneity: the excluded instruments should be uncorrelated with the error term of the gravity equation in order to be considered suitable. In other words, our three excluded instruments affect only regional export flows indirectly through TA institutional quality.

Our second exercise is to estimate a gravity equation for regional exports:

$$\begin{aligned} \ln X_{ijt} = {} & \gamma_0 + \gamma_1 \ln Y_{ijt} + \gamma_2 Yh_{it} + \gamma_3 Yh_{jt} + \gamma_4 D_{ij} + \gamma_5 Lang_j + \\ & \gamma_6 BP_i + \gamma_7 BF_i + \gamma_8 Coast_i + \gamma_9 TA_{jt} + \gamma_{10} rem_{it} + \gamma_{11} rem_{jt} + \\ & \gamma_{12} port_{it} + \tau_t + \omega_{ijt} \end{aligned} \quad (1)$$

where $\ln X_{ijt}$ denotes the logarithm of exports from a Spanish region i to an importing country j in year t; $\ln Y_{ijt}$ is the logarithm of the product of GDP for exporter i and importer j in year t; Yh_{it} (Yh_{jt}) is GDP per capita in the exporting region (importing country) in year t. $Lang_j$, BP_i, BF_i and $Coast_i$ are dichotomous variables that take a value of one when the same language is spoken in i and j (Spanish), when region i shares a border with Portugal (BP) or France (BF), and when i is a coastal region ($Coast$). Our right-hand-side (RHS) variable of interest is TA_{jt}, which takes the value of zero when Spain and the corresponding trading partner have not signed a TA in year t, and the value of the IIQ index provided by Kohl et al. (2013), i.e. TA institutional quality, when a TA is in force. As a baseline regression, however, we also estimate equation (1) by including a TA dummy instead of TA institutional quality.

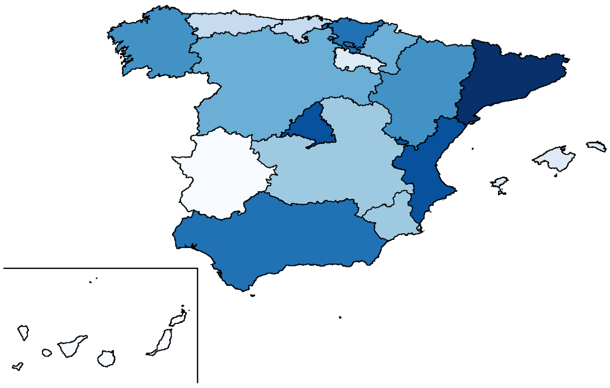
In keeping with Carrère (2006) and Márquez-Ramos (2016a), this study includes remoteness of the exporter (rem_{it}) and importer (rem_{jt}) to proxy for MRT. Port facilities (standardised) variables ($port_{it}$) and year dummies are also included in the regression. By following the strategy of including typical RHS gravity variables in the regression model, we are following the recommendation given by Beugelsdijk, Mudambi (2013) of explicitly distinguishing between discontinuous border (BP and BF) and continuous distance (D) effects.

Benchmarking and further discussion is necessary in terms of testing whether the effect of the institutional quality of TAs differs across regions within a country. We do so in the empirical analysis by using QR (see, for more details, Koenker, Bassett Jr. 1978, Koenker 2004, Figueiredo et al. 2016). One of the advantages of QR is its semi-parametric nature; it is more robust under heteroskedasticity and under non-normal distributions of the response variable (see, for example, the brief outline of QR methods by Peiró-Palomino, Tortosa-Ausina 2013). In the context of the present research, QR allows us to capture heterogeneous effects of TAs for different trade levels across regions. The gravity identification using QR in a country-to-country dataset is discussed by Figueiredo et al. (2016). Similarly, a QR could be carried out in a region-to-country dataset. Our QR analysis is performed by including in the RHS the controls presented in equation (1), together with year fixed effects and the variable of interest; and by using as the left-hand-side (LHS) variable (X_{ijt}), first, the log of the value of regional exports (testing Hypothesis 2) and, second, the log of the number of exporting firms in i (origin region) that export to j (destination country) in year t. By considering this additional variable as the LHS variable in this second (QR) analysis we also study the determinants of the EM of trade in Spanish regions, which allows us to test Hypothesis 3.

4 Results

4.1 Main results

First, we look at regional statistics of total export flows (to proxy for the IM) and number of firms exporting to the selected destinations (to proxy for the EM) within Spain. Figure 2 shows the NUTS2-level regions where the most important international trade flows are concentrated in 2008; these are identified with dark colours (darker blue shades reflect higher levels of flows while lighter blues indicate lower flow levels). Figure 3 shows the evolution over the period 2000-2008 of the number of firms that export to the selected



Source: Own elaboration with data from Datacomex

Figure 2: Average Spanish exports in 2008, by region

destinations by region. The importance of regional heterogeneity is clearly illustrated, in this case study the region of Catalonia (the Valencian Community is included in the same group) is the principal exporting centre within Spain.

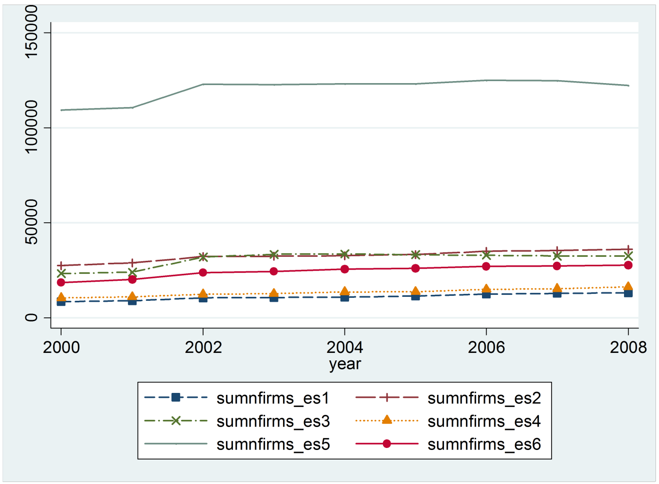
Second, we run a naïve regression of TA institutional quality on nothing more than a constant and the three excluded instruments. The three phenomena that we consider to allow for the use of IV techniques in a regionalised sample when analysing the role of the institutional quality of TAs in regional exports are: the rule of law at country level, the news media and the quality of government at the subnational level (see Appendix B.2). Results displayed in Table A.2 (Appendix A) show that our three excluded instruments significantly affect TA institutional quality and so they correlate with TA institutional quality, thus fulfilling the requirement of instrument relevance. More specifically, the underidentification test shows that we can reject the null hypothesis that the equation is underidentified. Additionally, the F-statistic for the joint significance of the coefficients on the additional instruments shows that they are jointly significantly different from zero. Also, according to the F-statistic obtained, $F(3, 6055) = 51.3422$, the additional instruments have significant explanatory power for TA institutional quality after controlling for the effect of explanatory exogenous variables.

Third, we estimate the gravity equation presented in equation (1) by both pooled OLS and IV. The first and second columns of Table 1 show the results obtained by using pooled OLS for all Spanish regions to estimate equation (1). Specifically, the results obtained show that the estimated TA institutional quality coefficient (column 2) is positive and significant, with a magnitude of 1.086, while the TA dummy (column 1) presents a magnitude of 0.884. These results validate Hypothesis 1, which states that better institutional quality of trade agreements leads to an increase in regional exports.

With regards to the rest of the explanatory variables, the "economic mass" of trading partners has a coefficient approaching one, as theory predicts (Baldwin, Taglioni 2006), and the coefficient of distance displays the expected sign (negative) and is statistically significant. Remoteness, port facilities and the dichotomous variables that are included as extra factors that facilitate trade (sharing a border with Portugal, a border with France, language and coastal region) are significant and have the expected sign, i.e. in line with Márquez-Ramos (2016a).

Given that our main focus is on TA institutional quality, the third column of Table 1 shows the results obtained by IV using this regressor (instead of the TA dummy). The instruments pass the Hansen J-test for exogeneity and the endogeneity test performed confirms that TA institutional quality can be treated as exogenous. Our most "conservative" results are those obtained by pooled OLS and show that an increase in TA institutional quality increases, ceteris paribus, Spanish regional exports. Additionally, as we are unable to reject that our variable of interest is exogenous, this specification is the preferred one (column 2 of Table 1).

There are two possible reasons behind the rationale of TA institutional quality being



Source: Own elaboration with data from Datacomex
Note: A single firm can export to only one or to several destinations. To construct this graph, we exclude islands and we group regions at the NUTS1 level as follows: ES1 for Asturias, Cantabria and Galicia; ES2 for Aragon, the Basque Country, La Rioja and Navarre; ES3 for Madrid; ES4 for Castile-and-Leon, Castile-La Mancha and Extremadura; ES5 for Catalonia and the Valencian Community; ES6 for Andalusia, Ceuta, Melilla and Murcia.

Figure 3: Number of exporting firms exporting to the 45 selected destinations, by region (2000-2008)

an exogenous regressor in a region-to-country framework. First, Spain has been a member of the EEC since 1986, joining after the transition from Franco's dictatorship to democracy. Spain had already requested to join the EEC during the dictatorship, but since a democratic regime was a necessary requirement, its accession was denied. It could therefore be argued that Spain's entry into the EEC at that time was not driven by particular circumstances at regional level. Second, the analysis of the role of TAs in a Southern European country, and specifically a GIIPS country (the Eurozone countries, Greece, Ireland, Italy, Portugal and Spain are denoted here as GIIPS), is an ideal testing ground. For example, a special report by The Economist (2013) that used unit labour costs as a measure of competitiveness traced the evolution of unit labour costs for six countries: Britain, France, Germany, Italy, Spain and the United States. Of those countries, Spain is the only one in which unit labour costs have decreased from 2009 onwards. Indeed, becoming part of the Eurozone – Spain has been a member since 1999 – has limited the ability of GIIPS countries to set national policies to maintain their competitiveness levels. Therefore, it could be argued that TAs are exogenous in a gravity equation that aims to analyse the effect of the institutional quality of TAs on the determinants of subnational exports, at least in the case of Spain.

4.2 Quantile regressions

In Hypothesis 2 and Hypothesis 3, we stated that the effect of TA institutional quality on exports might differ across regions within a country. To test these two hypotheses, we use the methodology recently proposed by Figueiredo et al. (2016) in a gravity framework, the QR approach allows us to capture heterogeneous effects of TA institutional quality for different levels of the IM and the EM.

In fact, in the context of the present research, it is worth considering that the effect of TAs may be heterogeneous across the bilateral trade distribution and affect small trade relationships differently than high-volume trade relationships. Obtaining different results by quantile would be indicative of heterogeneous effects of TA institutional quality for different levels of the IM and the EM in Spanish regions.

