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RETURNS TO SCALE, TECHNICAL PROGRESS AND OUTPUT GROWTH IN BRANCHES OF INDUSTRY: THE CASE OF EASTERN EUROPE AND THE USSR, 1961–75

Erkin I. BAIRAM

Abstract: In this article the degree of returns to scale and the rate of technical progress for six major branches of the European COMECON industry are estimated using orthodox production function specifications and the Verdoorn Law. The results provide no support for the hypothesis of increasing returns to scale. All six branches are subject to either constant or decreasing returns. Estimates of the rate of technical progress obtained suggest the rate differs from one branch to another and that the heavy industry branches are more progressive than the rest. These estimates also confirm the validity of the diffusion hypothesis. They reveal that the less developed COMECON countries experience significantly faster rates of technical progress when compared with the more developed ones.

I. INTRODUCTION

In this paper we are concerned with estimating the degree of returns to scale and the rate of technical progress for six major branches of the European COMECON countries. For this purpose we shall use the conventional Cobb-Douglas production function and the Verdoorn Law.

The outline of the paper is as follows. In Sections II and III we discuss the models and the pooled cross-country data, 1961–75, used for estimation purposes. Then, in section IV, we present the estimated equations for the six branches [Energy, Ferrous Metallurgy, Machine Building and Metal Working (MBMW), Chemicals, Textiles and Food Processing]. In this section we also test whether any economies of scale are due to primarily to inter-branch specialisation or are internal to the specific branches of the industry. Finally, in Section V, the results and the conclusions are summarized.

II. THE MODEL

Recently, Kennedy (1971), Kennedy and Foley (1978) and McCombie (1985) estimated the degree of returns to scale in branches of the Irish and the US manufacturing. For this purpose they used the following relationship

$$tfp=\phi_1+\psi_1 q \tag{1}$$

where *tfp*, the growth of total factor productivity, is defined as $q-(\alpha' e+\beta' k)$. The variables q, k and e are the exponential growth rates of output, capital stock and employment, respectively. α' and β' are the relevant weights of e and k and sum to unity. ψ_t provides an estimate of $[1-(1/\nu)]$, where ν is the degree of homogeneity and ϕ_1 provides an estimate of $(1/\tau)$, where τ is the rate of technical progress.

Equation (1) is a prefered specification of the Verdoorn Law [Verdoorn (1949)] although the latter has been traditionally specified as the regression of the growth of labour productivity on that output [Bairam (1986a)]. The use of total factor productivity has the advantage that it explicity incorporates the contribution of capital. Hence, it separates the impact of the accumulation of capital from that of economies of scale.

Since the growth of output appears on both sides of equation (1), a specification which avoids the problem of spurious correlation is

$$f=\phi_2+\psi_2 q \tag{2}$$

where f is the growth of total factor inputs, $(\alpha' e+\beta' k)$. The coefficient ψ_2 is the estimate of $(1/\nu)$ and ϕ_2 is an estimate of $-(1/\tau)$.

The specification of the Verdoorn Law with output growth as the regressor is based on the assumption that growth is essentially demand and not supply constrained and, in the long run, the growth of capital is a function of output [see, for example, Kaldor (1966)]. If, on the other hand, the converse assumption is made, namely, that growth of output is determined by exogenously given rates of growth of factor inputs, the correct specification is either

$$q=\lambda+\alpha e+\beta k \tag{3}$$

or

$$q=\lambda+\nu f \tag{4}$$

where

$$(\alpha+\beta)=\nu(\alpha'+\beta')=\nu \qquad \text{and} \qquad \lambda=\tau\,.$$

Consequently, McCombie (1985) estimated these conventional Cobb-Douglas specifications as well. His Verdoorn Law [equation (3)] estimates suggest that nearly all branches of the US manufacturing industry are subject to substantial economies of scale. However, his conventional specification [equation (4)] estimates refute the increasing returns hypothesis. These conventional production function estimates suggest that nearly all branches of the US manufacturing industry are subject to constant or decreasing returns to scale. Thus, McCombie (1984, p. 68) concluded;

> "... Even using the same data set, contradictory results are obtained which are dependent upon the exact specification chosen. ... The results suggest the need for further work with perhaps more narrow specifications which are also plausible on *a priori* grounds. At the very least, the results show that the estimates are sensitive to the exact error structure assumed and provide a warning against the uncritical acceptance of a singe model, merely because the coefficients are statistically significant and the correlation coefficient high."

Fortunately, as far as this study is concerned, the correct specification is not controversial. This is because it is widely accepted that industrial growth in the socialist countries of Europe (especially since the early 1960s) has been essentially supply constrained. [See, for example, Feshbach and Rapawy (1976), Bergson (1978), Cameron (1981), Gomulka (1983) and Bairam (1987).] Consequently, the growth of inputs rater than that of output should be regarded as the independent variables. Thus, on *a priori* grounds, for these countries the orthodox specifications [equations (3) and (4)] are a more approporiate model than the Verdoorn Law [equation (2)].

Nevertheless, despite this, in this paper we present the estimates of all three specifications [equations (2), (3) and (4)] for the six major branches of COMECON industry. This will give use the opportunity to examine the sensitivity of the estimated parameters to specification changes.

