ECONOMIC GROWTH AND VERDOORN'S LAW IN THE SPANISH REGIONS, 1962-1991

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Abstract

The aim of this paper is to test for the presence of dynamic increasing returns to scale in Spanish regional growth between 1962 and 1991. The theoretical framework within which this paper is based is the so-called Verdoorn's Law. Tests of the law are performed not only for the manufacturing sector but also for agriculture, construction, services and total value added. The results show substantial increasing returns for manufacturing for the services sector and for total value added. The static-dynamic paradox found by McCombie (1982) is also discussed and tested. We find no support for the hypothesis of a Cobb-Douglas as the underlying technical relationship of the law.

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I Introduction

The Kaldorian view of regional growth has long emphasised the role played by manufacturing and increasing returns in determining growth rate differences. Kaldor's second law of growth (Kaldor, 1966) states that the manufacturing sector is subject to substantial increasing returns to scale. This law has been widely known as Verdoorn's Law: the growth of productivity in manufacturing is an endogenous result of the growth of output. The importance of the existence of this regularity is not only that it provides support for the hypothesis that the manufacturing sector is the "engine of growth" but that it also sets the basis for the cumulative causation models of growth. Several works by Fingleton and McCombie (1998), Hildreth (1988-89), Leon-Ledesma (1998) and McCombie and de Ridder (1983, 1984) have tested Verdoorn's Law in a regional context.

This paper is an attempt to test Verdoorn's Law with different specifications for the 17 Spanish regions using a pool of average rates of growth between 1962-73, 1973-83 and 1983-91. The results of this work will be complemented with the estimation of that relationship for others sectors of the economy and for total value added. Modern economies can have more than one sector subject to increasing returns, especially in some service activities, but most of the available studies do not emphasise this point. This fact leads to a mis-interpretation of the sectoral effects on the overall economic growth of a country (or region), and can give a better understanding of the economic performance of some economies. In addition, the so called static-dynamic Verdoorn's Law paradox will be tested. This paradox is related to the substantial differences in the degree of returns to scale estimated when the law is tested with the variables in growth rates (dynamic) or in levels (static). The underlying technological relationship of the Verdoorn Law is hardly reconcilable with the traditional Cobb-Douglas specification of most production function studies of economic growth.

The paper will be organised as follows. Section II briefly outlines Verdoorn's Law and the specifications used in our estimations. Section III presents the results for the manufacturing sector, while Section IV presents results for the non-manufacturing sectors. In Section V the static-dynamic paradox is discussed and tested. Section VI concludes.

II Some issues relating to Verdoorn's Law controversies

The hypotheses of increasing returns to scale in the manufacturing sector was initially tested by Kaldor (1966) using the regression of either:

$$p_i = a + bq_i \tag{1}$$

or

$$e_i = c + dq_i \tag{2}$$

where p_i, q_i and e_i are the rates of growth of labour productivity, output and employment of the manufacturing sector of economy i. Since $p_i \equiv q_i - e_i$, then $a = -c$ and $d = (1-b)$. Equation (2) is preferred for estimation purposes due to the correlation between p and q. The results obtained by Kaldor found a value of b and d of around 0.5. Kaldor's interpretation of the Verdoorn coefficient (i.e. b) of one half, was that substantial increasing returns to scale exist, which may be interpreted as a technical relationship. Kaldor did not derive his regressions from an explicit technology model. However, it is clear that he was thinking of some version of his technical progress function[1]. As Kaldor himself notes:

> "It is a dynamic rather than a static relationship - between the rates of change of productivity and output, rather than between the *level* of productivity and the *scale* of output - primarily because technological progress enters into it, and is not just a reflection of the economies of large-scale production" (Kaldor, 1966, pp. 288-289).

