

INTERNAL VERSUS EXTERNAL ECONOMIES IN EUROPEAN INDUSTRY

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This paper presents estimates of indexes of internal returns to scale and external economies for two-digit manufacturing industries in the four European countries for which the requisite data are available in adequate length: West Germany, France, the U.K., and Belgium. Overall, we find very little evidence of internal increasing returns to scale: of the thirteen two-digit industries, only Rubber and Plastic Products, Agricultural and Industrial Machinery, and Mineral Products exhibit any significant internal increasing returns to scale, and for none of the three is internal increasing returns present in more than two of the four countries. Evidence of external economies, on the other hand, exists for all four countries, the effects of which are especially strong in France and Belgium.

1. Introduction

The extent and nature of increasing returns in European industry is a topic of considerable import, particularly as it relates to the likely sources for gains in the transition to the Europe of 1992 and beyond. Indeed, the Commission of the European Communities (1988a) estimates that over one-third of the economic benefits of the 1992 program will have as its source the further exploitation of economies of scale. To date, however, there remains a lack of macro-level empirical evidence. This paper addresses that gap. We present estimates of an index of returns to scale for two-digit manufacturing industries in the four European countries for which the requisite data are available in adequate length: West Germany, France, the U.K., and Belgium. The strength of our approach¹ is that it permits us to discriminate between internal and external economies.

Our hypothesis testing procedure draws on Hall's work (1988a, b), in which he estimated indexes of returns to scale, γ , and monopolistic compe-

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¹Developed in detail in Caballero and Lyons (1989).

tion, μ , for U.S. industry. Fundamental in his procedure is the use of macro-instrumental variables, which permits a disentangling of the effects of productivity growth from those of proper increasing returns. Unfortunately, this proved to hamper dramatically the power of Hall's testing procedure. In this paper we circumvent the loss of power due to Hall's instrumental variable approach. We justify our procedure in two ways. First, we quantify the potential biases introduced by productivity growth on the parameters of primary concern. Then, we conduct some appropriate Hausman (1978) specification tests. The explicit bias analyses coupled with the Hausman tests demonstrate that simple OLS or SUR regressions yield estimates of the indexes of increasing returns in European industry that have only second order asymptotic biases.² In the end, the results we obtain are strikingly sharp³ relative to those of Hall, permitting more forceful conclusions.

Hall's approach, however, is not aimed at capturing the potential role of external economies in production. In fact, if his measured γ is interpreted as the elasticity of output with respect to total input then the estimate is upward-biased when external economies are present (given the positive correlation between industry inputs and aggregate inputs). Accordingly, we develop and estimate a model which discriminates between economies that are internal to a given two-digit industry and those that are external. Overall, we find very little evidence of internal economies: of the thirteen two-digit industries, only Rubber and Plastic Products, Agricultural and Industrial Machinery, and Mineral Products exhibit any internal increasing returns to scale, and for none of the three is internal increasing returns present in more than two of the four countries. Evidence of external economies, on the other hand, exists for all four countries, the effects of which are especially strong in France and Belgium. We view these results as an important first step in explicitly considering the potential role of external economies in empirical work. The concluding section of the paper discusses extensions necessary to bring this research closer to the type of information required for policy analysis, especially with regards to the transition to the 1992 single market objective.

The theoretical literature on increasing returns is vast. The distinction between internal and external economies was first introduced by Marshall (1920). The distinction is fundamental since the role of increasing returns cannot be dealt with unless their nature is specified, given their implications for firm behavior. The importance of this point is highlighted in the debate between Graham (1923, 1925) and Knight (1924, 1925) on the welfare effects of trade, in which Knight's view was that Graham's analysis of the possible losses from trade was valid if economies of scale are external to the firm, but

²Caballero and Lyons (1989) show that this is indeed the case for the U.S. too.

³Especially when one considers the limitation of European data when compared with U.S. data.

not if they are internal. Much of the subsequent work on external economies focuses on economies external to the firm but internal to the industry, so-called industry- and country-specific external effects [see, for example, Ohlin (1933) and Stigler (1951)]. The sources for the external effects include advantages of within-industry specialization, conglomeration, indivisibilities, and public intermediate inputs such as roads. More relevant for our work than the external to the firm/internal to the industry distinction, however, is the theoretical work that considers cross industry externalities, since our unit of empirical analysis is the two-digit level industry. Recent work in this area includes Manning and Macmillan (1979), Chang (1981), and Herberg, Kemp and Tawada (1983).

The body of empirical work concerning increasing returns in Europe and the implications of 1992 is growing very rapidly. The current principal references on the topic are three sources published by the Commission of the European Communities (1988a, b, c).⁴ Contained in the latter of the three is an inventory of recent studies concerning economies of scale by Pratten (1987). The results of his survey derive from various engineering estimates of the minimum efficient scale (MES)⁵ and cost gradients for a number of NACE three-digit industries. Basing the rankings primarily upon unit cost elasticities at a scale of one-half the MES, he found that the industry categories for which economies of scale were estimated to be the largest include transport equipment, machinery and instrument manufacture, chemicals, and paper and printing. Of course, the engineering estimates he surveyed necessarily concern only internal economies of scale. The question of external economies was left wide open. Moreover, the question of whether and to what extent opportunities for internal economies of scale have already been exhausted were not directly addressed.

The above-referenced body of economic analysis offered by the Commission vis-à-vis increasing returns has been strongly criticized, particularly in the recent work of Davis et al. (1989). The authors argue that the importance of economies of scale has been grossly exaggerated in much of manufacturing, as well as in other areas. Correspondingly, they are doubtful about the merits of the ongoing European-wide wave of mergers and joint ventures among existing large firms. Yet, here too the potential role for external economies is largely ignored.