III. THE DATA

In the next section we present the estimated equations for the six largest branches of the European COMECON industry. These branches [Energy, Ferrous Metallurgy, Machine Building and Metal Working (MBMW), Chemicals, Textiles and Food Processing] account for 70–75% of total industrial production in each COMECON country considered here.

All the statistics used (see APPENDIX III) are from the 'official' sources. They are edited by the Vienna Institute for Comparative Economic Staudies and published by Macmillan Press in the statistical handbook called: *COMECON DATA.* [We used 1980 edition.] These statistics are not entirely consistent or reliable. We suspect measurement errors, cspecially in gross output and fixed assets (fixed capital stock) statistics. However, the data show wide variation between countries and, therefore, minor inaccuracies are hopefully of little significance. Nevertheless, we used Durbin's (1954) instrumental varible technique to minimize any possible efects of measurement errors on the estimated parameters.

The growth rates used in estimating the specifications are for the subperiods: 1961–65, 1966–70 and 1971–75. Since we used pooled samples, the maximum number of observations that could be drawn for each branch was twenty-one (7 European COMECON countries x 3 subperiods). Unfortunalely, there were no statistics on gross fixed assets (at the branch level of aggregation) for Rumania for any period and for Poland before 1965. Consequently, we excluded Rumania totally and Poland for first subperiod (1961–65) from the samples and used only the data drawn from Bulgaria, the CSSR, the GDR, Hungary, Poland (1966–75) and the USSR. This reduced the number of observations used for each branch from twenty-one to seventeen.

Finally, the growth rates of total factor inputs used to estimate the Verdoorn Law and the conventional production function are computed from the index:

$$F_i = E_i^{\alpha'_i} K_i^{\beta'_i} \qquad (5)$$

where F_i, K_i and E_i are the indices of total factor inputs, capital stock (gross fixed assets) and employment (number of employees) in branch i, respectively. It is well known that for Western capitalist countries the market shares of capital and labour in total inputs earnings are generally used to estimate α'_i and $\beta'_i\,(1-\alpha'_i)$ Unfortunately, not enough information is available to compute these parameters for all the six COMECON countries from the income shares of capital and labour used in each branch. But even if we were able to calculate α'_i or β'_i from the available information on earnings (or from other similar information), the estimated values would not be very accurate. This is because socialist countries are not competitive economies. Hence, the marginal productivity theory of distribution (which is the theoretical justification of such calculations) is not valid for these economies. However, this problem notwithstanding, most authorities believe [see, for example, Weitzman (1970) and Desai (1976a and b)] that β'_i are close the following values: Ferrous Metallurgy (0.3), MBMW (0.3), Chemicals (0.6), Textiles (0.2), and Food Processing (0.5). These values are confirmed by β'_i estimates in Bairam (1986b) obtained using the CES production function. Furthermore, we explicitly tested that validity of these weights using the unrestricted and the restricted specifications of the conventional production function [equations (3) and (4), respectively] and F-tests. The tests revealed that, at the 0.95 confidence level, the restriction $(\alpha_i+\beta_i)=\nu_i(\alpha'_i+\beta'_i)$ holds for all branches (see the results in Appendix I). Similar F-tests also showed that α'_i and β'_i values do not significantly vary from one subperiod to another. Therefore, the above weights are indeed appropriate. Consequently, we used them as the correct weights to compute F_i for the six branches of the six European COMECON countries.

IV. THE REGRESSION RESULTS

1. *Orthodox* (*Cobb-Douglas*) *Specifications*

We estimated the following conventional specifications

$$q_{ij}=\lambda_i+\chi_iD_j+\alpha_ie_{ij}+\beta k_{ij} \qquad (6)$$

and

$$q_{ij}=\lambda_i+\chi_iD_j+\nu_if_{ij} \qquad (7)$$

where q_{ij}, e_{ij}, k_{ij} and f_{ij} are the rates of growth of output, employment, capital stock and total factor inputs in branch i, country j, respectively. D_j is the intercept dummy and was introduced to test the differences in the rate of technical progress between the more and the less developed countries. $D_j=1$ if Bulgaria or Poland and $D_j=0$ if otherwise. We expect χ_i to be positive for all branches of the less developed countries. For convenience, we shall call (6) the 'individual inputs speecification' and (7) the 'total factor inputs specification'.

A summary of the main results is reported in table 1.A. The full results are contained in Appendix I. From these results the following main conclusions can be drawn:

i) The use of instrumental variable approach provides very similar results to those obtained by ordinary least squares. Theis suggest that biases induced by measurement errors are not large-which is reassuring because it implies that the OLS estimates are efficient.[1]

ii) The R^2s are very high for the heavy industry branches (Ferrous Metallurgy, MBMW and Chemicals) but low for the light industry (consumer goods) branches (Textiles and Food Processing) and Energy. It can be seen from the estimated equations in Appendix I that for the former group 80–90% of the total variance in q is explained by the explanatory variables, whereas for the latter group only 20–40% of the total variance is explained by the same explanatory variables. This suggests that mis-specification is less for the heavy industry branches when compared with the light industry branches and Energy.

