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KALDOR-VERDOORN'S LAW AND INCREASING RETURNS TO SCALE: A COMPARISON ACROSS DEVELOPED COUNTRIES

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Abstract

The object of this study is to investigate the validity of the Kaldor-Verdoorn's Law in explaining the long run determinants of the labor productivity growth for the manufacturing sector of some developed economies (Western European Countries, Australia, Canada, Japan and United States). We consider the period 1973-2006 using data provided by the European Commission - Economics and Financial Affairs. Our findings suggest that the law is valid for the manufacturing of Italy, US, Belgium and Australia. Capital growth and labor cost growth do not appear relevant in explaining productivity growth. The estimated Verdoorn coefficients are found to be stable throughout the period. [JEL Classification: C32, O47, O57]

Keywords: increasing returns, Kaldor-Verdoorn law, productivity growth, manufacturing sector.

Introduction

The Verdoorn's Law affirms that in the long run productivity generally grows proportionally to the square root of output. In Kaldor's view (1966), the reasons are to be found: i) into the irrelevance of the initial endowment in the growth process; ii) in the presence of static and dynamic economies of scale and of learning by doing processes; iii) in the relevance of the specialization and interaction process among firms; iv) in the endogeneity of the technical progress, embodied in capital[1].

As reviewed in McCombie *et al.* (2002), empirical literature in the last decades has extensively focused on the estimation of the Kaldor-Verdoorn's Law (hereafter, KVL). Numerous methodologies have been employed using data from different countries, sectors and time periods. Estimated Verdoorn coefficients are in most cases significant and range between 0.3 and 0.6. Under certain conditions, this evidence supports the existence of economies of scale.

Bernat (1996) estimated the KVL for US for the period 1977-99 by using spatial econometric techniques and found a statistically significant coefficient in the dynamic law with parameter value of about one third. Fingleton and McCombie (1998), using as Bernat spatial econometric techniques, focused on the manufacturing sector of the EU-regions for the

[1]This argument was studied among others by endogenous growth theorists like Romer (1986, 1990), Lucas (1988), Grossman and Helpman (1991) and Aghion and Howitt (1992, 1998).

period 1979-89. They obtained a significant coefficient of 0.57 and found the presence of significant spatial autocorrelation. Leon-Ledesma (2002) estimated the KVL for the Spanish regions for the period 1962-91 and obtained a Verdoorn coefficient of 0.45. Harris and Lau (1998) studied the UK regions for the period 1968-91 considering each industry of the manufacturing sector by using the cointegration technique. They found that most of the manufacturing industries has increasing returns to scale. Harris and Liu (1999) focused on a large number of countries for the period from 1962 to 1990 and found increasing returns for most of the observed countries. Bianchi (2002) considered the Italian economy both in general and for some specific sectors in the period 1951-97. He found that, while traditional estimates suggest the validity of the KVL both for the whole economy and each individual sector, a partial adjustment model seems to indicate that the KVL is valid only for the case of industry and for the entire sample period. Moreover, Bianchi suggested an international comparison with European Union and United States, finding evidence of wide differences across these areas. While the estimated Verdoorn coefficient is often statistically significant for the EU countries, this is not the case for US. Destefanis (2002) used a non-parametric frontier analysis for a sample of 52 countries for the period 1962-92. The obtained results pointed to a pervasive existence of increasing returns to scale across developed and developing countries. Finally, Ofria (2008) considered a strict definition of manufacturing (not including constructions, mining and the energy production and distribution) for the Centre-North and the Southern of Italy during the period 1951-2006. He found that the KVL is valid with parameter value of 0.68 for the Centre-North and of 0,77 for the South of Italy (the so-called "*Mezzogiorno*").

The object of this study is to investigate the validity of the KVL in explaining the long run determinants of the labor productivity growth for the manufacturing industry sector of some developed economies (Western European Countries, Australia, Japan and United States)[2]. We consider the period 1973-2006 using the data provided by the European Commission - Economics and Financial Affairs (AMECO database). The robustness of estimates is checked by means of the Chow and the CUSUM and CUSUMQ tests.

With respect to previous studies focusing on developed economies, this paper improves on a number of aspects. We test the KVL on 11 developed countries, for which 34 annual observations are available, including the most recent years. Moreover, we test the relevance of the KVL with respect to alternative hypotheses such as those related to the existence of supply constraints. Finally, we investigate empirically whether the KVL is stable throughout the period under consideration. Our findings suggest that the law is valid for the manufacturing of Italy, US, Belgium and Australia. Capital growth and supply factors do not appear to be relevant in explaining productivity growth. Finally, it emerges that the estimated parameters are

[2] Some developed countries (for instance, Germany and Spain) are not included because for some years data are not available.

stable throughout the period and in particular after 1986, when a significant reduction in oil prices occurs. Our evidence in favor of structural stability also suggests that the mid-nineties decline in productivity growth, observed particularly in European countries, is well compatible with the KVL and estimated coefficients.

The structure of the paper is as follows. Firstly, we discuss the main aspects of the KVL. Secondly, we focus on the econometric model and estimation strategy. Finally, we show the main results from the estimation of the KVL and suggest a comparison across the observed countries.

