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Spatial inequality in the European Union: does regional efficiency matter?

Roberto Ezcurra
Universidad Pública de Navarra

Belén Iráizoz
Universidad Pública de Navarra

Abstract

This paper examines the sources of spatial disparities in output per capita across the European regions over the period 1986-2004. To this end, a decomposition of the Theil´s second measure of inequality is used. The analysis carried out shows the important role played by labour productivity in determining the degree of dispersion in output per capita within the European Union. In turn, our results reveal the relative importance of regional differences in the levels of technical efficiency when it comes to explaining spatial disparities in labour productivity.

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1 Introduction

The last fifteen years have seen the publication of a great deal of research on regional disparities in the European Union (EU) using a variety of different approaches (e.g. Ezcurra *et al.*, 2007; Le Gallo, 2004; Meliciani, 2006). There are various factors underlying the interest in this issue. Among them, it is worth mentioning the major advances made over the last two decades in economic growth theory (Barro and Sala-i-Martin, 1995), and the important development of the "new economic geography" (Ottaviano and Puga, 1998). Academic debate aside, however, the increasing relevance of this topic in the EU is largely due to the strong focus placed on achieving economic and social cohesion in the framework of the economic integration process currently underway in Europe (European Commission, 2007).

Against this background, and in a quest for empirically well-founded, stylized facts, this paper aims to delve more deeply into the analysis of the sources of spatial inequality in the EU. Specifically, the Theil's second measure of inequality is used to break down regional disparities in output per capita into the contributions of factors such as labour productivity, employment rate or the ratio of active population to total population. In any event, the main novelty of our study derives from the inclusion of technical efficiency into the analysis. In this respect, it should be recalled that the literature on regional disparities in the EU has tended so far to ignore the degree of efficiency with which the various regions use their productive resources. This omission is particularly important in this context since, as pointed out by Maudos *et al.* (2000), the exclusion of the phenomenon of inefficiency may affect the validity of the results.

2 Theoretical framework

2.1 The measurement of regional efficiency

Technical efficiency in a production unit refers to the achievement of the maximum potential output from given amounts of factor inputs, taking into account physical production relationships. Data Envelopment Analysis (DEA) is used in this paper to estimate the levels of technical efficiency of the European regions. DEA is a deterministic technique that offers the advantage of not requiring a predetermined functional form for the frontier production function (Coelli *et al.*, 2005). The basic model assumes that the production technology exhibits constant returns to scale. In our application we have considered an output-oriented model. Accordingly, the level of technical efficiency measures the proportion of the technically obtainable output that the region really obtains.

The model involves optimizing a scoring function, defined as the ratio of the weighted sum of outputs and the weighted sum of inputs. The output-oriented model, after the necessary reformulation and using duality, can be expressed in the envelopment form (for details about this methodology, see Cooper *et al.*, 2000). Let us consider that each region employs m inputs $X_i = (X_{1i}, \ldots, X_{mi}) \in \mathbb{R}^m_+$ to obtain q outputs

$Y_i = (Y_{1i}, \dots, Y_{qi}) \in \mathbb{R}^q_+$. For each region i, the following linear program needs to be solved in order to have an estimate of its global technical efficiency (e_i^g):

$$
\begin{aligned}
&\text{Max } \; e_i^g \\
&\text{subject to:} \\
&\quad e_i^g Y_{ri} \leq \sum_{i=1}^{n} Y_{ri}\lambda_i, \; r = 1, \dots, q \\
&\quad X_{ji} \geq \sum_{i=1}^{n} X_{ji}\lambda_i, \; j = 1, \dots, m \\
&\quad \lambda_i \; \geq 0, \forall \; i
\end{aligned}
\tag{1}
$$

This efficiency measure assumes that the technology exhibits constant return to scale. It is possible to allow variable returns to scale including the restriction that $\sum_{i=1}^{n} \lambda_i = 1$. In this case, the model measures technical efficiency regardless of scale issues. This measure is known as pure technical efficiency (e_i^p). Since the efficiency comparison group was constrained to estimate e_i^p, it is satisfied that $e_i^p \geq e_i^g$. Having obtained e_i^g and e_i^p estimates, the relationship between them gives us scale efficiency ($e_i^s = \frac{e_i^g}{e_i^p}$).