The rest of the paper is divided into five sections. Section 2 lays out the methodology in detail and outlines our approach for discriminating between

⁴An extensive list of relevant references is included in the Commission's study (1988a). See also Smith and Venables (1988) for much of the theoretical basis for the Commission's work.

⁵Pratten used the following definition of the MES: 'the minimum scale above which any possible doubling in scale would reduce total unit costs by less than five percent and above which any possible subsequent doubling in scale would reduce value added per unit by less than 10 percent'.

internal and external economies; section 3 describes the data; section 4 presents the analysis of potential bias from not using instrumental variables and the specification test results; section 5 presents the results for the indexes of returns to scale and external effects; and section 6 provides our conclusions and discusses extensions and limitations of the approach followed in the paper.

2. Methodology

2.1. The basic model

Consider a generalization of Hall's derivation which treats both external economies and technological progress explicitly. For this, define the production function as

$$Y = F(K, L, E, V),$$

where Y , K , L , E , and V are value added, capital, labor, an external economy index and a productivity index, respectively. Furthermore, assume F is homogeneous of degree $\gamma(t)$ in capital and labor, of degree one in the productivity index, and of degree one in the external effects index.⁶

Let $x = \log X$ and $F_x = \partial F / \partial X$, then

$$dy = \left(\frac{F_K K}{Y} \right) dk + \left(\frac{F_L L}{Y} \right) dl + \left(\frac{F_E E}{Y} \right) de + \left(\frac{F_V V}{Y} \right) dv. \quad (1)$$

Given the homogeneity properties of $F(\cdot, \cdot, \cdot, \cdot)$, we have

$$\gamma(t) = \left(\frac{F_K K}{Y} \right) + \left(\frac{F_L L}{Y} \right),$$

$$1 = \left(\frac{F_E E}{Y} \right), \quad \text{and}$$

$$1 = \left(\frac{F_V V}{Y} \right).$$

Replacing these conditions in (1) yields:

⁶This is just a normalization. Since E and V are simply indexes, homogeneity of degree one imposes no constraint.

$$dy = \gamma(t) dk + \left(\frac{F_L L}{Y} \right) (dl - dk) + de + dv. \tag{2}$$

Under the very strong assumption that conditions faced by firms are such that their dynamic optimization problem can be well approximated by a sequence of frictionless static problems, it is possible to obtain a simple expression for $(F_L L/Y)$, since the first order condition with respect to labor of a profit maximizing firm with some degree of monopoly power in the goods but not in the factor market is:

$$P \left(\frac{\eta(t) - 1}{\eta(t)} \right) F_L = W,$$

where P , W and η are the value added price, wage and elasticity of demand (absolute value), respectively.

A firm with monopoly power will set its price such that $P/MC = (\eta(t)/(\eta(t) - 1))$, where MC denotes marginal cost. Defining the markup coefficient as $\mu(t) \equiv P/MC$ yields:

$$\left(\frac{F_L L}{Y} \right) = \mu(t) \alpha_v(t), \tag{3}$$

where $\alpha_v(t) \equiv WL/PY$ is the share of labor in value added.

Replacing (3) in (2) results in:

$$dy = \gamma(t) dk + \mu(t) \alpha_v(t) (dl - dk) + de + dv. \tag{4}$$

This equation establishes the percent change in output as the sum of four different components. The first is the product of the elasticity of output with respect to total input and the percent change in capital. The second is the elasticity of output with respect to labor, which equals $\gamma(t)\alpha_v(t)$, times the change in the labor/capital ratio. Finally, de is the external economy and dv is the percent change in the productivity index.

Excluding the external economy term, Hall's (1988a) formulation corresponds to the case in which $\gamma(t) = 1$, whereas Hall's (1988b) model is obtained by recognizing that $F(\cdot, \cdot, \cdot)$'s homogeneity of degree $\gamma(t)$ with respect to K and L together with the first order conditions with respect to both factors yields:

$$\frac{PY}{WL + rP_K K} = \frac{\mu(t)}{\gamma(t)}, \quad (5)$$

where r and P_K are the real (rental) cost of capital and price of capital, respectively.

If $\alpha_c(t)$ denotes the labor share in total factor costs, eq. (5) implies

$$\alpha_c(t) = \alpha_c(t) \frac{\gamma(t)}{\mu(t)}, \quad \text{hence}$$

$$dy = \gamma(t)[\alpha_c(t) dl + (1 - \alpha_c(t)) dk] + dw, \quad (6)$$

where $dw \equiv de + dv$. This is the first estimating equation of this paper. As discussed above, it matches Hall's (1988b) formulation. It establishes the percent change in output as the weighted percent changes in inputs, multiplied by the returns to scale index γ , plus some non-observable. The weights for the inputs are the corresponding cost shares. Some intuition for the appropriate weights being the cost shares comes from cost minimization. Consider a slight substitution of l for k at the marginal rate of technical substitution (i.e., such that $dy = 0$). Given factor prices, the percent rise in the total labor bill equals dl and the percent fall in the total capital bill equals dk . The only way these (typically) different percent changes can result in no change in total cost is to weigh them by their corresponding cost shares. Thus, $[\alpha_c(t) dl + (1 - \alpha_c(t)) dk] = 0$ when $[F_l dl + F_k dk] = 0$. These two expressions establish a clear link between the cost share and the corresponding marginal product.

