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**Conference Paper**

## Endogenous productivity and scale economies. a verdoorn law application in the Portuguese regions

44th Congress of the European Regional Science Association: "Regions and Fiscal Federalism",  
25th - 29th August 2004, Porto, Portugal

**Provided in Cooperation with:**

European Regional Science Association (ERSA)

*Suggested Citation:* Martinho, Vitor João Pereira (2004) : Endogenous productivity and scale economies. a verdoorn law application in the Portuguese regions, 44th Congress of the European Regional Science Association: "Regions and Fiscal Federalism", 25th - 29th August 2004, Porto, Portugal, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

<https://hdl.handle.net/10419/116930>

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**TITLE:** Endogenous productivity and scale economies. A verdoorn law application in the portuguese regions.

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# **ENDOGENOUS PRODUCTIVITY AND SCALE ECONOMIES.**

## **A VERDOORN LAW APPLICATION IN THE PORTUGUESE REGIONS**

### **ABSTRACT**

In agreement with the Verdoorn law the growth rate of the work productivity is endogenous and it depends on the growth rate of the industrial product. This relationship (with the coefficient of Verdoorn inferior to the unit) evidences substantial scale economies that are in the base of economic growth models with circular and cumulative causes. With this work we intend to test the Verdoorn Law, with the alternatives specifications of Kaldor (1966), for the 5 Portuguese regions (NUTs II) in the period from 1986 to 1994 and for the 28 Portuguese NUTs III in the period from 1995 to 1999. We intend, like this, to analyse the existence of increasing returns to scale that characterize the polarization processes with circular and cumulative causes and can explain the processes of regional divergence. A little to the similarity of what has been effectuated in other works associated to the New Economic Geography, in that they try to analyse the existence of increasing returns to scale and agglomeration processes with circular and cumulative causes. Although the theoretical base is different, in other words, macro-economic in the Keynesian developments associated to the Verdoorn Law and micro-economic in the New Economic Geography. We intend to test, still in this work, the alternative interpretation of Rowthorn (1975) of the Verdoorn Law for the same regions and periods. The results of this work will be complemented with estimates of these relationships for others economic sectors besides the industry (primary sector and services), for each one of the manufactured industries to operate in the Portuguese regions and for the total of the economy of each region. We did estimates for the others economic sectors (primary sector and services), because the modern economies could have more than a sector subject to increasing returns, especially in some services activities. The estimates for the total of the regional economy intend to verify the scale economies at regional level.

## 1. Introduction

Verdoorn (1949) was the first author to reveal the importance of the positive relationship between the work productivity growth and the output growth, defending that the causality comes from the output for the productivity, assuming this way that the work productivity is endogenous. An important empiric discovery of the relationship is the work productivity elasticity with regard to the output that in agreement with Verdoorn is approximately 0,45 on average, with external limits between 0,41 and 0,57. This author verified although the relationship between the productivity growth and the output growth reflect a type of production technology and the existence of increasing returns to scale, what contradicts the Neoclassical hypothesis of constant returns to scale, or decreasing, and of regional absolute convergence (Soukiazis, 1995).

Kaldor rediscovered this Law in 1966 and ever since the Verdoorn Law has been tested in several ways, using specifications, samples and different periods. However, the obtained conclusions diverge, some of them rejecting the Verdoorn Law and another supporting this Law validity. Kaldor (1966, 1967) in his intention of explaining the weak growth rate causes of United Kingdom, reconsidering and investigating the Verdoorn Law empirically, verified that there is a strong positive relationship among the work productivity growth ( $p$ ) and the output ( $q$ ), or  $p=f(q)$ . Or alternatively among the employment growth ( $e$ ) and the output growth, in other words,  $e=f(q)$ . This because, Kaldor beside of having estimated the relationship between the productivity growth and the industrial output growth, gave preference to the relationship between the labour growth and the output growth, to avoid effects “spurious”<sup>1</sup>. This author defends that a relationship statistically significant between the employment growth rate or work productivity and the output growth rate, with the coefficient of regression smaller or equal to the unit and superior or equal to zero ( $0 \leq b \leq 1$ ), it can be the enough condition for the presence of increasing scale economies of static and dynamic nature<sup>2</sup>. The theoretical base of the Verdoorn Law is assumed for reflected properties from the function of technical progress or the curve of “learning by doing”,

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<sup>1</sup> These effects result of the possibility of having double counting, once  $p=a+bq$ ,  $p=q-e$  and as such  $q-e=a+bq$ . In this case, if the employment growth is weak ( $e \rightarrow 0$ ), then  $q \approx a + bq$ .

