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Approximating the impact of COVID–19 on regional production in countries with scarce subnational data: A proposal and application for Argentina during the first wave

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Abstract. In this paper we propose an index to approximate the territorial economic impact of the COVID–19 pandemic in contexts with scarce or outdated regional data, which is often the case in developing countries. This index is based on data that are usually available in most countries: a) the sectoral productive structure of the regions, b) the operational level of each sector, c) the mobility of workers in each region, and d) the possibility of remote work among sectors. The empirical application for Argentina describes the impact of the pandemic on regional production during the second and third quarters of 2020, both for the provinces and labor market areas. Our results show that the regional impact of COVID–19 on private economic activity was highly heterogeneous between and within provinces. The proposed index is also highly correlated with sporadic official data coming from national agencies, while it has a wider geographical and temporal scope, especially in terms of labor market areas.

1 Introduction

The COVID–19 pandemic and the different regulations imposed by governments to contain the spread of the virus have produced deep transformations, as well as multiple social and economic costs (Baldwin, Weder di Mauro 2020, Barua 2020, Noguchi 2020). The trade-off between epidemiological prevention and economic activity is one of the most pressing issues that governments and societies are facing (Kok 2020). In addition, the economic impacts of the pandemic and mitigation measures have been highly uneven. Winners and losers can be identified between countries, regions, sectors, businesses, households, or workers (Adams-Prassl et al. 2020, Blundell et al. 2020, ECLAC 2020a,b, Sokol, Patacccini 2020).

Recent studies highlight that, unlike other crises such as that of 2008-2009, the impact of the pandemic has been regional rather than national, and in the case of developed countries, the territorial differences observed within them have been greater than those registered between nations (Bailey et al. 2020, Amdaoud et al. 2021). This is why the literature raises the need to adopt a regional perspective in the analysis of the economic impact of the COVID–19 pandemic, in order to understand and adequately manage the uneven impact of isolation and mobility restriction measures (Benedetti et al. 2020, Brinks, Ibert 2020, Cerqua, Letta 2020, Giannone et al. 2020, OECD 2020).

However, the study of the regional economic impact often faces several limitations, in many cases due to the limited availability of updated information at the subnational level. The abundance of real-time epidemiological statistics for multiple geographical scales – countries, regions, cities, neighborhoods – contrasts with the scarcity of economic statistics, which in developing countries are often non-existent or very outdated. On the other hand, available estimates of the economic impact of COVID–19 are usually presented at an aggregate level, that is, by country or by sector.

In this paper we intend to make a contribution especially relevant for the developing world, which is often missing in the urban and regional economics literature (Castells-Quintana, Herrera-Idárraga 2019). In particular, we explore how to approximate the territorial economic impact of the COVID–19 pandemic in contexts with scarce or outdated regional data. Argentina is a good example of this, since there are no homogeneous and updated statistics on GDP or sectoral value added at the territorial level. The latest official data, available only for provinces, correspond to 2004. In addition, there are no regional input-output tables to analyze the interactions between activities in the different regions, or factor intensities in the different sectors and regions.

In this context, it is necessary to introduce some caveats. First, based on the limited data available in Argentina, we can only approximate the regional impact of COVID–19 on private economic activity. Secondly, we will address the territorial economic impact from the supply side, considering the immediate or short-term impact on private production in each region, and not from the measurement of the different components of regional demand.

Bearing in mind these caveats, we propose the calculation of an index that, with some adjustments or adaptations to each context, could be used to approximate the regional economic impact of the pandemic and isolation measures, based on data or statistics that are usually available in most countries. Our index of territorial economic impact by COVID–19 (ITEI-COVID) takes into account: a) the sectoral production structure of the different regions, based on pre-pandemic data, b) the operational level of each sector, based on secondary post-pandemic information at the national level, c) the mobility of workers in each region, based on the easily accessible data from Google Mobility Reports, and d) the possibility of remote work across different activities or sectors, based on recent studies that have been carried out in many countries. Unlike other very interesting studies that require, for example, the availability of regional input-output tables (Bonet-Morón et al. 2020, Haddad et al. 2020, Porsse et al. 2020, Haddad et al. 2021), the relative simplicity and lower data requirements of the index could facilitate the implementation in broader contexts.

As an application, we will show the results of the ITEI-COVID for the 24 provinces and the main 85 Labor Market Areas (LMAs) of Argentina, according to the evolution of the national and regional restrictions imposed both on people's mobility and on different economic activities. In Argentina, the provinces are the first subnational political-administrative level, followed on a much smaller scale by the municipalities or local governments. Meanwhile, the LMAs are defined as the portion of territory delimited by workers' daily movements between their workplace and their home (Borello 2002, Rotondo et al. 2016). In this sense, they are made up of a central city or node and a set of other localities linked in labor terms. A similar geographical unit has also been analyzed in other Latin American countries, such as Chile, for example (Rowe et al. 2017).

The results of the ITEI-COVID shown in this paper cover the six months – or two quarters – of greatest economic contraction in Argentina, from April to September 2020. This period also coincides with the first wave of the pandemic in the country. According to official indicators from the National Institute of Statistics and Censuses (INDEC, in Spanish), the year-on-year fall in national GDP in the second quarter of 2020 was 19.1% – exceeding the 16.3% fall recorded in the first quarter of 2002, at the epicenter of the convertibility crisis – and 10,2% in the third quarter of 2020. The year-on-year fall in the monthly economic activity estimator (EMAE, in Spanish) was above 25% in April, 20% in May, around 12-13% from June to August, and about 7% in September.

The paper is structured as follows. After a brief review of recent literature (Section 2), we contextualize the Argentinean case (Section 3) and present both the methodology and data used for the calculation of the index (Section 4). In Section 5 we first show the results obtained for the different provinces and LMAs and then present some validation exercises, comparing these results with regional official indicators that have been published discontinuously. Finally, we close with some conclusions.

2 The regional economic impact of the pandemic across the literature

In the same way that the pandemic increases individual and sectoral inequalities (either between workers in essential and non-essential sectors, between activities that can be carried out remotely and those that cannot, between formal and informal wage earners, or between companies that have invested in new technologies and the ones that do not find resources to do so in this context), it is also expected to affect regional inequalities. This uneven territorial impact is, to some extent, predictable. It is due in part to the different speeds of regional circulation of the virus, but also to differences in terms of the timing of public policies, the intensity and duration of quarantine or isolation measures, the restrictions on mobility within and outside each region, the composition of local production structures, and other characteristics of the regions, such as labor and income inequalities among the population or the regional dependence on international trade and global value chains (Aalbers et al. 2020, Bailey et al. 2020, Bonaccorsi et al. 2020, Cerqua, Letta 2020, Inoue et al. 2020, Kapitsinis 2020, Ponce et al. 2020, Shen et al. 2020, Ascani et al. 2021, Beyer et al. 2021).