1. The Kaldor-Verdoorn's Law

The Verdoorn's Law describes a simple long-run relation between productivity and output growth, whose coefficients were empirically estimated in 1949 by the Dutch economist. The relation takes the following form:

[1] $$\dot{p} = a + n \cdot \dot{y}$$

where $\dot{p}$ is the labor productivity growth, $\dot{y}$ the output growth (value added), n is the Verdoorn coefficient and a is the exogenous productivity growth rate. This functional form reflects the more traditional specification of the Verdoorn's Law, where the variables are expressed in growth rates (dynamic version)[3]. As pointed out by McCombie and Roberts (2007), the static version, to be correctly estimated, would need the use of data belonging to the same "*Functional Economic Area*" (FEA), which is the area where economic spatial processes take place[4]. When this condition is not satisfied, the dynamic version has to be preferred. In the earlier empirical estimations by Verdoorn (1949), the average elasticity for the manufacturing sector of some countries was about 0.45, with extreme values of 0.41 (United Kingdom) and 0.57 (US)[5].

Though initially Verdoorn (1949) did not attribute to n the prevalent meaning of index of the effects due to externalities, this meaning has become primary in the interpretation given by Kaldor (1966). In his Inaugural Lecture of 1966, Kaldor adds to the original Verdoorn's Law the contribution due to the capital stock growth, estimated by the gross investment that is considered a proxy of the endogenous technical progress. The investment not only contributes to the economic growth by itself, that is by its effects on the aggregate demand and on the level of output, but also

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[3] As known, the static-dynamic paradox, firstly mentioned by McCombie (1982), relates on the fact that different results are found whether the law is estimated by using variables in levels (static version) or growth rates (dynamic version): in the first case, estimates show the existence of approximately constant returns to scale; in the second case, the empirical evidence suggests the existence of increasing returns to scale.

[4] On this point, the authors affirm (p.187): "This concept of a FEA is intended to capture the idea that whilst, because of agglomeration economies and other externalities, the ideal unit of observation is not the firm, neither is it the type of administrative region that forms the basis for the provision of regional data by the major statistical agencies" […] FEAs are idealized units of observation at a level of aggregation corresponding to that at which spatial economic processes are assumed to operate".

[5] For a detailed review on the values of n estimated in literature, see among others: McCombie (2002) and Soro (2002).

introduces "new" capital goods and hence technological progress in the overall economy.

In Kaldor's view, the exogeneity of $\dot{y}$ in eq. [1] is motivated by the fact that the output growth unlike the neoclassical interpretation is not constrained by the supply-side[6]. Moreover the increasing returns to scale are essentially a "macroeconomic phenomenon" (and in particular of the manufacturing sector) and arise from specialization, learning and accumulation mechanisms as indicated by Young (1928)[7] and in the theory of incorporated technical progress (Maddison, 1979).

Into his *extended lectures* at the University of Cornell, Kaldor (1967) added the investment to output ratio (*I/Y*) as a proxy of the capital growth rate[8] to eq. [1], to consider the contribution of this variable for the industrial sector of 11 countries (6 CEE countries, UK, Austria, Norway, United States and Canada) along the period 1953–1964. The statistical non-significance of the variable *I/Y* confirms the Kaldor's initial hypothesis that most of the investments are to be considered endogenous in a growth path

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[6] The Kaldorian exogeneity of $\dot{y}$ was object of critics by Rowthorn (1975*a*, 1975*b*), determining a relevant debate with Kaldor (1975). For further analyses, see: McCombie and Thirlwall (1994), Gambacorta (2004) and McCombie and Roberts (2007), Ofria (2008).

[7] Young (1928, pp. 538-39) affirms that the phenomenon of increasing returns to scale is a macro phenomenon, since most of the economies of scale are a consequence of the increasing differentiation, of the introduction of new goods, and of new industries, they cannot be adequately perceived observing the effects of changes in the dimension of an individual firm or of a specific industry.

[8] Capital growth can be expressed as the product between I/Y and the output to capital stock ratio (Y/K) less the rate of depreciation. Following Kaldor, (1966) and Scott (1989), we assume Y/K and the rate of depreciation as constant in the long run.

driven by demand[9]. Similar results on the Verdoorn's Law were obtained in almost all subsequent studies where alternative indicators for capital stock were employed (for review, see: McCombie and Thirwall, 1994; McCombie, 2002; McCombie *et al.* 2002). Moreover, the literature on this subject attempted to enrich the [1] adding some *proxies* among regressors to capture the effects on the productivity growth due to supply factors. Ofria (2008) pointed out how labor cost indicators are expected to have a significant and positive impact on the dependent variable for two main reasons: 1) It should encourage processes of substitution between labor and capital, generating more and more innovative processes; 2) It would determine the so-called "incentive effect" as discussed in the New Keynesian Macroeconomics literature, mainly where it focuses on the *efficiency wages theory*. However, the inclusion of regressors like human capital growth, R&S and labor cost indicators did not improve significantly previous estimates (Targetti and Foti, 1997; Leòn-Ledesma, 2002, Ofria, 2008).

2. Econometric analysis and empirical results

In this section, we search for the determinants of the labor productivity growth in the manufacturing industry. We distinguish the long-term influence of the demand on the productivity growth rate from that deriving

[9]See McCombie (2002).

from the short-term business cycle which instead reflects the behavior of the so-called Okun Law. To remove the short-term cyclical component from variables, we estimate a dynamic equation, whose optimal lag structure is chosen by means of the "Schwarz Bayesian Criterion". Such a procedure allows to calculate the long-run elasticity of the productivity growth with respect to output growth (*n*), keeping constant the other variables. To solve the simultaneity problem (i.e. the risk that estimates can be influenced by the feedback of the dependent variable on the independent), we adopt the method of instrumental variables, including lags of each endogenous variable as instruments[10]. The validity of the adopted instruments is checked by the Sargan test.