Rowthorn (1975) argued that the appropriate specification of Verdoorn's Law is the regression of *q* or *p* on *e*, since Kaldor's original interpretation of the slow rate of growth of UK manufacturing industries was a shortage of labour. The exogenous variable, then, should be the rate of growth of employment, namely:

$$p_i = \lambda_1 + \varepsilon_1 e_i \qquad (3)$$

or

$$q_i = \lambda_2 + \varepsilon_2 e_i \qquad (4)$$

However, Kaldor subsequently changed his mind[2] and argued that the constraint on growth comes from the demand for exports and not from the supply of labour, even more so in a regional context where the labour mobility is high. This point was lately developed by Thirlwall (1980), for whom the differences in regional growth rates arise from the dynamic version of Harrod's Trade Multiplier. Assuming this interpretation, equations (1) or (2) would be the correct specification. It is possible, however, that both specifications are subject to some degree of simultaneity. However, the different attempts to solve the problem of

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[1] See Dixon and Thirlwall (1975) for a derivation of *b* from Kaldor's technical progress function.
[2] See for example Kaldor (1970).

simultaneity using instrumental variables estimation (as in McCombie and de Ridder, 1983) have been shown to have an insignificant effect on the parameters obtained for both specifications. Added to this, there is the problem of identifying variables that can be deemed to be exogenous in economical terms. Our procedure will be one of showing both specifications in each of the regressions.

Another important weakness of these specifications is that neither consider the contribution of capital to increasing returns[3]. Moreover, unless some assumption is made about the evolution of the capital stock, the degree of the returns to scale cannot be directly obtained. Let α and β be the elasticities of output with respect to labour and capital respectively[4]. If the capital-output ratio is constant the Verdoorn coefficient b gives an unbiased estimate of $(1-\alpha)/\beta$. Having a measure of the ratio of α to β, an estimate of $\alpha + \beta$ (that is, the degree of returns to scale) can be obtained. If $\alpha + \beta$ is significantly greater than one, it is possible to assert the existence of increasing returns to scale. If a measure of the rate of growth of the capital stock (k) is available, then the preferred equations to estimate would be:

$$e_i = \pi + \gamma q_i + \phi k_i \qquad (5)$$

as Kaldor's specification, and

$$q_i = \theta + \psi e_i + \xi k_i \qquad (6)$$

as Rowthorn's specification. From (5), $\alpha + \beta = (1-\phi)/\gamma$, and from (6) $\alpha + \beta = \xi+\psi$ and a direct

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[3] The contribution of capital would be implicit on Kaldor's specification if the Verdoorn Law is thought of as a form of his technical progress function. See footnote 1.

[4] At this point it is worth noting that these elasticities may not be derived from a Cobb-Douglas production function. This point will be discussed in Section V.

measure of the returns to scale can be obtained[5]. As pointed out by Bairam (1987), results from other studies reflect that, in equation (5), *k* is statistically insignificant or has the wrong sign while, in equation (6), *k* always has the correct sign and is statistically significant. The former may be due to mis-specification error. If there is a demand constraint, *k* cannot be included as a regressor in (5) because that assumes *k* is exogenous. If the growth of capital stock is endogenous in the sense that it is mainly determined by the growth of output, then a better specification of the law would be:

$$tfi_i = \delta_1 + \sigma_1 q \qquad (7)$$

or

$$q_i = \delta_2 + \sigma_2 tfi_i \qquad (8)$$

where *tfi* is the rate of growth of the total factor input, measured as $tfi = \omega e + (1-\omega)k$, and ω is a weight of the employment share in the national accounts. Equation (7) is Kaldor's specification, while equation (8) is Rowthorn's specification. The degree of returns to scale would be $\alpha + \beta = 1/\sigma_1$ in (7) and $\alpha + \beta = \sigma_2$ in (8).

The estimates of Verdoorn's Law using regional data, as in McCombie and de Ridder (1983, 1984) and Fingleton and McCombie (1998), have been shown to have a number of advantages related to the problems of simultaneity and mis-specification that are present when estimating the law with international or inter-industry data. These advantages are related to the greater homogeneity of socio-economic factors between regions and the existence of fewer barriers to the flow of factors of production that prevent regions from being supply constrained. Finally,

[5] See McCombie and de Ridder (1984).

the fact that prices are mainly fixed at the national level makes the influence of productivity growth on output growth weaker, because productivity growth does not feed through into increased competitiveness. This last point eliminates one of the most important sources of simultaneous equations bias. In the next section, Verdoorn's Law as specified in equations (5) to (8) will be estimated across the manufacturing sector of the Spanish regions.

