EXTERNAL ECONOMIES AS A MECHANISM OF AGGLOMERATION IN OECD MANUFACTURING

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1. Introduction

An essential reason for the geographic concentration of an industry is the existence of scale economies in production or internal economies in companies. But besides increasing returns in the individual production function, the Marshallian tradition of economic analysis has emphasised that there can also be scale economies outside companies and inside industries, or externalities, which generate positive effects in the productivity of companies. One type of externalities is those called economies of agglomeration, which produce a spatial concentration of economic activity which is endogenously self-reinforcing. They occur mainly because the transport of goods is expensive and both suppliers and clients prefer to be geographically united in order to save on costs; this can begin a trend towards grouping new companies in the nearest geographical area, which often leads to an entire process of industrial localisation (Hoover 1937; Weber 1929). Besides permitting savings in costs, geographical proximity is very important for the flow of knowledge and facilitates the transmission of ideas, so we should expect particularly important knowledge spillovers between neighbouring regions. Definitively, externalities give rise to agglomeration processes whose mechanisms have obvious effects on industry productivity.

The purpose of this research is, indeed, to analyse the existence of productive externalities in industry and their effect on productivity as an agglomeration mechanism. Although some evidence exists, it is still scanty and comes from studies on specific industries or aggregated analyses of the productive activity. This work approaches an analysis desegregated by industrial activity and in the economic context of the OECD, a contribution in itself.

1

Our analysis also gathers sources of externalities studied individually in the literature, attempting to keep to the division between pecuniary and technological externalities, which resemble static and dynamic economies respectively, although the terminology used is often ambiguous.   Thus, starting from the theoretical foundation which gathers interindustrial externalities in the production function, analysed for the maritime industries by Midelfart-Knarvik and Steen (2002), for various industries by Henriksen et al (2001), or the machine industry in Feser (2002), we also consider knowledge spillovers by means of what have been called external economies of specialisation and of diversity within each country, which have been analysed for aggregated industry by Serrano (2000), or by sectors by De Lucio et al (2002). Our analysis also considers the effect of geography on externalities, as these may be more powerful with proximity or weaker at a distance. The effect of geography is introduced in two ways: On one hand, we have considered the international specialisation of each country in each activity as a source of externality which we have called "international specialisation" as opposed to "national specialisation", also considered in the analysis. On the other, we have included an indicator of the peripherality of the country, given that the effects of international externalities may be weaker on the activity of a distant country.

The influence of externalities and of geography on productivity is derived from the conventional analysis of the production function amplified for each industrial activity. A panel of data is also used, segregating countries, years and sectors of activity in order to determine the impact of national and international externalities and of geography on productivity growth in the industrial activities that experience these effects.

The paper is structured as follows: first, the basic theoretical foundations of externalities in production are reviewed, as are recent studies which have investigated the relationship between externalities, economies of agglomeration and productivity. Second, the model and variables used, the sample chosen, the statistical sources and the estimation method are specified. Third, the results obtained are discussed; finally, we list the conclusions derived from the analysis.

2. External economies in production: Theoretical foundations and empirical evidence

From the origins of the literature on externalities in production, in the contribution of Marshall (1923), different typologies have been formulated and connections established with the New Economic Geography and Regional and Urban Economy, [1] as illustrated in figure 1.

Marshall distinguishes three origins of externalities which create advantage in the spatial concentration of economic activity. First, the existence of agglomerations of companies favours the establishment of other complementary activities supplying specialised inputs, goods and services for each sector, generating forward and backward interindustrial linkages. Second, the creation of a specialised job market shared by all the businesses in the same territory. And third, the flow of technological information related to specific knowledge which is shared by the companies of a sector and enables a cumulative process of improvement in production (know-how), called intraindustrial knowledge spillovers.

Later, Scitovsky (1954) distinguished between pecuniary and technological externalities. The former give rise to a reduction in input costs which is transmitted to market prices and may correspond to the first two sources described by Marshall. Technological externalities, like the Marshallian ones, are associated with the diffusion of technology and knowledge between companies which improves production. This distinction is similar to that used by Regional and Urban Economy, which differentiates between static externalities, similar to pecuniary ones and which relate to the size of an industry in a localisation, and dynamic externalities relating to the diffusion of knowledge and its influence on the growth of an activity, both intra and interindustrial. The different typologies of dynamic and external effects can be theoretically satisfactory but turn out to be highly ambiguous in practice, as the size and growth of an activity are closely related, and are at once cause and effect of a single phenomenon.

Their endogenous character is highlighted in the concept of economies of agglomeration in the New Economic Geography, according to which there is a trade-off between two opposing forces which act on economic productivity and begin a cumulative process between productivity and agglomeration. These two forces are on one hand, centripetal forces, consisting of pecuniary and technological external economies; on the other, centrifugal forces which promote the

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[1] For an exhaustive review, see Duranton and Puga (2004).