For instance, if the selected optimal lag structure of the dynamic equations is respectively (1,1) and (1,1,0,0), we will estimate the following two equations:

[1'] $\dot{p} = a + b_1 \dot{y} + b_2 \dot{y}_{-1} + c \dot{p}_{-1}$

[2] $\dot{p} = a + b_1 \dot{y} + b_2 \dot{y}_{-1} + c \dot{p}_{-1} + d \frac{I}{Y} + e \dot{w}$

where $\frac{I}{Y}$ is the investment to output ratio, $\dot{w}$ the average labor cost growth, which is given by the ratio between labour income – that account for not

10 Referring to the Verdoorn's Law, this procedure was also adopted by McCombie and DeRidder (1984), Ofria (1997, 2008).

only real wage but also payroll and related taxes and benefits - and number of employed workers. ($_{-1}$) denotes one year lag.

The long-run elasticity (or Verdoorn coefficient) either for the [1'] and the [2] is given by the expression

$$n = \frac{b_1 + b_2}{1 - c}$$

The results obtained from the estimates are reported respectively in tables *1* and *2* [11].

[Table 1 About Here]

[Table 2 About Here]

For Italy, the *n* coefficient is significant at 1% for all estimated equation with value around 0.63. This finding, that under certain conditions implies a high degree of increasing returns to scale for the Italian manufacturing in the period 1973-2006, is near the 0.65 estimated in Bianchi (2002) for the period 1951-1997 and less than the 0.75 obtained in Gambacorta (2004) for the period 1970-2002. This result is also similar to the one found in Ofria (2008) for the Northern and Central areas of Italy in the longer period 1951-

[11] Estimations are employed by the use of the software *Microfit 4.0* by B. Pesaran and M.H. Pesaran.

2006, while the "Mezzogiorno" showed a higher parameter. US show significant Verdoorn coefficients with values that are around a half of the ones observed for the Italian manufacturing (0.3). This result is in line with previous evidence (for instance, see Bianchi 2002). Australia and Belgium show a significant *n* parameter at least in an equation with the substantial high values of 0.55 and 0.83, respectively. Japan, Sweden and Denmark show weak evidence (significant only at 10% level) in favor of the KVL in at least an equation. The remaining countries never show statistically significant Verdoorn parameters.

When estimating eq. [2], results do not appear to change significantly. The investment-output ratio (I/Y) is statistically significant for US and only weakly (significant at 10%) for Belgium. The fact that this term is not relevant for most countries seems to confirm the Kaldor's hypothesis (1966, 1967) that most of the investments is generally to be considered endogenous in a growth process driven by demand. The average labour cost growth, $\dot{w}$, is not statistically significant for any country. This result is in line with previous empirical evidence and may suggest that supply factors do not play an important role in explaining productivity growth.

To evaluate the adequacy of the estimated equations, we assess their post-sample predictive performance and structural stability by the Chow test (1960). As a breaking point we choose the 1986 that corresponds to the beginning of a period characterized by low oil prices. Results, reported in Table 3, show that estimated equations are stable across the periods 1973-86 and 1987-2006. Moreover, as the Chow test's result may be affected by the choice of singling out 1986 as a break point, we also perform CUSUM and CUSUMQ tests (Brown *et al.*, 1975) and find confirming results[12]. Therefore, such evidence seems to suggest that the KVL well describes the long term productivity dynamics even in presence of relevant macroeconomic shocks and is compatible with the decline in productivity growth rates observed in some European countries by the mid-nineties.

[Table 3 About Here]

3. Concluding Remarks

Several studies in literature attempted to detect the long-run determinants of the labor productivity growth for the developed countries. As known,

[12] CUSUM and CUSUMQ tests results are available upon request from the authors.

these studies can be grouped in two main schools. The first concentrates on supply factors. The second, following the KVL, claims that it exists a stable long-run relation between labor productivity growth and output growth. For the first group, the nineties world crisis in the productivity growth rates can be explained as a consequence of the human capital scarcity, the existence of distortions in the goods and services markets, the excessive labor costs and the low level of investments. For the second group, it is mainly driven by the demand growth crisis.

The objective of this work has been to check whether the KVL for the period 1973-2006 is able to explain the long term behavior of productivity growth better than possible alternative hypotheses based on supply factors. The results support the validity of the KVL for Australia, Belgium, Italy and US. This can be interpreted as evidence of the presence of increasing returns to scale for the manufacturing sector in these countries. On the contrary, for the other observed countries, the hypothesis of constant returns to scale cannot be rejected. The adequacy of our estimates has been checked by the use of Chow (1960) and CUSUM and CUSUMQ tests. The estimated parameters appear to be stable throughout the period and, in particular, before and after 1986, years in which the world economy was characterized by relatively low oil prices. Finally, the investment to output ratio and the labor cost growth (proxies of the supply factors), when included among the regressors, do not appear significant.