III Data and estimation for manufacturing

The data used for estimation purposes is a pool of the average growth rates of the variables during the periods 1962-1973, 1973-1983 and 1983-1991 for the 17 Spanish regions. Data was obtained from the various issues of *National Income and its Provincial Distribution*, of Banco Bilbao Vizcaya. The real capital stock series were obtained from *The Capital Stock of the Autonomous Communities 1964-1991*, also from the same institution. The availability of key variables for the Spanish regions, such as regional deflators and regional capital stock estimates, makes it unnecessary to make adjustments from national data as in other studies. Employment is defined as total employment of the industrial sector except construction. Output is defined as value-added of the same activities. The rate of growth of the capital stock for the period 1962-1973 was assumed equal to that of the period 1964-1973 because data on capital stock only goes back to 1964. The use of panel data permits the control of unobservable heterogeneity between individuals (regions in our case).

Tables 1 and 2 provide the estimates of equations (5), (6), (7) and (8). Both the results of the individual inputs (Table 1), and the total factor inputs (Table 2), specifications show little variation in the coefficients obtained from the different methods implemented (i.e. OLS, one way fixed and random effects models)[6]. This could be due to the existence of small unobservable differences between the regions that otherwise may have biased the levels estimations obtained in the OLS and random effects models. This factor shows that there are only small regional-characteristics components in the estimation of the Verdoorn Law. In the four estimated equations the Hausman test does not reject the null hypothesis of no correlation between the regressors and the regional effects, indicating a preference for the more efficient random effects model.

In the individual factors equations, Kaldor's specification shows a low significance of the capital growth variable, as expected by the discussion in Section II. All the specifications are jointly significant. However, the degree of returns to scale obtained from Kaldor's specification is considerably larger. This could be due to measurement errors of the variables that tend to bias downwards the coefficients obtained, giving an implausibly large degree of returns to scale in the Kaldor interpretation. However, the measurement errors in the employment and capital variables may be larger than in the output variable and, hence, Rowthorn's specification could be more subject to this problem. The returns to scale (v) vary from 1.374 in equation (d) to 2.239 of equation (a) in the individual factors equations, and from 1.416 in equation (d) to 2.101 in equation (b) of the total factor inputs approach. The real value of the degree of returns to scale may be between these values, but it is important to note that all the calculated v's are significantly greater than unity at the 99% confidence level (except for equation (f) in Table 1 that is significantly greater than one at the 95% level), confirming the existence of substantial increasing returns to scale. This fact is shown in the

[6] Previous estimations including time effects (two-way errors model) showed that these time effects were not significant.

Wald tests of the null hypothesis of constant returns to scale (CRS) reported for each estimation. In other words, Kaldor's "second law of growth" seems to be confirmed for the Spanish regions.

IV Non-manufacturing sectors

The importance of Kaldor's (1966) contention that substantial increasing returns in the manufacturing sector exist is twofold. On the one hand it shows the dual nature of modern economies, with a manufacturing sector subject to a faster growth of productivity and the rest acting as "passive" sectors that respond to the growth of the former[7]. In this sense, Verdoorn's Law is a crucial element in Kaldor's model of growth and development where manufacturing acts as an "engine of growth"[8]. Secondly, the induced growth of labour productivity achieved by means of industrial growth can lead to a process of cumulative growth through improved competitiveness or agglomeration of industrial activities. Verdoorn's Law is, thus, an underlying force that leads to the polarisation of economic activity between regions (or countries).

However, most of the works related to the test of Kaldor's Laws and, in particular, Verdoorn's Law, have paid attention only to the manufacturing sector. This procedure does not permit the identification of other sectors that could be playing an important role in the development of an economy. Moreover, in modern economies, it may be possible to identify some activities, especially in the services sector, that could also be subject to increasing returns. Activities

[7] This dualist view of the process of economic development was formerly in the view of many structuralist economists and, as well, in the works of Kalecki, Myrdal, Rosenstein-Rodan and Hirschman among others. Kaldor, following Myrdal, extended this analysis to the developed economies.

intensive in technology and information-intensive capital (such as hardware and software), can also be considered to be crucial. This argument can be related to those proposed by the New Growth Theories, especially the second generation that emphasises the role played by R&D and technological spillovers[9]. It is also relevant to show if the total value added or gross domestic product of one economy is subject, to some extent, to increasing returns. Although this last point is more difficult to interpret, because it could be the result of different effects, it is important in the sense that can shed some light in the debate of whether or not economies tend to converge in per capita income.