dispersion of activities and generate external economies, mainly related to transport costs, increasingly expensive productive factors, technological change and changes in demand.
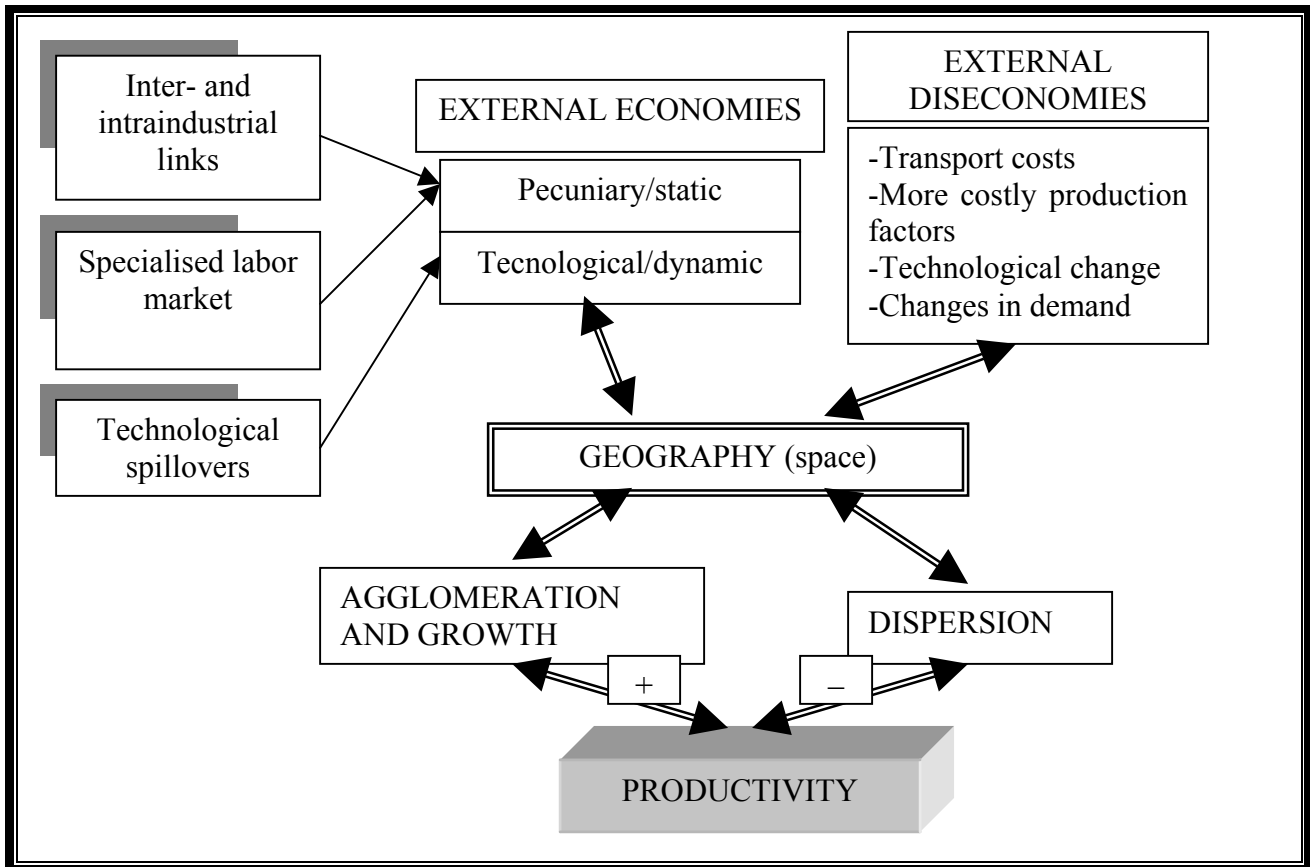

Figure 1

There is mixed evidence in the literature on the part played by externalities and by geography in productivity, with pronounced heterogeneity in the analysed countries or sectors.

A first group of work studies the impact on productivity of externalities distinguished by their origin, whether pecuniary or static, technological or dynamic; each of these may imply specialisation or diversification, or be interindustrial or intraindustrial. Also, these externalities may take place in a national or international ambit.

The existing relationship between externalities and the productivity of labor in the industrial sector is studied in Partridge and Rickman (1999), where it is examined in 48 states of the USA. As a result evidence is found that in static externalities specialisation is more common than diversification, and in dynamic ones, interindustrial externalities outnumber intraindustrial

ones. Serrano (2000) also analyses the impact of external technological economies in the growth of productivity of labor in the Spanish regions. The increase in diversity in the other activities of the region increases the differential in sectorial productivity growth between the region and the national average in agriculture, energy, industry and services geared to sales. While economies if diversity require a maturing period, those of specialisation have a notably positive impact on all sectors in the present period, which is losing intensity as time goes on due to the accumulation of knowledge and obsolescence in the companies of the sector.

In turn, Caballero and Lyons (1990, 1992) ask if an increase in activity in a manufacturing sector leads to a significant increase in productivity in other sectors in four OECD countries. They obtain a high positive correlation between national activity and productivity, both sectorial and aggregated, and thus, significant evidence of national and international pecuniary externalities.

Henriksen *et al.* (2001) carry out a similar analysis to that of Caballero and Lyons in four EU countries, but they add externalities between clusters, interindustrial national and international intraindustrial externalities. They find evidence of both, positive and negative; the greatest percentage of the positive national externalities is in the high technology industry cluster, and among the international ones, in transport. The highest percentage of negative effects is in textiles and leather. Among countries, Germany is the biggest receiver of these externalities, both national and international.

The interindustrial links and the spillovers, which define Henriksen's clusters, are analysed for the Norwegian maritime sector and its service and transport sectors by Midelfart-Knarvik and Steen (2002). They use a function of production amplified by the size and growth of the supply sectors as a proxy of externalities towards the maritime cluster, and obtain evidence that vertical links reinforce agglomeration.

De Lucio *et al* (2002) study labor productivity growth by sector and Spanish province, following Martin and Ottaviano (1996), who consider the distribution of innovation to be lineal and to increase proportional to economic activity. Thus, labor productivity growth in a region is affected by the generation and diffusion of innovations, depending on the degree of specialisation, diversity and competitiveness of its industries. They obtain evidence of dynamic effects due to industrial specialisation, deducing from this that technological spillovers happen

when there is a high degree of specialisation. These results are in line with those of Henderson (2003), who identifies technological spillovers with specialisation in high technology industries, and with Glaeser (1992) who associates them with large regions specialising in large industries; but both, particularly Glaeser, present evidence of interindustrial externalities and of the importance of specialisation or diversification for growth in all sectors.

A second group of studies related to Regional and Urban Economy highlights how productivity increases with the size of the industry itself (economies of localisation, outside the company but within the industry) or with the size of the region (economies of urbanisation, outside the company and the industry, but within the region).

For Japanese industries, Nakamura (1985) proves how small industry receives more productive advantages from economies of urbanisation. In contrast, the larger industries receive more benefits form localisation, both in the same city and in nearby ones.

Along these lines, although remarking on the importance of economies of urbanisation, we can mention the work of Moomaw (1998) for the USA and Dogan (2001) for Turkey. Some authors go further and attempt to identify the relationship that exists between economies of agglomeration, the type of industries that become localised and the characteristics of the regions where they do so.

Thus, Feder (2001) and Henderson (1986) identify high technology industries as those that present the most economies if localisation in the USA. Henderson (1986) underlines the strong correlation between the industries which present economies of localisation and specialisation in the regions where they localise; later works (Henderson 1994 and 2003) show that, depending on each industrial activity, its localisation may be determined by specialisation or diversity in the region. The same result is emphasised by De Lucio et al (2002) in their analysis of technological spillovers which appear with high specialisation; however for other authors such as Glaeser et al (1992) large industries localise in large regions, but the impact of diversification is much greater on productivity growth. Finally, Lall et al (2004) examine the determinants of agglomeration of companies in 9 industries in India, including infrastructures facilitating access to markets, but market size of the region does not appear to play a significant part.

