Cities as engines of regional growth

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Cities as engines of regional growth (*)

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The paper analyses the role of central cities as engines of economic growth in their metropolitan area or region. We sought to determine whether there are increasing returns to central city growth at the metropolitan level arising from the positive externalities associated with the unique features of big cities. To answer this question, we analysed the causality between the economic growth of Spain’s central cities and the growth of the other jurisdictions belonging to their metropolitan area. The analysis uses population and economic activity data for a sample of Spanish cities over the last thirty years. The relationship between the growth of the city and that of the metropolitan area is analysed by means of a Vector Error Correction Model. The results suggest that central city growth has a positive long-run effect on the growth of the metropolitan area. We also examined whether this positive effect depended on the size of the central city. Our results suggest that in the case of smaller cities there is no positive effect, but that this effect is quite high in the case of their larger counterparts.

Key Words: cities, growth, externalities

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1. Introduction

In most countries, big cities usually receive preferential attention from the public sector. This attention may take several forms ranging from specific arrangements in the financial system of the local government to the targeting of major investment projects in the upper reaches of government. The rationale behind such policies are various. First, the costs of providing public services may be higher in big central cities (Oates, 1988). Second, central cities usually provide public services that benefit populations living in the rest of the metropolitan area but who work, study or shop in the central city (Greene et al., 1977). These arguments have been widely discussed in the urban economic literature, although the conclusions reached do not always point in the same direction\(^1\)\(^2\).

In this paper we wish to contribute to the debate on the role of big cities, focusing here on an aspect that has perhaps been somewhat neglected: the role of big cities as engines of the metropolitan or regional economy. We wish to address such questions as to whether the economic health of a region depends on the growth of the central city, and whether a city that is competitive at national and international levels provides any sort of benefit for its surrounding area. A number of articles have empirically addressed these questions (Ihlandfelt, 1995, Brooks and Summers, 1997, Voith, 1992, 1993, 1998) with the general conclusion that the greater the growth of the central city, the more likely growth is to be recorded in the metropolitan area. More recently, Voith (1998) has reported that the effect of the central city on its surrounding area increases with the size of the central city, while Haughwout (1999) forwards evidence to show that the provision of infrastructure in the central city contributes to the growth of the whole metropolitan area. It should be noted, however, that all these studies were conducted in the United States, where the far-reaching process of sub-urbanisation and

\(^{1}\) For example, although some empirical papers report higher provision costs in big cities (Ladd and Yinger, 1989), others (Glaeser, 1997, Fenge and Meier, 2001), more concerned with efficiency, argue for the need to compensate for these high costs. Indeed, if the higher costs (e.g., wages or rents) are derived from the greater attractiveness of urban areas (i.e., higher productivity or amenities), targeting more resources for urban areas would lead to an excessive concentration of population and economic activity in these areas.

\(^{2}\) A similar situation occurs with local expenditure spillovers. Although their significance is generally acknowledged, several authors also highlight the fact that a share of a central city’s tax burden is also exported out of its jurisdiction (Ladd, 1975). However, only a few studies quantify the magnitude of these benefit spillovers (Solé-Ollé, 2001).
the deterioration in the living standards of the central cities give these issues a particular relevance.

This said, sub-urbanisation is a process that is affecting most countries in Europe, though in the particular case of Spain its consequences for the health of central cities may not be so pronounced (Alonso, 1999). Here, in Spain, the exact role of big cities is the subject of considerable debate (Nel.lo, 1997), though a number of authors have suggested that central cities can play a key role in regional growth (Rotllant and Soy, 1993). In spite of this interest, few studies have examined the determinants of the growth of Spanish cities (Viladecans, 2002, being an obvious exception to this rule), while there has been no study of the interdependencies between central cities and their metropolitan areas.

The purpose of this paper is, therefore, to examine empirical evidence for the impact of big Spanish cities on their surrounding areas, our point of comparison being Voith’s study (1998) in the United States. We analyse the causal links between the economic growth of Spain’s main central cities and growth in their metropolitan areas. The analysis draws on population and economic activity data for a sample of Spanish cities over the last thirty years. The relationship between the city growth and that of the metropolitan area is analysed by means of a Vector Error Correction Model (VECM), which allows us to take into account the simultaneous causality that presumably exists between the central city and its surrounding area, to isolate any shocks that might be common to both economies, and to separate short- from long-run interactions. As Voith (1998) before us, we also study as to whether this depends on the size of the central city.

The paper is organised as follows. The second section presents the data used in our empirical analysis and briefly describes the growth undergone by Spanish central cities and their metropolitan areas over the last thirty years. The third section summarises the main theories that predict a degree of interaction (positive or negative, short- or long-run) between the economies of the central city and its metropolitan area. The fourth section presents the econometric model, discusses the estimation problems encountered and presents the results. Finally, the last section concludes with some comments about the implications of our results in designing economic policy.

2. Growth of cities and metropolitan areas in Spain
**Unit of analysis and data**

In Spain, there is no formal register of metropolitan areas and their jurisdictions. Therefore, in this paper, we have had to define the metropolitan areas of big Spanish cities based on economic and geographical criteria. First, in line with the Urban Initiative (European Commission) we selected the big cities for analysis from those with more than 100,000 inhabitants in 2001. In the case of Spain, 36 cities met this criterion. However, eight of them do not have a suburban area of any significant size and they were therefore eliminated from the sample. Second, the metropolitan area for each city was defined as that area containing all jurisdictions at less than 35 kilometres from the central city. This geographical criterion is the same as that used in the “Report on big cities and their areas of urban influence”, carried out by the Spanish Ministry of Public Administrations in 2001. For statistical reasons, jurisdictions with fewer than 3,000 inhabitants were not included. Finally, our database comprised 28 central cities plus 559 jurisdictions belonging to their metropolitan areas. The number of jurisdictions in each metropolitan area varied greatly depending on the urban structure and, more specifically, on the land area of the central city.

Two statistical sources were used to measure the demographic and economic size of the central cities and their metropolitan areas. The population data was obtained from the Population Censuses compiled by the Spanish National Institute of Statistics, while the economic size of the cities was based on a variable that has been estimated by a financial institution since 1967 (Annual Spanish Economic Report, Banesto-La Caixa). This variable is the so-called *market share* and is calculated as a function of a range of economic activity indicators (e.g., number of telephones, number of bank branch offices, number of vehicles and number of commercial activities). For the period under analysis, 1967-2001, this source provides the only available information at the local level. We found a high correlation between *market share* and GDP at the regional (NUTS 2) level (0.99 each year), indicating that this variable is a good estimate of the GDP of each jurisdiction.