For these reasons we have estimated Verdoorn's Law for the services sector, construction, agriculture and total value added following the same procedure used in Section III for manufacturing. It would be desirable to have long run regional data for a more disaggregated division by sub-sectors. The unavailability of such disaggregated data does not allow us to test for the different behaviour of activities, especially within the services sector, which is the most heterogeneous. The data sources used are the same as for manufacturing. The existence of capital stock series disaggregated by sector allows us to measure the contribution of capital to returns to scale. The deflators used to put the series of sectoral value added in constant prices are those of the total value added for each region. The case of the services sector is where more problems were found. The total capital stock of the sector would include the capital stock owned by the public sector. This capital stock could not be properly used in the regressions because public capital is used by all the sectors of the economy and, therefore, cannot be thought of as an input of the services sector only. For this reason, we have used the

[8] For a complete and clear exposition of Kaldor's growth laws see Thirlwall (1983).
[9] See Barro and Sala-i-Martin (1995), for a complete survey of New Growth Theories.

growth of private capital in the services as a proxy. Since the variables are in rates of growth, the difference between the growth of private capital and total capital inputs in this sector may not be substantial.

Another problem with the services sector is that stressed by McCombie and Thirlwall (1994) about the methodology used in the construction of output series for this sector. For some activities in the services sector, such as public services, the output indicators consist simply of employment changes. This fact would imply that there is no substantial change in labour productivity, and then to the conclusion that returns to scale cannot be increasing. However "[...] It would be surprising if there were not some economies of scale in, for example, wholesaling and retailing, as evidenced by the recent growth of hypermarkets and the demise of the corner grocery shop, etc." (McCombie and Thirlwall, 1994, p.191). The use of employment and capital growth rates in the estimation of Verdoorn's Law partially removes this problem. That is, in our estimations, the growth of employment or product is not directly regressed on the growth of output or employment respectively, as in the traditional tests of the law. The contribution of capital is considered as well. The regressions applied have a behavioural component that avoids to some extent the spurious relationship. In other words, the use of the individual inputs (or total factor inputs) does not necessarily have to be subject to the accounting identity that underlies some of the activities. If this measurement problem overwhelms the behavioural component one would expect a contribution of labour to the returns to scale close to unity, but, as we shall see, this is not the case in our estimates.

The results of the sectoral Verdoorn Law (both Kaldor's and Rowthorn's specifications) are presented in Table 3 together with the degree of returns to scale (v) obtained. In all the sectors, except for total value added, the random effects estimations were chosen. For total value added, a fixed effects model was applied[10].

The results for the agricultural sector are not surprising. In all the estimations obtained the model has a very low goodness of fit. In Kaldor's individual factors specification the capital stock variable has the unexpected sign while in the total factors inputs the coefficient of the growth of output has a low statistical significance. In Rowthorn's specification the capital coefficient is not significant, and the total factor input coefficient has also a low statistical significance. The degree of returns to scale in Kaldor's specification is implausibly large, while in Rowthorn's it is very low. However, in Kaldor's specification, the Wald test cannot reject the hypothesis of constant returns to scale at the 90% confidence level. This big variation reflects the weak relationship that exists between factor inputs and outputs in this sector. This would reflect the Kaldorian thesis that in agriculture there is a negligible or no relationship between employment of resources and output obtained. That fact allows for the transfer of labour (and capital) from agriculture to industry in the process of economic development. This should not be interpreted as necessarily implying a negative growth of output in this sector. Since there is a weak relation between inputs and output, the constant reduction in agricultural labour force did not affect the total value added generated. Additionally, exogenous productivity improvements such as those related to fertilisers and pest controls allowed for a steady volume of production with a decreasing labour force.

For the construction sector, the overall results show what could be interpreted as constant returns to scale. While Kaldor's specification gives marginally increasing returns, Rowthorn's

[10] For sake of space just the selected estimations are reported. All the different specifications and selection tests used are available from the author on request.

gives slightly decreasing returns to scale. Three out of four Wald tests support the hypothesis of constant returns to scale in this sector. This result can be interpreted as a consequence of the low rate of technical progress in this sector, the labour intensive production processes (as reflected by the low capital elasticities) and the lack of external competition in this activity discouraging technological improvements.

