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Economies of scale in European manufacturing revisited

by

Espen R. Henriksen
Karen Helene Midelfart Knarvik
Frode Steen

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Economies of scale in European manufacturing revisited*

Espen R. Henriksen
Norwegian School of Economics and Business Administration
and Carnegie Mellon University

Karen Helene Midelfart Knarvik
Norwegian School of Economics and Business Administration
and CEPR

Frode Steen
Norwegian School of Economics and Business Administration

ABSTRACT:
We test for internal and external economies of scale in European manufacturing employing a more disaggregated data set than what has been used in earlier analyses, and aim to separate externalities from common business cycle effects. Fifteen European manufacturing industries in Germany, France, the U.K. and Italy are analysed. We focus on economies of scale at three levels: the national industry, the national industrial cluster, and the transnational industry. Our results suggest that external economies of scale arising from inter-industry external effects and cross-country effects are less prevalent than increasing returns at the level of the industry and firm. Our results underscore the importance of level of disaggregation in studies of internal and external economies of scale, and also that the external effects are highly country and industry specific.

J.E.L. Classification: C 33, D 24, O 47, R 12

Keywords: internal and external economies of scale, new economic geography, clusters

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Address for correspondence:
Department of Economics,
Norwegian School of Economics and Business Administration
Helleveien 30, 5045 Bergen, Norway
e-mail: karenhelene.knarvik@snf.no
frode.steen@nhh.no

NON-TECHNICAL SUMMARY

Scale economies and externalities are assumed to be important determinants of welfare and economic growth. Among the explicit arguments for further European economic integration are the potential scale economies and agglomeration gains that integration may untangle, as they allow for increased specialization among the EU countries. The gains to be reaped from an integration process with respect to increased economies of scale do, however, depend on production technology and the nature and reach of positive externalities from economic activity. Are externalities mainly mediated within or between industries? Are externalities mainly intranational or international? The answers to these questions are decisive for the impact economic integration will have on production pattern and economic growth.

In this paper we analyse internal and external economies of scale (EoS) in European manufacturing industries. Hence, we focus on economies of scale at the level of an industry (internal EoS), look at inter-industry externalities generating economies of scale at the level of national industrial clusters; and consider international intra-industry externalities between European countries. This allows us to evaluate the importance of internal versus external economies of scale, and the importance of intranational interindustry externalities relative to international intraindustry externalities.

The nature and reach of scale economies and externalities have been the subject of a number of studies during the recent years. There is a large number of studies of *R&D spillovers*, while closest in methodology to the present work are the contributions by Caballero and Lyons which analyse *activity-based* externalities within the context of EU and U.S. manufacturing.

The empirical evidence on external and internal economies of scale is, however, conflicting. The reason for differences in results may be explained by different methods, different aggregation levels of the data sets, or by regional, country, and industry-specific differences in economies of scale. The objective of this paper is to add to the ongoing debate on economies of scale: their presence, their magnitude, and sources. With a considerably more disaggregated data set than those which have been used to analyse economies of scale in European manufacturing before, we analyse economies of scale in European manufacturing. In order to avoid a potential bias towards increa
sing returns, we use gross output data instead of value added data. Moreover, we aim at improving the methodology further by including a range of parameters representing industry, industrial cluster and country specific effects. Including the latter parameters allows us to separate real externalities from effects from common business cycles in a more satisfactory way.

Our dataset covers fifteen three- and four-digit manufacturing industries in four European countries (Germany, France, the U.K., and Italy) for the period 1970 to 1995. We group the industries into four clusters – groups of related industries – according to apparent input-output and technology linkages: textiles & leather, machinery & electronics, transport, and high-tech industries. We estimate 16 different industry systems (four industry clusters in each of the four countries), providing us with a considerable amount of cross-industry and cross-country information on economies of scale and possible spillovers within European manufacturing. The model we employ allows for estimation of internal economies of scale at the industry

level, external economies of scale at the level of the industrial clusters, and cross-country intra-industry external effects.

Our empirical analysis of economies of scale in European manufacturing shows that previous results on economies of scale and short-run activity based spillovers are not robust to level of industrial aggregation – and underlines the importance of using disaggregated data when investigating externalities empirically.

The reported evidence on externalities in EU manufacturing suggests that on average domestic interindustry positive externalities are of similar importance as are international intraindustry positive externalities. Nevertheless, we note that domestic inter-industry externalities dominate international intraindustry externalities in the high-tech industry group, while the opposite is true for the transport equipment group of industries. German manufacturing was found to experience a substantial degree of inter-industry externalities within national industrial clusters, as well as to be a major receiver of international intra-industry spillovers from other European countries.

However, external economies of scale – regardless of source – are considerably less prevalent than are internal economies of scale arising from increasing returns at the level of the national industry or firm. This suggests that positive externalities are, thus, limited in reach in a geographical as well as technological sense.

The evidence on both internal and external economies of scale supports the view that there are significant differences across industries and industrial clusters regarding the level at which economies of scale are present; their magnitude; and the source of economies of scale. In general, the splitting of industries into groups – industrial clusters – according to linkages and technology, seems as a promising approach, in the sense that it allows for more insight into the prevalence – and nature – of externalities and economies of scale.

1. INTRODUCTION

Scale economies and externalities are assumed to be important determinants of welfare and economic growth. Among the explicit arguments for further European economic integration are the potential scale economies and agglomeration externalities that integration may untangle, as they allow for increased specialization among the EU countries. The gains to be reaped from an integration process with respect to increased economies of scale, do however, depend on production technology and the nature and reach of positive externalities from economic activity. Are externalities mainly mediated within or between industries? Are externalities mainly intranational or international? The answers to these questions are decisive for the impact economic integration will have on production pattern and economic growth.

In this paper we analyse internal and external economies of scale (EoS) in European manufacturing industries. Hence, we focus on economies of scale at the level of an industry (internal EoS), look at inter-industry externalities generating economies of scale at the level of national industrial clusters; and consider international intra-industry externalities between European countries. This allows us to evaluate the importance of internal versus external economies of scale, and the importance of intranational interindustry externalities relative to international intraindustry externalities.

The nature and reach of scale economies and externalities have been the subject of a number of studies during the recent years. There are a large number of studies of *R&D spillovers*,[1] while closest in methodology to the present work are the contributions by Caballero and Lyons (1990, 1991, and 1992) that analyse *activity-based* externalities within the context of EU and U.S. manufacturing. Hence, we shall mainly refer to the latter studies for comparisons.