iii) The individual inputs specification [equation (6)] and the total factor inputs specification [equation (7)] estimates give very similar, if not identical, values for the degree of returns to scale, ν_i, and the rate of exogenous technical progress, τ_i, for each branch i. However, since the total factor inputs specification is a restricted version of the individual inputs specification (that is to say since we imposed the restriction: $\nu_i\alpha_i'e_i+\nu_i\beta_i'k_i=\alpha_ie_i+\beta_ik_i$) and, since this restriction proved to be statistically significant, it is not surprising to find that the individal and the total factor inputs specifications yield virtually identical estimates.[2]

The degree of returns to scale given by the instrumental variable estimates of the total facor inputs specification are summarized in Table 1.A. It can be seen form table that the hypothesis of increasing returns to scale is consistently refuted at the 0.95 confidence level. It is obvious form the results in the table that the ν_i estimates suggest constant returns to scale in Ferrous Matallurgy and Machine Building and Metal Working (MBMW) and statistically significant decreasing returns in Energy, Chemicals, Textiles and Food Processing. These estimated ν_i values are very similar, if not identical, to those obtained by Desai (1976a), Bairam (1986b, 1987) for the same Soviet branches and by McCombie (1985) for similar American branches. This confirms that the degree of returns to scale in an industrial branch is mainly independent of the prevailing economic system (socialism or capitalism) and chiefly determined by the technology of production.

vii) Finally, the estimated technical progress parameters, τ_i, summarized in Table 1.A confirm both Salter's (1966) and Gomulka's (1971) diffusion hypotheses.

Firstly, it is obvious from the results that the rates of technical progress are higher in the heavy industry branches in general and in MBMW and Chemicals, in particular, when compared with the light induslry (consumer goods) branches.

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[1] The instrumental variable estimates reported in this paper are those obtained using Durbin's (1954) ranking method. But we initially estimated the same equations using Wald's and Bartlett's grouping methods. Ehe results obtained using these latter methods (not reported) were remarkably close to those suggested by Durbin's ranking method.

[2] Note that this means we can confine our discussions to the total factor inputs specification estimates which are summarized in table 1.A.

TABLE 1. THE DEGREE OF RETURNS TO SCALE, ν, AND THE RATE OF TECHNICAL PROGRESS, τ (in % per annum) BY COMECON BRANCH, 1961–75: SUMMARY RESULTS

A. Orthodox Specification

$$q_{ij}=\lambda_i+\bar{\lambda}_i D_j+\nu_i f_{ij}$$

Instrumental Variable Estimates

Branch, i,	τ_∂: λ_i	$\bar{\lambda}_i$	τ_l: $(\lambda_i+\bar{\lambda}_i)$	ν_i: ν_i
(1) Energy	4.05	2.44*	6.49	0.60
(2) F. Metallurgy	3.69	2.89	6.58	0.92^+
(3) MBMW	5.00	3.36	8.36	0.90^+
(4) Chemicals	5.63	1.78	7.41	0.68
(5) Textiles	3.81	1.59*	5.40	0.53
(6) Food Processing	3.25	0.63*	3.88	0.48

B. The Verdoorn Law

$$f_{ij}=\phi_i+\theta_i D_j+\psi_i q_{ij}$$

Instrumental Variable Estimates

Branch, i,	τ_∂: (ϕ_i/ψ_i)	(θ_i/ψ_i)	τ_l: $(\phi_i+\theta_i/\psi_i)$	ν_i: $(1/\psi_i)$
(1) Energy	−3.95*	1.00*	−2.95*	2.13
(2) F. Metallurgy	2.44*	0.63*	3.07*	1.26^+
(3) MBMW	0.87*	−0.30*	0.57*	1.89
(4) Chemicals	4.72	1.28*	6.00	0.81^+
(5) Textiles	2.48*	−0.60*	1.88*	1.56^+
(6) Food Processing	0.32*	−1.08*	−0.76*	1.29^+

Sources: Appendices I and II.

Variables: q_{ij} and f_{ij} are the rates of growth of output and total factor inputs in branch i, country j, respectively. $D_j=1$ if Bulgaria or Poland and $D_j=0$ if the USSR, the CSSR, the GDR or Hungary.

Notes: τ_∂ and τ_l are the rates of technical progress in the more and the less developed countries, respectively, and ν_i is the degree of returns to scale in branch i. * denotes the estimated τ value is not significantly different from zero and $^+$ denotes the estimated ν value is not significantly different from unity in a one tailed test at the 0.95 confidence level.

This evidence supports Salter's hypothesis that suggest that τ_i differs from branch to branch *and* that it is generally higher in the relatively new capital-intensive branches. Secondly, the results in Table 1.A reveal that the rates of technical progress in the heavy industry branches of the two less developed COMECON countries (Bulgaria and Poland) are significantly greater than the corresponding rates in the more developed COMECON countries (the USSR, the CSSR, the GDR and Hungary). This evidence implies that the diffusion of advanced foreign technology plays an important role in determining τ_i, and hence the rate of growth of output, in the heavy industry branches of the less developed COMECON economies. But the results also reveal that, as far as the light industry branches are concerned, the technical progress rate differences betweeen the more and the less developed countries (χ_i in Table 1.A) are small and, at the 0.95 test level, statistically insignificant. Therefore this suggests that, as far as the technologically less-sophisticated old branches are concerned, the exploitation of advanced foreign technology is exhausted; and the less developed European COMECON countries are not technologically far behind the more developed European COMECON countries.

