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By **Emanuele Millemaci,** Dipartimento DESMaS "V. Pareto", Università degli Studi di Messina, Italy

Ferdinando Ofria, Dipartimento DESMaS "V. Pareto", Università degli Studi di Messina, Italy

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Summary

The objective 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 as countries show increasing returns to scale. Capital growth and labor cost growth do not appear important in explaining productivity growth. The estimated Verdoorn coefficients are found to be substantially stable throughout the period.

Keywords: Increasing Returns, Kaldor-Verdoorn Law, Productivity Growth, Manufacturing Sector

JEL Classification: C32, O47, O57

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Address for correspondence:

Ferdinando Ofria
Università di Messina
Via T. Cannizzaro, 278
98122 Messina
Italy
Phone: +39906411070
Fax.: +390906416275
E-mail: ofriaf@unime.it

Kaldor-Verdoorn's Law and increasing returns to scale: a comparison across developed countries

Emanuele Millemaci[*] Ferdinando Ofria[*]

Università di Messina

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*Dipartimento DESMaS “V. Pareto”, Università degli Studi di Messina, via T. Cannizzaro, 278, 98122 Messina, Italy. Tel.: +39906411070; fax.: +390906416275. E-mail: millemaci@unime.it (corresponding author); ofriaf@unime.it.

Abstract

The objective 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 as countries show increasing returns to scale. Capital growth and labor cost growth do not appear important in explaining productivity growth. The estimated Verdoorn coefficients are found to be substantially stable throughout the period. [JEL Classification: C32, O47, O57]

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Introduction

The Verdoorn's Law states 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 including OLS, instrumental variable techniques, time series, error correction models and cointegration methods. For regional data, methods to account for spatial autocorrelation have been used. Moreover, non-parametric frontier analysis has been undertaken (Destefanis, 2002)[2]. Estimated Verdoorn coefficients are in most cases significant and range

[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).

[2] See, for instance, Bernat (1996), Fingleton and McCombie (1998), Leòn-Ledesma (2002), Bianchi (2002), Harris and Lau (1998) and Alexiadis and Tsagdis (2010) for studies using data at a regional level of aggregation. For country level cross-sectoral studies, see among others Pieper (2003).

between 0.3 and 0.6. Under some conditions[3], this evidence supports the existence of economies of scale.

This paper investigates 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)[4]. We consider the period 1973-2006[5] 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.

Other studies focused on data at the country level. For instance, Targetti and Foti (1997), using a three stage least squares estimation method, find that estimated Verdoorn elasticities are significantly different across OECD and Latin-American country samples. They also suggest that the Verdoorn coefficient may not be constant through the years. Focusing on a large number of countries for the period from 1962 to 1990, Harris and Liu (1999) find increasing returns for most of the observed countries. Bianchi (2002), using partial adjustment models, considers Italy both in general and

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[3] For instance, the Verdoorn Law can be derived from a Cobb-Douglas production function of the form $Q_i=K_i^a\ (Ae^{\lambda t}L_i)^{(1-a)}$, where Q, K and L are the levels of output, capital and labour respectively. λ is the rate of technological progress and a and $(1-a)$ are production function parameters. A key assumption of the Verdoorn Law is that the rate of technological progress is endogenously determined (Angeriz et al., 2008).

[4] Some other developed countries (for instance, Germany, UK and Spain) are not included because data on these countries are not available for all years.

[5] We opted to perform regressions on the same years for each country. Therefore, the choice of restricting estimations on the period comprised between 1973 and 2006 is the compromise between the desire to use more years and to focus on a number of countries being as large as possible.

for some specific sectors in the period 1951-97 and suggests an international comparison with European Union and United States. He finds 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) applies non-parametric statistical procedures to the investigation of Verdoorn's Law in 52 economies for the period 1962-92. The obtained results pointed to a pervasive existence of increasing returns to scale across developed and developing countries. In a study focusing on Latin-American countries, Vogel (2009) suggests that long-run growth rate differences between industrial and developing countries could be partly due to low demand in the latter.