The study of the regional economic impact of the COVID–19 pandemic is relevant for several reasons. First, it is a basic input for designing and executing place-based responses (Friedman et al. 2020, Rahman et al. 2020), rather than centralized (one-size-fits-all) policies that have failed in many countries (Morrison, Doussineau 2019, Bailey, Tomlinson 2020, Benedetti et al. 2020, Giannone et al. 2020, OECD 2020). As highlighted by Giannone et al. (2020), isolation measures established evenly at the national level can be very early in some cities – mainly small, where the virus takes longer to spread – or very late in others, such as large urban centers. The possibility of mitigating the direct economic impact and the indirect effects of the recession depends crucially on the existence of place-based policies and targeted instruments, which generally imply a greater decentralization of functions, powers, and resources at the regional level. Secondly, the economic problems caused by the pandemic also tend to be region-specific, such as higher unemployment and poverty rates, business closures, and multiple impacts on local production systems, among others. Finally, the systematization of empirical evidence in different countries will allow us to better understand the regional patterns whose stylized features are still unknown (Bailey et al. 2020). In this sense, the analysis of the short-term impact of the pandemic is a necessary starting point for future studies regarding the expected effects in the medium- and long-term, such as changes in the configuration of global value chains, impacts on internal migration, greater diseconomies of agglomeration, changes in values of the real estate, and geography of discontent, among others.

Since the outbreak of COVID–19, and given its global scope, several papers have analyzed the regional economic impact of the pandemic. For example, it is possible to identify studies for the United States (Barrot et al. 2020, Chetty et al. 2020, Muro et al. 2020), for different countries or regions in Europe (Bachtrögler et al. 2020, Bustos Tapetado, Solla Navarro 2020, Cerqua, Letta 2020, De la Fuente 2020, González Laxe et al. 2020, Kitsos 2020, Pérez, Maudos 2020, Prades Illanes, Tello Casas 2020, Gombos et al. 2021), for China and India (Gong et al. 2020, Huang et al. 2020, Beyer et al. 2021), for Marruecos (Haddad et al. 2020), and for Colombia and Brazil (Bonet-Morón et al. 2020, Hernández-Díaz, Quintero 2020, Porsse et al. 2020, Haddad et al. 2021), among others. For Argentina, the few studies on the territorial economic impact of the pandemic are based on national and sectoral surveys with highly aggregated geographical units, such as the five or six geographical macro-regions in which the 24 provinces are usually grouped (FOP 2020a,b,c, UIA 2020). Other studies estimate the impact on the GDP of a single province, such as Santa Fe (BCSF 2020), or at best of the different municipalities within Buenos Aires Province (Lódola, Picón 2020).

As we show in the next section, the ITEI-COVID combines some topics that come from different strands of literature. For example, the analysis and definition of operational or vulnerability levels for the different economic sectors has been a common step in several of the papers mentioned (Bachtrögler et al. 2020, Bonet-Morón et al. 2020, Bustos Tapetado, Solla Navarro 2020, González Laxe et al. 2020, Haddad et al. 2020, Hernández-Díaz, Quintero 2020, Lódola, Picón 2020, Pérez, Maudos 2020, Prades Illanes, Tello Casas 2020, Haddad et al. 2021).

Another line of research that has quickly become popular is the estimation of models that relate local epidemiological statistics with data on people's mobility from the location of their mobile devices (Badr et al. 2020, Kraemer et al. 2020, Lai et al. 2020, Weill et al. 2020). The use of mobility data, from Google Mobility or similar sources, has also been a frequent input in several papers that analyze the regional impacts of the pandemic (Bonaccorsi et al. 2020, Chetty et al. 2020, Haddad et al. 2020, Huang et al. 2020, Campos-Vazquez, Esquivel 2021, Marcén, Morales 2021), as well as in some cross-country studies (Askitas et al. 2020, Chen et al. 2020, König, Winkler 2020, Maloney, Taskin 2020, Sampi, Jooste 2020).

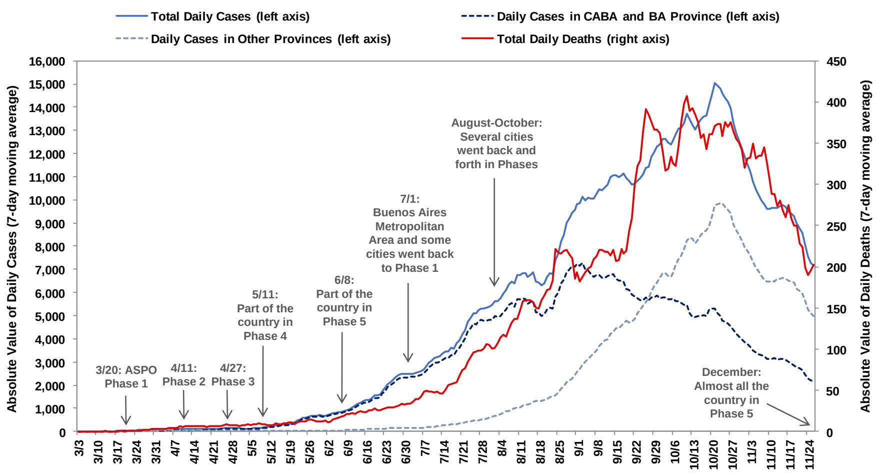
Finally, as we have mentioned, the analysis of the potential for remote work or teleworking as a possible response to certain economic activities and especially of some types of workers to mobility restrictions, has been the subject of numerous international studies (Crowley, Doran 2020, Delaporte, Peña 2020, Del Río-Chanona et al. 2020, Dingel, Neiman 2020, Garrote Sanchez et al. 2020, Hatayama et al. 2020, Saltiel 2020). In the particular case of Argentina, we can also find some specific studies on this topic (Albrieu 2020, Gasparini, Bonavida Foschiatti 2020, Red ISPA 2020).

3 The COVID–19 pandemic and isolation measures in Argentina

The first imported case of COVID–19 in Argentina was confirmed on March 3rd. A few days later, the national government established a mandatory quarantine for travelers entering or returning to the country, suspended all artistic and sports shows, as well as classes at all educational levels, and finally closed the national borders. On March 19th, when confirmed cases in the country were barely 130 and there were still no signs of community circulation (80% of cases were imported and the remaining 20% were close contacts), the President announced the beginning of a strict and mandatory quarantine for the entire country, the phase 1 of the Preventive and Compulsory Social Isolation (ASPO, in Spanish). Only those activities and workers considered essential were exempted, such as medical services and supplies, security personnel, food production, pharmacies, local food and cleaning supplies stores, public services, public transportation for essential workers, and fuel dispensing, among others. It is worth noting that on the day of the announcement, about half of the 24 Argentinean provinces had not yet registered any positive cases. Moreover, in more than half of the provinces with cases, there were only one or two infected people. In most cities, there were no confirmed cases for several weeks or even months. However, during the first phases of strict quarantine and isolation, no territorial criteria were taken into account.

During this first stage and phase 2 of administrative isolation – end of March and practically all of April – the restrictions and exceptions to economic activity were established at the level of sectors. While the economic activities considered essential continued in a relatively normal way (food and beverage processing, health services), there were others whose operations were significantly reduced (transportation) or indefinitely suspended (tourism, recreation, cultural services). On the other hand, despite mobility restrictions, some activities could be adapted and carried out remotely (various professional services, education), but others that required a physical presence in the workplace (manufacturing, construction) were naturally much more affected (Albrieu 2020, Gasparini, Bonavida Foschiatti 2020, Red ISPA 2020).

From the beginning of May, with the passage to phase 3 of geographic segmentation, the quarantine administration and especially the exempted activities began to take into account the context and epidemiological evolution of each region. The latter was deepened when some parts of the country advanced to phase 4 of progressive re-opening. In June the isolation measures were further relaxed in many regions, and even several cities moved



Source: Authors' calculation based on data reported by the Ministry of Health.