<sup>2</sup> The static increasing scale economies link with the volume and the production scale, resulting from the largest division and specialization of the labour (Adam Smith increasing returns notion) and the dynamics are the result of the induced technical progress, “learning by doing”, external economies in the production, capital accumulation, etc.

where the productivity is endogenous and dependent of the demand forces (unlike the Neoclassic that considered the supply forces as the main determinant of the economic growth processes). In these terms, the relationship between the productivity growth and the output growth captures static and dynamic increasing returns to scale. Kaldor adopt, like this, two fundamental ideas: the notion of Arrow (1962) of “learning by doing” and the theory of Young (1928) of increasing returns as macro-economic processes. The relationship between the work productivity growth and the output growth is expected that is weak for the others economy sectors (services and agriculture), once, the services produce products not exportable (for the Keynesian Theory, the exports demand is the main determinant of the economic growth) and the agriculture that exhibits decreasing returns to scale<sup>3</sup> and suffers of occult unemployment. In the developments of Kaldor, the growth processes with circular and cumulative causes result of a relationship between exports demand and the productivity in the industry, where without the verification of the Verdoorn Law the cumulative growth doesn't work. In other words, an exogenous increase of the exports demand of industrial products induce an output increase, through the external trade multiplier of Harrod (1933 and 1939), and this output increase induces a productivity increase, through the Verdoorn Law. The productivity increase allows the reduction of the unitary costs, of the efficiency wages and of the prices, with consequent won of competitiveness and new exports increases. With new exports increases the process described before repeat again and like this we have circular and cumulative processes.

Another interpretation of the Verdoorn Law, in alternative to the one of Kaldor, is that presented by Rowthorn (1975, 1979). Rowthorn defends that the most appropriate specification of the Verdoorn Law is the relationship of the output growth (q) and work productivity growth (p) with the employment growth (e), in other words,  $q=f(e)$  and  $p=f(e)$ , respectively (the exogenous variable in this case is the employment). On the other hand, Rowthorn considers that the empiric works of Kaldor (1966) for the period from 1953-54 to 1963-64 and the one of Cripps and Tarling (1973) for the period from 1951 to 1965 that confirm the Kaldor Law, cannot be accept, given that are based in small samples of countries, where extreme cases like Japan have great influences in the obtained global results. For this author the economies support constant returns to

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<sup>3</sup> This because, the agriculture is a sector with a limited supply and demand. In other words, the supply is conditioned by the climatic conditions and subjects to biological restrictions (with productive cycles for long times and subject to diseases) and the demand is subject to the agrarian products specifications, because are goods of first need and as such have low elasticities income and prices.

scale, unlike the increasing returns defended by Kaldor in their works. What is proven, according to Rowthorn, when the coefficient of the relationship between the output growth and the employment growth is not statistically different from the unit. Another important aspect is that it is waited that the relationship between the work productivity growth and the employment growth is weak or negative, once won of work productivity are associated to declines in the employment and unemployment increases in the industrial sector.

Of referring, last, that several authors have been developing a group of works with the objective of testing the Verdoorn Law in a regional context, namely, Kennedy (1971), Cripps and Tarling (1973), Cornwall (1977), Thirlwall (1983), McCombie and of Ridder (1983, 1984), Hildreth (1988-89), Fingleton and McCombie (1998) and Leon-Ledesma (1998). Leon-Ledesma (1998), for instance, developed recently a work where tested the Verdoorn Law with different specifications (some similar to the presented following in this work and another including the capital) in the 17 Spanish regions, considering the contributions of Kaldor (1966, 1970 and 1975). In the estimates that effectuated, Leon-Ledesma used data in panel and a group of average growth rates among 1962-73, 1973-83 and 1983-91. All the obtained results indicate the existence of strong returns to scale in the Spanish regions.

## 2. Alternative specifications of the Verdoorn Law

The hypothesis of increasing returns to scale in the industrial sector was tested initially by Kaldor (1966) using the following relationships:

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

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

where  $p_i$ ,  $q_i$  and  $e_i$  are the work productivity growth rate, output and employment of the industrial sector in the economy  $i$ .

Once  $p_i \equiv q_i - e_i$ , then  $c = -a$  e  $d = (1-b)$ . Kaldor prefers the second equation for estimate purposes, due, as referred previously, to the possibility of double counting. The

results obtained by Kaldor in the estimates that realized with the two equations for the manufactured industry of OCDE twelve countries, in the period from 1953-54 to 1963-64, show values of  $b$  and  $d$  to near 0,5. The Kaldor interpretation of the Verdoorn coefficient (that is  $b$ ) of 0,5, is that to 1% of output growth increase is associated 0,5% of productivity growth increase or of employment, what evidences substantial increasing returns to scale in the manufactured industry. Of referring that, Kaldor didn't derive this regression of an explicit technological model, however, it admitted that it constitutes a function of technical progress. Soukiazis (1995) realized, also, a group of estimates with these equations to the OCDE countries, in the period of 1960-1991, and display that the coefficient of the Kaldor equation (equation (2)) it is always positive and smaller than the unit, as expected for the theory. However only in the decade of 70 is that it presents a value (0,46) similar to the found by Kaldor (0,5) and precisely equal to the Verdoorn (0,45). On the other hand, the coefficient of the Verdoorn equation (equation (1)) presents more satisfactory values in face of the expected, considering the developments of Kaldor.