For the reasons pointed out above, the results of the service sector must be interpreted with caution. The first point to note is the good performance of the estimations and, second, the existence of increasing returns in all the specifications used. The degree of increasing returns is substantially lower than that found for the industrial sector, but the results vary between 1.12 and 1.51. The Wald tests reject the hypothesis of constant returns to scale in Kaldor's specification but not in Rowthorn's specification. Taking into consideration the heterogeneity of this sector including e.g. public services (for which one would expect to find no increasing returns), the values obtained are revealing. Rowthorn's individual factor specification shows high elasticities of capital, and elasticities of labour significantly less than one. This result confirms our hypothesis of the behavioural component of this regression for the service sector. The interpretation of the growth of the Spanish regional economies, then, could be mis-understood without the consideration of some of the activities in the service sector for which the increasing returns can be substantial.

Turning finally to the total value added, the regression results show a high degree of increasing returns to scale. This must be interpreted not just as the result of technical progress but also as the result of inter-sectoral transfers of labour. Those sectors with low productivity or a weak relationship between inputs and production (such as agriculture, construction and some services) can transfer labour to the increasing returns ones without affecting the overall productivity of the economy (see Chatterji and Wickens, 1982, and McCombie, 1991). However, the large degree of returns to scale can also be deemed to be the result of economy-wide technical progress. The results give a value of v between 1.47 and 2.16 that, again, reflects differences between both specifications. In all the estimations is possible to reject the existence of constant returns to scale at the 99% confidence level. The values obtained are high enough to assert that there could be a cumulative force at work in Spanish regional growth, for the increasing returns can lead to the concentration of economic activities, higher competitiveness and higher rates of investment through induced higher profitability. This fact casts doubts on the Solovian interpretation of the convergence among different geographical disaggregates of the Spanish regions found, for example, in Mas *et al* (1995). As pointed out by Chesire and Carbonaro (1995), the final convergent path can be the result of a multitude of forces, ones leading to convergence and others to divergence. In our case, we have identified a divergence force in the regional economic performance of Spain[11].

V The static-dynamic paradox

An interesting finding in the empirical work on the Verdoorn Law is the fact, found by McCombie (1982), that the log levels estimations of the dynamic specification give very small or no increasing returns. Black (1962) showed that Kaldor's technical progress function could be derived from a typical Cobb-Douglas production function. Using the total factor inputs specification of a Cobb-Douglas yields:

$$Q = Ae^{at} TFI^{v} \tag{9}$$

[11] For a discussion of this finding applied to the European regions see Fingleton and McCombie (1998).

where *v* is the degree of returns to scale and *a* is the exogenous rate of growth of productivity. Taking logarithms and differentiating with respect to time we obtain:

$$tfi = c + bq \tag{10}$$

where $c = -a/v$ and $b = 1/v$. This is the dynamic specification of Verdoorn's Law. However, the fact that Verdoorn's Law can be derived from a Cobb-Douglas does not necessarily mean that this production function is the underlying technical relationship of the law. In fact, if the underlying structure of Verdoorn's Law is the Cobb-Douglas, the values of the elasticities obtained from the static (log levels) and dynamic functions should be the same. When this exercise was done, McCombie (1982) found substantial differences in the degree of returns to scale from the static and dynamic specifications. The static specification yielded nearly constant returns to scale, while the dynamic showed substantial increasing returns. The most plausible explanation for this paradox is the existence of a second order identification problem. The form of the static function obtained from the dynamic depends on the assumptions on the constant of integration. There is no need for the Cobb-Douglas to be the static specification, since from a number of different functions one can derive the dynamic Verdoorn Law. It is possible, as well, that the correct specification of the law is the dynamic one, the static being mis-specified, because the phenomena of increasing returns could be related to the rate of growth of the variables instead of their levels.