Next, we examine the estimates of ν_i and τ_i obtained from the Verdoorn Law specification for each branch and try to see whether or not they are consistent with the results reported in this sub-section.

2. *The Verdoorn Law Specification*

The Verdoorn Law estimates presented in Appendix II are from the following specification

$$f_{ij}=\phi_i+\theta_i D_j+\psi_i q_{ij} \tag{8}$$

where q_{ij}, e_{ij} and f_{ij} are the rates of growth of output, employment and total factor inputs in branch *i*, country *j*, respectively. $D_j=1$ if Bulgaria or Poland and $D_j=0$ if otherwise.

Equation (8) is the total factor inputs specification of the Verdoorn Law. The degree of returns to scale, ν_i, in branch *i* is equal to the reciprocal of ψ_i. Therefore, a necessary condition for the presence of increasing returns is to find the ψ_i parameter estimates are significantly less than unity. The expected sign of ϕ_i and θ_i is negative, as the rate of technical progress, τ_i, in any branch *i* of country *j* is given by: $-[(\phi_i+\theta_i D_j)/\psi_i]$.

The implications of the full results, presented in Appendix II, can be summarized as follows:

i) Both the ordinary least squares (OLS) and the instrumental variable (IV) estimates are reported. OLS implicitly assume the estimated equations are correctly specified and that the explanatory varible, q_{ij}, is measured without any error. Unfortunately, the IV estimates reveal that this may not be the case. It can be seen particularly from the results for Ferrous Metalluryg, Chemicals and Food Processing that there are large differences between the OLS and the IV estimates of the parameters. This, therefore, suggests that OLS may not be appropriate. Consequently, below we focus on the IV estimates of the parameters. [For convenience, a summary of the ν_i and τ_i values obtained from the IV estimates are reported in table 1.B.]

ii) As it has already been suggested by the results in Appendix I, the R^2s are high for MABMW, Chemicals and Ferrous Metallurgy and low for Energy, Textiles and Food Processing. However, the estimated equations for the three heavy industry branches also reveal that the R^2s obtained from the Verdoorn Law estimates are generally significantly lower that the R^2s obtained from the corresponding orthodox specification estimates (see Appendices I and II). This is mainly because the intercept dummy for the heavy industry branches is statistically significant in the orthodox specification estimates but insignificant in the Verdoorn Law estimates. This suggests that, most probably, the orthodox specifications used are a more appropriate model for the socialist countries of Europe.[3]

iii) Confining ourselves to the summary results in table 1.B it will be seen that the estimates of the returns to scale, ν_i, are greater than unity in all branches but Chemicals. Nevertheless, despite this, because of the large standard errors in the estimated scale parameters, the ν_i estimates for only Energy and MBMW proved to be statistically significantly greater than unity at the 0.95 confidence level. The ν_i estimates for these two branches are, however, rather *implausibly* large—being reported in equations (1) and (3) in table 1.B, respectively. Furthermore, the fact that the estimates of the rate of technical progress, τ_i, are statistically insignificant and much lower than found in other studies, such as Desai (1976a) and Bairam (1986b), suggests that these results should be treated with caution.

iv) The results clearly show that the technical progress parameter, τ_i, estimated by the Verdoorn Law gives biased values. These τ_i parameter estimates suggest that the rates of technical progress in Energy and Food Processing are negative; and the rate in MBMW is lower than the rate in Textiles! The only τ_i value which is statistically significant, and is consistent with the corresponding τ_i value obtained from the orthodox specifications, is the estimated τ_i parameter for Chemicals. Consequently, it is not at all surprising to find that Chemicals is the only branch that the τ_i values implied by both the Verdoorn Law and the two orthodox specifications estimates are very close.

Therefore, as a conclusion, we can say that if we compare the Verdoorn Law estimates with the orthodox production function estimates, some of the results are contradictory. The results obtained, as McCombie (1985) pointed out, depend crucially upon the specification chosen. However, it is also clear that the orthodox specification estimates are more suitable and plausible than the Verdoorn Law estimates. But this is hardly surprising because, as we mentioned earlier, the two conventional specifications *a priori* are more appropriate for the European socialist countries.

3. *The Industrial Branch Specification and the Externalities Hypothesis*

Kaldor (1966) and many others [see the review of the literature by Bairam (1986a)] believe that an important element of increasing returns is derived from the increasing inter-branch specialisation of the industry. This clearly means that the estimaters reported in the previous sub-sections could be mis-leading, as they abstract from this potentially important component. In this sub-section we consider the possibility that substantial economies of scale originate in inter-branch specialisation which will not be captured by the industrial branch specifications used earlier in the paper.

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[3] However, note that solely on the basis of the estimated equations this may not be the case, as a totally mis-specified model may give the higher R^2s. The model must also be justifible on *a priori* grounds.