Figure 1: COVID–19 daily cases and deaths in Argentina (7-day moving average)

to phase 5 of social distancing (called DISPO), in which the circulation and development of a large number of additional activities were allowed. On the other hand, other cities with a marked community circulation of the virus, such as the Metropolitan Area of Buenos Aires, Resistencia, or San Salvador de Jujuy, among others, continued under the ASPO measures and even went back in phases by the end of June or beginning of July.

Until June the vast majority of cases were concentrated in the city of Buenos Aires (CABA, in Spanish) and its surroundings (Figure 1), which explains the gradual relaxation of the restrictions on mobility and economic activities in different parts of the country. Since July and especially during August and September, the epidemiological situation in many cities became more complicated and complex, but despite the setbacks in ASPO phases and the re-imposition of de jure restrictions, the levels of de facto mobility did not necessarily respond in the same way (Levy Yeyati, Sartorio 2020).

This evolution allows us to anticipate an unequal regional impact of the pandemic and the consequent isolation measures during the first wave in Argentina. On the one hand, when the exemptions were established at the sectoral level (phases 1 and 2), the territorial impact could be conditioned by the heterogeneous sectoral distribution of production and employment in the country, which is reflected in different regional productive specializations. On the other hand, in the later stages of ASPO, the unequal health impact of the virus in the different regions was an extra source of heterogeneity and, associated with this, the advances and setbacks in phases, as well as the tension between de jure restrictions and de facto mobility.

4 Data and methods

During the month t of April (phases 1 and 2 of ASPO, with restrictions and exceptions defined at the sectoral level), the ITEI-COVID in region j is calculated as:

$$ITEI_{jt} = 100 - \sum_{i=1}^{n} S_{ij} * OP_{it}$$

where S_{ij} is the weight of sector i in region j and OP_{it} is the operational level of sector i in the country in this month.

Meanwhile, for the months t from May to September, where mobility restrictions were relaxed or re-imposed with different (de jure or de facto) intensities, according to the regional context, the $ITEI$ for each region j is obtained as follows:

$$ITEI_{jt} = 100 - \sum_{i=1}^{k} S_{ij} * OP_{it} - \sum_{i=k+1}^{n} S_{ij} * OP_{it} * LMI_{jt} * RWI_j$$

where we distinguish, on the one hand, the k sectors that showed a high operational level during April – the stage of greatest restrictions – and therefore also in the following months regardless of the regional context, and on the other hand, the rest of the sectors whose operational level effectively depended on the flexibility or not of labor mobility in each region. In this sense, LMI_{jt} is an index of people's mobility to their workplace – or labor mobility index – in region j, based on Google Mobility Reports, during the working days of month t. RWI_j is a remote work index, which reflects in what proportion the workers in region j could carry out their work activities from their home, so they would not need to go to their workplace[1].

Given that in Argentina there is no complete, homogeneous, and updated sectoral value-added statistics at the territorial level, we use data on formal salaried employment in the private sector to define the sectoral weights (S_{ij}). This information comes from the databases of provinces and LMAs elaborated by the Employment and Business Dynamics Observatory (EBDO), under the Ministry of Labor, Employment, and Social Security. In particular, we use average employment data from the year 2019 and we calculate the weight of formal private employment in each sector (ISIC at 2 digits) over the total formal private employment in each province or LMA.

It is worth noting that the regional data offered by EBDO cover the entire universe of formal salaried employment in the private sector in each province or LMA,[2] based on the crossing of administrative records of the Argentinean Integrated Pension System and the Federal Administration of Public Revenues (AFIP, in Spanish). It is not an estimate or projection according to sample data, as it happens with the National Population Survey (NHS) of INDEC. Obviously, the limitation of using data on formal salaried employment in the private sector to describe the regional (private) production structure is that informal salaried employment and self-employed workers are not considered[3]. However, in a previous working paper (Niembro, Calá 2020) we show that the general patterns for April remain relatively unchanged when we incorporate data on informality and self-employment using information from NHS.

The operational level of each sector in each month (OP_{it}) ranges from a maximum of 100 (complete) to a minimum of 0 (null), going through intermediate values of 75 (high), 50 (medium), and 25 (low). In order to carry out a simple sensitivity analysis – and since we cannot affirm a specific and exact level – we define for each sector a hypothesis of minimum operational level and another of maximum level, based on the search and interpretation of secondary information, such as recent statistics published by INDEC and other official agencies, reports from consultants and research centers, and information from various surveys and sectoral chambers[4]. The Appendix presents the list of the sectors considered (the k sectors of the second formula are highlighted) the two possible hypotheses defined, and the sources reviewed in each case. As mentioned, the definition

[1]Since we can consider the impact of the pandemic on regional production during April–September 2020 as a short-term impact, we can also assume that substitution between production factors may have been limited during the first months of the pandemic. In this sense, we are implicitly assuming that production functions behind the index would resemble a fixed-proportions production function. Therefore, in those production processes that require the physical presence of workers who cannot work remotely, the reduction of mobility and attendance at the workplace would also translate into lower production, regardless the labor intensity of each sector.

[2]Although some localities are not included within the main 85 LMAs, these LMAs account for around 95% of formal salaried employment in the private sector in Argentina. Obviously, in the case of the 24 provinces, all the national universe is covered.

[3]Employment in the public sector is not taken into account either, although it is not the purpose of this paper to analyze the impact of the pandemic and isolation measures on the production of services in this sector.

[4]For several sectors, official statistics are available at the national level, such as the Manufacturing Industrial Production Index published by INDEC. In these cases, we can analyze year-on-year variations. According to the ranges (100, 75, 50, 25, 0), we define the hypotheses of minimum and maximum operational level -that is, a lower and upper bound of operational level-. For example, a 40% drop translates into an operational level between 50 and 75. A similar procedure is followed with the percentages of production or sales decline reported by different sectoral surveys or business chambers.

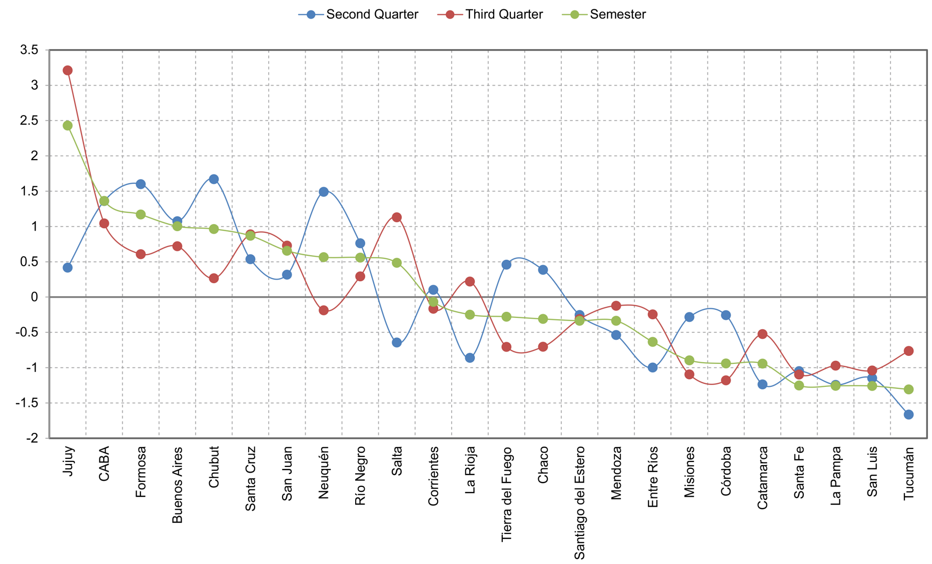


Figure 2: ITEI for provinces: standardized values per quarter and semester

of operational or vulnerability levels for each sector has been common in recent studies on the economic impact of the pandemic.