In their European studies Caballero and Lyons looked at economies of scale in a number of two-digit industries in four EU countries. They distinguished between economies of scale that are external and internal to an industry – the former arising from inter-industry externalities. Evidence of external economies of scale was found in all four countries, but hardly any signs of internal economies of scale. One major criticism against the method employed by Caballero and Lyons, though, is the potential bias towards increasing returns resulting from the use of value added as regressand, which leaves important production factors as parts of the residual (see Basu and Fernald, 1995). Analysing the same set of European countries and industries as Caballero and Lyons, but using gross output instead of value added data, Basu and Fernald report little findings of externalities and strong evidence of internal economies of scale being constant.

However, analysing Canadian data with a methodology similar to that of Basu and Fernald, Benarroch (1997) finds external economies of scale. Evidence on activity based externalities is also found by Bartelsman, Caballero, and Lyons (1994), who use gross output data for four-digit U.S. manufacturing industries. With a disaggregated dataset for a set of closely linked Norwegian maritime industries, Midelfart-Knarvik and Steen (1999) extend the method suggested by Caballero and Lyons, and Basu and Fernald further. By including variables representing technological development and trends common to the industries, they seek to disentangle common business cycles from real externalities. Moreover, their formulation is more flexible, and allows for tests of external economies of scale at different levels. Their results indicate significant external economies of scale within sub-clusters of the Norwegian maritime industries.

[1] See Griliches (1992) and Mohnen (1998) for surveys of this literature.

The empirical evidence on external and internal economies of scale is, thus, conflicting. The reason for differences in results may be explained by different methods, different aggregation levels of the data sets, or by regional, country, and industry-specific differences in economies of scale. The objective of this paper is to add to the ongoing debate on economies of scale: their presence, their magnitude, and sources. With a considerably more disaggregated data set than that of Caballero and Lyons (1990, 1991) and Basu and Fernald (1995), we analyse economies of scale in European manufacturing. Following Basu and Fernald we use gross output data, and moreover we aim at improving the methodology further by including a range of parameters representing industry, industrial cluster and country specific effects. Including the latter parameters allows us to separate real externalities from effects from common business cycles in a more satisfactory way.

Our dataset covers fifteen three- and four-digit manufacturing industries in four European countries (Germany, France, the U.K., and Italy) for the period 1970 to 1995. We group the industries into four clusters – groups of related industries – according to apparent input-output and technology linkages: textiles & leather, machinery & electronics, transport, and high-tech industries.[2] We estimate 16 different industry systems (four industry clusters in each of the four countries) including a total of 70 industry equations, providing us with a considerable amount of cross-industry and cross-country information on economies of scale and possible spillovers within European manufacturing. The model we employ allows for estimation of internal economies of scale at the industry level, external economies of scale at the level of the industrial clusters, and cross-country intra-industry external effects.

[2] The high-tech cluster includes the entire machinery & electronics cluster and two other industries. See the appendix for details on industries included in each of the clusters.

Our analysis suggests that external economies of scale arising from intranational inter-industry or international intra-industry external effects are less prevalent in European manufacturing than are economies of scale arising from increasing returns at the level of the national industry or firm. This suggests that positive externalities are limited in geographical as well as technological reach, i.e. are predominantly enjoyed by firms within the same national industry. We find that domestic inter-industry externalities dominate international intraindustry externalities in the high-tech industry group, while the opposite is true for the transport equipment group of industries. Finally, German manufacturing was found to experience a substantial degree of inter-industry externalities within national industrial clusters, as well as to be a major receiver of international intra-industry spillovers from other European countries. Hence, our results underscore the fact, which has also been emphasized by for instance Mohnen (1998) in his review of the literature on R&D spillovers, that the prevalence, and magnitude, of external effects are indeed country as well as industry specific.

2. THE EMPIRICAL MODEL

We test for economies of scale working at different levels: (a) at the industry level; (b) at the level of national industrial clusters – defined by a set of related industries; and (c) at the transnational level of an industry. In order to allow for such a test, we need a model that discriminates between economies of scale that are internal or external to a national industry. Drawing on the work of Caballero and Lyons (1990), and Basu and Fernald (1995) the production function is given by

$$Q = F(L, K, M, E, V), \tag{1}$$

where output (Q) in an industry is defined as a function of the inputs labour (L), capital (K), intermediates (M), the state of technology (V), as well as activity based externalities (E), that spill over from national and foreign firms. Note that activity based externalities may include pure as well as pecuniary externalities (see Griliches, 1992; and Scitovsky, 1954). We do not make any attempt here to separate between the two types, since this is secondary to the present focus.

Empirical productivity studies tend to use value added instead of gross value of output as left hand side variable. However, Basu and Fernald (1995) show that in the presence of increasing returns to scale and/or imperfect competition, the use of value added as regressand may lead to spurious findings of large apparent externalities. Hence, following Basu and Fernald we employ gross value of output as regressand and assume F to be homogenous of degree γ in L, K, and M, and use log differences as approximation for logarithmic derivatives. Letting $\Delta l = \ln L_t - \ln L_{t-1}$, we define the input aggregate $\Delta x \equiv s_L \Delta l + s_K \Delta k + s_M \Delta m$, where s_L, s_K, s_M denote cost shares, *e.g.* $s_L = wL/\left(wL + P_K K + P_M M\right)$, and reformulate (1) as:

$$\Delta q_i^k = \gamma \Delta x_i^k + \beta \Delta e_i^k + \eta \Delta v_i^k , \tag{2}$$

with subscript *i* referring to the industry, and superscript *k* to the country. γ measures internal returns to scale, i.e. economies of scale at the level of the industry. Since we are working with industry – not firm – data, γ has no unambiguous interpretation: $\gamma > 1$ may imply (i) increasing returns at the level of the firm, (ii) economies of scale external to the firm but internal to the industry, or (iii) be the outcome of entry and exit (see Klette, 1999). β expresses the presence of economies of scale that are external to an industry. β>0 depicts external economies of scale, while β<0 depicts external diseconomies of scale. We consider two potential sources of externalities generating external economies of scale: (a) activity in related industries within the same country; and (b) activity in the same industry in other EU countries. While (a) refers to economies of scale at the level of national industrial clusters, (b) refers to economies of scale working at the transnational level of an industry. We accordingly decompose the external economies of scale term into:

$$\Delta e_i^k = \Delta\tilde{q}_i^k + \Delta\hat{q}_i^k + \Delta u_{1i}^k \tag{3}$$

with $\tilde{q}_i^k = \ln\left(\sum_{j\neq i} Q_i^k\right)$ and $\hat{q}_i^k = \ln\left(\sum_{l\neq k} Q_i^k\right)$.

