Explorando o papel da oferta e demanda nas trajetórias setoriais de desenvolvimento

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Resumo

Este trabalho avalia a interação entre demanda e oferta em trajetórias de desenvolvimento setorial. Um modelo evolucionário baseado em Nelson e Winter (1982) é introduzido e suas hipóteses discutidas teorica- e empiricamente com a ajuda de dados para cinco categorias de tamanhos de empresas para 35 países. Beneficiando-se da versatilidade dos elementos da teoria Kaldoriana, a seção final fornece estimativas da influência da oferta e demanda nas trajetórias de desenvolvimento setorais. Os resultados explicam a controvérsia em torno da validade empírica da hipótese schumpeteriana e lançam luz sobre os fundamentos dos requisites de demanda e oferta para o crescimento.

Palavras-chave

Tamanho da firma; Teoria Evolucionária; Função de progresso técnico; Elasticidade da demanda; Coeficiente de Verdoorn.

Área temática

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Exploring the role of supply and demand in sectoral growth trajectories

1. Introduction

This paper assesses the interplay between demand and supply in sectoral development trajectories. The first part of the work introduces a growth model based on Nelson and Winter (1982) that emphasises the role of the firm size in innovation. Sectoral characteristics are kept exogeneous. The model suggests that the intra-sectoral process of development requires the concentration of the market structure. Data productivity and investment rates from the manufacturing sector of 35 countries are then compared across five size-categories to show that most of the hypothesis of the model are corroborated. Nevertheless, the evidence shows a divergence between the predicted logistic path and the actual quadratic (inverted U) relationship between concentration of the market-structure and sectoral development. This indicates that the development traverse involves the concentration market-structure at early stages and de-concentration in mature stages. The supply dynamics incorporated in the trajectory of technological development can only explain the first part of the traverse. The ensuing discussion proposes an unaccounted influence of demand influencing the final trajectory, changing the expected traverse.

Profiting from the versatility of the of the Kaldorian analytical framework – in special of the structural parameters representing each the demand and supply requisites for growth – the paper provides estimates of Verdoorn's coefficient[1] and income elasticities for each size class. This seminal approach aims at both investigating whether the logistic function of technological progress is empirically supported, and assessing the role of demand, represented by the income elasticity, in the actual trajectories.

The investigation leads to two important conclusions: (i) the level of returns to scale increases logistically with firm size, as proposed by the model; (ii) the income elasticities, however, is considerably lower for large firms, indicating a central role of demand in the noted divergence in trajectories. In summary, the approach reveals that the intra-sectoral 'natural trajectories' are supply-led. Nevertheless, the influence of the demand is key for the final shape of the market-structure and the equilibrium growth rate. This explains much of the controversy around the empirical validity of Schumpeterian hypothesis in the literature. The inverted U path makes it necessary to estimate the impact of firm size on innovation locally or by non-linear methods, since the role of firm size in the growth process varies in the traverse. Such an approach has yet another important contribution. By estimating the Kaldorian parameters at the intra-sectoral level, the approach casts light on the foundations of these important elements enabling a range of policy implications (King, 2010).

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[1] Although much of the recent efforts in the Kaldorian literature focus on exploring the foundations of these parameters, to date, the Verdoorn law and income elasticities have never been assessed at the intra-sectoral level.

2. Firm size, market structure and growth: an Evolutionary model of sectoral development

The Evolutionary school is the branch of the Schumpeterian theory that stresses the role of both resilience and 'variation' in the process of growth. It is the combination of these factors – 'hysteresis' and 'non-homogeneous productive factors' – that shape the most distinguishable characteristic of this theoretical body: the assignment of singular technological trajectories to distinct firms and sectors. Innovation is described as a stochastic and complex process determined by aspects at either the firm- (Patel and Pavitt, 1997), sector- (Malerba and Orsenigo, 1993) and country-levels (Lundvall, 1993; Freeman and Soete, 1997).

Building upon the seminal studies in the tradition, this section introduces a model based on Nelson and Winter (1982) to show that the firm-size is a key element in the process of sectoral development. According to Schumpeter, large firms enjoy of a privileged condition in the innovation competition, "*for there are advantages which, though not strictly unattainable on the competitive level of enterprise, are as a matter of fact secured only on the monopoly level*" (Schumpeter, 1942 p.101). These technological advantages respond to the scale of the internal innovative activities, that is, the number and quality of brains, structure, and sphere of influence of the firm. Even though neither a necessary nor sufficient condition for innovation, the Schumpeterian hypothesis[2] establishes that size is a key factor determining the rhythm with which the process of technical change takes place at both firms and sectors (e.g., Nordhaus, 1969; Nelson and Winter, 1982; Cohen and Klepper, 1996).

To see this, assume that the output of firm i at any time is given by the stock of capital and labour employed in a specific fashion. If $q = \frac{Q}{L}$ represents the output per worker, $k = \frac{K}{L}$ the capital-labour ratio[3], and $A > 0$ the technical coefficient, the output per unit of labour can be portrayed as in the classical AK endogenous growth model (Romer, 1990):

$$q_i = Ak \tag{1}$$

The growth rate of labour productivity ($\dot{q}$) – and thus the capital/labour ratio – will depend on the investment rate ($\dot{k}$), which responds positively to the technology (A) and to the savings rate (s), and negatively to the growth of labour employment (n) and to the depreciation rate (δ):

$$\dot{q} = \dot{k} = sA - (n + \delta) \tag{2}$$

From (2), $\dot{q}$ is ultimately constrained by the nature of the process of technical change[4] (A), since δ is exogenous and, in a monetary economy, s (ex-post) is determined by investment (ex-ante). The key point is thus defining the shape of A, which is assumed dependent on the nature of the knowledge base governing the specific sector (Marsili, 2001).

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[2] As the advantages of large firms in the innovation process were named in the literature.

[3] k denotes both physical and human capital.

[4] If technological progress is exogenous, provided that investment surpasses the depreciation, growth will occur indefinitely, and no convergence is expected.

In the Evolutionary tradition, albeit dependent of the level of spending on search activities, innovation is usually defined as a disruptive, non-linear and stochastic process (Nelson and Winter, 1982). Even within the technical boundaries set by the knowledge base governing the sector, for an individual firm, there are countless alternative strategies for innovation and even more possible outcomes. A usual solution in the literature is to assume different rates of return and success for each innovation strategy[5]. Were each of these parameters and odds known, the outcome of any strategy could be represented by a discount factor in the firm's cost/profit function, e.g.:

$$\pi_i = PA_j - c - r_j \qquad (3)$$

In (3) a linear revenue function determined by a constant technique (A_j) is assumed. $c = (wL_i + rK_i)$ represents the total costs, and r_j the cost/return of the innovative activity j. As the market is competitive, the actions of individual firms have a negligible impact on prices, which are determined at the sectoral level, by a downward-sloping demand function[6].

Innovative firms should be more profitable and if investment is profit-led[7] and the market follows the Schumpeterian type of competition[8], where successful firms replace less successful ones in the market, the firm size becomes intrinsically connected with the firm's technology. The firm size should reflect its previous accomplishments in the innovation competition, or the level of capabilities accumulated. Hence, the bigger the firm, the higher its capital-labour ratio and output per worker. Retrieving the AK model solution:

$$\dot{q}_i = \dot{k}_i = \lambda_i \pi_i \qquad (4)$$

where $0 < \lambda < 1$ is proportionality factor between investment and profitability, which depends on the firm's perception of the investment's return (profit-elasticity of the investment). It follows that any positive investment only occurs if $\bar{W}L_i < \bar{P}A_i$. In such

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[5] Innovation is ultimately a stochastic process in the sense that both the discovery and choice for the successful technique has a large component of randomness. Market factors, historical and institutional conditions, and/or a mere act of circumstance can impart on the success or failure of a new marketed innovation. This is obviously reflected in the costs of innovation and in profitability rates.

