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Martinho, Vítor João Pereira Domingues

Escola Superior Agrária, Instituto Politécnico de Viseu

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Vitor João Pereira Domingues Martinho

Unidade de I&D do Instituto Politécnico de Viseu
Av. Cor. José Maria Vale de Andrade
Campus Politécnico
3504 - 510 Viseu
(PORTUGAL)
e-mail: vdmartinho@esav.ipv.pt

ABSTRACT

This work aims to test the Verdoorn Law, with the alternative specifications of (1)Kaldor (1966), for the 28 NUTS III Portuguese in the period 1995 to 1999. It is intended to test, also in this work, the alternative interpretation of (2)Rowthorn (1975) about the Verdoorn's Law for the same regions and periods. With this study we want, also, to test the Verdoorn´s Law at a regional and a sectoral levels (NUTs II) for the period 1995-1999. The importance of some additional variables in the original specification of Verdoorn´s Law is also tested, such as, trade flows, capital accumulation and labour concentration. The main objective is to confirm the presence of economies to scale that characterise the polarisation process with cumulative causation properties, explaining regional divergence. By introducing new variables to the original specification of Verdoorn´s Law we intend to examine how the economies to scale are influenced by the consideration of factors related to the Polarisation (Keynensian tradition) and Agglomeration (spatial economics tradition) phenomena. This study analyses, yet, through cross-section estimation methods, the influence of spatial effects in productivity in the NUTs III economic sectors of mainland Portugal from 1995 to 1999, considering the Verdoorn relationship.

Keywords: Verdoorn law; spatial autocorrelation; Portuguese regions.

1. INTRODUCTION

(3)Verdoorn (1949) was the first author to reveal the importance of the positive relationship between the growth of labor productivity and output growth, arguing that the causality is from output to productivity, thus assuming that labor productivity is endogenous. An important finding of the empirical relationship is the elasticity of labor productivity with respect to output that according to Verdoorn is approximately 0.45 on average, external limits between 0.41 and 0.57. This author also found that the relationship between productivity growth and output growth reflects a kind of production technology and the existence of increasing returns to scale, which contradicts the hypothesis of neoclassical constant returns to scale, or decreasing, and absolute convergence Regional.

Kaldor rediscovered this law in 1966 and since then Verdoorn's Law has been tested in several ways, using specifications, samples and different periods. However, the conclusions drawn differ, some of them rejecting the Law of Verdoorn and other supporting its validity. (4)Kaldor (1966, 1967) in his attempt to explain the causes of the low rate of growth in the UK, reconsidering and empirically investigating Verdoorn's Law, found that there is a strong positive relationship between the growth of labor productivity (p) and output (q), i.e. p = f (q). Or alternatively between employment growth (e) and the growth of output, ie, e = f (q).

Another interpretation of Verdoorn's Law, as an alternative to the Kaldor, is presented by (5)Rowthorn (1975, 1979). Rowthorn argues that the most appropriate specification of Verdoorn's Law is the ratio of growth of output (q) and the growth of labor productivity (p) with employment growth (e), i.e., q = f (e) and p = f (e), respectively (as noted above, the exogenous variable in this case is employment). On the other hand, Rowthorn believes that the empirical work of Kaldor (1966) for the period 1953-54 to 1963-64 and the (6)Cripps and Tarling (1973) for the period 1951 to 1965 that confirm Kaldor's Law, not can be accepted since they are based on small samples of countries, where extreme cases end up like Japan have great influence on overall results.

It should be noted, finally, that several authors have developed a body of work in order to test the Verdoorn's Law in a regional context, including (7-9)Martinho (2011a, 2011b and 2011c).

2. ALTERNATIVE MODELS THAT CAPTURE ECONOMIES OF SCALE

Kaldor (1966) in their attempt to revitalize the Verdoorn Law presented the following relations and tested them in an analysis "cross section" between industrialized countries (Martinho, 2011a):

$$p_i = a + bq_i, \qquad \text{Verdoorn law} \qquad (1)$$

$$e_i = c + dq_i, \qquad \text{Kaldor law} \qquad (2)$$

where pi, qi and ei are the growth rates of labor productivity, output and employment, respectively, with pi = qi - ei. Since then, and d = c = (1-b), which shows that in practice the estimation of an equation can define the parameters of the other.

Rowthorn (1975 and 1979) suggested an alternative specification. That is, if it is assumed that the rate of growth is constrained by the supply of labor (hypothesis of the neoclassical theory of externalities), then the proper way to test the Verdoorn Law is directly link productivity growth (or output) with employment, considering, well, employment growth is exogenous. Thus, the equations Rowthorn considered to test the scale economies are the following:

$$p_i = \lambda_1 + \varepsilon_1 e_i ,$$ first equation of Rowthorn (3)

$$q_i = \lambda_2 + \varepsilon_2 e_i ,$$ second equation of Rowthorn (4)

where $\lambda_2 = \lambda_1$ e $\varepsilon_2 = (1 + \varepsilon_1)$.