The two external economies of scale variables ($\Delta\tilde{q}_i^k$ and $\Delta\hat{q}_i^k$) represent the growth rate of aggregate output of all the other industries within the same national industrial cluster ($\Delta\tilde{q}_i^k$), and the growth rate of output in the same industry in other EU countries ($\Delta\hat{q}_i^k$). Δu_{1i}^k reflects any departure from a deterministic relationship between the growth of aggregate output and external economies of scale.

The productivity term (Δv_i^k), measuring technological progress, can be decomposed into orthogonal aggregates representing productivity development common to all industries in country k (Δv^k), and to all activity in industry i regardless of country of location (Δv_i) respectively, and an idiosyncratic component (Δu_{2i}^k):

$$\Delta v_i^k = \Delta v^k + \Delta v_i + \Delta u_{2i}^k\,. \tag{4}$$

Adding up the information in the expressions (2), (3), and (4), and including a time subscript (t) we have that

$$\Delta q_{it}^k = \alpha_i^k + \gamma\Delta x_{it}^k + \beta_1\Delta\tilde{q}_{it}^k + \beta_2\Delta\hat{q}_{it}^k + \eta_1\Delta v_t^k + \eta_2\Delta v_{it} + \Delta u_{it}^k\,. \tag{5}$$

with $\Delta u_{it}^k = \beta\Delta u_{1it}^k + \eta\Delta u_{2it}^k$.

We estimate equation (5) using Zellner's seemingly unrelated regressions (SURE). To allow for possible differences across industries and countries not accounted for in the other variables, the constant term is allowed to vary according to industry and country.[3] The appendix provides details on the calculation of cost shares – used to construct the input aggregates - and on how the other variables are created.

We will let $\tilde{\mathbf{q}}$ and $\hat{\mathbf{q}}$ be vectors of external economies of scale variables; $\tilde{q}_i$ and $\hat{q}_i$, and consistent with the above definition, they will be industry and country specific (β_1, β_2>0 indicate external economies of scale). Earlier analyses, see Caballero and Lyons (1990, 1991), let the external variable be a vector over non-industry-specific aggregates of manufacturing industries in a country. As a consequence, the industry *i* is actually "counted twice". Here, own output is never included in the external economies of scale variable. Thus, the model is more consistent with economic theory and the endogeneity problem arising from "double counting" is avoided.

The chosen formulation is flexible in the sense that it allows us to carry out different tests of external economies of scale. First, it enables us to test how each industry depends on the activities of other industries within an industrial cluster. Second, it allows us to test for cross-country effects. Hence, we are able to discriminate between national inter-industry effects and international intra-industry external effects.

Data

We focus on four groups of related industries, employing three digit manufacturing time series data. The data set contains annual data for the period 1970-1995 from the OECD STAN (Structural Analysis Database) and OECD ISDB (International Sectoral Database). The industry groups are:

[3] Allowing for different constant terms in a SURE system corresponds basically to a fixed effect panel data model.

(1) Textiles and leather [4 industries],

(2) Machinery and electronics [3 industries],

(3) Transport equipment [6 industries],

(4) High-tech [5 industries].

Number of three digit industries within each group is given in square brackets, and the appendix provides further details. Like Caballero and Lyons and Basu and Fernald we use time series for Germany (West), the U.K. and France. But unlike them, we leave out Belgium, and include one of the Southern European countries instead, namely Italy. Ideally we would have liked to include all EU countries in our sample, but data availability prevents us from doing so.

Econometric issues

Measured inputs tend to fluctuate less than measured output. Hence, it might be difficult to disentangle whether the impact of $\tilde{\mathbf{q}}$ and $\hat{\mathbf{q}}$ actually indicates externalities, or whether it is just the result of shocks – common to all industries in a country, or to all activity in this industry in Europe. This might lead to unmeasured fluctuations in the utilization of various inputs and effort levels (Grilliches, 1991). In productivity analyses it is moreover common to let the error term be defined by the aggregate of the last three right hand side variables in (5). Defining the error term as such an aggregate implies that it may be difficult to disentangle general economy wide shocks common to all industries in a country from real externalities. And similarly, international shocks affecting specific industries may also be difficult to separate from external economies at the transnational level.

To mitigate these problems we use information on variables that represent important determinants of the country and industry specific business cycles to disentangle $\Delta\mathbf{v}^{\mathbf{k}}$ and

$\Delta\mathbf{v}_i$ from the error term. First, we let $\Delta\mathbf{v}^k$ be a matrix of the change in real GDP, GDP trend, and the real exchange rate between the home currency and US$ for each country, the latter is included to correct for demand changes resulting from changes in the exchange rate. GDP trend was estimated using Hodrick-Prescott-filter on the country observations.[4] $\boldsymbol{\eta}_1$ then consists of three parameters; η_{1GNP}, $\eta_{1\Delta GNP}$, and η_{1ER}. The three parameters are allowed to differ across industries to account for industry specific heterogeneity not captured in the model. Second, $\Delta\mathbf{v}_i$ is defined as a matrix of variables that are exogenous to the industries, but that represent important determinants of the analysed industries' business cycles. Hence, we use industry specific business cycle indicators. These indicators include a cotton price index for textiles and wearing apparel; an index for price of hide for leather products and footwear; price indices for copper and tin for machinery & electronics and high-tech industries; and the price of Brent Blend crude oil as well as a general metal price index for transport industries.

3. RESULTS

Let us first briefly review the evidence on internal and external economies of scale in Europe based on the studies by Caballero and Lyons (1990, 1991), and Basu and Fernald (1995). These studies examine internal and external economies of scale in four EU countries – France, West Germany, the U.K., and Belgium for the period 1970-86;[5] and employ 2 digit manufacturing data. Caballero and Lyons find no evidence of internal increasing returns to scale, but clear evidence of external economies of scale arising from inter-industry

[4] Originally we also included a linear time trend. As a result of the high correlations between estimated Hodrick-Prescott GDP trends and a linear time trend, the linear trend was omitted.
[5] For West Germany, the time series for the period 1960-1986 are used.

externalities within a country (Caballero and Lyons, 1990), and mild evidence of cross country intra-industry externalities (Caballero and Lyons, 1991).

The results on economies of scale obtained by Caballero and Lyons are, however, contradicted by Basu and Fernald (1995), who point out that the use of value added data may lead to spurious findings of large apparent external effects and to a downward-biased estimate of internal increasing returns to scale. Basu and Fernald employ the same European data as Caballero and Lyons, but use gross output instead of value added. They find no evidence of external economies of scale – in the sense of inter-industry external effects, and strong evidence that internal returns are approximately constant. We are left with a picture of a European manufacturing sector that is characterised by essentially constant returns to scale and no short-run spillovers.