**Descriptive analysis**

During the last few decades, the economic weight of Spain’s central cities has fallen while that of the rest of their metropolitan areas has risen. In 1967, the economic activity of the 28

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3 The cities eliminated from the sample were those in which the population of the surrounding jurisdictions amounted to less than 15% of the population of the central city.
central cities represented 55.9% of the economic activity of their regions (NUTS 2), while in 2001 it accounted for only 35%. In contrast, their metropolitan areas represented 20.3% of regional economic activity in 1967 rising to 33% in 2001. Thus, today it would seem that economic activity is equally distributed between the central cities, their metropolitan areas and the rest of their regions. The demographic distribution between these three geographical levels is, however, slightly different. In 1967, 37.4% of the regional population lived in the central cities, while in 2001 this percentage had fallen to 34%. In contrast, in 1967 the metropolitan areas accounted for 25.8% of the population, while today this share has increased to 34%.

Table 1 shows that the growth rates of central cities and metropolitan areas vary greatly as a function of central city size (more than 100,000 inhabitants, more than 300,000 inhabitants and, the five biggest cities of the database, with more than 500,000 inhabitants). In the period 1967-2001, the population growth rate in the metropolitan areas was greater than that in their respective central cities.

<table>
<thead>
<tr>
<th>Period</th>
<th>All the cities (&gt;100.000 inhab.)</th>
<th>Bigger cities (&gt;300.000 inhab.)</th>
<th>The 5 biggest cities (&gt;500.000 inhab.) (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Central city</td>
<td>Metropolitan area.</td>
<td>Central city</td>
</tr>
<tr>
<td>1967-1975</td>
<td>2.24</td>
<td>4.97</td>
<td>1.51</td>
</tr>
<tr>
<td>1977-1985</td>
<td>0.33</td>
<td>1.05</td>
<td>0.22</td>
</tr>
<tr>
<td>1987-2001</td>
<td>-0.06</td>
<td>0.83</td>
<td>-0.11</td>
</tr>
<tr>
<td>1967-2001</td>
<td>0.50</td>
<td>1.60</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period</th>
<th>All the cities (&gt;100.000 inhab.)</th>
<th>Bigger cities (&gt;300.000 inhab.)</th>
<th>The 5 biggest cities (&gt;500.000 inhab.) (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Economic activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1967-1975</td>
<td>6.33</td>
<td>11.76</td>
<td>5.01</td>
</tr>
<tr>
<td>1977-1985</td>
<td>0.38</td>
<td>1.49</td>
<td>0.27</td>
</tr>
<tr>
<td>1987-2001</td>
<td>0.66</td>
<td>3.98</td>
<td>0.42</td>
</tr>
<tr>
<td>1967-2001</td>
<td>1.95</td>
<td>4.83</td>
<td>1.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.41</td>
</tr>
</tbody>
</table>

Source: Own elaboration from the data of the Spanish National Institute of Statistics (population) and the Annual Spanish Economic Report (economic activity).

The annual cumulative population growth rate was 1.6% in the case of the former and 0.5% in that of the latter. In the case of the biggest central cities, this difference was even more marked. So, while the population of the five biggest cities grew only at a modest annual rate of 0.15%, the metropolitan areas saw their population increase by an annual 2.5%. A similar trend can be seen in the evolution of economic activity. During this period, the economic
activity located in the central cities grew at an annual rate of 2% while in their metropolitan areas the rate was 4.8%. Similarly, while the biggest central cities experienced a growth rate of 1.4%, their metropolitan areas grew at a higher rate of 6%.

As the urban growth process has changed considerably over the last thirty years, it is interesting to divide the analysis into smaller periods. The first period, from 1967 to 1975, includes the years of greatest economic growth and industrialisation. In this period, the growth of population in the central cities was particularly high, although the five biggest cities experienced a somewhat lower rate. Also, the metropolitan areas underwent greater population growth than did their central cities. The rates of economic growth were also very high - around 6.3% for the central cities and 11.8% for their metropolitan areas. During the period of economic downturn (1977-1985), population growth rates fell sharply with the central cities recording zero growth. By contrast, the growth rate in the metropolitan areas was moderate, contrasting markedly with the evolution in the five biggest central cities. The evolution in economic activity followed a similar trend but growth in the metropolitan areas outstripped that of the central cities.

The most recent changes in the Spanish urban map date from 1986. In this period, central cities suffered population losses in all three size groupings, while their metropolitan areas grew at annual rates of 1%. Metropolitan population growth was at its highest in the areas surrounding the biggest central cities. At the same time, economic growth in the central cities was moderate, with an annual rate of 0.7 %, while metropolitan areas grew at an annual rate around 4%. The five biggest central cities lost economic activity, but their metropolitan areas enjoyed annual increases of 4.3%.

Table 2:
Correlation between the annual growth rates of the central cities and their metropolitan areas

<table>
<thead>
<tr>
<th></th>
<th>All the cities (&gt;100,000 inhab.)</th>
<th>Bigger cities (&gt;300,000 inhab.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Δ Population  Δ Activity</td>
<td>Δ Population  Δ Activity</td>
</tr>
<tr>
<td>1967-1975</td>
<td>0.111 *</td>
<td>0.189 *</td>
</tr>
<tr>
<td>1977-1985</td>
<td>-0.072 *</td>
<td>-0.128 *</td>
</tr>
<tr>
<td>1987-2001</td>
<td>0.127 *</td>
<td>-0.491 *</td>
</tr>
</tbody>
</table>

Note: * = significance of the correlation coefficients at 95%
Table 2 shows the correlation coefficients between the growth rates of the central cities and the rest of the metropolitan area, both for population and economic activity. The correlation coefficients are calculated for the three periods (1967-1975, 1977-1985 and 1987-2001) and for two different groups of cities depending on their size. In the case of all the central cities, their population growth and that of their metropolitan areas correlated positively in the two periods of economic expansion (1967-1975 and 1987-2001) and negatively in the period of economic downturn. In terms of economic activity, the correlation between the growth rates of the central cities and those of their metropolitan areas was negative in the first two periods and positive in the last one. This might reflect the progressive decline in industrial activity in central cities which was not compensated for until the nineties when the service sector was expanded.

The correlation coefficients for the economic activity of the biggest central cities in the sample were similarly not positive until the last period and the correlation pattern for population growth rates was only positive (and then strongly so) in the last period. This simple analysis might suggest that a process of sub-urbanisation of economic activity took place during the early years of the period analysed and only more recently has it affected the population. These phenomena have been reversed in recent years for the whole sample, but not in the case of the biggest central cities.