To sum up, the evidence in existing literature reveals the significant importance of the size of the industry itself on economic productivity, as well as the specialisation or diversification

of a region, aspects linked in turn with technological spillovers, and which we consider to be of central relevance in our own analysis.

The geographical dimension of technological externalities refers to the third group of studies, mainly Graham (2000), Ciccone (2002), Feser (2002) and Davis and Weinstein (2003). This literature not only solidifies and justifies the concept of technological externalities or spillovers and their influence on productivity growth, it also emphasises that proximity is important for the flow of know-how. If geographic proximity facilitates the transmission of ideas, we should expect that when this is greater, knowledge spillovers are particularly important.

Graham (2000) identifies how spatial externalities affect variation in labor productivity in the manufacturing sector. He defines externalities between regions of the UK on the basis of total employment, employment density and the distance between regions, and analyses their impact on the regions themselves and their neighbours. In any case the results do not show a significant influence on variation in productivity, whereas the degree of intensity of capital, industry structure and the qualification of the labor force do.

Another way of incorporating the effect of geography is that of Ciccone (2002), who approximates spatial externalities with production density – production per unit of cultivated area – in the European regions (NUTS 3) or alternatively, in each country. Production density, monitored by the proportion of added agricultural value in the region, has a significant influence only on the productivity of each NUT but not on that of the countries, and production density of neighbouring NUTs has a significant additional effect.

Feser (2002) obtains evidence of the importance of the geographical component via the inclusion of distance which considers three possible sources of externalities: the possible supply of intermediate inputs, approximating the distance to supply regions; the availability of specialised labor, which measures access to a specialised labor market; and the total spending on research carried out by the universities, which approximates knowledge externalities.

Similarly, Davis and Weinstein (2003) analyse the potential market impact on Japanese regions, together with cost and demand linkages and the existence of intra- and international externalities. The results identify important effects of the size of the region and of cost linkages between producers and input suppliers, but the potential market and intraindustrial externalities do not seem to be robust determinants.

Thus, given a definition of region or country, distance considered by some indicator of economic activity offers good results for analysing the impact of geography in the relationship between externalities and productivity, and so we will use the same focus in our analysis.

3. **Specification of an empirical model with externalities in the production function.**

The base of our analysis takes as its starting point the amplified production function, in line with the work of Midelfart-Knarvik and Steen (2002), Serrano (2000) or De Lucio et al (2002). Together with factor endowments, we include the sources of externalities indicated in the previous section, with special emphasis on technological externalities, besides introducing the effect of economic geography. Starting with the premise that agglomeration affects the total productivity of the factors and that this in its turn affects output, we will analyse the existence of externalities on the growth rate of labor productivity by sectors. Among the externalities which we consider in production function, we distinguish between externalities within the industry itself – intraindustrial – and coming from other industries - interindustrial - and between national and international ones. Therefore we need a model which discriminates between internal and external scale economies in a national industry.

If we consider a production function of the Cobb Douglas type:

$$Q_{i,c} = A_{i,c} K_{i,c}^{\alpha} L_{i,c}^{1-\alpha} \tag{1}$$

where $Q_{i,c}$ is the gross added value at market prices, K is the gross capital stock, L is employment, α measures the degree of scale returns, c is the country and i the productive sectors. We use the same equation in relative terms, and thus obtain an expression of the productivity of labor,

$$\left(\frac{Q}{L}\right)_{i,c} = A_{i,c} \left(\frac{K}{L}\right)_{i,c}^{\alpha} \tag{2}$$

Taking differences in logarithms,

$$\ln\left(\frac{Q}{L}\right)_{i,c} = \ln A_{i,c} + \alpha \ln\left(\frac{K}{L}\right)_{i,c} \tag{3}$$

Given that we are interested in looking for the effects of dynamic externalities in the productivity growth rate, we take equation (3) in growth rates,

$$\Delta \ln\left(\frac{Q}{L}\right)_{i,c} = \Delta \ln A_{i,c} + \alpha\Delta \ln\left(\frac{K}{L}\right)_{i,c} \qquad \text{(4) which is equivalent to}$$

$$g_{PvLi,c} = g_{TFPi,c} + \alpha g_{\left(K/L\right)_{i,c}} \qquad (5)$$

Thus we have the labor productivity growth rate $\left(g_{PvLi,c}\right)$ on the left of the equation, measured as gross added value (VA) per worker, and on the right the total productivity growth rate of the factors and the growth rate of their use, respectively.

$g_{\left(K/L\right)_{i,c}}$, is the relative factor endowment growth rate measured by the capital/labor ratio. The urban and regional areas of greatest economic size have a greater ratio which in turn is associated with higher levels of technology and human resources. Thus, there is both a spatial and a sectorial association between factor endowments and productivity. Therefore, we expect the coefficient associated with this variable to be a positive value.

Externalities have an effect on the use of productive factors, which means an impact on the total productivity of the factors and thus on output and labor productivity. For this reason we suppose that this productivity depends on technological externalities, both interindustrial and intraindustrial, national or international.

$$TFP_{i,c} = f(\widetilde{q}_{j,c}, C_{i,c}, D_{i,c}, E_{i,c}) \qquad (6)$$

where $\widetilde{q}_{j,c}$ approximates national interindustrial externalities;

$C_{i,c}$ approximates the national intraindustrial externalities of concentration of activity in sector i;

$D_{i,c}$ approximates the national interindustrial externalities, in this case due to the productive diversification of the country;

$E_{i,c}$ approximates the international intraindustrial externalities;

We go on to explain how each of these variables is measured, and according to theory, the hypothesis on its behaviour:

$\widetilde{q}_{j,c}$ Is the output variation of country c in all sectors j different to i within the country, and we expect a positive impact on productivity. This behaviour is due to the economies that can be obtained in large scale production. Increases in the size of markets permit greater specialisation which is reflected in productivity increases, while a growth of the supply market reduces production costs.