How robust is this picture to the level of industrial aggregation used in the empirical analyses? This is one of the main questions addressed here. It is widely believed that externalities may be limited in reach – i.e. mainly accrue to similar activities – in which case the level of aggregation is essential to empirical analyses of economies of scale. Hence, we proceed by studying economies of scale in Europe at a considerably more disaggregated level than what has been done in previous work, and examine the impact this has on the empirical evidence.

We focus on four groups of related industries, employing three digit manufacturing data, with the time period stretching from 1970 to 1995. Details on data and industries are given in the appendix. The industry groups were described in the previous section, and include: Textiles and leather, Machinery and electronics, Transport equipment, and High-tech.

3.1 Internal Economies of scale

Results on internal economies of scale are reported by industry and country in Tables 1a – 1d. In more than 50% of the cases the point estimate of γ is significantly greater than one – reflecting increasing returns to scale at the industry level and/or firm level.[6] Compared to the existing evidence on internal economies of scale in Europe, our findings illustrate that one should be careful when drawing general conclusions with respect to economies of scale, as these are highly sensitive to level of industrial aggregation.

{Tables 1a, 1b, 1c, and 1d, approximately here}

Are there differences across countries with respect to findings on increasing returns to scale? If we were to use micro (firm) data, we would *a priori* not expect to see major differences in internal economies of scale across EU countries – based on the presumption that there are minor technology differences between these countries. However, as we are employing industry data, variation in internal economies of scale across countries may just as well reflect that within some national industries there are more positive externalities being generated than in others. This may for instance rely on differences in how firms within an industry interact, and how closely they are connected through different channels. Internal economies of scale are found to be especially strong in French manufacturing, and also present in quite a few U.K. manufacturing industries. This may suggest a greater extent of localized inter-firm positive externalities in these countries relative to other EU countries. France separates from the rest

[6] Actually, as many as 43 out of 48 industry estimates are larger then 1, and 26 of these significantly larger then 1.

especially with respect to the Wearing apparel, Radio, TV & communication, and Aircraft industries.

Comparing different *groups* of industries, we find that increasing returns are especially prevalent in the textile & leather group, as well as in transport industries. In the textile & leather group we find significant increasing returns in 56% of the cases; 9 out of 16, whereas in the transport industries the figure is 64% with significant increasing internal returns in 14 out of 22 cases. Only one third of the industries within the two other groups exhibited increasing returns to scale. The use of industry and not firm data means that findings on internal economies of scale may reflect economies of scale at the firm and/or industry level, or merely be due to entry and exit. But the review of information on returns to scale from other studies does, nevertheless, allow for a more precise interpretation of our results. Pratten (1988) provides estimates of returns to scale at the firm level. According to his rankings, textile and leather firms' technology is characterised by rather small returns to scale, whereas transport industries typically rank very high in terms of increasing returns in production. This suggests that the findings on high internal economies of scale at the industry level in textile and leather industries are more likely to reflect economies of scale external to the firm – but internal to the industry. In contrast, significant internal economies of scale in transport industries may reflect economies of scale at the firm as well as at the industry level, or possibly just at the firm level.

3.2 External economies of scale in industrial clusters: Inter-industry externalities

We next look at inter-industry externalities within national industrial clusters of related industries. The evidence on external economies of scale is mixed: approximately half of the estimates are positive, suggesting increasing returns external to the industries but internal to the industrial clusters. However, only 16 out of a total of 70 estimates are *significantly* positive at a 10% level. The results are presented in Tables 2a to 2d.

{Tables 2a, 2b, 2c, and 2d, approximately here}

There are rather distinct differences across countries and industries. Inter-industry externalities – generating economies of scale at the level of national industrial clusters – are more prevalent in Germany than in France, Italy and the U.K. In Germany we find indication of externalities in two thirds of the cases, and 7 out of 12 cases are significant at a 5% level. Table 2e furthermore reveals the extent to which there are systematic differences across groups of industries. It provides a summary of estimated parameter signs and significance levels. The high-tech cluster ranks number one in terms of prevalence of inter-industry externalities. However, even here, only 20% of the cases indicate significant positive externalities. Textile and leather rank number two, but we note that the magnitude of the estimated coefficients is considerably less than in the high-tech group. Another interesting feature is that in the machinery & electronics group β_1 is either positive or zero. No β_1's are found to be significantly negative. Within the transport equipment cluster we find the least evidence of positive inter-industry externalities, and more significantly negative than significantly positive β_1's.

{Table 2e approximately here}

The most outstanding industry when it comes to enjoying externalities from other industries, is Radio, TV & Communication Equipment (3832). In the high-tech system (Table 2d, second row) all β_1's are positive and two of them significant. The same pattern, but less significant, can be seen in the machinery & electronics system (Table 2b, second row), where 3 out of 4 β_1's are positive.

Comparing the results on external economies of scale arising from national inter-industry externalities with those on internal economies of scale, we observe that in most industries and countries there is more evidence on economies of scale at the industry level than at the level of the industrial cluster. There are two notable exceptions: the Radio, TV and communication industry distinguishes itself from other industries, and Germany separates from other countries. The combined evidence on internal and external economies of scale suggests that in these cases inter-industry externalities may be at least as important as intra-industry externalities to firms.

3.3 International external economies of scale: Cross-country externalities

Turning to international intra-industry externalities in European manufacturing the overall picture is also mixed, with both negative and positive, insignificant and significant estimates. The percentage of parameter estimates that is significantly positive is almost the same as what we reported for national inter-industry externalities. Tables 3a, 3b, 3c and 3d report cross country effects for industries within the respective industrial cluster, and should be read as follows: the source of cross country externalities is found in the rows, while receiving countries are ordered by column.

{Tables 3a, 3b, 3c, and 3d, approximately here}

Again, it is instructive to consider individual countries and industries. While examining intra-national, inter-industry externalities in the preceding subsection, we found that one country – Germany – dominated the picture. Also in the context of international, intra-industry effects, Germany stands out. German industry dominates as a receiver of positive externalities from other EU countries. However, when it comes to generating international positive externalities that benefit the rest of the EU, Germany is not found to be a particularly important source country.

{Tables 3e approximately here}

In Table 3e we have summarised the cross-country effects in order to reveal distinct differences across industry groups. The transport equipment industries have the highest relative number of positive externality parameters when looking at international intraindustry effects. Another interesting feature is that the transport equipment clusters seem to be characterised by relatively more international intraindustry than domestic interindustry externalities. In this sense, this industry group distinguishes itself from the textile & leather, machinery & electronics, and high-tech industries, where positive domestic inter-industry externalities appear more prevalent than positive international intraindustry externalities (see Tables 2e and 3e).