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Tab. 1

Estimations eq. [1']

Years 1973-2006 obs. n. 34

	Australia	Belgium	Denmark	Finland	France	Japan	Italy	Norway	Sweden	UK	US
a	0,0066	0,0078	0,0072	0,0116	0,0093	0,0080	0,0028	0,0039	0,0882	0,0038	0.0115
	(2,31)	(4,39)	(3,64)	(6,40)	(6,50)	(5,27)	(2,17)	(2,04)	(4,08)	(1,49)	(5.05)
$\dot{y}$	0,9206	0,5512	0,6434	0,6995	0,5607	0,6468	0,9171	1,0250	0,8025	0,7850	0,5558
	(3,14)	(3,86)	(4,82)	(10,00)	(8,28)	(9,27)	(15,1)	(3,56)	(6,95)	(3,10)	(5,12)
$\dot{y}_{-1}$	-0,1921	-0,667	-0,5060	-0,6092	-0,499	-0,4703	-0,578	-0,8095	-0,586	-0,5119	-0,291
	(-1,09)	(-4,56)	(-3,83)	(-8,44)	(-6,31)	(-4,85)	(-4,52)	(-4,49)	(-5,11)	(-3,45)	(-2,81)
$\dot{p}_{-1}$	-0,3225	0,5933	0,2949	0,3715	0,3433	0,3408	0,4664	0,3977	0,3789	0,6898	0,0577
	(-1,56)	(3,34)	(2,01)	(3,48)	(3,19)	(2,54)	(3,33)	(2,33)	(2,53)	(4,12)	(5,12)
R^2	0,0850	0,8318	0,6959	0,8610	0,8258	0,8715	0,9070	0,4835	0,8060	0,7394	0,6799
R^2_{bar}	0,1365	0,8150	0,6655	0,8472	0,8084	0,8587	0,8977	0,4318	0,7866	0,6816	0,6468
S.E.	0,0121	0,0056	0,0084	0,0061	0,0032	0,0054	0,0054	0,0088	0,0085	0,0072	0,0079
DW	1,7848	2,0259	1,8483	1,5412	2,0634	2,1944	1,6823	1,6391	1,4876	1,8574	1,9318
S.Cor	0,7767	0,0779	0,5801	2,1721	0,1472	1,0285	1,0448	1,4084	3,7453	0,3148	0,0985
chi.sq=1	[0,378]	[0,780]	[0,446]	[0,141]	[0,70]	[0,311]	[0,307]	[0,235]	[0,053)	[0,575]	[0,754]
Reset	0,0039	0,0008	0,1214	0,5935	2,5360	0,9361	0,1553	0,7209	0,2671	1,2818	1,3131
chi.sq=1	[0,950]	[0,977]	[0,728]	[0,441]	[0,11]	[0,333]	[0,694]	[0,396]	[0,605]	[0,258]	[0,252]
Norm	0,4395	1,7799	5,9656	1,6729	0,8721	0,6317	1,5576	0,6904	1,3231	0,0797	0,2111
chi.sq=2	[0,803]	[0,411]	[0,51]	[0,433]	[0,65]	[0,729]	[0,459]	[0,708]	[0,516]	[0,961]	[0,900]
Heter.	0,1637	0,0780	0,0759	0,0959	0,0041	0,1757	0,1289	0,8237	0,0030	1,3494	0,0629
chi.sq=1	[0,686]	[0,780]	[0,783]	[0,757]	[0,95]	[0,675]	[0,720]	[0,364]	[0,957]	[0,252]	[0,802]
Sargan	6,3901	13,331	13,3628	3,8788	5,0151	2,2268	3,9881	2,9336	5,1937	9,0033	12,967
	[0,495]	[0,64]	[0,64]	[0,794]	[0,66]	[0,817]	[0,781]	[0,710]	[0,268]	[0,109]	[0,174]
chi.sq	*chi.sq=7*	*chi.sq=7*	*chi.sq=7*	*chi.sq=7*	*chi.sq=7*	*chi.sq=5*	*chi.sq=7*	*chi.sq=5*	*chi.sq=4*	*chi.sq=5*	*chi.sq=9*
n	0,5508*	-0,285	0,1950	0,1435	0,0933	0,2678***	0,6342*	0,3578	0,3491***	0,8804	0,2807***
	(2,45)	(-0,38)	(0,74)	(1,07)	(0,65)	(1,76)	(4,31)	(1,01)	(1,80)	(1,09)	(1,85)

Note: a is the exogenous productivity growth rate; $\dot{y}$ *is the output growth;* $\dot{p}$ *is the productivity growth;* $_{-1}$ *indicates a year lag.* R^2_{bar} *is for* R^2 *corrected for degrees of freedom. DW indicates the Durbin Watson test; S.E. reports the standard error of the entire regressions; S.Cor reports the Lagrange multiplier for the serial correlation of residuals; Reset (Regression Specification Error Test) is the Ramsey test; Norm is for Normality test; Heter. indicates the heteroskedasticity test; Sargan is for Sargan test and chi.sq indicates the number of instruments minus the number of endogenous variables.* ***n*** *is the Verdoorn coefficient.T-stats are reported in parenthesis. *,** and *** indicate that coefficients are significant at 1%, 5% and 10% level, respectively.*

Tab. 2

Estimations eq. [2]