With respect to previous studies focusing on developed economies, this paper has the advantage of considering also the most recent years before the financial and economic downturn of years 2007-2010. It may be of interest to check the validity of the KVL in these recent years as characterized by i) a constant decline in the average GDP growth rates in most of the developed countries under consideration; ii) a productivity growth decline in some advanced countries for the latest years; iii) the long-term reduction in the manufacturing share of total employment[6]. Moreover, we examine the importance of alternative hypotheses such as those related to the existence

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[6] Pitelis and Antonakis (2003) find that the change in manufacturing shares has a positive and significant impact on competitiveness, measured by per capita income. This evidence of interdependence between competitiveness and changes in manufacturing shares suggests the possibility of cumulative effects, as pointed out by Kaldor (1966).
See also Tregenna (2009) for an international comparison on manufacturing, GDP, productivity and employment dynamics.

of supply constraints. Finally, we check the stability of the KVL throughout the period under consideration and across countries.

In an early paper, Vaciago (1975) finds that the effect of economies of scale on productivity growth diminish at relatively high output growth rates for the advanced economies of the 1950s and 1960s. By using nonparametric data smoothing techniques in a study on developing countries, Pieper (2003) examines the statistical regularity of the Verdoorn coefficient and finds that for the manufacturing sector in developing countries it reaches the magnitude of 0.5 (as found by Verdoorn and Kaldor) only at high industrial output growth rates (about 7 percent). At 5 percent manufacturing output growth the Verdoorn coefficient is considerably lower at just 0.25. Within a Cobb-Douglas framework, Perälä (2008) finds stronger evidence for aggregate increasing returns among samples including economies in the early stages of development. We aim at contributing to this literature by evaluating whether and to what extent, in the case of the most mature economies, economies of scale are significant and the Verdoorn coefficient is stable or reduces through the years.

Our findings are supportive of the validity of the law as most of the countries considered show a significant Verdoorn parameter. Some countries show a parameter value that is similar to the originally estimated by Verdoorn (0.5), and in general the magnitude of all estimated parameters varies from about 0.28 to 0.75. We find that the inclusion of oil price and exports allows to improve slightly estimates of the KVL. Capital growth and supply factors do not appear to be relevant in explaining productivity growth. Finally, it emerges that the estimated parameters are substantial 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:

$$(1') \quad \dot{p} = a + n \cdot \dot{y}$$

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)[7]. 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[8]. 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)[9].

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 augments the original Verdoorn's Law with the contribution due to the capital stock growth, estimated by the gross

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[7] 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.

[8] 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".

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

investment that is considered a proxy of the endogenous technical progress. Gross investment not only contributes by itself on the aggregate demand and on the level of output, but also 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[10]. 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)[11] 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[12] 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 variable *I/Y* confirms Kaldor's initial hypothesis that gross

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[10] 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), McCombie and Roberts (2007) and Ofria (2009).

[11] 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.

[12] 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.

investment is to be considered endogenous in a growth path driven by demand[13]. 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 (2009) pointed out how labor cost indicators are expected to have a significant and positive impact on the dependent variable for two main reasons: 1) they would encourage processes of substitution between labor and capital, generating more and more innovative processes; 2) they 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&D and labor cost indicators did not improve significantly previous estimates (Targetti and Foti, 1997; Leòn-Ledesma, 2002; Frantzen, 2008).