Rowthorn (1975 and 1979) criticized the Kaldor specification of the Verdoorn Law<sup>4</sup> and suggested an alternative specification. In other words, if is assumed that the growth rate is restricted by the labour supply (as Kaldor believed initially for the United Kingdom case), then the appropriate form to test the Verdoorn Law is to regress the productivity growth (or the output) in the employment, being considered, like this, the employment growth as exogenous. This way, the mathematical form of the Rowthorn specification is the following:

$$p_i = \lambda_1 + \varepsilon_1 e_i, \text{ Rowthorn first equation (3)}$$

$$q_i = \lambda_2 + \varepsilon_2 e_i, \text{ Rowthorn second equation (4)}$$

where  $\lambda_1 = \lambda_2$  and  $\varepsilon_2 = (1 + \varepsilon_1)$ , given that  $p_i = q_i - e_i$ . Because,  $q_i - e_i = \lambda_1 + \varepsilon_1 e_i$ ,  $q_i = \lambda_1 + e_i + \varepsilon_1 e_i$ , then,  $q_i = \lambda_1 + (1 + \varepsilon_1) e_i$ .

Rowthorn estimated these equations to the same OCDE countries considered by Kaldor (1966), with exception of Japan, and for the same period and it verified that  $\varepsilon_2$

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<sup>4</sup> The critics are due to the fact of Kaldor above all to have considered the employment growth as endogenous and of having estimated the Verdoorn Law in a small number of countries, where the special case of Japan contributed strongly to the obtained results.

wasn't statistically different from the unit and consequently  $\varepsilon_1$  wasn't statistically different from zero. This author confirmed, like this, the hypothesis of constant returns to scale in the manufactured industry of the developed OCDE countries. Thirlwall (1980), criticized these results, for considering that the Rowthorn interpretation of the Verdoorn Law is static, once, it assumes that the Verdoorn coefficient only depends on the output partial elasticity with regard to the employment. Thirlwall defends, like this, that the Verdoorn coefficient has to be interpreted in a dynamic form, given that this coefficient depends on the output total elasticity in relation to the employment and one the capital grows rate relatively to the employment. Other authors rejected, also, the Rowthorn results for consider that the capitalists advanced economies are characterized by the labour supply that leaves the non-industrial sectors and then the growth isn't restricted by the labour supply.

### **3. The data**

Considering the variables relative to the Kaldor and Rowthorn models presented, previously, and the readiness of statistical information, the data were used disaggregated at regional level. Annual data for the period from 1986 to 1994 corresponding to the five regions of Continental Portugal (NUTs II), for the several economic sectors, including the several manufactured industries existent in these regions and for the total of the economy of these regions. These data were obtained in Eurostat (Regio of Eurostat Statistics 2000) and are relative to the employment (E, employment number) and to the gross value added (Q, in “escudos”). The productivity was calculated through the ratio between the output and the employment, in other words,  $P=Q/E$ . They were, also, used data for the period from 1995 to 1999 corresponding to twenty-eight NUTs III of the Continental Portugal regions and with the same sector disaggregation before referred. The data for the period from 1995 to 1999 were obtained in INE (Regional Accounts 2003) and are relative to the same variables (of referring that the gross value added is expressed in this period in “euros”). The data relative to the gross value added for each one of the regions and sectors, in the period from 1986 to 1994, were deflation for the national price indexes (at constant prices of 1986), for lack of regional price indexes. The same data for the period from 1995 to 1999 are already presented by INE



at constant prices of 1995. The used data are not presented in this document, in face of the need in regarding the established limits of pages.

#### **4. Empiric evidences of the Verdoorn Law and on the scale economies**

The objective of this part of the work is to estimate the Verdoorn equation (with the alternative specifications) and to verify the scale economies to regional and sector level. The differences among Verdoorn, Kaldor and Rowthorn consist on Verdoorn, according to the interpretation of Kaldor, to consider that there is a relationship between the productivity growth and the output growth, with the productivity growth endogenous. Kaldor presented an alternative specification where considers that there is a relationship between the employment growth and the output growth, with the employment growth endogenous. Rowthorn, for his time, presented, still, more two alternative specifications, where the employment growth is exogenous, being solid with the Neoclassical theory of the exogenous productive factors. Rowthorn, in their specifications, considers that the economies work with constants scale economies. Kaldor, in the Verdoorn Law interpretation, admits the existence of increasing economies to scale, above all in the industry, that are so much larger the more close of the unit is the coefficient value of the Verdoorn equation presented by Kaldor and consequently closer of zero is the coefficient of the Kaldor equation. However, admitted that a value closer of 0,5 for the Verdoorn coefficient will be the most pragmatic.

