ISSN 2392-1641
e-ISSN 2450-0097

Economics and Business Review

Volume 10 (2) 2024

CONTENTS

Poznań University of Economics and Business Press

Paper based publication

https://doi.org/10.18559/ebr.2024.2

ISSN 2392-1641
e-ISSN 2450-0097

POZNAŃ UNIVERSITY OF ECONOMICS AND BUSINESS PRESS
ul. Powstańców Wielkopolskich 16, 61-895 Poznań, Poland
phone +48 61 854 31 54, +48 61 854 31 55
https://wydawnictwo.ue.poznan.pl, e-mail: wydawnictwo@ue.poznan.pl
postal address: al. Niepodległości 10, 61-875 Poznań, Poland

Printed and bound in Poland by:
Poznań University of Economics and Business Print Shop

Circulation: 80 copies

sciendo

sciendo
Economics and Business Review
https://www.ebr.edu.pl
Vol. 10 (2), 2024: 92–117
https://doi.org/10.18559/ebr.2024.2.1027

Labour productivity in Italian regions: A gravitational model approach

Katarzyna Filipowicz[1] **Oleksij Kelebaj**[2]
Tomasz Tokarski[3]

Abstract

The aim of the paper is to assess the causes of spatial variations in labour productivity of Italian regions using the gravitational model of economic growth. The model is an extension of Robert Solow's economic growth model. The model parameters are calibrated using historical data and numerical simulations of the long-run equilibrium states of the model are carried out. The scenarios considered in the paper vary in forecast investment rates, employment growth rates and urbanisation rates. Based on the results of numerical simulations, it is claimed that to achieve the full convergence in labour productivity, it is necessary to maintain higher investment rates in the south of the country than in Lombardy (by about 4%–11%), and to keep investment rates in central and northern Italy at a similar level as in Lombardy. The fall in investment has affected the poorest regions, Southern Italy, the most, followed by central Italy and the richest regions of the north of the country the least.

Keywords

- model of economic growth
- labour productivity
- Italian regions

JEL codes: R11, O47, C2, E23

Article received 31 October 2023, accepted 18 April 2024.

Suggested citation: Filipowicz, K., Kelebaj, O., & Tokarski, T. (2024). Labour productivity in Italian regions: A gravitational model approach. *Economics and Business Review*, *10*(2), 92–117. https://doi.org/10.18559/ebr.2024.2.1027

[1] Department of Mathematical Economics, Jagiellonian University, 24 Gołębia St, 31-007 Cracow, Poland, k.filipowicz@uj.edu.pl, https://orcid.org/0000-0003-2131-0414.

[2] Faculty of Management and Social Communication, Jagiellonian University, 24 Gołębia St, 31-007 Cracow, Poland, corresponding author: oleksij.kelebaj@doctoral.uj.edu.pl, https://orcid.org/0000-0001-6037-1231.

[3] Department of Mathematical Economics, Jagiellonian University, 24 Gołębia St, 31-007 Cracow, Poland, t.tokarski@uj.edu.pl, https://orcid.org/0000-0002-9551-0892.

Introduction

Italy is both a highly developed country and a very spatially differentiated country in terms of economic development. At the end of the 1970s, analyses of the regional differentiation of the country's economic development began to use the division into so-called first, second and third Italy (Bianchini, 1991). Indeed, each of these areas is characterised by a different economic structure and significant differences in the level of economic development.

The paper's added value is to identify the causes of spatial differentiation of labour productivity in Italian regions using the gravitational model of economic growth. The gravitational growth model (which is a modification and extension of the Solow (1956) neoclassical model of growth) takes into account interactions between the economies being analysed (in this case, Italian regions). In general, it is assumed that an increase in the capita-labour ratio in one economy influences the increase in total factor productivity in the remaining economies.

The first version of gravitational growth model has been proposed in Mroczek et al. (2014), extension in Mroczek et al. (2015). A similar model has been used to analyse the spatial differentiation of economic development in the Polish economy (Filipowicz, 2019; Mroczek et al., 2014; Wisła & Nowosad, 2020), the Ukrainian economy (Wisła & Nowosad, 2020), the economies of EU countries (Wisła et al., 2018), as well as the economies of all European countries (Nowosad & Wisła, 2016) or Balkan countries (Filipowicz et al., 2015).

The structure of the paper is as follows: Section 1 contains a literature review, Second 2 presents the gravitational model of economic growth, and Section 3 describes the calibration of model parameters and numerical simulations. The study ends with the summary of the most important conclusions from the analysis.

1. Literature review

The search for the causes of heterogeneity in Italy's regional development is of great interest to researchers and has been the subject of an ongoing debate for several decades. Possible sources of spatial differentiation of economic development are explained in various ways. Those that stand out here include migration, differences in total factor productivity, economic complexity and diversity at the regional level and related trade links, fluctuations in unemployment, sectoral reallocation of resources, urban development, corruption and education.

Fratesi and Percoco (2014) point out that skill-selective migration can lead to an even greater polarisation of regional development in Italy. They also note that between 1980 and 2001 the migration of people with tertiary education from the southern regions of Italy to the north reduced the level of human capital in the south of the country, which had a negative impact on the economic development of this part of Italy.

The impact of interregional migration in Italy on disparities in total factor productivity between 1995 and 2015 was also analysed in the work by Calcagnini et al. (2021). Their empirical analysis indicated a non-linear (U-shaped) relationship between the employment of temporary workers and the increase in total factor productivity (i.e. the increase in total factor productivity in some southern Italian regions was favoured by an increase in the proportion of temporary workers, while the central and northern regions experienced a decrease). In addition, migration flows of skilled personnel had a positive impact on the increase in total factor productivity in the regions of migration destination.

The importance of the impact of the level of regional total factor productivity on differences in labour productivity was highlighted by Maffezzoli (2004), who studied convergence in Italian regions in relation to technological convergence. He pointed out that differences in relative total factor productivity between Italian regions were important and were the main source of convergence between 1980 and 2000.

Di Giacinto and Nuzzo (2004), on the other hand, attribute differences in labour productivity at the regional level in Italy to three factors. These factors are as follows: the structure of the regional economy in the south of Italy (a significant part of the labour force is employed in less productive sectors of the economy), the accumulated stock of physical and human capital in the region, and differences in the level of total factor productivity (which, broadly speaking, is in line with the economic growth model in Mankiw et al. (1992). The study also assessed the role of the aforementioned determinants of total factor productivity and empirically evaluated the factors influencing this variable. The factors influencing the variation in total factor productivity were: public and social capital, R&D investment, international openness, development of financial markets, development of agglomeration and diversification of economies, and geographical factors.

Changes in: labour productivity, technology efficiency and physical and human capital that occurred in Italian regions between 1980 and 2006 were also analysed by Gitto and Mancuso (2015). Their results show that the importance of labour productivity, technology efficiency and capital accumulation in terms of economic growth differs significantly between the southern regions of Italy and the rest of the country.

Basile and Cicerone (2022) studied the role of economic complexity as a driver of regional variation in labour productivity in Italy. Here, the economic complexity was measured by their Economic Complexity Index (ECI). This index specifically seeks to explain the accumulated knowledge in the population, which is expressed in economic activity in a city, a country or a region. Basile and Cicerone argue that economic complexity plays a key role in the observed trend towards polarisation of labour productivity in Italian regions.

Regional diversity and trade links may be further determinants of differences in the economic growth of Italian regions. In the articles by Boschma and Iammarino (2007, 2009), the empirical part is based on export and import data for the period 1995–2003. Their results show that Italian regions with complementary sectors in terms of competences grow better economically. The study also assesses the impact of relatedness of international trade links on economic growth at the regional level. The authors conclude that related extra-regional knowledge stimulates cross-sectoral learning in regions and becomes a catalyst for regional economic development.

On the other hand, Busetta and Corso (2012) analyse Italian regions in terms of the impact of unemployment fluctuations on economic growth. The authors base their study on Okun's law, which can also be observed in Italy at the regional level. The issue of unemployment in the context of variations in Italy's level of regional development was also addressed by Carmeci and Mauro (2002). More specifically, these researchers analysed the relationship between stopping the convergence process of Italian regions in the early 1970s and the increase in regional differences in unemployment levels. In their analysis, they use a neoclassical growth model with an imperfect labour market. On this basis, they argue that labour market imperfections have a negative effect on the growth rate of output. In addition, they conclude that setting the national minimum wage too high (in relation to labour productivity) can negatively affect economic growth mainly in the less developed regions of Italy, as there a high minimum wage has a much stronger, negative impact on labour demand than in regions with high labour productivity.