3. Interactions between cities and their metropolitan areas: theoretical foundations

The correlation coefficients between the growth rates of central cities and their metropolitan areas shed interesting light on the growth of Spanish urban areas over the last thirty years. However, they do not provide any evidence as to the underlying factors affecting growth rates in both areas. The correlation (positive or negative) is in all probability caused by external economic forces that affect both the central city and the rest of the metropolis in similar ways. For example, the structural decline in an industrial sector might be concentrated in one region and affect equally the central city and the metropolitan area. In this case, a positive correlation between the decreasing growth rates of both areas would not imply the existence of a true causal relationship. In a similar way, central cities might be more greatly affected than their suburbs during an economic crisis, which would be reflected as a negative correlation between their respective growth rates. But here again, no clear conclusions can be drawn about causality. We are not, therefore, interested in the correlation between the growth rates of the central city and its surrounding area that might arise from a common economic shock. Rather
we are interested in identifying those economic interactions that indicate real causality between central city growth and metropolitan growth. This section reviews the main theoretical approaches that seek to do just that.

*Equilibrium location models*

In these models, people and firms are perfectly mobile and choose their jurisdictions in accordance with exogenous factors of attraction (Rosen, 1979 and Roback, 1982). Since attractive locations are scarce in relation to demand, wages and rents adjust until there are no people and firms wanting to change their location. In the simplest version of models of this type, different locations are perfect substitutes and population or economic activity losses in some areas automatically imply gains in other areas. This suggests a possible negative causality between central city growth and the growth of its surrounding area. However, this effect will only be seen in the short run, while the system converges to a new equilibrium. In the context of these models, the long-run level of economic activity in the metropolitan area \( y^m \) only depends on the population living in this area \( p^m \)\(^4\) and on location fundamentals (e.g., land area, amenities) in the central city \( \mu^c \) and in the rest of the metropolitan area \( \mu^m \). A similar relationship exists between the economic activity and the population of the central city \( y^c, p^c \), respectively). The long-run relationship between these variables may be represented as:

\[
(1) \quad y^m = \Psi_1(p^m, \mu^c, \mu^m) \quad \text{and} \quad y^c = \Psi_2(p^c, \mu^c, \mu^m)
\]

A natural extension of this model is to allow for commuting. In this case, the long-run level of economic activity in the central city and the rest of the metropolitan depends on the whole population living in the metropolitan area:

\[
(2a) \quad y^m = \Phi_1(p^m, p^c, \mu^c, \mu^m) \quad \text{and} \quad y^c = \Phi_2(p^m, p^c, \mu^c, \mu^m)
\]

Similarly, the long-run population in the central city and its surroundings depends on the level of economic activity in the overall metropolitan area:

\[
(2b) \quad p^m = \Phi_3(y^m, y^c, \mu^c, \mu^m) \quad \text{and} \quad p^c = \Phi_4(y^m, y^c, \mu^c, \mu^m)
\]

This is, in fact, the starting point of several empirical models that analyse local growth at an intra-metropolitan level (Carlino and Mills, 1987, Boarnet, 1994, Deitz, 1998). The main

\(^4\) The simplest models do not allow for commuting.
objective of these articles consists of determining the direction of causality between population and economic activity, usually quantified as the employment level. That is to say, they aim to determine if “the residents follow the jobs” or if, alternatively, “the jobs follow the residents.”

However, although the results of the empirical analysis presented in the following section will also provide some evidence on this question, this is not the main objective of this paper. The objective consists in analysing the direction of the causality between $y^m$ and $y^c$, and between $p^m$ and $p^c$. It is easy to check from expressions (1) and (2) that the classical equilibrium location models do not allow for any long-run interaction between the central city and the rest of the metropolitan area. In this model, however, interactions can take place between the growth rates of economic activity (and/or population) during the adjustment process to the new equilibrium that follows an exogenous shock (e.g., an improvement in the accessibility of the central city). The adjustment process to a new equilibrium can be long and its consequences on social welfare, although transitory, should be kept in mind.

Models with external effects

Recent developments have extended equilibrium location models to include external effects between jurisdictions. There are three main reasons that account for these external effects. First, external effects may arise as a consequence of agglomeration economies (Blomquist et al., 1988). In the case of firms, agglomeration economies imply a level of productivity that rises with the size of the urban area. The decline of the central city in terms of economic activity and/or population will affect, therefore, the whole metropolitan area, and the same will be true of a decline in the suburbs. This will happen unless the decline in a part of the metropolitan area is exactly compensated by the improvement in another part. If this is the case, population and/or economic activity in the whole metropolitan area will not be affected and, therefore, the agglomeration economies will not diminish.

Second, externalities can be generated by the existence of location factors that are particular to the central city but that are valued by the rest of the metropolitan area (Voith, 1991). For example, central cities have certain characteristics (e.g., commercial diversity, cultural, artistic activities and leisure) that can attract high income residents (Glaeser et al., 2001) and highly qualified workers that, though living in the metropolitan area, can also enjoy these factors. If the demand for these amenities grows with the level of economic activity of the central city,
then, a crisis in the central city can reduce its provision level and, therefore, affect the rest of the metropolitan area that also enjoys them.

Due to the relative scale and centrality advantages of central cities, they also have certain business attraction factors that are difficult for their metropolitan areas to replicate (Raines, 2000). For example, because of their size, central cities have a bigger impact on public opinion both at national and international level and usually control the image of the whole metropolis (and, on some occasions even of the whole country). Usually, outside the region, good or bad news about the central city quickly extends to the rest of the region. Also, certain innovative activities need to locate near research centres where knowledge is transferred more quickly and efficiently (Audretsch, 1998, Duranton and Puga, 2001a). A similar situation is experienced by financial activities, regulated economic sectors and the headquarters of big companies, which usually locate near the regulating bodies and political powers, in general (Vives, 2000, Duranton and Puga, 2001b). The loss of weight of central cities in these aspects is not something that can then be easily transferred to the suburbs. Since the benefits to be gained from the location of economic activities of this type in the central city extend to the whole metropolitan area, both periods of crisis and boom in the central city will affect its surroundings. Moreover, if agglomeration economies and market power exist, all these effects will increase with the size of the central city (Voith, 1998). Indeed, the relevance of the specific attributes of central cities will be higher in the case of very big cities. It is expected, therefore, that the impact of the central city on its metropolitan area will increase with the size of the central city.