2.2 Factor decomposition of spatial inequality

Let y_i be the output per capita of region i. That is, $y_i = \frac{Y_i}{N_i}$, where Y_i and N_i stand for output and total population of region i. Likewise, let L_i and A_i be region's i total employment and active population, respectively. It should be noted that output per capita can be broken down into the product of various factors: labour productivity ($p_i = \frac{Y_i}{L_i}$), employment rate ($l_i = \frac{L_i}{A_i}$), and the ratio of active population to total population ($a_i = \frac{A_i}{N_i}$). Consequently, y_i can be written as:

$$y_i \equiv p_i \cdot l_i \cdot a_i \tag{2}$$

In turn, p_i can be expressed as:

$$p_i \equiv {p_i}^p \cdot e_i^s \cdot e_i^p \tag{3}$$

where p_i^p is the level of output per worker obtained by region i if it could eliminate all its technical inefficiency. Using the terminology employed by Cheng and Li (2006), we call this term the "pure labour productivity".

The main purpose of this paper is to investigate the role played by the different factors in expressions (2) and (3) when it comes to explaining regional disparities in the EU. To this end, let us consider the following inequality measure proposed by Theil (1967):

$$T_0(S) = \sum_{i=1}^{n} \frac{1}{n} \ln\left(\frac{\mu}{S_i}\right) \tag{4}$$

where S_i is the value of the variable object of study in region i, with $i = 1, \ldots, n$. Likewise, μ stands for the average of vector $S = (S_1, \ldots, S_n)$. $T_0(S)$ is known in the literature as the Theil's second measure or mean logarithmic deviation. This inequality measure is symmetric, independent of scale and population size, and satisfies the Pigou–Dalton transfer principle (Cowell, 1995). Additionally, as shown by Bourguignon (1979) and Shorrocks (1980), this measure is additively decomposable by population subgroups, which explains its popularity in the literature.

In order to explore the sources of regional inequality in China, Cheng and Li (2006) have proposed a decomposition of $T_0(S)$ when the variable under study can be expressed as the product of two multiplicative factors. In turn, in a recent contribution, Alcalde-Unzu *et al.* (2009) have extended this decomposition to the general case when S can be written as the product of k multiplicative factors. That is,

$$S_i = \prod_{f=1}^{k} s_{if} \tag{5}$$

where s_{if} denotes the value of factor f in region i. Substituting (5) into (4) and using the properties of the logarithms, the Theil's second measure of inequality can be written as:

$$T_0(S) = \sum_{i=1}^{n} \frac{1}{n} \ln\left(\frac{\prod_{f=1}^{k} \mu_f}{\prod_{f=1}^{k} s_{if}} \cdot \frac{\mu}{\prod_{f=1}^{k} \mu_f}\right) = \sum_{f=1}^{k} T_0(s_f) + \ln\left(\frac{\mu}{\prod_{f=1}^{k} \mu_f}\right) \tag{6}$$

where $s_f = (s_{1f}, \ldots, s_{nf})$ and μ_f is the average of this vector. As can be observed, this decomposition is particularly useful in the context that concerns us, since it allows us to break down the degree of inequality in S into the unweighted sum of the level of inequality registered in the different factors, and a residual term.[1]

[1]Note that the residual term is equal to 0 only when $\mu = \prod_{f=1}^{k} \mu_f$. In this particular case, $T_0(S) = \sum_{f=1}^{k} T_0(s_f)$.

3 Data

The empirical application carried out in this paper is based on data drawn from the Cambridge Econometrics regional database. Specifically, our sample consists of 196 NUTS-2 regions.[2] Real GVA (expressed in 1995 euros) was employed as output variable. In order to obtain the levels of regional efficiency, labour input was quantified by average hours worked, and capital input was estimated by the perpetual inventory method using gross investment data. Specifically, following standard practice in the literature, the capital stock of each region in 1986 was estimated using the formula $K_0 = I/(g + \delta)$, where I is the average level of gross investment over the period 1980-1986,[3] g is the growth rate of gross investment throughout that period, and δ the rate of capital depreciation. It should be mentioned that we considered different values for the depreciation rate. However, the most reasonable cross-regional estimates of capital-GVA ratios were obtained with $\delta = 0.05$. The capital stocks of the next years were calculated according to the equation $K_t = K_{t-1}(1 - \delta) + I_t$.