Another two dimensions of national externalities are economies of concentration of intraindustrial activity – sometimes called of diversity $(C_{i,c})$, and interindustrial economies of diversification $(D_{i,c})$. The concentration of the country in activity i can be measured via the "sectorial diversity coefficient" which is the Herfindhal index of the proportions of each activity in the country as a whole. If it is high this indicates that activity is highly concentrated in one or a few industries. We opt to use the VA as a measurement of activity and proxy of innovation processes, so the variable $C_{i,c}$ can be measured by the index:

$$C_c = \sum_i \left(VA_{i,c} / VA_c \right)^2$$

Given that we cannot distinguish which is the activity which concentrates the VA of a country, and we are interested in approximating the effects of the concentration on this activity, we interact the coefficient C_c by the production level itself. Thus a high value of this interaction approximates the concentration of VA in activity I and will be an indicator of national intraindustrial externalities.

We also considered distinguishing impact from other sectors, interacting the coefficient by production in other industries. However this has been excluded from the analysis because we would not identify the sector where the externality comes from, and in the case of a sector-by-sector interaction the degrees of freedom are enormously reduced.

A practicable alternative is to include the influence of the rest of the sectors by the diversification of industries in the country. The index of diversity $D_{i,c}$ in the country c excludes

activity i from the above concentration coefficient C_c, so we can know if the variety of other production in the country has an influence on activity i.

$$D_{i,c} = \sum_{j \neq i} \left(VA_{j,c} / VA_c \right)^2$$

A lower value of this index is the result of the variety of activities and a more homogenous distribution of the country's production; a greater value indicates production concentration in one of the remaining activities and perhaps less diversification. The literature supposes that greater diversification generates more productivity, as suppliers and clients are plentiful in the region, empowering interindustrial linkages; thus, we expect the coefficient assigned to this variable to be negative.

The international intraindustrial externalities are measured by the index of specialisation of country c in activity i:

$$E_{i,c} = \left(\left[\frac{VA_{i,c}}{VA_c} \right] \middle/ \left(\frac{VA_{i,OECD}}{VA_{OECD}} \right) \right)$$

calculated in terms of VA in country c in the ith sector. With this variable we measure the relative size of the sector in the country compared to the average of all the OECD countries, or, along similar lines, the international localisation of a given sector. It is supposed that a bigger sector in the country, or in other words a more specialised country, can attract new resources while increasing productivity in the existing ones. This is an additional agglomeration mechanism which feeds back to specialisation and productivity growth. As such, we expect this variable to be positive.

Once the variables which approximate the externalities are defined, supposing that the total productivity growth of the factors is a multiplying function of them, and considering that geography will colour this effect, so that more distant regions will receive a smaller effect from the same externality than more central regions, we can estimate labor productivity as follows,

$$g_{PvLi,c,t} = \alpha g_{\left(K/L \right)_{i,c,t}} + \beta_{\tilde{q}} g_{\tilde{q}_{j,c,t}} + \beta_C g_{C_{i,c,t}} + \beta_D g_{D_{i,c,t}} + \beta_E g_{E_{i,c,t}} + \beta_G G_{i,c,t} + \beta_u u_{i,c,t} \quad (7)$$

where G_c is a control of the effect of geography in the relationship between externalities and total productivity of the factors, taking into account that each variable defined takes a different value each year t and that there is an error term for each observation $u_{i,c,t}$. A common way to monitor the effect of geography is to include an index of peripherality of the country receiving the externality, which weighs the distance to each country against its economic importance, and which we expect a negative value for,

$$G_c = \frac{\sum_{k \neq c} d_{c,k} * DP_k}{N - 1}$$

where $d_{c,k}$ is the bilateral distance between two countries c and k, DP_k is the gross interior product and N is the total of countries in the sample.

In principle we can suppose there to be a correlation between the error term and the explicative variables, which allows the use of fixed effects which monitor the characteristics of the countries which do not change over time. However, the estimation of the equation (7) can present a problem of endogeneity because of using the VA both in the endogenous variable and in some explicatives, and the growth of the VA by employee can determine the agglomeration of the activity reflected in concentration, diversification and specialisation indices. This has been contrasted by the Hausman test (1976) problems of endogeneity are tackled by the use of instrumental variables, a good alternative for consistent estimators. Thus the chosen estimation method is the Generalized Method of Moments (GMM) which uses the retards of the predetermined variables of the model as instruments.

The statistics have come from EUROSTAT for the principal aggregates of National Annual Accounts in millions of euros, such as Gross Value Added to basic prices, Gross Interior Product at market prices, Intermediate Consumption and Employment. The Gross Capital Stock has been obtained from the OECD STAN Structural Analysis Database 2005 Edition and the distance to large circles came from Jon Haveman's website[2]. All these data are available for 12

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[2] See http://www.macalester.edu/research/economics/PAGE/HAVEMAN/Trade.Resources/Data/Gravity/dist.txt

countries, 13 productive sectors and annually from 1995 to 2002, forming a total sample of 1248 observations.

Information is available for twelve OECD countries: Austria, Belgium, Germany, Denmark, Spain, Finland, France, Greece, Italy, the Netherlands, Portugal and Sweden.

The manufacturing sectors correspond to the Statistical Classification of Economic Activities (NACE) in Rev.1.1., and are the following thirteen: (1) Food products, beverages and tobacco; (2) textiles and textile products; (3) leather and leather products; (4) wood and wood products; (5) pulp, paper and paper products; publishing and printing; (6) coke, refined petroleum products and nuclear fuel; (7) chemicals, chemical products and man-made fibres; (8) rubber and plastic products; (9) other non-metallic mineral products; (10) basic metals and fabricated metal products; (11) machinery and equipment n.e.c.; (12) electrical and optical equipment; and (13) transport equipment.

4. Empirical estimation and results of the influence of externalities in production.

The estimation of our model has been carried out sequentially, considering first variables of national character such as factor endowments and national externalities, both inter and intraindustrial, and then introducing international externalities and the effect of geography. In each stage of the sequence, the estimation has been made via data panels by industries, and in each sector the absence of correlation has been contrasted between the explicative variables and the error term. In most sectors the rejection of this hypothesis allows us to suppose the existence of fixed effects and mainly, in a small sample such as ours, obtaining some unbiased estimators and the control of possible omitted variable. At the same time, the presence of endogeneity is contrasted among the dependent and explicative variables by the test Hausman (1979), in which case it is instrumentalised and re-estimated via the Generalized Method of Moments (GMM) and its correction by the use of valid instruments is indicated in the presented results which are discussed below.