Years 1973-2006 obs. n. 34

	Australia	***Belgium***	***Denmark***	***Finland***	***France***	***Japan***	***Italy***	***Norway***	***Sweden***	***UK***	***US***
a	0.0642 (2.29)	0,0082 (0,51)	-0,0193 (-1,30)	0,0191 (1,13)	0,0162 (1,11)	0,0110 (0,50)	0,020 (0,8)	-0,001 (-0,15)	-0,222 (-0,24)	-0,018 (-0,78)	-0,04 (-2,1)
$\dot{y}$	0,7087 (1,60)	1,0023 (3,04)	1,0436 (2,88)	0,7639 (2,45)	0,6166 (3,05)	0,6054 (1,85)	0,814 (5,8)	0,6561 (1,57)	3,8230 (0,36)	0,8028 (2,91)	0,612 (5,5)
$\dot{y}_{-1}$	-0.1114 (-0,53)	-0,254 (-0,85)	-0,3642 (-2,95)	-0,644 (-3,12)	-0,484 (-4,64)	-0,432 (-2,86)	-0,370 (-1,7)	-0,656 (-3,01)	-2,463 (-0,38)	-0,619 (-3,39)	-0,24 (-2,2)
$\dot{p}_{-1}$	-0.4423 (-2,20)	0,1000 (0,29)	0,2206 (1,66)	0,3484 (2,54)	0,3261 (2,36)	0,3173 (2,13)	0,293 (1,4)	0,4559 (3,22)	0,9676 (0,42)	0,5889 (3,08	-0,19 (-1,0)
I/Q	0,1737 (0,26)	-0,60*** (-1,80)	-0,63*** (-1,83)	-0,028 (-0,53)	-0,033 (-0,46)	-0,009 (-0,10)	-0,250 (-0,8)	0,0202 (0,83)	1,0262 (0,25)	0,1377 (1,06)	0,293* (2,8)
$(I/Q)_{-1}$	-0,3938 (-0,56)	0,60*** (1,86)	0,76*** (1,97)	-	-		0,176 (0,8)				-
$\dot{w}$	0,0001 (0,01)	0,0775 (0,34)	-0,0378 (-0,17)	0,0847 (0,40)	0,0464 (0,25)	-0,058 (-0,15)	-0,130 (-0,9)	-0,162 (-1,35)	1,6633 (0,30)	0,0342 (0,35)	0,058 (0,6)
R^2	0,2942	0,7307	0,7892	0,8604	0,8270	0,8694	0,930	0,6937	-4,153	0,7297	0,701
R^2_{bar}	0,1374	0,6709	0,7423	0,8355	0,7961	0,8461	0,915	0,6391	-5,073	0,6443	0,645
S.E.	0,0112	0,0075	0,0073	0,0063	0,0033	0,0056	0,005	0,0070	0,0453	0,0076	0,008
DW	2,0035	1,8462	1,6859	1,7005	1,9872	2,1650	1,934	1,7347	2,1374	0,0342	2,211
S.Cor *chi.sq=1*	0,0086 [0,93]	0,6342 [0,426]	1,7906 [0,181]	1,1282 [0,288]	0,0101 [0,920]	0,5863 [0,444]	0,007 [0,90]	0,8099 [0,368]	0,0988 [0,753]	0,0083 [0,927]	1,186 [0,3]
Reset *chi.sq=1*	0,2188 [0,640]	1,6144 [0,204]	4,8762 [0,27]	0,2107 [0,646]	1,3979 [0,237]	1,8288 [0,176]	0,052 [0,82]	0,2192 [0,640]	0,0591 [0,808]	0,2000 [0,655]	0,097 [0,8]
Norm *chi.sq=2*	1,5718 [0,456]	16,998 [0,000]	1,0033 [0,606]	3,3671 [0,186]	0,5645 [0,754]	0,4956 [0,781]	1,941 [0,38]	0,3642 [0,834]	0,9334 [0,627]	0,7421 [0,690]	0,219 [0,9]
Heter. *chi.sq=1*	0,4388 [0,508]	1,1882 [0,276]	0,1429 [0,705]	0,2922 [0,589]	0,0685 [0,793]	0,5804 [0,446]	0,007 [0,93]	2,4339 [0,119]	3,6175 [0,057]	0,0965 [0,756]	0,774 [0,4]
Sargan *chi.sq*	2,2375 [0,692] *chi.sq=4*	3,5708 [0,467] *chi.sq=5*	6,4978 [0,165] *chi.sq=4*	1,6436 [0,896] *chi.sq=5*	4,4668 [0,484] *chi.sq=5*	1,8127 [0,612] *chi.sq=3*	3,488 [0,48] *chi.sq=4*	1,4868 [0,685] *chi.sq=3*	0,0295 [0,985] *chi.sq=2*	5,7858 [123] *chi.sq=3*	4,794 [0,68] *chi.sq=7*
n	0,4142 (1,15)	0,832** (2,36)	0,87*** (1,82)	0,1826 (0,79)	0,1973 (0,67)	0,2533 (0,70)	0,623* (3,24)	-0,001 (0,00)	41,98 (0,01)	0,4460 (0,65)	0,314* (2,66)

Note: a is the exogenous productivity growth rate; $\dot{y}$ *is the output growth;* $\dot{p}$ *is the productivity growth; I/Q is the investment-output ratio; w is the average labor cost growth;* $_{-1}$ *indicates one year lag.* R^2_{bar} *is for* R^2 *corrected for degrees of freedom. DW indicates the Durbin Watson test; S.E. reports the standard error of the entire regressions; S.Cor reports the Lagrange multiplier for the serial correlation of residuals; Reset (Regression Specification Error Test) is the Ramsey test; Norm is for Normality test; Heter. indicates the heteroskedasticity test; Sargan is for Sargan test and chi.sq indicates the number of instruments minus the number of endogenous variables.* ***n*** *is the Verdoorn coefficient. T-stats are reported in parenthesis. *,** and *** indicate that coefficients are significant at 1%, 5% and 10% level, respectively.*

