Does country size affect the relationship between population density and labour productivity?

Theory and evidence for Europe

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1 The issue: how does "politics" influence the relationship between "population density" and "labour productivity"?

The direct association of *population density* and *labour productivity* has been widely shown in geographical economics as expressing several kinds of *agglomeration economies*. A dense population in a region or metropolitan area facilitates, among other effects (see for instance MARSHALL, 1949):

- Technological spillovers across densely packed plants.

- A good matching between workers'skills and the specific tasks that they are requested to perform within firms.

- The provision of specialized intermediate goods by upstream suppliers.

Furthermore, it has been shown that this economic relationship is subjected to **variable returns**.

Nevertheless, much less attention has been paid to the strong effect that "political boundaries" exert upon the association between "population density" and "labour productivity". Anecdotal evidence leads us to believe that this association is much stronger at the regional level within **small** countries than in **large** countries.

In this context, we try first to provide a theory and then an empirically based description of the strength of the relation across countries with differential size.

2 Why and how "population density" has a lesser effect on "productivity" in large countries.

In theoretical terms, we expect that the influence of "population density" upon "labour productivity" at the regional level, while remaining significantly positive, is not as important in large countries as it is in small countries.

2.1 A simple model for the direct association between "population density" and "productivity" at the regional level.

Firstly, we present a simple model of the positive relationship between "population density" and "labour productivity" at the level of a single region. This model was initially put forward by VON THÜNEN (1826) and tested empirically for roads by GLOVER and SIMON (1975).

The chain of reasoning is made up by the following links:

1. Labour productivity in a region is determined by the *quality in the provision of a set of "public goods"*, such as: education, health, justice, transportation and public administration and so on.

2. Since the act of travelling is a *disutility* for the individual, the labour productivity in a region is reduced by the aggregate size of the journeys that an inhabitant must perform in order to access these public goods.

3. We assume that each public good (for instance **education**) is supplied by a network of regularly spaced plants (i.e. **"schools"**). For simplicity, we assume that the cost related with each "school" is entirely fixed, i.e. a set up cost, operating costs being presupposed to be zero.

4. We consider two regions, L and S, with the same geographical area, but with very different populations. Then, population is much denser in region L than in region S. Thus, if we assume that both regions have the same amount of money available to spend in education per inhabitant, economies of scale in education determine that the same budget constraint

will be compatible with a **much denser** networks of "schools" in L than in S. Consequently, education quality will be much higher in L in S thereby leading to a higher labour productivity in the former region.

2.2 Why and how this association works less well for large countries

While a small country may even coincide with a **single** region, the market of a large country usually emerges as the outcome of a process of economic integration of formerly independent regional markets, through the elimination of internal customs and heavy investments in internal transportation infrastructure. This process is either carried along with political unification (as in Germany and Italy, during the second half of the XIXth century), or through mere economic integration across regions within a formerly unified nation-state (as in France during the XVIIth century).

Therefore, **internal** transport costs within a large country are as a rule significantly higher than **costs of links between locations within and outside the country**. This asymmetry leads to an internal specialization across

regions that compose the large country, each region specializing in a different "public good". Consequently, in addition of having to travel to the nearest supply point of a specific "public good" within each region, the inhabitant of a large country must travel **across** different regions in order to access all the "public goods" that he needs.

This latter type of interregional journeys also constrains "labour productivity" but it is not related at all with "population density" in the regions that compose the large country. The overall result is that the degree of association between "population density" and "labour productivity" becomes less important in a large country.

3 Testing the theoretical conjecture

By using the *Eurostat's* regional database for year 2015, the following linear regression across NUTS2 regions for EU28 member states was run:

$$GDP_{i,j}^{pc} = b_1 + b_2 Dens_{i,j} + \gamma_j + \varepsilon_{i,j}$$

where subscripts i and j denote the NUTS2 region and its country, respectively.

We also define,

GDP^{pc} measures NUTS2 per capita GDP in Purchasing Power Standard (PPS), a proxy for labour productivity. The variable is taken in logs.

$Dens$ measures NUTS2 population density, taken in logs.

γ_j is country-specific fixed-effect, which accounts for country specific heterogeneity.

The model is estimated by OLS for the regions in all EU28 countries and separately for regions within small countries and within large countries. The two subsets of European Countries are,

Large countries$\equiv$

$$\equiv \left\{ \begin{array}{l} \text{Bulgaria, Finland, France, Germany, Greece, Italy,} \\ \text{Poland, Romania, Spain, Sweden, United Kingdom} \end{array} \right\}$$

Small countries$\equiv$

$$\equiv \left\{ \begin{array}{c} \text{Austria, Belgium, Croatia, Cyprus,} \\ \text{Czech Republic, Denmark, Estonia,} \\ \text{Hungary, Ireland, Latvia, Lithuania, Luxembourg,} \\ \text{Malta, Netherlands, Portugal, Slovakia, Slovenia} \end{array} \right\}$$

The main results of this regression are,

1. The model's explanatory power is good, ranging between 53% and 72% (in terms of adjusted R^2).

2. There is a positive relation between population density and labour productivity. The elasticity for the full sample of countries is 0.109.

3. **When we estimate the model separately for small and large countries, we observe that the magnitude of the relation is considerably larger for smaller countries:** 0.193 **versus** 0.088.

4 The theoretical expectation of the paper is therefore empirically confirmed!