Perhaps the most common criticism to the above derivation is that capital and/or labor are costly to adjust, therefore the static first order conditions are inadequate. Our previous paper, however, shows that as long as the marginal rate of substitution between capital and labor is not 'grossly' distorted, the static first order conditions can be violated (even systematically) without invalidating our procedure.⁷

The above formulation, however, fails to recognize a potentially very important consideration. In our previous paper we show that when the unobservable includes an external economy component the estimates of γ do not in general represent the degree of homogeneity of the production function with respect to capital and labor, but a combination of this homogeneity and external economies. The next subsection reproduces that paper's main arguments on the internal-external economies distinction.

⁷By 'grossly' we mean disequilibria between the actual and desired capital/labor ratios that exceed by several fold those estimated by, for example, Morrison (1988) for the U.S. and Japan.

2.2. Internal vs. external economies

Consider a model in which there is a continuum of firms indexed by $i \in [0, 1]$, with shares of aggregate output (manufacturing in this case) equal to δ_i . Adopting the notation:

$$dx_i \equiv [\alpha_{ci} dl_i + (1 - \alpha_{ci}) dk_i],$$

it is possible to rewrite eq. (6) for each firm i as follows:

$$dy_i = \gamma dx_i + de_i + dv_i, \quad (7)$$

where for convenience the time index has been dropped and γ has been assumed constant across firms.⁸

Productivity change can be decomposed into orthogonal aggregate (dv) and idiosyncratic (du_{1i}) components:

$$dv_i = dv + du_{1i}. \quad (8)$$

For simplicity external economies can be summarized by a linear term, so:

$$de_i = \beta dy + du_{2i}, \quad (9)$$

where constants have been suppressed for convenience and du_{2i} represents any departure from a deterministic relationship between aggregate output and external economies.⁹

Many models can lead to a specification like (9). For instance, a model in which there is learning by *others* doing and current aggregate production is a good proxy for what others are doing. An alternative motivation could be described as a 'greasing' of the input-output matrix that permits savings in terms of, say, transaction-oriented personnel.¹⁰ Similar motivations, as well as new ones, can be found in Romer (1986) and Lucas (1988).

Notice that the 'externality' parameter, β , can take either positive or negative values. The former corresponds to external *economies* whereas the latter corresponds to external *diseconomies*. The empirical section shows that the case of external *economies* prevails in the data for the four countries under study.¹¹

⁸See Caballero and Lyons op. cit. for more general cases in which both β and γ differ across countries.

⁹E.g. a random coefficient model with $\beta_i = \beta + \omega_i$.

¹⁰This could explain the association between non-production workers and observed increasing returns to scale found by Rotemberg and Summers (1989).

¹¹Caballero and Lyons op. cit. show that this is also the case for the U.S.

Replacing (8) and (9) back in (7) yields

$$dy_i = \gamma dx_i + \beta dy + dv + du_i, \quad (10)$$

where $du_i \equiv du_{1i} + du_{2i}$. Now, multiplying both sides of (10) by δ_i , assuming that the production shares are equal to the input shares, and integrating over the support of i , yields the aggregate (manufacturing) estimating equation:

$$dy = \frac{\gamma}{1-\beta} dx + \frac{1}{1-\beta} dv. \quad (11)$$

Therefore Hall's estimate [i.e., eq. (6)] applied to the aggregate reflects more than just the average degree of internal returns to scale at the industry level. Given the degree of homogeneity with respect to capital and labor of the technologies at the industry level, as the degree of external economies (within manufacturing) rises, the OLS¹² estimate of γ in (6) also rises, reflecting the fact that industry level external effects as specified in our model are internal to the manufacturing sector as a whole.

In a similar vein, when eq. (6) is estimated at the industry level, the OLS¹³ estimate of γ , henceforth denoted θ , has a probability limit that in general does not coincide with γ :

$$\text{plim } \theta = \gamma + \psi \frac{\gamma\beta}{1-\beta}, \quad (12)$$

where $\psi = \sigma_{dx dx_i} / \sigma_{dx_i}^2$.

Hence, if individual and aggregate inputs are positively correlated and external effects exist, as the results below strongly suggest, θ is an (asymptotically) upward biased estimator of γ . In fact θ reflects an interesting concept: If conditional expectations are assumed to be linear in inputs, θ is a consistent estimator of the expected increase in a given sector's output each time this sector increases its inputs by one percent. This expectation, however, takes into account the likelihood of simultaneous input demand increases in the rest of the industries.

In contrast, estimation of eq. (10) permits a disentangling of internal and external economies. Given the apparent correlation between dy and dv this requires using instrumental variables. Fortunately, eq. (11) yields the required instrument for dy . The next subsection describes the estimation procedures.

¹²Issues of potential correlation between inputs and technological progress are considered in the next subsection. However, the main arguments also hold for the standard instrumental variables procedures used in the literature.

¹³Again, potential correlation between inputs and technological progress are postponed to the next subsection.

2.3. Testing procedure

Estimation of eqs. (10) and (11) has the inconvenience that (unobservable) productivity growth is likely to be correlated with changes in capital and labor, yielding a classical case of specification error. Hall noticed this and advocated using an instrumental variable procedure. Although theoretically correct, the lack of good macro-instruments rendered his insightful procedure powerless. Our previous work proposed an alternative that proved to be particularly useful for U.S. industry: The reason to worry about specification error is the inconsistency of parameter estimates. However, the magnitude of this asymptotic bias decreases with the size of the variance of the regressors relative to their covariance with changes in productivity growth. If the latter is small relative to the former, there is no need to forgo the relative power of OLS or SUR procedures (i.e., relative to IV with instruments mildly correlated with regressors). Furthermore, the same reasoning shows that a very small correlation between instruments and changes in productivity growth may prove much more problematic than the OLS or SUR biases since the covariance between instruments and regressors is likely to be far smaller than the variance of the latter.¹⁴

If only orthogonality restrictions are being tested, the validity of powerful OLS and SUR procedures can be assessed using a Lagrange Multiplier test. However, if the main purpose is parameter estimation, as it is in this paper, a more convenient metric is that captured by Hausman's (1978) specification test. The approach in this paper, as well as in our previous paper, is to compare OLS and SUR estimates under Hausman's metric.¹⁵ If the model passes this test, estimation continues with the most powerful procedure available (SUR). Section 4 demonstrates that the model indeed passes Hausman's specification test. Furthermore, for most industries and countries SUR estimates are very tight, allowing us to draw sharper conclusions.