2. Econometric analysis and empirical results

In this section, we present the empirical strategy we adopt to estimate the Verdoorn Law and show main results. Firstly, to distinguish the long-term

[13] See McCombie (2002).

influence of the demand on the productivity growth rate from that deriving from the short-term business cycle, which instead reflects the behavior of the so-called Okun Law, we estimate a dynamic equation, whose optimal lag structure is chosen by means of Akaike's information criterion (AIC) and Schwarz's Bayesian information criterion (SBIC). 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. As for all countries the selected optimal lag structure of the dynamic equation is (1,1), we estimate the following two equations:

$$(1) \quad \dot{p} = a + b_1 \dot{y} + b_2 \dot{y}_{-1} + c\,\dot{p}_{-1}$$

$$(2) \quad \dot{p} = a + b_1 \dot{y} + b_2 \dot{y}_{-1} + c\,\dot{p}_{-1} + d\frac{I}{Y} + e\dot{w}$$

Equation (1) represents the empirical counterpart of the original specification of the Verdoorn Law (1'). Equation (2) differs from eq. (1) only in that investment to output ratio ($\frac{I}{Y}$) and average labor cost growth[14] ($\dot{w}$) are added. ($_{-1}$) denotes one year lag.

[14] The average labor cost is calculated as the ratio between labour income (that account for not only real wage but also payroll and related taxes and benefits) and number of employed workers.

To solve the simultaneity problem (i.e. the possibility that estimates are influenced by the feedback of the dependent variable on the independent), we adopt the method of instrumental variables[15].

We estimate three specifications of eq. (1) and a specification of eq. (2). Specification I consists in the estimation of eq. (1) using as excluded instruments for output growth the level of output at time t-2 and t-3. Specification II also includes as excluded instruments the log of oil price[16] and the log of exports[17]. Specification III includes log of oil price and log of exports as control variables rather than excluded instruments. Finally, specification IV consists in the estimation of eq. (2). In line with previous studies, we consider investment-output ratio and average labor cost growth as endogenous variables. We instrument $\dot{y}$, $\frac{I}{Y}$ and $\dot{w}$ with output at time t-2 and t-3, $\frac{I}{Y}$ at time t-1and $\dot{w}$ at time t-1, log of oil price and log of exports.

Oil price may affect output growth as high oil prices raise production costs and reduce income available for spending in high oil importing economies. Empirical evidence suggests the existence of a significant effect of energy price increases on economic activity (Finn, 2000). Considering exports as exogenous, a number of empirical studies find that this variable statistically

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[15] Referring to the Verdoorn's Law, this procedure was also adopted by McCombie and DeRidder (1984) and Ofria (2009).

[16] Oil prices are from the Energy Information Administration (EIA). We used real West Texas Intermediate (WTI) crude oil spot prices. We also took into account alternative measures for oil price as futures and import crude oil prices and we found that results did not vary significantly.

[17] Other candidate variables were not included as data are not available for a sufficient length of time.

significantly affects output growth by its contribution to aggregate demand and productivity growth (Marin, 1992; D'Acunto et al., 2004; Thangavelu and Owyong, 2003).

Even when IV estimators are consistent, they are biased in finite samples, and the problem is particularly serious when instruments are weak (Davidson and MacKinnon, 2004). Apart from reporting the Shea's partial R-squared, we refer to the robust Kleibergen-Paap Wald rk F statistic, which is the counterpart of the Cragg-Donald Wald statistic for the case of non-i.i.d. errors. Critical values have been compiled for the Cragg-Donald F-statistic by Stock and Yogo (2002, 2005). If the statistic lies below critical values, instruments are considered weak. Furthermore, we estimate equation (1) by means, not only of the 2SLS estimator, but also of the LIML, as the latter typically has better small sample properties than 2SLS, especially with weak instruments. Although LIML and 2SLS have the same asymptotic distribution and are algebraically equivalent in just-identified models, in overidentified models their finite-sample distributions can be very different. Most importantly, LIML is approximately unbiased in the sense that the median of its sampling distribution is generally close to the population parameter being estimated (Anderson et al., 1982; Angrist and Krueger, 2001).

The long-run elasticity (or Verdoorn coefficient) in the case of equation (1) is given by the expression

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

The results obtained from the estimation of the three specifications of eq. (1) are reported in Tables 1-3[18].

[Tables 1-3 About Here]

Overall, results are supportive of the KVL as nine out of ten countries show a positive and significant Verdoorn parameter at conventional levels. The parameter value ranges between 0.28 and .75 and is often close to 0.5, which corresponds to the one obtained in the seminal works by Verdoorn and Kaldor and in subsequent estimations by other authors.