4 Results

We began our empirical analysis by examining the evolution of regional inequality in GVA per capita throughout the study period. As can be observed in Figure 1, the value of $T_0(y)$ decreased by 20% between 1986 and 2004, revealing the reduction registered by the cross-sectional spread of GVA per capita over time.

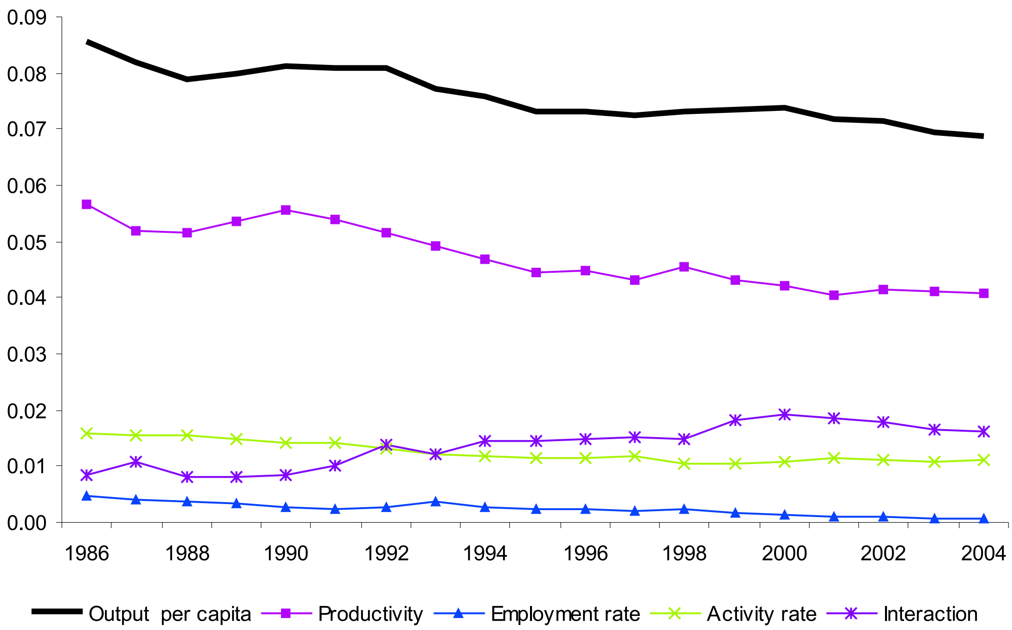
In order to go more deeply into the analysis of the sources of regional inequality in output per capita within the EU, we carried out the decomposition of $T_0(y)$ based on the three factors considered in expression (2). According to our results, regional disparities in labour productivity, employment rate and the ratio of active population to total population decreased between 1986 and 2004. Nevertheless, Figure 1 indicates clearly that labour productivity is the most relevant factor in explaining regional differences in output per capita across the European regions. Specifically, the relative contribution of this factor to overall inequality ranged from 66% to 60% over the study period. In turn, the relative importance of regional disparities in employment rate and the ratio of active population to total population is considerably more reduced. Finally, it is worth noting that the interaction term is positive in the nineteen years considered. This reveals that the interaction term contributed to increase the degree of dispersion in GVA per capita caused by the remaining factors. In fact, as a result of the upward trend experienced between 1986 and 2004, at the end of the study period the interaction term accounted for 24% of $T_0(y)$.

The analysis performed so far shows the relevance of spatial differences in labour productivity in explaining regional disparities in output per capita within the EU. Bearing

[2]The lack of complete series obliged us to exclude from our study the countries incorporated into the EU in 2004 and 2007, the *Länder* of former East Germany, the French Overseas Departments and Territories, and the Portuguese islands in the Atlantic.

[3]The regional data provided by Cambridge Econometrics are only available from 1980.