A different issue arises in estimating eq. (10) even when inputs and technological progress innovations are 'nearly' independent since dy and dv are obviously correlated. A 3SLS procedure in which all the x_i are used as instruments is feasible, however, the shortage of observations renders very few degrees of freedom in the first stage regression. A more appealing procedure¹⁶ is to use the restricted reduced form in the first stage. In fact the latter is given by eq. (11). An equivalent procedure is to just replace eq. (11) in (10), yielding

¹⁴Notice that these are all large sample arguments. See Nelson and Startz (1988a, 1988b) for very compelling reasons in the small sample context to prefer OLS procedures over IV with poor first-stage regression properties.

¹⁵Notice that under the alternative both OLS and SUR are inconsistent; however their probability limit differs almost surely due to the different weighting involved, yielding the power of the test [see Domowitz and White (1982)].

¹⁶These are certainly only small sample issues.

$$dy_i = \gamma dx_i + \frac{\beta\gamma}{1-\beta} dx + \frac{1}{1-\beta} dv + du_i, \quad \text{or}$$

$$dy_i = \gamma dx_i + \kappa dx + \frac{1}{1-\beta} dv + du_i. \quad (13)$$

The parameter κ represents the external economy in terms of aggregate inputs. Given an estimate of κ it is easy to recover the parameter β .

3. Data

The data for each country are from the Cronos data bank which is compiled and maintained at the Statistical Office of the European Communities (Eurostat) in Luxembourg. The database includes the requisite series in adequate length for only four of the twelve EC countries: West Germany, France, the U.K., and Belgium. For each of these four countries the necessary series are available for all thirteen of the NACE two-digit industries at annual frequency. In the case of West Germany the data spanned the period from 1960 to 1986. In the case of each of the other three countries the data spanned the period 1970 to 1986.

The relevant series included real gross value-added, real fixed capital, and real compensation of employees (includes gross wages and salaries, employers' actual social security contributions, and imputed social security contributions). In calculating the rental price of capital we used an economic rate of depreciation of ten percent. (Our results are not substantively changed by any realistic departure from this rate.) The real interest rate was calculated from the government bond yield and the change in the CPI index, both from International Financial Statistics. We checked some of our results in the case of the U.K. using the dividend yield as a measure of the real cost of funds and found very little effect on the estimated coefficients.¹⁷

The inadequacy of the data for the other EC countries was due to various reasons. For example, in the case of Italy only 5 observations were available for regressions since the compensation of employees series included 6 observations. While both Denmark and Luxembourg had 10 observations each, Denmark was missing data for six of the thirteen industries and Luxembourg for three. The data were even less appealing for the remaining five members of the EC.

4. Bias analysis and specification tests

In this section we investigate whether disregarding the potential correlation between productivity growth and the explanatory variables is too costly

¹⁷The U.K. was the only country for which dividend yield was readily available.

in terms of asymptotic bias. We first use an example to illustrate that this cost is indeed likely to be small.

For this example, let us specialize $F(\dots)$ to a Cobb–Douglas technology. Let us also assume that the demand conditions are such that the mark-up coefficient is constant¹⁸ and equal to 1.6. Wages, capital costs, demand and productivity growth are assumed to be driven by independent random variables.¹⁹ Both demand and productivity shocks have idiosyncratic (industry specific) and aggregate components. Assuming that the cost share of labor is 0.75, and taking the conservative approach that all shocks but those to wages and capital costs have the same degree of uncertainty (wages and capital costs are assumed to have a standard deviation twice as large as that of other shocks) it is possible to construct ‘reasonable’ bounds for the potential bias of disregarding the possible correlation between regressors and productivity growth. Caballero and Lyons (1989) present analytical expressions for these biases; here we use those expressions to quantify the potential biases.

Figs. 1a and 1b report the bias involved in OLS estimation for different true values of γ and β . The vertical axes measure the size of the biases and the horizontal axes specify the corresponding value of β , the external economy parameter. The two figures differ only in the true γ assumed. The support of these figures suggests that the biases are never very large.²⁰ For example, if $\gamma=1.0$ and $\beta=0.3$, the asymptotic bias of OLS estimates are: 0.016 for β , 0.004 for γ , 0.039 for κ and 0.04 for ϕ . All of these are negligible numbers when compared with the true parameter values.