In face of the presented objectives, were effectuated estimates with the equations of Verdoorn, of Kaldor and of Rowthorn before presented, for each one of the economic sectors and for the total of the economy of each one of the considered regions, in the periods from 1986 to 1994 and from 1995 to 1999. Were considered these two periods, once, the data base used for each one of these periods is different, as well as the methodology of collects the statistical information. In the first period were done, still, estimates with referred equations of the models of Verdoorn, of Kaldor and of Rowthorn for each one of the manufactured industries. These estimates were not presented in the second period by the obtained results be unsatisfactory, possibly for the temporary series from 1995 to 1999 to be small and the degrees of freedom obtained

after the estimates be insufficient<sup>5</sup>.

The estimate methods in panel used were the random effects and the one of the fixed effects with variables “dummies.” However, we opted to not to present the results of the estimate method with variables “dummies”, once, the “dummies” didn't present, in most of the estimates, statistical significance, indication that no there are significant structural differences, in the several economic sectors, among the different Portuguese regions. They were, still, realized estimates “cross-section” with the Verdoorn equation (equation (1)), through the method OLS, for the different economic sectors and in the second period (given the number of observations to be larger).

#### **4.1. Results obtained for each one of the economic sectors and for the total of the economy, of the five considered regions, in the period 1986-1994**

For the Table 8 results, obtained in the estimates realized with the equations of Verdoorn, of Kaldor and of Rowthorn for each one of the economic sectors and for the total of the economy of each one of the 5 regions considered in the first period, of referring the following:

The industrial sector is what presents larger increasing returns to scale, following by the agriculture and of the services sector. The services without the public function present values for the scale returns unacceptable and the manufactured industry presents values surprisingly very low, as reflex of a more intensive labour factor use.

Analysing the coefficients of each one of the estimated equations is verified that the industry presents elasticities of 0,992 and of -0,449 for the Verdoorn coefficient Verdoorn and for the coefficient of the Rowthorn first equation, respectively, and both with statistical significance. These values indicate the existence of strong increasing returns to scale, as it would be of waiting, in face of the referred by Kaldor, in other words, the industry is the growth engine with strong scale returns. Kaldor (1966), explains that the industry is the economic sector with more potential, for two fundamental reasons: first because is the only sector with increasing economies to scale and second because the industry produces majority marketable products. These two factors constitute the base of the cumulative growth. The coefficient of Kaldor doesn't

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<sup>5</sup> Another possibility would be effectuate the estimates for NUTs III, as effectuated for each one of the economic sectors, but the inexistence of data disaggregated for each one of the manufactured industries in these space units, it disabled, also, to consider this possibility.

present statistical significance and the one of the Rowthorn second equation presents statistical significance and the expected value in face of the coefficient of this author's first equation. Of referring, like this, that unlike the referred by Rowthorn, or be the economies support constant returns to scale, the coefficients obtained for them equations, indicate the existence of increasing returns to scale in the industry. The manufactured industry presents increasing returns to scale weakest, as it was verified previously, given the four coefficients values, in other words, 0,319, 0,681, -0,240 and -0,760, respectively.

The agriculture, the Verdoorn coefficient (b, of the equation (1)) presents a unit close value (0,878) and with statistical significance. Reflex, as it was seen, that there were strong increasing returns to scale in this sector and in this period, essentially, as a result of to strong labour factor decrease. The elasticity indicates that when the output increased 1%, the productivity increased 0,878%. The Kaldor coefficient (d, of the equation (2)) presents the expected value (0,123), in face of the value obtained for the Verdoorn coefficient presented previously, although it has a very low statistical significance. The coefficient value of the Rowthorn first equation ( $\varepsilon_1$ , of the equation (3)) is relatively lower than would be of waiting (-0,621), considering the coefficients values referred before, and has very low statistics significance. The coefficient value of this author's second equation (equation (4)) is the expected (0,379), considering the obtained for the first equation coefficient, but doesn't have statistical significance. For the Rowthorn equations values, is verified that the agriculture will be characterized more by constant returns to scale than for increasing returns to scale, once, the coefficient value of this author's first equation is statistically almost non different from zero and the one of second is statistically non different from one. We find, like this, contradictory conclusions, for this sector, with the estimates values of the equations of Verdoorn and of Kaldor and with the one of the equations of Rowthorn. Although the  $R^2$  values of the Rowthorn equations are very low (0,087 and 0,034, respectively for the equation (3) and (4)).

In the services sector, the 0,802 and -0,694 values (respectively for the Verdoorn coefficient and for the Rowthorn first equation coefficient), with statistical significance, also indicate the existence of strong increasing returns to scale in this sector. What wasn't referred for Kaldor, given that, only the industry and the manufactured industry are sectors that had, preferentially, increasing returns to scale and were the main sectors responsible for the economic growth, once, they produce

products exported. The Kaldor and the Rowthorn second equation elasticities don't have statistical significance. The elasticities obtained for the services without the public function are unsatisfactory, once, the Verdoorn coefficient, is superior to one.