Results for the main percentiles for equation (1) in our variable of interest (i.e. TA institutional quality) are displayed in Table 2 and they confirm that location in terms

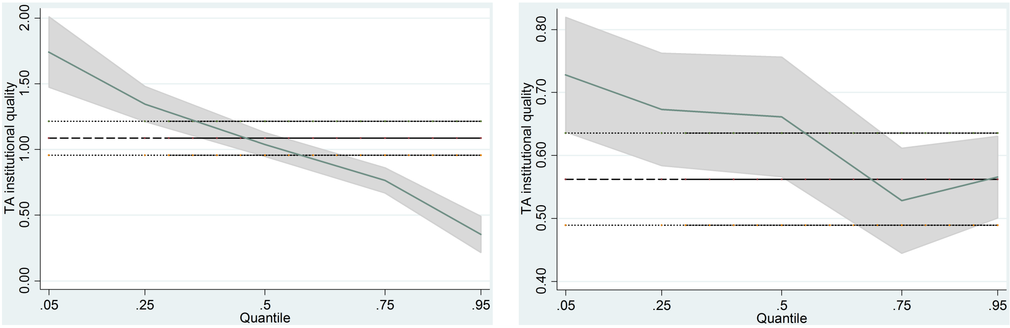
Table 1: Results of the estimation. Equation (1)

	(1) OLS	(2) OLS	(3) IV
VARIABLES	TA dummy	TA instit. quality	TA instit. quality
ly_{ijt}	0.998***	1.004***	1.000***
	[0.0128]	[0.0128]	[0.041]
lyh_{it}	0.135	0.124	-0.165
	[0.120]	[0.119]	[0.160]
lyh_{jt}	0.0945***	0.120***	0.136***
	[0.0165]	[0.0161]	[0.026]
ldist	-0.268**	-0.256**	-0.183
	[0.112]	[0.112]	[0.119]
lang	1.179***	1.155***	1.089***
	[0.0504]	[0.0501]	[0.061]
bportugal	-0.324***	-0.327***	-0.307***
	[0.0507]	[0.0505]	[0.057]
bfrance	0.472***	0.472***	0.597***
	[0.0410]	[0.0408]	[0.043]
coast	-0.392***	-0.392***	-0.069
	[0.0559]	[0.0557]	[0.053]
TA_{jt}	0.884***	1.086***	1.794*
	[0.0542]	[0.0590]	[0.997]
$lrem_{it}$	-26.58***	-26.67***	-24.32***
	[0.787]	[0.782]	[0.826]
$lrem_{jt}$	-0.675***	-0.725***	-0.578*
	[0.116]	[0.116]	[0.326]
$port_{it}$	0.452***	0.449***	0.285***
	[0.0278]	[0.0276]	[0.037]
Constant	204.9***	204.7***	183.0***
	[6.458]	[6.410]	[6.900]
Observations	6,949	6,949	6,077
Adjusted R^2	0.748	0.749	
Hansen J-test of overidentification (p-value)			2.448 (0.2941)
Endogeneity test (p-value)			0.754 (0.3853)

Source: Own elaboration
Note: Robust standard errors in square brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

of subnational region matters. Interestingly, results show that when a region reaches a certain level of intensity of trade, the impact of TA institutional quality (as observed in the estimated coefficient) on export flows is notably reduced. It seems that after the 75th percentile, the estimated coefficient decreases sharply. Note that the same pattern, i.e. lower estimated coefficients for relatively more important exporters, is also obtained when analysing the determinants of the EM for Spanish regional exports (see Figure 4). In this case however, the reduction of the estimated coefficient is lesser than the reduction for the IM. In both cases (i.e. for the IM and the EM), our results corroborate that the magnitude of the coefficients of TA institutional quality does in fact differ across quantiles. In sum, TA institutional quality exerts a differential effect on regional IM and EM therefore our findings provide support for Hypotheses 2 and 3.

Finally, we provide a robustness test estimating equation (1) by the Poisson Pseudo-Maximum-Likelihood (PPML) estimator using our definition of both the IM and the EM. While for the case of the IM our variable of interest is not statistically significant, the estimated coefficient for TA institutional quality on the EM is positive and statistically significant. Specifically, the estimated coefficient is 0.475 (with a robust standard error of 0.064). This coefficient is close to the corresponding value of 0.562 (with a robust standard error of 0.037) obtained in the OLS regression, which is represented with the black solid line in Figure 4 (Fig. 4b).



(a) Intensive margin (b) Extensive margin

Notes: The slopes for TA institutional quality, estimated by QR, are plotted as a function of the different quantiles, represented on the horizontal axis. The vertical axis represents the values of the estimated coefficient of the variable of interest (i.e. TA institutional quality) for each quantile. The shaded area represents the confidence interval of the QR. OLS estimates and the corresponding confidence interval of the OLS regression are represented by the black horizontal lines, constant across quantiles.

Figure 4: Regression quantiles for TA institutional quality

Table 2: Results of the quantile estimation: the role of TA institutional quality in the intensive and extensive margins of trade

LHS: Log of exports					
quantile	0.05	0.25	0.5	0.75	0.95
	1.741***	1.346***	1.037***	0.764***	0.353***
	(0.158)	(0.095)	(0.049)	(0.051)	(0.061)
LHS: Log of number of firms					
quantile	0.05	0.25	0.5	0.75	0.95
	0.728***	0.673***	0.661***	0.527***	0.565***
	(0.046)	(0.049)	(0.046)	(0.039)	(0.032)

Source: Own elaboration
Notes: Standard errors in brackets. *** $p < 0.01$

5 Conclusions

Our study has two main objectives. First, it analyses the effect of the institutional quality of TAs on international trade and, second, it includes subnational spatial variation in the challenging analysis facing international trade researchers examining the effect of regional integration on international trade. Furthermore, it takes into consideration the fact that TA institutional quality might be exogenous in a gravity approach when the dependent variable is bilateral trade from specific regions within a country. By doing so, this paper not only follows the "regionalising with regionalism" strategy recently proposed by Márquez-Ramos (2016b), but is also in line with those econometricians who suggest using the OLS estimator as the default estimation method and who argue that IV should only be used for improving OLS (Dufour 2016). Interestingly, in our framework the partial effect of TA institutional quality on trade flows can be determined by using OLS.

In the empirical analysis, we have used IV techniques to test the endogeneity of TA institutional quality in the case of Spanish regional exports. In the search for valid instruments, we have examined the rule of law at country level, the importance of regional public attention on trade policy affairs and the quality of government at regional level. Our results confirm that TA institutional quality can be treated as exogenous.

Additionally, we have performed a QR analysis. As the magnitude of the coefficients of TA institutional quality does in fact differ across quantiles, we are able to provide evidence that the effects of TA institutional quality differ by region within a country, thus showing that the effects of TAs cannot be generalised for all regions within a country. This result occurs not only when analysing the determinants of the IM of trade for Spanish regions, but also when the determinants of the EM are analysed.

In light of the obtained results, future research should deal with heterogeneity at the region-partner level when analysing the effect of regional integration on international trade in terms of IM and EM.

This study has several implications for theory building. First, by demonstrating that the effect of TA institutional quality changes by region within the boundaries of a country, this article calls for subnational spatial variation to be taken into account. Second, it has implications for the literature on international trade, as using regional trade data might help to avoid endogeneity biases when analysing the effect of country-level variables (such as regional integration) on trade flows by means of the widely-used gravity equation. Third, it also has implications for research on economic development since if it is the case that the creation (and improvement) of TAs increases the within-country differences in levels of income per capita (or welfare levels), trade may exacerbate agglomeration forces in the largest economic centres. The results of previous research indicating that TAs foster economic development, as they increase exports at country level, might not in fact be so desirable if said increase is only achieved in the largest economic centres or in the less peripheral areas within a country. We believe that what is important in terms of economic development is the TA-generated increase of exports in many regions within the same country.

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A Appendix 1

Table A.1: Descriptive statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
lx_{ijt}	6949	9.572318	2.780863	-7.87534	16.11139
TA dummy	7695	0.5358025	0.4987489	0	1
TA institutional quality	7695	0.4059753	0.3882384	0	1
ly_{ijt}	7695	36.35972	1.988802	29.61949	42.49604
lyh_{it}	7695	-3.962174	0.2406549	-4.608844	-3.467954
lyh_{jt}	7695	9.014545	1.399206	5.870131	11.04452
ldist	7695	8.347339	0.9699618	5.495445	9.897844
lang	7695	0.0888889	0.2846018	0	1
bportugal	7695	0.2105263	0.407709	0	1
bfrance	7695	0.2105263	0.407709	0	1
coast	7695	0.6315789	0.4824077	0	1
$lrem_{it}$	7695	8.857459	0.0404728	8.803171	9.002162
$lrem_{jt}$	7695	-9.245832	0.9438859	-11.16977	-7.643587
$port_{it}$	7695	-4.01E-09	1	-0.751892	2.983713

Source: Own elaboration with data from Márquez-Ramos (2016a) and Kohl et al. (2013)

Table A.2: First-stage regression

	First_all
rule of law	0.065***
	(0.004)
lmedia	-0.091***
	(0.003)
lqog	-0.114***
	(0.039)
Constant term	0.876***
	(0.171)
Observations	6,120
R2	0.0897

Source: Own elaboration
Notes: Robust standard errors in brackets. Pooled regression for Spanish regions. The full sample of regions and importing countries (19 exporting regions × 45 importers × 9 years) is reduced due to missing observations in the rule of law. First instrument: rule of law of importer j in year t. Second instrument: the (standardised) value of the proxy for the importance of regional public attention on trade policy affairs (lmedia). Third instrument: the (log of) quality of government at regional level (lqog).

B Appendix 2

B.1 Provisions and the index of institutional quality of trade agreements

Consultations: Signatories wishing to address issues arising from the implementation of the TA may engage in diplomatic dialogue known as consultations, "with a view to finding a mutually satisfactory solution". When specified, consultation procedures provide details on when and where consultations are to be held, which parties may be allowed to attend, and the issues that may be addressed. In most cases, signatories must first attempt to solve disputes according to consultation procedures before accessing the TA's dispute settlement mechanism.

Definition: By providing definitions of key concepts, signatories increase the clarity, scope and certainty of their commitments.

Dispute Settlement: By agreeing on dispute settlement procedures, signatories reduce ambiguity and create a judicially binding mechanism that ensures the implementation of the TA.

Duration and Termination: Signatories reduce ambiguity about their commitments by specifying the duration of the TA and the means by which it can be terminated.

Evolutionary Clause: Signatories commit themselves to a built-in periodic review mechanism that facilitates amendments and improvements to the original TA.

Institutional Framework: The signatories provide details on the institutional framework that will be used to oversee the implementation of the TA.

Objectives: The signatories enhance the clarity and context of their commitments by specifying the objectives they envision by signing the TA.

Plan and Schedule: The signatories commit themselves to a specific timetable by detailing the schedule according to which the TA is to be implemented.

Transparency: The signatories commit themselves to creating greater institutional transparency.

Three clarifications to the notion "institutional quality of trade agreements" should be added here. First, normally, one would expect such a notion to refer to the breadth and depth of commitments (e.g. average tariff, coverage of agriculture, number of service sectors covered) or to the scope of issues in a TA (e.g. investment, intellectual property rights, domestic regulation). The criteria referred to in the definition used by Kohl et al. (2013) are common features in nowadays' TA language, especially of the European Union, which means that a TA could be of high institutional quality and, paradoxically, still exclude the whole agriculture sector. Second, one might also expect that the more recent an EU agreement is, the more likely it will be that it includes these expressions, leading to a time-trend to a higher IIQ. Finally, many of the TAs are like living organisms and continue to evolve. However, given the characteristics of our sample and the time period taken into account, we believe that the IIQ is a good proxy for institutional quality of EU's TAs.

B.2 An explanation of the chosen excluded instruments

We detail here the logic underlying the choice of the three excluded instruments that are used in the empirical analysis: a dimension relating to country governance, the importance of regional public attention on trade policy affairs and the quality of regional government.