The next step is to provide a statistical metric for the importance of these biases. Hausman’s test is particularly suitable for this purpose. This test relies on the comparison of the parameter of primary concern yielded by two alternative procedures leading to consistent estimates under the null hypothesis (no specification error) and diverging under the alternative. Call $\hat{\beta}_1$ and $\hat{\beta}_2$ these estimates, then Hausman’s test is

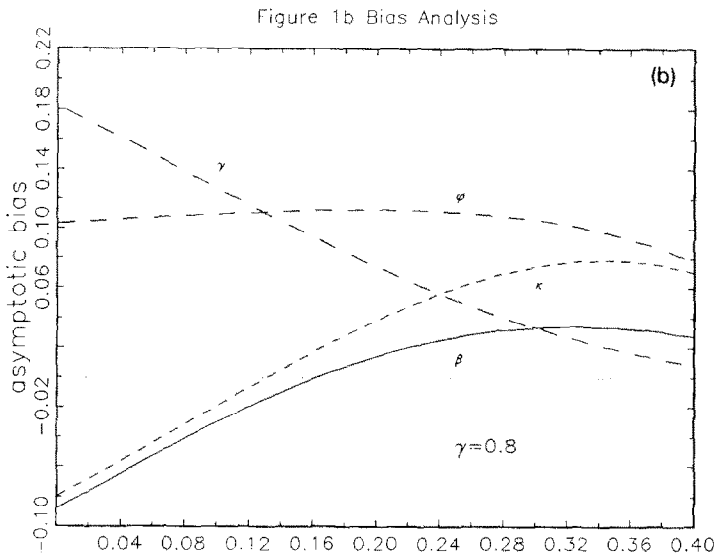
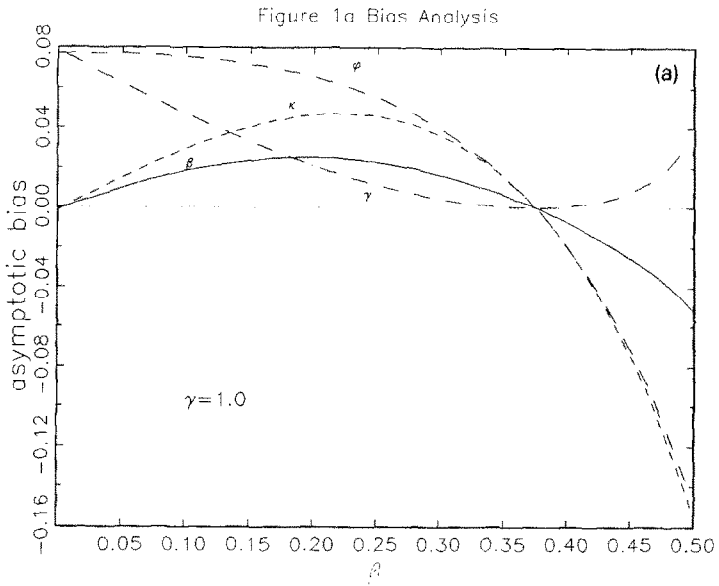
$$(\hat{\beta}_1 - \hat{\beta}_2)^T V(\hat{\beta}_1 - \hat{\beta}_2)^+ (\hat{\beta}_1 - \hat{\beta}_2),$$

where $V(x)^+$ denotes the generalized inverse of the variance covariance matrix of the vector x , and x^T is the transpose of x .

¹⁸E.g. an isoelastic demand function.

¹⁹Some of the independence assumptions are more questionable than others. For example factor price uncertainty is likely to be positively correlated with technology and demand shocks, especially if they are not industry specific. Under the parametric assumptions made here, however, these assumptions can be relaxed (within ‘reasonable’ margins) without altering results by much.

²⁰Especially when compared with the estimated coefficients and standard errors. This holds a fortiori when one considers the standard errors when the parameters are estimated with poor macro-instruments.



Figs 1a and b. Bias analysis.

Table 1
Hausman tests: *P*-value of OLS–SUR test.

$$\text{Eq. (13): } dy_i = \gamma_i dx_i + \frac{\beta_i \bar{y}}{1 - \beta} dx + \left(\frac{1}{1 - \beta} dv + dv_i \right)$$

	$\beta_i = \beta_j, \gamma_i$ unconstr.	$\beta_i = \beta_j$ and $\gamma_i = \gamma_j$
West Germany	0.28	0.75
France	0.95	0.95
United Kingdom	1.00	1.00
Belgium	1.00	0.53

Table 2
The extent of increasing returns in aggregate manufacturing.

$$\text{OLS of eq. 6: } dy = \phi [\alpha_c(t) dl + (1 - \alpha_c(t)) dk] + dw$$

	Germany	France	U.K.	Belgium
Agg. manufacturing* ϕ	1.22 (0.26)	1.59 (0.29)	1.13 (0.48)	1.42 (0.50)

*Standard errors in parentheses.

Under the null hypothesis this statistic is distributed χ^2 with degrees of freedom equal to the rank of the variance–covariance matrix. Most of the complications come from calculating the variance–covariance matrix. A notable exception, pointed out by Hausman (1978), is the case in which one of the estimators is relatively efficient. In this case an asymptotic version of Rao–Blackwell’s Theorem applies, yielding the variance of the difference equal to the difference of the variances.

Table 1 represents the *p*-value of Hausman’s tests comparing OLS and SUR estimates within country for eq. (13). The fact that the smallest *p*-value is around 0.3 is, with all the caveats mentioned above, strong evidence in favor of avoiding powerless instrumental variable procedures. Hereafter we proceed with OLS (aggregates) and SUR (industry level) estimation.

5. Empirical evidence

5.1. Industry aggregates

Before getting into individual two-digit industry results we first consider the extent of increasing returns at the level of aggregate manufacturing. Table 2 presents OLS results for eq. (6) with standard errors in parentheses. The

sample extends from 1961 to 1986 in the case of West Germany, 1971 to 1986 for the others. According to that model, the coefficient represents the elasticity of output with respect to K and L . Unlike eq. (6), however, we do not denote the returns to scale coefficient as γ since the presence of any external economies calls for the model of aggregate manufacturing described by eq. (11) in which the coefficient is shown to represent $\gamma/(1-\beta)$, where β is capturing the external effect and γ reflects the average degree of internal returns to scale at the industry level.