The evidence on both negative and positive international external effects in European manufacturing suggests that to the extent that there are significant cross-country effects, competition effects are just as important as positive external effects. The data lend some support to a characterisation of industrial groups according to positive and negative cross-country effects, and particularly in the textiles and leather industries competition effects seem to dominate.[7]

Using a constrained model with parameter estimates restricted to be equal across industries and countries, Caballero and Lyons (1991) found positive – but insignificant – cross country external effects. Our results are somewhat more encouraging. When employing more disaggregated industry data we find signs of cross-country effects – especially within the transport equipment industries.

To ensure robustness of our model against possible existence of autocorrelation, we carried out Ljung-Box tests for autocorrelation (Ljung and Box, 1979). We have a total of 16 SURE systems with altogether 70 equations. We have undertaken tests for all the equations, and could reject autocorrelation in 68 of the cases.[8]

4. CONCLUSIONS

Our empirical analysis of economies of scale in European manufacturing shows that previous results on economies of scale and short run activity based spillovers are not robust to level of industrial aggregation – and underlines the importance of using disaggregated data when investigating externalities empirically.

The reported evidence on externalities in EU manufacturing suggests that on average domestic interindustry positive externalities are of similar importance as are international intraindustry positive externalities. Nevertheless, we note that domestic inter-industry

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[7] This finding matches that of Midelfart-Knarvik *et al.* (2000), who state that textile and leather represent slow growing industries, where there has been an extensive amount of relocation across European borders over the last decades.

[8] The Ljung-Box test for autocorrelation was performed at different lag levels according to STATA's automatic lag determining algorithm. We also fixed the lag length to one and two lags (first and second order autocorrelation), only a few more equations showed autocorrelation. However, we could reject autocorrelation at a 1% and 2.5% significance level in most of these "extra" cases.

externalities dominate international intraindustry externalities in the high-tech industry group, while the opposite is true for the transport equipment group of industries. German manufacturing was found to experience a substantial degree of inter-industry externalities within national industrial clusters, as well as to be a major receiver of international intra-industry spillovers from other European countries.

However, external economies of scale – regardless of source – are considerably less prevalent than are internal economies of scale arising from increasing returns at the level of the national industry or firm. This suggests that positive externalities are, thus, limited in reach in a geographical as well as technological sense.

The evidence on both internal and external economies of scale supports the view that there are significant differences across industries and industrial clusters regarding the level at which economies of scale are present; their magnitude; and the source of economies of scale. In general, the splitting of industries into groups – industrial clusters – according to linkages and technology, seems as a promising approach, in the sense that it allows for more insight into the prevalence – and nature – of externalities and economies of scale.

REFERENCES

Bartelsman, E. J., R. J. Caballero, and R. K. Lyons (1994), "Customer- and supplier-driven externalities", *American Economic Review* 84, 1075-1084.

Basu, S. and J. G. Fernald (1995), "Are apparent productive spillovers a figment of specification error?", *Journal of Monetary Economics* 36, 165-188.

Benarroch, M. (1997), "Returns to scale in Canadian Manufacturing: An interprovincial comparison", *Canadian Journal of Economics* 30, 1083-1103.

Caballero, R. J. and R. K. Lyons (1990), "Internal versus external economies in European industry", *European Economic Review* 34, 805-830.

Caballero, R. J. and R. K. Lyons (1991), "External effects and Europe's integration", in L. A. Winters and A. J. Venables (eds.)*, European integration: trade and industry* (CEPR), Cambridge University Press, Cambridge.

Caballero, R. J. and R. K. Lyons (1992), "External effects in U.S. procyclical productivity", *Journal of Monetary Economics* 29, 209-225.

Griliches, Z. (1991), "Comments on the Caballero-Lyons paper", unpublished manuscript.

Griliches, Z. and V. Ringstad (1971), *Economies of scale and the form of the production function: An econometric study of Norwegian manufacturing establishment data*, North-Holland, Amsterdam and London.

Klette, T. J. (1999), "Estimating price-cost margins and scale economies from a panel of microdata", *Journal of Industrial Economics* 47, 451-476.

Ljung, G. and G. Box (1979), "On measure of lack of fit in time series models", *Biometrika* 66, 265-70.

Midelfart-Knarvik, K. H. and F. Steen (1999), "Self-reinforcing Agglomerations? An Empirical Industry Study" *Scandinavian Journal of Economics*, 101, 515-32.

Midelfart-Knarvik, K. H., H. G. Overman, S. J. Redding, and A. J. Venables (2000), "The location of European industry", Discussion paper no. 142, European Commission, DG for Economic and Financial affairs, April 2000.

Mohnen P., (1998), "International R&D spillovers and economic growth", mimeo Université du Quebec à Montreal.

Pratten, C. (1988), "A survey of the economies of scale", in Commission of the European Communities: Research on the "cost of non-Europe", vol. 2: Studies on the economics of integration.

APPENDIX: DATA AND INDUSTRIES

The data set uses annual data for the period 1970 - 1995 from the OECD STAN (Structural Analysis Database) and OECD ISDB (International Sectoral Database) databases.

Growth in output, labour, capital, and materials was calculated using gross value of output, employment (including number of employees as well as self-employed, owner proprietors and unpaid family workers), gross fixed capital formation, and gross value of output minus value added as a measure for materials. Measuring growth, deflated values were used throughout. The country and industry specific deflators used were the implied price index in the data series – derived using value added in current prices and value added at fixed prices.

Cost shares necessary to construct the input aggregate were calculated applying the Tornquist approximation to the continuous time Divisia index. To compute cost shares, we used nominal values of labour compensation (which include wages as well as the costs of supplements such as employer's compulsory pension or medical payments), materials (gross value of output minus value added), and capital services. Necessary for the cost share of capital to be calculated is an estimation of capital services. To estimate capital services, we adopted a method similar to the one suggested by Griliches and Ringstad (1971) and Klette (1999), but where rental cost of capital is not included. In our dataset, costs related to the renting of physical capital are included in the intermediate aggregate.