First, we consider information on the rule of law in trading partners' respective countries, which is obtained from the World Governance Indicators database provided by the World Bank (see http://info.worldbank.org/governance/wgi/index.aspx#home). This variable is available at country level and measures the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract

Table B.3: Descriptive statistics of the variable "TA institutional quality"

IIQ	Frequency	Trade agreements involved	Year
0	3572	No TA	–
0.67	2565	European Community, Egypt, Tunisia	1958 (EC); 1973 (Egypt); 1998 (Tunisia)
0.78	285	Lebanon, Turkey	1996 (Turkey); 2003 (Lebanon)
0.89	817	Algeria, Czech Republic, Jordan, Mexico, Poland	1976 (Algeria); 1992 (Czech Republic and Poland); 2000 (Mexico); 2002 (Jordan)
1	456	Chile, Morocco, South Africa	2003 (Chile); 2000 (Morocco; South Africa)
Total obs.	7695		

Source: Own elaboration with data from Kohl et al. (2013).
Notes: Total obs. 7695 = 19 exporters × 45 importers × 9 years

enforcement, the police and the courts. Then, we construct a variable that varies by importing country and year ("rule of law$_{jt}$") and we argue that rule of law in trading partners might affect the institutional quality of trade agreements in which Spanish regions are involved.

Second, in order to have (at least) one overidentifying restriction and to be able to compute both the overidentification test and the test of endogeneity when using IV, we require two exogenous variables that do not appear in the structural equation (i.e. equation 1). In the search for additional valid excluded instruments, and taking into account the importance of news media, the fact that Germany has been qualified as a hegemon in the economic press (The Economist 2013) gives cause for reflection on how important public opinion is to foreign policy, and trade policy in particular. Soroka (2003) shows that issue salience in the media may have a direct effect on policymaking. Previously, Cohen (1963) stated that the press may not be successful much of the time in telling people what to think, but is stunningly successful in telling its readers what to think about. Therefore, the mass media plays a significant role in directing public attention to foreign affairs.

To gain a general idea of what issues concern citizens, we can compare the press salience of trade policy in different EU countries. Specifically, we compare the number of times that the Transatlantic Trade and Investment Partnership (TTIP) is mentioned in both the Spanish and German press (the searches were made through Lexis-Nexis database in May 2014. For German media, we ran searches for "*Transatlantisches Freihandelsabkommen*", while for Spanish media we ran searches for "*Asociación Transatlántica para el Comercio y la Inversión*"). In the case of Spanish news, we found 4 documents in the Newswires & Press Releases category (category 1), 3 documents in the Newspapers category (category 2), 2 documents in the Websites category (category 3) and 1 document in the Treaties & International Agreements category (category 4). For German news, we found 247 in category 1,428 in category 2 and 155 in category 3, with a total of 1,051 documents if we include other categories such as Web-based Publications, Magazines & Journals and Industry Trade Press. On 13 January 2015, the European Commission published a report of findings following an online consultation in which 97 percent of submissions were opposed to the inclusion of a mechanism known as investor-to-state dispute settlement (ISDS) in the TTIP (European Commission 2015). From a total of 149,399 replies, 79.2% of replies were from the UK (52,008 replies), Austria (33,753 replies) and Germany (32,513 replies), while only 1.7% of the replies were from Spain (with a total of 2,537).

In light of these figures, it might be argued that Spain is taking trade policy for granted and that British and German-speaking citizens give greater weight to current TA negotiations. Furthermore, if EU foreign policy changes in response to changing evaluations (Soroka 2003), it could be said that Spanish-speaking citizens do not play an active role in determining European trade policy.

In order to examine the implications of the work of Cohen (1963) and Soroka (2003), we use all articles appearing in *El Mundo* (one of the largest printed daily newspapers in Spain with different editions printed for regions such as Andalusia, Valencia, Castile-and-Leon, the Balearic Islands and the Basque Country) that include mentions of each importing country j during year t. By doing so, we aim to proxy for the knowledge about trading partners in Spain. We interact this variable with a dummy that equals one when maritime exports, by Spanish exporting region, represent at least 50% of total exports in year t. Therefore, the interaction variable has regional-country-time variability, and we use it as a proxy for the importance of regional public attention on trade policy affairs. We believe that if a foreign policy issue is of potential interest for regional public opinion, it might affect the institutional quality of TAs. The reasoning is as follows: Spain is already involved in the EU integration process, but improvements in TA institutional quality at European level might be related to the importance of third countries as destination markets for EU members. As maritime trade is very important for Spain, but most trade with major trading partners is by road (as the main export partners for Spain are from the EU), a number of firms might be particularly interested in increasing the institutional quality of TAs with non-EU partners in order to facilitate commerce and reduce trade costs.

Lastly, the quality of government at subnational level is taken into account. A crucial assumption in this paper is that TA institutional quality (decided by a supranational agency, i.e. the EU) might be exogenous for Spanish regions. This might, however, be considered a rather strong assumption; firms from specific regions can still lobby the EU via their regional governments to have an active involvement in the process of generating new forms of formal institutions (Cantwell et al. 2010). Geographical Indications (GIs) might be mentioned, as the EU has increasingly moved towards securing protection of EU-based GIs through TAs (Engelhardt 2015). Also, according to Nyman-Metcalf, Papageorgiou (2016), regional integration is not an irreversible process (see Brexit, for example) and, with the possible exception of the EU, national governments have a higher degree of legitimacy than regional integration organisations.

So, we use an indicator that proxies for the quality of regional governments as a suitable excluded instrument of TA institutional quality. The underlying logic is that there may be a link between government quality and its capacity to negotiate "favourable" TAs, which might boost exports from specific regions within a country.

We thus use the data provided by Charron et al. (2014), i.e. the European Quality of Government Index, or EQI index (re-scaled from 0-100), which combines indicators of government quality for each European region at NUTS2 level. These data focus on both perceptions and experiences of public sector corruption, along with the extent to which citizens believe various public sector services are impartially allocated or of good quality. This is the first source of data to date that allows a comparison of government quality within countries in a multi-country context.

Additionally, we use the time series available for Spain on rule of law (obtained from the World Governance Indicators), and we multiply the EQI100 index by the rule of law in year t to incorporate time variation to this indicator of government quality at the regional level in Spain.

Although we use these three excluded instruments, it is worth mentioning that to get valid instruments, we do not necessarily need consistent estimates of the parameters of the reduced-form equation as long as we use instruments which are correlated with our (possibly) endogenous regressor in the structural equation but not correlated with the error term (see, for example, Alamá-Sabater et al. 2016). Accordingly, the chosen instruments pass the tests (see column 3 in Table 1).

Resources

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LaTeX – Know what you are missing

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Abstract. This article gives a brief introduction to LaTeX and related tools. The aim is to give an overview, to demonstrate the flexibility and versatility of the software, and to assist the reader taking first steps using it. The article links to a number of valuable resources for further information.

1 Introduction

There are not many cases of software developed in the 1970s that are still in use today. Donald Knuth's program TeX is such a case. He developed it in the late 1970 in reaction to the bad quality typesetting of one of his manuscripts. Nowadays, almost forty years later, the program is still used intensively, mostly via the standard macro package LaTeX that builds on TeX. This package, which was developed in the 1980s by Leslie Lamport, makes the power of TeX much more accessible to occasional users, and opened the door for a much wider use of the typesetting program. Today, although everything builds on Donald Knuth's TeX, LaTeX is the term most widely used. LaTeX runs on all major computer platforms, is supported by major publishers, and forms the de-facto standard in all formal scientific disciplines. But, LaTeX offers more than just nicely formatted equations; actually, *a lot* more. It is the intention of this brief introduction to give you a glimpse of that.

True, LaTeX is not the type of program that the average user just starts up and intuitively knows how to use. On the other hand it is also far from rocket science. The support that some of the modern tools like TeXstudio and web-based versions provide reduces the learning requirement for beginners substantially. So, if you have decided some time ago that LaTeX is too difficult for you, now may be the time to reconsider.

In the next section we will briefly discuss what LaTeX is and what it is not. Then, we will turn to the flexibility of LaTeX and will demonstrate some of the strengths of the software system.

2 What LaTeX is and what LaTeX is not

As has been mentioned in the introduction, LaTeX is a typesetting system. Technically, it takes an input file, processes it, and produces some output file. There are different versions and flavors of LaTeX available in an installation that can generate different output formats. pdflatex, for example, writes a PDF-file. Standard LaTeX produces a DVI[1]-file, which can be converted into various output formats in a second step. It is

[1] DVI stands for "device independent".

the task of the user to generate the necessary input file, feed the correct compiler and then handle the output file appropriately. Viewed from today's menu and window based user interfaces, this is rather archaic procedure. Recent add-on programs like TeXstudio (http://texstudio.sourceforge.net/), however, integrate it into a modern computing environment and support the user with all kinds of nice features.

The typesetting quality of LaTeX shows up in many seemingly minor features. Take the previous paragraph, for example, and look closely at the words "file" and "flavors". You will see that "f" and "i" and "f" and "l" seem to form just one character. Such ligatures have been developed in the typesetting craft over the centuries and are by default respected by LaTeX. Similarly, you can see that spacing between words, which is proportionally entered in order to produce blocks of text, is slightly smaller than the space that is inserted after the period at the end of a sentence. These features make it easier to read the text and contribute to the typesetting quality of documents produced by LaTeX.

Nevertheless, and despite of the fact that it produces much nicer output, LaTeX is not a word processor. WYSIWYG – "What You See Is What You Get" – is not on the agenda of LaTeX. Your input file will never show you exactly how the output will eventually look. Because of that, if you occasionally want to type a letter or some short texts, it is probably not worth installing LaTeX in the first place. Use your pre-installed WordPad or download one of the many free word processors and do not bother to learn about packages, commands and environments. In all other cases, LaTeX may be your best friend. In particular, these are documents

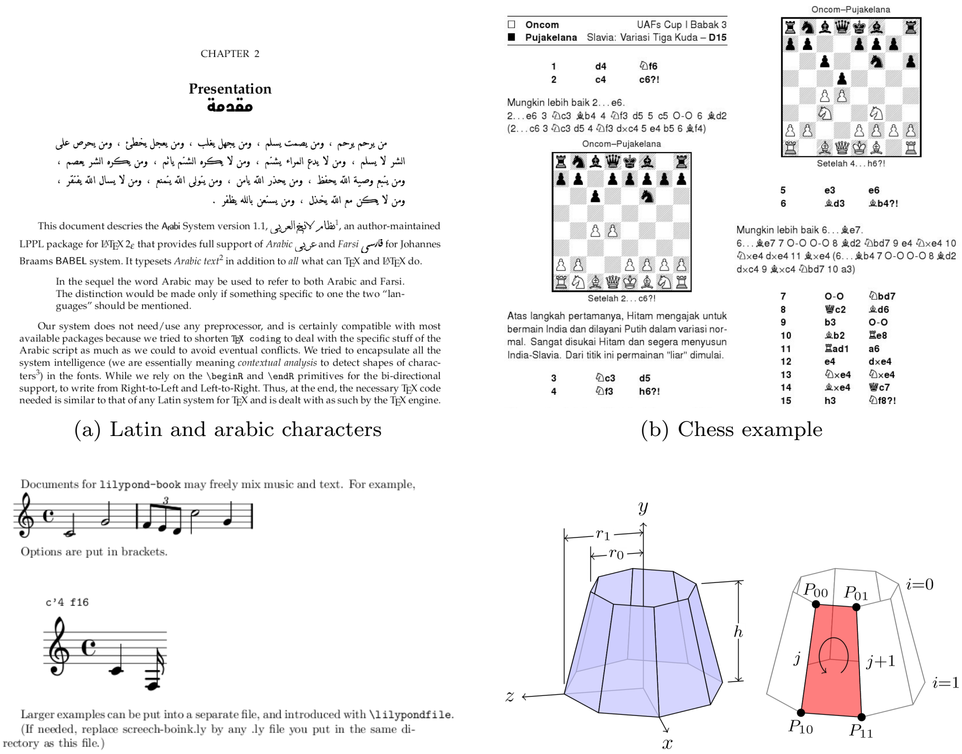
- with more than a hand full of equations;
- with more than 100 pages;
- with substantial cross-referencing (to sections, tables, figures, equations, etc.);
- with an extensive bibliography;
- with unusual content like text in foreign characters, written music, etc.;
- with close connections to statistical analyses.