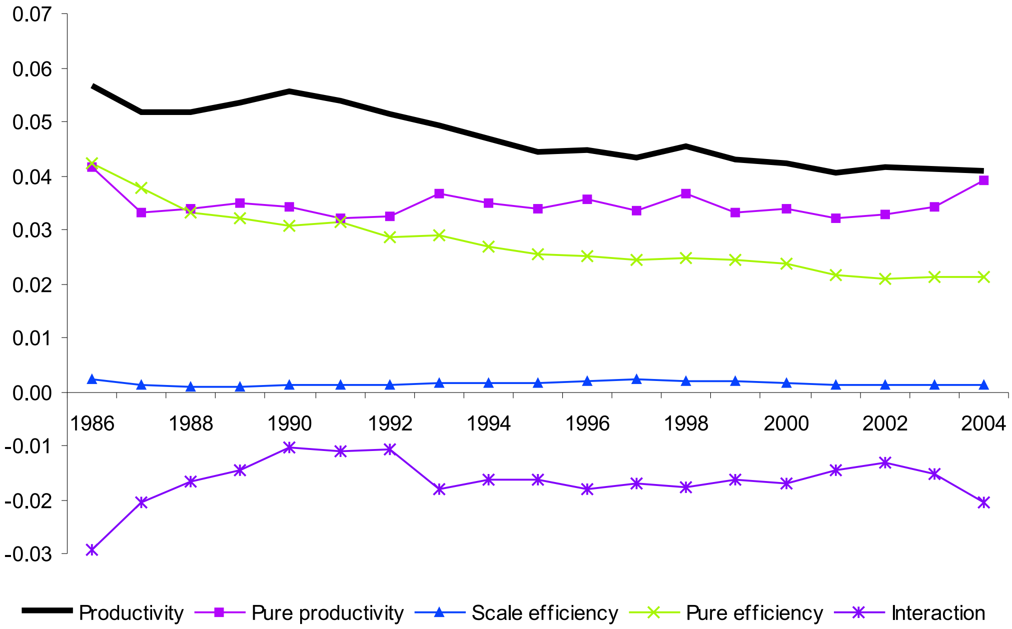
Figure 1: Factor decomposition of $T_0(y)$.



this in mind, and in order to complete our previous results, we used expression (3) to decompose regional inequality in output per worker into the contributions of different factors: pure labour productivity, scale efficiency and pure efficiency. At this point, it is important to recall that various authors have explored the sources of spatial inequality in labour productivity across the EU regions (e.g. Ezcurra *et al.*, 2007). None of the existing studies, however, have considered so far the role played in this context by technical efficiency.

As can be seen in Figure 2, despite the process of convergence in output per worker observed during the sample period, regional differences in pure labour productivity remained practically constant. Consequently, the relative contribution of this element to spatial inequality in labour productivity rose from 73% in 1986 to 96% in 2004. Nevertheless, the relative importance of pure efficiency in this context should not be over overlooked. Although the degree of dispersion in this factor decreased over the study period, it still accounted for 52% of regional inequality in GVA per worker in 2004. In turn, Figure 2 reveals that the contribution of scale efficiency is virtually negligible. In any event, these results are particularly important, since they highlight the relevance of technical efficiency when it comes to determining the magnitude of territorial imbalances in the EU. To conclude, a brief comment on the interaction term is in order. Unlike the previous case, the interaction term is now negative. This means that, throughout the study period, this element had a compensatory effect on the labour productivity differences resulting from the various factors in expression (3).

Figure 2: Factor decomposition of $T_0(p)$.



5 Conclusions

In this paper we have investigated the sources of spatial disparities in output per capita across the European regions during the period 1986-2004. To this end, we have used a decomposition of the Theil's second measure of inequality, which has allowed us to determine the role played in this context by different factors.

The analysis carried out shows the presence of a convergence process in GVA per capita in the EU during the sample period. This is closely linked to the evolution followed over time by spatial inequality in labour productivity, given that our results reveal that this factor is the main element in explaining regional differences in output per capita. On the contrary, the role played in this context by the employment rate and the ratio of active population to total population is considerably less relevant.

Bearing this in mind, we have gone more deeply into the study of the driving forces of spatial inequality in output per worker within the EU. To do so, we have included into the analysis the level of technical efficiency registered by the sample regions. In this respect, it is important to note that the literature on regional convergence in the EU tends to ignore the degree of efficiency with which the various regions use their productive resources. Nevertheless, this omission may be particularly relevant in this context, since our results show that regional differences in the levels of technical efficiency account for a relatively important portion of spatial inequality in labour productivity.

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