The 0,907 and  $-0,648$  values (respectively for the Verdoorn coefficient and for the Rowthorn first equation), for the total of the regional economy, show that the regions were subject in this period to strong increasing economies to scale. The Kaldor and the Rowthorn second equation coefficients, once again don't present statistical significance.

Of referring, last, for the group of results of this Table the following:

The Verdoorn equation is the most satisfactory in terms of statistical significance of the obtained coefficient and of the explanation degree in the several estimates. It is verified, like this, that the productivity is endogenous and generated by the regional and sectors output growth.

The Kaldor relationship doesn't adapt well in the Portuguese economic sectors, with the manufactured industry exception.

The Rowthorn first equation indicates a negative correlation between the employment growth and productivity growth, indicating that the productivity earnings are obtained at the employment expense.

The Rowthorn second equation indicates a strong relationship of the employment with the industrial output, but weak in the others sectors. This evidence reveals the importance of the technological progress and of the factors qualification that are absent of the production function.

The Verdoorn equation and Rowthorn first equation values indicate similar conclusions in terms of increasing returns to scale (contradicting the referred by Rowthorn). Of stressing, still, that the Verdoorn coefficients values are a little high, considering the obtained by Kaldor and Verdoorn, possibly because lack another variables in the equations, namely the capital.

**Table 8: Scale economies analysis through the equations of Verdoorn, Kaldor and Rowthorn, for each one of the economic sectors and in Continental Portugal five NUTs II, for the period from 1986 to 1994.**

sectors and in Continental Portugal five NO 18 11, for the period from 1966 to 1977.						
Agriculture						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn $p_i = a + bq_i$	0.042* (5.925)	0.878* (12.527)	1.696	0.805	38	8.197
Kaldor $e_i = c + dq_i$	-0.042* (-5.925)	0.123** (1.750)	1.696	0.075	38	
Rowthorn1 $p_i = \lambda_1 + \varepsilon_1 e_i$	-0.010 (-0.616)	-0.621** (-1.904)	1.568	0.087	38	
Rowthorn2 $q_i = \lambda_2 + \varepsilon_2 e_i$	-0.010 (-0.616)	0.379 (1.160)	1.568	0.034	38	
Industry						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn	-12.725* (-4.222)	0.992* (8.299)	2.001	0.587	37	125.000
Kaldor	12.725* (4.222)	0.008 (0.064)	2.001	0.869	37	
Rowthorn1	15.346* (9.052)	-0.449* (-3.214)	1.889	0.326	37	
Rowthorn2	15.346* (9.052)	0.551* (3.940)	1.889	0.776	37	
Manufactured Industry						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn	8.296* (4.306)	0.319* (2.240)	1.679	0.139	37	1.468
Kaldor	-8.296* (-4.306)	0.681* (4.777)	1.679	0.887	37	
Rowthorn1	12.522* (12.537)	-0.240* (-2.834)	1.842	0.269	37	
Rowthorn2	12.522* (12.537)	0.760* (8.993)	1.842	0.891	37	
Services						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn	-0.045* (-3.253)	0.802* (6.239)	1.728	0.506	38	5.051
Kaldor	0.045* (3.253)	0.198 (1.544)	1.728	0.059	38	
Rowthorn1	0.071* (4.728)	-0.694* (-3.607)	1.817	0.255	38	
Rowthorn2	0.071* (4.728)	0.306 (1.592)	1.817	0.063	38	
Services (exception public function)						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn	-0.074* (-4.250)	1.020* (7.695)	1.786	0.609	38	---
Kaldor	0.074* (4.250)	-0.020 (-0.149)	1.786	0.001	38	
Rowthorn1	0.076* (4.350)	-0.903* (-4.736)	1.847	0.371	38	
Rowthorn2	0.076* (4.350)	0.097 (0.509)	1.847	0.007	38	
All Sectors						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn	-0.020* (-2.090)	0.907* (8.367)	1.595	0.648	38	10.753
Kaldor	0.020* (2.090)	0.093 (0.856)	1.595	0.019	38	
Rowthorn1	0.056* (6.043)	-0.648* (-2.670)	2.336	0.255	32	
Rowthorn2	0.056* (6.043)	0.352 (1.453)	2.336	0.225	32	

Note: \*Coefficient statistically significant to 5%; \* \* Coefficient statistically significant to 10%; G.L., Degrees of freedom; E.E., Scale economies.

#### **4.2. Results obtained for each one of the manufactured industries, of the five considered regions, in the period 1986-1994**

Applying the same methodology for each one of the manufactured industries, were obtained the results presented in the Table 9.