In all these cases it may be worth spending a little bit of time exploring LaTeX. The return of this investment will probably be quite large. And, your investment will only be in terms of time and effort, because LaTeX is open source software and therefore freely downloadable. If you are using a Mac or a Unix-based machine, chances are that you don't even have to install the software. It may already be sitting there waiting for you to use it.

While TeX is a very flexible system for typesetting, LaTeX implements many of the rules for high quality typesetting. To some extent, LaTeX does the formatting for you. For example, it takes care of the font used for section headings and of the space before and after the heading. It numbers them correctly and also makes sure a section heading does not show up as the last item on a page. Generally, the formatting standards of LaTeX make good sense. Nevertheless, most of them can be changed by redefining parameters or via the use of external packages. But, if you want to exert full control over all the formatting of your document, LaTeX might not be the right tool. In that case you probably should turn directly to TeX. But, be warned: this involves substantial time and effort.

One important feature of LaTeX that is not immediately visible is that it is largely using plain text files. In particular, the input for your document is just plain text. Everything is in plain view and nothing is hidden or stored in a proprietary file format. This implies a high level of data security because even after years you will still be able to access your old documents. Outdated file formats are simply not an issue with LaTeX. Moreover, the text-based format also allows you to read the input file with a program and reformat it into a new version very easily.

This feature is important for some tools that can be viewed as extensions of LaTeX. For example, "knitr" (see Xie 2015) provides a link between R and LaTeX which allows for automatic inclusion of R-output into LaTeX code and thus for the generation of dynamic documents of high typesetting quality.



(a) Latin and arabic characters (b) Chess example

(c) Music output (d) Picture generated with tikz

Figure 1: Output produced solely from LaTeX by use of packages.

3 The versatility of LaTeX

In this short document we cannot give an introduction to the use of TeX or LaTeX. Classic references are Knuth (1984) and Lamport (1994). They cover TeX and plain LaTeX. Mittelbach et al. (2005), en.wikibooks.org (2016), and many others also describe some of the more popular LaTeX packages. The best starting point on the Internet is CTAN, the Comprehensive TeX Archive Network, at http://www.ctan.org. It offers a wealth of information and acts as the official repository of packages and styles. They adjust and adapt plain LaTeX in many different ways thus adding to the versatility of the system.

In the next section we will make suggestions for your first steps toward using LaTeX and guide you through some very basic steps. Before we do this, we want to highlight the versatility of LaTeX and show some of the unexpected things that can be done with the software – without explaining how to do that.

Figure 1 shows examples of unusual output produced by LaTeX and publicly available packages. They demonstrate the use of different character sets in one document, the creation of complex figures via package "`tikz`", as well as documents with music and chess output. None of these examples uses any other software but LaTeX and its packages and therefore demonstrates the versatility of this software. Of course, LaTeX can also embed graphics files that were produced by external software. With the "`media9`" package you can even embed videos and other interactive media content (requiring a Flash component for playback).

4 LaTeX for the absolute beginner

Now that you are hopefully convinced that LaTeX is worth a closer look, let us turn to some of the specifics. Again, the aim is not a complete description of all the commands and options, but to help you with the first steps. We want to lay the foundation for your own exploration of the world of LaTeX. We do this assuming that you are an absolute

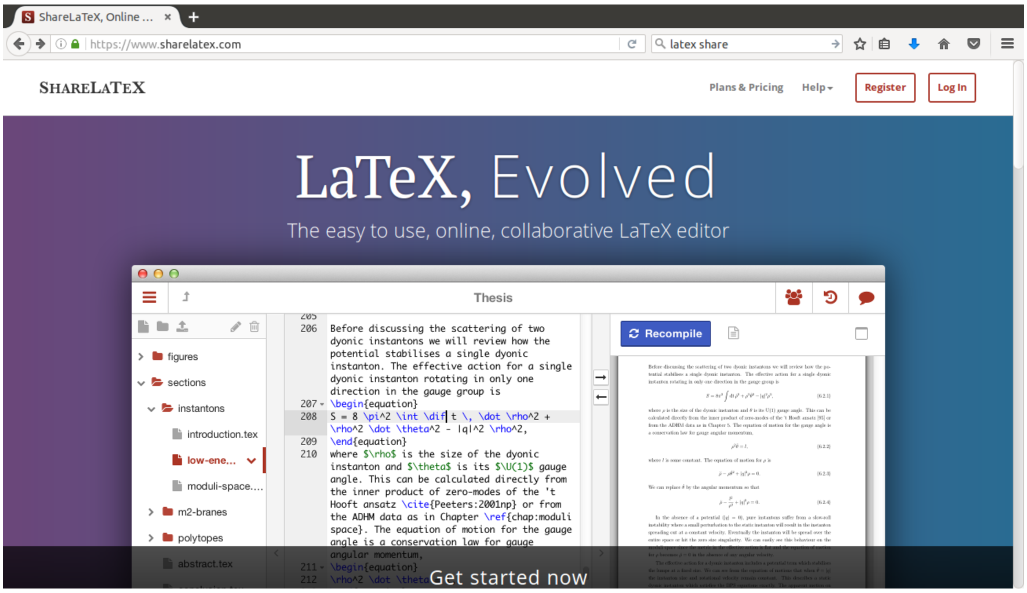


Figure 2: ShareLaTeX starting page

beginner and have not been exposed to LaTeX before.

In subsection 4.1 we will tell you how to get access to the software. Subsection 4.2 will then describe the language basics and guide you through the creation of your first LaTeX document.

4.1 Getting the software

If you are an absolute beginner and just want to explore LaTeX, your best option is probably *not* to install the software on your local computer but to use LaTeX interactively over the Internet. There are different sites available. We will use "ShareLaTeX" (www.sharelatex.com).

When you type in the URL or click the link above, you will see Figure 2. Register or log in and you are ready to run. One of the obvious advantages of using a web based version of LaTeX is collaboration. Provided they are registered with ShareLaTeX, you can invite your coauthors to your document so that you always work on the same version.

The traditional form of using LaTeX, however, is from an installation on your private computer. CTAN (http://www.ctan.org/starter) offers detailed instructions for all major operating systems. Unless it is absolutely necessary and you have expert help available, stay away from manual installation and use one of the distributions (like "`mikTeX`" for Windows). In addition to the basic programs these distributions typically also install many commonly used packages and management software.

In addition to TeX, LaTeX, and friends in a local installation, you will also need an editor to write your documents. I use TeXstudio, which provides a lot of support both for generating documents and for compiling them.

4.2 Language basics

When you have logged in to ShareLaTeX, you will see the – initially empty – projects page (Figure 3). Click "New Project" and – for our example – then "Blank Project". Name your project and you will get the bare minimum of a working LaTeX document in your editing environment (Figure 4). The environment has three columns. The left one lists the involved files, the middle one the LaTeX code, and the right one the compiled output. The middle column is a text editor where you can enter text and LaTeX code. Whenever you want to update the output, click the blue "Recompile" button. If there is an error in your code, the respective information can be found in the log file.

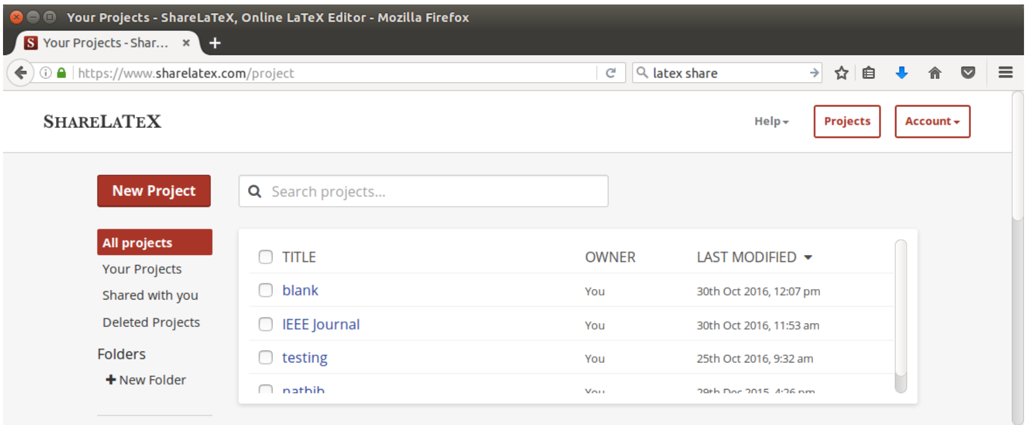


Figure 3: ShareLaTeX projects page

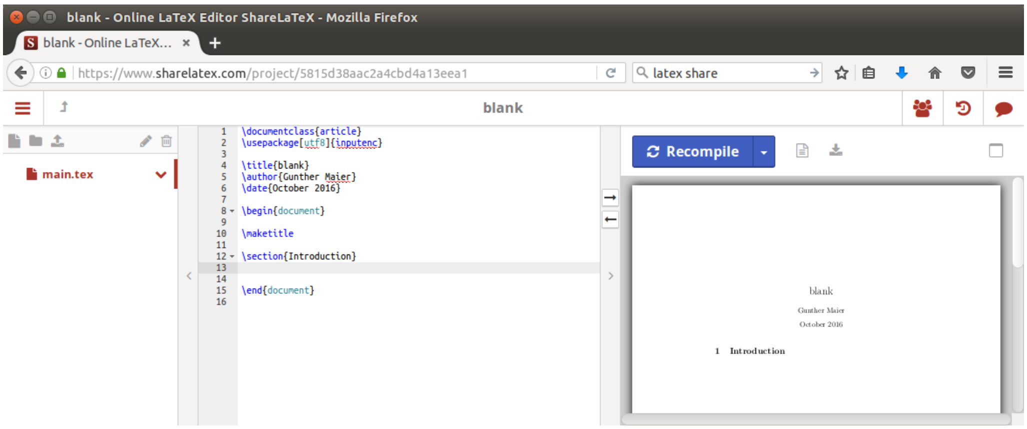


Figure 4: ShareLaTeX editing environment

Let us look more closely at the LaTeX code in the middle column of Figure 4. All statements beginning with "\" are LaTeX commands or environments. Environments have a `\begin{}` and an `\end{}` statement like `document` in our example. Commands – like `\section{}` or `\maketitle` – consist of only the "\", the command name, and maybe some argument. Every LaTeX document starts with the command `\documentclass{}`. The parameter defines the type of document that will be generated. In our example, we instruct LaTeX to produce an article.