To account for people's mobility to their workplace (LMI_{jt}) in the different regions and months, we use data from Google Mobility Reports which, in the case of Argentina, is published for the provinces and the main departments within them[5]. These calculations reflect how mobility and permanence in different places – shops and leisure spaces, supermarkets and pharmacies, parks, transport stations, residential areas and, what interests us here, workplaces – have changed in percentage terms with respect to a pre-pandemic baseline value (the median for each day of the week during the 5 weeks from January 3rd to February 6th). As mentioned, the use of data from Google Mobility or similar sources has become very popular. First, we obtain for each province or department the average mobility to workplaces for the working days of each month, excluding weekends, holidays, and non-working days. Second, taking as a benchmark the value of April (mobility explained mainly by the sectoral restrictions and exceptions and the different regional production structures), we obtain the differences in mobility from May to September; that is, the recovery of mobility depending on the different evolution of each region. Then, based on a correspondence table that we have prepared, we obtain the respective values for the different LMAs, weighing the departments according to their population when it is necessary to combine two or more departments. Finally, the values for each province and LMA are divided by the national value. In other words, the labor mobility index indicates the greater or lesser recovery in mobility (above or below 1, the national level) in the provinces and LMAs with respect to the whole country.

It should be taken into account that less territorial mobility to workplaces could reflect both less flexibility in isolation measures and a greater ability of workers in that region to perform their activities from home. Therefore, the last component of the ITEI (RWI_j) accounts for the potential of remote work in each region, based on the Remote Work Indicator (RWI) proposed by Red ISPA (2020) in the case of Argentina. In general, the methodology for the RWI calculation (inspired by Del Río-Chanona et al. 2020) consists of identifying the tasks performed by a worker in each one of the occupational categories that companies declare for their employees, and detecting which of them can be carried out under a telework model. The RWI then indicates the possibility of a worker performing their activities from home, being 0 if none of the tasks can be carried out by teleworking, and 1 if all the tasks can be carried out under this modality. The RWI, which in principle

[5]In Argentina, the provincial territory is divided into departments, which generally include different localities or municipalities and also rural areas.

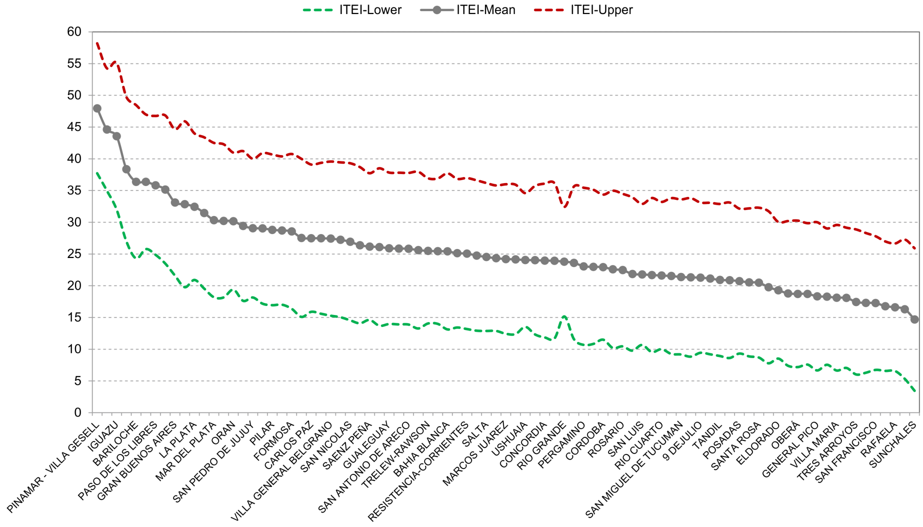


Figure 3: Lower, upper, and average ITEI for LMAs (semester)

characterizes each job position (accountant, mechanical engineer, waiter, bricklayer), can then be added to characterize the different sectors or Argentinean provinces (Red ISPA 2020). For the different LMAs, we obtain a local proxy of the RWI_j based on the RWI for each sector and the respective sectoral weights (S_{ij}). As with the labor mobility index, the values for each province and LMA are divided by the national value[6].

Due to its form of calculation, the ITEI must be interpreted as a negative index – that is, it takes higher values if the economic (private) activity has been greatly affected by the pandemic and isolation measures, and vice versa. As with any other index, the ITEI should be interpreted with some caution, prioritizing a relative comparison between regions and not an interpretation of the absolute values in each case.

5 Results

5.1 Economic impact on Argentinean provinces and LMAs

Table 1 shows the average values of the ITEI by province, for each month, quarter, and the whole semester. It is the average between the minimum and maximum values of the index, corresponding to the hypotheses of maximum and minimum operational level, respectively. Meanwhile, the quarterly and six-monthly values are obtained as a simple average of the respective monthly values. In line with the evolution of the EMAE, our index shows, in the aggregate of all provinces (last row), a very considerable negative impact in the first month, but also a sustained recovery in economic activity between April and June – a substantial fall in the index. From June onwards, this value remains relatively stable in the range of 21–23 points.

In general, there is considerable stability in the relative position of the most and least affected provinces. For example, the five most affected provinces in the semester (from Jujuy to Chubut) were among the worst ten positions in most of the months. At the other extreme, of the ten least affected provinces in the semester (from Tucumán to Santiago del Estero), half of them never were in the top ten of the most affected, and the other half only appeared there in one of the six months analyzed.

[6]It is possible to obtain a result greater than 100 -value that defines complete operativity- when multiplying the operational level of each sector (OP_{it}) by the labor mobility index LMI_{jt}) and the remote work index (RWI_j). Since this does not make sense, on such occasions the value is truncated at the upper limit of 100.

Table 1: ITEI for provinces: monthly, quarterly, and six-monthly values and ranking