The manufactured industries that present, respectively, larger increasing returns to scale are the transport equipments industry (5,525), the food industry (4,274), the minerals industry (3,906), metals industry (3,257), the several products industry (2,222), the textile industry (1,770), the chemical industry (1,718) and the equipments and electric goods industry (presents unacceptable values). The paper industry presents values exaggeratedly high. Of pointing out that, as it would be of waiting, the transport equipments industry and the food industry present the best scale economies (they are modernized industries) and the textile industry presents of the lowest scale economies (industry still very traditional, intensive in labour, and in small dimension units).

Analysing, more, the Table 9 results, of referring the following:

The transport equipments industry presents elasticities of 0,819, -0,628 and of 0,372, respectively for the Verdoorn relationship and for the Rowthorn relationships. The Kaldor coefficient doesn't present statistical significance.

The food industry presents a Verdoorn coefficient 0,766, with statistical significance, and the remaining elasticities present the expected values, in face of this coefficient, and with statistical significance. What indicates agreement among the estimated values of the four equations.

The values of 0,744 and of -0,898 (respectively for the Verdoorn and the Rowthorn first equation coefficients), with statistical significance, prove that the minerals industry has strong increasing returns to scale. The coefficients of the others two equations don't present statistical significance.

The metals industry presents a Verdoorn coefficient 0,693, indicating that when the output increases 1%, the productivity increases 0,693%. The Kaldor coefficient Kaldor presents the expected value and with statistical significance. For the coefficients of the Rowthorn equations were obtained unsatisfactory values.

The several products industry presents results very similar to the obtained by Kaldor and Verdoorn. The coefficients results of the Rowthorn equations are unsatisfactory.

The textile industry presents for the Verdoorn equation elasticity lightly lower than the one of the previous industry (although also very similar to obtained by Verdoorn), but presents elasticities with statistical significance for the four equations.

The chemical industries present values of 0,418 and of 0,582, respectively for the Verdoorn and Kaldor coefficients, with statistical significance. The Rowthorn equations coefficients present unsatisfactory values.

The equipments and electric goods industry presents unsatisfactory values for the Verdoorn and kaldor coefficients and presents elasticities, with statistical significance, of  $-0,287$  and of  $0,713$ , respectively for the Rowthorn equations coefficients. The results obtained for this last industry contradict, therefore, the increasing returns to scale theory of Kaldor and of Verdoorn and the constant returns to scale theory of Rowthorn.

The paper industry presents strange values for the Verdoorn coefficient and for the Rowthorn first equation coefficient, once, they cross the unit.

Considering the Verdoorn and Kaldor elasticities, is verified that, to the exception of the values obtained for the equipments and electric goods and the paper industries, all the results obtained in the estimates for the manufactured industries confirm the existence of increasing returns to scale. Although, once again, the Verdoorn relationship presents values more satisfactory statistically than the Kaldor relationship. On the other hand, all the values obtained for the Rowthorn equations coefficients in the different manufactured industries, to the exception of the obtained in the metals, chemistry and several products industries, contradict the Rowthorn theory of constant returns to scale.

Still in the Table 9, are presented results of an estimate effectuated with the 9 manufactured industries disaggregated and together (with 405 observations). For the analysis of these data it is verified that were obtained, respectively for the four equations coefficients, the following elasticities:  $0,608$ ,  $0,392$ ,  $-0,275$  and  $0,725$ . Therefore, values that don't indicate very strong increasing returns to scale, as in previous estimates, but they are close of the obtained by Kaldor and Verdoorn.

**Table 9: Scale economies analysis through the equations of Verdoorn, Kaldor and Rowthorn, for each one of the manufactured industries and in five NUTs II of Continental Portugal, for the period from 1986 to 1994.**