The command `\usepackage{}` includes external packages. In our example the package "inputenc" is included. This package allows one to use different character sets for input. Which character encoding to use is defined in an additional parameter in square brackets. For details see the documentation of "inputenc" on CTAN.

The next three commands, `\title{}`, `\author{}`, and `\date{}` are used to internally store the respective information. These commands do not produce any output. The later used command `\maketitle` takes this information and typesets the title of the article.

The most fundamental environment in LaTeX is the `document` environment. Only text within this environment can generate output. The part before the `\begin{document}` is called preamble, statements after `\end{document}` are ignored by the compiler.

The final command in the code is `\section{}`. This command produces a section heading and numbers it accordingly. The command also enters information to an auxiliary file that can be used for generating a table of content. Depending on the type of document, additional sectioning commands are available. Books, for example, can have parts (`\part{}`) and chapters (`\chapter{}`). Sections can be structured further with `\subsection{}` and `\subsubsection{}`. After every such statement you can insert a `\label{}` statement with a unique label. They can be the target of cross referencing by use of `\ref{}` statements. LaTeX replaces those statements with the respective numbers.

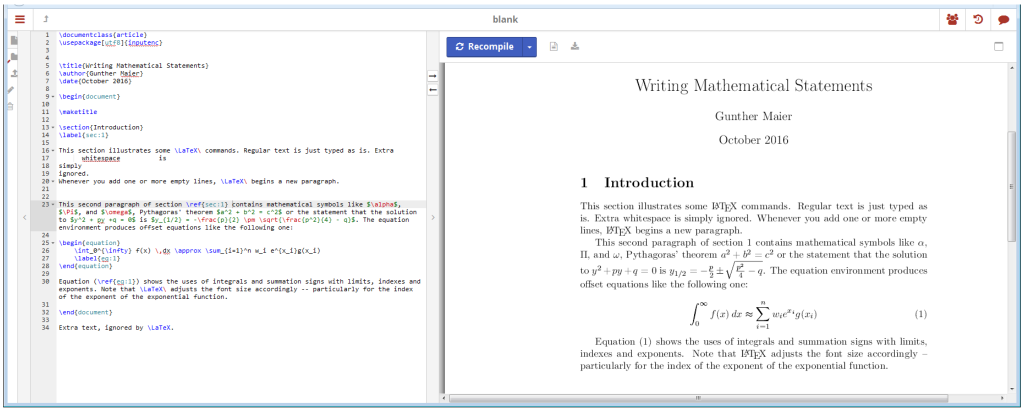


Figure 5: ShareLaTeX some mathematical commands

The most important element for structuring text is not a LaTeX command at all, i.e. a statement that begins with a "\", but an empty line. Empty lines – one or more – mark the end of a paragraph. Line breaks within a block of text are simply treated as blanks by LaTeX.

There are many, many more commands and environments even in plain LaTeX. Packages typically add additional commands and environments or redefine existing ones. For details see Lamport (1994). Important environments are

figure defines a floating element to display a figure. Normally, this element is not typeset at that location in the output where it is defined. By default, floating elements like 'figure" and 'table" are positioned at the top of output pages and shifted to the "best" location. As usual, this behavior can be influenced by optional parameters.

table defines a floating element to display a table. It behaves just like the `figure` environment.

itemize defines a list of bullet points. The items of the list are marked with `\item`.

enumerate defines a numbered list. Again, the items of the list are marked with `\item`.

equation defines an offset mathematical equation. Key aspects of typesetting mathematical equations are discussed in the next subsection.

4.3 Math mode in LaTeX

LaTeX can operate in two different modes: text mode and math mode. The two modes accept different commands and also produce different output. LaTeX starts operation in text mode and all the statements shows in Figure 4 are in text mode.

Various commands are used to switch from one mode to the other. One is the `equation` environment. With `\begin{equation}` LaTeX switches to math mode, with `\end{equation}` it switches back to text mode. When mathematics is needed within a block of text, the `$` character switches between the two modes. Sometimes one needs to insert text into a mathematical statement. This is done with the `\mbox{}` command.

Distinguishing between text mode and math mode is important for two reasons: first, most LaTeX statements only work in one mode or the other; second, the two modes produce very different output even with the same input. In math mode LaTeX typesets all input as mathematical statement. Characters are treated as mathematical variables, a series of characters as a product of variables. For example, the text "math mode" is formatted as "$mathmode$" in math mode. Note the slanted characters and that the blank between the two words disappears. This also applies to expressions like "log", "exp", "sin", etc. To format them correctly, LaTeX offers commands like `\log`, `\exp`, and `\sin`.

LaTeX offers a large number of mathematical symbols, operators, commands, etc. This set is extended further by the American Mathematical Society via some packages. These statements are described in the standard literature on LaTeX and summarized by many pages on the Internet[2].

The ShareLaTeX screenshot in figure 5 illustrates some of the more common statements. This example extends the one in figure 4. Besides math mode commands, which will be described below, the example also illustrates (1) that extra whitespace does not impact the formatting, (2) that a blank line separates paragraphs, and (3) cross referencing by use of `\label{}` and `\ref{}`. Of course, you are completely free in choosing the label strings and do not have to indicate the type of label as we did in our example. This is just a convention that we apply. It makes it easier to keep track of all the labels in larger documents.

The example shows both, separate mathematical expressions (equation environment) and mathematics embedded in the text (enclosed by dollar-signs). There is no difference in the command set of the two. However, when mathematics is embedded in the text, LaTeX tries to format the mathematical statements in such a way that the line spacing is disturbed as little as possible. Because of that, the two options may produce slightly different output.

The use of Greek letters is quite self explanatory. Besides these, there are many other symbols that can be used in math mode. The other mathematical statements in the text illustrate subscripts (`_`) and superscripts (`^`). These characters shift just the next character. If more characters need to be shifted, they have to be enclosed by curly braces. For example, `y_{t-1}` produces the variable y at time period $t-1$ (y_{t-1}). Without the curly braces you subtract one from the value of y at time t ($y_t - 1$).

The math in the text also demonstrates the commands `\frac` for fractions and `\sqrt` for square roots. The command `\pm` produces the plus-minus operator ($\pm$).

Additional math commands are used in equation (1) in the example. This equation is generated by use of the equation environment. In the style we used LaTeX centers the equation and places the numbering on the right margin. The sample demonstrates the use of `\int` for generating integrals and of `\sum` for summation signs. Both commands allow you to optionally add margins via subscript and superscript characters. Note that `\infty` generates the infinity character (∞). The integral on the left hand side of the equation shows an additional feature. The command `\,` adds a small amount of extra space between $f(x)$ and dx so that the differential is visually separated from the function. Usually, such explicit formatting should be avoided. In this case, however, it is necessary to add this command to ensure proper formatting. `\,` is just one of a number of commands for adding extra space in math mode.

The command `\approx` ($\approx$) demonstrates that LaTeX knows more relational operators than =. Other examples are `\neq` ($\neq$), `\geq` ($\geq$), and `\leq` ($\leq$). The right hand side of the equation also demonstrates the effect of subscripts in superscripts. Note that the index i in the exponential function is smaller than that of the w or that of the x in the function $g()$. LaTeX makes these adjustments automatically and can go much further than just two layers.

5 Features of LaTeX we did not cover

In this short paper we can only describe a few of the services that LaTeX can provide. There are many more important tools and some of them we at least want to mention. In section 1 we listed features of documents that may best be handled by LaTeX. Among those were large documents and documents with extensive bibliographies. We will touch the arguments in this context briefly below in this section.

Most word processors load the whole document into memory and do all the text manipulations there. This implies the risk of losing your work in case of a program bug or power loss. But, even when the software is bug free, the necessary memory management will slow down operations considerably once your document exceeds a certain size. LaTeX on the other hand only reads in the document source when compiling and reads it in chunks. Because of that compile runs in LaTeX can never jeopardize the source document

[2]See, for example, http://www.colorado.edu/physics/phys4610/phys4610_sp15/PHYS4610_sp15/-Home_files/LaTeXSymbols.pdf and ftp://ftp.ams.org/pub/tex/doc/amsmath/short-math-guide.pdf

and can read documents of very large size. One of the disadvantages of this strategy is that usually one compile run is not enough to get all the citations and cross-referencing right. Many LaTeX users therefore employ the habit of recompiling before they look at the result.

LaTeX includes commands for – selectively – inserting files into a master document. This allows you to split, for example, a book manuscript into chapter files and still compile the whole, consistently formatted book in one run. It is also worth mentioning that LaTeX can produce a *table of contents*, a *list of figures*, a *list of tables*, and an *index* automatically. Custom lists can be produced with a little bit of extra code.

A special and potentially very demanding list in a publication is the *list of references*. LaTeX is installed with various tools for the integration of citations and lists of references into a document. Probably the most popular one is BibTeX. It allows one to build a repository[3] of citations. LaTeX draws from this repository for generating both, the citations in the text and the entries in the list of references; and both formatted accordingly. This formatting can be adjusted very flexibly by use of packages and style files. REGION uses this mechanism for managing citations and references in all of the papers it publishes.

BibTeX can save a lot of work retyping and reformatting bibliographical entries. In addition, many literature databases offer BibTeX as one of the formatting options in data export. Examples are ISI Web of Science, Google Books, and the ERSA journal archive.

6 Concluding remarks

This short article wanted to provide an introduction to LaTeX. Rather than trying to be complete, the goal was on the one hand to demonstrate the enormous flexibility of the system and on the other hand to help the reader taking first steps in using LaTeX. The availability of on-line installations like ShareLaTeX make such first steps much easier. They save you the sometimes tedious installation of a LaTeX distribution. Try LaTeX out on-line, enjoy writing your first texts, articles, slides, and then decide whether or not it is worth for you digging deeper into the topic. There are plenty of books, videos, and on-line tutorials that can help with all the tasks involved. Some of these resources are listed in the references and in the appendix.

Of course, LaTeX is not the one and only super tool for everyone and every task. But, it is a great tool for many tasks that researchers frequently do. With this introductory article you can just click on a few links, try it out and see for yourself. So that at least you know what you are missing.

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[3]Some publications call this a "database". This term is somewhat misleading because it is again just a plain text file that stores the information.

A Appendix: Some electronic resources

The ultimate source for TEX and LATEX is CTAN (https://www.ctan.org). It provides distributions, packages, documentations, tutorials, links to user groups and much more. The content of CTAN is mirrored to about one hundred computers all over the world.