Third, some authors suggest that although the sub-urbanisation of population and/or economic activity may be a zero sum process in the short run, it may bring global losses in the long run. This might happen, for example, if the movement of population towards the suburbs causes a stratification of residents by income levels (Benabou, 1993, 1996a and 1996b). According to Benabou, social segregation in schools and neighbourhoods reduces learning externalities (peer group effects) that mainly benefit low class students. In the long run this process may produce a mismatch between the human capital of low and high skill workers and, therefore, a reduction in the productivity of the whole metropolitan area. The effects of this stratification might also

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5This argument might seem more applicable to the USA than to Spain, since in Spain the education provision is not decentralised in the local governments. However, some empirical analyses show peer group effects to have more influence than educational expenditure on educational levels (Jencks and Mayer, 1990). In this case, the stratification of the schools can produce similar effects to those described by Benabou (1996a) without the need for a decentralised provision.
be noted in firms. The sub-urbanisation of some industrial sectors may cause a greater specialisation both between the central city and its suburbs, and among different locations outside the central city. If, as some authors suggest, innovation (and, therefore, growth) is facilitated by the diversity of the local economy (Glaeser et al., 1992, Duranton and Puga, 1999), then an increasing specialisation may have negative consequences for the whole metropolitan area. Also, as Duranton and Puga (1999) point out: on the one hand, diversity tends to grow with city size and, on the other, most of the new companies are created in diversified environments. This suggests a new untransferable role for the cities: that of “incubators” of business projects (Duranton and Puga, 2001a). This role, also, becomes more important as the size of the city increases (see Costa et al., 2001, for evidence of the situation in Spain).

To sum up, the arguments analysed in this section suggest that the level of economic activity in one part of the metropolitan area will have long-run effects on the level of activity in its surroundings. Although some of the arguments can be equally applied to the effects of the central city on the suburbs and the effects of the suburbs on the central city, they also suggest that the most intense effects move in a direction that goes from the central city to the rest of the metropolitan area and that these effects increase with the increasing size of the city. In order to illustrate these hypotheses, the long-run relationship can be described as:

(3a) \[ y^c = \Gamma^1(y^m, p^c, y^m, \mu^c, \mu^m) \quad \text{and} \quad y^m = \Gamma^2(p^m, p^c, y^m, \mu^c, \mu^m) \]

(3b) \[ p^c = \Gamma^3(y^m, y^c, p^c, \mu^c, \mu^m) \quad \text{and} \quad p^m = \Gamma^4(y^m, y^c, p^m, \mu^c, \mu^m) \]

Therefore, in this case a long-run causal relationship is expected between \( y^c \) and \( y^m \) and between \( p^c \) and \( p^m \). Obviously, there might also be in this case a short-run causal relationship between the growth rates of these variables.

4. Model specification and estimation

The correlation coefficients presented in the second section suggest that the economies of the central city and its metropolitan area may be related. The theoretical considerations of the previous section are also consistent with the hypothesis that the growth of the central city fosters the growth of the rest of the metropolitan area. However, none of this demonstrates a causal relationship between the growth of the city and the growth of its metropolitan area. The empirical evidence regarding this question is subject to considerable econometric problems.
The first of these is simultaneity, since the effects might be operating in two directions: from the city to the metropolitan area, and from the metropolitan area to the city. The second is the existence of common shocks that affect both economies at the same time. For example, the structural decline in an industrial sector might equally affect the central city and the metropolitan area. In this case, a positive correlation between the decreasing growth rates would not imply the existence of a true causal relationship. The procedure used by some authors to solve this problem (Voith, 1998) makes use of instrumental variables methods. The problem associated with this method, though, is that it is extremely difficult to find variables that are correlated with the growth in one of the two areas (central city and rest of the metropolitan area) but not with the growth in the other one.

With the aim of avoiding this problem, we analysed the relationship between the growth of the city and that of its metropolitan area with a Vector Error Correction Model (VECM) for panel data. This approach has several advantages. First, it avoids the need to use instrumental variables methods, which would be difficult to implement in our case because of the problems in finding suitable instruments. Second, this methodology allows us to disentangle the interactions between the central city and the metropolitan area that occur in the short run from those that take place in the long run. This will allow us to differentiate between the interactions happening during the convergence to the new equilibrium (and which are, therefore, transitory) from the permanent or long run interactions.

*Vector Error Correction Model*

The relationship between the levels of economic activity and population in the central city and the rest of the metropolitan area \((y^c, p^c, y^m, p^m)\) can be modelled by means of a vector auto-regression model (VAR) that captures the evolution of these four variables. This procedure has the advantage of avoiding the need to impose any constraint on the direction and magnitude of the response to a shock in any of the variables. Although the responses to a shock might be recorded in any future period, the standard approach is to focus on a limited number of periods. Then, once the lag order has been determined and the model has been estimated, the causal relationships between the variables can be analysed.

Recall that the relationships between the variables identified in the theoretical section also include the location fundamentals of the central city and the rest of the metropolitan area \((\mu^c\) and \(\mu^m)\). This broad concept includes such aspects as the land area of the city and the suburbs
(which, to a great extent, determines the size of the metropolis in the long run), the climate, 
the environmental quality and the infrastructure endowment, among others. Many of these 
factors can be considered as remaining unaltered with time. Therefore, and since we will 
make use of a panel of data to estimate the model, individual effects should be included in the 
VAR in levels. These can subsequently be eliminated by removing differences (Holtz-Eakin 
et al., 1988).

However, if some of the variables analysed are not stationary, this method may not be entirely 
appropriate. Indeed, if some of the variables have a long-run relationship (i.e., they are co-
integrated) it will be more appropriate to add this long-run relationship (Error Correction 
Mechanism) to the equation (Hamilton, 1994). Following this approach the model estimated 
in this section is a Vector Error Correction Model (VECM), that may be expressed as:

\[
\Delta y_{it}^c = \sum_{l=1}^{k} \alpha_{l1}^{11} \Delta y_{it-l}^c + \sum_{l=1}^{k} \alpha_{l1}^{21} \Delta y_{it-l}^m + \sum_{l=1}^{k} \alpha_{l1}^{31} \Delta p_{it-l}^c + \sum_{l=1}^{k} \alpha_{l1}^{41} \Delta p_{it-l}^m \\
+ \beta_{11}^{11} \cdot y_{it-1}^c + \beta_{21}^{21} \cdot y_{it-1}^m + \beta_{31}^{31} \cdot p_{it-1}^c + \beta_{41}^{41} \cdot p_{it-1}^m + f_{1t} + \delta_1 \cdot t_t + \epsilon_{it}^c
\]