TABLE 1	FACTORS+ NATIONAL EXTERNALITIES				+ INTERNATIONAL EXTERNALITIES					+ GEOGRAPHY					
VARIABLES	$g\left(\frac{K}{L}\right)_{i,c}$	$g\,\tilde{q}_{j,c}$	$g\,C_{i,c}$	$g\,D_{i,c}$	$g\left(\frac{K}{L}\right)_{i,c}$	$g\,\tilde{q}_{j,c}$	$g\,C_{i,c}$	$g\,D_{i,c}$	$g\,E_{i,c}$	$g\left(\frac{K}{L}\right)_{i,c}$	$g\,\tilde{q}_{j,c}$	$g\,C_{i,c}$	$g\,D_{i,c}$	$g\,E_{i,c}$	G_c
1 Food products; beverages and tobacco	0.42		0.46	-0.77	0.53	-0.02			0.77	0.40	-0.02			0.79	0.53^{-10}
2 Textiles and textile products	1.14		1.16	-1.20	0.82		0.52		0.86	0.71		0.34		1.04	-0.44^{-09}
3 Leather and leather products	1.01		0.65	-0.97	1.05		0.36		0.65	1.05	0.01	0.28		0.74	-0.35^{-09}
4 Wood and wood products	0.52	-0.03	0.69		0.69	0.03	0.30		0.90	0.84	0.03	0.34	-0.22	0.93	-0.33^{-09}
5 Pulp, paper; publishing, printing	0.64		0.63	-0.30	0.55		0.46	0.20	0.33	0.76		0.60			-0.29^{-09}
6 Coke, refined petroleum, nuclear fuel					0.74	0.13			1.10	0.91	0.23			1.30	
7 Chemicals, and man-made fibres	0.47	-0.03	0.68	-0.99	0.73	-0.03	0.33		0.86	0.67	-0.03	0.35		0.83	-0.20^{-09}
8 Rubber and plastic products	0.93		0.61	-0.51	1.53				0.56	1.12	-0.03		1.31	1.08	
9 Other non-metallic mineral products	0.58		0.56		0.73		0.18	0.65	0.82	0.78			0.53	0.86	
10 Basic metals and metal products	1.14	-0.02	0.67	-0.83	1.13	-0.02	0.57	-0.52	0.35	1.14	-0.02	0.58	-0.52	0.35	
11 Machinery and equipment n.e.c.	0.68		0.89		0.73		0.93			1.10	0.02	0.58	-0.62	0.56	0.32^{-09}
12 Electrical and optical equipment	1.01		0.47	-1.19	0.84		0.36			1.36		0.31	-0.76		-0.78^{-09}
13 Transport equipment			0.40	-1.26			0.30	-1.02	0.43			0.31	-1.01	0.46	

$$C_{i,c} = q_{i,c} \sum_i \left(VA_{i,c}/VA_c\right)^2 \; ; \; D_{i,c} = \sum_{j\neq i}\left(VA_{j,c}/VA_c\right)^2 \; ; \; E_{i,c} = \left(\left[\frac{VA_{i,c}}{VA_c}\right] \middle/ \left(\frac{VA_{i,OECD}}{VA_{OECD}}\right)\right); \; G_c = \frac{\sum_{k\neq c} d_{c,k}*DP_k}{N-1}$$

The summary table (table 1) synthesises the variables which turn out to be significant in each case and the value of the coefficients obtained. The details of the complete estimation and the relevant statistics are in the Appendix.

First, as seen in equation (8), the effect of relative factor endowments on labor production growth is estimated $g_{(K/L)_{i,c}}$ and the national externalities, intrasectorial $g_{C_{i,c}}$ and intersectorial, approximated by the dynamism of the remaining sectors which can be linked to $g_{\tilde{q}_{j,c}}$ and their diversification $g_{D_{i,c}}$. The coefficients of the variables that are found to be significant are the first column of table 1 (see also table A1 of the Appendix).

$$g_{PvLi,c,t} = \alpha g_{(K/L)_{i,c,t}} + \beta_{\tilde{q}} g_{\tilde{q}_{j,c,t}} + \beta_C g_{C_{i,c,t}} + \beta_D g_{D_{i,c,t}} + \beta_u u_{i,c,t} \qquad (8)$$

The results confirm the relevance of factor endowments in practically all sectors and of national externalities of concentration and diversification, especially the former, which highlights the importance of growth of national localisation of industrial activity. In all cases the signs obtained are as expected, and we can affirm that a greater endowment of capital per worker has a positive influence on productivity growth; the same effect is deduced from the growth of concentration of activity within the country and the growth of its diversification in the supply and client sectors. Only in the transport equipment industry (13) do we find that endowment factors are not relevant, but externalities are; this may indicate that the mechanisms of agglomeration and interindustrial linkages propounded by the New Economic Geography play a very important part in this sector. At the same time it is noticeable that neither endowment factors nor national externalities are relevant in coke, refined petroleum products and nuclear fuel (6), logically enough if we think of our dependence on the exterior regarding these products, which leads us to think that international externalities will have more influence.

The growth of concentration or national specialisation contributes to the growth of productivity in all sectors – except, as mentioned, petrol refinery – and is usually accompanied by a significant diversification of suppliers and clients within the country. Dynamism in diversification or in interindustrial linkages does not seem to be relevant for the sectors of other non-metallic mineral products (9) or for machinery and equipment n.e.c. (11), where only endowments and the increase of national specialisation are significant. But diversification – or

less concentration – goes hand-in-hand with a negative dynamism in interindustrial relationships in chemicals, chemical products and man-made fibres (7) and in basic metals and fabricated metal products (10); this indication of external diseconomies leads us to think that concentration and growth of activity in other sectors implies a reduction in productivity in metal and chemical products, indicating perhaps the sensitivity of these sectors to imbalance in their interindustrial relationships.

The second column in table 1 and table A2 of the Appendix show the estimation of the production function amplified also by externalities of international specialisation $E_{i,c}$, according to the equation (9):

$$g_{PvLi,c,t} = \alpha g_{\left(K/L\right)_{i,c,t}} + \beta_{\tilde{q}} g_{\tilde{q}_{j,c,t}} + \beta_C g_{C_{i,c,t}} + \beta_D g_{D_{i,c,t}} + \beta_E g_{E_{i,c,t}} + \beta_u u_{i,c,t} \qquad (9)$$

Together with the significance of the relative abundance of capital in all sectors except transport equipment, the results confirm the relevance of growth of localisation of activity in the international context in all sectors except machinery and equipment n.e.c (11) and optical and electrical equipment (12). It appears that in these two sectors their specialisation within the country has more relevance than international specialisation, but in the other sectors it is noticeable how their productivity growth improves when, besides specialisation at national level, an international agglomeration is also produced. Together with this, the growth of international specialisation becomes more relevant than the national in three sectors: Food products, beverages and tobacco; (1), rubber and plastic products (8) and coke, refined petroleum products and nuclear fuel (6); however, both national and international specialisation continue to have a positive and significant effect on the other sectors.