The analysis of the factors differentiating Italy's regional economic development also raises the issue of sectoral reallocation of resources. Paci and Pigliaru (1997, 1998) conclude that aggregate convergence is to a large extent the result of structural change and that the shift from agriculture to non-agricultural production is particularly important for aggregate convergence. In doing so, it is important that the outflow of labour from low-productivity agriculture (in poorer regions) is a source of expansion of non-agricultural sectors.

Urban development, corruption and education are further determinants of regional labour productivity differences in Italy. Di Liddo (2015) draws attention to urban sprawl and its impact on economic development at the regional level. He also points out the negative impact of urban sprawl in Italian cities and recommends stimulating urban development in the main cities rather than in the provinces. On the other hand, Fiorino et al. (2012) analysed the impact of corruption on Italian economic growth at the regional level. They found a negative correlation between corruption and economic growth. They argue, in addition, that in Italy corruption undermines the positive impact of public spending in mitigating regional economic growth differences.

Education is another determinant of differences in labour productivity at the regional level. Research by Di Liberto (2008) shows that an increase in educational attainment appears to have a statistically significant effect on labour productivity growth in the southern regions of Italy.

The problem of regional convergence in Italy is also addressed in the study by Terrasi (1999), which analyses the regional convergence of GDP per capita between 1953 and 1993. This research shows that 1960–1975 was a period of strong regional convergence in Italy, while after 1975 there was a tendency towards regional divergence. These latter processes are caused by both national development and spatial factors (Paci & Pigliaru, 1997, 1998; Terrasi, 1999). Moreover, a study of per capita income convergence in Italy over the period 1951–2000 confirmed the occurrence of convergence clubs (i.e. Italian regions with similar structural characteristics become more similar to each other, bridging the gap in per capita income (Arbia & Basile, 2005).

2. Gravitational model of economic growth

In analysing the determinants of spatial variation in labour productivity in Italian regions, we make the following assumptions:

I. The level of labour productivity in region is described by the labour productivity function (derived from the Cobb-Douglas production function) given by the formula:[4]

$$\forall i \; y_i(t) = a_i e^{\gamma t} g_i^{\beta}(t) k_i^{\alpha}(t) \tag{1}$$

where y_i is labour productivity (in region i), a_i – total factor productivity[5], g_i – total gravitational effects, k_i – capital per worker, $\alpha, \beta \in (0, 1)$ – elas-

[4] We assume that all macroeconomic variables analysed in this section are continuous and differentiable functions of time $t \in [0, +\infty)$. Moreover $\dot{x}_i(t) = \frac{dx_i}{dt}$, $\forall_i$ means $\forall_i = 1, 2, \ldots, N$. Records $\Pi_i x_i$ and $\Sigma_i x_i$. Records and are defined by formulas: $\Pi_i x_i = \prod_{i=1}^{n} x_i$ and $\Sigma_i x_i = \sum_{i=1}^{n} x_i$.

[5] Precisely speaking, a_i is a part of the total factor productivity $TFP = \frac{y}{k^{\alpha}} = \left(\frac{Y}{K}\right)^{\alpha} \cdot \left(\frac{Y}{L}\right)^{1-\alpha}$, which does not result from gravitational effects and is not the result of technical progress in the Hicks sense (for more on this, see Allen, 1975; or Dykas et al., 2023). Moreover, in the further empirical analyses, we assume that a_i is at a higher level the higher the urbanization rate urb_i in region i, which is described by the function $a_i = be^{\psi \cdot urb_i}$, where $b, \psi > 0$.

ticities of labour productivity with respect to capital per worker and to gravitational effects, $\gamma > 0$ – rate of technical progress in the Hicks sense. In addition, we assume (to obtain the asymptotic stability of the steady state of the model under consideration) that: $\beta < \frac{1-\alpha}{2}$.

II. The total gravitational effects g_i affecting region i are the geometric mean of the gravitational effects connecting region i to the other regions, i.e. g_{ij}. We therefore have:

$$\forall(i, j \wedge j \neq i)\, g_i(t) = \sqrt[N-1]{\prod\nolimits_{j\neq i} g_{ij}(t)} = \prod\nolimits_{j\neq i} g_{ij}^{1/(N-1)}(t) \qquad (2)$$

III. Individual gravitational effects are given by the formula:

$$\vee(i, j \wedge i \neq i)\, g_{ij}(t) = \frac{k_i(t)\, k_j(t)}{d_{ij}^2} \qquad (3)$$

where $d_{ij} > 0$ denotes the distance from the capital of region i to the capital of region j.

IV. As in the Solow model, the capital accumulation process is described by the differential equation:

$$\forall i\, \dot{k}_i(t) = s_i y_i(t) - \mu_i k_i(t) \qquad (4)$$

where $s_i \in (0, 1)$ is an investment rate (in region i), μ_i – capital depreciation rate per working person, i.e. the sum of capital depreciation rates $\delta \in (0, 1)$ and growth rate of the number of workers $n_i > 0$.
Equations (2–3) give:

$$\forall i\, g_i(t) = k_i(t) \prod\nolimits_{j\neq i} \frac{k_j^{1/(N-1)}(t)}{d_{ij}^{2/(N-1)}} = \frac{k_i(t)}{\bar{d}_i^2} \prod\nolimits_{j\neq i} k_j^{\frac{1}{(N-1)}}(t) \qquad (5)$$

where $\bar{d}_i = \prod_{j\neq i} d_{ij}^{1/(N-1)}$ is the geometric mean distance of the capital of the i-th region to the capitals of the other regions. Equations (1) and (5) give us:

$$\forall i\, y_i(t) = a_i e^{\gamma t} \left(\frac{k_i(t)}{\bar{d}_i^2} \prod\nolimits_{j\neq i} k_j^{\frac{1}{(N-1)}}(t) \right)^{\beta} \cdot k_i^{\alpha}(t) = \frac{a_i e^{\gamma t}}{\bar{d}_i^{2\beta}} \left(\prod\nolimits_{j\neq i} k_j^{\frac{\beta}{(N-1)}}(t) \right) k_i^{\alpha+\beta}(t) \qquad (6)$$

We make substitutions:

$$\forall i\, y_{Ei}(t) = \exp\left(-\frac{\gamma}{1-2\beta-\alpha} t \right) y_i(t) \Rightarrow y_i(t) = \exp\left(\frac{\gamma}{1-2\beta-\alpha} t \right) y_{Ei}(t) \qquad (7)$$

and:

$$\forall i\, k_{Ei}(t)=\exp\left(-\frac{\gamma}{1-2\beta-\alpha}t\right)k_i(t)\Rightarrow k_i(t)=\exp\left(\frac{\gamma}{1-2\beta-\alpha}t\right)k_{Ei}(t) \quad (8)$$

From equation (8) it follows that:

$$\forall i\frac{\dot{k}_{Ei}(t)}{k_{Ei}(t)}=-\frac{\gamma}{1-2\beta-\alpha}+\frac{\dot{k}_i(t)}{k_i(t)}$$

and hence and from the capital accumulation equation (4) we get:

$$\forall i\frac{\dot{k}_{Ei}(t)}{k_{Ei}(t)}=s_i\frac{y_i(t)}{k_i(t)}-\left(\mu_i+\frac{\gamma}{1-2\beta-\alpha}\right)=s_i\frac{y_{Ei}(t)}{k_{Ei}(t)}-\left(\mu_i+\frac{\gamma}{1-2\beta-\alpha}\right)$$

and finally:

$$\forall i\,\dot{k}_{Ei}(t)=s_i y_{Ei}(t)-\eta_i k_{Ei}(t) \quad (9)$$

where $\forall i\,\eta_i=\mu_i+\frac{\gamma}{1-2\beta-\alpha}>0$. We include the substitutions (7–8) in the labour productivity function (6). Therefore, we obtain:

$$\forall i\; y_{Ei}(t)=\frac{a_i}{\overline{d}_i^{2\beta}}\left(\prod_{j\neq i}k_{Ej}^{\beta/(N-1)}(t)\right)k_{Ei}^{\alpha+\beta}(t) \quad (10)$$

Relationship (10) is inserted into relationship (9) to obtain the following system of differential equations:

$$\forall i\,\dot{k}_{Ei}(t)=\frac{a_i s_i}{\overline{d}_i^{2\beta}}\left(\prod_{j\neq i}k_{Ej}^{\beta/(N-1)}(t)\right)k_{Ei}^{\alpha+\beta}(t)-\eta_i k_{Ei}(t) \quad (11)$$