Tab. 3

Chow test

Years 1973-1986 and 1987-2006

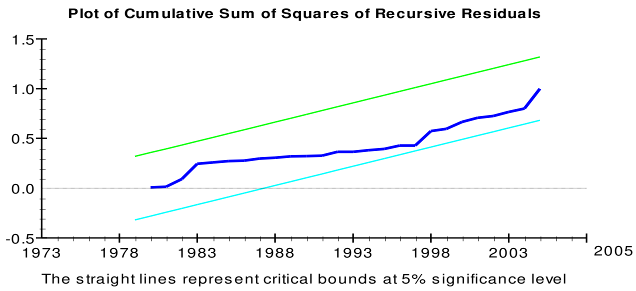
	Australia	Belgium	Denmark	Finland	France	Japan	Italy	Norway	Sweden	UK	US
	[1']										
Predictive failure Ch.sq	1,7824 [0,173] *F(22, 10)*	1,114 [0,45] *F(20,9)*	0,1466 [1,00] *F(21, 10)*	1,0469 [0,493] *F(21, 10)*	0,7242 [0,745] *F(21,10)*	0,5303 [0,897] *F(22, 10)*	1,2296 [0,380] *F(21,10)*	1,6491 [0,209] *F(21,10)*	2,8592 [0,10] *F(21,10)*	1,379 [0,35] *F(20 7)*	0,7503 [0,726] *F(22,10)*
Structural stability Ch.sq	1,4255 [0,251] *F(4, 28)*	0,745 [0,59] *F(5,24)*	0,9901 [0,430] *F(4, 27)*	1,9709 [0,128] *F(4, 27)*	1,7191 [0,175] *F(4, 27)*	0,6291 [0,646] *F(4, 28)*	1,0177 [0,416] *F(4, 27)*	0,1571 [0,958] *F(4, 27)*	2,1587 [0,133] *F(4, 27)*	0,875 [0,54] *F(7 20)*	1,049 [0,400] *F(4, 28)*
	[2]										
Predictive failure Ch.sq	0,9878 [0,548] *F(20, 7)*	0,756 [0,71] *F(20,7)*	0,7369 [0,726] *F(21, 7)*	1,5458 [0,188] *F(21, 8)*	2,4348 [0,100] *F(20, 8)*	0,5671 [0,855] *F(20, 8)*	1,0332 [0,521] *F(21, 7)*	1,9046 [0,176] *F(21, 8)*	3,2144 [0,084] *F(21, 8)*	1,414 [0,38] *F(20,5)*	0,4621 [0,920] *F(19, 8)*
Structural stability Ch.sq	0,6313 [0,732] *F(7, 20)*	1,126 [0,39] *F(7,20)*	1,6781 [0,38] *F(7, 21)*	2,1925 [0,810] *F(6, 23)*	2,3205 [0,118] *F(6, 22)*	1,2461 [0,322] *F(6, 22)*	0,7355 [0,645] *F(7, 21)*	1,3391 [0,280] *F(6, 23)*	1,5894 [0,195] *F(6, 23)*	1,643 [0,29] *F(9,16)*	1,0394 [0,428] *F(6,21)*

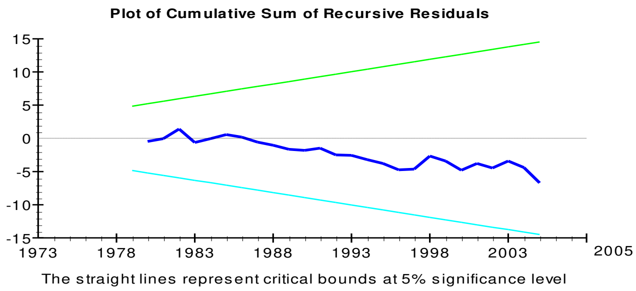
Appendix

CUSUM AND CUSUMQ TESTS

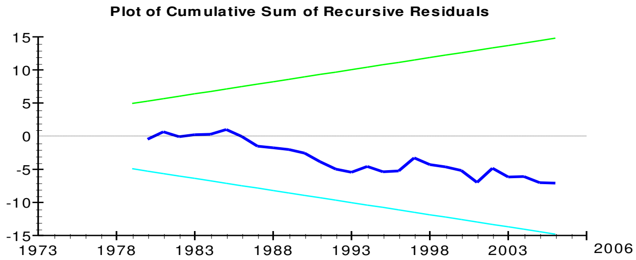
(note n. 12 from the text)

AUSTRALIA

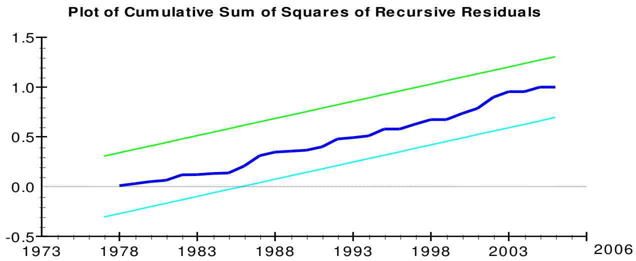




BELGIUM



The straight lines represent critical bounds at 5% significance level



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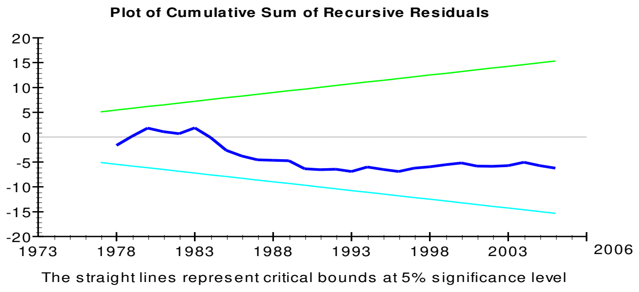