The evidence of intraindustrial economies of specialisation, both national and international, is more abundant than that of economies of diversification, something frequently found in the literature, for example in De Lucio (2002) and Henderson (2003). While the sectors of basic metals and fabricated metal products (10) and of transport equipment (13) benefit from growth in the diversity of productions in the country, others such as pulp, paper and paper products; publishing and printing(5) and other non-metallic mineral products (9) seem to benefit, in contrast, from the growth of only a few suppliers or clients.

The evidence of interindustrial externalities is also weaker than that of intraindustrial externalities of specialisation, with sectors that benefit from the dynamism of other sectors, such as wood and wood products (4) or coke, refined petroleum products and nuclear fuel (6). In this last case we can highlight the significant effect that the abundance of capital and the dynamism of the other sectors have on productivity, once we consider the influence of its international localisation, which can indicate both its intensity in physical capital and its sensitivity as a supplier to the whole economy. However there is evidence of external diseconomies in Food products, beverages and tobacco (1), chemicals, chemical products and man-made fibres (7) or basic metals and metal products (10). We would have to dig deeper to find the causes of this negative effect on productivity, although in the case of metals and metal products (10) there is also evidence that it is a sector which benefits from the growth in diversity in the activities of the country, and less so from the growth of other sectors. Nevertheless, these are three sectors where the evidence in favour of specialisation, international in the case of food and both national and international in the rest, is robust.

It is also noticeable that national specialisation is less important than international in the sector of Food products, beverages and tobacco (1) and rubber and plastic products (8), and that international externalities affect coke, refined petroleum products and nuclear fuel (6), as they are linked to natural resources.

The last column in table 1 and table A3 of the Appendix shows the effect of factor endowments and externalities, as well as the effect of the peripherality of the country G_c on the growth of productivity of each sector, shown in equation (7). Again, the evidence of the relevance of the abundance of capital is robust and agrees with the literature (Feser, 2002, for example). The effect is positive and significant in all sectors except transport equipment (13). We also see how once externalities and geography are monitored, the coefficient of growth in the abundance of capital is greater, and there is evidence of scale economies in metal products (10) and machinery and equipment n.e.c (11), where both national and international specialisation are important; in rubber and plastic products (8), where international specialisation is important, and in electrical and optical equipment (12), where national specialisation is relevant. A notable exception is the textiles and textile products sector (2) where, before monitoring externalities, we observe apparent scale economies, which disappear when we consider the effect of international

specialisation and of geography. This result leads us to think that the textile industry localises in the countries where there is an abundance of the labor factor. In the other activities, by way of contrast, when externalities are controlled the effect of relative capital endowment is increased; this result may indicate a negative correlation between abundance of capital and international specialisation; that is, in the sectors which present international agglomeration, this takes place where there is an abundance of labor, and perhaps lower salaries, demonstrating the mechanism most often used in the New Economic Geography.

The evidence in favour of national and international intraindustrial externalities of specialisation is also robust, and more plentiful than the evidence of interindustrial externalities, both through the dynamism of the other sectors and through that of the diversification of production in the country. The group where the significant externalities are national and international specialisation are still the sectors of textiles and textile products (2), leather and leather products (3) and chemicals, chemical products and man-made fibres (7), except the sector of pulp, paper and paper products; publishing and printing (5).

Together with specialisation externalities, there is evidence of externalities of diversification in wood and wood products (4), basic metals and fabricated metal products (10), machinery and equipment n.e.c (11) and transport (13). The evidence is repeated that 10 benefits from growth of variety in the economy but not from growth in other sectors.

The dynamism of interindustrial links presents less robust evidence, as new results appear showing positive external economies in the sectors of leather and leather products (3) and machinery and equipment n.e.c (11) and negative external economies in rubber and plastic products (8), although our results see a repetition of external diseconomies in the sectors of Food products, beverages and tobacco (1), chemicals, chemical products and man-made fibres (7) and basic metals and fabricated metal products (10), although this last does benefit from diversity; and external economies in wood and wood products (4) and coke, refined petroleum products and nuclear fuel (6). The literature shows evidence of externalities in interindustrial relationships in Midelfart-Knarvik and Steen (2002) and Caballero and Lyons (1990, 1992). Our results are in line with those obtained by Henriksen et al. (2001), as they obtain national interindustrial effects and international intraindustrial effects, both positive and negative, although the sectorial desegregation of the study is different.

When the central or peripheral position of the countries is controlled, the importance of national interindustrial externalities becomes evident, in wood (4) through the dynamism of diversification; in machinery and equipment (11) through the dynamism of other activities and growth of diversification; and electronic and optical equipment (12) through diversification.

Peripherality does not appear to be relevant in coke, refined petroleum products and nuclear fuel (6), rubber and plastic (8), non-metallic minerals (9), metals (10) and transport (13). Regarding the sectors of coke, refined petroleum products and nuclear fuel (6), mineral products (9) and metals (10), the result is logical if we think that these sectors are tied to the existence of natural resources, so international specialisation is tied to factor endowments. The transport sector (13) is so important in many countries that governments treat it as a barometer of the economy. For this reason, governments will pull out all the stops to attract new investment or give grants to vulnerable companies. Many developing countries have tried to provide themselves with, for example, a car manufacturing industry (motor vehicles have a higher exportation coefficient than the transport equipment manufacturing sector), with mixed results. Most of the world's car production is concentrated in only six countries: Japan, the USA, Germany, France, Spain and South Korea, followed by six more, the UK, Canada, Italy, Belgium and Brazil. Within those that correspond to our study sample, Spain and Italy are regarded as peripheral. Also, the rubber and plastics sector (8) depends largely on the car manufacturing sector and is closely tied to its progress. Generally, in all these activities the importance of national and/or international specialisation is seen both in peripheral and in central countries, and thus geography is not an influence.