Metals Industry						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn $p_i = a + bq_i$	-4.019* (-2.502)	0.693* (9.915)	1.955	0.898	29	3.257
Kaldor $e_i = c + dq_i$	4.019* (2.502)	0.307* (4.385)	1.955	0.788	29	
Rowthorn1 $p_i = \lambda_1 + \varepsilon_1 e_i$	-12.019 (-0.549)	0.357 (1.284)	1.798	0.730	29	
Rowthorn2 $q_i = \lambda_2 + \varepsilon_2 e_i$	-12.019 (-0.549)	1.357* (4.879)	1.798	0.751	29	
Minerals Industry						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn	-0.056* (-4.296)	0.744* (4.545)	1.978	0.352	38	3.906
Kaldor	0.056* (4.296)	0.256 (1.566)	1.978	0.061	38	
Rowthorn1	-0.023 (-0.685)	-0.898* (-9.503)	2.352	0.704	38	
Rowthorn2	-0.023 (-0.685)	0.102 (1.075)	2.352	0.030	38	
Chemical Industry						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn	0.002 (0.127)	0.418* (6.502)	1.825	0.554	34	1.718
Kaldor	-0.002 (-0.127)	0.582* (9.052)	1.825	0.707	34	
Rowthorn1	9.413* (9.884)	0.109 (0.999)	1.857	0.235	33	
Rowthorn2	9.413* (9.884)	1.109* (10.182)	1.857	0.868	33	
Equipment and electric goods Industry						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn	0.004 (0.208)	-0.126 (-1.274)	1.762	0.128	32	---
Kaldor	-0.004 (-0.208)	1.126* (11.418)	1.762	0.796	32	
Rowthorn1	0.019 (1.379)	-0.287* (-4.593)	1.659	0.452	32	
Rowthorn2	0.019 (1.379)	0.713* (11.404)	1.659	0.795	32	
Transport equipment Industry						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn	-0.055* (-2.595)	0.819* (5.644)	2.006	0.456	38	5.525
Kaldor	0.055* (2.595)	0.181 (1.251)	2.006	0.040	38	
Rowthorn1	-0.001 (-0.029)	-0.628* (-3.938)	2.120	0.436	32	
Rowthorn2	-0.001 (-0.029)	0.372* (2.336)	2.120	0.156	32	
Food Industry						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn	0.006 (0.692)	0.766* (6.497)	2.191	0.526	38	4.274
Kaldor	-0.006 (-0.692)	0.234** (1.984)	2.191	0.094	38	
Rowthorn1	0.048* (2.591)	-0.679* (-4.266)	1.704	0.324	38	
Rowthorn2	0.048* (2.591)	0.321* (2.018)	1.704	0.097	38	
Textile Industry						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn	-0.008 (-0.466)	0.435* (3.557)	2.117	0.271	34	1.770
Kaldor	0.008 (0.466)	0.565* (4.626)	2.117	0.386	34	
Rowthorn1	0.002 (0.064)	-0.303* (-2.311)	1.937	0.136	34	
Rowthorn2	0.002 (0.064)	0.697* (5.318)	1.937	0.454	34	



Paper Industry						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn	-0.062* (-3.981)	1.114* (12.172)	1.837	0.796	38	∞
Kaldor	0.062* (3.981)	-0.114 (-1.249)	1.837	0.039	38	
Rowthorn1	0.028 (1.377)	-1.053* (-4.134)	1.637	0.310	38	
Rowthorn2	0.028 (1.377)	-0.053 (-0.208)	1.637	0.001	38	
Several products Industry						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn	-1.212 (-0.756)	0.550* (8.168)	2.185	0.529	37	2.222
Kaldor	1.212 (0.756)	0.450* (6.693)	2.185	0.983	37	
Rowthorn1	8.483* (24.757)	0.069 (1.878)	2.034	0.175	37	
Rowthorn2	8.483* (24.757)	1.069* (29.070)	2.034	0.975	37	
All 9 Manufactured Industries together						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn	-0.030* (-6.413)	0.608* (19.101)	1.831	0.516	342	2.551
Kaldor	0.030* (6.413)	0.392* (12.335)	1.831	0.308	342	
Rowthorn1	-0.003 (-0.257)	-0.275* (-4.377)	1.968	0.053	342	
Rowthorn2	-0.003 (-0.257)	0.725* (11.526)	1.968	0.280	342	

Note: \*Coefficient statistically significant to 5%; \* \* Coefficient statistically significant to 10%; G.L., Degrees of freedom; E.E., Scale economies.

#### **4.3. Results obtained for each one of the economic sectors and for the total of the economy, of twenty-eight Portuguese NUTs III, in the period 1995-1999**

For the Table 10, with results of estimates realized for each one of the economic sectors and in the period from 1995 to 1999, of stressing that the industry again presents larger increasing returns to scale (9,091), following by the services (1,996). The agriculture, on other side, presents unacceptable values. Or be:

The agriculture presents values for the Verdoorn coefficient and for the Rowthorn first equation coefficient strange, once, are superior to the unit. The industry presents values of 0,890, of 0,110, of -0,617 and of 0,383 (respectively, for the four coefficients), with statistical significance, sign that there were strong increasing returns to scale in the industry in this period. The services present very close elasticities of the obtained by Verdoorn and by Kaldor and in global terms the economies of Portuguese NUTs III present strong increasing economies to scale, with values of 0,851, of 0,149, of -0,734 and of 0,266, respectively for the four coefficients. Relatively, to the estimates “cross-section”, of referring that the values obtained are very weak, in other words, always very close of zero.

In the Table 11 are the results of an estimate effectuated for the 9 manufactured industries disaggregated and together, given that in face of the readiness of data (short temporary period and lack of data disaggregated for these industries in NUTs III) this will be a form of estimate the equations considered for the different manufactured industries in this period. For the analysis of the data it is verified that the coefficients values of the four equations are, respectively, 0,774, 0,226, -0,391 and 0,609 (all with statistical significance), reflex that the increasing returns to scale increased lightly in this economic sector, in other words, of 2,551 (Table 9) for 4,425.