McCombie (1985) respecificed the conventional production function and the Verdoorn Law, and tested tha validity of this 'externalities' hypothesis for individual branches using cross-state data from the USA. The specifications he used were as follows

$$q_{ij}=\lambda_i+\nu_i f_{ij}+\eta_i f_j \tag{9}$$

and

$$f_{ij}=\phi_i+\psi_i q_{ij}+\zeta_i q_j \tag{10}$$

where q_{ij} and f_{ij} are the rates of growth of output and total factor inputs in branch i, country or state j, respectively. q_j and f_j are the rates of growth of *total* (*aggregate*)

TABLE 2. The Industrial Branch Laws and the Externalities Hypothesis (OLS Estimates)
OS: $q_{ij}=\lambda_i+\bar{\lambda}_i D_j+\nu_i f_{ij}+\eta_i f_j$
VL: $f_{ij}=\phi_i+\theta_i D_j+\psi_i q_{ij}+\zeta_i q_j$
Pooled Data: 1961–65, 1966–70 and 1971–75, $n=17$

OS: Branch	λ_i	$\bar{\lambda}_i$	ν_i	η_i	R^2	σ
(1) Energy	.70	.07	.07	1.48	.410	2.57
	(.32)*	(.08)*	(.46)*	(1.83)	.410	2.57
(2) F. Metal.	3.08	2.81	.94	−.02	.895	1.93
	(1.71)*	(2.10)	(7.96)	(−.03)*		
(3) MBMW	4.85	3.38	.80	.18	.821	1.57
	(3.33)	(2.61)	(1.54)*	(.20)*		
(4) Chemicals	5.57	1.63	3.62	.19	.812	1.47
	(4.04)	(1.64)*	(3.73)	(.31)*		
(5) Textiles	6.99	2.48	.97	−1.15	.607	1.32
	(4.73)	(2.79)	(3.56)	(−2.26)		
(6) Food	1.38	−.13	1.15	.94	.322	1.64
	(.93)*	(−1.21)*	(.44)*	(1.60)*		

VL: Branch	ϕ_i	θ_i	ψ_i	ζ_i	R^2	σ
(1) Energy	−6.24	−4.39	.01	1.68	.324	2.18
	(−1.56)*	(−2.00)	(.04)*	(2.26)		
(2) F. Metal.	−2.53	−1.77	.91	.03	.868	1.91
	(−.79)*	(−.99)*	(8.09)	(.06)*		
(3) MBMW	−.75	.01	.56	.01	.723	1.25
	(−.44)*	(.01)*	(3.61)	(.03)*		
(4) Chemicals	−6.48	−1.72	1.03	.39	.772	1.90
	(−2.07)	(−.98)*	(4.36)	(.64)*		
(5) Textiles	−7.04	−1.93	.26	1.06	.619	1.25
	(−3.39)	(−1.76)	(1.22)*	(3.08)		
(6) Food	−1.41	.81	.55	.33	.452	1.46
	(−.79)*	(.92)*	(2.66)	(1.89)		

Source: See the text.

Variables: q_{ij} and f_{ij} are the growth rates of output and total factor inputs in branch i, country j, respectively. q_i and f_j are the growth rates of the same variables for total (aggregate) in country j. D_j is the intercept dummy ($D_j=1$ if Bulgaria or Proland and $D_j=0$ if the USSR, the CSSR, the GDR or Hungary).

Notes: See Appendix II.

industrial output and total factor inputs in country or state *j*, respectively.

In these specifications it is assumed that the growth of productivity of a particular branch is not only a function of that branch's output or inputs growth, but also of the expansion of *total* industrial output or inputs within the same country—with the latter representing the externalities effect. If the external economies of scale are important one would expect the coefficients of f_j and q_j (η_i and ζ_i, respectively) be statistically significant with $\eta_i<0$ and $\zeta_i<0$. However, McCombie (1985) obtained results that show the externalities effect is statistically insignificant in branches of the US manufacturing industry. The results he obtained further give ζ_i estimates which generally have the wrong sign (positive).

We estimated equations (9) and (10) for the six major branches of the European COMECON industry using the relevant cross-country data. The OLS estimates of equation (9) and (10) are reported in table 2, where it can be seen the total industrial growth has negligible impact in most equations. In (9) the externalities coefficient, η_i, has the correct sign (positive) in all the estimated equations but two [equations (2) and (5)] and, unfortunately, the externalities coefficient is statistically significantly different from zero only in one of these latter equations, namely equation (5) [Textiles]. In the Verdoorn Law the externalities coefficient, ζ_i, is significantly different from zero in two equations [equation (1), Energy and equation (5), Textiles] but have the wrong sign (positive) in *all* the estimated equations. Therefore, the results in Table 2, like McCombie (1985), suggest that any gains from inter-branch specialisation are not likely to be important. This means that, even though the estimates presented earlier in the paper do not take into account the role of external economies, they are not mis-leading.

V. SUMMARY AND CONCLUSIONS

In this paper we estimated the degree of returns to scale, ν_i, and the rate of technical progress, τ_i, for the six major branches of the European COMECON industry using orthodox specifications and the Verdoorn Law.