The system of equations (11) is a simple generalisation of the system of differential equations from the gravitational model of economic growth. Thus, using the Grobman-Hartman theorem (Ombach, 1999) it can be shown (Mroczek et al., 2014) or (Dykas et al., 2023) that at $\beta<\frac{1-\alpha}{2}$ the system has an asymptotically stable steady state $(k_{E1}^{*},\ldots,k_{EN}^{*})\in(0,+\infty)^N$, where:

$$\forall i\frac{k_i^{*}}{k_B^{*}}=\frac{k_{Ei}^{*}}{k_{EB}^{*}}=\left(\frac{a_i s_i\eta_B\overline{d}_B^{2\beta}}{a_B s_B\eta_i\overline{d}_i^{\,\beta}}\right)^{\frac{1}{1-\alpha-\frac{N-2}{N-1}\beta}}\;\wedge\;\frac{y_i^{*}}{y_B^{*}}=\frac{y_{Ei}^{*}}{y_{EB}^{*}}=\frac{\left(\frac{a_i s_i\eta_B}{a_B s_B\eta_i}\right)^{\frac{\alpha+\frac{N-2}{N-1}\beta}{1-\alpha-\frac{N-2}{N-1}\beta}}}{\left(\frac{\overline{d}_i^2}{\overline{d}_B^2}\right)^{\frac{\beta}{1-\alpha-\frac{N-2}{N-1}\beta}}} \quad (12)$$

where *B* subscripts refer to a base region[6] (the base region in the empirical analyses carried out hereafter is Lombardy, as the region with the highest economic potential in Italy). The quotients $\frac{y_i^*}{y_B^*}$ described by compounds (12), after taking into account the substitutions $\forall i\, \eta_i = \mu_i + \frac{\gamma}{1-2\beta-\alpha} > 0 \wedge \mu_i = \delta + n_i > 0$, reduce to the relation:

$$\forall i \frac{y_i^*}{y_B^*} = \frac{\left(\frac{a_i s_i \left(\delta + \frac{\gamma}{1-2\beta-\alpha} + n_B \right)}{a_B s_B \left(\delta + \frac{\gamma}{1-2\beta-\alpha} + n_i \right)} \right)^{\frac{\alpha + \frac{N-2}{N-1}\beta}{1-\alpha-\frac{N-2}{N-1}\beta}}}{\left(\frac{\bar{d}_i^2}{\bar{d}_B^2} \right)^{\frac{\beta}{1-\alpha-\frac{N-2}{N-1}\beta}}} \tag{13}$$

Equation (13) describes the relationship between the level of labour productivity in region and the value of this macroeconomic variable in the base region *B* in the long-run equilibrium of the gravitational growth model. From equation (13) we can also determine the combination of investment rates $(s_1, \dots, s_N) \in (0, 1)^N$ at which full labour productivity convergence will occur in the long run (and thus $\forall i \frac{y_i^*}{y_B^*} = 1$). Thus, for all $i\; y_i^* = y_B^*$ if and only if:

$$\forall i \frac{s_i}{s_B} = \left(\frac{\bar{d}_i^2}{\bar{d}_B^2} \right)^{\frac{\beta}{\alpha + \frac{N-2}{N-1}\beta}} \cdot \frac{a_B \left(\delta + \frac{\gamma}{1-2\beta-\alpha} + n_i \right)}{a_i \left(\delta + \frac{\gamma}{1-2\beta-\alpha} + n_B \right)} \tag{14}$$

3. Calibration of model parameters and numerical simulations

For numerical simulations of the long-run equilibrium states of the gravitational economic growth model (equation (13), it is necessary to estimate

[6] Throughout the study, we refer regional macroeconomic variables to the base region, Lombardy. The choice of Lombardy is due to the fact that it is the region with the greatest economic potential in Italy (despite the fact that the highest GDP per capita is recorded in the Autonomous Province of Bolzano, which, however, is characterized by low demographic potential, so it does not play such an important role in the economic development of Italy as Lombardy).

the parameters of the labour productivity function (1). The parameters of this function were estimated in two ways. Firstly, they were estimated without taking external gravitational effects into account (i.e. without the impact of foreign countries on Italian regions, as is the case of the original gravitational model), and secondly, with these effects taken into account.

The labour productivity function without external gravitational effects (taking its logarithm) is given by the formula:

$$\ln y_{it} = a + b \cdot covid + \gamma t + \psi \cdot urb_{it} + \beta \ln g_{it} + \alpha \ln k_{it} \tag{15}$$

where y_{it} is labour productivity (in region i in year t), urb_{it} – percentage of people living in cities with more than 100 000 inhabitants,[7] g_{it} – total gravitational effects, k_{it} – capital per worker, t – time trend equal to 2010, 2011, ..., *covid* – dummy variable equal to 1 in 2020, 0 in others, $a, b, \gamma, \psi, \beta, \alpha$ – parameters of the estimated equation (where γ is the rate of technical progress in the Hicks sense). Equation (16) shows that the total factor productivity in region i in year t, which is unrelated to the effect of gravity (denoted as TFP_{it}), satisfies the relationship:

$$\ln TFP_{it} = a + b \cdot covid + \gamma t + \psi \cdot urb_{it} \tag{16}$$

According to (16), the dummy variable $covid$ modifies TFP_{it} for the peak period of the pandemic. This is because, at that time, the volume of output (with given factor inputs) was falling for two reasons. Firstly, it was smaller because the volume of aggregate demand in the economy was decreasing due to Covid restrictions (catering, tourism, passenger transport, etc.). Secondly, TFP_{it} was also declining because part of the labour pool periodically did not take up work (illness, quarantine, etc.) (cf. Bärwolff, 2020; Dykas et al., 2023; Dykas & Wisła, 2022; Gori et al., 2022). In turn, the link between TFP_{it} and the previously defined urbanisation rate can be justified by the fact that it is easier to do business in large cities and (usually) the level of human capital is higher there (the best tertiary schools in Italy are traditionally located in a few of the largest cities, and graduates of these schools coming from the provinces often stay in these cities, thus increasing the human capital stock there at the expense of the provinces).

The parameters of equation (15) were estimated using the ordinary least squares method (OLS) and the generalised method of moments (GMM). Fixed

[7] Since the authors did not have access to data on the total number of city inhabitants or the rate of urbanization, they replaced this rate with the index: $urb_{it} = \frac{C_{it}}{POP_{it}}$, where $c_{it}t$ denotes the number of inhabitants in cities with more than 100,000 inhabitants in the region i and in the year t, POP_{it} – the total population in region i in year t. This indicator will be referred to (not very precisely) as the urbanisation rate.

effects were not included in these estimates due to the fact that the variables urb_{it} and g_{it} are strongly differentiated in geographical space and little differentiated in time (parameter estimates of equations in which the dependent variable was urb_{it} or $\ln g_{it}$, and the independent variables were a matrix of fixed effects variables yielded adjusted coefficient of determination of 0.968 and 0.867, respectively). Therefore, these variables are strongly collinear with the fixed effects.

Table 1. Estimated parameters of equation (15)

Independent variables	Method of estimation			
	OLS		GMM	
Constant	–27.972 (–7.117)	–33.300 (–7.631)	–35.401 (–7.926)	–42.700 (–8.580)
Covid	–	–0.0568 (–2.664)	–	–0.0722 (–3.413)
t	0.0146 (7.623)	0.0173 (8.079)	0.0183 (8.356)	0.0219 (8.968)
urb	0.371 (8.345)	0.370 (8.446)	0.369 (8.041)	0.369 (8.244)
$\ln g$	0.0378 (2.977)	0.0381 (3.041)	0.0394 (3.009)	0.0382 (2.994)
$\ln k$	0.572 (16.083)	0.574 (16.345)	0.601 (16.230)	0.593 (16.467)
R^2 Adjusted R^2	0.659 0.653	0.669 0.662	0.671 0.665	0.689 0.682
Sample	2010–2020		2011–2020	
Number of observations	231		210	

Note: t-Student statistic is given in brackets under the parameter estimates, R^2 is the coefficient of determination, adjusted R^2 is the adjusted coefficient of determination, in the GMM estimates, the instruments are lagged by one year for the dependent variable and the independent variables.

Source: own calculations.

Estimates of the parameters of equation (15) are presented in Table 1. Thus, all independent variables had a statistically significant effect on the regional variation of labour productivity in Italy. From the estimates presented, the rate of Hicksian technical progress was around 1.5%–2.2% between 2010 and 2020 or 2011–2020. In 2020, the COVID-19 pandemic led to an average decrease in production volumes in the Italian regions of 5.7%–7.2%. A 1-percentage-point increase in the urbanisation rate translated into a 0.37% increase in labour productivity. Elasticity of labour productivity with respect to total gravitational effects is smaller then 0.04, elasticity of $\frac{Y}{L}$ with respect to $\frac{K}{L}$ is equal to 0.57–0.60. The OLS and GMM estimations of parameters of equation (15) are close to each other. It can therefore be hypothesised that these equations provide a good description of the regional variation of labour productivity in Italy.