	April		May		June		**Second Quarter**		July		August		September		**Third Quarter**		**Semester**	
	ITEI (mean)	Rank	ITEI (mean)	Rank	ITEI (mean)	Rank	**ITEI (mean)**	**Rank**	ITEI (mean)	Rank	ITEI (mean)	Rank	ITEI (mean)	Rank	**ITEI (mean)**	**Rank**	**ITEI (mean)**	**Rank**
Jujuy	37.9	22	27.9	17	37.2	1	**34.3**	**9**	45.9	1	44.3	1	38.1	2	**42.7**	**1**	**38.5**	**1**
CABA	45.2	8	37.2	2	33.0	4	**38.5**	**4**	33.8	2	29.7	4	22.5	10	**28.7**	**3**	**33.6**	**2**
Formosa	48.0	5	37.5	1	33.1	3	**39.5**	**2**	29.7	4	25.0	10	22.7	9	**25.8**	**7**	**32.7**	**3**
Buenos Aires	44.8	9	35.9	5	30.9	6	**37.2**	**5**	31.2	3	27.4	6	21.0	15	**26.5**	**6**	**31.9**	**4**
Chubut	48.6	4	35.3	6	35.5	2	**39.8**	**1**	24.8	6	20.7	13	25.2	6	**23.6**	**9**	**31.7**	**5**
Santa Cruz	51.3	3	32.6	8	20.7	15	**34.9**	**7**	24.4	7	31.9	2	26.5	5	**27.6**	**4**	**31.3**	**6**
San Juan	46.2	7	31.5	11	24.1	9	**33.9**	**11**	18.6	14	31.4	3	29.8	3	**26.6**	**5**	**30.3**	**7**
Neuquén	53.4	2	36.4	4	27.3	8	**39.0**	**3**	21.4	10	19.9	15	20.6	17	**20.6**	**13**	**29.8**	**8**
Río Negro	41.0	18	36.6	3	30.0	7	**35.9**	**6**	23.4	8	25.6	8	22.3	11	**23.8**	**8**	**29.8**	**9**
Salta	40.0	21	26.5	18	22.6	11	**29.7**	**17**	20.7	11	25.9	7	41.0	1	**29.2**	**2**	**29.5**	**10**
Corrientes	43.5	12	31.7	10	23.7	10	**33.0**	**12**	20.1	12	19.0	17	23.3	8	**20.8**	**12**	**26.9**	**11**
La Rioja	41.4	17	29.6	14	15.3	19	**28.8**	**18**	17.5	16	25.2	9	27.2	4	**23.3**	**10**	**26.0**	**12**
Tierra del Fuego	55.5	1	34.7	7	13.4	23	**34.5**	**8**	11.1	24	28.8	5	11.9	23	**17.3**	**18**	**25.9**	**13**
Chaco	42.1	15	29.2	16	31.3	5	**34.2**	**10**	23.2	9	16.2	19	12.4	22	**17.3**	**17**	**25.7**	**14**
Santiago del Estero	46.2	6	29.6	13	18.4	17	**31.4**	**13**	12.6	21	24.7	11	22.2	12	**19.8**	**15**	**25.6**	**15**
Mendoza	40.6	19	29.2	15	20.8	14	**30.2**	**16**	18.0	15	21.3	12	24.0	7	**21.1**	**11**	**25.6**	**16**
Entre Ríos	36.5	23	25.6	20	22.4	12	**28.2**	**19**	20.0	13	20.2	14	20.6	16	**20.3**	**14**	**24.2**	**17**
Misiones	40.4	20	31.7	9	21.7	13	**31.3**	**15**	16.2	17	15.4	20	12.6	21	**14.7**	**22**	**23.0**	**18**
Córdoba	43.8	11	31.3	12	19.1	16	**31.4**	**14**	13.8	19	14.7	21	14.0	20	**14.2**	**24**	**22.8**	**19**
Catamarca	43.3	13	23.8	23	14.3	22	**27.1**	**22**	26.4	5	11.6	24	17.3	19	**18.4**	**16**	**22.8**	**20**
Santa Fe	43.2	14	25.7	19	15.0	20	**28.0**	**20**	12.0	22	13.6	22	18.6	18	**14.7**	**23**	**21.3**	**21**
La Pampa	41.9	16	23.2	24	16.2	18	**27.1**	**23**	15.3	18	19.5	16	11.7	24	**15.5**	**20**	**21.3**	**22**
San Luis	44.6	10	24.7	21	13.3	24	**27.5**	**21**	11.6	23	11.7	23	22.0	13	**15.1**	**21**	**21.3**	**23**
Tucumán	36.3	24	24.5	22	15.0	21	**25.3**	**24**	12.9	20	16.6	18	21.2	14	**16.9**	**19**	**21.1**	**24**
Provincial Average	**44.0**		**30.5**		**23.1**		**32.5**		**21.0**		**22.5**		**22.0**		**21.9**		**27.2**	

Notes: Dark red (green) shows the five most (least) affected provinces. Light red (green) shows the next five most (least) affected provinces. Yellow shows the remaining four provinces in an intermediate position.

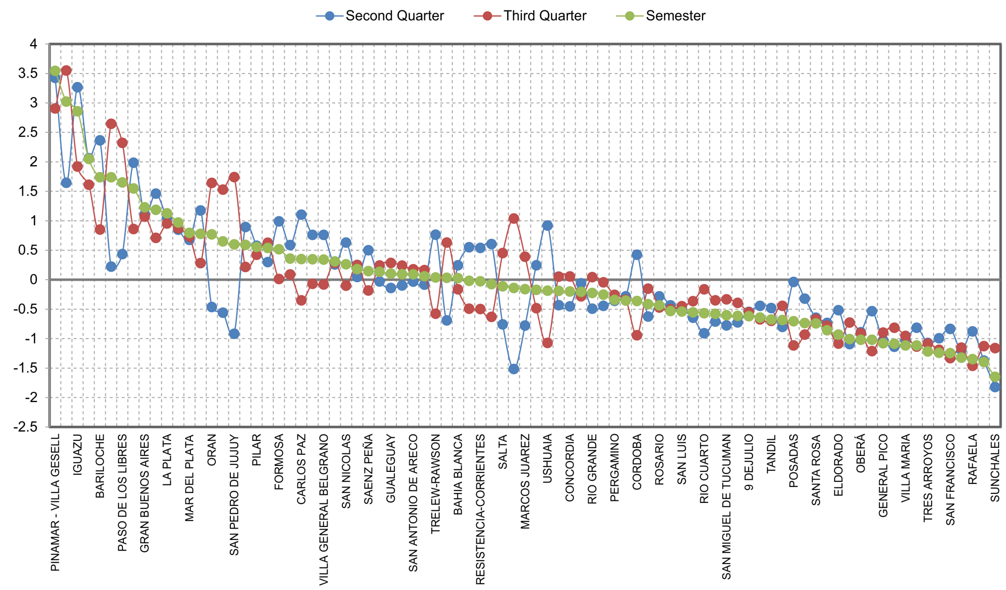


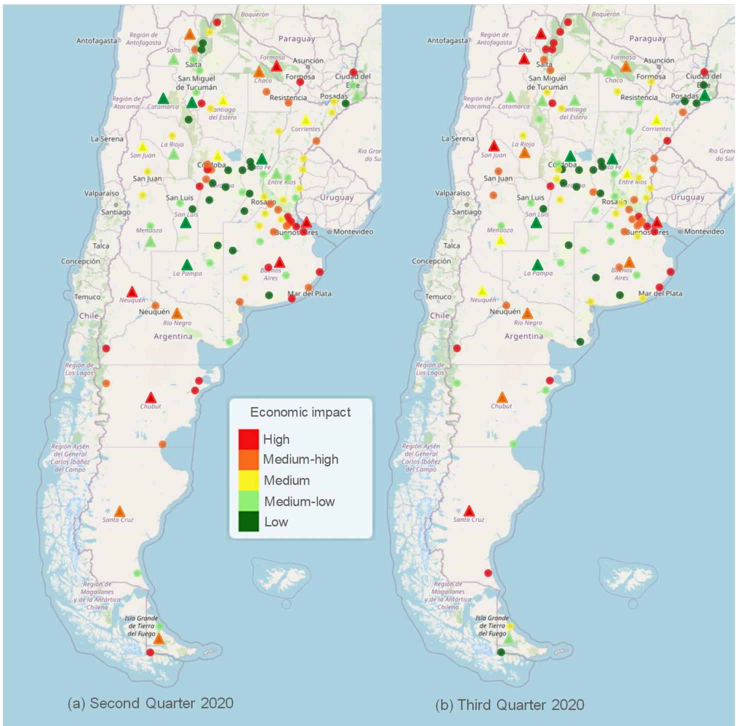
Figure 4: ITEI for LMAs: standardized values per quarter and semester

Figure 2 shows only the quarterly and six-monthly values of the ITEI in standardized values (ITEI minus the average of all provinces, divided by the standard deviation). The marked stability of the ten least affected provinces is again evident, as they are consistently below the provincial average. It can also be seen that the most affected provinces tend to have ITEI values above the average, although the fluctuations between quarters are a little more marked – Jujuy is the case with the greatest variability.