The two conventional Cobb-Douglas production function specifications used provide no support for the hypothesis of increasing returns. The ν_i estimates from these specifications suggest constant returns to scale in Ferrous Metallurgy and decreasing returns to scale in Energy, Chemicals, Textiles and Food Processing. On the other hand, the values of ν_i estimates given by the Verdoorn Law specification are greater than unity for all branches except for Chemicals. However, because of the large standard errors of the scale parameters, taking the null hypothesis that $\nu_i=1$, at the 0.95 confidence level the hypothesis of increasing returns can be accepted only for two branches—Energy and MBMW. For the remaining branches the estimates ν_i parameters are not statistically significantly different from unity, implying only constant returns to scale. Therefore, the results suggest that, even when the same data sets are used, orthodox specifications and the Verdoorn Law may yield contradictory results. Nevertheless, despite this, as far as our estimates are concerned, we are prepared to argue that the ν_i parameter estimates obtained from the two conventional specifications are more appropriate than those obtained from the the Verdoorn Law specification. This is because, on *a priori* grounds, we consider these specifications as the correct model for the European COMECON countries. Consequently, we maintain that all the branches are subject to either constant or decreasing returns to scale. Our respecified models which take the externalities effect into account also confirm this. The results from these latter specifications suggest that any gains from inter-branch specialisation are not likely to be important at the level of disaggregation we have considered.

Estimates of the rate of exogenous technical progress, τ_i, obtained from the conventional specifications confirm Salter's and Gomulka's hypotheses. Firstly, there is evidence in support of Salter's hypothesis that asserts τ_i differs from one branch to another and that the heavy industry is generally more progressive than the rest. Secondly, the τ_i estimates obtained from these specifications support Gomulka's diffusion hypothesis. The τ_i estimates reveal that the less developed European COMECON countries (Bulgaria and Poland) experience significantly faster rates of technical progress in their heavy industry branches, when compared with the corresponding rates in the more developed European COMECON countries (the USSR, the CSSR, the GDR and Hungary). However, these τ_i estimates also reveal that, as far as the light industries are concerned, the exploitation of advanced foreign technology is exhausted. That is to say, as far as these latter branches are concerned, the less developed COMECON countries are not technologically far behind the more developed COMECON countries. Unfortunately, once more, some of the conclusions drawn from the orthodox production function estimates can not be drawn from the Verdoorn Law estimates. But the ν_i values obtained from the Verdoorn Law are often implausible and generally inconsistent with the available results in the literature. Furthermore, with the exception of the estimated τ_i values for Chemicals, all the estimated τ_i parameters obtain from the Verdoorn Law are statistically insignificant. Adding to these *a priori* grounds implausibility of the Verdoorn Law specification, we once more incline to support the τ_i estimates obtained from the orthodox Cobb-Douglas specifications.

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APPENDIX I

Orthodox Specifications

(1) $q_{ij}=\lambda_i+\bar{\lambda}_i D_j+\alpha_i e_{ij}+\beta_i k_{ij}$ and (2) $q_{ij}=\lambda_i+\bar{\lambda}_i D_j+\nu_i f_{ij}$

COMECON Industrial Branches

Pooled Data: 1961–65, 1966–70 and 1971–75, $n=17$

Branch, *i*:	Energy		F. Metallurgy		MBMW		Chemicals		Textiles		Food Processing	
OLS Estimates	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
λ_i	5.64	4.32	2.54	3.01	4.88	4.94	6.03	5.56	3.62	3.81	4.13	3.17
	(1.98)	(2.56)	(1.51)*	(4.85)	(3.37)	(4.62)	(5.00)	(5.80)	(3.33)	(7.52)	(3.29)	(3.07)
λ_i	1.78	2.45	2.83	2.84	3.29	3.33	1.62	1.74	1.57	1.60	1.24	0.58
	(1.01)*	(1.60)*	(2.37)	(2.60)	(2.84)	(2.83)	(1.89)	(2.13)	(1.61)*	(1.76)*	(1.09)*	(0.55)*
α_i	.57		.54		.63		.48		.38		.72	
	(1.02)*		(1.08)*		(2.03)		(1.56)*		(1.39)*		(1.98)	
β_i	.11		.35		.28		.40		.13		.00	
	(0.23)*		(1.09)*		(1.24)*		(1.46)*		(0.76)*		(0.00)*	
ν_i		.56		.93		.92		.69		.52		.51
		(2.69)		(8.94)		(3.92)		(7.01)		(2.49)		(2.00)
R^2	.84	.280	.900	.901	.831	.844	.843	.453	.453	.469	.277	.246
σ	3.03	2.84	1.89	1.88	1.54	1.54	1.33	1.34	1.56	1.50	1.69	1.72
ν_i	0.68^+	0.56	0.89^+	0.93^+	0.91^+	0.92^+	0.78^+	0.69	0.51^+	0.52	0.72^+	0.51
IV Estimates	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
λ_i	5.37	4.05	2.86	3.69	4.86	5.00	6.21	5.63	3.33	3.28	3.28	3.25
	(1.75)*	(2.55)	(1.30)*	(3.99)	(3.33)	(4.66)	(5.19)	(6.52)	(2.98)	(7.45)	(2.37)	3.06)
λ_i	1.60	2.44	3.22	2.89	3.32	3.36	1.71	1.78	1.59	1.59	0.71	0.63
	(0.91)*	(1.62)*	(2.23)	(2.29)	(2.28)	(2.89)	(1.97)	(2.16)	(1.55)*	(1.73)*	(0.61)*	(0.59)*
α_i	.64		.52		.62		.46		.31		.65	
	(0.97)*		(0.72)*		(2.00)		(1.53)*		(1.09)*		(1.58)*	
β_i	.13		.38		.31		.27		.19		.13	
	(0.26)*		(0.81)*		(1.26)*		(1.44)*		(1.02)*		(0.46)*	
ν_i		.60		.92		.91		.68		.53		.48
		(2.61)		(3.99)		(3.75)		(6.44)		(2.45)		(2.00)
σ	3.03	2.84	1.92	1.90	1.55	1.48	1.36	1.34	1.58	1.50	1.72	1.72
ν_i	0.77^+	0.60	0.89^+	0.92^+	0.93^+	0.91^+	0.73^+	0.68	0.50^+	0.53	0.78^+	0.48