In addition, equation (15) was extended to include the impact on the subsequent Italian regions of gravitational effects flowing from abroad (so-called external gravitational effects). The parameters of the relationship were then estimated:

$$\ln y_{it} = a + b \cdot covid - \alpha_G \cdot Genewa_i + \gamma t + \psi \cdot urb_{it} + \beta \ln g_{it} + \alpha \ln k_{it} \quad (17)$$

or:

$$\ln y_{it} = a + b \cdot covid + \gamma t + \psi \cdot urb_{it} + \beta \ln g_{it} + (\alpha - \alpha_G Genewa_i) \ln k_{it} \quad (18)$$

where $Genewa_i$ is (expressed in mingeo) distance of the capital of the i-th region from Geneva. The choice of Geneva as the main foreign centre of gravity affecting the Italian regions is due to the fact that Geneva and Zurich are among the most important financial centres in Europe. Furthermore, Geneva is a highly internationalised city, home to the largest number of international organisations, i.e. the UN (European Headquarters), the WHO, the ILO or the WTO. It should be stressed that Italy's level of economic development (particularly in the northern regions) is influenced not only by cooperation with Switzerland, but also (for historical reasons) with France, Austria or (to a lesser extent) Germany. Geneva is a reflection of the external gravitational effects arising from the cooperation of Italian regions with the economically highly developed countries of Western Europe.

Equation (17) shows that each successive geographical minute of distance of the capital of the i-th region from Geneva translated into a decrease in labour productivity of α_G%. In equation (18), on the other hand, distance from Geneva interactively modifies the elasticity α of labour productivity with respect to capital per worker. Specifically, it follows from this equation that if the distance of the capital of the i-th region from Geneva were G_i the elasticity of labour productivity with respect to capital per worker would be equal to $\alpha - G_i \alpha_G$.

The estimated OLS and GMM parameters of equations (17–18) can be found in Table 2. The following conclusions can be drawn from the estimates presented that as with the parameter estimates of the relationship (15), the parameter estimates of equations (17–18) also proved to be statistically significant. The estimated rate of Hicksian technical progress was around 1.3% (with OLS) or 1.7% (with GMM). So the estimates were slightly lower than the estimates without foreign gravitational effects. The parameter estimates of equations (17–18) show that the COVID-19 pandemic (ceteris paribus) translated into an average decrease in labour productivity of about 5.4% (with OLS) or about 6.8% (with GMM). This means that the parameter estimates with the covid dummy variable after accounting for external gravitational effects were lower than the estimates with this variable without these effects. The same is true of the parameter estimates for the urbanisation rate. Estimates of the parameters of equation (15) indicated that each additional percentage point in the urbanisation rate translated into an increase in labour productivity of about 3.7%, while estimates of the parameters of equations (17–18) concluded that this increase amounted to about 3%.

Table 2. Parameter estimates for equations (17–18)

Independent variable	Method of estimation			
	OLS		GMM	
Constant	–23.026 (–5.219)	–22.811 (–5.214)	–31.980 (–6.286)	–31.694 (–6.284)
covid	–0.0541 (–2.725)	–0.0542 (–2.744)	–0.0677 (–3.415)	–0.0677 (–3.433)
t	0.0126 (5.886)	0.0125 (5.863)	0.0170 (6.865)	0.0168 (6.848)
Genewa	–0.000220 (–5.969)	–	–0.000202 (–5.258)	–
urb	0.297 (6.977)	0.297 (7.024)	0.303 (6.902)	0.302 (6.942)
$\ln g$	0.0274 (2.322)	0.0288 (2.468)	0.0283 (2.337)	0.0296 (2.467)
Geneva $\ln g$	–	$-4.67 \cdot 10^{-5}$ (–6.226)	–	$-4.31 \cdot 10^{-5}$ (–5.523)
$\ln k$	0.421 (10.116)	0.434 (10.962)	0.448 (10.307)	0.460 (11.130)
R^2 Adjusted R^2	0.715 0.707	0.718 0.711	0.729 0.721	0.732 0.724
Sample	2010–2020		2011–2020	
Number of observations	231		210	

Note: t-Student statistic is given in brackets under the parameter estimates, R^2 is the coefficient of determination, adjusted R^2 is the adjusted coefficient of determination, in the GMM estimates, the instruments are lagged by one year for the dependent variable and the independent variables.

Source: own calculations.

Elasticity of labour productivity with respect to gravitational effects is equal to about 0.03. The parameter estimates of equation (17) also show that the elasticity of labour productivity with respect to capital per worker was around 0.421–0.460. Analysing the parameter estimates of the expression $\alpha - \alpha_G\, Genewa_i$, we conclude that each successive geographic minute of distance of the capital of the i-th region from Geneva reduced the elasticity of labour productivity with respect to capital per worker by $4.31 \cdot 10^{-5} - 4.67 \cdot 10^{-5}$. Thus, e.g., the elasticity of y with respect to k in Lombardy was about 0.425–0.452, in Lazio 0.413–0.440, in Sicily 0.404–0.430, in Sardinia 0.413–0.440.

The resulting GMM estimates of parameters of equation (17) allowed labour productivity relations to be determined in the long-run equilibrium of the gravitational growth model, according to relations (13). Note, however, that (according to relations (17) the expressions a_i in equation (13) were replaced by:

$$a_i = \exp(a - \alpha_G \cdot Genewa_i + \psi \cdot urb_i^*)$$

where urb_i^* denotes the assumed long-run urbanisation rate. Since the quotients $\frac{y_i^*}{y_B^*}$ are higher, the higher the relations $\frac{a_i^*}{a_B^*}$ are, these expressions are equal to:

$$\exp\left(\alpha_G \cdot (Genewa_B - Genewa_i)\right)$$

Thus, the long-run labour productivity relationship $\frac{y_i^*}{y_B^*}$ presented hereafter is (*ceteris paribus*) the lower, the further the capital of the i-th region is located from Geneva.

Numerical simulations of the long-run labour productivity relationship in Italian regions in relation to the value of this variable in the base region (Lombardy) were carried out in two variants: a so-called baseline variant and a variant with development based on the six largest cities. In each of these variants, several scenarios are distinguished.

The baseline variant was simulated with the following several assumptions (scenarios):

1. Investment rates (s_i), employment growth rates (n_i) and urbanisation rates (urb_i) will evolve, as they did on average between 2000 and 2019 (these rates will be referred to hereafter as historical investment rates, historical employment growth rates and historical urbanisation rates).
2. n_i and urb_i rates: as they were on average in 2000–2019, while s_i – at a certain, same level in all regions $\overline{s} \in (0, 1)$.
3. s_i, n_i as they were on average in 2000–2019, $urb_i = \overline{urb} \in (0,1)$.

4. Urbanisation rates: as before, while s_i and n_i rates – at levels $\overline{s} \in (0, 1)$ and $\overline{n} > 0$.
5. The growth rate of the number of employees: as on average in the period 2000–2019. While the investment rates at $\overline{s} \in (0, 1)$, the urbanisation rates: $urb \in (0, 1)$.
6. Investment rates: as before n_i and $\overline{n} > 0$ equal to and $urb_i = \overline{urb} \in (0, 1)$.
7. Investment rates equal to $\overline{s} \in (0, 1)$, growth rates of employment: $\overline{n} > 0$ and urbanisation rates: $urb \in (0, 1)$.

The simulation results of the baseline variant are summarised in Table 3. From the estimates of presented there, we notice that in Scenario 1 (i.e. with historical investment rates, labour growth rates and urbanisation rates), in the long run, the regions of northern Italy should have labour productivity 8.5% higher than in Lombardy, Central Italy 3.5% lower than the base region, while the south of the country should be 4% lower (for the Italian economy as a whole, output per worker should be 2.4% higher than in Lombardy).[8] In this scenario, the highest relative labour productivity $\frac{y_i^*}{y_B^*}$ will be recorded in the Aosta Valley (1.228), Piedmont (1.217), Molise (1.185), Emilia-Romagna (1.178) and the Autonomous Province of Bolzano and Umbria (1.119 each), and the lowest in Puglia (0.862), Marche (0.904), Sicily (0.925) and Lazio (0.940).