In the sectors of food products, beverages and tobacco (1) and machinery and equipment (11) the indication of geography is the opposite to what is expected. The former is a sector with interindustrial diseconomies, is negatively influenced by the dynamism of other sectors, and benefits from international but not from national specialisation, even before controlling its geographical position, i.e., it is important not at a national level but when compared with other countries. A descriptive analysis of this sector shows us its importance in countries such as Greece, Spain and Italy, countries where culturally the sector related to food may carry enormous weight despite being peripheral, which indicates that they could reasonably be benefited by their geographical position. The second is now remarkable for its externalities of national and international specialisation and diversification. It is characterised by a highly qualified workforce

and highly technological content where the diffusion of know-how plays a very important part. Competition is also very relevant, which in this case is not diminished by distance, as the sector has high activity in peripheral countries as well as in central ones. Perhaps de-localisation, frequent in the internationalisation process of many large companies and most of all in specific high technology sectors, is playing an important part here.

To sum up, we can distinguish four groups of sectors according to the effect of externalities on productivity growth. In all except the transport sector (13) capital endowments per worker are also determinants of productivity.

A first group covers sectors where national and international specialisation is relevant: textile (2), leather (3) and chemical products (7) where this last receives diseconomies.

The second group is formed by branches with national externalities of specialisation and diversification such as wood (4), machinery and equipment (11) and electronic and optical equipment (12) where controlling the peripheral position highlights the importance of diversification (and in machinery, sector 11, international specialisation and the dynamism of other sectors).

The third group includes the metal sector (10) which as already noted, benefits from the growth of diversity in the economy but not from the dynamism of other sectors. This is to say, on one hand, it is prejudiced by activity being concentrated in a few sectors because it needs the existence of variety, reflected in a special environment where its production development is efficient and less damaging to the natural environment, by taking advantage of the cost advantages offered by transport infrastructures, the security of having a regulated judicial framework, the push of competition, scale economies which permit access to a wide market; definitively, a living business fabric. On the other hand, it is prejudiced if there are other sectors with a lot of efficient growth as these can drain its workforce or production resources in general, especially with the growing privatisation process which is taking place in this activity. Next to this sector we highlight that of transport (13), as even before controlling the geographical position both benefit from national and international specialisation as well as diversification. We can also point out that more than factor endowments, externalities of all kinds are what determine productivity growth. This fact may be related to the upwards links that exist in this industry, such as the manufacture of rubber elements, tyres, plastics, glass, paints, electronic components and

textiles; and downwards operations such as sales, after-sales services, repairs, fuels, financial and insurance staff, etc.

Lastly, in the fourth group we find international specialisation in sectors such as food products, beverages and tobacco (1), coke, refined petroleum products and nuclear fuel (6), rubber and plastics (8) and non-metallic minerals (9); food (1) and rubber and plastics (8) with external interindustrial diseconomies and petrol products (6) with external economies. In contrast, in the paper and printing sector (5), when geography is introduced the importance of diversification and international specialisation disappears due to the effect of the need for a spatially central position for carrying out the activity.

5. Conclusions

The proposal of this study was to analyse the existence of productive externalities in the manufacturing industries of the OECD countries, desegregated by sectors of activity and for the period 1995-2002.

Externalities have a positive effect on the use of productive factors, which means greater total productivity of the factors and thus on output and labor productivity. For this reason we suppose that productivity growth depends on pecuniary and technological externalities, interindustrial and intraindustrial, national or international. At the same time their effect is made more pronounced by geography, given that peripheral countries may find the effect of externalities on productivity of economic activities is lessened.

The results confirm the positive influence on labor productivity growth of factor endowments in practically all the sectors analysed, even with the appearance of scale economies in some of them. It is also obvious that there are intraindustrial economies of specialisation, both national and international, which are also more abundant than the interindustrial ones, whether because of the dynamism of the rest of the sectors or because of diversification in production, a result which is in line with most of the existing literature.

These results are confirmed in the sectors of textiles and textile products (2), leather and leather products (3), wood and wood products (4), chemicals, chemical products and man-made fibres (7), basic metals and fabricated metal products (10), machinery and equipment (11) and transport (13) where national and international intraindustrial specialisation is found, and there is

diversification of these in wood and wood products (4), basic metals and fabricated metal products (10), machinery (11) and transport (13). We can also highlight the sector of coke, refined petroleum products and nuclear fuel (6) for its evidence of international specialisation as there is a great deal of dependence on the countries where the natural resource is found; and that of transport (13) where factor endowments do not determine productivity growth, but all types of externalities do.

The results obtained clearly demonstrate the importance of external economies and of the geographical position of countries in the growth of productivity of the sectors analysed, which will determine the aggregated growth. Thus, it would be beneficial to implement development policies which support sectors whose productivity is liable to benefit from the positive effects of national and international externalities, which will result in greater economic growth.

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7. Appendix. Detail of the total estimation