Industrial industries and Industry groups – defining industrial clusters

	ISIC rev.2 code	Industrial sector description
Textiles	321	Textiles
	322	Wearing apparel
	323	Leather and leather products
	324	Footwear
Machinery & Electronics	382	Non-electrical machinery
	3832	Radio, TV and communication equipment
	3839	Electrical apparatus, nec
Transport	3841	Shipbuilding and repairing
	3842	Railroad equipment
	3843	Motor vehicles
	3844	Motorcycles and bicycles
	3845	Aircraft
	3849	Transport equipment not else specified
High Tech	382	Non-electrical machinery
	3832	Radio, TV and communication equipment
	3839	Electrical apparatus, nec
	3845	Aircraft
	385	Professional goods

Capital services are given by $P_{K_i} K_i = (\rho + \delta_i) K_i$, where ρ is the real rate of return, and is set to be 0.07 to approximate the average real rate of return to physical capital in manufacturing; δ_i is the country and industry specific depreciation rate, calculated for each industrial sector in each country from the given average service life of capital in ISDB; and K is the real value of the estimated capital stock.

To accommodate country specific business cycles, we used:

(i) Series for GDP for each country (source: International Financial Statistics);

(ii) Real exchange rates of local currency relative to US dollars (source: International Financial Statistics);

(iii) GDP trends; estimated using Hodrick-Prescott filter on quarterly data with lambda 100.

As a result of the linearity of the estimated trends in (iii), additional trends were dropped. Among the other country specific variables we experimented with – but rejected due to insignificant impact – were national stock market indices.

To accommodate sector specific business cycles, a range of different variables were used:
In addition to the variables listed below, a range of other variables were tested, but rejected. Among these were stock market industry indices. In order to distinguish between the exchange rate effect and the effect of the price changes, all the employed variables were first converted into national currencies and then used on difference form. The variables were:

Industries	**Variable**	**Source**
Textiles (321) and Wearing apparel (322)	Cotton Liverpool Index	IFS
Leather (323) and Footwear (324)	Hides U.S. Chicago	IFS
Machinery & electronics and High-tech industries	Copper U.K. Tin all origins	IFS IFS
Transport industries	Brent Blend crude oil Metal index	Econwin Econwin

Table 1a: Internal economies of scale (γ): Textiles & leather

		Germany	France	Italy	UK
321	Textiles	1.377 ***†	1.214 ***†	1.066 *	1.240 ***†
		(0.063)	(0.057)	(0.044)	(0.058)
322	Wearing apparel	1.015	1.267 ***†	1.019	0.938
		(0.060)	(0.092)	(0.033)	(0.074)
323	Leather & products	1.081 **	1.233 ***†	0.967 **	1.123 **†
		(0.043)	(0.050)	(0.015)	(0.049)
324	Footwear	1.002	1.302 ***†	1.001	1.247 **†
		(0.067)	(0.089)	(0.045)	(0.107)

Note: Standard errors reported in brackets.
*significance level 90%, **significance level 95%, ***significance level 99%, referring to two sided test $\gamma \neq 1$.
†indicates increasing returns to scale ($\gamma > 1$) at a 97.5% significance level

Table 1b: Internal economies of scale (γ): Machinery & Electronics

		Germany	France	Italy	UK
382	Non-electrical machinery	1.366 ***†	1.086	0.934 **	1.246 **
		(0.084)	(0.104)	(0.025)	(0.114)
3832	Radio, TV & communication	0.609 ***	1.250 **†	0.694 ***	1.088 **
		(0.054)	(0.096)	(0.052)	(0.043)
3839	Electrical apparatus, nec.	0.895	0.934	0.977	1.001
		(0.076)	(0.062)	(0.039)	(0.070)

Note: Standard errors reported in brackets.
*significance level 90%, **significance level 95%, ***significance level 99%, referring to two sided test $\gamma \neq 1$.
†indicates increasing returns to scale ($\gamma > 1$) at a 97.5% significance level

Table 1c: Internal economies of scale (γ): Transport equipment

		Germany	France	Italy	UK
3841	Shipbuilding & repairing	0.995	1.528 ***†	1.306 ***†	1.907 ***†
		(0.094)	(0.128)	(0.026)	(0.087)
3842	Railroad equipment	1.379 **†	1.314 **†	1.298 ***†	
		(0.147)	(0.141)	(0.101)	
3843	Motor vehicles	1.247 ***†	1.221 **†	0.978	1.167 ***†
		(0.074)	(0.089)	(0.038)	(0.022)
3844	Motorcycles & bicycles	0.965	1.153 *	1.126 ***†	1.333 **†
		(0.027)	(0.105)	(0.030)	(0.124)
3845	Aircraft	1.029	1.506 ***†	1.126 ***†	1.040
		(0.207)	(0.097)	(0.032)	(0.044)
3849	Transport equipment, nec.	0.774 ***		1.119 **	1.186 *
		(0.063)		(0.061)	(0.103)

Note: Standard errors reported in brackets.
*significance level 90%, **significance level 95%, ***significance level 99%, referring to two sided test $\gamma \neq 1$.
†indicates increasing returns to scale ($\gamma > 1$) at a 97.5% significance level

Table 1d: Internal economies of scale (γ): High-tech industries

		Germany	France	Italy	UK
382	Non-electrical machinery	1.369 ***†	1.177 **	0.901 ***	1.185 ***†
		(0.087)	(0.087)	(0.026)	(0.053)
3832	Radio, TV & communication	0.588 ***	1.215 **†	0.721 ***	1.055 *
		(0.049)	(0.082)	(0.047)	(0.037)
3839	Electrical apparatus, nec.	0.892 *	1.009	0.974	0.990
		(0.068)	(0.054)	(0.038)	(0.061)
3845	Aircraft	0.907	1.275 **	1.225 ***†	1.066
		(0.131)	(0.141)	(0.046)	(0.052)
385	Professional goods	1.134	0.898	0.823 ***	1.158 **†
		(0.145)	(0.260)	(0.040)	(0.068)

Note: Standard errors reported in brackets.
*significance level 90%, **significance level 95%, ***significance level 99%, referring to two sided test $\gamma \neq 1$.
†indicates increasing returns to scale ($\gamma > 1$) at a 97.5% significance level

Table 2a: External economies of scale (β_l); within country and cluster: Textiles & leather

		Germany	France	Italy	UK
321	Textiles	-0.043	0.076 **	0.001	-0.254 ***
		(0.052)	(0.031)	(0.038)	(0.061)
322	Wearing apparel	0.093 **	-0.092	0.092 *	-0.069
		(0.050)	(0.084)	(0.053)	(0.069)
323	Leather & products	-0.106	0.084	0.084 **	-0.182 **
		(0.089)	(0.085)	(0.041)	(0.080)
324	Footwear	0.009	0.040	-0.029	-0.408 ***
		(0.077)	(0.082)	(0.059)	(0.133)

Note: Standard errors reported in brackets.
*significance level 90%, **significance level 95%, ***significance level 99%, two sided test.