If all Italian regions had the same investment rates (Scenario 2), labour productivity would be 2.3% higher in the northern Italian regions than in Lombardy, 2.1% higher in Central Italy and 3.9% lower in the south than in the base region. Moreover, with the same investment rate, the highest relative labour productivity would be in Liguria (1.118), Piedmont (1.074), Emilia-Romagna (1.051), Umbria (1.044) and Lazio (1.002), while the lowest would be in Basilicata (0.900), Calabria (0.911) and Sardinia (0.920).

In Scenario 3 (and therefore with the same labour growth rates and historically shaped investment and urbanisation rates), labour productivity in northern Italy would be 6.6% higher than in Lombardy, 3.2% lower in Central Italy, while in the south the value of this variable would be just over 90% of labour productivity in the base region. For the Italian economy as a whole, labour productivity would be 0.1% lower than in Lombardy. The regions with the highest value of this variable should then be Emilia-Romagna (1.177), the Autonomous Province of Bolzano (1.154), the Aosta Valley (1.142), the Autonomous Province of Trento (1.106), Umbria (1.099), Molise (1.060) and Veneto (1.055), while the lowest relative labour productivity should re-

[8] The fact that labour productivity in Lombardy will be at a relatively low level (especially in relation to the regions of northern Italy) in the variants assuming historical investment rates is due to the fact that these rates in Lombardy were low in the period 2000–2019 (19.0%), while, for example, in the Aosta Valley they were 23.8%, in Molise and the Autonomous Province of Bolzano they were 23.1%, and in the Italian economy as a whole they were 19.5%.

Table 3. Labour productivity in long-run equilibrium—baseline variant (Lombardy = 100)

Region or group of regions	Year 2020	Scenario							
		1	2	3	4	5	6	7	8
Piedmont	85.8	121.7	107.4	114.2	120.2	100.8	106.0	112.8	99.5
Aosta Valley	100.6	122.8	101.1	114.5	129.1	94.3	106.2	120.4	99.1
Liguria	93.2	107.1	111.8	100.9	101.5	105.4	105.9	95.6	99.8
Autonomous Province of Bolzano	113.1	111.9	93.8	115.4	113.6	96.7	95.2	117.2	98.2
Autonomous Province of Trento	101.9	107.9	97.8	110.6	106.8	100.3	96.8	109.5	99.3
Veneto	86.8	107.6	100.2	105.5	107.7	98.3	100.4	105.7	98.4
Friuli-Venezia Giulia	86.8	106.3	97.6	103.1	106.6	94.7	98.0	103.4	95.0
Emilia-Romagna	91.1	117.8	105.1	117.7	112.4	105.1	100.3	112.4	100.3
Northern Italy	**93.5**	**108.5**	**102.3**	**106.6**	**107.2**	**100.6**	**101.1**	**105.4**	**99.4**
Tuscany	85.9	99.6	101.9	98.2	99.3	100.4	101.5	97.8	100.0
Umbria	73.3	111.9	104.4	109.9	107.9	102.5	100.7	106.0	98.9
Marche	76.9	90.4	96.6	88.0	93.5	94.0	99.9	91.0	97.2
Lazio	96.3	94.0	103.6	96.5	85.8	106.4	94.6	88.1	97.2
Central Italy	**88.7**	**96.5**	**102.1**	**96.8**	**92.6**	**102.4**	**98.0**	**92.8**	**98.2**
Abruzzo	76.4	100.9	97.0	98.4	103.4	94.7	99.5	100.9	97.1
Molise	70.2	118.5	100.0	106.0	124.5	89.5	105.2	111.4	94.1
Campania	77.1	100.4	98.0	95.0	99.6	94.5	99.0	94.3	93.8
Apulia	70.6	86.2	93.8	81.0	86.6	88.2	94.3	81.4	88.6
Basilicata	75.3	103.7	90.0	99.5	109.1	86.3	94.6	104.6	90.7
Calabria	71.1	96.5	91.1	89.1	98.9	84.2	93.4	91.4	86.3
Sicily	74.5	92.5	97.9	85.7	90.4	90.7	95.6	83.8	88.6
Sardinia	69.6	104.7	92.0	103.3	105.0	90.8	92.3	103.6	91.0
Southern Italy	**73.7**	**96.0**	**96.1**	**90.7**	**96.1**	**90.7**	**96.1**	**90.7**	**90.8**
ITALY	**87.2**	**102.4**	**100.5**	**99.9**	**100.9**	**98.1**	**99.1**	**98.5**	**96.7**

Source: own calculations based on equation (13).

cord: Puglia (0.810), Sicily (0.857), Marche (0.88) and Calabria (0.891). In the case where all regions were characterised by the same urbanisation rates (Scenario 4) then labour productivity in northern Italy would be 7.2% higher than in Lombardy, in Central Italy by 2.4%, while in the south it would be

3.9% lower than in the base region (in the whole economy relative labour productivity should be 1.009). The Aosta Valley (1.291), Molise (1.245) and Piedmont (1.202) would then have the highest value for this characteristic, while Lazio (0.858), Puglia (0.866), Sicily (0.904) and Marche (0.935) would have the lowest.

If, in all regions, investment rates and growth rates in the number of workers had been at the same level while urbanisation rates had been the same as in the first two decades of the 21st century (Scenario 5), then in the regions of northern and Central Italy labour productivity would have been similar to that recorded in Lombardy, while in the south the value of this variable would have been almost 10% lower than in the base region. Then, in the Autonomous Province of Trento, Tuscany, Piedmont, Umbria, Emilia-Romagna, Liguria and Lazio, the value of this variable would be a few percent higher than in Lombardy, while in Calabria, Basilicata, Apulia and Molise, it would be more than 10% lower. In Scenario 6 (and therefore with the same s_i and urb_i rates and historically shaped n_i rates), labour productivity in northern Italy would be 1.1% higher than in Lombardy, while in the central and southern Italian regions the value of this macroeconomic variable would be 2% and 3.9% lower, respectively. The highest values of this characteristic would be recorded in the Aosta Valley (1.062), Piedmont (1.06), Liguria (1.059), Molise (1.052), and the lowest in Sardinia (0.923), Calabria (0.934), Apulia (0.943), Basilicata (0.946) and Lazio (0.946).

If, on the other hand, investment rates had evolved as they did in the first two decades of the 21st century, and employment growth and urbanisation rates had been the same in all regions (scenario 7), labour productivity in the north of Italy would have been 5.4% higher than in Lombardy, 7.2% lower in Central Italy and 9.3% lower in the south of Italy than in the base region. For the Italian economy as a whole, relative labour productivity would be 0.985. The highest values for this characteristic should then be found in the Aosta Valley (1.204), the Autonomous Province of Bolzano (1.172) and the regions of Piedmont (1.128), Emilia-Romagna (1.124) and Molise (1.114). In the last scenario (and therefore with the s_i, n_i and urb_i rates the same for all regions), labour productivity levels in the north and centre of Italy would be 1%–2% lower than in Lombardy, while in the south they would be more than 9% lower than the base region (Italy's relative labour productivity would then be 0.967). In this scenario, labour productivity levels in Tuscany would be similar to Lombardy, in Emilia-Romagna they would be 0.3% higher than in the base region. In Calabria, Puglia and Sicily, on the other hand, the value of this variable should be more than 10% lower than in Lombardy. It is worth noting that in this scenario, the variation in labour productivity is the result of the geographical location of the regions alone.