Figure 3 shows, for the whole semester, the lower and upper value of the ITEI and the average of both for the main 85 LMAs in the country. In a simple robustness analysis, we verify that the main results at the extremes of the distribution remain relatively unchanged even if we bring, on the one hand, the sectoral operational level closer to its maximum hypothesis for the most affected LMAs, and on the other hand, we bring the operational level to the minimum hypothesis for the least affected LMAs. The ITEI-Lower for the 8 most affected LMAs is 28.8 on average, while the ITEI-Upper for the 8 least affected LMAs is on, average, 27.6.

Figure 4 shows the quarterly and six-monthly standardized values of the ITEI for each LMA, analogous to Figure 2 for provinces. Several of the above-mentioned fluctuations at the provincial level are also reflected in variations of the main LMAs in each province. For example, the situation within the province of Jujuy (San Salvador de Jujuy, San Pedro de Jujuy, Libertador General San Martín) worsened between the second and third quarter, mainly due to health problems, restrictions, and reductions in labor mobility. Another interesting issue in Figure 4 is that the variability among the least affected LMAs is much lower than the most affected ones, indicating that the situation of the former barely changed along the semester. In terms of the regional productive structure, touristic areas continuously appear among the most affected LMAs throughout the whole semester. On the other hand, among the least affected LMAs, there are some areas specialized in agri-food production and several other areas with a more diversified agro-industrial profile.

Finally, and as a kind of summary, the maps in Figure 5 show the provinces and LMAs distributed throughout the country, according to the average economic impact in the second and third quarters. Apart from emphasizing some of the previous results, such as the deteriorating situation in the northwest of the country (Jujuy and Salta), the figure highlights the heterogeneity among the LMAs within the provinces. This is evident not only in large and diverse provinces, such as Córdoba or Buenos Aires, but also in smaller ones, such as Misiones or Tierra del Fuego.



Notes: the triangle indicates the economic impact in each province. The point shows the location of the central city or node of each LMA, but not its entire geographical scope.

Figure 5: Quarterly maps of economic impact: quintiles for provinces and LMAs

5.2 Comparison and validation against official indicators

As mentioned, few regional data are periodically produced in Argentina. However, given the severity of the crisis caused by the COVID–19 pandemic, some national agencies have sporadically calculated and published some indicators that could be taken as proxies of the regional economic impact of the pandemic and isolation measures. The comparison of these statistics with the ITEI values allows us to analyze their degree of correspondence and reliability (as in Fezzi, Fanghella 2020).

For the moment, the most interesting official statistic, and also the most comprehensive in territorial terms, is the percentage of companies with zero or minimum sales. This indicator was calculated for the 24 provinces and several cities in the country between April and August, based on data from all formal companies that pay taxes to AFIP (CEPXXI 2020). In order to compare this indicator of cities with the ITEI for LMAs, we weighted the data by the population of each city in those cases where one LMA covers more than one of these cities. It is worth noting that, in this way, we have information for only 50 of the 85 LMAs, showing the greater geographical and temporal coverage of the ITEI.

Figure 6 contrasts the values of the ITEI and the percentage of companies with zero or minimum sales for the two months of greatest economic impact in the country (April and May) and the latest available (August). In all cases, there is a positive relationship between the two indicators. Higher levels of the ITEI, both for provinces and LMAs, generally coincide with higher percentages of companies in a critical situation. In dynamic terms there is also a certain correspondence between these indicators, especially for the provinces. The shift, month by month, from the top to the bottom, i.e., a reduction in the economic impact measured by the ITEI, corresponds to a shift from the right to the left, i.e., a reduction in the percentage of companies with zero or minimum sales. For the LMAs the correspondence is a little weaker, above all in the comparison with August, showing a greater heterogeneity in the situation of the companies among the different localities.

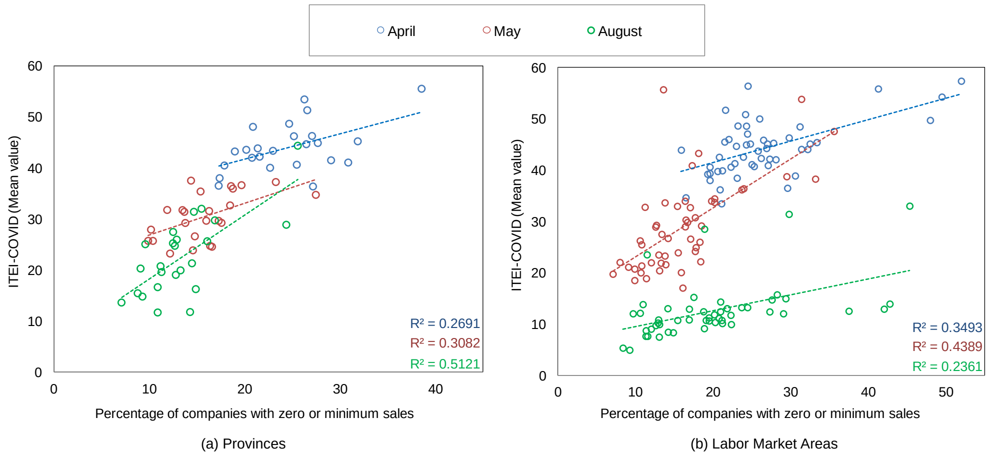


Figure 6: ITEI values versus the percentage of companies in a critical situation

The previous linkages are also evident when computing Pearson's correlations between the two indicators, as can be seen, in particular, along the diagonals highlighted in bold in Table 2. These correlations are positive and significant in all months in the case of the LMAs, and in April, May, and August for the provinces. If, instead of comparing the absolute values, we analyze the percentage changes with respect to April – that is, the recovery of both indicators against the month of greatest economic impact – we can appreciate positive and significant correlations for all months, both for provinces and LMAs (Table 3).

Table 2: Pearson's correlations between ITEI values and companies in a critical situation

		ITEI for Provinces				
		April	May	June	July	August
% of companies with zero or minimum sales	April	**0.5188*****	0.4323**	-0.1501	-0.1622	0.2293
	May	0.5935***	**0.5551*****	-0.0382	-0.0564	0.2707
	June	0.519***	0.5629***	**0.1839**	0.1158	0.378*
	July	0.4808**	0.4289**	0.1269	**0.1463**	0.3604*
	August	0.2408	0.2179	0.2491	0.4024*	**0.7156*****

		ITEI for Labor Market Areas				
		April	May	June	July	August
% of companies with zero or minimum sales	April	**0.5910*****	0.6026***	0.359**	0.3104**	0.3594**
	May	0.5944***	**0.6625*****	0.4150***	0.3547**	0.3382**
	June	0.5960***	0.6972***	**0.5252*****	0.4570***	0.4124***
	July	0.5755***	0.6665***	0.5119***	**0.4731*****	0.4294***
	August	0.5685***	0.6044***	0.4524***	0.4261***	**0.4859*****

Notes: Significance level: *p <0.10, **p <0.05, ***p <0.01.