Table 2b: External economies of scale (β_l); within country and cluster: Machinery & electronics

		Germany	France	Italy	UK
382	Non-electrical machinery	-0.127	-0.031	-0.051	-0.033
		(0.128)	(0.116)	(0.046)	(0.122)
3832	Radio, TV & communication	0.063	0.122 *	0.124	-0.023
		(0.059)	(0.073)	(0.127)	(0.040)
3839	Electrical apparatus, nec.	0.170 **	0.309 **	-0.010	0.046
		(0.071)	(0.124)	(0.039)	(0.063)

Note: Standard errors reported in brackets.
*significance level 90%, **significance level 95%, ***significance level 99%, two sided test.

Table 2c: External economies of scale (β_l); within country and cluster: Transport equipment

		Germany	France	Italy	UK
3841	Shipbuilding & repairing	-0.153	-0.165	-0.376 ***	-0.090
		(0.156)	(0.372)	(0.115)	(0.087)
3842	Railroad equipment	0.521 **	0.152	-0.220	
		(0.250)	(0.274)	(0.322)	
3843	Motor vehicles	0.023	-0.048 *	-0.014	0.035 **
		(0.036)	(0.031)	(0.018)	(0.015)
3844	Motorcycles & bicycles	-0.019	-0.250 *	-0.137 *	-0.767 **
		(0.065)	(0.164)	(0.089)	(0.309)
3845	Aircraft	0.192	-0.288 *	-0.363 ***	-0.108
		(0.173)	(0.190)	(0.075)	(0.077)
3849	Transport equipment, nec.	0.497 ***		-0.397 ***	0.015
		(0.113)		(0.111)	(0.232)

Note: Standard errors reported in brackets.
*significance level 90%, **significance level 95%, ***significance level 99%, two sided test.

Table 2d: External economies of scale (β_1); within country and cluster: High-tech industries

		Germany	France	Italy	UK
382	Non-electrical machinery	-0.128	-0.154 **	-0.166 **	0.028
		(0.126)	(0.069)	(0.062)	(0.044)
3832	Radio, TV & communication	0.049	0.114 *	0.213 *	0.015
		(0.058)	(0.066)	(0.149)	(0.035)
3839	Electrical apparatus, nec.	0.199 ***	0.067	-0.039	0.073
		(0.063)	(0.097)	(0.054)	(0.058)
3845	Aircraft	0.650 ***	-0.535 *	0.699 ***	0.041
		(0.194)	(0.352)	(0.146)	(0.135)
385	Professional goods	0.600 ***	-0.361 *	-0.043	-0.146 **
		(0.168)	(0.199)	(0.075)	(0.073)

Note: Standard errors reported in brackets.
*significance level 90%, **significance level 95%, ***significance level 99%, two sided test.

Table 2e: A summary of the external economies of scale results within country and industrial cluster (based on tables 2a-2d)

	Total number of β_1's	Total number of β_1 >0	Total number of β_1>0 significant on a 5% level	Total number of β_1<0 significant on a 5% level
Textiles & leather	16	56 %	19 %	19 %
Machinery & electronics	12	50 %	17 %	0 %
Transport equipment	24	38 %	13 %	17 %
High-tech	20	65 %	20 %	15 %
Total all 4 clusters	72	51 %	17 %	14 %

Table 3a: External economies of scale (β_2); intra-industry cross-country: Textiles & leather

			Germany	France	Italy	U.K.
Germany	321	Textiles		-0.029	0.008	-0.044
				(0.038)	(0.038)	(0.059)
	322	Wearing apparel		-0.038	0.128 **	-0.126 **
				(0.071)	(0.070)	(0.061)
	323	Leather & products		0.158 ***	0.074 ***	0.061
				(0.042)	(0.028)	(0.059)
	324	Footwear		-0.025	-0.217 ***	-0.168 **
				(0.070)	(0.054)	(0.088)
France	321	Textiles	0.026		-0.013	0.041
			(0.028)		(0.039)	(0.055)
	322	Wearing apparel	0.026		-0.022	0.098 **
			(0.023)		(0.052)	(0.042)
	323	Leather & products	0.094 ***		-0.061 ***	0.031
			(0.031)		(0.019)	(0.046)
	324	Footwear	-0.057		0.014	0.080
			(0.044)		(0.049)	(0.079)
Italy	321	Textiles	-0.105 ***	-0.027		-0.010
			(0.031)	(0.037)		(0.049)
	322	Wearing apparel	-0.019	-0.021		0.002
			(0.016)	(0.035)		(0.026)
	323	Leather & products	-0.019	-0.031 *		-0.058 **
			(0.020)	(0.022)		(0.031)
	324	Footwear	-0.005	0.043		-0.036
			(0.034)	(0.048)		(0.067)
U.K.	321	Textiles	0.033 **	-0.052 **	-0.035 *	
			(0.017)	(0.022)	(0.024)	
	322	Wearing apparel	0.000 ***	-0.123 ***	-0.019	
			(0.000)	(0.047)	(0.044)	
	323	Leather & products	-0.128 **	0.039 **	-0.015	
			(0.067)	(0.021)	(0.013)	
	324	Footwear	-0.039 **	-0.023	-0.012	
			(0.016)	(0.035)	(0.030)	

Note: Standard errors reported in brackets.
*significance level 90%, **significance level 95%, ***significance level 99%, two sided test.

Table 3b: External economies of scale (β_2); intra-industry cross-country: Machinery & Electro.

			Germany	France	Italy	U.K.
Germany	382	Non-electrical machinery		0.055	-0.114 *	0.009
				(0.053)	(0.070)	(0.037)
	3832	Radio, TV & communication		-0.286 ***	0.029	-0.160 ***
				(0.083)	(0.152)	(0.049)
	3839	Electrical apparatus, nec.		-0.121 *	-0.120	0.034
				(0.065)	(0.101)	(0.068)
France	382	Non-electrical machinery	0.042		-0.128 *	0.130
			(0.072)		(0.079)	(0.107)
	3832	Radio, TV & communication	0.065		0.177	-0.008
			(0.060)		(0.145)	(0.035)
	3839	Electrical apparatus, nec.	0.068		-0.127 *	0.030
			(0.063)		(0.075)	(0.055)
Italy	382	Non-electrical machinery	-0.009	-0.020		-0.013
			(0.020)	(0.020)		(0.030)
	3832	Radio, TV & communication	0.047 **	0.051 **		0.041 **
			(0.024)	(0.023)		(0.019)
	3839	Electrical apparatus, nec.	0.094 **	0.001		-0.017
			(0.041)	(0.028)		(0.033)
U.K.	382	Non-electrical machinery	0.088 **	0.054 *	0.147 ***	
			(0.034)	(0.033)	(0.038)	
	3832	Radio, TV & communication	0.005	0.021	-0.002	
			(0.035)	(0.030)	(0.093)	
	3839	Electrical apparatus, nec.	0.083 *	-0.015	-0.060	
			(0.051)	(0.042)	(0.071)	

Note: Standard errors reported in brackets.
*significance level 90%, **significance level 95%, ***significance level 99%, two sided test.