\[
\Delta y_{it}^m = \sum_{l=1}^{k} \alpha_{l2}^{12} \Delta y_{it-l}^c + \sum_{l=1}^{k} \alpha_{l2}^{22} \Delta y_{it-l}^m + \sum_{l=1}^{k} \alpha_{l2}^{32} \Delta p_{it-l}^c + \sum_{l=1}^{k} \alpha_{l2}^{42} \Delta p_{it-l}^m \\
+ \beta_{12}^{12} \cdot y_{it-1}^c + \beta_{22}^{22} \cdot y_{it-1}^m + \beta_{32}^{32} \cdot p_{it-1}^c + \beta_{42}^{42} \cdot p_{it-1}^m + f_{2t} + \delta_2 \cdot t_t + \epsilon_{it}^m
\]

\[
\Delta p_{it}^c = \sum_{l=1}^{k} \alpha_{l3}^{13} \Delta y_{it-l}^c + \sum_{l=1}^{k} \alpha_{l3}^{23} \Delta y_{it-l}^m + \sum_{l=1}^{k} \alpha_{l3}^{33} \Delta p_{it-l}^c + \sum_{l=1}^{k} \alpha_{l3}^{43} \Delta p_{it-l}^m \\
+ \beta_{13}^{13} \cdot p_{it-1}^c + \beta_{23}^{23} \cdot p_{it-1}^m + \beta_{33}^{33} \cdot y_{it-1}^c + \beta_{43}^{43} \cdot y_{it-1}^m + f_{3t} + \delta_3 \cdot t_t + \epsilon_{it}^c
\]

\[
\Delta p_{it}^m = \sum_{l=1}^{k} \alpha_{l4}^{14} \Delta y_{it-l}^c + \sum_{l=1}^{k} \alpha_{l4}^{24} \Delta y_{it-l}^m + \sum_{l=1}^{k} \alpha_{l4}^{34} \Delta p_{it-l}^c + \sum_{l=1}^{k} \alpha_{l4}^{44} \Delta p_{it-l}^m \\
+ \beta_{14}^{14} \cdot p_{it-1}^c + \beta_{24}^{24} \cdot p_{it-1}^m + \beta_{34}^{34} \cdot y_{it-1}^c + \beta_{44}^{44} \cdot y_{it-1}^m + f_{4t} + \delta_4 \cdot t_t + \epsilon_{it}^m
\]

where \( \alpha \) are the coefficients of the variables in differences, the superscript indicates the order 
of the variable and the equation, and the subscript indicates the lag order, where \( k \) is the 
maximum lag. The parameter \( \beta \) indicates the coefficient of the variables in levels, where the 
superscript is interpreted in the same way. The individual effects are denoted by means of \( f_i \), 
while \( t_t \) is a linear time trend.
The simultaneous introduction of variables in differences and in levels allows us to disentangle short-run causality (differences) from long-run causality (levels). For example, in the second equation \( (y^m) \), the long-run relationship is:

\[
y_{it}^m = \lambda_{22} y_{it}^c + \lambda_{32} p_{it}^m + \lambda_{42} p_{it}^c + f_i^2 + \delta^2 t_t
\]

where \( \lambda_{22} = -(\beta_{22}/\beta_{12}) \), \( \lambda_{32} = -(\beta_{32}/\beta_{12}) \), \( \lambda_{42} = -(\beta_{42}/\beta_{12}) \). In our case, the main parameter of interest is \( \lambda_{22} \), since it shows the long-run impact of economic activity in the central city \( (y^c) \) on the level of activity in the rest of the metropolitan area \( (y^m) \). The parameter \( \beta_{22} \) is also of interest, since it shows the impact on the annual activity growth rate in the suburbs during the adjustment to the new equilibrium.

*Estimation of the model*

The model presented in (4) will be estimated using data from 28 Spanish cities for every two years throughout the period 1967-2001 (\( NT = 28 \times 18 = 504 \)). The data sources for the variables \( (y^c, y^m, p^c \text{ and } p^m) \) are described in section 2. All of them were taken as log transformations so that increments can be interpreted as growth rates and coefficients as elasticities. The method used to estimate the model presented in (4) comprises various stages.

a) *Unit roots*

First, we test for the stationarity of each of the variables. The availability of only 18 years’ data might call into question the validity of the standard unit root tests carried out city by city. Recent papers have, however, developed more powerful unit root tests that exploit the panel structure of the data. We use two of these test developed by Breitung and Meyer (1994) and Im et al. (1995). The Breitung and Meyer (1994) test starts from a first order autoregressive specification with fixed coefficients. For example, for \( y^m \) this equation may be written as:

\[
y_{it}^m = \rho \cdot y_{it-1}^m + (1 - \rho) f_i + \epsilon_{it}
\]

where \( f_i \) is an individual effect and \( \epsilon_{it} \) is the spherical error term. The individual effect disappears from (6) in the null hypothesis \( (\rho = 1) \) but not in the alternative. The OLS

---

6 This test is in fact very similar to that popularised by Levin and Lin (1993).
estimation of (6) gives biased estimators for values of T fixed and N→∞ (Nickell, 1981). But, as Breitung and Meyer (1994) demonstrate, in this case the typical instrumental variables estimators of the dynamic models of panel data cannot be used (Arellano and Bond, 1991), because they are not valid under the null hypothesis \( \rho = 1 \). The solution proposed by Breitung and Meyer (1994) to this problem consists of eliminating the fixed effect subtracting to both sides of (6) the first observation of the sample:

\[
y_{it}^m - y_{i0}^m = \rho(y_{it-1}^m - y_{i0}^m) + u_{it} \quad \text{where} \quad u_{it} = \varepsilon_{it} + (1 - \rho)(y_{i0}^m - f_i)
\]

The procedure would also include lags of the dependent variable with the purpose of correcting the possible autocorrelation in \( u_{it} \). The OLS estimator of (6) is also biased due to a common component in \( u_{it} \), although the bias is much smaller than that in the rest of procedures if the dispersion of the individual effects is high.

The test developed by Im et al. (1995) is based on the set of unit root statistics computed for each city. After eliminating the individual effect by subtracting the time mean of each city, a different equation can be estimated for each city:

\[
\Delta y_{it}^m = \rho_1 y_{it-1}^m + \varepsilon_{it}
\]

Lags of the dependent variable would also be included in this case to correct the possible autocorrelation in \( u_{it} \). The statistic of Im et al. (1995) is calculated as the average of the \( t \) statistics of \( \rho_1 \) for the 28 cities.

Table 3 shows the values of the two unit root tests including from between one to three lags of the dependent variable and a linear time trend. In both cases, the test is at one tail and the critical value is -1.65. In most of the cases, the null hypothesis of a unit root in the series in levels cannot be rejected. The only doubt arises in the case of the IPS test for the population of the central city, but this doubt vanishes when we include additional lags in the regression. Moreover, the tests applied to the series in first differences allow us to reject the hypothesis of a second unit root in all the cases. Therefore, there is enough evidence to conclude that the four variables are I(1).