Table 3: Pearson's correlations between ITEI and companies in a critical situation, measured as percentage changes with respect to April

		Change in ITEI for Provinces			
		May	June	July	August
Change in companies with zero or minimum sales	May	**0.3754***	0.1172	0.0714	0.0257
	June	0.3286	**0.5813*****	0.4847**	0.3525*
	July	0.1192	0.506**	**0.5558*****	0.3768*
	August	0.0719	0.5391***	0.703***	**0.7391*****

		Change in ITEI for Labor Market Areas			
		May	June	July	August
Change in companies with zero or minimum sales	May	**0.5563*****	0.3352**	0.2517*	0.1025
	June	0.5354***	**0.5405*****	0.4583***	0.2776*
	July	0.4418***	0.494***	**0.4879*****	0.2988**
	August	0.2737*	0.405***	0.4689***	**0.5396*****

Notes: Significance level: *p <0.10, **p <0.05, ***p <0.01.

6 Conclusions

In this paper we propose the construction of an index to approximate the territorial economic impact of the COVID–19 pandemic and the consequent isolation measures in contexts with scarce or outdated regional data. This can be particularly useful for developing countries, where not only national and regional statistical systems are usually weaker, but also tend to focus mainly on sectoral data. This sectoral bias is explained by the high degree of productive specialization of some regions – frequently related to the exploitation of natural resources – and often leads to reducing the analysis of the territorial impact to what happens only in a few sectors in which each region is specialized. However, contexts as disruptive as the COVID–19 pandemic require both a comprehensive sectoral view (since the vast majority of the economic activities have been affected to some extent) and a recognition of territorial particularities in terms of the political management of the pandemic.

With some adjustments or adaptations to each context, the proposed index can be used to analyze the uneven territorial economic impact of the pandemic elsewhere, based on data or statistics that are usually available in most countries: a) the sectoral production structure of the different regions (pre-pandemic data), b) the operational level of each sector (post-pandemic data at the national level), c) the mobility of workers in each region (post-pandemic data from Google Mobility Reports or other available sources), and d) the possibility of remote work among the different sectors (calculated by several recent studies).

In line with recent literature, the empirical application for Argentina showed the uneven impact of the COVID–19 pandemic on regional (private) production or economic activity. In this sense, the ITEI revealed large disparities between the 24 provinces and the main 85 LMAs of the country, as well as the heterogeneity within some provinces, which revalues the use of smaller geographical units. The results also showed that, although the economic impact of the pandemic has been decreasing over the months for the country as a whole, there is considerable stability in the relative position of the most and least affected regions. Finally, the comparison with sporadic official indicators of the regional impact of the pandemic has emphasized the validity of the proposed index, which also has a higher geographical and temporal coverage.

Although in this paper we have proposed a relatively simple and descriptive exercise, the calculation of an index of territorial economic impact can be a relevant input for the design, implementation, and monitoring of targeted and place-based policies, which seek to mitigate the harmful economic impacts of the pandemic and isolation measures. In the future, the collection of evidence on the immediate or short-term impacts of the pandemic may give rise to other studies that analyze the medium- and long-term impacts, especially concerning the evolution of regional asymmetries. Likewise, economic impact indicators such as the ITEI can be the starting point (or the dependent variable) for future studies that seek to analyze with more detail the regional factors behind this phenomenon.

As mentioned, given the limited subnational data available in Argentina, the ITEI also has some limitations that could be taken into account in future research or in applications for other countries. For example, the use of regional demand indicators could be an alternative avenue to explore, instead of analyzing the territorial economic impact from the supply side. On the other hand, the use of employment or labor data could also be expanded or complemented, taking into account the different labor intensities in the different sectors and the importance of other inputs and intermediary products. The construction of regional input-output tables would be a necessary step to consider these inter-sectoral and inter-regional linkages.

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Appendix: Sectoral operational hypotheses applied to EBDO data (ISIC)