Taking the above into account, our interest is to test empirically the relationship Verdoorn for the Portuguese economy at regional and sectoral, in order to identify savings to scale. Therefore, below is also presented an alternative specification that will later be estimated and analyzed. This specification, as noted earlier, equation Verdoorn results presented before, but now adding the ratio of GFCF/output ratio the flow of goods/output and the variable concentration of labor. The purpose of this specification is to test in the various economic sectors of the Portuguese regions in the period 1995-1999, the importance of capital (built with technical progress), thus avoiding errors incomplete specification. Introducing the flow of goods and the variable concentration is intended to test the importance of spatial factors in determining the economies of scale. The fundamental goal turns out to be joining the forces of polarization and clustering of this specification. The increased Verdoorn relationship is as follows (Martinho, 2011b):

$$p_i = a_0 + a_1 q_i + a_2 (C_i / Q_i) + a_3 (F_i / Q_{ik}) + a_4 (E_i / E_n) ,$$ increased Verdoorn equation (5)

This equation is estimated for each economic sectors and all sectors of the five NUTS II of Portugal, over five years (1995 to 1999) and after individually for each NUTS II, with data disaggregated by four economic sectors, over the same period of time.

In this equation the variables increased pi and qi represent the growth of productivity and output, respectively. The variable (Ci/Qi) represents the ratio of GFCF/output (such as "proxy" for the variation of the ratio capital/output that incorporates technological progress), (Fi/Qik) represents the ratio of the flow of goods/output and (Ei/En) represents the variable concentration. C is GFCF, Q is the gross value added, F is the flow of goods out of each of the regions (reflecting regional exports) and E is employment. Indexes i and n represent each of the regions and the national total, respectively. The index k represents the total industry.

Bearing in mind the previous theoretical considerations, what is presented next is the model used to analyse Verdoorn's law with spatial effects, at a regional and sector level in mainland Portugal.

As a result, to analyse Verdoorn's Law in the economic sectors in Portuguese regions the following model was used (Martinho, 2011c):

$$p_{it} = \rho W_{ij} p_{it} + \gamma q_{it} + \varepsilon_{it} ,$$ Verdoorn's equation with spatial effects (6)

where p are the rates of growth of sector productivity across various regions, W is the matrix of distances across 28 Portuguese regions, q is the rate of growth of output, , γ is Verdoorn's coefficient which measures economies to scale (which it is hoped of values between 0 and1), ρ is the autoregressive spatial coefficient (of the spatial lag component) and ε is the error term (of the spatial error component, with, $\varepsilon = \lambda W \varepsilon + \xi$). The indices i, j and t, represent the regions being studied, the neighbouring regions and the period of time respectively.

The sample for each of the economic sectors (agriculture, industry, services and the total of sectors) is referring to 28 regions (NUTs III) of mainland Portugal for the period from 1995 to 1999.

3. DATA ANALYSIS

Considering the variables on the models of Kaldor and Rowthorn, presented previously, and the availability of statistical information, we used data for the period from 1995 to 1999, disaggregated at regional level, obtained from the INE (National Accounts 2003).

4. EMPIRICAL EVIDENCE OF THE VERDOORN'S LAW

At Table 1, with results of estimations presented for each of the sectors and in the period 1995 to 1999, to stress that the industry has the greatest increasing returns to scale (9.091), followed by services (1.996).

Table 1: Analysis of economies of scale through the equation Verdoorn, Kaldor and Rowthorn, for each of the economic sectors and NUTS III of Portugal, for the period 1995 to 1999