**Table 10: Scale economies analysis through the equations of Verdoorn, Kaldor and Rowthorn, for each one of the economic sectors and in NUTs III of Continental Portugal, for the period from 1995 to 1999.**

Agriculture						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn <sup>(1)</sup>	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 <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn <sup>(1)</sup>	0.017 (0.319)	0.053 (0.673)	0.195	2.380	23	9.091
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	
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 <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn <sup>(1)</sup>	0.003 (0.306)	0.096* (8.009)	0.773	2.492	23	1.996
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	
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 <sup>2</sup>	G.L.	E.E. (1/(1-b))
Verdoorn <sup>(1)</sup>	0.007 (0.188)	0.090* (2.524)	0.203	2.588	23	6.711
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	
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; \*Coefficient statistically significant to 5%; \* \* Coefficient statistically significant to 10%; G.L., Degrees of freedom; E.E., Scale economies.

**Table 11: Scale economies analysis through the equations of Verdoorn, Kaldor and Rowthorn, for the 9 manufactured industries together, for the period from 1995 to 1999 and in five NUTs II of Continental Portugal.**

All Manufactured Industries						
	Constant	Coefficient	DW	R <sup>2</sup>	G.L.	E.E. (1/(1-b))
<b>Verdoorn</b> $p_i = a + bq_i$	0.004 (0.766)	0.774* (20.545)	2.132	0.703	178	4.425
<b>Kaldor</b> $e_i = c + dq_i$	-0.004 (-0.766)	0.226* (6.010)	2.132	0.169	178	
<b>Rowthorn1</b> $p_i = \lambda_1 + \varepsilon_1 e_i$	0.049* (4.023)	-0.391* (-3.392)	2.045	0.112	132	
<b>Rowthorn2</b> $q_i = \lambda_2 + \varepsilon_2 e_i$	0.049* (4.023)	0.609* (5.278)	2.045	0.214	132	

Note: \*Coefficient statistically significant to 5%; \* \* Coefficient statistically significant to 10%; G.L., Degrees of freedom; E.E., Scale economies.

## 5. Conclusions

In the estimates effectuated for each one of the economic sectors, in the first period (1986-1994), it is verified that the industrial sector is what presents larger increasing returns to scale, following by the agriculture and the services sector. The services without the public function present values for the increasing returns to scale exaggeratedly high and the manufactured industry presents very low values. Of referring, still, that the estimates realized for these sectors and in this period, above all, with the Verdoorn equation and with the Rowthorn first equation, indicate similar conclusions, in other words, of increasing returns to scale (contradicting the referred by Rowthorn). On the other hand, the elasticities of the Kaldor equation and of the Rowthorn second equation don't usually have statistical significance.

At the level of the estimates realized for the manufactured industries, it is verified that the ones that present, respectively, larger returns to scale are the transport equipments industry, the food industry, the minerals industry, the metals industry, the several products industry, the textile industry, the chemical industry and the equipments and electric goods industry. The paper industry presents values exaggeratedly high. Of pointing out that, as it would be of waiting, the transport equipments and the food industries present the best scale economies (they are modernized industries) and the textile industry presents of the lowest scale economies (industry still very traditional). Considering the Verdoorn and Kaldor elasticities, it is verified that, to the exception of the values obtained for the equipments and electric goods and the paper industries, all the results obtained in the estimates for the manufactured industries confirm the existence of increasing returns to scale. Although, once again, the Verdoorn relationship presents values more satisfactory statistically than the Kaldor relationship. On the other hand, all the values obtained for the Rowthorn equations coefficients in the different manufactured industries, to the exception of the obtained in the metals, chemistry and several products industries, contradict the constant returns to scale theory of Rowthorn.

For the results of the estimates effectuated for each one of the economic sectors, in the second period (1995-1999), it is observed that the industry again presents larger increasing returns to scale, following by the services. The agriculture, on other side, presents values exaggeratedly high. Therefore, the industry isn't the only sector to have increasing returns to scale in the Portuguese regions, but it is the sector where these are larger, what proves in a certain way the referred by Kaldor, in other words, the industry

is the engine of the growth generating positive externalities that benefit all the other sectors.

When we see the data (not presented in this work), it is verified that the economic sectors that more grew at the level of the product, of the job and of the productivity, they are not the ones that present larger increasing economies to scale, namely, the services are the sector that more grew at the level of the three variables before referred, but it presents, as it would be of waiting in face of the theory, increasing economies to scale inferior to the one of the industry (because are a sector that produces products not exportable). This context shows that Portugal has been coming to move, along the considered periods, resources for economic sectors with smaller increasing economies to scale, with the waiting consequences in terms of economic development, namely, in the loss of competitiveness in the international context.

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