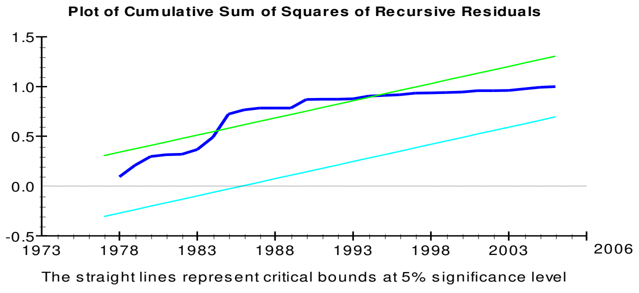

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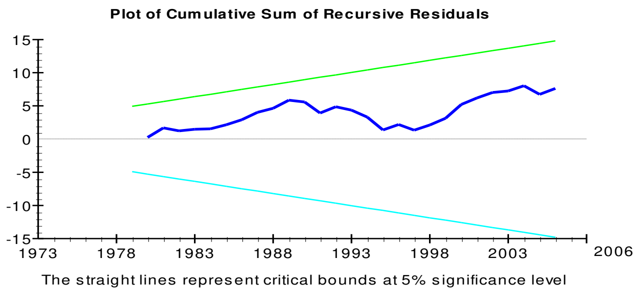

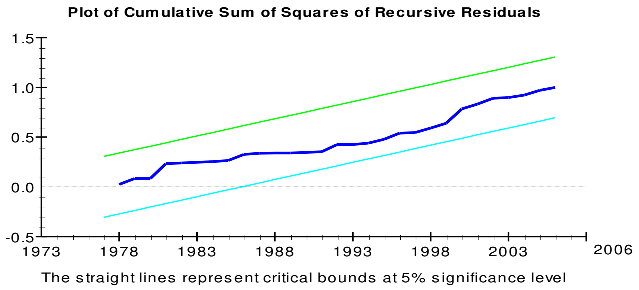
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1.5
1.0
0.5
0.0
-0.5
1973
1978
1983
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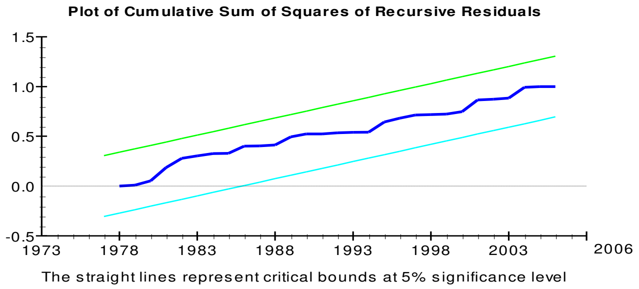
1998
2003
2006
The straight lines represent critical bounds at 5% significance level

FRANCE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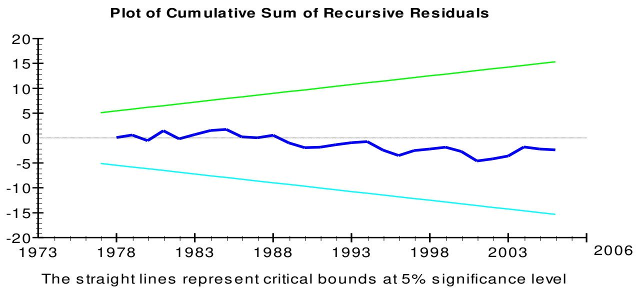
The straight lines represent critical bounds at 5% significance level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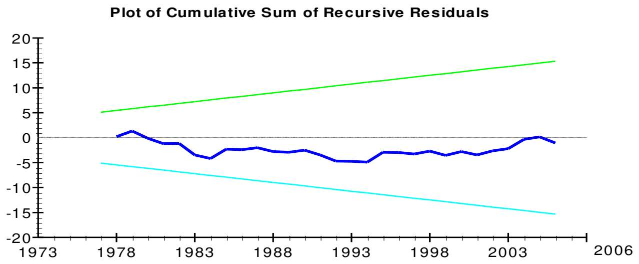
The straight lines represent critical bounds at 5% significance level

JAPAN



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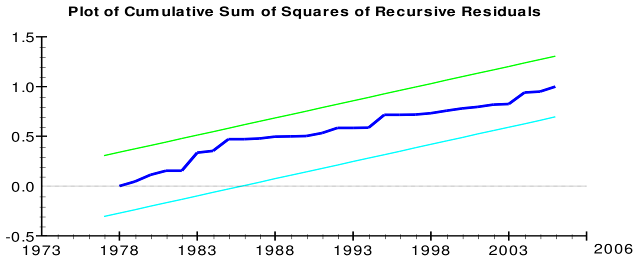
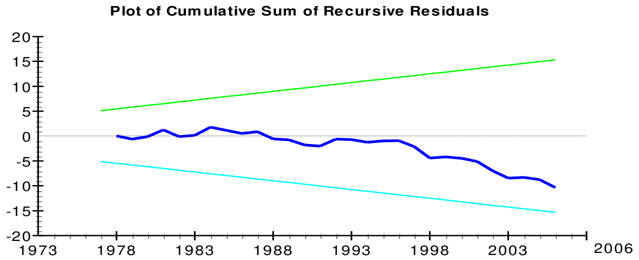
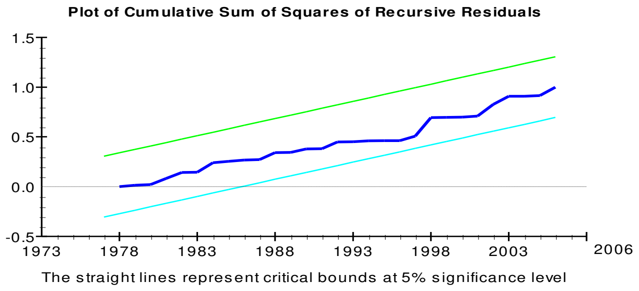