A.1 Introductory texts and tutorials

Introductory texts

- Introduction to LATEX (http://www.latex-project.org/about/)
- A short introduction to LATEX (http://ricardo.ecn.wfu.edu/ cottrell/ecn297/latex_-tut.pdf)
- The not so short introduction to LATEX (https://tobi.oetiker.ch/lshort/lshort.pdf)
- An Introduction to Using TEX in the Harvard Mathematics Department (http://-www.math.harvard.edu/texman/)

Video tutorials

- An introduction to LATEX (https://www.youtube.com/watch?v=YMhcc9VQ6Uk)
- A series of introductory videos (https://www.youtube.com/watch?v=FXujG7c9p8g-&list=PLNnwglGGYoTtW7o4PHFOSWGevcdFa3v3D)
- Bibliography in LATEX (https://www.youtube.com/watch?v=lwy6pn5vi5A)

A.2 ShareLaTeX videos

- A series of YouTube videos (https://www.youtube.com/user/ShareLaTeX)
- Comparing Authorea, ShareLaTeX and Overleaf for academic writing (https://-www.youtube.com/watch?v=OcBGDSE9kaM)
- How to use ShareLaTeX (https://www.youtube.com/watch?v=iWlc5ufcsdk)
- Templates in ShareLaTeX (https://www.youtube.com/watch?v=fSgi-Mwvs6g)

A.3 Installation and setup videos

Windows

- Windows 10 (https://www.youtube.com/watch?v=G4uIAOPq1UE)
- Various versions(https://www.youtube.com/watch?v=CX-I0op0z4k)

MacOS

- Any version (https://www.youtube.com/watch?v=5CNmIaRxS20)

Linux

- Ubuntu (https://www.youtube.com/watch?v=46LHjKucDbg)
- Linux Mint (https://www.youtube.com/watch?v=z6HPyqvomrI)

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A primer for working with the *Sp*atial *Int*eraction modeling (SpInt) module in the python spatial analysis library (PySAL)

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Abstract. Although spatial interaction modeling is a fundamental technique to many geographic disciplines, relatively little software exists for spatial interaction modeling and for the analysis of flow data. This applies particularly to the realm of free and open source software. As a result, this primer introduces the recently developed spatial interaction modeling (SpInt) module of the python spatial analysis library (PySAL). The underlying conceptual framework of the module is first highlighted, followed by an overview of the main functionality, which will be illustrated using migration data. Finally, some future additions are discussed.

1 Introduction

Spatial interaction modeling involves the analysis of flows from an origin to a destination, either over physical space (i.e., migration) or through abstract space (i.e., telecommunication). Despite being a fundamental technique to many geographic disciplines, there is relatively little software available to carry out spatial interaction modeling and the analysis of flow data, especially in the realm of free and open source software. Therefore, the purpose of this primer is to provide an overview of the recently developed spatial interaction modeling (SpInt) module[1] of the python spatial analysis library (PySAL)[2]. First, the current framework of the module will be highlighted. Next, the main functionality of the module will be illustrated using migration flows with a dataset previously used for spatial interaction modeling tutorials in the R programming environment (Dennett 2012). Finally, some future additions are discussed.

2 The SpInt framework

2.1 Modeling framework

The core purpose of the SpInt module is to provide the functionality to calibrate spatial interaction models. Since the "family" of spatial interaction models put forth by Wilson (1971) are perhaps the most popular, they were chosen as the starting point of the module. Consider the basic gravity model (Fotheringham, O'Kelly 1989),

[1]This primer is based on the 1.13 release of PySAL. For up-to-date code examples and namespaces, it is recommended to consult the documentation pertaining to the latest version of PySAL

[2]http://pysal.github.io/

$$T_{ij} = k\frac{V_i^{\mu} W_j^{\alpha}}{d_{ij}^{\beta}} \tag{1}$$

where

- T_{ij} is an $n \times m$ matrix of flows between n origins (subscripted by i) to m destinations (subscripted by j)
- V is an $n \times p$ and vector of p origin attributes describing the emissiveness of i
- W is an $m \times p$ vector of p destination attributes describing the attractiveness of j
- d is an $n \times m$ matrix of the costs to overcome the physical separation between i and j (usually distance or time)
- k is a scaling factor to be estimated to ensure the total observed and predicted flows are consistent
- μ is a $p \times 1$ vector of parameters representing the effect of p origin attributes on flows
- α is a $p \times 1$ vector of parameters representing the effect of p destination attributes on flows
- β is a parameter representing the effect of movement costs on flows.

When data for T, V, W, and d are available we can estimate the model parameters (also called calibration), which summarize the effect that each model component contributes towards explaining the system of known flows (T). In contrast, known parameters can be used to predict unknown flows when there are deviations in model components (V, W, and d) or the set of locations in the system are altered.

Using an entropy-maximizing framework, Wilson derives a more informative and flexible "family" of four spatial interaction models (Wilson 1971). This framework seeks to assign flows between a set of origins and destinations by finding the most probable configuration of flows out of all possible configurations, without making any additional assumptions. By using a common optimization problem and including information about the total inflows and outflows at each location (also called constraints), the following "family" of models can be obtained,

Unconstrained:

$$T_{ij} = V_i^{\mu} W_j^{\alpha} f(d_{ij}) \tag{2}$$

Production-constrained:

$$T_{ij} = A_i O_i W_j^{\alpha} f(d_{ij}) \tag{3}$$

$$A_i = 1 \,/\, \sum_j W_j^{\alpha} f(d_{ij}) \tag{4}$$

Attraction-constrained:

$$T_{ij} = B_j D_j V_i^{\mu} f(d_{ij}) \tag{5}$$

$$B_j = 1 \,/\, \sum_i V_i^{\mu} f(d_{ij}) \tag{6}$$

Doubly-constrained:

$$T_{ij} = A_i B_j O_i D_j f(d_{ij}) \tag{7}$$

$$A_i = 1 \,/\, \sum_j B_j D_j f(d_{ij}) \tag{8}$$

$$B_j = 1 \,/\, \sum_i A_i O_i f(d_{ij}) \tag{9}$$

where

- O_i is an $n \times 1$ vector of the total number of flows emanating from origin i
- D_j is an $m \times 1$ vector of the total number of flows terminating at destination j
- A_i is an $n \times 1$ vector of the origin balancing factors that ensures the total out-flows are preserved in the predicted flows
- B_j is an $m \times 1$ vector of the destination balancing factors that ensures the total in-flows are preserved in the predicted flows
- $f(d_{ij})$ is a function of cost or distance, referred to as the distance-decay function. Most commonly, this is an exponential or power function given by,

$$\text{Power:} \quad f(d_{ij}) = d_{ij}^{\beta} \tag{10}$$

$$\text{Exponential:} \quad f(d_{ij}) = \exp(\beta d_{ij}) \tag{11}$$

where β is expected to take a negative value. Different distance-decay functions assume different responses to the increasing costs associated with moving to more distant locations. Of note is that the unconstrained model with a power function distance-decay is equivalent to the basic gravity model in equation (2), except that the scaling factor, k, is not included. In fact, there is no scaling factor in any of the members of the family of maximum entropy models because there is a total trip constraint implied in their derivation and subsequently their calibration (Fotheringham, O'Kelly 1989). Another aside is that in the doubly-constrained maximum entropy model, the values for A_i and B_j are dependent upon each other and may need to be computed iteratively depending on calibration technique. It is also usually assumed that all locations are both origins and destinations (i.e., $n = m$) for doubly-constrained models.

Each member of the family of models provides a different system structure, which can be chosen depending on the available data or the specific research question at hand. The so-called unconstrained model does not conserve the total inflows or outflows during parameter estimation. The production-constrained and attraction-constrained models conserve either the number of total inflows or outflows, respectively, and are therefore useful for building models that allocate flows either to a set of origins or to a set of destinations. Finally, the doubly-constrained model conserves both the inflows and the outflows at each location during model calibration. The quantity of explanatory information provided by each model is given by the number of parameters it provides. As such, the unconstrained model provides the most information, followed by the two singly-constrained models, with the doubly-constrained model providing the least information. Conversely, the model's predictive power increases with higher quantities of built-in information (i.e. total in or out-flows) so that the doubly-constrained model usually provides the most accurate predictions, followed by the two singly-constrained models, and the unconstrained model supplying the weakest predictions (Fotheringham, O'Kelly 1989).

2.2 Calibration framework

Spatial interaction models are often calibrated via linear programming, nonlinear optimization, or, increasingly more often, through linear regression. Given the flexibility and extendability of a regression framework it was chosen as the primary model calibration technique within the SpInt module. By taking the natural logarithm of both sides of a spatial interaction model, say the basic gravity model, it is possible to obtain the so-called log-linear or log-normal spatial interaction model,

$$\begin{aligned}
&\text{Power-function:} \\
\ln T_{ij} &= k + \mu \ln V_i + \alpha \ln W_j - \beta \ln d_{ij} + \epsilon \quad (12) \\
&\text{Exponential-function:} \\
\ln T_{ij} &= k + \mu \ln V_i + \alpha \ln W_j - \beta d_{ij} + \epsilon \quad (13)
\end{aligned}$$

where ϵ is a normally distributed error term with a mean of 0. The only difference between equations (12) and (13) is the functional distance-decay specification, which results from plugging either equation (10) for a power function or (11) for an exponential function into equation (2) before linearizing it. The only practical difference here is that the distance is logged in equation (12) whereas in equation (13) it is not. Constrained spatial interaction models can be achieved by including fixed effects for the origins (production-constrained), fixed effects for the destinations (attraction-constrained) or both (doubly-constrained). However, there are several limitations of the log-normal gravity model, which include,

1. flows are often counts of people or objects and should be modeled as discrete entities;
2. flows are often not normally distributed;
3. downward biased flow predictions due to producing estimates for the logarithm of flows instead of actual flows;
4. zero flows are problematic since the logarithm of zero is undefined.

Therefore, the Poisson log-linear regression specification for the family of spatial interaction models was proposed (Flowerdew, Aitkin 1982, Flowerdew, Lovett 1988). This specification assumes that the number of flows between i and j is drawn from a Poisson distribution with mean, $\lambda_{ij} = T_{ij}$, where λ_{ij} is assumed to be logarithmically linked to the linear combination of variables,

$$\ln \lambda_{ij} = k + \mu \ln V_i + \alpha \ln W_j - \beta \ln d_{ij} \quad (14)$$

and exponentiating both sides of the equation yields the unconstrained Poisson log-linear gravity model,

$$T_{ij} = \exp(k + \mu \ln V_i + \alpha \ln W_j - \beta \ln d_{ij}) \quad (15)$$

where equations (14) and (15) refer to the unconstrained model with a power function distance-decay. As previously mentioned, using fixed effects for the balancing factors in equations (4), (6), (8) and (9), the constrained variants of the family of spatial interaction models can be specified as,

$$\begin{aligned}
&\text{Production-constrained:} \\
T_{ij} &= \exp(k + \mu_i + \alpha \ln W_j - \beta \ln d_{ij}) \quad (16) \\
&\text{Attraction-constrained:} \\
T_{ij} &= \exp(k + \mu \ln V_i + \alpha_j - \beta \ln d_{ij}) \quad (17) \\
&\text{Doubly-constrained:} \\
T_{ij} &= \exp(k + \mu_i + \alpha_j - \beta \ln d_{ij}) \quad (18)
\end{aligned}$$

where μ_i are origin fixed effects and α_i are destination fixed effects that achieve the same results as including balancing factors (Tiefelsdorf, Boots 1995). Notice that k is the estimated intercept and must be included in these log-linear models (equation 12–18) to ensure the total number of flows is conserved, despite not being included in the maximum entropy models where such conservation is implied. Similar to equation (13), the exponential function distance-decay can be specified in equation (15, 16–18) by omitting the logarithm associated with d_{ij}. Using Poisson regression is more representative of flows and satisfies limitations (1) and (2) and it also alleviates limitations (3) and (5) since we no longer need to take the logarithm of T_{ij}. Using fixed effects within Poisson regression to calibrate the doubly-constrained model also avoids the need for iterative computation of the balancing factors that exists in other calibration methods (Fotheringham, O'Kelly 1989).