Only Finland does not show a significant Verdoorn parameter at conventional levels in any specification and with any of the two estimators considered. Norway and Sweden show only weak evidence in favor of the KVL as only in one specification the Verdoorn coefficient is statistically significant (specifications I for Norway and specification II for Sweden).

Looking at results reported in Tables 1-3, we can distinguish on the one hand countries like Australia and France showing a particularly low, although statistically significant, Verdoorn parameter (0.28-0.50); on the

[18] Estimations are employed by using the STATA 11's routines ivregress (with the post-estimation commands "estat overid" and "estat firststages") and ivreg2. The option robust allows to control for heteroskedastic errors.

other hand, Denmark, Italy[19], Japan, Norway, Sweden and United States show larger significant Verdoorn parameters (0.51-0.75).

Oil price and exports, included either as excluded instruments or controls (specifications II and III), do not seem to improve significantly estimates. Coefficients on these variables are rarely statistically significant and the goodness of fit increases only slightly respect to the more parsimonious specification I, as shown by R-squareds.

The test of the overidentifying restrictions suggests that we cannot reject the null that the overidentifying instruments are valid.

As the values of the Kleibergen-Paap Wald rk F statistics for the specifications I-III are rather close to the rule-of-thumb value of 10 suggested by Staiger and Stock (1997) and also appear reasonable when compared to the reported (where available[20]) critical values for the Cragg-Donald F-statistic compiled by Stock and Yogo, we are reassured that the problem of weak instruments does not seem to harm our estimates. Moreover, we perform estimates using the LIML estimator, which has a smaller small sample bias, as a check on the reliability of 2sls estimates. The more the coefficients estimated by the two estimator are similar the more the

[19] Italy shows coefficients (0.66-0.75) that are close to the value of 0.65 estimated by Bianchi (2002) and to estimates reported by Ofria (2009).

[20] Critical values by Stock and Yogo are only available when the model has at least two overidentifying restrictions.

bias is small. We find that 2SLS and LIML estimates of the Verdoorn coefficient are in most cases very similar[21].

Results from specification IV are reported in Table 4.

[Table 4 About Here]

The values of the Kleibergen-Paap Wald rk F statistic are in this case largely below the Stock and Yogo's critical values, suggesting that a problem of weak instruments may considerably bias estimates from this specification. Also the Shea's adjusted partial R-squared seem to confirm this concern. Moreover, we note that in the cases of Denmark, Italy and United States coefficients estimated by the 2SLS differ somewhat from those by the LIML.

Although with caution for the reason explained above, we can interpret results from specification IV as evidence that investment-output ratio *(I/Y)* and $\dot{w}$ are not important alternative explanations[22]. The fact that *I/Y* is not important for most countries seems to confirm the Kaldor's hypothesis (1966, 1967) that most of the investments is generally to be considered

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[21] As a further robustness check of results obtained in presence of possibly weak instruments, we also used the STATA's command "condivreg" (Mikusheva and Poi, 2006) to obtain more reliable critical values, p-values and confidence intervals than those typically obtained using the standard asymptotic theory. As this method is only available for the case with only one endogenous variable, we could not use it with specification IV. For specifications I-III, we obtained results (available upon request from the authors) in line with the reported evidence.

[22] We also performed estimates considering investment-output and average labor cost growth as controls rather than endogenous variables and found that coefficients are again very rarely statistically significant.

endogenous in a growth process driven by demand. The nonsignificance of the average labour cost growth, $\dot{w}$, confirms previous empirical evidence and suggests that supply factors do not play an important role in explaining productivity growth.

To evaluate the adequacy of the estimated equations, we assess their 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 2 show that estimated equations are substantially stable across the periods 1973-86 and 1987-2006[23]. 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[24] on specifications I, III and IV (Brown *et al.*, 1975) and find comforting results[25].