Agriculture						
	Constant	**Coefficient**	**DW**	**R^2**	**G.L.**	**E.E. (1/(1-b))**
Verdoorn[(1)]	0.010 (0.282)	0.053 (0.667)	0.542	1.690	23	
Verdoorn $p_i = a + bq_i$	0.023* (3.613)	1.105* (17.910)	1.959	0.745	110	
Kaldor $e_i = c + dq_i$	-0.023* (-3.613)	-0.105** (-1.707)	1.959	0.026	110	---
Rowthorn1 $p_i = \lambda_1 + \varepsilon_1 e_i$	-0.032* (-5.768)	-1.178* (-9.524)	1.713	0.452	110	
Rowthorn2 $q_i = \lambda_2 + \varepsilon_2 e_i$	-0.032* (-5.768)	-0.178 (-1.441)	1.713	0.019	110	
Industry						
	Constant	**Coefficient**	**DW**	**R^2**	**G.L.**	**E.E. (1/(1-b))**
Verdoorn[(1)]	0.017 (0.319)	0.053 (0.673)	0.195	2.380	23	
Verdoorn	-0.014* (-2.993)	0.890* (18.138)	2.253	0.749	110	
Kaldor	0.014* (2.993)	0.110* (2.236)	2.253	0.044	110	9.091
Rowthorn1	0.053* (6.739)	-0.617* (-3.481)	2.069	0.099	110	
Rowthorn2	0.053* (6.739)	0.383* (2.162)	2.069	0.041	110	
Services						
	Constant	**Coefficient**	**DW**	**R^2**	**G.L.**	**E.E. (1/(1-b))**
Verdoorn[(1)]	0.003 (0.306)	0.096* (8.009)	0.773	2.492	23	
Verdoorn	0.007 (1.098)	0.499* (6.362)	2.046	0.269	110	
Kaldor	-0.007 (-1.098)	0.502* (6.399)	2.046	0.271	110	1.996
Rowthorn1	0.059* (19.382)	-0.432* (-5.254)	1.993	0.201	110	
Rowthorn2	0.059* (19.382)	0.568* (6.895)	1.993	0.302	110	
All Sectors						
	Constant	**Coefficient**	**DW**	**R^2**	**G.L.**	**E.E. (1/(1-b))**
Verdoorn[(1)]	0.007 (0.188)	0.090* (2.524)	0.203	2.588	23	
Verdoorn	-0.015* (-3.245)	0.851* (13.151)	2.185	0.611	110	
Kaldor	0.015* (3.245)	0.149* (2.308)	2.185	0.046	110	6.711
Rowthorn1	0.057* (13.017)	-0.734* (-5.499)	2.092	0.216	110	
Rowthorn2	0.057* (13.017)	0.266** (1.989)	2.092	0.035	110	

Note: (1) cross-section Estimation * Coefficient statistically significant at 5%, ** Coefficient statistically significant at 10%, GL, Degrees of freedom; EE, Economies of scale.

Analyzing the coefficients of each of the estimated equations with the two estimation methods considered (Table 2), to point out, now and in general, the values obtained with both methods have some similarities. For agriculture, it appears that the Verdoorn coefficient has an elasticity outside acceptable limits, since it is above unity.

At the industry level Verdoorn coefficient (with an elasticity between 0.957 and 0.964, respectively, for the method of fixed effects and random effects) indicates the existence of strong increasing returns to scale, as expected, in the face of that by Kaldor, the industry is the engine of growth showing strong gains in productivity.

Table 2: Analysis of sectoral economies of scale in five NUTS II of Portugal Continental, for the period 1995-1999

	M.E.	Const.	q_i	C_i/Q_i	F_i/Q_{ik}	E_i/E_n	DW	R^2	G.L.
Agriculture									
Verdoorn	DIF		1.112* (10.961)	0.066 (0.177)	-0.153* (-2.283)	-0.717 (-0.295)	1.901	0.945	11
	GLS	0.483* (2.597)	1.117* (14.538)	-0.668 (-1.560)	-0.182* (-3.594)	0.065 (0.152)	2.501	0.945	9
Industry									
Verdoorn	DIF		0.957* (5.425)	0.213* (2.303)	-0.001 (-0.041)	-4.787* (-2.506)	2.195	0.930	11
	GLS	-0.089 (-0.591)	0.964* (3.620)	0.217 (1.558)	-0.023 (-0.515)	0.042 (0.135)	2.818	0.909	9
Services									
Verdoorn	DIF		1.021* (5.430)	-0.116* (-2.587)	-0.020 (-0.856)	-5.458** (-1.895)	1.369	0.846	11
	GLS	-1.590 (-0.734)	1.084* (5.577)	-0.106* (-2.319)	-0.020 (-0.815)	-5.985** (-2.063)	1.629	0.717	9
All Sectors									
Verdoorn	DIF		0.905* (4.298)	-0.342* (-4.872)	-0.090* (-4.430)	-3.102* (-2.178)	1.402	0.919	11
	GLS	1.559 (1.675)	0.859* (3.776)	-0.371* (-4.665)	-0.096* (-4.404)	-3.158* (-2.098)	1.459	0.912	9

Note: * Coefficient statistically significant at 5%, ** Coefficient statistically significant at the 10% ME, estimation method, Const., Constant; Coef., Coefficient, GL, degrees of freedom; DIF method of estimation with fixed effects and variables in differences; GLS method of estimation with random effects.