TABLE A1: FACTORS + NATIONAL EXTERNALITIES				
	$g_{(K/L)_{i,c}}$	$g_{\tilde{q}_{j,c}}$	$g_{C_{i,c}}$	$g_{D_{i,c}}$	
1 Food products; beverages and tobacco	0.42 (1.88)	-0.0013 (-0.13)	0.46 (3.13)	-0.77 (-3.43)	R^2Aj= 0.28 F(6,32) = 1.66 Nobs= 43 CHISQ(2) = 3.05
2 Textiles and textile products	1.14 (4.41)	-0.03 (-1.59)	1.16 (4.22)	-1.20 (-3.28)	R^2Aj= 0.52 F(4,23) = 3.85 Nobs= 32 CHISQ(3) = 6.67
3 Leather and leather products	1.01 (16.11)	-0.01 (-0.84)	0.65 (4.49)	-0.97 (-2.40)	R^2Aj= 0.81 F(4,23) = 6.57 Nobs= 32 CHISQ(1) = 0.0022
4 Wood and wood products	0.52 (2.11)	-0.03 (-1.95)	0.69 (5.07)	0.13 (0.66)	R^2Aj= 0.32 F(5,29) = 0.48 Nobs= 39 CHISQ(3) = 0.74
5 Pulp, paper and paper products; publishing and printing	0.64 (4.78)	-0.02 (-1.52)	0.63 (5.33)	-0.30 (-2.25)	R^2Aj= 0.44 F(6,32) = 2.01 Nobs= 43 CHISQ(2) = 31.28
6 Coke, refined petroleum products and nuclear fuel	0.45 (0.40)	0.01 (0.05)	0.06 (0.14)	-5.14 (-0.97)	R^2Aj= -0.08 F(6,32) = 0.80 Nobs= 43 CHISQ(1) = 0.75
7 Chemicals, chemical products and man-made fibres	0.47 (2.59)	-0.03 (-3.30)	0.68 (7.58)	-0.99 (-4.43)	R^2Aj= 0.66 F(5,29) = 2.48 Nobs= 39 CHISQ(2) = 1.59
8 Rubber and plastic products	0.93 (5.08)	-0.0093 (-0.97)	0.61 (4.99)	-0.51 (-1.71)*	R^2Aj= 0.39 F(5,29) = 0.84 Nobs= 43 CHISQ(2) = 0.021
9 Other non-metallic mineral products	0.58 (4.54)	-0.01 (-1.39)	0.56 (4.29)	-0.41 (-1.36)	R^2Aj= 0.32 F(6,32) = 0.72 Nobs= 43 CHISQ(2) = 0.60
10 Basic metals and fabricated metal products	1.14 (7.53)	-0.02 (-3.20)	0.67 (8.15)	-0.83 (-5.14)	R^2Aj= 0.81 F(4,23) = 14.28 Nobs= 32 CHISQ(1) = 7.78
11 Machinery and equipment n.e.c.	0.68 (2.54)	0.0017 (0.07)	0.89 (2.41)	-0.56 (-1.34)	R^2Aj= 0.49 TOVER=2.91[CORR] Nobs= 29
12 Electrical and optical equipment	1.01 (4.24)	0.00076 (0.04)	0.47 (3.66)	-1.19 (-3.08)	R^2Aj= 0.77 F(6,32) = 3.41 Nobs= 28 CHISQ(3) = 7.98
13 Transport equipment	0.14 (0.58)	-0.0032 (-0.19)	0.40 (2.50)	-1.26 (-3.40)	R^2Aj= 0.25 F(6,32) = 1.56 Nobs= 43 CHISQ(3) = 3.21

Note. t-statistics in parentheses. 5% significance level except *at 10%. [CORR] endogeneity corrected by valid instruments. CHISQ(n) Hausman test statistic. TOVER Test of overidentifying restrictions. F () Statistic for homogeneity of individual effects hypothesis.

	$g_{(K/L)_{i,c}}$	$g_{\tilde{q}_{j,c}}$	$g_{C_{i,c}}$	$g_{D_{i,c}}$	$g_{E_{i,c}}$	
TABLE A2: FACTORS + NACIONAL EXTERNALITIES+ INTERNATIONAL EXTERNALITIES						
1 Food products; beverages and tobacco	0.53 (2.82)	-0.02 (-1.72)*	0.09 (0.67)	0.26 (0.87)	0.77 (4.87)	$R^2Aj= 0.47$ $F(6,31) = 3.29$ Nobs= 43 CHISQ(1) = 0.36
2 Textiles and textile products	0.82 (4.62)	-0.66 (-0.62)	0.52 (3.24)	-0.24 (-0.75)	0.86 (6.49)	$R^2Aj= 0.81$ $F(4,22) = 8.18$ Nobs= 32 CHISQ(1) = 8.58
3 Leather and leather products	1.05 (27.79)	0.0087 (1.07)	0.36 (3.72)	-0.37 (-1.39)	0.65 (6.53)	$R^2Aj= 0.84$ $F(4,22) = 19.53$ Nobs= 32 CHISQ(1) = 0.060
4 Wood and wood products	0.69 (3.77)	0.03 (2.04)	0.30 (2.63)	-0.07 (-0.50)	0.90 (6.90)	$R^2Aj= 0.64$ $F(5,28) = 2.99$ Nobs= 39 CHISQ(2) = 0.39
5 Pulp, paper products; publishing and printing	0.55 (3.69)	0.01 (0.62)	0.46 (3.70)	0.20 (2.12)	0.33 (2.75)	$R^2Aj= 0.46$ $F(6,31) = 1.88$ Nobs= 43 CHISQ(1) = 179.19
6 Coke, refined petroleum products and nuclear fuel	0.74 (3.01)	0.13 (2.13)	0.10 (1.04)	-0.63 (-0.55)	1.10 (30.73)	$R^2Aj= 0.96$ $F(6,31) = 1.27$ Nobs= 43 CHISQ(1) = 0.014
7 Chemicals, chemical products and man-made fibres	0.73 (4.58)	-0.03 (-3.06)	0.33 (3.57)	-0.07 (-0.30)	0.86 (6.24)	$R^2Aj= 0.86$ $F(5,28) = 5.23$ Nobs= 39 CHISQ(2) = 7.99
8 Rubber and plastic products	1.53 (5.80)	-0.0089 (-0.75)	0.21 (0.74)	0.95 (1.58)	0.56 (1.70)*	$R^2Aj= 0.50$ TOVER=2.81[CORR] Nobs= 21
9 Other non-metallic mineral products	0.73 (8.63)	0.01 (1.24)	0.18 (1.73)*	0.65 (2.81)	0.82 (5.92)	$R^2Aj= 0.58$ $F(6,31) = 1.91$ Nobs= 43 CHISQ(1) = 35.93
10 Basic metals and fabricated metal products	1.13 (7.25)	-0.02 (-3.04)	0.57 (5.32)	-0.52 (-1.98)	0.35 (1.76)*	$R^2Aj= 0.83$ $F(4,22) = 13.29$ Nobs= 32 CHISQ(2) = 8.44
11 Machinery and equipment n.e.c.	0.73 (3.53)	-0.02 (-0.93)	0.93 (5.35)	-0.42 (-1.20)	0.36 (1.08)	$R^2Aj= 0.51$ TOVER=4.36[CORR] Nobs= 22
12 Electrical and optical equipment	0.84 (2.26)	0.03 (0.92)	0.36 (2.12)	-0.95 (-1.21)	0.07 (0.23)	$R^2Aj= 0.70$ TOVER=10.82[CORR] Nobs= 15
13 Transport equipment	0.25 (1.08)	-0.02 (-1.00)	0.30 (2.07)	-1.02 (-2.93)	0.43 (3.15)	$R^2Aj= 0.38$ $F(6,31) = 1.95$ Nobs= 43 CHISQ(3) = 0.64

Note. t-statistics in parentheses. 5% significance level except *at 10%. [CORR] endogeneity corrected by valid instruments. CHISQ(n) Hausman test statistic. TOVER Test of overidentifying restrictions. F () Statistic for homogeneity of individual effects hypothesis.