[6] As the good produced in the sector is considered homogenous, its price is determined at the sectoral level, having an individual firm negligible influence on it. Likewise, capital and labour costs both (interest rates and wages, respectively) are assumed homogeneous and determined at the sector level, i.e.:

$$P_i = D(Q_i), W_i = W(L_i), R_i = R(K_i)$$

[7] The existence of financial institutions lending capital changes this picture. Especially if one considers that credit is not equally available to smaller firms as it is to larger ones. On average, though, assuming that investment responds to the profitability conditions is not far-fetched. Investment (or process of search and selection) is far more likely to be pursued by profitable firms. Financial institutions also require health certificates from firms applying for money and are likely to grant credit only to profitable ones.

[8] "*Schumpeterian competition is, like most processes we call competitive, a process that tends to produce winners and losers. Some firms track emerging technological opportunities with greater success than other firms; the former tend to prosper and grow, the latter to suffer losses and decline. Growth confers advantages that make further success more likely, while decline breeds technological obsolescence and further decline*" (Nelson and Winter, 1982 p.325).

conditions, the firm's decision to invest depends on the rate of success of the technique adopted, i.e., how the technical quotient (A_i/L_i) behaves[9].

Ultimately, λ represents the intra-sectoral range of technologies, which is determined by the actual stock of capital of the firm, i.e., the firm size. With the firm size mediating the relationship between profitability and investment, λ should increase with size, as large firms are in a better technological position in the innovation competition, receiving a higher payout (less-risky) for the investment. The process has a cap, however, as the scale of production itself might start hurting the level of innovation due to: (i) the absence of active competition in concentrated markets, which reduces the investment in search activities; (ii) the rise of opportunity costs to innovating, since this activity displaces part of the monopolistic returns for dominant firms, and also reduces the profit outlook for smaller firms; (iii) bureaucratic inertia and loss of managerial control, usually associated with the large scale of production[10] (Cohen, 1995).

2.1. The sectoral technology: beyond microfoundations

With A_j determined by the knowledge base governing the sector, the sectoral productivity will depend on the distribution of capital amongst the firms populating the sector, that is, the distribution of firm-sizes. This important result follows from the technical condition that makes, for each sector, large firms more productive in every unit of labour employed. Accordingly, since the technology is labour-saving in most of its producible branch, the sectoral output will be as high as the level of concentration of the market-structure. Nelson and Winter (1982) illustrate this condition with a traditional Herfindhal-Hirshman index, although any concentration index would suffice:

$$q_t = \sum_{i=1}^{n}\left(A_j \cdot k_{it}\right) = \sum_{i=1}^{n}\left(\frac{k_i}{k}\right)^2 s.t\ \bar{A} \tag{5}$$

Three important results derive from the above. Firstly, within a technological regime, the investment rate, level of output, and ultimately the growth rate are determined by the sectoral level of market concentration. Secondly, from the sectoral perspective, economic development can be expressed as a simple selection process, as in the linear model (Scherer, 1965) and the seminal Evolutionary models (cf. Nelson and Winter, 1982). Finally, given the logistic shape of the sectoral function of technological progress (A_j), mid-concentrated sectors will grow faster than sectors that are highly or lowly concentrated.

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[9] Note, however, that changes in the relative prices (P⁄w), which are determined at the sectoral level, also impart on the firm's choice to invest. For example, changes in the number of firms in the sector, or at the level of concentration, and even the exit of a big player can modify those relative prices and change the firm's behaviour.

[10] Many other facts prevent the system from an explosive trajectory: (i) despite its cumulative nature, innovation success is ultimately stochastic at the firm level, making the winners and losers, up to a point, unpredictable; (ii) technological spillovers may also contribute to increasing the productivity of the surrounding - less innovative - firms; (iii) a number of firms may choose to compete by imitating the technological leader, reducing the market share of the latter; (iv) successful firms tend to follow their basic routines and not necessarily increase search activities (also known as 'investment restraint'); (v) because of demand conditions and scale economies, large scale enterprises do not produce for the smaller market niches, even though these tend to become especially relevant at higher levels of income and development; and (vi) the effect of anti-trust regulations, etc.

2.2. Illustrating the sectoral traverse

The most interesting aspect of the model above is what it has to say about the new traverse and the characteristics of the industry along the path. To simplify the analysis, consider an economy with only one sector, but two types of technology: the first adopted by low scale enterprises and the second, more efficient, adopted by large scale ones. Let thus A_s represent the productivity of the technology employed in small enterprises, and $A_l = \alpha A_s$ ($\alpha > 1$) the technology in large enterprises. At any time, the output per unit of input will be the weighted average of employment by each sector, the weights being the output share of each technology:

$$q = A_s k_s + \alpha A_s k_l = (k_s + \alpha k_l) A_s \qquad (6)$$

Where k_x represents the fraction of the input for each of the technologies. Since prices are exogenous and $\dot{q}_i = \dot{k}_i = \lambda \pi_i = \lambda(P - rA_i)$, the path of equilibrium for this economy is given by the rate of take-over of the small by the large firm technology:

$$\frac{d}{dt} log\left(\frac{k_l}{k_s}\right) = \dot{k}_l - k_s = \lambda r(A_l - A_s) = \lambda r(1 - \alpha)A_s \qquad (7)$$

Where r, as before, represents the costs of inputs (wages and services of capital).

Hence, the rate of growth of k_l/k_s (and q_l/q_s) will be greater the bigger is λ, the growth of input costs r, and the relative productivity of the large scale technology in comparison to the small scale one. Over the traverse, k_l/k_s and q_l/q_s will trace a logistic trajectory, being slow at the beginning, followed by an acceleration and then slowing again when the higher equilibrium is approached[11]. The optimal level of concentration in a sector will depend on the characteristics of the competition and other institutional and political elements that affect the behaviour of the firms within it. As a rule, though, one can say that the more concentrated the market, the higher the sectoral level of productivity.

3. Empirical investigation

In the model above, a number of simplifying hypotheses are made: i) innovation is broadly assumed as any form of investment expenditure that resulted in the accumulation of capital by the firm; ii) the path of technological progress is determined at the sectoral level, i.e., by the knowledge base governing the sector; iii) within a sector, the only source of technological variability comes from the actual stock of capital, which also gives the scale of production. As a corollary of the above propositions, the firm's level of innovation is represented by its size or, in other words, the current stock of capital gives the position of the firm in the path of technological progress.

The exploratory analysis in the previous section seems to confirm the cycle that connects innovation, profitability, investment and growth. Since technological progress is a cumulative process, which results in capital deepening as the firm grows, the firm size possibly influences the subsequent innovation. This is not a monotonic process, as firms will face decreasing incentives to turn their profits into further expansion as they grow larger. If not, the concentration of the market-structure would persist until one firm

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[11] Nelson and Winter (1982, chap. 10) give more detail on the hypotheses and also present the analytical result for the case with several technologies and inputs. The overall conclusions are though unchanged.

dominates the entire market. From the above, at least two key hypotheses deserve a more thoroughly investigation: (i) the positive relationship between firm size and technology level; and (ii) the non-linear relationship between investment and profitability and how it is influenced by size.

This section tests the hypotheses of the above model. Data for the exercises is from the Structural and Demographic Business Statistics (SDBS) and comprises unbalanced annual information for all OECD countries plus a number of highlighted economies (35 in total) disaggregated in five firm size categories[12] for the period between 1990 and 2007. As the results reveal, part of the intra-sectoral development process still needs further qualification, especially in what concerns the role of demand in the growth process, which is discussed in the next section.

3.1. *Preliminary exploratory analysis*

Table 1 compares average investment ratios, surplus and the labour productivity for the World Economy across firm-size classes, i.e., averages for total of all 35 countries by year and size class[13]. The productivity index increases monotonically with size, indicating the close relationship between size and technology level. The table also informs about another crucial hypothesis of the model: the close relationship between the level of investment, technical change (productivity growth) and profitability. The values for the rate of growth of the productivity and the investment rate (as a share of the output) match each other in each size class, except in the group of large business, for which the first exceeds the latter. This is a clear indicative of the cumulativeness of the innovation process, and of the special importance of large firms for sectoral growth.

Table 1 - Investment ratios, surplus and productivity by size class: world economy, average (1990-2007)

National Size class	Productivity		Investment		Surplus*	λ***
	Index	Growth rate	Total*	R&D**		
NSC-1	0.095	0.032	0.032	0.095	11.60%	0.275
NSC-2	0.115	0.021	0.021	0.077	6.74%	0.312
NSC-3	0.145	0.026	0.025	0.054	5.48%	0.456
NSC-4	0.192	0.031	0.030	0.085	6.04%	0.497
NSC-5	0.312	0.036	0.031	0.387	6.36%	0.487
Average	**0.172**	**0.029**	**0.028**	**0.140**	**7.24%**	**0.405**

Notes: *Proportion of total revenue. **Proportion of total investment.
*** Investment share/surplus share.

Source: author's own calculation (data from the SBDS)

The R&D spending as a proportion of the total investment also shows a disproportional level of R&D expenditures by large companies (NSC-4 and, especially, NSC-5). For comparison, R&D accounts for an average of 40% of the total investment in large firms,

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[12] These are: NSC-1, with firms with 1 to 9 employees; NSC-2 with 10 to 19 employees; NSC-3 with 20-49 employees; NSC-4 with 50 to 249 employees; and NSC-5 comprising the firms with more than 250 employees.

[13] The productivity is measured as the ratio gross output per unit of labour. Section 4 provides estimates of TFP growth and the ratio of value added by hours worked. The measures are all highly correlated, however, the number of missing information is vastly superior in the last two. This explains the choice for the first.

but only 5% in medium firms. This difference indicate that either smaller business pursue alternative innovation strategies and/or large-firms expenditures are less focused on the pure expansion of business, but in the development of new production techniques, i.e., pushing out the technological frontier, as many studies suggest that R&D expenditures are essential for radical innovation (Freeman and Soete, 1997).

Lastly, Table 1 also reports a measure of λ, the factor of proportionality between investment and profitability. The measure is presented as a simple quotient of the investment and surplus proportions of the total revenue. As seen, it seems to describe a quadratic path across size classes. Yet close, the parameter for NSC-4 and NSC-5 firms are not equal. This divergence from the expected logistic trajectory will be further discussed in the next sections.

3.2. Profitability, investment and size

According to Equation (4), profitability and investment are intimately connected ($\dot{k}_{it} = \lambda_{it}\pi_{it}$)[14]. One key hypothesis in the model is that firm size mediates the relationship between profitability and investment, so that understanding the shape of λ_{it}, the coefficient of proportionality between the two, is central. Consider thus the following econometric model derived from (4):

$$\log(\dot{k})_{it} = \propto_1 \log(\pi_{it}) + \propto_2 \lambda_{it} + \beta \log(X_{i,t}) + \mu_{i,t} \qquad (8)$$

Where $\dot{k}_{it}$ is the total investment in country i and year t, π_{it} profits, $X_{i,t}$ is a vector of control variables and $\mu_{i,t}$ the error term. Both investment and profits (gross surplus) are from the SDBS. The control group includes de the income per capita (Y) and human capital from the Penn World Table 9.0, and country and year dummies.

Table 2 summarises the results of the regression of equation (8) for the 35 countries in the database using robust panel data methods with fixed-effects. Different methods and aggregations of the data are presented, where all show the same pattern. λ_{it} is proxied by the share of NSC-5 in total employment. The coefficient is positive and significant at 1% level in all specifications. More importantly, the relationship between concentration of the market-structure and investment is not linear, as the significance of the quadratic term (λ^2) shows. The fact that λ^2 is negative indicates that the concavity of the curve is negative, suggesting a quadratic relationship. Profits, as expected, present a positive and significant relationship with investment. The logarithm of per capita income and human capital were excluded from estimations (ii) to (iv) due to their non-significance.

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[14] The reverse relationship is also expected as higher investment increases the technology and thus profits.

Table 2 - Investment function: cross-country (1990-2007)

Variable	Fixed-effects	Fixed effects	FE IV regression	FE IV regression
Log (investment)	(i)	(ii)	(iii)	(iv)
λ	7.3285***	16.0678***	19.4191***	16.1757***
Log(π)	0.2697***	0.2648***	0.2614***	
λ^2	-89.4137*	-97.4220**	-90.3665*	
Log(Y)	0.0578			
Constant	4.2493***	4.1727***	5.8664***	3.4604
N	1456	1456	2059	1456
R^2	0.1686	0.1676	0.0476	0.2254
rmse	0.3091	0.308	0.366	0.308
corr	0.0105	-0.0014	0.0635	0.0653
F	23.526	16.7421	20.1143	13.6869

Notes: λ = share of employment of NSC-5 firms. π = surplus. Y = income per capita. *** significant at 0.1% ** significant at 1% * significant at 5% .
Estimated in the panel across countries and time by robust variance methods.
The results are similar when estimated using only an average of the years in the sample. Year dummies were not significant. NSC5 was instrumented by Y and π in column (iv).
Source: author's own elaboration (data from the SDBS)

In a different exercise, equation (8) was estimated for each size class[15]. The estimates in Table 3 show a clear decreasing pattern in the relationship between profits and investment across size classes. Since the model was estimated in log-levels, the parameters should be interpreted as elasticities. Hence, an increase of 1% in profits will result in an increment of 0.75% in the investment for NSC-1 firms, whereas for NSC-5 firms the investment will increase by only 0.41%. The differences across size classes are not affected by the inclusion of controls[16].

Table 3 - Investment function by Firm Size class: cross-country (1990-2007)

Variable Log(Investment)	NSC-1	NSC-2	NSC-3	NSC-4	NSC-5
Log(π)	0.7477***	0.5301***	0.4475***	0.4441***	0.4142*
Constant	0.9758	2.4194***	3.1768***	3.7437***	4.3585**
N	137	137	139	136	130
R^2	0.4008	0.3267	0.3487	0.3187	0.3805
rmse	0.4586	0.5114	0.4692	0.4782	0.5546
corr	-0.3224	0.0289	0.179	0.1348	0.3084
F	36.3177	47.6938	24.5655	27.0448	6.302

Notes: Estimated in the panel across countries and time by robust variance methods. The endogenous variable is the output. The results are similar when estimated using only an average of the years in the sample. Controls omitted.
*** significant at 0.1% ** significant at 1% * significant at 5%.
Source: author's own elaboration (data from the SDBS)

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[15] Note that λ is omitted from the specification since the I-P relationship is estimated for each size class.

[16] The high correlation between residuals and estimators for NSC-1 and NSC-5 firms suggest though that the specifications for these classes might be omitting important variables, even though the F test attest the validity of the model and the R^2 indicates a good adjustment.

The results above confirm the hypothesis that firm size seems to influence the relationship between profits and investment. As firms grow, they face less incentive for turning profits into further growth, suggesting fewer technological opportunities for these large firms, which are close to the technological frontier. Against the initial expectations, however, the decreasing cross-size estimates of λ and the significant λ^2 indicates the influence of an unexpected factor in the choices of large business, resulting in a quadratic and not logistic λ.

3.3. A general function of technological progress?

Overall, the data above seems to confirm and reinforce the premises of the model[17], with a qualification yet to explore regarding λ trajectory. One important aspect not explored in the statistics above is the role of the sector (sectoral knowledge base) in the technological trajectories.

The importance of the sectoral knowledge base in shaping innovation has long been emphasised in the Evolutionary tradition (Nelson and Winter, 1982; Pavitt, 1984; Malerba and Orsenigo, 1993; Breschi and Malerba, 1997)[18]. Accordingly, the picture above could change significantly if a sectoral disaggregation were provided. However, since this study has an intra-sectoral and not firm-level perspective, the influence of the knowledge base on the trajectories is reduced. This is illustrated in the picture below, where the data on the sectoral level of concentration is plotted against the country complexity index for each of the ISIC 2-digit manufacturing sectors to demonstrate the sectoral trajectories of development[19]. Two distinct phases of the traverse are revealed and separated by the vertical line[20]: (i) at the left side of the red line, the level of concentration is increasing with the sophistication of the productive structure (kc), peaking at around the value of 0.5 of the index; (ii) a de-concentration pattern is noticed from this point on, as the productive structure of the country moves from a medium to a high level of sophistication. It is important to note the significant sectoral differences in both the sectoral level of concentration (y axis) and the steepness of the curve.

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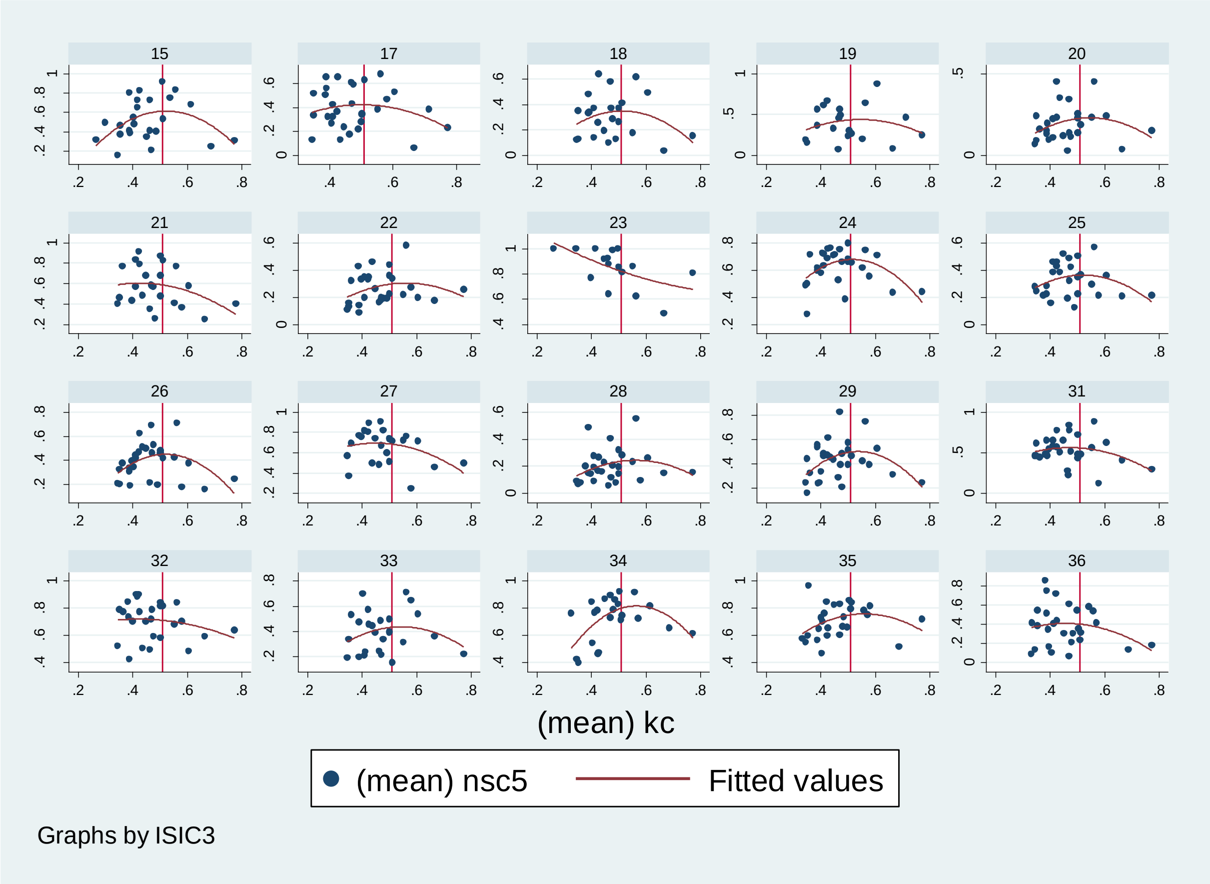
[17] There is a multiplicity of patterns associated to specific sectors, even though the general conclusions are not changed for country subsets of the data.

[18] The characteristics of the knowledge, particularly its level of cumulativeness, appropriability, opportunity, etc., define what is called by 'technological regime'. The technological regime provides a synthetic representation of the economic properties of sectoral technologies and learning process. These set the boundaries of what can be achieved by problem-solving activities, shaping 'natural trajectories' along which solutions to these problems can be found (Castellacci, 2004). Ultimately, a technological regime gives a simplified yet considerably more accurate description of the nature of technological progress in comparison to the linear model, for which innovation was an undifferentiated process that emerges as a natural consequence of R&D expenditures.

[19] If the complexity index is replaced by income per capita the patterns are not so clear and present a much higher variance across sectors, which illustrates the appropriateness of country sectoral complexity index in the measurement of the of sectoral trajectories of development.

[20] The vertical line in the Figure is at the exact point 0.5091 of the kc index, where 75% of the less sophisticated countries in the sample are on the left and the 25% more sophisticated on the right.

Figure 1 - Sectoral participation of large business (NSC-5) and country complexity: world economy, selected ISIC-2 sectors, average (1990-2006)



Notes: Horizontal axis = country complexity index (kc); Vertical axis = labour share of NSC-5 in total employment
Source: author's own elaboration (Data from the SDBS)

Figure 1 show important sectoral patterns, which diverge in both the level of concentration (vertical axis) and speed of the process of concentration (inclination) but tend to follow a general quadratic path, which validates the general approach of the model in section 2. The above figure, however, confirms an anomaly compared to the baseline model, which couldn’t predict the second half of the sectoral development trajectory. Why sectors deconcentrate as the manufacturing sector of an economy becomes more complex? Is it caused by changes in the sectoral composition or another factor is influencing the market structure?

The next section tests the hypothesis that demand constraints act at the intra-sectoral level limiting and ultimately reverting the consolidation process at the cost of the full realisation of the technology of individual sectors.

4. Supply and demand requisites for the sectoral development: investigating the Kaldorian parameters at the intra-sectoral level

Profiting on versality of the Kaldorian general framework (see McCombie and Thirlwall, 1994), this section investigates two different hypothesis, namely: (i) that the function of technological progress has the logistic shape described in the model in section 2; and (ii) that [unaccounted] demand influence explaining the reversal in the trajectory of concentration of the market structure as the economy develops.

This is implemented by estimating both the demand and supply requisites in the Kaldorian growth model: the income elasticities of demand and Verdoorn's coefficient, respectively. Understanding how each of these change across firm size classes can reveal the role of demand and supply in the development traverse. Such an approach has yet the additional advantage of casting light on the foundations of these elements, contributing to fill a gap in the Kaldorian literature.

4.1.The intra-sectoral demand elasticities

The demand elasticities can be estimated directly from the following function:

$$Q_j = P^{E_p} Y^{E_y} \qquad (9)$$

Where E_Y is the income elasticity of demand, E_p the price elasticity of demand, and Q the demand for the output of each of firm size classes in the database, i.e., $j = [NSC - 1, \dots, NSC - 5]$. Taking logarithms of equation (6.5), it becomes:

$$ln(Q)_{it} = \beta_0 + \beta_1 ln(Y)_{it} + \beta_2 ln(P)_{it} + \beta_3 X_{it} + u_{it} \qquad (10)$$

Where the subscript i represents the sectors and t is time. β_0 is a constant, β_1 the income elasticity, β_2 the price-elasticity, X_{it} is a group of control variables which include sectoral, country and year dummies, and u_{it} is the error term.

Table 4 reports the results for the estimation of Equation (10) for each firm size class adopting fixed-effects, which capture the sectoral specific effects. Since a volume index is not available in the database, the income elasticities are estimated without controlling for size-specific prices. As a way to reduce the potential bias of the estimation, the approach considers each country's sector to be an idiosyncratic sector, so that the hypothesis of homogeneity of prices needs to hold only at the specific sector in a country and not across countries. Besides, the multinational country-sector panel considerably increases the number of observations available, improving the efficiency and consistency of the regressions.

Table 4 - Income elasticities by size classes: panel data estimation (1990-2007)

Variables	NSC-1			NSC-2			NSC-3			NSC-4			NSC-5		
	IV-FE	SYS-GMM	SYS-GMM	IV-FE	SYS-GMM	SYS-GMM	IV-FE	SYS-GMM	SYS-GMM	IV-FE	SYS-GMM	SYS-GMM	IV-FE	SYS-GMM	SYS-GMM
Log (output)	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)
Log(income)	1.22***	1.098***	0.974***	0.87***	1.039***	1.026***	1.130***	1.082***	1.014***	1.058***	0.977***	0.929***	0.621***	0.958***	0.894***
	0.044	0.0984	0.0415	0.038	0.126	0.0388	0.0353	0.118	0.040	0.033	0.093	0.036	0.039	0.0952	0.053
Constant	-9.6***	-8.13***	-6.66***	-5.4***	-7.699**	-7.46***	-7.96***	-7.43***	-6.48***	-6.08***	-5.11***	-4.33***	0.334	-4.04***	-3.17***
	0.5574	1.2364	0.5128	0.49	1.6238	0.4898	0.4545	1.5126	0.5094	0.4398	1.2018	0.452	0.515	1.215	0.652
N	4258	5337	5337	4333	5425	5425	3819	4921	4921	3725	4806	4806	3391	4330	4330
R^2	0.550			0.557			0.5947			0.4926			0.418		
corr	-0.33			0.106			-0.2337			-0.3115			0.200		
F		124.73	85.26		68.08	98.38		83.70	93.66		108.57	89.44		101.39	42.25
sargan		1500	1600		4000	94.53		2500	101.94		4800	35.75		1500	35.53
sarganp		0	0		0	0		0	0		0	0.216		0	0.1548
hansen		143.82	129.13		123.8143	89.25		115.46	105.91		122.73	122.71		112.24	99.39
hansenp		0	0		0	0		0	0		0	0		0	0
chi2	120000			160000			260000			400000			360000		

Notes: Variable dependent: log(output). *p<0.1, **p<0.05, ***p<0.01. Year dummies omitted.

Source: Author's own elaboration (data from SDBS)

Several different fixed-effects panel data methods, including FE-GMM, IV-FE and the System GMM approaches of Blundell and Bond (2000) are reported[21]. The estimated coefficients are highly significant and stable at different specifications, indicating a good adjustment of the model to the data. This is confirmed by the highly significant F statistics. The coefficients are significant at 1% confidence level. Altogether, smaller businesses (NSC-1 to 3) present a significantly higher elasticity compared to larger firms (NSC-4 and 5).

The first column of each size class depicts the results for the specification with lags of the explanatory as instruments and 2-year averages to reduce the temporal correlation of the data[22]. Columns (ii) report the results for the model with the lagged income and logarithms of human capital and population as instruments[23], and columns (iii) the model with 2-year temporal dummies, added to control for the autocorrelation found in the AR statistic of the previous model.

The higher average coefficient for smaller firms (NSC-1 to NSC-3), compared to larger ones (NSC-4 and NSC-5), indicates an important (and unaccounted) influence of demand on the intra-sectoral trajectory. The differences indicate that the demand stimulate the de-concentration of sectors. That is, the output of smaller firms grows at a much faster pace compared to larger ones as income grows. In the former, the estimated elasticities are higher than 1, i.e., the output of these firms increases by more than 1% as income grows 1%. For the latter, the output is relatively inelastic[24].

The results indicate a fundamental role for the demand in the sectoral development traverse and may explain the evidence presented in the previous sections that the market-structure de-concentrate after a certain level of development is reached. That is, the second (and unexpected) half of the development traverse might be the result of the demand constraints to the process of sectoral growth.

It is important to note that the income elasticities reveal singular characteristics of the dynamics of the demand component. Different responses of demand in face of income changes prompt divergences in firms' profitability, investment and patterns of growth. These differences indicate that firms of different size classes face different demand curves, which can be explained by different market niches or quality of the production. The causes of these divergences, however, are still not fully understood in the literature, especially in the Kaldorian tradition, which has never explored the intra-sectoral level of analysis.

4.2.Returns to scale and Kaldor-Verdoorn's law

Kaldor's (1966) inaugural lecture at the University of Cambridge represented the starting point of a long tradition on the investigation of returns to scale in manufacturing. Different versions of Verdoorn's Law are found in the literature, which tends to conclude for substantial increasing returns to scale in manufacturing. The results are generally

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owth in the Kaldorian framework of both (i) the lagged endogenous variable, to capture convergence effects, and (ii) the lagged exogenous variables, that act as an instrument.

[22] Estimates with traditional 5-year averages deliver the same conclusions but compromises the statistical power by reducing the degrees of freedom of the estimation.

[23] All control variables were drawn from the Penn World Table 9.0.

[24] The estimation of equation (6.6) for two aggregated size groups, NSC-1-3 and NSC-4-5, reveal a coefficient around 1.07 in the first and 0.9 in the second.

robust to estimation methods and levels of levels of aggregation of the data, period under investigation and unit samples. Notwithstanding, the foundations of the phenomenon have historically received little attention. Much of it due to the fact that the law was originally developed as a macroeconomic stylised fact of growth[25]. Only recently, Romero (2015) investigated whether the characteristics of goods produced in different industries influence the degree of returns to scale, showing that the explanation might be at the supply-side, i.e., level of technology of the product. To date, however, Verdoorn's law has never been tested at the intra-sectoral level.

In its dynamic demand-side version, the Verdoorn law describes a relationship between output growth and productivity growth, with the causality running from the former to the latter. Formally:

$$q_i = \rho + \lambda y_i \tag{11}$$

where q_i, ρ and y_i are the rate of growth of productivity, autonomous productivity, and total output of firm i, respectively. Equation (11) assumes the stability of the capital-output ratio ($k = y$), which is known as one of Kaldor's stylised facts of growth.

Since productivity growth is definitionally equal to the growth of output minus the growth of employment, i.e., $q_i = y_i - l_i$, the Verdoorn law may also be expressed as:

$$l_i = \gamma + \beta y_i \tag{12}$$

In spite of the simplicity of Kaldor's original formulations, the estimation of Verdoorn's law has been subjected to a number of empirical criticisms over the years (McCombie, Pugno and Soro, 2002). According to Wolfe (1968), the exclusion of the growth rate of capital stock as a determinant of labour productivity growth in Equation (12) creates a bias in the estimates. Knowing the potential effect of capital accumulation on productivity growth, Kaldor (1967) explicitly included the investment-output ratio as a proxy for the growth of the capital stock. A different specification of the law, which includes the variable of capital stock, is found in Fingleton and McCombie (1998):

$$l_i = \gamma + \beta y_i + \tau k_i \tag{13}$$

The adoption of TFP growth (tfp_i) instead of employment or labour productivity as the regressand, also addresses the problem. This approach also avoids multicolinearity between the growth rates of output and capital stock (Romero, 2015). The Verdoorn coefficient, in this case, can be derived directly from the production and technological progress functions as a number of authors have recently demonstrated (Roberts, 2007; Angeriz, McCombie, and Roberts, 2009; Romero, 2015)[26].

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[25] According to Britto (2008), regardless of the source of the increasing returns (internal, external, dynamic or static), economies of scale should still be verified at the firm-level.

[26] That is,

$$y = \gamma + v(ak) + v(1-a)l$$

Where v= degree of increasing returns.

$$\left(\frac{1}{v}\right)y = \frac{1}{v}\gamma + ak + (1-a)l$$

$$ak + (1-a)l = -\left(\frac{1}{v}\right)\gamma + \frac{1}{v}y$$

$$tfp_i = \beta_0 + \beta_1 y_i + \beta_2 G_i \qquad (14)$$

where G_i is the technological gap between sector i and the leading sector. G_i captures the convergence of the productivity, i.e., the effect of technological diffusion.

The estimation of (14) requires first circumventing a few problems. The first is connected with the construction of the TFP growth measure[27]. A first empirical concern is with the physical capital stocks, which are not available in the database adopted in this study. The capital stock is thus constructed by perpetual inventory method. The initial value of the capital stock for a specific country-sector is defined as $I_{to}/(g+d)$, where g is calculated as the average geometric growth rate for all available data of the investment series for the country-sector. The depreciation rate (d) is assumed equal and constant at 6 percent, as in Hall and Jones (1999)[28].

The summary statistics of the productivity growth rates presented in Table 5 show that even though the number of missing information is extremely high for the TFP measure, its values are directly comparable to alternative productivity measures (Δ(Y/L) and Δ(VA/hours worked)) and also to the output measure (y). The correlation between these are all above 90%.

Table 5 - Summary statistics: productivity growth rates

Variables	N	Mean	SD	Percentiles	
				10%	90%
tfp	410	0.023	0.182	-0.180	0.214
y	3391	0.027	0.231	-0.146	0.199
Δ value added	849	0.012	0.259	-0.224	0.240
ΔL	3376	-0.018	0.206	-0.159	0.114
Δ (VA/hours worked)	203	0.079	0.191	-0.102	0.269
Δ (Y/L)	3391	0.046	0.163	-0.085	0.185

Source: Author's own elaboration (Data from the SDBS)

The estimation strategy should also explicitly account for three problems[29]: (i) the unobserved country and industry fixed-effects (FE); (ii) the potential endogeneity problem arising from the simultaneity between productivity growth and output growth,

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$$y - \alpha k - (1-\alpha)l = tfp = \frac{1}{v}\gamma + \left(1-\frac{1}{v}\right)y$$

Hence, the equation for the Verdoorn law using TFP is

$$tfp = \frac{1}{v}\gamma + \left(1-\frac{1}{v}\right)y$$

[27] The growth rate of TFP is defined as $tfp = y - tfi$, where $tfi = \alpha k + (1-\alpha)l$ is the growth rate of Total Factor Inputs (TFI) and α represents the capital-labour ratio.

[28] Provided the investment series is limited (also the reason why this study adopted labour productivity as prime measure of productivity), the number of degrees of freedom of the estimations are severely reduced with the TFP measure.

[29] The TFP growth measure can also introduce endogeneity to the estimation of the Verdoorn coefficient because they both require the growth rate of gross output. The literature presents a few alternatives to circumvent this problem. Firstly, TFI can be used as a proxy for TFP. Another option is to change the specification of the law to introduce the lag of the endogenous variable and estimate it with GMM methods. Both alternatives were tried.

and between productivity growth and some of the controls, especially the lagged technology gap[30]; and (iii) the potential autocorrelation, which requires separating long-term effects of demand growth on productivity growth from short-term business cycle fluctuations (Okun's law).

The first problem is tackled with the use of the Two-Step Feasible Efficient Generalized Method of Moments (GMM) estimator with fixed-effects. This enables the capturing the effects of observed and unobserved fixed-effects with the introduction of both time and sector dummies in the estimation. The endogeneity problem is addressed with the 'Difference' and 'System' GMM approach of Blundell and Bond (2000). The latter enables the inclusion of the lagged endogenous variable among the estimators. It employs a system of equations in levels and differences to estimate the parameters where lags of the variables are used as instruments. Non-observable fixed-effects are controlled via differencing (Roodman, 2009). Finally, the third problem is dealt by taking temporal averages in order to smooth business cycles fluctuations. In this study, since the time-spam is relatively short, 2-year averages are adopted[31]. Alternatively, the problem can also be tackled by introducing one-period lags of the variables into the regression model, as proposed by Millemaci and Ofria (2014).

A final note on the methodology, this study opted for estimating the law for the whole sample of countries and sectors jointly, using robust panel-data methods. This strategy increases considerably the number of observations available, improving the efficiency and consistency of the estimates (Romero, 2015). As a consequence though, the estimates should not be read as the original Verdoorn’s Law, but a mix between it and Fabricant’s (1942) Law[32]. As shown by Salter (1960), however, the results are similar for both.

Table 6 shows the results of the estimation of equation (13) using FE and System-GMM. The Verdoorn coefficient is significant at the 1% confidence level for all specifications and the parameters are close to Verdoorn's (1949) and Kaldor's (1966) estimations, around 0.5. That is, a 1% rise in the growth of output increases TFP growth by 0.5 percentage points.

The figures are, however, lower than recent estimations (Angeriz, McCombie and Roberts, 2008; Alexiadis and Tsagdis; 2010; Romero, 2015). Possibly, the answer is in the fact the firm-level estimation of the parameter cannot account for all sources of increasing returns in manufacturing, especially static and dynamic externalities. This would be in accord with Kaldor’s expectations.

Column (ii) reports the estimation using SYS-GMM and including the lag of the productivity growth in order to capture the adjustment between short and long-term productivity growth rates as proposed by Dixon and Thirlwall (1975). Column (iii) also includes the lagged output growth to capture the adjustment between short and long-term

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[30] Rowthorn (1975) argued that employment growth should be the explicatory and if so, even using instruments, the results suggest constant returns to scale. This issue still has not been resolved. See Magacho and McCombie (2018).

[31] Five-year averages were also tested without much effect on the parameters estimated, even though the statistical power is significantly reduced by the decrease in the degrees of freedom.

[32] The difference between the two is that the latter assesses the relationship between output growth and productivity growth across industries, while the former carries out the same assessment across countries.

output growth rates. None of these were significant, being the Verdoorn coefficient highly stable.

Table 6 - Dynamic demand-side Kaldor-Verdoorn's Law: panel data estimation, country-size class (1990-2006)

Variable tfp	FE (i)	SYS-GMM (ii)	SYS-GMM (ii)
y	0.5255*** (0.0562)	0.5729*** (0.0278)	0.5729*** (0.0248)
tfp_{-1}		-0.0306 (0.0348)	-0.1698 (0.1586)
y_{-1}			0.0886 (0.0872)
Constant	0.0422*** (0.0048)	0.0128* (0.0059)	0.0099 (0.0065)
N	841	615	615
R^2	0.5701		
rmse	0.3671		
corr	0.0649		
F	87.3902	209.7559	123.4019
Sargan		155.678	226.5196
Prob > chi2		0	0
Hansen		29.4996	27.3261
Prob > Z		0.2019	0.1991

Notes: Gap, L1.gap and Year dummies omitted in columns (iii) and (iv).

Standard deviations in parenthesis. *p<0.1, **p<0.05, ***p<0.01

Source: Author's own elaboration (Data from the SDBS)

Robustness tests corroborate the results in all the estimations. The Sargan-test reported for SYS-GMM estimations reject the null hypothesis of over-indentified restrictions in the instruments. Also, the 'Arellano-Bond' AR-test for autocorrelation did not reject the null hypothesis of no autocorrelation in any of the regressions at the 5% significance level, while Hansen's J test did not reject the null hypothesis of the validity of the instruments at the 5% significance level.

Table 7 reports the results of the estimation of Kaldor-Verdoorn's law by size class (Equation 14). Columns (i) are for the more parsimonious specification estimated by FE and columns (ii) and (iii) report the SYS-GMM estimations of more complete models.

The table shows a number of important results. First, the Kaldor-Verdoorn coefficient is significant for all size classes. Secondly, the estimates of parameters increase with firm size (from NSC-1 to NSC-4), which corroborates the evidence in the previous section. The size classes differences in the estimates are independent of controls, lags and instruments included. One interesting result is that the coefficient for the NSC-5 firm class is lower than the coefficient for the NSC-4 firm class in estimations (ii) and (iii). Wald tests confirm the statistical difference at 1% level of confidence. This indicates that the returns to scale increase with firm size, but the technological benefits of expanding the business reduces for large firms, justifying the 'investment restraint' hypothesis (Nelson and Winter, 1982).

Table 7 - Dynamic demand-side Kaldor-Verdoorn's Law by size class: panel data estimation (1990-2007)

Variable	NSC-1			NSC-2			NSC-3			NSC-4			NSC-5		
	FE	SYS-GMM	SYS-GMM	FE	SYS-GMM	SYS-GMM	FE	SYS-GMM	SYS-GMM	FE	SYS-GMM	SYS-GMM	FE	SYS-GMM	SYS-GMM
tfp	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)	(i)	(ii)	(iii)
y	0.49***	0.46***	0.50***	0.49***	0.49***	0.47***	0.49***	0.53***	0.53***	0.51***	0.70***	0.70***	0.65***	0.63***	0.64***
	0.084	0.0647	0.0649	0.0768	0.0698	0.0778	0.0455	0.0701	0.0574	0.0607	0.1238	0.1055	0.0529	0.0452	0.0675
Log(Gap)		0.0001	0.1319		0.0001	0.198*		0	-0.0001		0.0003	0.0006		0.0001	-0.0003
		0.0001	0.0001		0.0001	0.0001		0.0002	0.0003		0.0003	0.0004		0.0002	0.0002
tfp_{-1}		-0.185	-0.3***		-0.129	-0.34*		-0.094	-0.409*		-0.046	-0.362		-0.135	-0.17
		0.1059	0.0879		0.0831	0.1346		0.1	0.1762		0.0781	0.2636		0.0847	0.1313
y_{-1}			0.0785			0.0856			0.2600**			0.2472			0.0305
			0.0127			0.0442			0.0884			0.2073			0.09
Constant	0.0024	0.0157	0.0161	0.01***	0.0215*	0.0243	0.008***	0.006	0.0047	0.009*	0.0071	-0.007	0	0.0104	0.02**
	0.003	0.013	0.015	0.0033	0.015	0.03	0.0013	0.006	0.0095	0.0039	0.0071	0.0131	0.0019	0.0104	0.0069
N	563	339	339	554	331	331	589	375	375	408	251	251	410	277	277
R^2	0.2941			0.2466			0.3015			0.6089			0.4965		
rmse	0.2543			0.2036			0.1586			0.0755			0.1223		
corr	-0.0122			-0.1368			0.0372			0.2242			-0.047		
F	34.23	17.95	14.26	41.67	18.62	11.77	114.68	20.74	27.24	70.34	10.90	23.45	151.59	65.51	24.68
Sargan		143.47	143.12		146.11	140.74		90.81	290.53		8214.48	9156.9		66.29	564.60
Prob > chi2		0	0		0	0		0.0001	0.0001		0	0		0.0332	0.0292
Hansen		49.83	46.58		53.59	49.42		53.79	44.63		48.43	50.34		46.49	43.78
Prob > Z		0.361	0.4071		0.236	0.3008		0.2304	0.4871		0.4149	0.2701		0.4934	0.5232

Notes: *p<0.1, **p<0.05, ***p<0.01. Year dummies omitted.

Source: Author's own elaboration (Data from the SDBS).

Table 8 - Dynamic demand-side Kaldor-Verdoorn's Law by size class: panel data estimation (1990-2007)

Variable	NSC-1		NSC-2		NSC-3		NSC-4		NSC-5	
	Dependent: ΔL (i)	Dependent: ΔKFP (ii)	Dependent: ΔL (i)	Dependent: ΔKFP (ii)	Dependent: ΔL (i)	Dependent: ΔKFP (ii)	Dependent: ΔL (i)	Dependent: ΔKFP (ii)	Dependent: ΔL (i)	Dependent: ΔKFP (ii)
y	0.2541***	0.6711***	0.3506***	0.7674***	0.3843***	0.9002***	0.3998***	0.9687***	0.5206***	0.9599***
	0.0484	0.0835	0.0263	0.0558	0.0431	0.0663	0.0296	0.043	0.0444	0.083
Log(investment)	0.0019	0.0001	0.0067*	0.0001	-0.0005	-0.0002	0.0069**	0.0004	0.0088**	0.0004
Log(GAP)	0.0036	0.0001	0.0031	0.0001	0.0035	0.0002	0.0022	0.0004	0.0029	0.0003
L1.y	0.0687	0.3028**	0.2718**	0.2051	0.3477***	0.1084	0.1139	0.4235***	0.1532	0.4157**
	0.0677	0.1064	0.0909	0.1305	0.0852	0.0883	0.0889	0.1141	0.1284	0.1509
L1. ΔL	-0.1495	-0.4357***	-0.8073**	-0.2725	-0.8739***	-0.1103	-0.1535	-0.4081***	-0.2377	-0.4596**
L1. ΔK	0.196	0.0911	0.2458	0.1689	0.2543	0.0853	0.2051	0.1197	0.239	0.1587
Constant	0.0053	0.0162	-0.018	0.0269*	-0.0079	-0.0038	-0.0516***	-0.0119	-0.0994***	0.0008
	0.0147	0.0145	0.0107	0.0116	0.0165	0.0072	0.0128	0.0061	0.023	0.008
N	1735	450	1839	542	1805	590	1730	420	1546	459
F	10.7447	40.9555	65.7518	50.2518	28.7195	44.0202	49.3257	141.423	40.1614	29.726
Sargan	118.4994	243.2396	53.8934	221.048	110.432	6 123.724	383.9815	8 161.6	174.2774	343 130.2303
Prob > chi2	0	0	0.0003	0	0	0	0	0	0	0
Hansen	36.2016	60.6725	21.2509	69.1472	27.1352	78.1738	32.8119	56.9434	27.3958	64.1129
Prob > Z	0.0393	0.4877	0.5658	0.2777	0.2503	0.0943	0.0844	0.6907	0.2395	0.4373

Notes: Dependent: tfp growth rate. $^{*}p<0.1$, $^{**}p<0.05$, $^{***}p<0.01$. Year dummies omitted.

Source: Author's own elaboration (Data from the SDBS).

Moreover, the coefficients are compatible with the logistic (S) shape proposed for the technological progress function. The final inverted-U shape trajectory is thus explained by the influence of demand on the sectoral traverse (decreasing income elasticities in firm size).

Among the lags and controls, one should highlight the previous TFP growth, which is negative and significant for the first 3 firm size classes (NSC-1-3). This is possibly capturing short-term inertial growth in productivity, stemming from ongoing increases in productivity. The technological gap variable was only significant in one estimation, in line with Romero's (2015) findings.

Regarding the consistency of the estimations, again the results for the AR test did not reject the null hypothesis of no serial correlation in the error term. Also, Sargan test shows that the instruments and their subsets are valid, and Hansen's J test that the correlation between the instruments and the fixed-effects are not statistically different of zero[33].

The first column of Table 8 depicts the result of the estimation of Equation (13). The results are all significant, profiting from a more complete database on the variables, especially labour productivity. The estimates, however, are against the initial expectations.

Since the TFP measure is generated by the weighted shares of capital and employment productivity, and the estimation of (14) revealed a logistic cross-size pattern, one would expect a decreasing pattern in the estimation of (13), that is, that labour requirements were decreasing with size. In spite of it, columns (i) show a clear cross-size exponential pattern (the coefficient is especially high the class of large firms). Furthermore, the elasticities are much smaller than the ones estimated with the TFP measure.

These contradictory results inspired the estimation of the Verdoorn's law using and index of capital productivity instead of TFP[34]. The results of the estimation of the law with capital productivity only (hereby KFP) are reported in Columns (ii). The estimates resemble the ones reported in Table 7, with the exception that the level of the coefficient is much higher and the difference between the coefficient of the NSC-4 and NSC-5 are not statistically different one from the other. These findings explain both why [the weighted average presented by] the TFP resulted in smaller coefficients, and the quadratic cross-size evolution when using the TFP in the estimation[35]. Therefore, these apparently contradictory results actually reinforce the previous findings, showing that the technology alone furnishes incentives for the firm to grow logistically, while the labour requirement forces businesses, especially large ones, to end the continuous expansion of their output.

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[33] In all the SYS-GMM regressions the number of instruments was kept low to avoid spurious significance due to instrument proliferation (Roodman, 2009). The number of lags adopted in each model was guided by the analysis of the validity of the instruments, following the Arellano-Bond AR Test and the Hansen J Test. Attention was also paid to the stability of the results found with different lags.

[34] The lag of the labour productivity was included as a control.

[35] It is important to note that the estimations for the two versions of the law are very distinct. In one case the growth of labour employment is used and the sample of data is much bigger (columns (i) in Table (6)), whereas in columns (ii) of this table, the growth of the capital productivity is measured by subtracting the capital productivity growth rate from the growth rate of the value added, with a much smaller sample. A version of the law as originally proposed by Verdoorn (1949), with labour productivity as dependent variable was also estimated and results and patterns are similar to the ones reported in columns (i), which is evidence that the findings are consistent in subsamples of the data and with different versions of the law.

In summary, the tests reported in this section are an important contribution to the Kaldorian literature. More than demonstrating that Verdoorn's law can explain the dynamics of the supply side at a disaggregated analytical perspective, it shows that labour and capital actually impose opposite incentives to the sectoral development process.

5. Concluding remarks

This paper showed that since technological progress requires some level of capital deepening as the firm grows, firm size is a key element in the growth trajectory. This was shown to be a non-monotonic process though, with firms facing decreasing incentives to turn profits into a further expansion of capacity as they grow. The empirical evidence confirmed both a positive relationship between size and technology level, and a non-linear relationship between size, investment and profitability, corroborating some of the hypotheses of the model introduced in the section 2.

The results confirm the logistic shape of ‘natural trajectories’, yet demand constraints end up shaping the actual market-structure composition differently. The analysis showed that the difference between the predicted and actual response in the intra-sectoral development trajectory is explained by the influence of the demand, which blends with the 'technological incentives' to define the final shape of the market-structure. As shown, the income elasticity of demand is inelastic for large firms (NSC4-5) and elastic for small firms (NSC1-3), being especially low in NSC-5 firms. This indicates that small businesses are benefited as the country increases its income level (this is specially marked at the highest levels of income). This phenomenon occurs against the technological incentives, which largely favour larger businesses. Ultimately, as demonstrated by the firm-level Verdoorn, the 'S' trajectory would prevail if the sectoral development traverse was determined purely by the technological aspects (see the KFP estimation).

One hypothesis is that as income grows by result of the development process, demand grows and smaller firms regain part of the market share lost in the sectoral process of capital deepening, when sectors are increasing concentration to reap the benefits of scale economies. The repopulation of smaller firms probably occurs because they attend specific niches opened by the process of economic development, thus reducing the level of sectoral concentration. This explains the highlighted importance of medium-sized firms for growth in misallocation studies (see Hsieh and Klenow, 2009; Jones, 2011). Developed countries should indeed display an intermediate level of sectoral concentration.

This paper makes a number of contributions to the economic literature, especially for the Kaldorian and Schumpeterian growth theories. First, it reinforces the importance of both the demand and supply factors for growth. Secondly, the approach confirms the versatility of the Kaldorian parameters in growth analyses. Finally, the seminal estimates of both the demand elasticities and the Verdoorn's law across firm sizes groups provide some much-needed foundations for the Kaldorian framework.

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