On the whole the coefficient ϕ is very well-determined. For all four countries it is both very significantly different from zero and in the neighborhood of one. Although the point estimates are all above one, only in France is ϕ significantly greater than one, suggesting increasing returns to when both internal and external effects are lumped into a single composite measure. And aggregate increasing returns, of course, have important implications for growth theory [e.g., Romer (1986)]. The next subsection shows that a large fraction of the returns to scale at the aggregate level is due to external economies at the industry level.

5.2. *Internal vs. external economies: The constrained model*

Section 2.2 demonstrates that the composite measure presented above is an upward biased estimate of the average degree of industry level internal returns when external economies at the industry level are present.²¹ We now present estimates that allow us to discriminate between the two different sources of returns to scale. Table 3 presents the within country SUR results for both the model described in eq. (7) (first row) and the richer model described in eq. (13) which discriminates between internal and external effects (rows 2–5). To provide an overview of the story the data appear to be telling, we present the results for the two models with all industry coefficients constrained equal within each country.²² The marginal significance levels of the tests of the constraints appear in rows 6 and 7.

Row 1 of the table provides an individual two-digit industry estimate of the composite measure of returns to scale from eq. (7), denoted here at the industry level as θ . The coefficients are all in the neighborhood of one and very precisely estimated. Row 6 provides the marginal significance of the test that the θ s are in fact equal across all industries in each country. The test is very sharply rejected in Germany, the U.K., and Belgium.

Rows 2 through 5 provide estimates relevant for isolating the role of

²¹If external diseconomies prevailed the sign of the bias would be reversed.

²²All the equations estimated in this paper include a constant for each equation (different). Hence, when a SUR model is estimated with the γ s and β s constrained to be equal across equations, it corresponds to the *within* estimator of panel data, although with a more general variance-covariance matrix.

Table 3

Internal vs. external economies: SUR results for constrained models^a.

	Germany	France	U.K.	Belgium
Eq. (7): $dy_i = \theta_i dx_i + [de_i + dv_i]$				
Eq. (13): $dy_i = \gamma_i dx_i + \kappa_i dx + [(1/(1-\beta))dv + dv_i]$				
plim $\theta = \gamma + \psi[\beta\gamma/(1-\beta)]$				
$\kappa \equiv \beta\gamma/(1-\beta)$				
θ	0.96 (0.06)	1.18 (0.07)	0.87 (0.06)	1.01 (0.07)
$\bar{\psi}$	0.63	0.68	0.66	0.44
γ	0.80 (0.06)	0.33 (0.09)	0.82 (0.04)	0.73 (0.09)
κ	0.32 (0.10)	1.40 (0.14)	0.29 (0.05)	0.68 (0.31)
β	0.26	0.88	0.26	0.48
Marginal significance $\theta_i = \theta_j$	0.0002	0.150	0.0005	0.004
Marginal significance $\beta_i = \beta_j$ and $\gamma_i = \gamma_j$	0.12	0.61	0.48	0.32

^aStandard errors in parentheses.

country-specific external effects. Row 2 presents the arithmetic mean of the estimated ψ s for each industry in each country, where $\psi = \sigma_{dx dx_i} / \sigma_{dx_i}^2$. Thus, there exists on average considerable positive covariance between industry input and aggregate input levels. Rows 3 and 4 present the estimates of the internal elasticities of output with respect to K and L and the role of external economies as captured by κ . Row 5 reports the implied values for β . Note that the disentangled coefficients are also very sharply estimated. In none of the four countries is internal increasing returns present. However, in all four countries the external economy parameter is positive and significant. External economies are clearly present. Moreover, the fact that the aggregate estimates of ϕ (table 2) are substantially larger than the estimates of γ at the industry level, as well as the fact that θ is between these two estimates,²³ is fully consistent with eqs. (11) and (12), confirming further the presence of external economies. Row 7 presents the marginal significance levels of the tests that the internal and external returns parameters are equal across all industries within each country. The constraint cannot be rejected at conventional significance levels for any of the countries. This stands in sharp contrast to the results for the θ constraint test reported in row 6. This seems to suggest that the main source of rejection of the latter constraint is the fact that the ψ_i are very different across industries, as the next tables will show.

²³As it should be according to eq. (12) when $\beta > 0$ and $0 < \psi < 1$. In fact plim θ can be written as plim $\theta = \phi + (\psi - 1)\gamma\beta/(1 - \beta)$.

Table 4a
West Germany within industry estimates (SUR).

	θ	ψ	γ	κ
Ores and Metals (13)	0.52 (0.44)	0.52 (0.09)	0.64 (0.30)	0.28 (0.12)
Mineral Products (15)	1.30 (0.35)	0.73 (0.10)	0.73 (0.19)	0.28 (0.12)
Chemical Products (17)	0.98 (0.58)	0.65 (0.12)	0.68 (0.31)	0.28 (0.12)
Metal Products (19)	1.32 (0.25)	0.63 (0.09)	0.99 (0.14)	0.28 (0.12)
Ag./Ind. Machinery (21)	1.69 (0.26)	0.69 (0.08)	1.48 (0.12)	0.28 (0.12)
Office Machinery (23)	1.00 (0.22)	0.50 (0.08)	0.62 (0.14)	0.28 (0.12)
Electrical Goods (25)	1.22 (0.16)	0.51 (0.05)	0.90 (0.09)	0.28 (0.12)
Transport Equipment (28)	0.93 (0.38)	0.54 (0.08)	0.64 (0.25)	0.28 (0.12)
Food/Bev./Tob. (36)	0.97 (0.19)	0.96 (0.21)	0.68 (0.14)	0.28 (0.12)
Textiles (42)	1.27 (0.23)	0.74 (0.10)	0.92 (0.18)	0.28 (0.12)
Paper/Printing (47)	0.39 (0.33)	0.65 (0.12)	0.31 (0.15)	0.28 (0.12)
Rubber/Plastic (49)	1.32 (0.22)	0.50 (0.06)	0.92 (0.13)	0.28 (0.12)
Other Manufacturing (48)	1.41 (0.48)	0.63 (0.18)	1.04 (0.28)	0.28 (0.12)

In sum, the data appear to speak quite clearly as to the extent and nature of increasing returns at the macro level.