---

7 The bias decreases with T. In fact, 18 years could be considered as being greater than the typical number of years available for most panel data analyses. This would lead us to estimate (6) by OLS adducing that the bias will not be very high. However, Jude et al. (1999) demonstrate that the bias is still considerable for \( T < 25 \).
Table 3: Unit root tests for panel data \( (N=28, T=18) \)

<table>
<thead>
<tr>
<th>Lags</th>
<th>BM</th>
<th>IPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: * = rejection of the null hypothesis of non-stationarity at the 5% level. BM = Breitung and Meyer test (Breitung and Meyer, 1994), IPS = Im et al. test (Im et al., 1995). In all the tests a constant and a linear time trend have been included and the individual effects have been eliminated.

b) Cointegration

The use of a Vector Error Correction Model (VECM) requires all the series to be I(1) and also that (at least) a linear combination of these series is I(0). In other words, the series must be cointegrated or there must be a long-run relationship between them. In time series models, cointegration relationships are usually estimated by means of Engle and Granger’s two stage procedure (1987). The first stage involves estimating an equation in levels (cointegration equation) and testing for the stationarity of the residuals. In the second stage, the model is estimated in differences including the residuals of the first stage regression as an additional variable. This procedure is justified because the first stage estimators converge at a rate \( T \) instead of a rate \( \sqrt{T} \) of the second stage estimators. However, as Breitung and Meyer (1994) point out, this argument is not applicable to the panel data analyses that assume \( T \) is fixed. Also, as Kremers et al. (1992) show, on occasions the power of the traditional method is not sufficient to detect unit roots, due to the common factor constraint it imposes.

Here we use an alternative procedure suggested by Kremers et al. (1992). This procedure involves verifying the cointegration hypothesis by means of a test of joint significance of the variables in levels included in the VECM \(^8\). This method has the additional advantage of not

\(^8\) For fixed \( T \), the LR statistic \( LR \), which compares the log-likelihood function of the model with and without the variables in levels, is distributed as a \( \chi^2 \) with four degrees of freedom. It is shown that the results of this procedure are very similar to those of the maximum likelihood procedure developed by Johanssen (1988).
assuming the existence of a single long-run relationship between the variables\textsuperscript{9}. An additional
difficulty in the application of this procedure is the presence of individual effects. These
effects do not cause any difficulty in the interpretation of the suggested test under the null
hypothesis of cointegration. However, under the alternative the variables might be
cointegrated at a different level, and so the estimation of the cointegration equation could be
biased. Note that this observation is consistent with the theory discussed in the previous
section, since we considered that the long-run relationship between the variables depends on
locational fundamentals that can be accounted for by individual effects. The individual effects
are also eliminated in this case by subtracting the first observation of each of the variables
(Breitung and Meyer, 1994). The model differentiated in this way is estimated equation by
equation by OLS.

c) Specification tests

Table 4 presents a number of specification tests of the VECM. The first is an LR test of the
joint significance of the individual effects. This test was carried out from the OLS estimation
of (4) considering the individual effects to be constants. This procedure though will not be the
one applied later when estimating the model\textsuperscript{10}. It is used here only to test the significance of
the individual effects. It can be seen from Table 4 that, irrespective of the number of lags used
in the estimation, the statistical significance of the individual effects can not be rejected.

Table 4 also presents specification tests on the appropriate number of lags to be used in the
estimation of the VECM (4). We started with 4 lags of the variables in differences, testing for
the possibility of reducing them successively. The LR test indicated that it is always possible
to reduce the number of lags from 4 to 3. However, it was not possible for the whole system
to reduce the number of lags from 3 to 2, but it was possible for the equations $y^m$ and $p^m$.

\[ \text{Table 4: Specification tests (N=28, T=18)} \]

---

\textsuperscript{9} Besides the LR joint significance test, we used an LR test to compare the model with all variables in
levels with a model that excludes those variables in levels with high standard errors.

\textsuperscript{10} As discussed above, this procedure provides biased values of the parameters of interest, unless T is
very high.
The same conclusion was reached when analysing the reduction in the Shwartz criterion. Therefore, the final specification used included 3 lags in the equations $y^c$ and $p^c$ and 2 lags in the equations $y^m$ and $p^m$. Since the variables finally included in the four equations were not exactly the same, the system was estimated jointly by a Seemingly Unrelated Equations (SURE) method. The results are presented in Table 5.
Table 5: Results of the SURE estimation of the Vector Error Correction Model (VCE). (N=28, T=18)