[Table 5 About Here]

In general, our findings seem to suggest that the KVL well describes the long term productivity dynamics even in presence of relevant

[23] The only exception is for the case of Belgium where we cannot reject the hypothesis of structural change.

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

[25] CUSUM and CUSUMQ tests detect possible structural changes for Denmark with specification I and IV, France with specification III and IV, Italy with specification I and IV and Sweden with specification I and III.

macroeconomic shocks and is compatible with the decline in productivity growth rates observed in some European countries by the mid-nineties.

3. Concluding Remarks

Several studies in literature attempted to detect the long-run determinants of labor productivity growth for the developed countries. As known, 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. This can be interpreted as evidence of the presence of increasing returns to scale for the manufacturing in advanced economies. 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 substantially 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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Table 1. Estimation results. Specification I

Dependent variable: ln(Pt/Pt-1)		Australia		Belgium		Denmark		Finland		France	
		2sls	*liml*	*2sls*	*liml*	*2sls*	*liml*	*2sls*	*liml*	*2sls*	*liml*
ln(Yt/Yt-1)	*coeff*	0.877	0.9	0.967	0.998	0.944	0.951	0.035	-3.229	0.828	0.83
	st. er.	0.314	0.337	0.13	0.147	0.151	0.155	0.886	33.118	0.132	0.134
ln(Pt-1/Pt-2)	*coeff*	-0.217	-0.22	0.232	0.214	0.144	0.142	0.66	1.935	0.278	0.277
	st. er.	0.155	0.157	0.184	0.195	0.188	0.189	0.365	12.8	0.179	0.18
ln(Yt-1/Yt-2)	*coeff*	-0.286	-0.29	-0.444	-0.437	-0.395	-0.394	-0.5	0.091	-0.467	-0.468
	st. er.	0.123	0.126	0.115	0.121	0.157	0.158	0.189	6.031	0.093	0.094
constant	*coeff*	0.005	0.005	0.008	0.007	0.007	0.006	0.017	0.046	0.008	0.008
	st. er.	0.004	0.004	0.002	0.003	0.002	0.002	0.01	0.306	0.002	0.002
Verdoorn	*coeff*	0.485	0.5	0.681	0.714	0.641	0.649	-1.368	3.358	0.499	0.501
coefficient	*st. er.*	0.216	0.228	0.176	0.189	0.171	0.175	3.572	17.105	0.113	0.114
R-squared		0.198	0.177	0.683	0.654	0.516	0.51	0.299	.	0.696	0.694
N		46	46	44	44	40	40	45	45	45	45
Test of the	*Chi2/F*	0.299	0.295	0.749	0.718	0.148	0.147	1.88	0.332	0.148	0.147
overidifying restr.	*p-value*	0.584	0.59	0.387	0.402	0.7	0.703	0.17	0.568	0.701	0.703
rk F statistic		3.85	3.85	7.83	7.83	6.08	6.08	0.294	0.294	8.83	8.83
Shea's adj.p.R2: ln(Yt/Yt-1)		0.0469	0.0469	0.13	0.13	0.111	0.111	-0.0628	-0.0628	0.216	0.216
		Italy		Japan		Norway		Sweden		United States	
		2sls	*liml*	*2sls*	*liml*	*2sls*	*liml*	*2sls*	*liml*	*2sls*	*liml*
ln(Yt/Yt-1)	*coeff*	1.012	1.016	0.839	0.844	1.262	1.273	0.786	162.083	1.31	1.378
	st. er.	0.087	0.089	0.072	0.076	0.382	0.392	0.673	1.77E+06	0.999	1.141
ln(Pt-1/Pt-2)	*coeff*	0.401	0.399	0.253	0.254	0.35	0.348	0.379	-95.892	-0.467	-0.522
	st. er.	0.104	0.105	0.099	0.1	0.144	0.145	0.406	1.06E+06	0.92	1.038
ln(Yt-1/Yt-2)	*coeff*	-0.563	-0.563	-0.364	-0.368	-0.886	-0.891	-0.577	-7.411	-0.105	-0.083
	st. er.	0.097	0.098	0.081	0.083	0.254	0.259	0.14	75029.17	0.439	0.488
constant	*coeff*	0.002	0.002	0.006	0.006	0.003	0.003	0.009	-0.285	0.005	0.005
	st. er.	0.001	0.001	0.002	0.002	0.002	0.002	0.002	3222.582	0.008	0.009
Verdoorn	*coeff*	0.748	0.753	0.635	0.638	0.578	0.585	0.337	1.596	0.821	0.851
coefficient	*st. er.*	0.12	0.122	0.074	0.076	0.244	0.249	0.804	88.353	0.48	0.508
R-squared		0.886	0.884	0.893	0.892	0.297	0.284	0.786	.	.	.
N		45	45	46	46	44	44	36	36	45	45
Test of the	*Chi2/F*	0.315	0.314	1.07	1.06	0.0596	0.0591	7.81	0.392	0.0579	0.0543
overidifying restr.	*p-value*	0.574	0.579	0.301	0.308	0.807	0.809	0.00521	0.536	0.81	0.817
rk F statistic		5.67	5.67	14.3	14.3	2.08	2.08	0.213	0.213	0.489	0.489
Shea's adj.p.R2: ln(Yt/Yt-1)		0.22	0.22	0.328	0.328	0.0141	0.0141	-0.0801	-0.0801	-0.0528	-0.0528
Excluded Intruments	ln(Yt-2), ln(Yt-3)										