Classification of economic activities used by EBDO (ISIC) 2 digit		April Min	April Max	May Min	May Max	June Min	June Max	July Min	July Max	August Min	August Max	September Min	September Max	Based on statistics, surveys or reports from chambers, centers or organizations:
1	Agriculture, livestock farming, hunting and related service activities	75	100	75	100	75	100	75	100	75	100	75	100	INDEC-EMAE; INDEC-ICA; CONINAGRO; Fund. Observ. PYME (FOP); CENE-UB
2	Forestry, wood extraction and related service activities	50	75	50	75	75	100	75	100	75	100	75	100	INDEC-EMAE; INDEC-ICA; AFOA; ASORA; FAIMA
5	Fishing and fishing-related activities	50	75	75	100	50	75	25	50	75	100	75	100	INDEC-EMAE; INDEC-ICA; Subsecr. de Pesca y Acuic.; Intercám. Ind. Pesquera
11	Extraction of crude oil and natural gas; activities related to oil and gas extraction, except prospecting activities.	25	50	50	75	50	75	75	100	75	100	75	100	INDEC-EMAE; Secr. de Energía; CEPH; CEIPA; Ecolatina; Revista Trama
13	Extraction of metalliferous minerals	25	50	25	50	50	75	50	75	75	100	75	100	INDEC-ICA; INDEC-EMAE; CAEM
14	Exploitation of other mines and quarries	25	50	25	50	50	75	50	75	75	100	75	100	INDEC-ICA; INDEC-EMAE; CAEM
15	Foods	75	100	75	100	75	100	75	100	75	100	75	100	INDEC-IPIM; CAME; FIEL; FOP; UIA
16	Tobacco	25	50	50	75	75	100	75	100	75	100	75	100	INDEC-IPIM; CIT; FIEL; UIA
17	Textile products	25	50	50	75	75	100	50	75	75	100	75	100	INDEC-IPIM; CAME; FIEL; UIA
18	Confections	0	25	25	50	50	75	50	75	50	75	75	100	INDEC-IPIM; CAME; CIAI; FIEL; UIA
19	Leather	0	25	25	50	50	75	50	75	50	75	50	75	INDEC-IPIM; CAME; FIEL; UIA
20	Wood	50	75	75	100	75	100	75	100	75	100	75	100	INDEC-IPIM; AFOA; ASORA; FAIMA
21	Paper	75	100	75	100	75	100	75	100	75	100	75	100	INDEC-IPIM; FIEL; UIA
22	Edition	75	100	75	100	75	100	75	100	75	100	75	100	INDEC-IPIM; UIA
23	Petroleum products	50	75	50	75	75	100	75	100	75	100	75	100	INDEC-IPIM; FIEL; UIA
24	Chemical products	75	100	75	100	75	100	75	100	75	100	75	100	INDEC-IPIM; CAME; FIEL; UIA
25	Rubber and plastic products	50	75	50	75	75	100	75	100	75	100	75	100	INDEC-IPIM; CAME; UIA
26	Other non-metallic minerals	25	50	50	75	75	100	75	100	75	100	75	100	INDEC-IPIM; INDEC-ISAC; FIEL; UIA
27	Common metals	25	50	25	50	50	75	50	75	50	75	75	100	INDEC-IPIM; CAA; FIEL; UIA
28	Other metal products	25	50	50	75	75	100	75	100	75	100	75	100	INDEC-IPIM; ADIMRA; FIEL; UIA
29	Machinery and equipment	50	75	50	75	75	100	75	100	75	100	75	100	INDEC-IPIM; ADIMRA; FIEL; UIA
30	Office machinery	0	25	25	50	75	100	75	100	50	75	75	100	INDEC-IPIM; CAME; UIA
31	Electric appliances	0	25	25	50	50	75	50	75	50	75	75	100	INDEC-IPIM; CAME; UIA
32	Radio and television	0	25	25	50	75	100	75	100	50	75	75	100	INDEC-IPIM; CAME; UIA
33	Medical instruments	50	75	75	100	75	100	75	100	75	100	75	100	INDEC-IPIM; ADIMRA; UIA
34	Automotive	0	25	25	50	50	75	50	75	75	100	75	100	INDEC-IPIM; ADEFA; FIEL; UIA
35	Other transport equipment	0	25	25	50	50	75	50	75	50	75	50	75	INDEC-IPIM; UIA
36	Furniture	25	50	50	75	75	100	75	100	75	100	75	100	INDEC-IPIM; ASORA; CAME; FAIMA
37	Waste and scrap recycling	50	75	50	75	75	100	75	100	75	100	75	100	INDEC-IPIM
40	Electricity, gas and water	75	100	75	100	75	100	75	100	75	100	75	100	INDEC-ISSP; INDEC-EMAE; Secr. de Energía; ENARGAS;
41	Collection, purification and distribution of water	75	100	75	100	75	100	75	100	75	100	75	100	INDEC-ISSP; Ecolatina
45	Building	0	25	25	50	50	75	50	75	50	75	50	75	INDEC-ISAC; INDEC-EMAE; CAMARCO; FOP
50	Sale, maintenance and repair of motor vehicles and their parts, pieces and accessories. sale, maintenance and repair of motorcycles and their parts, pieces and accessories. retail sale of fuel for motor vehicles and motorcycles.	25	50	50	75	50	75	50	75	50	75	75	100	ACARA; CECHA
51	Wholesale trade	25	50	50	75	75	100	75	100	75	100	75	100	INDEC-EMAE; CAC; CADAM
52	Retail trade and repair of personal and household goods	25	50	50	75	50	75	75	100	75	100	75	100	INDEC-EMAE; CAC; CACE; CAME; FOP
55	Hotel and restaurant services	0	25	0	25	25	50	25	50	25	50	25	50	INDEC-EOH; INDEC-ETI; INDEC-EMAE; FEHGRA; INPROTUR
60	Rail, automotive and pipeline transportation service	50	75	50	75	50	75	50	75	50	75	50	75	INDEC-ISSP; INDEC-EMAE; CNRT; FADEEAC
61	Sea and river transport service	50	75	50	75	75	100	75	100	75	100	75	100	INDEC-ISSP; CAPYM
62	Air transport service for cargo and passengers	0	25	0	25	0	25	0	25	0	25	0	25	ANAC
63	Cargo handling, storage and warehousing services. complementary services for transportation. travel agency services and other complementary tourist support activities. management and logistics services for the transport of goods	50	75	50	75	50	75	50	75	50	75	50	75	INDEC-ISSP; INDEC-EMAE
64	Postal and telecommunications services	75	100	75	100	75	100	75	100	75	100	75	100	INDEC-ISSP; Ecolatina; Lódola & Picón (2020); Red ISPA (2020)
65	Financial intermediation and other financial services	75	100	75	100	75	100	75	100	75	100	75	100	INDEC-EMAE; ADEBA; Albrieu (2020); Bonavida Foschiatti & Gasparini (2020); Lódola & Picón (2020); Red ISPA (2020)
66	Insurance services. retirement and pension fund management services	75	100	75	100	75	100	75	100	75	100	75	100	INDEC-EMAE; CENE-UB; Albrieu (2020); Bonavida Foschiatti & Gasparini (2020); Lódola & Picón (2020); Red ISPA (2020)
67	Auxiliary services to financial activity, except insurance and pension fund management services	75	100	75	100	75	100	75	100	75	100	75	100	INDEC-EMAE; CENE-UB; Albrieu (2020); Bonavida Foschiatti & Gasparini (2020); Lódola & Picón (2020); Red ISPA (2020)
70	Real estate services	0	25	25	50	50	75	50	75	50	75	50	75	CAC; CECBA; CIA; Reporte Inmobiliario; Lódola & Picón (2020)
71	Rental of transport equipment and machinery and equipment n.c.p. rental of personal and household goods n.c.p.	0	25	25	50	50	75	50	75	50	75	50	75	CENE-UB; Lódola & Picón (2020)
72	Computer activities. Consultant services. data processing. maintenance and repair of office, accounting and computer machinery	50	75	75	100	75	100	75	100	75	100	75	100	CAC; CESSI; CENE-UB; FOP; Albrieu (2020); Bonavida Foschiatti & Gasparini (2020); Red ISPA (2020)
73	Research and experimental development in the field of engineering and of the exact and natural sciences and of the social sciences and humanities	75	100	75	100	75	100	75	100	75	100	75	100	CAC; CENE-UB; FOP; Albrieu (2020); Bonavida Foschiatti & Gasparini (2020); Red ISPA (2020)
74	Legal and accounting, bookkeeping and auditing services; tax advice; market research and public opinion polls; business and management advice. architectural and engineering services and technical services n.c.p. advertising services. business services n.e.c.	50	75	75	100	75	100	75	100	75	100	75	100	CAC; CENE-UB; FOP; Albrieu (2020); Bonavida Foschiatti & Gasparini (2020); Red ISPA (2020)
75	Temporary employment agencies	0	25	25	50	25	50	25	50	25	50	50	75	CENE-UB
80	Teaching. initial, primary, secondary, higher and postgraduate training. adult education and educational services n.e.c.	75	100	75	100	75	100	75	100	75	100	75	100	INDEC-EMAE; Ecolatina; FOP; Albrieu (2020); Bonavida Foschiatti & Gasparini (2020); Lódola & Picón (2020); Red ISPA (2020)
85	social and Health Services	75	100	75	100	75	100	75	100	75	100	75	100	INDEC-EMAE; Lódola & Picón (2020)
90	Waste and sewage disposal, sanitation and similar services	75	100	75	100	75	100	75	100	75	100	75	100	INDEC-ISSP
91	Services of business, professional and employers organizations. union services. association services n.c.p.	75	100	75	100	75	100	75	100	75	100	75	100	CAC; CENE-UB; FOP; Bonavida Foschiatti & Gasparini (2020); Red ISPA (2020)
92	Cinematography, radio and television services and entertainment and artistic entertainment services n.e.c. news agency services. library, archive and museum services and cultural services n.c.p. services for sports and entertainment practice n.e.c.	0	25	25	50	25	50	25	50	25	50	50	75	SICA; CENE-UB; Red ISPA (2020)
93	Services n.c.p.	0	25	0	25	25	50	25	50	25	50	50	75	INDEC-EMAE; CENE-UB; Bonavida Foschiatti & Gasparini (2020)

Note: The (k) sectors highlighted in gray are those considered essential, of rapid recovery, or reconversion to teleworking, which is reflected in the fact that during April, the month of greatest restrictions, the hypothesis of maximum operational level was already equal to 100, or 75 in April but in May and June it already reaches 100; the latter only occurs in 3 sectors.