<table>
<thead>
<tr>
<th>Equation</th>
<th>$\Delta y^c$</th>
<th>$\Delta y^m$</th>
<th>$\Delta p^c$</th>
<th>$\Delta p^m$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta y^c$ (t-1)</td>
<td>-0.072</td>
<td>0.093</td>
<td>0.014</td>
<td>-0.012</td>
</tr>
<tr>
<td></td>
<td>(-1.946)</td>
<td>(1.743) **</td>
<td>(2.145)**</td>
<td>(-0.064) **</td>
</tr>
<tr>
<td>$\Delta y^c$ (t-2)</td>
<td>-0.021</td>
<td>-0.036</td>
<td>0.009</td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td>(-1.180)</td>
<td>(-0.749) **</td>
<td>(1.755) **</td>
<td>(0.461) **</td>
</tr>
<tr>
<td>$\Delta y^c$ (t-3)</td>
<td>-0.098</td>
<td>--</td>
<td>0.018</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>(-2.103) **</td>
<td>--</td>
<td>(2.234) **</td>
<td>--</td>
</tr>
<tr>
<td>$\Delta y^m$ (t-1)</td>
<td>0.166</td>
<td>-0.090</td>
<td>0.010</td>
<td>0.041</td>
</tr>
<tr>
<td></td>
<td>(4.600)</td>
<td>(-2.101) **</td>
<td>(1.758) **</td>
<td>(3.181) **</td>
</tr>
<tr>
<td>$\Delta y^m$ (t-2)</td>
<td>-0.037</td>
<td>0.094</td>
<td>-0.014</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>(-1.531)</td>
<td>(1.986) **</td>
<td>(-2.139) **</td>
<td>(0.202) **</td>
</tr>
<tr>
<td>$\Delta y^m$ (t-3)</td>
<td>0.017</td>
<td>--</td>
<td>-0.004</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>(1.537)</td>
<td>--</td>
<td>(-0.985)</td>
<td>--</td>
</tr>
<tr>
<td>$\Delta p^c$ (t-1)</td>
<td>0.744</td>
<td>0.055</td>
<td>0.981</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>(3.375) **</td>
<td>(0.187)</td>
<td>(23.774) **</td>
<td>(0.068)</td>
</tr>
<tr>
<td>$\Delta p^c$ (t-2)</td>
<td>-0.047</td>
<td>0.074</td>
<td>-0.277</td>
<td>-0.055</td>
</tr>
<tr>
<td></td>
<td>(-0.010)</td>
<td>(0.243)</td>
<td>(-3.990) **</td>
<td>(-0.685) **</td>
</tr>
<tr>
<td>$\Delta p^c$ (t-3)</td>
<td>0.208</td>
<td>--</td>
<td>-0.133</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>(1.320)</td>
<td>--</td>
<td>(-3.229) **</td>
<td>--</td>
</tr>
<tr>
<td>$\Delta p^m$ (t-1)</td>
<td>-0.149</td>
<td>0.092</td>
<td>-0.003</td>
<td>0.974</td>
</tr>
<tr>
<td></td>
<td>(-1.678) *</td>
<td>(1.687) *</td>
<td>(0.043)</td>
<td>(47.275) **</td>
</tr>
<tr>
<td>$\Delta p^m$ (t-2)</td>
<td>0.242</td>
<td>0.442</td>
<td>0.001</td>
<td>-0.304</td>
</tr>
<tr>
<td></td>
<td>(2.310) **</td>
<td>(3.896) **</td>
<td>(0.043)</td>
<td>(-8.998) **</td>
</tr>
<tr>
<td>$\Delta p^m$ (t-3)</td>
<td>-0.074</td>
<td>--</td>
<td>0.004</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>(-1.141)</td>
<td>--</td>
<td>(0.191)</td>
<td>--</td>
</tr>
<tr>
<td>$y^c$ (t-1)</td>
<td>-0.102</td>
<td>0.096</td>
<td>0.024</td>
<td>-0.003</td>
</tr>
<tr>
<td></td>
<td>(-4.352) **</td>
<td>(2.455) **</td>
<td>(3.644) **</td>
<td>(-0.178)</td>
</tr>
<tr>
<td>$y^m$ (t-1)</td>
<td>0.011</td>
<td>-0.199</td>
<td>-0.012</td>
<td>0.028</td>
</tr>
<tr>
<td></td>
<td>(0.956)</td>
<td>(-6.845) **</td>
<td>(-1.546)</td>
<td>(1.668) *</td>
</tr>
<tr>
<td>$p^c$ (t-1)</td>
<td>0.095</td>
<td>0.041</td>
<td>-0.066</td>
<td>0.066</td>
</tr>
<tr>
<td></td>
<td>(3.784) **</td>
<td>(0.391)</td>
<td>(-5.393) **</td>
<td>(4.136) **</td>
</tr>
<tr>
<td>$p^m$ (t-1)</td>
<td>-0.011</td>
<td>0.044</td>
<td>-0.014</td>
<td>-0.044</td>
</tr>
<tr>
<td></td>
<td>(-0.948)</td>
<td>(1.784)</td>
<td>(-1.417)</td>
<td>(-2.873) **</td>
</tr>
<tr>
<td>Constant</td>
<td>0.079</td>
<td>-0.006</td>
<td>-0.004</td>
<td>-0.003</td>
</tr>
<tr>
<td></td>
<td>(1.445)</td>
<td>(-4.166) **</td>
<td>(-2.262) **</td>
<td>(-0.672) **</td>
</tr>
<tr>
<td>Trend</td>
<td>0.052</td>
<td>0.014</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(5.137) **</td>
<td>(5.504) **</td>
<td>(1.895)</td>
<td>(0.063)</td>
</tr>
<tr>
<td>R²</td>
<td>0.617</td>
<td>0.541</td>
<td>0.816</td>
<td>0.871</td>
</tr>
<tr>
<td>Panel DW</td>
<td>1.881</td>
<td>1.902</td>
<td>2.042</td>
<td>2.13</td>
</tr>
<tr>
<td>Log-F. Ver.</td>
<td>3.269.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: the system has been estimated jointly by the Seemingly Unrelated Equations Method (SURE)

**d) Causality**

Table 6 presents the results of the causality tests. We distinguish between short-run and long-run causality. Short-run causality is interpreted in line with Granger (1969). For example, we consider that a variable $y^c$ does not cause another variable $y^m$ if the lags of $y^c$ do not improve the forecast of $y^m$. The test used is an LR test that compares the log of the likelihood function of the $y^m$ equation presented in Table 5 with that of the $y^m$ equation that excludes the lags

...
of \( y^c \). The test is distributed as a \( \chi^2 \) with degrees of freedom equal to the number of lags in the model (that is to say, the number of excluded variables). The results in Table 6(a) show that short-run effects are not present among all the variables in the system. In the short run: a) \( y^c, p^c \) and \( p^m \) cause \( y^c \); b) \( p^m \) (but neither \( y^c \) nor \( p^c \)) causes \( y^m \); c) \( y^c \) and \( y^m \) (but not \( p^m \)) cause \( p^c \); d) only \( y^m \) (but neither \( y^c \) nor \( p^c \)) causes \( p^m \). Therefore, in the short run, both the activity and the population of the central city are influenced by what happens in the rest of the metropolitan area. However, the economic activity and the population of the suburbs do not depend on what happens in the central city. Causality between activity and population is bidirectional. In the short run, the “population follows activity” and “activity follows the population”, both for the central city and for the suburbs.

Table 6:

<table>
<thead>
<tr>
<th>Excluded Var.</th>
<th>( \Delta y^c )</th>
<th>( \Delta y^m )</th>
<th>( \Delta p^c )</th>
<th>( \Delta p^m )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta y^c )</td>
<td>( \Delta y^m )</td>
<td>( \Delta p^c )</td>
<td>( \Delta p^m )</td>
<td></td>
</tr>
<tr>
<td>( \Delta y^c )</td>
<td>23.00**</td>
<td>8.38**</td>
<td>10.60**</td>
<td></td>
</tr>
<tr>
<td>( \Delta y^m )</td>
<td>22.15**</td>
<td>1.92</td>
<td>--.--</td>
<td></td>
</tr>
<tr>
<td>( \Delta p^c )</td>
<td>6.44*</td>
<td>7.25**</td>
<td>0.52</td>
<td>--.--</td>
</tr>
<tr>
<td>( \Delta p^m )</td>
<td>3.784**</td>
<td>0.391</td>
<td>--.--</td>
<td>4.136**</td>
</tr>
</tbody>
</table>

Notes: (1) Granger causality test; LR test with Ho=coefficients of the excluded variable equal to zero; it is distributed as a \( \chi^2 \) in all the equations to the exception of the last one which is distributed as a \( \chi^2(3) \). (2) t-statistic of the variable in levels. ** and *=rejection of the null hypothesis at 5% and 10% levels, respectively.