In the second variant considered, based on the development of a few large cities, it was arbitrarily assumed that in the long run (i.e. at $t \to \infty$) the population of the six largest Italian cities (Rome, Milan, Naples, Turin, Palermo and Genoa) would increase by 50%, that of the remaining cities of 100,000 inhabitants by 25%, while the urb_i rate in regions without cities of 100,000 inhabitants would increase to 5%. Then (under the additional assumption that

Table 4. Urbanisation rates in the Italian regions in 2020 and at $t \to \infty$ (in %)

Region or group of regions	Year		Change in $t + \infty$ in relation to 2020 (percentage points)
	2020	$t \to \infty$	
Piedmont	22.3	27.9	5.6
Aosta Valley	0.0	5.0	5.0
Liguria	37.1	46.4	9.3
Lombardy	18.3	22.8	4.6
Autonomous Province of Bolzano	20.2	25.3	5.1
Autonomous Province of Trento	22.0	27.4	5.5
Veneto	17.1	21.4	4.3
Friuli-Venezia Giulia	16.7	20.8	4.2
Emilia-Romagna	36.1	47.3	11.2
Northern Italy	**22.6**	**28.6**	**6.0**
Tuscany	19.5	24.4	4.9
Umbria	31.5	39.3	7.9
Marche	0.0	5.0	5.0
Lazio	50.7	63.3	12.7
Central Italy	**33.1**	**42.0**	**8.9**
Abruzzo	9.2	13.8	4.6
Molise	0.0	5.0	5.0
Campania	20.8	31.2	10.4
Apulia	16.6	20.7	4.1
Basilicata	0.0	5.0	5.0
Calabria	9.2	13.8	4.6
Sicily	26.3	32.9	6.6
Sardinia	17.0	21.3	4.3
Southern Italy	**18.3**	**24.9**	**6.6**
ITALY	**23.2**	**30.0**	**6.8**

Source: own calculations based on www.istat.it.

the population of the regions does not change[9]) these rates should evolve as in Table 4. Based on the urbanization rates summarised in this Table, the observation can be made (in 2020 and at $t \to \infty$) that in 2020, in 4 regions the percentage of people living in cities with a population over 100,000 exceeded 30% (Lazio 50.7%, Liguria 37.1%, Emilia-Romagna 36.1% and Umbria 31.5%. On the other hand, in four regions (Aosta Valley, Marche, Molise and Basilicata) there were no cities with a population over 100,000. Based on the assumptions made here about long-term urbanization rates, six provinces (as in 2020 Lazio 63.3%, Emilia-Romagna 47.3%, Liguria 46.6%, Umbria 39.3%, and, additionally, Sicily 32.9% and Campania 31.2%) should be characterized by an index value of more than 30% of urb_i.

Comparing urbanisation rates at $t \to \infty$ with those recorded in 2020, it emerges that based on the assumptions made here, the highest (over 10 percentage points) increases in the value of this indicator should occur in Lazio (by 12.7 percentage points), Emilia-Romagna (11.2 points) and Campania (10.4 points). The lowest (less than 5 points) are to be found in Apulia (4.1 points), Friuli-Venezia Giulia (4.2 points), Sardinia (4.3 points), Veneto (4.3 points), Abruzzo, Calabria and Lombardy (4.6 points each) and Tuscany (4.9 points). For the country as a whole, this percentage should increase by 6.8 percentage points, but with Central Italy growing much faster (mainly as a result of population growth in Rome) than in the north or south of the country.

In the variant based on the development of six large cities, simulations of $\frac{y_i^*}{y_B^*}$ the relationship are examined in the following scenarios:

1. investment rates and growth rates in the number of employees are following the same pattern as on average between 2000 and 2019,
2. the growth rates of the number of employees are as they have been on average over the last two decades, while the investment rates in each region are $\bar{s} \in (0, 1)$,

[9] However, this very strong assumption can be weakened relatively easily to come up with urbanisation rates, as in Table 4. Specifically, it can be assumed that the ratio of the population of the 6 largest cities to the population of the regions in which they are located will increase by 50%, while the remaining cities with populations between 100,000 and 500,000 will increase by 25%. Thus, denoting the current population of Rome (or any other city with a current population of more than 0.5 million people) by R, the long-run value of this characteristic by R_∞, the current population of Lazio (or the region in which any other city with a population of more than 500,000 people is located) as L, the long-run as L_∞ and assuming that $\frac{L_\infty}{L} = \lambda > 1$, we conclude that, by virtue of the assumption made, the following occurs: $R_\infty = 1{,}5\,\lambda R$. Therefore, assuming, for example, that with a 50% increase in population in the Italian regions the population of Rome should increase from 2.8 million people in 2020 to 6.3 million people in long run, Milan from 1.4 million to 3.1 million, Naples from 935,500 people to 2.1 million, Turin from 858,100 people to 1.9 million people, Palermo from 642,700 people to 1.4 million, and Genoa from 566,100 people to 1.3 million.

3. employment growth rates equal $\overline{n} > 0$, and investment rates equal $\overline{n} > 0$, as on average over the period 2000–2019,
4. these rates are equal to (respectively) $\overline{s} \in (0, 1)$ and $\overline{n} > 0$.

In the results of the simulations based on the development of the six cities presented in detail in Table 5, if investment and labour growth rates averaged as in 2000–2019 (Scenario I), in the long run labour productivity in the northern regions of Italy would be higher than in Lombardy (by 8.9%), while it would be lower in the central and southern regions of Italy (by 2.7% and 3.5%, respectively). Labour productivity in the Italian economy would then be 2.9% higher than in the base region. In the scenario considered, the highest relative labour productivity would be registered for Aosta Valley (1.229), Piedmont (1.218), Emilia-Romagna (1.202), Molise (1.186), the Autonomous Province of Bolzano (1.144) and Umbria (1.129). In contrast, Puglia (0.861) and Marche (0.890) would have the lowest relative labour productivity values. Changing the assumption on investment rates and assuming that they are the same in all regions changes the relationship in long-run labour productivity as follows. Northern and Central Italy would have higher labour productivity than Lombardy (by 2.7% and 3%, respectively), while Southern Italy would still have lower labour productivity than in the base region (by 3.4%). Total labour productivity for Italy would be 1% higher than in Lombardy. Liguria (1.130), Piedmont (1.075), Emilia-Romagna (1.073), Lazio (1.057) and Umbria (1.053) would have the highest relative labour productivity, while the Autonomous Province of Bolzano (0.959), Marche (0.951), Puglia (0.937), Sardinia (0.919), Calabria (0.911) and Basilicata (0.901) would have the lowest value of the analysed variable.

Changing (with respect to Scenario 1) the assumption on labour growth rates and assuming that they are the same in all regions results in simulated labour productivity in Northern Italy being 7.1% higher than in the base region. In the variant analysed, Central and Northern Italy have labour productivity lower than in Lombardy by 2.4% and 8.9%, respectively. In contrast, labour productivity in the Italian economy as a whole would be 0.5% higher than the value of this factor in Lombardy. Among the regions with the highest relative labour productivity were: Emilia-Romagna (1.202), Autonomous Province of Bolzano (1.180), Aosta Valley (1.147), Piedmont (1.144), Autonomous Province of Trento (1.109) and Umbria (1.109), while the lowest relative labour productivity would be characterised by: Calabria (0.891), Marche (0.866), Sicily (0.861) and Puglia (0.809).

In Scenario 4, it is assumed that both investment and labour growth rates are the same in all regions, in which case the variation in labour productivity is only affected by the geographical location of the regions. In this scenario, Central and Northern Italy would have 3.3% and 1% higher labour productivity than Lombardy, respectively, and Southern Italy would have 8.8% lower labour productivity than in the base region. In this scenario, labour productivity in the Italian economy as a whole would be lower than in Lombardy in the long term (by 1.4%). In the scenario analysed, the highest relative labour productivity would be in: Lazio (1.086), Emilia Romagna (1.072), Liguria (1.065), Umbria (1.035), Piedmont (1.009), the Autonomous Province of Trento (1.005) and Tuscany (1.004), while the lowest would be Molise (0.896), Apulia (0.881), Basilicata (0.864) and Calabria (0.842).

Table 5. Labour productivity in long-run equilibrium—variant based on the six largest cities (Lombardy = 100)

Region or group of regions	Scenario			
	1	2	3	4
Piedmont	121.8	107.5	114.4	100.9
Aosta Valley	122.9	101.2	114.7	94.4
Liguria	108.2	113.0	102.0	106.5
Autonomous Province of Bolzano	114.4	95.9	118.0	98.9
Autonomous Province of Trento	108.1	98.0	110.9	100.5
Veneto	107.3	100.0	105.2	98.1
Friuli-Venezia Giulia	106.0	97.4	102.9	94.5
Emilia-Romagna	120.2	107.3	120.2	107.2
Northern Italy	**108.9**	**102.7**	**107.1**	**101.0**
Tuscany	99.7	101.9	98.2	100.4
Umbria	112.9	105.3	110.9	103.5
Marche	89.0	95.1	86.6	92.6
Lazio	95.9	105.7	98.4	108.6
Central Italy	**97.3**	**103.0**	**97.6**	**103.3**
Abruzzo	100.9	97.0	98.4	94.7
Molise	118.6	100.2	106.1	89.6
Campania	101.9	101.3	96.5	96.0
Apulia	86.1	93.7	80.9	88.1
Basilicata	103.9	90.1	99.6	86.4
Calabria	96.5	91.1	89.1	84.2
Sicily	92.9	98.3	86.1	91.1
Sardinia	104.6	91.9	103.2	90.7
Southern Italy	**96.5**	**96.6**	**91.1**	**91.2**
ITALY	**102.9**	**101.0**	**100.5**	**98.6**

Source: own calculations based on equation (14).