In the services the Verdoorn coefficient, although statistical significance is greater than one.

For the total regions, the Verdoorn equation presents results that confirm the existence of strong growing economies to scale, with additional variables to show statistical significance.

In a general analysis of Table 2, we verified the presence of strong economies of scale in the industry, confirming Kaldor's theory that this is the only sector with substantial gains in production efficiency.

This part of the study will examine the procedures of specification by (10)Florax e al. (2003) and will firstly examine through OLS estimates, the relevance of proceeding with estimate models with spatial lag and spatial error components with recourse to LM specification tests.

The results concerning the OLS estimates of the Verdoorn's equation (equation (6), without spatial variables) with spatial specification tests are presented in Tables 3. In the columns concerning the test only values of statistical relevance are presented.

Table 3: OLS cross-section estimates of Verdoorn's equation with spatial specification tests (1995-1999)

Equation: $p_{it} = \alpha + \beta q_{it} + \mu_{it}$

	Con.	Coef.	JB	BP	KB	M'I	LM_l	LMR_l	LM_e	LMR_e	R^2	N.O.
Agriculture	0.013* (3.042)	0.854* (9.279)	1.978	5.153*	5.452*	0.331*	0.416	7.111*	8.774*	15.469*	0.759	28
Industry	-0.029* (-3.675)	1.032* (9.250)	3.380	2.511	1.532	-0.037	1.122	2.317	0.109	1.304	0.758	28
Services	0.033* (3.971)	0.169 (1.601)	1.391	1.638	1.697	0.212*	4.749*	1.987	3.607*	0.846	0.055	28
Total of sectors	0.002 (0.411)	0.659* (8.874)	1.585	5.174*	4.027*	0.030	0.008	0.087	0.069	0.149	0.742	28

Note: JB, Jarque-Bera test to establish parameters; BP, Breusch-Pagan test for heteroskedasticity; KB, Koenker-Bassett test for heteroskedasticity: M'I, Moran's I statistics for spatial autocorrelation; LM_l, LM test for spatial lag component; LMR_l, robust LM test for spatial lag component; LM_e, LM test for spatial error component; LMR_e, robust LM test for spatial error component; R^2, coefficient of adjusted determination; N.O., number of observations; *, statistically significant for 5%

From the table 3 the existence of growing scaled income in agriculture and in the total of all sectors is confirmed. Industry shows itself to be a sector with very strong growing scaled income, since, despite Verdoorn's coefficient being highly exaggerated it is very close to unity and when the null hypothesis is tested as β=1, a t-statistic of 0.287 is obtained. As it is a highly reduced value, it is accepted that industry is subject to strong scaled income.

The results for ML estimates with spatial effects for agriculture and services are presented in table 4.

Table 4: Results for ML estimates for Verdoorn's equation with spatial effects (1995-1999)

	Constant	Coefficient	Coefficient$^{(S)}$	Breusch-Pagan	R^2	N.Observations
Agriculture	0.016* (1.961)	0.988* (14.291)	0.698* (4.665)	4.246*	0.852	28
Services	0.011 (0.945)	0.134 (1.464)	0.545* (2.755)	3.050**	0.269	28

Note: Coefficient$^{(S)}$, spatial coefficient for the spatial error model for agriculture and the spatial lag model for services; *, statistically significant to 5%; **, statistically significant to 10%.

Only in agriculture the Verdoorn's coefficient improves with the consideration of spatial effects, since it goes from 0.854 to 0.988.

5. CONCLUSIONS

At NUTs III, the results of the estimations made for each of the economic sectors, in the period (1995-1999), notes that the industry provides greater increasing returns to scale, followed by services. Agriculture, on the other hand, has overly high values.

At NUTs II, the consideration of new variables (GFCF ratio/output ratio flow of goods/output and the variable concentration), in the equation of Verdoorn, little improvement have in the Verdoorn coefficient. Finally, it should be noted that the Verdoorn coefficient captures much of the agglomeration effects and is therefore not necessary to express explicitly these effects.

With the cross-section estimates, it can be seen, that sector by sector the growing scaled income is much stronger in industry and weaker or non-existent in the other sectors, just as proposed by Kaldor. With reference to spatial autocorrelation, Moran's I value is only statistically significant in agriculture and services. Following the procedures of Florax et al. (2003) the equation is estimated with the spatial error component for agriculture and the spatial lag component for services, it can be seen that it is only in agriculture that Verdoorn's coefficient improves with the consideration of spatial effects.

So, with the different ways of estimation the Keynesian models, we can conclude which the this theory said, about Portugal, that there was divergence between the continental regions, because we had increasing returns in the industry like Kaldor provided.

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