5.3. Internal vs. external economies: Within country evidence

We turn now to individual two-digit industry results. Tables 4a through 4d present the two-digit industry level coefficients from estimation of eq. (13) for each of the countries, with the external effects parameter β , hence κ , constrained equal across all sectors within each country.²⁴ The first, table 4a, describes the extent and nature of increasing returns in West German industry. The θ s, representing a composite returns to scale measure as estimated by Hall (1988b), are typically both quite significantly different from zero and in the neighborhood of one. Only one industry, Agricultural and Industrial Machinery, has a coefficient significantly greater than one at conventional significance levels. Columns 2 through 4 provide the disen-

²⁴Note that the $\gamma/(1-\beta)$ term in κ corresponds to the aggregate coefficient; hence it is the same for all sectors.

Table 4b
France within industry estimates (SUR).

	θ	ψ	γ	κ
Ores and Metals (13)	0.60 (0.67)	0.49 (0.10)	0.03 (0.42)	1.19 (0.21)
Mineral Products (15)	1.66 (0.49)	0.70 (0.07)	0.97 (0.26)	1.19 (0.21)
Chemical Products (17)	1.16 (0.68)	0.77 (0.13)	0.23 (0.35)	1.19 (0.21)
Metal Products (19)	0.74 (0.32)	0.76 (0.09)	-0.16 (0.18)	1.19 (0.21)
Ag./Ind. Machinery (21)	1.47 (0.45)	0.66 (0.11)	0.56 (0.23)	1.19 (0.21)
Office Machinery (23)	1.31 (1.02)	0.85 (0.12)	-0.44 (0.55)	1.19 (0.21)
Electrical Goods (25)	1.48 (0.40)	0.67 (0.09)	0.61 (0.19)	1.19 (0.21)
Transport Equipment (28)	1.60 (0.41)	0.49 (0.09)	0.69 (0.30)	1.19 (0.21)
Food/Bev./Tob. (36)	-0.19 (1.46)	0.76 (0.51)	-1.73 (0.51)	1.19 (0.21)
Textiles (42)	1.55 (0.46)	0.75 (0.17)	1.00 (0.30)	1.19 (0.21)
Paper/Printing (47)	0.50 (0.56)	0.91 (0.20)	-0.93 (0.36)	1.19 (0.21)
Rubber/Plastic (49)	1.00 (0.42)	0.49 (0.04)	0.50 (0.23)	1.19 (0.21)
Other Manufacturing (48)	0.58 (0.50)	0.51 (0.09)	0.11 (0.20)	1.19 (0.21)

tangling of the internal and external returns. The constrained κ , representing the external effects, is positive and significant. The size of the coefficient is quite similar to that in the case where both κ and γ are constrained equal across sectors (table 3). All the measured γ s are positive and significant. Moreover, they tend to be even more precisely estimated than the θ s in column 1. Only one industry exhibits significant internal increasing returns: Agricultural and Industrial Machinery. On the whole, the model appears to fit the German data extremely well.

Table 4b presents the same set of results for France. As with Germany, the composite measure θ is typically positive, significant, and in the neighborhood of one. In no case is θ significantly greater than one, although now the point estimates are concentrated above one. While the coefficient for the Food, Beverages, and Tobacco sector is slightly negative, it is also by far the most imprecisely estimated. The external economies in France, κ , appear to be nearly four times the magnitude of those in Germany. The coefficient is very tightly estimated and also compares well with the coefficient in table 3, though it seems to be too large. In fact, once the very large measured

Table 4c
U.K. within industry estimates (SUR).

	θ	ψ	γ	κ
Ores and Metals (13)	-0.10 (0.81)	0.54 (0.13)	-0.39 (0.14)	0.36 (0.09)
Mineral Products (15)	1.27 (0.49)	0.70 (0.11)	1.01 (0.05)	0.36 (0.09)
Chemical Products (17)	0.80 (0.86)	1.12 (0.19)	0.48 (0.13)	0.36 (0.09)
Metal Products (19)	0.36 (0.46)	0.55 (0.07)	0.16 (0.02)	0.36 (0.09)
Ag./Ind. Machinery (21)	0.91 (0.39)	0.58 (0.14)	0.78 (0.04)	0.36 (0.09)
Office Machinery (23)	1.10 (0.77)	0.39 (0.17)	1.25 (0.19)	0.36 (0.09)
Electrical Goods (25)	0.86 (0.34)	0.57 (0.08)	0.65 (0.47)	0.36 (0.09)
Transport Equipment (28)	0.96 (0.37)	0.85 (0.12)	0.90 (0.11)	0.36 (0.09)
Food/Bev./Tob. (36)	0.40 (0.21)	0.90 (0.17)	0.10 (0.02)	0.36 (0.09)
Textiles (42)	0.90 (0.36)	0.57 (0.10)	0.92 (0.03)	0.36 (0.09)
Paper/Printing (47)	0.97 (0.74)	0.88 (0.21)	0.69 (0.03)	0.36 (0.09)
Rubber/Plastic (49)	1.62 (0.38)	0.48 (0.08)	1.31 (0.11)	0.36 (0.09)
Other Manufacturing (48)	1.62 (0.41)	0.50 (0.13)	1.45 (0.06)	0.36 (0.09)

external economies are extracted, the remaining degree of internal returns tends to be quite low. Six of the thirteen remain significantly positive. However, four of the coefficients are negative, two significantly so, despite the fact that these tend to be the less precisely estimated of the group. Overall, although the results are not as clean as those for Germany, the model does provide some insights into the nature of increasing returns across French industry (especially when the data limitations are considered).