APPENDIX II

The Verdoorn Law

$f_{ij}=\phi_i+\theta_i D_j+\psi_1 q_{ij}$

COMECON Industrial Branches

Pooled Data: 1961-65, 1966–70 and 1971-75, $n=17$

Branch, *i*:	Energy	F. Metallurgy	MBMW	Chemicals	Textiles	Food Processing
OLS Estimates						
ϕ_i	2.16	−2.32	−0.83	−4.61	−1.37	1.41
	(1.32)*	(−2.94)	(−0.63)*	(−2.61)	(−1.19)*	(1.19)*
θ_i	−0.35	−1.71	−0.13	−1.06	0.52	1.38
	(−0.24)*	(−1.32)*	(−0.11)*	(−0.92)*	(0.49)*	(1.49)*
ψ_i	.42	.91	.58	1.12	.59	.44
	(2.09)	(8.93)	(3.92)	(7.00)	(2.09)	(2.00)
R^2	.152	.875	.755	.805	.395	.335
σ	2.47	1.86	1.18	1.70	1.59	1.60
ν_i	2.18	1.10^+	1.72	0.89^+	1.69^+	2.27
IV Estimates						
ϕ_i	1.86	−1.93	−.46	−5.81	−1.59	−0.25
	(1.11)*	(−1.76)*	(−0.33)*	(−2.76)	(−1.36)*	(−0.16)*
θ_i	−0.47	−0.57	0.16	−1.57	0.39	0.83
	(−0.32)*	(−0.45)	(0.13)*	(−1.24)*	0.37)*	(0.78)*
ψ_i	.47	.79	.53	1.23	.64	.77
	(2.24)	(3.99)	(3.46)	(6.40)	(2.07)	(2.44)
σ	2.49	2.01	1.18	1.73	1.60	1.73
ν_i	2.13	1.26^+	1.89	0.81^+	1.56^+	1.29^+

Data Source: See Appendix III.

Variables and Notes: q_{ij}, e_{ij}, k_{ij} and f_{ij} are the exponential growth rates of gross output, employment (number of employees), gross fixed capital stock (fixed assets) and total factor inputs, in country j, branch i, respeclively. D_j is the intercept dummy (see text). $D_j=1$ if Bulgaria or Poland and $D_j=0$ if otherwise. Figures in parantheses are t statistics. σ is the standard errror of the equation and ν_i is the degree of returns to scale. * indicates a coefficient not significantly different from zero and $^+$ denotes a degree of homogeneity not significantly different from unity in a one tailed test at the 0.95 confidence level.

APPENDIX III: DATA

Source: Vienna Institute of Comparative Economic Studies. *COMECON Data.* Macmillan Press, London, 1980.

Variables: q, e, k and f denote the rates of growth of gross output, employment, gross fixed assets and total factor inputs, respectively.

Notes: [1]. List of the European COMECON Countrier:

No:	*Country*:
(1)	USSR
(2)	Bulgaria
(3)	CSSR
(4)	GDR
(5)	Hungary
(6)	Poland
(7)	Rumania

[2]. For other notes see text (Section III).

[1]. ENERGY, Average Annual Growth Rates (in %), 1961–75

Country No.	1961–65:				1966–70:				1971–75:			
	q	e	k	f	q	e	k	f	q	e	k	f
(1)*	12.2	6.3	12.5	11.4	9.1	3.2	10.5	9.1	7.1	1.6	7.3	6.1
(2)	14.9	3.9	9.2	6.5	13.3	2.4	10.3	6.3	5.3	2.8	9.4	6.0
(3)	7.1	2.1	5.3	3.6	10.7	1.9	5.0	3.4	6.1	2.1	6.4	4.3
(4)	4.4	0.7	0.8	4.3	3.3	−3.1	4.3	0.5	2.7	2.2	6.0	4.1
(5)*	8.8	1.6	9.1	7.6	8.2	−2.3	2.1	1.2	7.6	1.7	8.8	8.4
(6)	10.6	2.4	NA	NA	8.6	3.7	7.7	5.7	9.1	9.6	9.6	6.3
(7)	20.6	16.4	NA	NA	16.7	2.4	NA	NA	9.7	1.4	NA	NA

* Electric Energy only.

[2]. FERROUS METALLURGY, Average Annual Growth Rates (in %), 1961–75

Country No	1961–65:				1966–70:				1971–75:			
	q	e	k	f	q	e	k	f	q	e	k	f
(1)	8.6	3.4	10.6	5.5	6.1	1.9	8.7	4.0	5.1	7.4	7.4	2.1
(2)	27.2	19.2	34.2	23.5	18.5	6.4	16.8	9.4	10.8	1.3	7.7	3.2
(3)	5.5	3.0	8.2	4.5	4.3	0.3	4.8	1.6	5.4	0.2	2.9	1.0
(4)*	4.1	0.9	7.3	2.7	6.2	0.8	6.2	2.2	6.9	1.1	5.7	1.7
(5)*	5.4	1.6	9.8	4.0	5.5	1.7	5.8	2.9	5.0	0.8	4.8	2.0
(6)	7.4	4.2	NA	NA	6.2	2.3	7.2	3.7	6.9	1.2	8.5	4.3
(7)	11.3	4.1	NA	NZ	12.3	3.0	NA	NA	11.3	3.8	NA	NA

* Total Metallurgy (i.e. Ferrous and Non-Ferrous Metallurgy).