In order to see if the same paradox can be found for the manufacturing sector of Spanish regions we proceeded to estimate the static Verdoorn Law with the same data base. In this case four static (log levels) observations for each region corresponding to the years 1962, 1973, 1983 and 1991, were used. We will analyse the total factor inputs specification, since the individual factors yielded similar results and also showed some collinearity problems in the case of Kaldor's specification[12]. In this case, time dummies were also included, together with regional dummies, and are shown to be significant, as one would expect, because of the changing pattern of the exogenous growth of productivity over this long period. Hence, we estimated the model as a two way error components model[13].

In Kaldor's specification, significant correlation between individual and time effects and the level of output (LogY) was found and, hence, the fixed effects estimation is used. In Rowthorn's specification, however, this correlation was not significant and a random effects model was estimated. This fact is interesting by itself because it reveals that there is a significant correlation of the exogenous determinants of total factor inputs in each region with the level of output but not with the level of inputs. In other words, the exogenous total factor productivity of manufacturing is some function of output but not of inputs. This fact can be interpreted as an endogenous response of "exogenous" technological improvements to the size of the market. This could support Abramovitz's (1986) contention that the catch-up process depends, among other factors, on the absorption capability of the laggard country (or region).

The estimation results are shown in Table 4, where, for sake of space just the preferred specifications are shown. As can be seen, in the case of Spanish regions the paradox appears in Rowthorn's specification. In the international context, McCombie (1982) found similar (or at least not very different) estimates of the degree of returns to scale in Rowthorn's specification but very different in the case of Kaldor's. In our case, it is in Rowthorn's

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[12] See footnote 10.

[13] In Kaldor's specification the Breusch-Pagan LM test of significance of the regional and time effects (distributed as $\chi^2(2)$) gave a value of 241.55 and in Rowthorn's specification a value of 354.64. In both cases we accept the hypothesis of the existence of different effects at

specification where we find substantial differences. The dynamic specification gave a value of *v* of around 1.5, while in the static specification, the value obtained is 1.02 and is not significantly different from unity as shown by the Wald test (see Table 4). Kaldor's static formulation gives us a value of 2.13, very similar to that obtained in Section III with the dynamic equation. Thus, one could assert that, in the case of Spanish regions, there is no such a paradox.

Comparing these results with those obtained by McCombie (1982) for the international context and McCombie and de Ridder (1984) for the US states, the difference is notable. A possible explanation of the divergence of the results can come from the measurement errors of the variables in the context of the panel data techniques used. The within estimator used for the estimation of Kaldor's static specification can exaggerate the errors in the measure of the variables, as stated by Baltagi (1995) and Biorn (1992), and tends to bias downwards the estimated coefficients. Griliches and Hausman (1986) argue that the between estimator is less affected by these measurement errors. Since the random effects estimator is an average of the within and between estimators weighted by the inverse of the corresponding variance, then the random effects estimator can be subject to less measurement errors bias. The results obtained by this method for the static Kaldor specification are:

$$Log\ TFI = \underset{(8.72)}{3.422} + \underset{(24.93)}{0.837} LogY$$

$$R^2 = 0.903 \quad v = 1.19$$

$$Wald\ CRS = 16.441$$
$$(p\text{-}value = 0.0001)$$

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the 99% level.

which reduces considerably the degree of returns to scale, although it is still significantly greater than unity. However, the existence of correlation between individual and time effects and LogY makes this estimation biased, preventing us from making strong assertions about the adequacy of this estimator even with measurement errors. Despite this, one can state that the true value of the degree of static returns to scale must lie somewhere between both estimates. If this is true, the values obtained in the static and dynamic specifications seem to be different and then, the underlying static function of the Verdoorn Law (if there is any) does not seem to be a Cobb-Douglas.

VI Conclusions

Three main conclusions can be obtained from the results of the different empirical analyses carried out. First, there is overwhelming support for the hypothesis of increasing returns to scale in the manufacturing sector of the Spanish regions. It also gives support to the preferred specification of using total factor inputs due to the endogeneity of capital accumulation. However, from the results obtained it is still difficult to discriminate between Kaldor's or Rowthorn's specifications.