Calibration of Poisson regression can be carried out within a generalized linear modeling framework (GLM) using iteratively weighted least squares (IWSL), which converges to the maximum likelihood estimates for the parameter estimates (Nelder, Wedderburn 1972). To maintain computational efficiency with increasingly larger spatial interaction datasets, SpInt is built upon a custom GLM/IWLS routine that leverages sparse data structures for the production-constrained, attraction-constrained, and doubly-constrained models. As the number of locations in these models increases, so the does the number of binary indicator variables needed to construct the fixed effects that enforce the constraints. Therefore, larger spatial interaction datasets become increasingly sparse and the utilization of sparse data structures takes advantage of this feature. As a metric, constrained models with $n = m = 3,000$ locations, which implies $nm = n^2 = 9,000,000$ observed flows when each location is an origin and destination, can be calibrated within minutes on a standard macbook pro notebook.

2.3 Model fit statistics

In order to evaluate the fit of spatial interaction models, it has been recommended that a variety of statistics be used (Knudsen, Fotheringham 1986), which is the approach taken in SpInt. For the log-normal regression specification, it is popular to utilize the coefficient of determination (R^2), though this statistic is not available within the GLM framework used by SpInt. In replacement of the R^2 statistic, the SpInt framework provides a pseudo R^2 based on the likelihood function (McFadden 1974),

$$R^2_{pseudo} = 1 - \frac{\ln \hat{L}(M_{full})}{\ln \hat{L}(M_{Intercept})} \tag{19}$$

where $\hat{L}$ is the likelihood of an estimated model, M_{full} is the model including all explanatory variables of interest, and $M_{Intercept}$ is the model with only an intercept (i.e., no covariates). Like the R^2 statistic, the pseudo version is at a maximum at a value of 1 with higher values denoting better model fit. To account for model complexity, there is also an adjusted version of this statistic,

$$R^2_{adj\text{-}pseudo} = 1 - \frac{\ln \hat{L}(M_{full}) - K}{\ln \hat{L}(M_{Intercept})} \tag{20}$$

where K is the number of regressors. If model fit does not sufficiently improve, then it is possible for this measure to decrease as variables are added, signaling that the additional variables do not contribute towards a better model fit. Henceforth, these pseudo R^2 statistics are referred to solely as R^2 and adjusted R^2. Another model fit statistic available in the SpInt module that also accounts for model complexity is the Akaike information criterion (AIC),

$$AIC = -2 \ln \hat{L}(M_{full}) + 2K \tag{21}$$

where lower AIC values indicate a better model fit (Akaike 1974). This statistic is grounded in information theory, whereby the AIC is an asymptotic estimate of the information that is lost by using the full model to represent a given theoretical process.

The R^2 and AIC are designed for model selection, which means they should not be used to compare between different spatial systems. One solution to this issue is the standardized root mean square error (SRMSE),

$$SRMSE = \frac{\frac{\sqrt{\sum_i \sum_j (T_{ij} - \hat{T}_{ij})^2}}{nm}}{\frac{\sum_i \sum_j T_{ij}}{nm}} \tag{22}$$

where the numerator is the root mean square error of the observed flows, T_{ij}, and the flows predicted by the model, $\hat{T}_{ij}$, and the denominator is the mean of the observed flows and is responsible for standardization of the statistic. Here, nm is the number of origin-destination pairs that constitute the system of flows. A SRMSE value of 0 indicates perfect model fit, while higher values indicate decreasing model fit; however, the upper limit of the statistic is not necessarily 1 and will depend on the distribution of the observed values (Knudsen, Fotheringham 1986).

One final fit statistic, a modified Sorensen similarity index (SSI), is included within the SpInt module because it has become increasingly popular in some spatial interaction literature that deals with non-parametric models (Lenormand et al. 2012, Masucci et al. 2012, Yan et al. 2013). Using the same symbol definition from the SRMSE, the SSI is defined as,

$$SSI = \frac{1}{(nm)} \sum_i \sum_j \frac{2\min(T_{ij}, \hat{T}_{ij})}{T_{ij} + \hat{T}_{ij}} \tag{23}$$

which is bounded between values of 0 and 1 with values closer to 1 indicating a better model fit.

3 An illustrative example: migration in Austria

3.1 The data

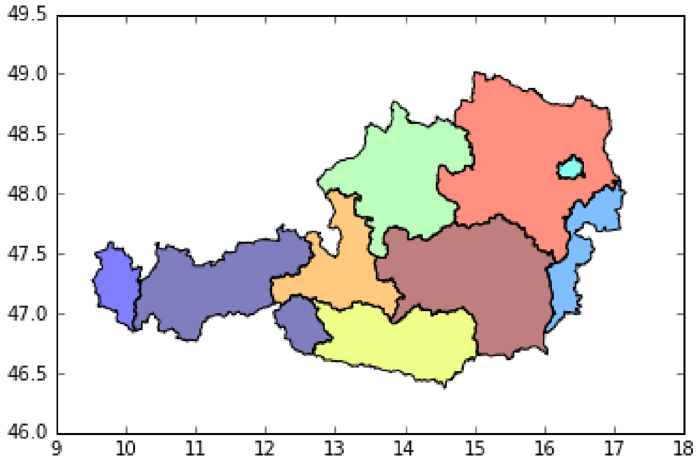
Despite being a small toy dataset, the following example is utilized for consistency since it was previously used to demonstrate spatial interaction modeling in the R programming language (Dennett 2012). The data are migration flows between Austrian NUTS level 2 regions in 2006. In order to use a regression-based calibration, the data has to be transformed from the matrices and vectors described in equations (1)–(9) to a table where each row represents a single origin-destination dyad, (i, j) and any variables associated with locations i and j. Details on how to do this are outlined further in LeSage, Pace (2008), though this has already been done in the example data. Let's have a look!

```
In [19]: import pandas as pd
         import geopandas as gp
         %pylab inline
         austria_shp = gp.read_file('austria.shp')
         austria_shp.plot()
         austria = pd.read_csv('austria.csv')
         austria.head()
```

```
Populating the interactive namespace from numpy and matplotlib
```

Out[19]:

	Unnamed: 0	Origin	Destination	Data	Oi	Dj	Dij
0	0	AT11	AT11	0	4016	5146	1.000000e-300
1	1	AT11	AT12	1131	4016	25741	1.030018e+02
2	2	AT11	AT13	1887	4016	26980	8.420467e+01
3	3	AT11	AT21	69	4016	4117	2.208119e+02
4	4	AT11	AT22	738	4016	8634	1.320075e+02



The **Origin** and **Destination** columns refer to the labels for origin locations, i, and the labels for destination locations, j, the **Data** column is the number of flows between i and j, the **Oi** and **Dj** columns are the number of total out-flows at i and total in-flows at j, respectively, and the **Dij** column is the Euclidian distance between the centroids of i and j. In this case we use the total out-flow and total in-flow as variables to describe how emissive an origin is and how attractive a destination is. If we want a more informative and interesting model we can replace these with application specific variables that pertain to different hypotheses. Next, lets format the data into arrays.

```
In [4]: austria = austria[austria['Origin'] != austria['Destination']]
        flows = austria['Data'].values
        Oi = austria['Oi'].values
        Dj = austria['Dj'].values
        Dij = austria['Dij'].values
        Origin = austria['Origin'].values
        Destination = austria['Destination'].values
```

The Oi and Dj vectors need not be $n^2 \times 1$ arrays. In fact, they can be $n^2 \times k$ where k is the number of variables that are being used to describe either origin or destination attributes associated with flows. It should also be noted that intra-zonal flows have been excluded (the first line of code above). This is sometimes done because intra-zonal flows are large compared to inter-zonal flows and would therefore heavily influence the model or because it is not possible to adequately define a distance associated with intra-zonal flows. Some solutions to these issues have been proposed (Kordi et al. 2012, Tsutsumi, Tamesue 2011), though for simplicity, intra-zonal were removed for this example.

3.2 Calibrating the models

Now, lets load the main SpInt functionality and calibrate some models. The "family" of spatial interaction models are found within the **gravity** namespace of the SpInt module and the estimated parameters can be accessed via the **params** attribute of a successfully instantiated spatial interaction model.

```
In [5]: from pysal.contrib.spint.gravity import Gravity
        from pysal.contrib.spint.gravity import Production
        from pysal.contrib.spint.gravity import Attraction
        from pysal.contrib.spint.gravity import Doubly
```

Unconstrained (basic gravity) model

```
In [6]: gravity = Gravity(flows, Oi, Dj, Dij, 'exp')
        print gravity.params

[ -8.01822841e+00   8.69316127e-01   8.91445153e-01  -6.22938370e-03]
```

Production-constrained model

```
In [7]: production = Production(flows, Origin, Dj, Dij, 'exp')
        print production.params[-2:]
```

```
[ 0.90285448 -0.0072617 ]
```

Attraction-constrained model

```
In [8]: attraction = Attraction(flows, Destination, Oi, Dij, 'exp')
        print attraction.params[-2:]
```

```
[ 0.90037216 -0.00695034]
```

Doubly-constrained model

```
In [9]: doubly = Doubly(flows, Origin, Destination, Dij, 'exp')
        print doubly.params[-1:]
```

```
[-0.00791533]
```

Note that for the above examples the print statement for the constrained models **params** attribute is limited to print only the main model variables (i.e., not fixed effects), though it is still possible to access the fixed effect parameters too.

```
In [10]: print production.params
```

```
[-1.16851884  1.68980685  2.15135947  0.59917703  0.88336198  1.20669895
  0.68945769  1.15434225  1.01013674  0.90285448 -0.0072617 ]
```

The first parameter is always the overall intercept with the subsequent 8 parameters representing the fixed effects in this case. You might ask, “why not 9 fixed effects for the 9 different regions?”. Due to the coding scheme used in SpInt, and many popular statistical programming languages, you would use $n-1$ binary indicator variables in the design matrix to include the fixed effects for all 9 regions in the model. While the non-zero entries in these columns of the design matrix indicate which rows are associated with which region, where a row has all zero entries then implicitly refers to the n^{th} region that has been left out. In SpInt, this is always the first origin or destination for the production-constrained and attraction-constrained models. For the doubly-constrained model, both the first origin and the first destination are left out (Tiefelsdorf, Boots 1995). In terms of interpreting the parameters, these dropped locations are assumed to be 0.

You can also access typical model diagnostics, such as standard errors (**std_err**), t-values (**tvalues**), p-values (**pvalues**), and confidence intervals (**cont_int**).

3.3 Interpreting the parameters

First, it will be demonstrated how to interpret the coefficients associated with the main model variables from a general Poisson regression. However, because the spatial interaction model is a log-linear Poisson regression (i.e., we take the log of the explanatory variables) the same interpretation often cannot be applied because we are working in logarithmic space. Therefore, it will also be demonstrated how to interpret the parameters when they are associated with a logged explanatory variable.