[3]. MBMW, Average Annual Growth Rates (in %), 1961–75

Country No	1961–65:				1966–70:				1971–75:			
	q	*e*	*k*	*f*	*q*	*e*	*k*	*f*	*q*	*e*	*k*	*f*
(1)	12.4	6.6	11.5	8.0	11.8	3.9	10.0	5.7	11.6	2.8	10.0	4.9
(2)	18.3	7.9	13.6	9.6	15.8	6.8	16.2	9.7	15.4	5.0	13.1	7.4
(3)	6.6	2.5	6.3	3.7	9.3	1.9	4.4	2.7	8.4	0.7	6.0	2.3
(4)	7.4	2.3	8.6	4.2	7.0	1.8	5.4	2.9	5.8	1.5	6.8	2.9
(5)	9.7	3.8	7.4	4.9	7.7	4.4	8.5	5.6	7.8	1.5	6.3	2.9
(6)	14.2	5.9	NA	NA	13.8	5.2	9.6	6.4	14.4	3.7	14.4	6.8
(7)	17.0	6.8	NA	NA	15.7	6.1	NA	NA	18.1	10.8	NA	NA

[4]. CHEMICAL, Average Annual Growth Rates (in %), 1961–75

Country No	1961–65:				1966–70:				1971–75:			
	q	*e*	*k*	*f*	*q*	*e*	*k*	*f*	*q*	*e*	*k*	*f*
(1)	13.4	9.6	18.3	14.7	12.2	4.6	12.2	9.1	10.5	2.3	9.6	6.6
(2)	17.0	8.0	19.1	14.5	21.5	10.1	21.5	16.7	11.4	4.9	12.2	9.3
(3)	10.7	4.0	6.5	5.5	10.9	3.0	8.3	6.1	9.9	1.6	7.8	5.4
(4)	7.9	0.8	6.4	4.1	7.7	0.5	6.4	4.0	8.2	0.7	7.4	4.7
(5)	13.8	5.6	14.1	10.7	11.6	5.3	10.0	8.1	10.5	3.0	11.6	8.1
(6)	13.8	4.4	NA	NA	13.3	4.8	13.0	9.6	12.3	3.0	9.7	610
(7)	25.6	11.3	NA	NA	21.3	8.3	NA	NA	21.3	6.3	NA	NA

[5]. TEXTILES, Average Annual Growth Rates (in %), 1961–75

Country No	1961–65:				1966–70:				1971–75:			
	q	*e*	*k*	*f*	*q*	*e*	*k*	*f*	*q*	*e*	*k*	*f*
(1)*	2.6	2.2	8.7	3.5	8.5	3.1	9.4	4.3	4.6	0.4	7.7	1.8
(2)	5.5	−0.6	9.3	1.3	8.5	4.1	11.5	5.6	7.2	2.5	8.5	3.7
(3)	3.1	0.1	1.1	0.3	4.9	0.4	3.5	1.1	5.9	−0.1	6.9	1.3
(4)	2.5	−3.2	3.2	−2.0	4.4	−2.3	2.1	−1.4	5.3	−0.3	5.6	0.9
(5)	6.3	2.5	8.8	3.7	1.6	0.7	5.9	1.7	4.0	−1.1	6.3	0.3
(6)	5.0	1.3	NA	NA	6.9	2.1	4.7	2.6	7.8	1.8	11.9	3.7
(7)	10.4	4.2	NA	NA	11.2	5.0	NA	NA	12.1	7.3	NA	NA

* Light Industry (i.e. Textiles, Garments, Shoes and Leather Products).

[6]. FOOD PROCESSING, Average Annual Growth Rates (in %), 1961–75

Country No	1961–65:				1966–70:				1971–75:			
	q	*e*	*k*	*f*	*q*	*e*	*k*	*f*	*q*	*e*	*k*	*f*
(1)	7.4	3.7	9.4	6.6	5.7	2.3	7.7	4.9	5.2	0.8	7.6	4.0
(2)	10.5	3.2	8.1	5.6	5.5	3.1	13.0	8.0	0.6	−0.1	8.0	3.9
(3)	2.9	−0.2	2.7	1.2	3.8	0.9	2.7	1.8	4.7	0.3	5.6	2.9
(4)	3.4	−1.8	3.2	0.7	4.5	1.4	5.5	4.3	5.5	2.3	6.0	4.1
(5)	7.4	2.4	4.0	3.2	4.7	3.5	7.9	5.7	4.7	2.2	7.8	4.7
(6)	4.3	3.0	NA	NA	3.0	1.9	6.8	4.3	8.2	3.0	10.4	6.7
(7)	8.4	5.2	NA	NA	6.6	3.0	NA	NA	7.4	4.1	NA	NA

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