Second, taking into account the difficulties of estimating the law for other sectors, some degree of increasing returns can also be found for the service sector. The service sector cannot, at least as a whole, be deemed to be just a "passive" sector in the growth of Spanish regions. For agriculture the result is of no significant systematic relationship between inputs and outputs, while for construction, constant returns to scale seem to exist. Total value added is subject to a high degree of induced productivity growth, so contradicting some neo-classical explanations of Spanish regional convergence.

Third, from the test of the static-dynamic paradox, the outcome is that Verdoorn's Law should not be derived from a Cobb-Douglas production function. Moreover, in the case of the Spanish regions, the paradox is also found using Rowthorn's specification, casting doubts on the adequacy of the production function approach to measuring economic growth. That is, the analysis of the level of productivity and output may be incomplete without the consideration of their dynamic behaviour.

Table 1

Verdoorn's Law: Spanish pooled regional data, 1962-73, 1973-83, 1983-91

Kaldor's specification, equation (5)

N × T = 51

Total OLS	(a) e = -0.007 + 0.552q - 0.169k (-5.46) (4.96) (-1.18)	R^2 =0.466 SEE= 0.006
Fixed effects	(b) e = + 0.591q - 0.267k (4.80) (-1.71)	R^2 =0.644 SEE= 0.006
Random effects	(c) e = -0.007 + 0.573q - 0.224k (-5.25) (6.14) (-1.88)	R^2 =0.570 SEE= 0.007

Hausman test (c) vs. (b) $\chi^2(2) = 0.2159$

Estimates of returns to scale (v)

Equation	(a)	(b)	(c)
v	2.239	2.144	2.136
Wald CRS $\chi^2(1)$	15.885	15.421	16.713
(p-value)	(0.0001)	(0.0001)	(0.0000)

Rowthorn's specification, equation (6)

N × T = 51

Total OLS	(d) q = 0.007 + 0.613e + 0.761k (4.25) (4.96) (7.12)	R^2 = 0.733 SEE = 0.006
Fixed effects	(e) q = + 0.709e + 0.764k (4.80) (6.64)	R^2 = 0.585 SEE =0.007
Random effects	(f) q = 0.007 + 0.657e + 0.763k (4.41) (6.02) (8.44)	R^2 = 0.771 SEE = 0.007

Hausman test (f) vs. (e) $\chi^2(2) = 0.3357$

Estimates of the returns to scale (v)

Equation	(d)	(e)	(f)
v	1.374	1.453	1.420
Wald CRS $\chi^2(1)$	9.251	10.431	4.237
(p-value)	(0.0023)	(0.0012)	(0.0395)

Notes:
1. Wald CRS is the Wald test of the null hypothesis of constant returns to scale.
2. Figures in parenthesis are t values and SEE is the standard error of the regression.

Table 2

Verdoorn's Law using total factor inputs: Spanish pooled regional data, 1962-73, 1973-83, 1983-91

Kaldor's specification, equation (7)

$N \times T = 51$

Total OLS	(a)	tfi = -0.003 + 0.488q	R^2 = 0.691
		(-3.91) (10.46)	SEE= 0.004
Fixed effects	(b)	tfi = 0.476q	R^2 = 0.808
		(9.80)	SEE= 0.004
Random effects	(c)	tfi = -0.003 + 0.486q	R^2 =0.714
		(-3.81) (10.68)	SEE= 0.005
Hausman test (c) vs. (b)		$\chi^2(2)$ = 0.3237	

Estimates of returns to scale (*v*)

Equation	(a)	(b)	(c)
v	2.049	2.101	2.058
Wald CRS $\chi^2(1)$	28.704	26.353	14.370
(p-value)	(0.0000)	(0.0000)	(0.0002)

Rowthorn's specification, equation (8)

$N \times T = 51$

Total OLS	(d)	q = 0.01 + 1.416tfi	R^2 = 0.691
		(8.92) (10.46)	SEE = 0.007
Fixed effects	(e)	q = 1.563tfi	R^2 = 0.782
		(9.79)	SEE =0.007
Random effects	(f)	q = 0.009 + 1.488tfi	R^2 = 0.740
		(7.44) (12.41)	SEE = 0.007
Hausman test (f) vs. (e)		$\chi^2(2)$ = 0.51422	

Estimates of the returns to scale (*v*)