Recall from the previous section that the exponential distance-decay specification results in a model that does not take the logarithm of d_{ij}. Therefore, we can use an unconstrained gravity model with an exponential distance-decay specification to demonstrate a typical interpretation of coefficients from a Poisson regression.

```
In [11]: gravity = Gravity(flows, Oi, Dj, Dij, 'exp')
         print gravity.params
```

```
[ -8.01822841e+00   8.69316127e-01   8.91445153e-01  -6.22938370e-03]
```

-6.22938370e-03 is the coefficient for the distance variable in the above example. In Poisson regression, the coefficients are typically interpreted as the proportionate change in the predicted response, here T_{ij}, if we increase an explanatory variable by 1 unit (Cameron, Trivedi 2013). Technically, this is expressed as,

$$\tilde{T}_{ij} = T_{ij} * \exp(\beta) \tag{24}$$

where $\tilde{T}_{ij}$ is the new value of T_{ij} and β is a coefficient, here the one typically associated with distance in a Poisson log-linear spatial interaction model with an exponential function distance-decay. For this example, this means from a 1 unit increase in distance, holding all other factors constant, if our model predicted 2,500 flows, then we can expect the number of flows to decrease to approximately 2,484.475. We can also identify the percent change expected from a one unit increase in distance using,

$$\Delta_{\%} = (1 - exp(\beta)) * 100.0 \tag{25}$$

which serves as an alternative interpretation of β. In this case, we could say that from a 1 unit increase in distance we could expect the number of predicted flows to decrease by approximately 0.621%.

However, neither equation (24) nor (25) is applicable when the coefficient is associated with a logged explanatory variable. This is important for Poisson log-linear spatial interaction models because this applies to the origin and destination variables when using an exponential function of distance-decay and to the origin, destination, and distance variables when using a power function of distance-decay. In these cases, the interpretation of the coefficients becomes the percent change in the predicted response, here T_{ij}, if we increase the associated explanatory variable by 1% (Cameron, Trivedi 2013). For example, 8.91445153e-01 is the coefficient associated with destination total in-flows (i.e., attractiveness) in the above example. Then if we increase the in-flows to location j by 1%, say from $25,000$ to $25,250$, and holding all other factors constant, we can expect the number of flows from i to j (i.e., T_{ij}) to increase from $2,000$ to $2,020$[3].

Finally, the fixed effects in the constrained models can be interpreted such that the mean predicted flows, T_{ij}, are e^{μ_i} (e^{α_j}) times larger if they originate (terminate) from location i (location j) (Cameron, Trivedi 2013), where e^{μ_i} is equivalent notation for $\exp(\mu_i)$.

3.4 Assessing model fit

We can compare the different model fit statistics across the four types of spatial interaction models for this example. Let's process the statistics into a tidy table and have a look.

```
In [12]: R2, adjR2, SSI, SRMSE, AIC = [], [], [], [], []
         model_name = ['grav', 'prod', 'att', 'doub']
         col_names = ['R2', 'adjR2', 'AIC', 'SRMSE', 'SSI']
         models = [gravity, production, attraction, doubly]

         for model in models:
             R2.append(model.pseudoR2)
             adjR2.append(model.adj_pseudoR2)
             SSI.append(model.SSI)
             SRMSE.append(model.SRMSE)
             AIC.append(model.AIC)

         cols = {'model_name': model_name,
                 'R2': R2,
```

[3]This example is only illustrative. Of course, if we increased the total in-flows, this would imply that we are also increasing the total out-flows from somewhere else and therefore the system could not truly be held constant. However, substantive modeling calls for origin and destination variables that are not derived from the interaction matrix. Therefore, this is not an issue in practice when there is the assumption of independence between flows. It should also be noted that it has been hypothesized that flows may not be independent and therefore more accurate estimates can be obtained using more advanced methods (LeSage, Pace 2008, Chun 2008).

```
                'adjR2': adjR2,
                'SSI': SSI,
                'SRMSE': SRMSE,
                'AIC': AIC }

        data = pd.DataFrame(cols).set_index('model_name')
        data[col_names]
```

Out[12]:

model_name	R2	adjR2	AIC	SRMSE	SSI
grav	0.885764	0.885718	20122.074349	0.607776	0.727358
prod	0.910156	0.910031	15841.253799	0.464520	0.740914
att	0.909355	0.909230	15982.313101	0.584048	0.752155
doub	0.943540	0.943335	9977.159141	0.379286	0.811852

From this table we can see that all of the fit statistics indicate a better model fit as constraints are introduced. That is, the weakest model fit is consistently related to the gravity model, with similarly increased model fit for the production-constrained and attraction-constrained models, and finally, the best model fit is associated with the doubly constrained model. We can also see that the R^2 and adjusted R^2 are very close, since these models have a very similar number of explanatory variables, thereby resulting in little or no penalization for model complexity.

We can also take a look at whether the power or exponential distance-decay specification results in a better model fit. For simplicity, lets just take a look at the SRMSE for a doubly constrained model.

```
In [13]: print 'SRMSE for exp distance-decay: ', doubly.SRMSE
         pow_doubly = Doubly(flows, Origin, Destination, Dij, 'pow')
         print 'SRMSE for exp distance-decay: ', pow_doubly.SRMSE
```

```
SRMSE for exp distance-decay:  0.37928618533
SRMSE for pow distance-decay:  0.277703139642
```

For this example, it looks like the power distance-decay specification results in a better model fit.

3.5 Local models

The SpInt module also makes it possible to calibrate "local" models, which subset the data by specific origins or destinations in order to investigate how spatial interaction processes vary over space (Fotheringham, Brunsdon 1999). Below is an example of how to get local parameters and local diagnostics for a gravity model subset by its origins. The result is a dictionary of lists where the keys are the different sets of local values including parameters, hypothesis testing diagnostics, and the previously reviewed fit statistics.

```
In [14]: gravity = Gravity(flows, Oi, Dj, Dij, 'pow')
         local_gravity = gravity.local(Origin, np.unique(Origin))
```

Lets take a look at the local distance-decay parameters. The origin, destination and distance-decay parameters are indexed sequentially through the design matrix starting with 0 as you move through the origin attributes, through to the destination attributes, and finally the distance-decay attribute. Therefore, for n variables, the distance-decay parameters are always the $n-1^{th}$ parameter, in this case of 3 variables: **param2**.

```
In [15]: print np.round(local_gravity['param2'], 4)
```

```
[-3.4028 -1.3583 -0.8307 -1.1492 -0.4781 -1.0095 -1.6758 -1.2156 -1.5397]
```

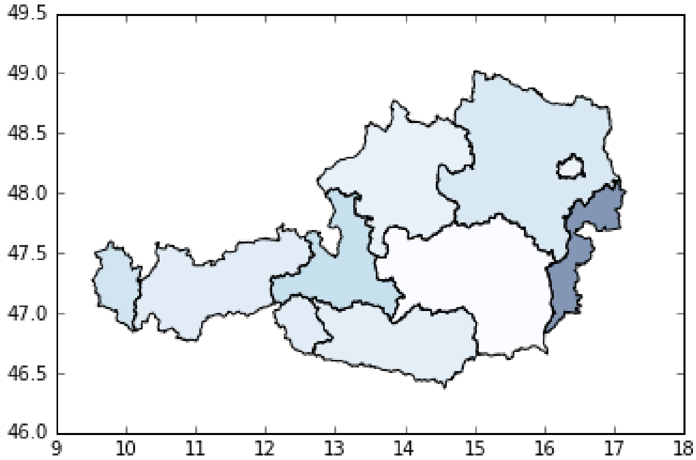
We can also take a look at the local R^2.

```
In [16]: print np.round(local_gravity['pseudoR2'], 4)
```

```
[ 0.9665  0.9894  0.9893  0.5205  0.676   0.7298  0.6333  0.432   0.515 ]
```

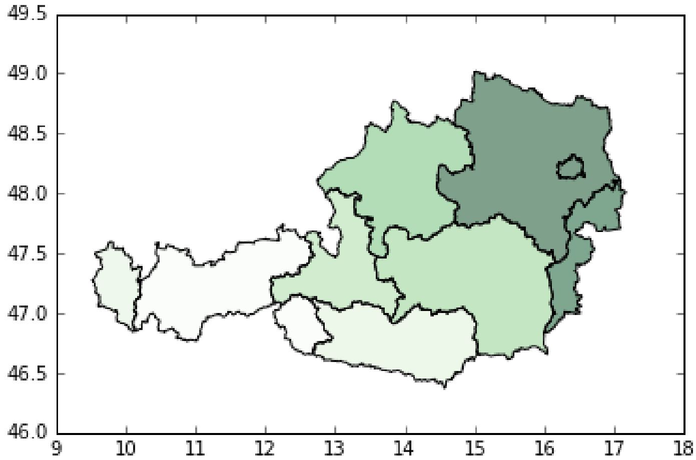
Both the local distance-decay and the R^2 show some variation. We can explore this spatially, by mapping the local values. First, lets join the local values to a shapefile and then plot the local distance-decay parameters

```
In [17]: #Join local values to census tracts
         local_vals = pd.DataFrame({'betas': local_gravity['param2'],
                                    'Dest':np.unique(Origin),
                                    'pseudoR2': local_gravity['pseudoR2']})
         local_vals = pd.merge(local_vals, austria_shp[['NUTS_ID', 'geometry']],
                               left_on='Dest', right_on='NUTS_ID')
         local_vals = gp.GeoDataFrame(local_vals)

         #Plot betas - use inverse so the most negative values are "higher"
         fig = plt.figure()
         ax = fig.add_subplot(111)
         local_vals['inv_betas'] = (local_vals['betas']*-1)
         local_vals.plot('inv_betas', cmap='Blues', ax=ax)

Out[17]: <matplotlib.axes._subplots.AxesSubplot at 0x115da9fd0>
```



Next, lets map the local R^2 values. Above we can see a much stronger distance-decay for the most westerly region. Below we can see that the model fit is stronger in the north-west and decreases in the south-east. Using these patterns, we could then further postulate why they arise or how we might be able to improve model fit.

```
In [18]: fig = plt.figure()
         ax = fig.add_subplot(111)
         local_vals.plot('pseudoR2', cmap='Greens', ax=ax)

Out[18]: <matplotlib.axes._subplots.AxesSubplot at 0x116f3b9d0>
```



4 Further functionality

In addition to all of the features presented here, there are several other tools that exist in SpInt or could be added. First, there are dispersion tests available in the **dispersion** namespace of the SpInt module, which can be used to test whether or not the Poisson equidispersion assumption is met. That is, that the conditional mean and variance are equivalent, which can be unrealistic in many scenarios. If these tests indicate overdispersion or underdispersion, then it might be appropriate to use a Quasi-Poisson model, which relaxes the equidispersion assumption of the Poisson model. The resulting parameter estimates are equivalent to the Poisson model, but the standard errors are typically larger whenever equidispersion does not hold (Wedderburn 1974). The Quasi-Poisson model specification can be carried out by setting **Quasi=True** in any of the spatial interaction models introduced here. Alternatively, it might be more appropriate to change the underlying probability model from Poisson to that of negative binomial or a zero-inflated model. However, this has not yet been implemented in SpInt and therefore remains as future work.

Another area of potential expansion is to accommodate several paradigms for incorporating spatial effects into spatial interaction models, such as competing destinations (Fotheringham 1983), a spatial lag autoregressive model (LeSage, Pace 2008), or an eigenvector spatial filter model (Chun 2008). These paradigms require code that computes additional variables, more complex calibration techniques, and specialized representations of spatial relationships. Some solutions to the latter are available in the **spintW** namespace of the **weights** module of PySAL. While there is still much work to be done to develop a more robust set of open source spatial interaction modeling tools, SpInt provides a starting point for which to build upon.

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