The spirit of the U.K. and Belgium results in tables 4c and 4d differs little from that of Germany or France. In the U.K., external economies are significant and approximately the same magnitude as those in Germany. External economies in Belgium are more comparable to those in France. As with the previous two countries, in neither does there appear to be evidence of widespread internal increasing returns. In the U.K., only the Rubber and Plastic Products sector and the Other Manufactured Products sector exhibit internal increasing returns. In Belgium the internal increasing returns sectors are limited to Rubber and Plastic Products and Mineral Products.

The most prominent feature of the above results is the across-the-board

Table 4d
Belgium within industry estimates (SUR).

	θ	ψ	γ	κ
Ores and Metals (13)	-0.65 (0.70)	0.34 (0.14)	-0.95 (0.25)	1.15 (0.08)
Mineral Products (15)	2.32 (0.60)	0.71 (0.18)	1.54 (0.23)	1.15 (0.08)
Chemical Products (17)	0.80 (1.43)	0.55 (0.20)	0.12 (0.48)	1.15 (0.08)
Metal Products (19)	1.80 (0.46)	0.43 (0.07)	1.11 (0.29)	1.15 (0.08)
Ag./Ind. Machinery (21)	1.26 (0.21)	0.24 (0.07)	0.94 (0.11)	1.15 (0.08)
Office Machinery (23)	0.12 (0.68)	0.16 (0.10)	-0.16 (0.24)	1.15 (0.08)
Electrical Goods (25)	0.42 (0.42)	0.32 (0.07)	-0.13 (0.16)	1.15 (0.08)
Transport Equipment (28)	0.93 (0.37)	-0.05 (0.08)	1.09 (0.25)	1.15 (0.08)
Food/Bev./Tob. (36)	0.45 (0.70)	1.15 (0.42)	-0.62 (0.34)	1.15 (0.08)
Textiles (42)	1.06 (0.46)	0.40 (0.10)	0.79 (0.22)	1.15 (0.08)
Paper/Printing (47)	1.23 (0.40)	0.42 (0.14)	0.92 (0.31)	1.15 (0.08)
Rubber/Plastic (49)	2.27 (0.51)	0.50 (0.06)	1.77 (0.16)	1.15 (0.08)
Other Manufacturing (48)	1.73 (0.59)	0.54 (0.10)	1.06 (0.31)	1.15 (0.08)

significance of the external effects parameter. In considering the economic significance of its magnitude, perhaps it is most informative to calculate the output effect for an industry that expands independently versus expanding in concert with all other (manufacturing) industries. Consider the following example which uses parameter values in the middle range of the estimated coefficients. An industry with a γ equal to 0.75 and a β equal to 0.4 (both assumed equal to the aggregate) increases its total inputs by 10 percent. If all industries act in concert then the added output is 5 percent higher than if the industry had acted alone. Thus, external economies contributes an added 50 percent of the input change to output, not a trifling amount, but not so large as to make it implausible either. Of course, this comparison considers two polar extremes that are in themselves not very realistic. Nonetheless, even for far less extreme comparisons the differential output effects of external economies are not trivial.

6. Conclusions

This paper applies a methodology which permits a disentangling of

internal and external economies, a distinction that is currently experiencing a resurgence of interest in the theoretical growth literature. We show in the European context that, in general, failure to take external economies into account in estimation results in upward-biased estimates of internal elasticities of output with respect to capital and labor at the industry level. Our results verify the importance of the distinction. We find very little evidence of internal economies in Europe: of the thirteen two-digit industries, only Rubber and Plastic Products, Agricultural and Industrial Machinery, and Mineral Products exhibit any significant internal increasing returns, and for none of the three is internal increasing returns present in more than two of the four countries. Nevertheless, evidence of external economies exists for all four countries, the effects of which are especially strong in France and Belgium.

In relating the above results back to previous empirical work, in particular the survey by Pratten (1987), we feel it best to view the disaggregated engineering estimates of economies of scale as complementary to ours rather than competing. Both levels of analysis provide needed insights, while neither captures all dimensions in the issues involved. Although the engineering studies provide important information at the plant level vis-à-vis the unit cost effects of various scales, they do not directly address the essential question of whether or not opportunities have in general been exhausted. Moreover, they necessarily neglect the role of external economies. In contrast, our procedure detects the apparent substantial role for external economies throughout Europe.

In the dimension of internal economies our results suggest, as have others [see Davis et al. (1989)], that opportunities for unexploited increasing returns in manufacturing are much less widespread than the Commission's (1988a) analysis concludes. Nonetheless, the relatively neglected dimension of external economies appears to be quite important in the European context. The implication is that there are added benefits to industrial growth that is balanced across industries. The flipside is that selective industrial targeting is not likely to be effective, at least as far as exploitation of internal scale economies is concerned.

We consider the results of this paper as an important step in understanding the nature of previous returns to scale measures observed at most aggregate levels. In fact, the paper has provided substantial evidence of external economies at the two-digit manufacturing level, a feature that although present in theoretical work had not been considered in empirical work, especially with regards to the 1992 process. Future research should undoubtedly include further exploration on the source of these external economies. Only then can clear policy advice be drawn. In spite of this, we believe this paper has added an important new dimension to our under-

standing of the potential consequences of a transition towards a unified European market.

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