The long run causality test included in Table 6 is the t-statistic of the variable in levels. Neither in this case are there relations between all the variables in the system. In the long run: a) \( y^c \) is only caused by \( p^c \); b) \( y^m \) is caused by \( y^c \) and \( p^m \); c) \( p^c \) is only caused by \( y^c \); d) \( p^m \) is only caused by \( p^c \) and \( y^m \). Therefore, in the long run, what happens in the central city does not depend on what happens in the rest of the metropolitan area, while what happens in this area depends to a great extent on what happens in the central city. Table 7 presents the long-run relationship implicit in the results of the VECM estimation. The first column presents the

---

11 This result can be clarified in the case of the \( y^m \) equation. Although in this case the Granger test is also not accepted, the \( y^c \)-slope coefficient is significant at a 90% level. However, in the \( p^m \) equation, none of the lags corresponding to the central city are significant.
long-run relationship, the second presents the coefficient of the error correction term, and the third and forth present the LR cointegration tests. It can be observed that in any case the null hypothesis of no-significance of the variables in levels is accepted, although the exclusion of certain variables from the long-run relationship is accepted. The coefficients of the variables in the long-run relationship can be interpreted as the long run effect of a 1% increase in this variable on the variable located on the left hand side of the expression.

### Table 7: Long run relationships (ECM) (N=28, T=18)

<table>
<thead>
<tr>
<th>Equation</th>
<th>Specification</th>
<th>Coefficient</th>
<th>LR(4)</th>
<th>LR(4 vs. rest)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\Delta y^c)</td>
<td>(y^c = 0.93 \times p^c + f_t + \delta t)</td>
<td>-0.102**</td>
<td>34.08*</td>
<td>0.19</td>
</tr>
<tr>
<td>(\Delta y^m)</td>
<td>(y^m = 0.48 \times y^c + 1.07 \times p^m + f_t + \delta t)</td>
<td>0.096*</td>
<td>42.95**</td>
<td>0.16</td>
</tr>
<tr>
<td>(\Delta p^c)</td>
<td>(p^c = 0.82 \times y^c + f_t + \delta t)</td>
<td>0.054**</td>
<td>12.37**</td>
<td>3.20</td>
</tr>
<tr>
<td>(\Delta p^m)</td>
<td>(p^m = 1.50 \times p^c + 0.42 \times y^m + f_t + \delta t)</td>
<td>0.076**</td>
<td>10.32**</td>
<td>0.32</td>
</tr>
</tbody>
</table>

Notes: (1) ECM=Error correction mechanism or long run relationship among the variables (levels). (2) Specification chosen alter testing for the exclusion of some variables from the long run relationship; \(f_t\)=individual effect and \(t\)=trend. (3) Coefficient of the ECM in each equation. (4) Joint significance tests for the long run relationships: LR(4) it is a test where \(H_0=\)all the coefficients of the variables in levels are zero; in LR(4 vs. restricted): \(H_0=\)only are zero the coefficients of the variables not present in the relationship showed in the table.

Recall that the causality relationship that is of most interest to us, given the purpose of this paper, is that which goes from the central city to the rest of the metropolitan area. The results in Table 7(a) suggest that the impact of the central city on its metropolitan area is quite high. A 1% increase in \(y^c\) causes a long-run increase of 0.48% in \(y^m\), and a 1% increase in \(p^c\) causes a long-run increment of 1.50% in \(p^m\). These results confirm the main hypothesis advanced in the paper, namely that the economic health of the whole metropolitan area depends on the economic health of the central city.

Table 8 presents the results when the analysis is repeated for central cities of different sizes. The sample has been divided into cities with fewer than 300,000 inhabitants, cities with more than 300,000 inhabitants and big cities, those with more than 500,000 inhabitants. The three groups comprise, respectively, 13, 15 and 5 cities (the last group only includes the cities of Madrid, Barcelona, Valencia, Sevilla and Málaga). Table 8(a) presents for each of these groups, the coefficients and \(t\) statistics of the variable \(y^c\) in the equation \(y^m\) and of the variable \(p^c\) in the equation \(p^m\). It also presents the long-run impact of the variables \(y^c\) and \(p^c\): that is,
The results show that the long-run impact of economic activity in the central city on its suburbs increases with the size of the central city. In fact, although the coefficient is not statistically significant, the long-run impact appears to be negative in the smallest cities. On the other hand, in cities with more than 300,000 inhabitants, a 1% increase in the economic activity of the central city leads to a 1.56% increase in the economic activity of the metropolitan area. The impact is much greater in cities with more than 500,000 inhabitants (6.25%). In the case of population, the results are similar, although the differences due to the size of the central city are smaller. These results corroborate the hypothesis advanced in section 3 – namely, that the larger the central city, the greater is its impact on the metropolitan area.

The results of the VECM specification and estimation tests for each of the three samples are available on request.

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12 The results of the VECM specification and estimation tests for each of the three samples are available on request.
5. Conclusions

This paper has analysed the role of big cities as the engines of the economy of their metropolitan areas or regions. We sought to determine whether the growth of central cities generates increasing returns for the whole metropolitan area. To answer this question we analysed the causality between the growth of Spanish central cities and that of the municipalities in their surrounding areas.

The results of the empirical analysis suggest that the growth of the central city is good for its surroundings. A 1% increase in the level of economic activity generates a long-run increase of 0.48% in the level of economic activity in the rest of the metropolitan area. Moreover, this positive effect increases with the size of the central city. Thus, while this effect seems not to be present for cities smaller than 300,000 inhabitants, it rises to 1.56% for cities with more than 300,000 inhabitants and to 6.25% for cities with more than 500,000 inhabitants.

These results have important implications for economic policy. The evidence suggests that greater attention to big cities in terms, for example, of higher infrastructure investments or improvements in local funding can provide long-run benefits even to residents in the suburbs. A better understanding of these effects should, therefore, ease the creation of coalitions supporting cities. In any case, as Haughwout (1999) points out, to admit this reasoning it is necessary to demonstrate that there are cost-effective ways of improving the growth of central cities. Therefore, future extensions of this analysis should identify the impact of certain public policies (e.g., infrastructures or local services) on the growth of central cities and their metropolitan areas.

References:


