Chapter 3
Economies of Scale and Cumulative Causation

Stilianos Alexiadis

Abstract This paper examines 'Verddorn's Law', i.e. the relation between employment and output growth across the NUTS-3 regions of the European Union. Moreover, an explanation is provided as to how 'Verdoorn's Law' sets up a process of cumulative causation. Following the relevant literature, the empirical assessment is conducted using spatial econometric techniques. The empirical results provide considerable support to the validity of 'Verdoorn's Law'. A more detailed analysis suggests that differences in regional growth rates perpetuate a 'dualistic' situation Europe, with advanced regions growing at the expanse of less-developed regions.

Keywords Cumulative Causation · Scale Economies · Regional Growth

JEL R10

3.1 Introduction

A major concern for economists is to find an explanation for why growth rates differ between economies, whether the term 'economy' is applied to countries or geographical areas within them, that is to say regions. It is quite possible that differences in growth rates operate 'cumulatively', perpetuating a 'centre-periphery' situation; an idea proposed by Myrdal (1944, 1957), who postulated that a mechanism of *cumulative causation*, or 'backwash-effects' allows successful regions growing at the expense of less-successful regions. In seeking to provide an explanation for this phenomenon attention is often diverted to concepts such as *dynamic increasing returns*. Kaldor (1967) used the relation between the growth of manufacturing output

The findings, interpretations and conclusions are entirely those of the author and, do not necessarily represent the official position, policies or views of the Ministry of Rural Development & Foods and/or the Greek Government.

S. Alexiadis (✉)
Department of Agricultural Policy & Documentation, Division of Agricultural Statistics, Ministry of Rural Development & Foods, Room 501, 5 Acharnon Street, 101 76 Athens, Greece
e-mail: salexiadis7@aim.com

T. Ishikawa and D. Nakamura (eds.), *Industrial Location and Vitalization of Regional Economy*, https://doi.org/10.1007/978-981-19-8128-9_3

and the growth of labour productivity, known as 'Verdoorn's Law', as an empirical approximation of increasing returns. In an explicit regional context, Kaldor (1970) rivets attention on 'Verdoorn's Law' in order to describe formally a process, through which once a region obtains a productivity advantage it grows at the 'expense' of the other regions. Initially successful regions exhibit higher growth rates while less-advanced regions find themselves in a position of relatively lower growth. It may be argued that such 'clusters' are caused by a mechanism that sustains initial differences across regions. Nevertheless, is it possible for this process to be reversed, or at least slowed down, in favour of the less-advanced regions? Kaldor (1970, p. 344) allows for such a possibility by stating that '[t]here are also important diseconomies resulting from excessive rates of growth in industrial activities in particular areas [...] and these at some stage should serve to offset the technological economies resulting from faster growth'. Increasing returns reach a critical limit after which results to lower growth. If this condition holds for advanced regions, then this may reverse the outcomes of cumulative causation. However, in the context of regional growth models, this remains a virtually unexploited mine of research.

'Verdoorn's Law' has been tested for the OECD (Romero & McCombie, 2016) and individual countries (e.g. Cornwall, 1976; McCombie, 1981; Australia, Metcalf & Hall, 1983) and for various regional contexts (e.g. for the USA states, Bernat, 1996; the UK regions, Hildreth, 1989a, 1989b, the regions of Japan, Casetti & Tanaka, 1992). Several studies (e.g., Fingelton & McCombie, 1998, Pons-Novell and Marshal, 1999) have looked at its applicability to extended regional contexts, such as the regions of European Union (hereafter EU). Nevertheless, few empirical studies examined the possibility of reversing the directionality of cumulative causation. This paper has two aims. A first aim is to extend and improve the empirical literature on 'Verdoorn's Law' using recent data from the EU regions while a second aim is to provide empirical evidence of the possibility of reversing the process of cumulative causation.

Following this introduction, this paper is divided into four sections. The context in which the paper's main question emerges, viz. that faster growth leads to an accelerating reinforcing circle is discussed in Sect. 3.2. An explanation is provided as to how 'Verdoorn's Law' sets up a process of cumulative causation. Section 3.3 discusses some issues relating to data use and manipulation. After outlining the estimation procedure, Sect. 3.4 discusses the econometric results. A final section summarises the econometric results and suggests an interesting policy conclusion.

3.2 Theoretical Foundations

'Verdoorn's Law' describes a statistical relationship between the growth of output and the growth of labour productivity. Kaldor (1966) in his Inaugural Lecture, held in Cambridge, used 'Verdoorn's Law' in order to provide an explanation for UK's slow growth rate.[1] He argued that industrial output in UK was constrained by the growth of labour supply and via 'Verdoorn's Law' industrial productivity grows at a slow rate. Subsequently, Kaldor (1970) offered an alternative view of 'Verdoorn's Law' as an indication of increasing returns to scale, when the expanding size of the local production fabric generates increasing productivity and a source of difference in regional growth rates.[2] Kaldor (1972) considers the presence of increasing returns as a direct challenge to the neoclassical equilibrium theory.[3] The central conceptual apparatus derives from an early model by Young (1928). Increasing returns are considered in *macro* sense as a function of the continual division of labour and more importantly operate in a cumulative way.[4] This argument has been admirably stated by Young (1928) and one can hardly do better than quote him in *extenso*: 'Modified, then, in the light of this broader conception of the market, Adam Smith's dictum amounts to the theorem that the division of labour depends in large part upon the division of labour. This is more than mere tautology. It means, if I read its significance rightly, that the counterforces which are continuously defeating the forces which make for economic equilibrium are more pervasive and more deeply rooted in the constitution of the modern economic system than we commonly realise. Not only new or adventitious elements, coming in from the outside, but elements which are permanently characteristics of the ways in which goods are produced make continuously for change. Every important advance in the organisation of production, regardless of whether it is based upon anything which, in a narrow or technical sense, would be called a new 'invention', or involves a fresh application of the fruits of scientific progress to industry, alters the conditions of industrial activity and initiates responses elsewhere in the industrial structure which in turn have a further unsettling effect. Thus change becomes progressive and propagates itself in a *cumulative way*.' (Young, 1928, p. 533) [emphasis added].

A simple conclusion follows from Young's model. Increasing returns can be considered as a primary force behind the process of cumulative causation. Despite its simplicity, its implications are quite deep. Moreover, several aspects of dynamic increasing returns refer to intangible concepts, such as organisational structure,

[1] In his Inaugural Lecture Kaldor (1966) put forward three propositions or Growth Laws. For a more detailed analysis see Thirlwall (1983).

[2] Increasing returns to scale turn out to be essential for explaining the uneven geographical distribution of economic activity (Scotchmer and Thisse, 1992, call this the 'folk theorem of spatial economics').

[3] Nevertheless, Verdoorn (1959) argues that this relationship holds only as an asymptotic case of long-run equilibrium development.

[4] Beginning by arguing that there is a common intellectual basis between development economics and economic geography, these factors were 'rediscovered' by Krugman (1991, 1995). In the words of Krugman (1995): 'Both development economics and economic geography experienced a flowering after World War II, resting on the same basic insight: the division of labour is limited by the extent of the market, but the extent of the market is in turn affected by the division of labour. The circularity of this relationship means that countries may experience self-reinforcing industrialisation (or failure to industrialise), and that regions may experience self-reinforcing agglomeration' (p. 3).

managerial systems, history, agglomerations and so forth. In order to accommodate the theory with empirical observations, an exact specification of scale effects is essential. An empirical approximation is provided by the relation between output and productivity growth.

Verdoorn (1949) linked the empirically endorsed relationship between labour productivity and output to the *division of labour*.[5] More specifically, 'in fact one could have expected a priori to find a correlation between labour productivity and output, given that the division of labour only comes about through increases in the volume of production; therefore the expansion of production creates the possibility of further rationalisation which has the same effects as mechanisation' (p. 3). This proposition may be expressed in a more general form. In particular, 'Verdoorn's Law' considers the growth of labour productivity ($\dot{\rho}_{i,t}$) as a function of the growth of output ($\dot{q}_{i,t}$): $\dot{\rho}_{i,t} = f(\dot{q}_{i,t})$ with $f' > 0$ (Chatterji & Wickens, 1983). Empirical applications usually involve estimation of the following regression equation:

$$\dot{\rho}_{i,t} = a + b\dot{q}_{i,t} + u \tag{3.1}$$

where i denotes a region, a stands for the rate of autonomous productivity growth, b is the Verdoorn coefficient and u is a serially independent random error with zero and constant variance. Given that labour productivity is defined as $\dot{\rho}_{i,t} = \dot{q}_{i,t} - \dot{l}_{i,t}$, where $\dot{l}_{i,t}$ is the growth rate of labour force, then Eq. (3.1) can be written as

$$\dot{l}_{i,t} = a + \beta\dot{q}_{i,t} + u \tag{3.2}$$

According to McCombie and de Ridder (1984) Eq. (3.2) is preferable[6] since it avoids the spurious correlation inherent in (1) resulting from the definition of productivity growth as . Scale returns can be estimated as $\nu = 1/(1 - \beta)$.

Verdoorn (1949), from an analysis of international and sectoral industry data, observed the relative consistency of average value of the elasticity of productivity with respect to output at approximately 0.45. He concluded that '[t]his means that over the long period a change in the volume of production, say of about 10 per cent, tends to be associated with an average increase in labour productivity of 4.5%'. On these grounds b is expected to display a positive sign. Specifically, $0.41 \leq b \leq 0.57$, while $b = \dot{p}/\dot{q}$ sets the 'limits' for increasing returns (Hildreth, 1989a, 1989b). Indeed, a large body of quantitative studies[7] show that b takes a value about 0.5, implying that a one-percentage-point increase in output growth induces an increase in the growth of employment of half a percentage point and an equivalent increase in the growth of productivity.

Nearly a decade after Kaldor's Inaugural Lecture, Rowthorn (1975a, 1975b) in a stimulating paper, rekindled interest in 'Verdoorn's Law' by suggesting that is

[5] It might be argued that Verdoorn (1949) provides an algebraic formulation of Young's verbal model.

[6] This is an indispensable element of Kaldor's growth model (Molana and Vines, 1989).

[7] See McComie et al., (2002) for a more detailed review.

incorrectly specified. To be more precise, Rowthorn (1975a, 1975b) argues that output growth should be regressed on employment growth; thus $\dot{q}_{i,t} = a' + b'\dot{l}_{i,t} + u$. The primary question here is whether employment or productivity is endogenously or exogenously determined. Rowthorn (1975a, 1975b) criticised Kaldor's interpretation on the grounds that if manufacturing growth is constrained by a shortage of labour, then the growth rate of labour force must be treated as the independent variable. Kaldor (1966), indeed, attributed the slow growth rate of the United Kingdom to the restriction on the availability of labour from agriculture, but subsequently (1975) changed his mind arguing that the demand for exports constrains the growth rate, not the supply of labour.[8] There is a major debate that has centred on the correct specification of 'Verdoorn's Law' (e.g. McCombie, 1981; Rowthorn, 1979; Thirlwall, 1980a, 1980b). It is clear that Rowthorn's specification is just a simple production relation and perhaps, more importantly, has little to say about the cumulative nature of growth.

Scale economies appear in many forms. For example, economies producing a larger volume of output occur mainly in the direct use of capital and labour and in inputs (maintenance, overhead costs of various kinds) related to them. Moreover, external economies arise when the real cost of supplying a given set of demand is less with coordinated investment decisions than with individual decisions based on existing market information (Chenery, 1959). At the regional level scale effects are present, for example, when large-scale investment in a region causes a decrease in the cost of supplying the demand for the products of surrounding regions; a movement towards spatial equilibrium. While this argument makes sense, there are forces working in the opposite direction. 'Verdoorn's Law' portrays a mechanism by which output growth induces further growth in productivity due to dynamic increasing returns, reflected in productivity gains growth which, in turn, make the products of a region more competitive and subsequently increase its exports, leading to even higher rates of growth.[9] However, this occurs at the expense of regions unable to realise dynamic increasing returns. Dixon and Thirlwall (1975) construct a formal model of cumulative causation in which 'the Verdoorn coefficient gives rise to the possibility that once a region obtains a growth advantage, it will keep it' (p. 205). In this light, the Verdoorn coefficient is a sustaining factor in the *persistence* of regional growth differences *once* they have emerged. A high degree of concentration, for example, of the economic activities within a region creates substantial increasing returns, which give this region an *initial* growth advantage, viz. faster productivity growth, leading to even higher concentration in successful regions creating a 'circle'[10]; a direct challenge to the neoclassical model of general equilibrium, which relays on factor movements across regions. Indeed, although less-developed regions offer the

---

[8] This holds not only internationally, but also even more so across regional economies. As Thirlwall (1980a) argues, regional problems are essentially, balance-of-payment problems.

[9] A similar process is implied by Fujita et al. (2001).

[10] This possibility is pointed out early by economic geographer. Abler et al. (1970), for example, argue that 'Spatial structure and spatial process are *circularly* causal. Structure is a determinant of the process as much as process is a determinant of structure.' (p. 60) [emphasis in the original].

advantage of low-wage labour, these benefits tend to be offset by the scale economies found in the industrialised regions (Dawkins, 2003). However, it is not yet clear if the effects of this circle can be slowed down or even reversed in favour of the less-developed regions.[11] McCombie (1988) pointed out the necessity for incorporating factors, like spatial agglomeration and negative external effects that *offset* the benefits of cumulative causation in 'central-successful' regions; a process that may be reinforced *deliberately* through regional policies. Surprisingly little attention has been devoted to this possibility, at least not in an explicit way.[12] Setterfield (1997), following Frankel (1955), outlines an approach that allows cumulative causation to occur at a slower 'pace'. In particular, regional growth is determined by a specific production 'technique', that a region implements, and it is very possible that this region in future will continue to grow due to that technique, viz. a '*lock-in*' in a specific growth-path. Some techniques lead to high growth paths while others to low growth paths for regions that implement them. However 'initially self-perpetuating high relative growth through cumulative causation may, therefore, endogenously create the conditions for a subsequent era of slow relative growth' (Setterfield, 1997, p. 372).

Assume that there is an estimate of v amongst two distinctive time periods; if $v_t - v_{t-1} < 0$ then this can be considered as an indication that there are tendencies for cumulative causation to operate at a slower rate. This may take place if regions in 'low growth paths' shift their production structure towards implementation of more advanced techniques, i.e. a technological diffusion effect. Overconcentration of establishments in advanced regions can be conceived as a source of reversing the effects of cumulative causation, provided that it suppresses their growth rates. In conjunction with a movement of manufacturing establishments from advanced towards less-advanced regions, then cumulative causation is to be reversed or, at least, to operate in a slower pace. Reversing the process of cumulative causation requires that conditions in less-advanced regions should become similar to those of the advanced regions. Another way of stating the same thing is to say that differences in conditions across regions should diminish over time.

The process of regional growth is complex and depends upon the relative extent of mechanisms such as factor mobility, price flexibility and transfer of knowledge/technology (e.g. Martin, 1999; Martin & Sunley, 1998). Where such mechanisms exist they are likely to be enhanced, rather than reduced, by *spatial dependence*. Econometrically, any effects from spatial interaction are captured in the error-term (u) of Eq. (3.1), which is modelled as $u = s\boldsymbol{W}u + e = (\boldsymbol{I} - s\boldsymbol{W})^{-1}e$, where s is a scalar spatial-error coefficient, e is the new error-term, $\boldsymbol{I}$ is the identity-matrix and $\boldsymbol{W}$ is a spatial-weights matrix. This matrix can be constructed in several ways. A

[11] Such an outcome is implied by a new generation of growth models; those belonging to New Economic Geography (NEG). A more detailed treatment of NEG is encapsulated in Fujita et al. (2001), Gruber & Soci (2010), Ottaviano (2007) together with a critical assessment of these models. For a more detailed review see Fingleton (2007).

[12] There are though a few notable theoretical exemptions. Roberts (2002), for example, argues that increasing real wages in conjunction with labour shortages might result to a slow-down in the process of cumulative causation.

usual practice is to construct spatial weights as $w_{ij} = 1/d_{ij}$. Here, d_{ij} denotes the distance between two regions i and j, typically represented by the distance between the regions' main cities where the majority of economic activities are located. Thus, Eq. (3.2) can be written as follows:

$$\dot{l}_{i,t} = a + \beta\dot{q}_{i,t} + (I - sW)^{-1} e \tag{3.3}$$

According to Eq. (3.3), the effects of a random shock on the growth rate of a given region will disperse beyond that region's boundaries, impacting on the growth rates of surrounding regions through the spatial transformation $(\boldsymbol{I} - s\boldsymbol{W})^{-1}$.. Moreover, the diffusion of the impact is such as to spread beyond a region's immediate neighbours throughout all regions in the economy. In this way, each region is viewed not as an independent unit, but rather as a functional unit-member of a complex geographical system. After all this approach is in accordance with the first law of geography: 'Everything is related to everything else, but near things are more related than distant things' (Tobler, 1970).

An alternative way to include spatial dependence in econometric estimations is by a *spatial-lag* model. The idea of this model is really quite simple. According to this approach, the dependent variable is adjusted by a spatial matrix as an additional explanatory variable. More specifically,

$$\dot{l}_{i,t} = a + \beta\dot{q}_{i,t} + \lambda(W i_{i,t}) + u \tag{3.4}$$

One immediately obvious implication of applying spatial econometric techniques is the possibility of *circularity*. Firms want to locate where market potential is high, that is, near large markets. But markets will tend to be large where lots of firms locate. So, one is led naturally to a consideration of the possibility of self-reinforcing regional growth or decline (Krugman, 1995). Consequently, spatial econometric techniques provide an appropriate framework to examine 'Verdoorn's Law' and the process of cumulative causation.

3.3 Empirical Application

In this section, some points about the methods and the data employed in econometric estimations are discussed, followed by the presentation and a detailed account of the econometric results.

3.3.1 Estimation Methods and Data Description

The analysis refers to the period 1995–2018 and is divided into several shorter time spans, forming a 'panel-data' framework. In such a framework the main concern is the appropriate time-span lengths. Technically, it is feasible to use annual time spans, given that the available data-set provides yearly observations. However, given that the model's underlying hypothesis refers to the long-run, annual time spans seem rather inappropriate. Throughout this section, regular non-overlapping intervals of four years were used. In particular, the entire time period was divided into 6 non-overlapping sub-periods, 1995–1998, 1999–2002, 2003–2006, 2007–2010, 2011–2014 and 2015–2018. Using these sub-periods, the error term is less likely to be influenced by business cycle fluctuations and the residuals are less serially correlated, compared to a yearly data-set. Estimation of the spatial specifications is carried out by the Maximum-likelihood method (ML), as Ordinary Least Squares (OLS) may result in problems of bias.[13]

Empirical analysis is carried out using data for the regions of EU, obtained from EUROSTAT. The regional groupings used are those delineated by EUROSTAT and correspond to NUTS-3 regions. Output growth is expressed as the Gross Value-Added (GVA) in the manufacturing sector as a whole, while the growth of employment is approximated by the number of workers employed in this sector. Although the ideal measure of labour input requires data on *working hours*, nevertheless, regionally disaggregated data on working hours are not available and consequently, the total number of workers in the manufacturing sector will be used as a proxy for labour inputs. GVA per-worker is chosen because it is a measure of regional productivity and in general this is a major component of differences in the economic performance of regions and a direct outcome of variation in factors that determine regional 'competitiveness' (Martin, 2001).

3.3.2 Empirical Results

The analysis is carried out in two stages. The first stage involves estimating Eqs. (3.1), (3.2) and (3.3), for the overall period. This is an important period since there are several events took place, e.g. the crisis of 2008, EU enlargement and introduction of euro. The second stage aims to test empirically the possibility that cumulative causation has reversed by estimating the above set of equations for two separate periods, viz. 1995–2006 and 2007–2018. A successful future for the EU requires eradication of regional imbalances. This is based on the contention that reversing cumulative causation in favour of the less-developed region of the EU. To this aim, EU has implemented an active regional policy, and continues to do so. Testing, therefore, 'Verdoorn's Law' for two successive time periods may provide an indication of whether regional policies were successful or not. Table 3.1 shows the estimates of 'Verdoorn's Law. for the period 1995–2018.

[13] Berant (1996) notes that spatial autocorrelation invalidates OLS regressions in a way similar to heteroscedasticity and serial autocorrelation and the estimated coefficients will be biased.

Table 3.1 'Verdoorn's law': Non-spatial specification, EU-27, 1995–2018

Estimated equation: $\dot{l}_{i,t} = a + \beta\dot{q}_{i,t} + u$, OLS, Sample: 1,294 NUTS-3 regions						
a	β	R^2	[ser]	F(1, 1292)	[p-value]	Implied v
−0.3329**	0.4615**	0.4380	[0.2492]	1007.117	[0.0000]	1.8570**
LIK	−36.9777	AIC	77.9555		SBC	88.2865
Diagnostic tests						
Ramsey REST specification test[1]			[p-value]			
Test statistic: F(1, 1291) = 2.9544			[0.0858]			
Test for Normality of the residuals[2]			[p-value]			
Test statistic: Chi-squared 5.5356			[0. 0627]			
Test Statistics for Heteroscedasticity[3]			[p-value]			
White	LM = 52.5745		[0.0000]			
Breusch-Pagan	LM = 72.9915		[0.0000]			
Koenker	LM = 32.1953		[0.0000]			

Notes (1) Null Hypothesis: Specification is adequate
(2) Null hypothesis: Error is normally distributed
(3) Null Hypothesis: Heteroscedasticity is not present
** indicates statistical significance at 95% level of confidence
[ser] denotes the standard error of the regression
AIC, SBC and LIK denote the *Akaike*, the *Schwartz-Bayesian* information criteria and Log-likelihood, respectively. For each diagnostic test, the associated statistics together with the p-values are reported. All numbers are rounded to four decimal places

Given the existing literature, it comes as no surprise that the point estimate of $\dot{q}_i$ is in accordance with the model discussed in Sect. 3.2[14]. The value of R^2 can be considered as satisfactory, given the nature of the data. Moreover, the probability associated with the F-statistic for overall significance of the regression rejects the null hypothesis of zero coefficients. According to the associated p-value, at least some of the regression parameters are nonzero and that the regression equation does have some validity in fitting the data (i.e. the independent variable is not purely random with respect to the dependent variable). A set of diagnostic test, however, indicates that estimating Eq. (3.2) at the NUTS-3 level has several problems. The probability associated with the x^2 test accepts the null hypothesis of normality only at 10% level of significance. Similarly, the null hypothesis of adequacy is accepted only at 10% level. More seriously, perhaps, is heteroscedasticity. In a spatial context, a frequent problem is the presence of non-constant variances. This is mainly due to problems related to data collection. These refer to the different dimensions or sizes of

[14] It is important to note that Verdoorn (1949) suggested that the relationship between the growth of productivity and the growth of employment could be used to *forecast* labour requirements and hence to give 'a rough idea of how much industrial productivity must be expand to absorb a certain availability of labour' (p. 4) [emphasis added]. Although this suggest another application of the 'Verdoorn's Law' and opens up a promising area of research, nevertheless, it goes beyond of the scope of this paper.

Table 3.2 'Verdoorn's law': Spatial specifications, 1995–2018

Estimated equation: $\dot{l}_{i,t} = a + \beta \dot{q}_{i,t} + (\boldsymbol{I} - s\boldsymbol{W})^{-1}e$, ML, Sample: 1,294 NUTS-3 regions		
a	−0.2187*	−0.1705*
b	0.4763*	0.4606*
s	0.7801*	
λ		0.6236
LIK	−32.2887	−33.0478
AIC	70.5774	72.0956
SBC	86.0739	87.5921
Estimates of returns to scale		
v	1.90	1.85

Notes (1) Figures in brackets are the t-ratios
(2) An asterisk (*) indicates statistical significance at 95% level of confidence
(3) LIK denotes the Log-Likelihood statistic. All numbers are rounded to four decimal places

the various spatial units that compose the area under consideration, the unbalanced distribution of population/economic activities within regions, variations in the degree of urbanisation, the presence of relatively large rural areas and so forth. The three tests set out in Table 3.1 accept the alternative hypothesis of heteroscedasticity. This is, perhaps, not so surprising if one considers the heterogeneity of the regions in the EU. Based on the aforementioned tests, the null hypothesis of homoscedasticity (or the assumption of constancy of the conditional variance) for Eq. (3.2) cannot be accepted, at the usual levels of significance. A spatial specification, therefore, might be more appropriate in the case of the EU regions. Table 3.2 presents the results from estimating Eqs. (3.3) and (3.4).

If one was to select one of the two models in terms of their ability to capture increasing returns, a criterion, used extensively in spatial econometrics is the *Log-Likelihood* statistic (LIK). According to this criterion, the best-fitted model is the one that yields the greater value of the LIK criterion (Anselin, 1988). It can be seen from Table 3.2 that the calculated values of this criterion increase, as anticipated, with the introduction of spatial interaction. Such results suggest a significant spatial dimension in the process of manufacturing growth across the EU regions. In short 'space matters' (Dawkins, 2003, p. 132). The LIK criterion shows a preference towards the spatial-error model. The superiority of this model is also supported by both the criteria for model selection applied here, namely the *Akaike* (AIC) and the *Schwartz-Bayesian* (SBC) information criteria.[15] It is important to note that all estimates show little variation and are very close to those implied by Kaldor's model. Thus, in line with Thirlwall's (2002, p. x) suggestion that 'the only way knowledge

[15] As a rule of thumb, the best fitting model is the one that yields the minimum values for the AIC or the SBC criterion. The SBC test has superior properties and is asymptotically consistent, whereas the AIC is biased towards selecting an overparameterized model.

can progress in the social sciences is by repeated experiments', the results reported in Table 3.2 provide further corroboration of 'Verdoorn's Law'. Moreover, estimates obtained from Eqs. (3.3) and (3.4) imply a higher degree of scale returns, compared to that by non-spatial specification of 'Verdoorn's Law'. This is an indication that spatial interaction enhances scale returns. Indeed, it is almost an article of faith of regional economics that production is characterised by substantial economies of scale. It might be argued, therefore, that spatial interaction in conjunction with scale returns sustain regional growth differentials, which in turn is a powerful source of dualism.

The validity of 'Verdoorn's Law' in the context of the EU regions is established by the statistical significance of the critical coefficient. All estimates are significantly greater than unity at the 0.95 confidence level. McCombie and de Ridder (1984) came to the conclusion that estimating the 'Verdoorn's Law' using *regional* data provides a strong confirmation of the existence of increasing returns in manufacturing. There can be little doubt that estimates of v reinforce the validity of the thesis that the manufacturing sector is subject to substantial increasing returns at the *regional* level; an element which is central to the theory of cumulative causation. Taken at face value the estimates in Table 3.2 seem to suggest that the process of manufacturing growth across the EU regions is a *cumulative* one[16]. This hypothesis, however, needs further empirical analysis. Recollect that the Verdoorn effect refers to the fact that growth in labour productivity is partly dependent on output growth. According to Dixon and Thirlwall (1975), the 'Verdoorn effect' is a source of regional growth rates differences only to the extent that the Verdoorn coefficient varies between regions. Estimating Eq. (3.3) for each EU country suggests that the nature of this relationship is far from uniform (Table 3.3)[17].

The obtained results clearly show that the Verdoorn coefficient is subject to considerable variation across the EU. The weight of evidence points to the possibility that the 'Verdoorn effect' is a sustaining factor of regional growth differentials. A comparison of the estimated values of v provides considerable support to the argument that the process of manufacturing growth in the EU is characterised by 'dualism'. Indeed, as the coefficient suggests manufacturing in 'advanced' North European countries (Belgium, Germany, Denmark, France and Austria) exhibits a higher degree of increasing returns. On the other hand, manufacturing in most Eastern countries seem to operate with constant returns. This contrition, however, does not characterise Hungary and Poland, countries located close to advanced Northern countries. Similarly, constant returns seem to appear in Southern countries, with Portugal and

[16] Disenchantment and scepticism with equilibrium ideas runs through geographical analysis. Indicatively, consider the following passage from Smith (1967): 'It is the periods and processes of geographical change, of active settlement and colonisation, of urban foundation and growth, or of industrial and commercial change, that stimulate most interest and that have been most significant in the formation of landscape (p. vi)'. Indeed, as Chisholm (1975) notes 'Smith stresses the importance of processes generating change and thereby adverts to an age-old problem [...], namely how to infer the causal chain of processes from observed spatial patterns (p. 116)'.

[17] Using Eq. (3.4) gave similar results. Nevertheless, using AIC and SBC criteria, Eq. (3.3) is preferred over the other two specifications. For brevity only the Verdoorn coefficient is reported.

Table 3.3 'Verdoorn's law', estimates for each EU country, 1995–2018

Belgium	0.6417
Bulgaria	0.3072
Czech Republic	0.3445
Denmark	0.5926
Germany	0.6062
Estonia	0.2557
Ireland	0.0456
Greece	0.3721
Spain	0.3333
France	0.6150
Italy	0.2748
Latvia	0.1806
Lithuania	0.2816
Hungary	0.5477
Nederland	0.2984
Austria	0.5677
Poland	0.4567
Portugal	0.5129
Romania	0.2871
Slovenia	0.2001
Slovakia	0.3900
Finland	0.3874
Sweden	0.1057
United Kingdom	0.3082

Greece exhibiting some degree of increasing returns. In short, the results suggest a significant spatial dimension to the phenomenon of scale effects.

In an attempt to test if the process of cumulative causation exhibits tendencies of reversing or, at least, occurring in a slower pace, 'Verdoorn's Law' is estimated using all three specifications by splitting the time span into two parts, i.e. 1995–2006 and 2007–2018. Although, the distinction can be seen as somehow arbitrary, nevertheless, it provides some indications if the process of cumulative causation has reversed or, at least, slowed down. A number of different specifications and estimation techniques were used and the results are reported in Table 3.4.

As perhaps, anticipated the results provide further support to 'Verdoorn's Law' and confirm the hypothesis of increasing returns in European manufacturing. The estimated coefficient is highly statistical significant while estimates of ν cluster around 1.62–1.72. As for the overall period, the results show a preference towards the spatial-error model. This condition also holds for the period 2007–2018 (Table 3.5).

Table 3.4 'Verdoorn's law': 1995–2006

Depended Variable: $\dot{l}_{i,t}$ Sample: 1,294 NUTS-3 regions			
	OLS	ML	ML
a	0.1401*	−0.0856*	−0.1148*
b	0.4058*	0.4182*	0.3842*
s		0.5181*	
λ			0.3804*
LIK	191.5065	195.3028	193.6601
AIC	−379.0129	−384.6056	−381.3202
SBC	−368.6819	−369.1091	−365.8237
Estimates of returns to scale			
ν	1.68	1.72	1.62

Notes (1) Figures in brackets are the t-ratios
(2) An asterisk (*) indicates statistical significance at 95% level of confidence
(3) LIK denotes the Log-Likelihood statistic. All numbers are rounded to four decimal places

Table 3.5 'Verdoorn's law': 2007–2018

Depended variable: $\dot{l}_{i,t}$ Sample: 1,294 NUTS-3 regions			
	OLS	ML	ML
a	−0.1343*	−0.1002*	−0.0816*
b	0.3717*	0.3807*	0.3677*
s		0.6453*	
λ			0.4788*
LIK	423.9716	445.2874	431.5001
AIC	-843.9432	−884.5748	−841.5037
SBC	−833.6122	−869.0783	−857.0002
Estimates of Returns to Scale			
ν	1.59	1.61	1.58

Notes (1) Figures in brackets are the t-ratios
(2) An asterisk (*) indicates statistical significance at 95% level of confidence
(3) LIK denotes the Log-Likelihood statistic. All numbers are rounded to four decimal places

Table 3.4 shows a lower value of *ν* for the period 2007–2018. It might be argued that after 2006 there was some improvement. This outcome can be considered as an indication that the pace of cumulative causation has slowed down. This may, partly, attributed to the effects of technology diffusion across the EU regions, leading some 'less-advanced' regions to shift their production structure towards more advanced techniques, reflected in high growth rates. Another explanation may possibly be sought in the operation of negative externalities caused by over-concentration of manufacturing establishments in initially advanced manufacturing regions. These regions may have reached a certain 'threshold' stage, which caused manufacturing establishments to move toward adjustment regions; a movement encouraged also by regional policy. Nevertheless, estimates of ν still remain high, reinforcing the argument that initially advanced manufacturing continues to grow at the expense of all other regions, although at a lesser extent. In other words, despite some improvements in favour of less-advanced regions, the process of cumulative causation was merely slowed rather than reversed.[18] The results reported here seriously cast doubt on the hypothesis of regional equilibrium and support to Kaldor's argument about the dualistic nature of advanced capitalist economies, in the sense that an advanced 'centre' coexists with a less-advanced 'periphery'. Further analysis, however, shows that this situation, although sustainable, nevertheless a reversing is not impossible.

Setterfield (1997) argues that '[…] initially self-perpetuating high relative growth through cumulative causation may, therefore, endogenously create the conditions for a subsequent era of slow relative growth' (p. 372). It might be argued that such conditions come about from the particular policies and in general 'responses' to the problems of growth and productivity (e.g. methods of production, approaches to process/product/organisational innovation, and extent of subcontracting, movements in the value chain). Moreover, certain responses could lock in some regions in high paths of growth while others in low growth paths as well as descend/ascend paths. Still this point deserves further thought.

The latter could occur, for example, if regions locked in low growth paths shift their production structure towards more advanced techniques, i.e. a technology diffusion effect. Cumulative causation could also operate in a slower pace if techniques that lock regions in high-growth paths become obsolete, causing a relative decline in their growth rates. As already mentioned, over-concentration in advanced industrial regions could also be conceived as a source of reversing the process of cumulative causation. Yet the root of the matter is here. If over-concentration of manufacturing establishments in advanced regions suppresses their growth rates, and if less-advanced regions provide incentives for the movement of manufacturing establishments towards less-developed regions, then cumulative causation could operate at a slower pace. More detailed analysis, both theoretically and empirically is necessary. In this context, some remarks from Chisholm (1975) are highly pertinent: 'All events occur in space as well as in time, and if there is a readily identified direction of causation in the time dimension—the more recent being affected by the less recent

[18] Several studies point out that there is a process of regional convergence in the EU (e.g. Corrado et al, 2005). Indeed, most studies find a negative relation between growth rates and the initial level of productivity. Richardson (1984), however, notes "In the relatively near future, an opportunity will develop to test the appropriateness of the neoclassical compared with the cumulative causation model. The key question is whether regional per capita income will stabilise close to equality (i.e. an approximation to neoclassical equilibrium) or whether they will cross over, with the 4 lower income regions (S. Atlantic, East South Central, West South Central and Mountain) then becoming progressively richer than the 4 regions of the Northeast and Midwest. The latter development would be more consistent with the cumulative causation model. The competing hypotheses of interregional income equilibrium and the "cross over" is the most intriguing question in contemporary regional economics" (pp. 22–23).

but not vice versa—the same cannot be said of space. And so it becomes necessary to seek out the frameworks within which to examine multi-directional systems of causation. This implies careful examination of the ways in which phenomena are linked in space, and especially the flows of goods, people and information between locations. [...] However, to link together the study of forms and of the processes that give rise to them, accurate description is not enough. We need a framework of explanatory theory, to provide us with a rational understanding of the inter-linking of processes and their relationships to spatial forms' (p. 121). These arguments suggest a host of questions. What are the factors leading to cumulative causation and why is their influence so different in different periods? What then is the purpose of this analysis? Perhaps the main purpose should be to provoke interest and discussion in the applicability of disequilibrium models of regional growth. Is it not time to abandon models of equilibrium in favour of more realistic approaches of regional analysis with more content?

3.4 Concluding Points

There appears to be a strong literature successfully testing 'Verdoorn's Law' across the European regions using spatial econometric techniques. Using regional data on growth in employment and output for the EU countries, the results reported here provide strong confirmation for the hypothesis of increasing returns in the European manufacturing and, hence, the cumulative nature of regional growth. Empirical estimation of 'Verdoorn's Law' indicates that a cumulative mechanism exists, locking regions in high or low growth paths. This is in accordance with the post-Keynesian view of regional growth, which adduces that increasing returns lead to a disequilibrium state. This in turn makes regional disparities even wider in a *cumulative* way perpetuating the gap between 'centre' and 'periphery'. In this respect, it is interesting to note that a estimation of 'Verdoorn's Law' for each country implies that the EU is characterised by geographical dualism, in the sense that initially successful regions follow high growth paths and less-successful regions are 'lock-in' a relatively lower growth-path. This can be attributed to the fact that manufacturing activity is concentrated in relatively few regions, which follow a high growth path at the expense of the remaining regions. Further analysis, however, indicates that the process of cumulative causation has slowed down in favour of the less-advanced regions, although at a slow pace. A spatial specification of 'Verdoorn's Law' was tested for the 1995–2018 period as well as for two sub-periods, viz. 1995–2006 and 2007–2018, so as to 'capture' a possible 'shift' in growth paths in favour of less-advanced regions, due to the combined effect of technology diffusion and negative externalities in developed regions. It is important, once more, to underline that degree of increasing returns in the period 2007–2018 is slightly lower than that obtained for the period 2007–2018. This exercise provides an indication, although rough, that less-developed regions shifted to a path of faster manufacturing growth. It seems that spatial agglomerations surpassed a certain threshold and became a diseconomy that slowed down the process of cumulative growth, despite the 'pessimistic' predictions of the theory of cumulative causation. However, reversing the process of cumulative causation turns out to be more difficult than that.

There is one last issue to which a few words must be devoted. Regional policies in EU have been in operation for many years, yet regional differentials in growth still remain. As already pointed out, it is established that the value of increasing returns is less in the terminal period, relatively to those obtained for the initial period. This may be taken as an indication the process of cumulative causation across the EU regions is slowing down. A definite opinion, however, seems to be worth further and detailed and focussed investigation. Despite some improvement cumulative causation still operates and 'locks-in' regions into high and slow growth paths. This may be a signal to policy-makers in EU to pursue a more active regional policy in order to overcome the process of cumulative causation. This may be a difficult task but not unachievable.

References

Abler, R., Adams, J., & Gould, P. (1971). *Spatial Organisation: The Geographer's View of the World*. Prentice-Hall.

Anselin, L. (1988). *Spatial Econometrics*: *Methods and Models*. Kluwer Academic Publishers.

Bernat, G. (1996). Does Manufacturing Matter? *A Spatial Econometric View of Kaldor's Laws, Journal of Regional Science, 36*(3), 463–477.

Casetti, E., & Tanaka, K. (1992). Spatial dynamics of Japanese manufacturing productivity: An empirical analysis by expanded verdoorn equations. Papers in Regional Science, *71*(1), 1–13.

Chatterji, M., & Wickens, M. (1983). Verdoorn's law and Kaldor's law: A revisionist interpretation? *Journal of Post-Keynesian Economics, 5*(3), 397–413.

Chenery, H. 1959. The interdependence of investment decisions, in Abramovitz et al (Eds.) *The Allocation of Economic Resources*. Stanford University Press, 80–12.

Chisholm, M. (1975). *Human Geography: Evolution or Revolution?* Penguin.

Corrado, L., Martin, R., & Weeks, M. (2005). Identifying and interpreting regional convergence clusters across Europe. *Economic Journal, 115*(502), C133–C160.

Cornwall, J. (1976). Diffusion, convergence and Kaldor's laws. *Economic Journal, 86*(342), 307–314.

Dawkins, C. (2003). Regional development theory: Conceptual foundations, classic works, and recent developments. *Journal of Planning Literature, 18*(2), 131–172.

Dixon, R., & Thirlwall, A. (1975). A model of regional growth differences on Kaldorian lines. *Oxford Economic Papers, 27*(2), 201–214.

Frankel, M. (1955). Obsolescence and technological change in a maturing economy. *American Economic Review, 45*(3), 296–319.

Hildreth, A. (1989a). The ambiguity of Verdoorn' law: A case study of the british regions. *Journal of Post Keynesian Economics, 11*(2), 279–294.

Fingelton, B., & McCombie, J. (1998). Increasing returns and economic growth: Some evidence from the european union regions. *Oxford Economic Papers, 50*(1), 89–105.

Fujita, M., Krugman, P., & Venables, J. (2001). *The Spatial Economy: Cities*. The MIT Press.

Hildreth, A. (1989b). The ambiguity of Verdoorn's Law: A case study of the British regions. *Journal of Post Keynesian Economics, 11*(2), 279–294.

Kaldor, N. (1966). *Causes of the Slow Rate of Economic Growth of the United Kingdom*. Cambridge University Press.

Kaldor, N. (1968). Productivity and Growth in Manufacturing Industry: A Reply. *Economica, 35*(140), 385–391.

Kaldor, N. (1970). The case for regional policies. *Scottish Journal of Political Economy, 17*(3), 337–348.

Kaldor, N. (1972). The irrelevance of equilibrium economics. *Economic Journal, 82*(328), 1237–1255.

Kaldor, N. (1975). Economic growth and Verdoorn's law: A comment on Mr. Rowthorn's Article. *Economic Journal, 85*(340), 891–896.

Krugman, P. (1991). Increasing returns and economic geography. *Journal of Political Economy, 99*(3), 483–499.

Krugman, P. (1995). *Development*. MIT Press.

Martin, R. (1999). The new 'geographical turn' in Economics: Some critical reflections. *Cambridge Journal of Economics, 23*(1), 65–91.

Martin, R. (2001). EMU versus the regions? Regional convergence and divergence in Euroland. *Journal of Economic Geography, 1*(1), 51–80.

Martin, R., & Sunley, P. (1998). Slow convergence? *The New Endogenous Growth Theory and Regional Development, Economic Geography, 74*(3), 201–227.

McCombie, J. (1981). What still remains of Kaldor's laws? *Economic Journal, 91*(361), 206–216.

McCombie, J. (1988). A synoptic view of regional growth and unemployment. *Part II: The Post Keynesian Theory, Urban Studies, 25*(5), 399–417.

McCombie, J., & De Ridder, J. (1984). The Verdoorn's law controversy: Some new evidence using US data. Oxford Economic Papers, *36*(2), 268–284.

McCombie, J., & Thirlwall, A. (1994). *Economic Growth and Balance of Payment Constraint*. Martins Press.

Metcalf, J., & Hall, P. (1983). The Verdoorn law and the salter mechanism: A note on Australian manufacturing industry. Australian Economic Papers, *22*(41), 364–373.

Molana, H., & Vines, D. (1989). North-South growth and terms of trade: A model on Kaldorian lines. *Economic Journal, 99*(396), 443–453.

Myrdal, G. 1944. *An American Dilemma*, Harper & Bros.

Myrdal, G. 1957. *Economic Theory and Underdeveloped Regions*, Duckworth.

Pons-Novell, J., & Viladecans-Marshal, E. (1999). Kaldor's laws and spatial dependence: Evidence for the European regions. *Regional Studies, 33*(5), 443–451.

Richardson, H. 1984. Approaches to regional development theory in Western–market Economies, in Demko G. (ed) *Regional development: Problems and policies in Eastern and Western Europe*, London: Croom Helm

Roberts, M. (2002). Cumulative causation and unemployment. In J. McCombie, M. Pugno, & B. Soro (Eds.), *Productivity Growth and Economic Performance: Essays on Verdoorn's Law* (pp. 165–196). Macmillan.

Romero, J., & McCombie, J. (2016). Differences in increasing returns between technological sectors: A panel data investigation using the EU KLEMS database. *Journal of Economic Studies, 43*(5), 863–878.

Rowthorn, R. (1975a). What remains of Kaldor's law? *Economic Journal, 85*(337), 10–19.

Rowthorn, R. (1975b). A reply to lord Kaldor's comment. *Economic Journal, 85*(340), 897–901.

Rowthorn, R. (1979). A note on Verdoorn's law. *Economic Journal, 89*(353), 131–133.

Setterfield, M. (1997). History versus equilibrium and the theory of economic growth. *Cambridge Journal of Economics, 21*(3), 365–378.

Setterfield, M. (1998). History versus equilibrium: Nicholas Kaldor on historical time and economic theory. *Cambridge Journal of Economics, 22*(5), 521–537.

Scotchmer, S., & Thisse, J. (1992). Space and competition: A puzzle. *Annals of Regional Science, 26*(2), 269–286.

Smith, C. 1967. *An Historical Geography of Western Europe before 1800*, Longmans.

Thirlwall, A. (1980a). Rowthorn's interpretation of Verdoorn's law. *Economic Journal, 90*(358), 386–388.

Thirlwall, A. (1980b). Regional problems are "balance-of-payments" problems. *Regional Studies, 14*(5), 419–425.
Thirlwall, A. (1983). A plain man's guide to Kaldor's growth law. *Journal of Post Keynesian Economics, 5*(3), 345–358.
Thirlwall, A. (2002). Forward. In J. McCombie, M. Pugno, & B. Soro (Eds.), *Productivity Growth and Economic Performance: Essays on Verdoorn's Law* (pp. iv–xi). Macmillan.
Tobler, W. (1970). A computer movie simulating urban growth in the Detroit region. *Economic Geography, 46*(2), 234–240.
Verdoorn, P. 1949. Fattori Che Regolano lo Sviluppo Della Productivita del Lovoro, *L' Industria*, 1: 3–10 (translation by G. and A. Thirlwall).
Verdoorn, P. (1959). Capital and technical development in long-term projection models. *Cahiers Economiques De Bruxelles, 5*, 59–69.
Young, A. (1928). Increasing returns and economic progress. *Economic Journal, 38*(152), 527–542.