The straight lines represent critical bounds at 5% significance level

ITALY



The straight lines represent critical bounds at 5% significance level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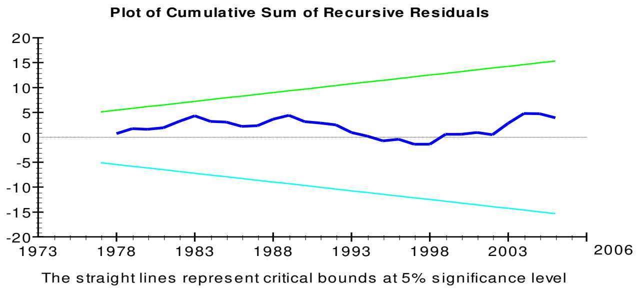
2006
The straight lines represent critical bounds at 5% significance level

NORWAY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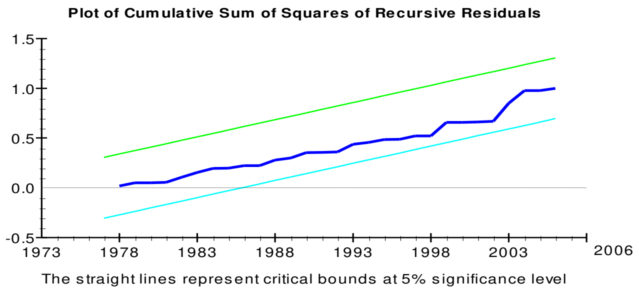
The straight lines represent critical bounds at 5% significance level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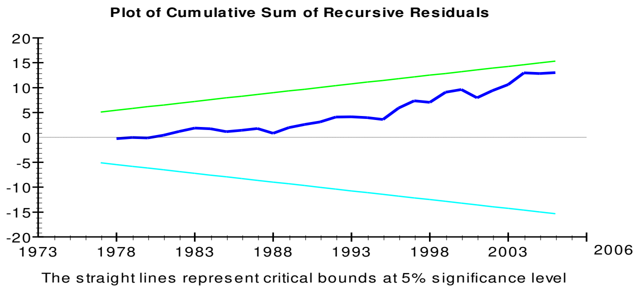
The straight lines represent critical bounds at 5% significance level

SWEDEN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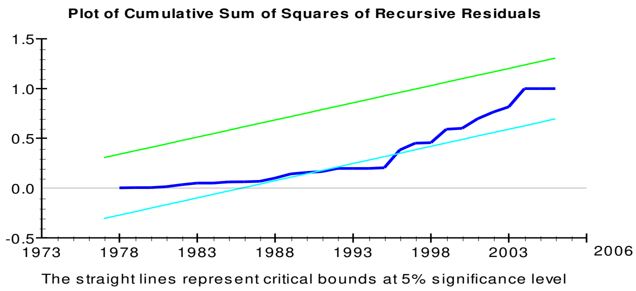
The straight lines represent critical bounds at 5% significance level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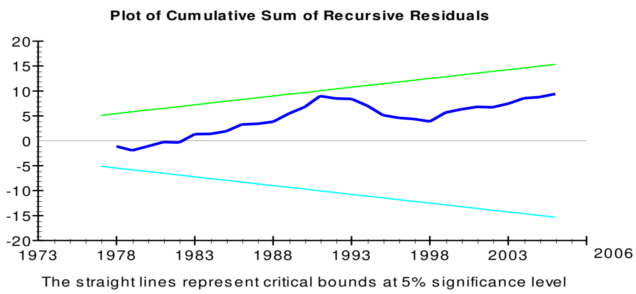
The straight lines represent critical bounds at 5% significance level

UK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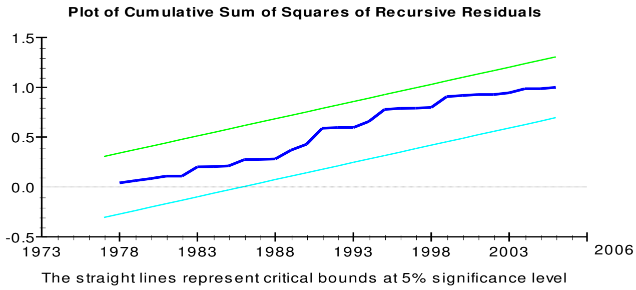
The straight lines represent critical bounds at 5% significance level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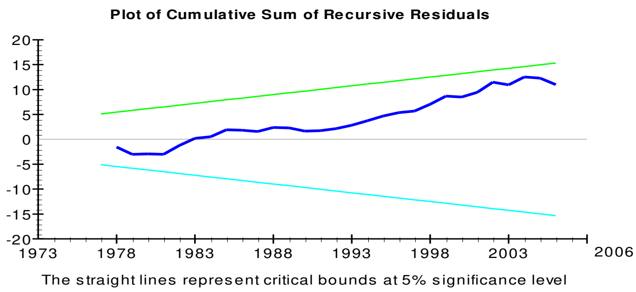
The straight lines represent critical bounds at 5% significance level

USA


Plot of Cumulative Sum of Recursive Residuals
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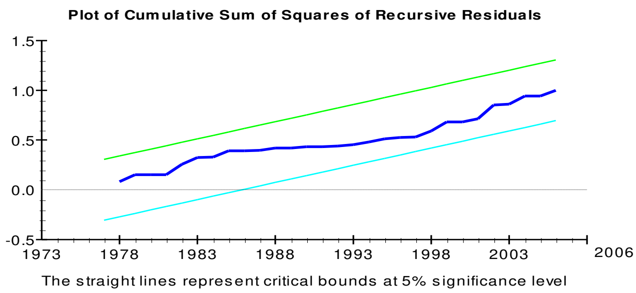
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The straight lines represent critical bounds at 5% significance level