In addition to the scenarios discussed for the development of labour productivity, using equation (14), the relationship between investment rates in the subsequent regions (relative to Lombardy's investment rate) at which full labour productivity convergence would occur was determined (please see Table 6). These simulations were performed under the following scenarios:

Table 6. Relationship of investment rates ensuring full convergence (Lombardy = 100)

Region or group of regions	Scenario			
	1	2	3	4
Piedmont	92.4	93.7	100.5	92.3
Aosta Valley	98.9	93.5	101.0	98.7
Liguria	88.4	93.8	100.2	87.3
Autonomous Province of Bolzano	107.3	105.5	102.0	104.7
Autonomous Province of Trento	102.5	103.7	100.8	102.2
Veneto	99.8	99.6	101.7	100.0
Friuli-Venezia Giulia	102.7	102.3	105.8	102.9
Emilia-Romagna	94.7	99.7	99.7	92.5
Northern Italy	**97.5**	**98.8**	**100.7**	**97.1**
Tuscany	98.0	98.4	100.0	97.9
Umbria	95.4	99.2	101.2	94.4
Marche	103.9	100.1	103.2	105.7
Lazio	96.1	106.3	103.2	94.0
Central Italy	**97.7**	**102.3**	**102.0**	**96.8**
Abruzzo	103.4	100.6	103.4	103.4
Molise	100.0	94.6	107.0	99.8
Campania	100.3	101.1	107.4	98.6
Apulia	107.3	106.8	114.3	107.4
Basilicata	112.4	106.3	111.4	112.2
Calabria	110.8	107.8	117.7	110.8
Sicily	102.4	105.1	114.3	101.9
Sardinia	109.6	109.3	110.9	109.8
Southern Italy	**104.5**	**104.4**	**111.3**	**103.9**
ITALY	**99.4**	**101.0**	**103.8**	**98.9**

Source: own calculations based on equation (14).

1. historically shaped growth rates of employment and urbanisation rates,
2. historically shaped growth rates of employment and the same rates of urbanization,
3. the same rates of growth in employment and the same rates of urbanisation,
4. historical growth rates of employment and urbanisation rates as in Table 4,
5. same growth rates of employment and urbanisation rates as in Table 4.

The results of simulations of investment rate relations guaranteeing full labour productivity convergence are presented in Table 6. These simulations show that in all the scenarios analysed, relative investment rates[10] (understood as the quotient $\frac{s_i}{s_B}$ defined by equation (14) in Southern Italy should exceed 1. In scenarios 1, 2 and 4, investment rates in the southern Italian regions should be about 4% higher than in Lombardy, in scenarios 3 and 5, more than 10% higher. In scenarios 1, 4 and 5, investment rates in the central Italian regions should be lower than in Lombardy (by around 3%–4%), while in scenarios 2 and 3 they should be higher by around 2%–2.5%. In the regions of northern Italy, outside scenario 3, investment rates in these regions should be 2%–3% lower than in the base region. Generally, it can be hypothesised that for full labour productivity convergence to occur in Italy, investment rates in the south of the country are needed to be higher than in Lombardy, while those in the centre and north are needed to be similar to the region.

Conclusions

The analyses presented in the paper can be summarised as follows: The fall in investment in the Italian economy following the global financial crisis has translated into a reduction in the rate of capital accumulation, a fall in the value of domestic gravitational effects, leading to a fall in production, labour productivity, employment and an increase in unemployment. In addition, a significant drop in production was recorded there in 2020 as a result of restrictions related to the COVID-19 pandemic. As a consequence of these processes, the volume of GDP in Italy in 2021 is close to the value of this macroeconomic variable at the beginning of the 21st century, while capital

[10] Since we are examining the quotients $\frac{s_i}{s_B}$, a value of this quotient of, say, 1.02 means that the investment rate in region i should be 2% higher than in the base region (i.e. if the base region had an investment rate of 20%, region i should have an investment rate of 20.4%).

per worker, gravitational effects and labour productivity are lower (which is unique among EU countries).

The fall in investment has affected the poorest regions, Southern Italy, the most, followed by Central Italy, and the richest regions of the north of the country the least. In turn, declines in investment have led to a further polarisation of capital per worker, gravitational effects and labour productivity in Italian regions. The coefficient of variation (defined as the quotient of the standard deviation and the unweighted mean) for capital per worker increased by more than 25% between 2010 and 2020, for gravitational effects by more than 3%, and for labour productivity by more than 5%. Generally, moving from north to south Italy, the level of capital per worker and labour productivity decreases, while the strongest gravitational effects are recorded in Central Italy in the quadrilateral connecting Rome, Florence, Bologna and Perugia.

Analysing the spatial variation in labour productivity on the basis of the gravitational growth model, we find that the level of labour productivity in the country's regions is most strongly influenced by the variation in capital per worker, followed by urbanisation rates and domestic and foreign gravitational effects. The study calibrated the parameters of the gravitational model of economic growth in two ways: not taking into account and taking into account external gravitational effects, i.e. effects coming from abroad. In both cases, estimates were made using the method of least squares (OLS) and the generalized method of moments (GMM). A better explanation of the model was obtained in the model with foreign effects. The GMM-estimated parameters of the model including external gravitational effects were used in numerical simulations.

Numerical simulations of the long-run relationship of labour productivity in Italian regions in relation to the value of this variable in the base region (Lombardy) were carried out in two variants: a baseline variant and a variant with development based on the six largest cities. The baseline variant assumed eight different scenarios for the development of investment rates, labour force growth rates and urbanization rates. In the variant with development based on the 6 largest cities, four different scenarios were analysed. In the baseline variant, regardless of the scenario adopted, Northern, Central and Southern Italy would have higher relative labour productivity in long-run equilibrium relative to Lombardy than in 2020. Northern Italy's relative long-run labour productivity would be highest under a scenario in which investment rates, labour force growth rates and urbanization rates would be at historical levels (that is, as they were on average from 2000 to 2019). The lowest relative labour productivity growth in the area would occur under the assumption that investment rates, urbanization rates and labour force growth rates equalize across all regions. In contrast, for the central Italian regions, the most favourable scenario was the one in which urbanization rates are assumed to be at historical levels and other rates are assumed to be at some level that is the same for all regions (in this scenario, Central Italy achieves a higher level of labour productivity than Northern Italy in long-term equilibrium). The least favourable scenario for the central regions is the one that assumes investment and labour growth rates at historical levels and an urbanisation rate that is the same for all regions. The southern Italian regions, regardless of the scenario adopted, are characterized in long-run equilibrium (as they are now) by the lowest relative labour productivity.

In the variant with development based on the six largest cities, the most favourable scenario for Northern Italy would be one with investment rates and labour growth rates maintained at historical levels, the least favourable for the area would be an equalization of investment rates and labour growth rates between regions (in this scenario, in long-term equilibrium, they would have lower relative labour productivity than central Italy). Equally favourable for Central Italy would be a scenario in which labour growth rates are at historical levels and only investment rates equalize across all regions (this is also the most favourable scenario for southern Italian regions). At the same time, as in the baseline scenario, Southern Italy would have the lowest relative level of labour productivity in the long term regardless of the assumptions used. The study also determined the relationship between investment rates in the regions relative to Lombardy, at which full labour productivity convergence would occur. From the analysis, a general conclusion can be drawn that for full convergence in labour productivity to occur in Italy, it is necessary to keep investment rates in the south of the country higher than in Lombardy (by about 4%–11%, depending on the scenario adopted for labour and urbanization growth rates), and investment rates in central and northern Italy at similar levels to those in Lombardy.

One can expect that the following three actions may be helpful in striving for the convergence of the economic development of Italian regions. Firstly, striving to increase broadly understood social capital in the southern regions of the country (that are more susceptible to corruption and crime actions at least since the unification of Italy in the second half of the 19th century). Secondly, differentiating the minimum wage depending on the situation on the labour market (which may result in an increase in demand for labour and an increase in employment in regions with the highest unemployment, without losses to the labour markets in regions with low unemployment). Thirdly, differential taxation of capital depending on regional investment rates.

Further analyses may concern extending the model with variables characterizing the diversity of the labour market (in order to capture the interaction between variables in the labour market and the product market). Moreover, the impact of the economic policy instruments mentioned in the comments on the processes of regional convergence (both on the product and labour markets) can also be analysed.

References

Allen, R. G. D. (1975). *Teoria makroekonomiczna. Ujęcie matematyczne*. Wydawnictwo Naukowe PWN.