Equation	(d)	(e)	(f)
v	1.416	1.563	1.488
Wald CRS $\chi^2(1)$	9.440	12.462	10.410
(p-value)	(0.0021)	(0.0004)	(0.0012)

Notes:

1. See Table 1

Table 3

Non-manufacturing sectors Verdoorn Law. Spanish regions

	Individual factors specification			
	Agriculture		Construction	
	Kaldor's	*Rowthorn's*	*Kaldor's*	*Rowthorn's*
Intercept	-0.051 (-12.5)	0.021 (2.31)	-0.037 (-8.29)	0.044 (14.85)
q	0.379 (3.79)	-	0.856 (11.94)	-
k	0.167 (2.36)	-0.097 (-1.11)	-0.030 (-0.92)	0.087 (2.86)
e	-	0.537 (2.85)	-	0.847 (11.89)
v	2.198	0.440	1.20	0.934
Wald CRS	2.475	9.312	3.305	0.632
(p-value)	(0.1156)	(0.0023)	(0.0691)	(0.4266)
R^2	0.286	0.241	0.768	0.795
SEE	0.024	0.028	0.021	0.021
	Total factor inputs specification			
Intercept	-0.012 (-3.62)	-0.005 (-1.01)	-0.024 (-3.15)	0.041 (9.67)
tfi	-	0.309 (1.86)	-	0.632 (8.54)
q	0.184 (1.84)	-	0.906 (8.64)	-
v	5.534	0.309	1.10	0.632
Wald CRS	1.539	11.234	0.421	16.229
(p-value)	(0.2148)	(0.0008)	(0.5164)	(0.0001)
R^2	0.125	0.096	0.583	0.577
SEE	0.023	0.030	0.035	0.030

Table 3

(continued)

	Individual factors specification			
	Services		Total Value Added*	
	Kaldor's	*Rowthorn's*	*Kaldor's*	*Rowthorn's*
Intercept	-0.001 (-0.82)	-0.003 (-2.04)	-	-
q	0.703 (5.26)	-	0.998 (6.39)	-
k	-0.061 (-0.42)	0.677 (9.14)	-0.857 (-4.86)	0.562 (6.40)
e	-	0.442 (5.25)	-	0.908 (13.31)
v	1.51	1.12	1.86	1.47
Wald CRS	7.205	2.024	27.009	20.826
(p-value)	(0.0073)	(0.1548)	(0.0000)	(0.0000)
R^2	0.669	0.851	0.711	0.898
SEE	0.005	0.004	0.005	0.003

	Total factor inputs specification			
Intercept	0.004 (4.12)	-0.0002 (-0.16)	-	-
tfi	-	1.139 (13.81)	-	1.534 (8.95)
q	0.667 (14.14)	-	0.462 (8.95)	-
v	1.5	1.14	2.16	1.53
Wald CRS	14.414	1.730	23.216	9.711
(p-value)	(0.0002)	(0.1884)	(0.0000)	(0.0018)
R^2	0.802	0.782	0.826	0.738
SEE	0.004	0.004	0.003	0.005

Notes:
1. All the estimations were carried using a one way error random effects model except * where fixed effects were used.
2. T-ratios in parenthesis, SEE is the standard error of the regression.
3. Wald CRS is the Wald test of the null hypothesis of constant returns to scale, distributed as a $\chi^2(1)$.
4. The periods used for estimation are the same as in Tables 1 and 2.

Table 4

Static Verdoorn Law. Manufacturing, Spanish regions, 1962, 1973, 1983, 1991

	Kaldor's Specification		
Level estimation	*LogTFI = 7.24 + 0.469LogY*		R^2= 0.996
	(10.57) (7.11)		
	v	2.13	
	Wald CRS	14.2309	
	(p-value)	(0.0002)	
	Rowthorn's Specification		
Level estimation	*Log Y = -1.98 + 1.021LogTFI*		R^2= 0.903
	(-4.83) (35.16)		
	v	1.02	
	Wald CRS	0.5133	
	(p-value)	(0.4737)	

Notes:

1. Kaldor's specification was estimated using a fixed effects two way error component model while in Rowthorn's specification a random effects model was used.
2. Wald CRS is the Wald test of the null hypothesis of constant returns to scale, distributed as a $\chi^2(1)$.
3. T-ratios in parentheses.

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