Table 3c: External economies of scale (β_2); intra-industry cross-country: Transport equipment

		Germany	France	Italy	U.K.
Germany	3841 Shipbuilding & repairing		-0.064	-0.125 **	-0.066
			(0.121)	(0.052)	(0.067)
	3842 Railroad equipment		-0.099 *	0.041	
			(0.060)	(0.106)	
	3843 Motor vehicles		0.011	-0.183 ***	0.049 **
			(0.050)	(0.038)	(0.023)
	3844 Motorcycles & bicycles		0.136 ***	-0.090 **	-0.765 ***
			(0.046)	(0.035)	(0.212)
	3845 Aircraft		-0.023	-0.121 **	0.115 *
			(0.065)	(0.051)	(0.070)
	3849 Transport equipment, nec.			-0.023	0.028
				(0.132)	(0.090)
France	3841 Shipbuilding & repairing	0.111 **		0.051 *	0.123 ***
		(0.047)		(0.030)	(0.040)
	3842 Railroad equipment	-0.097		0.026	
		(0.117)		(0.147)	
	3843 Motor vehicles	0.055		0.166 ***	-0.003
		(0.057)		(0.037)	(0.027)
	3844 Motorcycles & bicycles	0.195 ***		0.082 **	0.641 ***
		(0.036)		(0.045)	(0.204)
	3845 Aircraft	0.157		0.050	-0.019
		(0.175)		(0.049)	(0.047)
	3849 Transport equipment, nec.	-0.043 **		0.049	0.028
		(0.024)		(0.038)	(0.091)
Italy	3841 Shipbuilding & repairing	-0.001	0.013		0.027 *
		(0.025)	(0.040)		(0.017)
	3842 Railroad equipment	0.031	-0.033		
		(0.037)	(0.034)		
	3843 Motor vehicles	-0.008	-0.046		-0.024 *
		(0.025)	(0.037)		(0.015)
	3844 Motorcycles & bicycles	-0.015	-0.046		-0.356 ***
		(0.015)	(0.036)		(0.104)
	3845 Aircraft	-0.015	0.028		-0.043 *
		(0.036)	(0.039)		(0.027)
	3849 Transport equipment, nec.	0.072 *			-0.024
		(0.042)			(0.132)
U.K.	3841 Shipbuilding & repairing	-0.038	-0.289 **	0.194 ***	
		(0.066)	(0.118)	(0.051)	
	3842 Railroad equipment	-0.063	-0.054	0.576 ***	
		(0.105)	(0.080)	(0.131)	
	3843 Motor vehicles	0.067 **	0.005	0.135 ***	
		(0.033)	(0.034)	(0.026)	
	3844 Motorcycles & bicycles	0.033 **	-0.016	0.014	
		(0.017)	(0.029)	(0.020)	
	3845 Aircraft	-0.114 **	-0.013	0.017	
		(0.058)	(0.050)	(0.042)	
	3849 Transport equipment, nec.	-0.043 **		0.049 **	
		(0.024)		(0.038)	

Note: Standard errors reported in brackets.
*significance level 90%, **significance level 95%, ***significance level 99%, two sided test.

Table 3d: External economies of scale (β_2); intra-industry cross-country: High-tech industries

			Germany	France	Italy	U.K.
Germany	382	Non-electrical machinery		0.080 *	-0.147 **	0.003
				(0.045)	(0.060)	(0.040)
	3832	Radio, TV & communication		-0.282 ***	-0.041	-0.140 **
				(0.076)	(0.153)	(0.049)
	3839	Electrical apparatus, nec.		-0.050	-0.120	-0.029
				(0.067)	(0.098)	(0.070)
	3845	Aircraft		0.300 ***	-0.042	0.065
				(0.102)	(0.106)	(0.094)
	385	Professional goods		0.001	0.067	0.151 **
				(0.088)	(0.085)	(0.066)
France	382	Non-electrical machinery	0.066		-0.045	0.162 *
			(0.062)		(0.075)	(0.089)
	3832	Radio, TV & communication	0.098 *		0.178	-0.031
			(0.054)		(0.145)	(0.036)
	3839	Electrical apparatus, nec.	0.034		-0.111 *	0.015
			(0.056)		(0.078)	(0.051)
	3845	Aircraft	0.184 **		-0.056	-0.007
			(0.080)		(0.093)	(0.084)
	385	Professional goods	0.467 ***		0.132	0.107
			(0.108)		(0.131)	(0.107)
Italy	382	Non-electrical machinery	-0.036 **	-0.018		-0.007
			(0.017)	(0.016)		(0.019)
	3832	Radio, TV & communication	0.056 **	0.058 **		0.026 *
			(0.022)	(0.023)		(0.018)
	3839	Electrical apparatus, nec.	0.063 *	-0.001		-0.026
			(0.036)	(0.029)		(0.032)
	3845	Aircraft	0.030	0.026		-0.022
			(0.025)	(0.037)		(0.037)
	385	Professional goods	-0.237 ***	0.092		0.046
			(0.063)	(0.085)		(0.046)
U.K.	382	Non-electrical machinery	0.128 ***	0.037	0.143 ***	
			(0.029)	(0.028)	(0.033)	
	3832	Radio, TV & communication	0.008	0.037	0.012	
			(0.033)	(0.029)	(0.088)	
	3839	Electrical apparatus, nec.	0.059	0.018	-0.034	
			(0.046)	(0.043)	(0.073)	
	3845	Aircraft	-0.131 ***	-0.064	0.144 **	
			(0.044)	(0.061)	(0.056)	
	385	Professional goods	-0.004	0.004	-0.034	
			(0.061)	(0.075)	(0.055)	

Note: Standard errors reported in brackets.
*significance level 90%, **significance level 95%, ***significance level 99%, two sided test.

Table 3e: A summary of the external economies of scale results across country (based on tables 3a-3d)

	Total number of β_2's	Total number of β_2>0	Total number of β_2>0 significant on a 5% level	Total number of β_2<0 significant on a 5% level
Textiles & leather	48	38 %	15 %	21 %
Machinery & electronics	36	58 %	17 %	6 %
Transport equipment	66	52 %	21 %	14 %
High-tech	60	58 %	15 %	10 %
Total all 4 clusters	210	51 %	18 %	13 %