Arbia, G., & Basile, R. (2005). Spatial dependence and non-linearities in regional growth behaviour in Italy. *Statistica*, *65*(2), 145–167. https://doi.org/10.6092/issn.1973-2201/83

Bärwolff, G. (2020). Mathematical modeling and simulation of the COVID-19 pandemic. *Systems*, *8*(3), 24. https://doi.org/10.3390/systems8030024

Basile, R., & Cicerone, G. (2022). Economic complexity and productivity polarization: Evidence from Italian provinces. *German Economic Review*, *23*(4), 567–594. https://doi.org/10.1515/ger-2021-0070

Bianchini, F. (1991). The Third Italy: Model or myth? *Ekistics*, *58*(350/351), 336–345. https://www.jstor.org/stable/43646779

Boschma, R., & Iammarino, S. (2007). *Related variety and regional growth in Italy*. SPRU Electronic Working Paper Series.

Boschma, R., & Iammarino, S. (2009). Related variety, trade linkages, and regional growth in Italy. *Economic Geography*, *85*(3), 289–311. https://doi.org/10.1111/j.1944-8287.2009.01034.x

Busetta, G., & Corso, D. (2012). Labor productivity and Okun's law: An empirical application to Italian regional panel data. Rivista italiana degli economisti, *The Journal of the Italian Economic Association*, *2*, 279–298. https://doi.org/10.1427/37497

Calcagnini, G., Marin, G., & Perugini, F. (2021). Labour flexibility, internal migration and productivity in Italian regions. *Structural Change and Economic Dynamics*, *57*(C), 308–320.

Carmeci, G., & Mauro, L. (2002). The convergence of Italian regions and unemployment: Theory and evidence. *Journal of Regional Science*, *42*, 509–532.

Di Giacinto, V., & Nuzzo, G. (2004). *Explaining labor productivity differentials on Italian regions*. ERSA Conference Papers. European Regional Science Association.

Di Liberto, A. (2008). Education and Italian regional development. *Economics of Education Review*, *27*(1), 94–107. https://doi.org/10.1016/j.econedurev.2006.08.004

Di Liddo, G. D. (2015). Urban sprawl and regional growth: Empirical evidence from Italian regions. *Economics Bulletin*, *35*, 2141–2160.

Dykas, P., Tokarski, T., & Wisła, R. (2023). *The Solow model of economic growth. Application to contemporary macroeconomic issues*. Routledge.

Dykas, P., & Wisła, R. (Eds.). (2022). *The socioeconomic impact of COVID-19 on Eastern European countries*. Routledge.

Filipowicz, K. (2019). *Wpływ interakcji przestrzennych na zróżnicowanie rozwoju gospodarczego Polski*. Wydawnictwo Uniwersytetu Jagiellońskiego.

Filipowicz, K., Nowosad, A., & Tokarski, T. (2015). Oddziaływanie efektu grawitacyjnego na zróżnicowanie wydajności pracy w krajach bałkańskich. *Gospodarka Narodowa*, *2*, 15–53.

Fiorino, N., Galli, E., & Petrarca, I. (2012). Corruption and growth: Evidence from the Italian regions. *European Journal of Government and Economics*, *1*, 126–144.

Fratesi, U., & Percoco, M. (2014). Selective migration, regional growth and convergence: Evidence from Italy. *Regional Studies*, *48*(10), 1650–1668. https://doi.org/10.1080/00343404.2013.843162

Gitto, S., & Mancuso, P. (2015). The contribution of physical and human capital accumulation to Italian regional growth: A nonparametric perspective. *Journal of Productivity Analysis*, *43*, 1–12.

Gori, L., Manfredi, P., Marsiglio, S., & Sodini, M. (2022). COVID-19 epidemic and mitigation policies: Positive and normative analyses in a neoclassical growth model. *Journal of Public Economic Theory*, *24*, 968–992.

Maffezzoli, M. (2004). *Convergence across Italian regions and the role of technological catch-up*. IGIER Working Paper, 274. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=628481

Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A contribution to the empirics of economic growth. *The Quarterly Journal of Economics*, *107*(2), 407–437. https://doi.org/10.2307/2118477

Mroczek, K., Tokarski, T., & Trojak, M. (2014). Grawitacyjny model zróżnicowania rozwoju ekonomicznego województw. *Gospodarka Narodowa*, *3*, 5–34.

Mroczek, K., Tokarski, T., & Trojak M. (2015). Złote reguły akumulacji w grawitacyjnym modelu wzrostu gospodarczego. *Gospodarka Narodowa*, *3*, 27–47.

Nowosad, A., & Wisła, R. (red.). (2016). *Zróżnicowanie rozwoju współczesnej Europy*. Wydawnictwo Uniwersytetu Jagiellońskiego.

Ombach, J. (1999). *Wykłady z równań różniczkowych wspomagane komputerowa – Maple*. Wydawnictwo Uniwersytetu Jagiellońskiego.

Paci, R., & Pigliaru, F. (1997). Structural change and convergence: an Italian regional perspective. *Structural Change and Economic Dynamics*, *8*(3), 297–318. https://doi.org/10.1016/S0954-349X(96)00077-X

Paci, R., & Pigliaru F. (1998). *Growth and sectoral dynamics in the Italian regions*. Working Paper CRENoS 199803. Centre for North South Economic Research, University of Cagliari and Sassari.

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, *70*(1), 65–94. https://doi.org/10.2307/1884513

Terrasi, M. (1999). Convergence and divergence across Italian regions. *The Annals of Regional Science*, *33*, 491–510. https://doi.org/10.1007/s001680050117

Wisła R., Filipowicz, K., & Tokarski, T. (2018). Zróżnicowanie rozwoju ekonomicznego krajów UE na podstawie grawitacyjnego modelu wzrostu. *Wiadomości Statystyczne*, *7*, 37–55.

Wisła, R., & Nowosad, A. (Eds.). (2020). *Economic transformation in Poland and Ukraine. National and Regional Perspective*. Routledge.

Aims and Scope

The **Economics and Business Review** is a quarterly journal focusing on theoretical, empirical and applied research in the fields of Economics and Corporate and Public Finance. The Journal welcomes the submission of high quality articles dealing with micro, mezzo and macro issues well founded in modern theories and relevant to an international audience. The EBR's goal is to provide a platform for academicians all over the world to share, discuss and integrate state-of-the-art Economics and Finance thinking with special focus on new market economies.

The manuscript

1. Articles submitted for publication in the **Economics and Business Review** should contain original, unpublished work not submitted for publication elsewhere.
2. Manuscripts intended for publication should be written in English, edited in Word in accordance with the **APA editorial** guidelines and sent to: secretary@ebr.edu.pl**.** Authors should upload two versions of their manuscript. One should be a complete text, while in the second all document information identifying the author(s) should be removed from papers to allow them to be sent to anonymous referees.
3. Manuscripts are to be typewritten in **12' font in A4 paper** format, one and half spaced and be aligned. Pages should be numbered. Maximum size of the paper should be up to 20 pages.
4. Papers should have an abstract of about 100-150 words, keywords and the Journal of Economic Literature classification code (**JEL Codes**).
5. Authors should clearly declare the aim(s) of the paper. Papers should be divided into numbered (in Arabic numerals) sections.
6. **Acknowledgements** and references to grants, affiliations, postal and e-mail addresses, etc. should appear as a separate footnote to the author's name a, b, etc and should not be included in the main list of footnotes.
7. **Footnotes** should be listed consecutively throughout the text in Arabic numerals. Cross-references should refer to particular section numbers: e.g.: See Section 1.4.
8. **Quoted texts** of more than 40 words should be separated from the main body by a four-spaced indentation of the margin as a block.
9. **References** The EBR 2022 editorial style is based on the **7th editio**n of the Publication Manual of the American Psychological Association (**APA**). For more information see APA Style used in EBR guidelines.
10. **Copyrights** will be established in the name of the **EBR publisher**, namely the Poznań University of Economics and Business Press.

More information and advice on the suitability and formats of manuscripts can be obtained from:

Economics and Business Review
al. Niepodległości 10
61-875 Poznań
Poland
e-mail: secretary@ebr.edu.pl
www.ebr.edu.pl

Subscription

Economics and Business Review (EBR) is published quarterly and is the successor to the Poznań University of Economics Review. The EBR is published by the Poznań University of Economics and Business Press.

Economics and Business Review is indexed and distributed in Scopus, Claritave Analytics, DOAJ, ERIH plus, ProQuest, EBSCO, CEJSH, BazEcon, Index Copernicus and De Gruyter Open (Sciendo).

Subscription rates for the print version of the EBR: institutions: 1 year – €50.00; individuals: 1 year – €25.00. Single copies: institutions – €15.00; individuals – €10.00. The EBR on-line edition is free of charge.