Note: Reported 2SLS and LIML estimates are those obtained with allowing the option “robust” to account for possible heteroskedastic errors. The test of the overidentifying restrictions is the Sargan's (1958) and Basmann's (1960) Chi2 in the case of the 2sls estimator and the Basmann’s F in the case of the LIML. “rk F statistic” indicates the Kleibergen-Paap Wald rk F statistic. Shea's adj.p.R2 that is for Shea's adjusted partial R-squared is a generalization of the first stage R-squared useful for the case of more than one endogenous variable.

Table 2. Estimation results. Specification II

Dependent variable: ln(Pt/Pt-1)		Australia		Belgium		Denmark		Finland		France	
		2sls	*liml*	*2sls*	*liml*	*2sls*	*liml*	*2sls*	*liml*	*2sls*	*liml*
ln(Yt/Yt-1)	*coeff*	0.692	0.754	0.731	0.872	0.865	0.877	0.62	0.656	0.649	0.653
	st. er.	0.172	0.217	0.096	0.285	0.134	0.14	0.064	0.109	0.095	0.098
ln(Pt-1/Pt-2)	*coeff*	-0.224	-0.238	0.385	0.278	0.167	0.164	0.442	0.428	0.318	0.318
	st. er.	0.166	0.17	0.145	0.247	0.194	0.196	0.083	0.091	0.124	0.125
ln(Yt-1/Yt-2)	*coeff*	-0.191	-0.2	-0.498	-0.439	-0.403	-0.402	-0.609	-0.616	-0.459	-0.46
	st. er.	0.102	0.105	0.109	0.153	0.156	0.157	0.055	0.058	0.072	0.073
constant	*coeff*	0.007	0.007	0.008	0.008	0.007	0.007	0.011	0.011	0.009	0.009
	st. er.	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Verdoorn	*coeff*	0.409	0.448	0.378	0.599	0.555	0.568	0.02	0.07	0.278	0.282
coefficient	*st. er.*	0.157	0.178	0.199	0.388	0.177	0.18	0.134	0.178	0.126	0.128
R-squared		0.256	0.229	0.817	0.766	0.574	0.566	0.839	0.834	0.765	0.764
N		41	41	39	39	40	40	40	40	40	40
Test of the	*Chi2/F*	4.89	1.6	13.4	4.06	0.593	0.196	16.6	5.46	1.24	0.413
overidifying restr.	*p-value*	0.18	0.207	0.00393	0.0149	0.898	0.898	0.000847	0.00368	0.743	0.745
rk F statistic		6.9	6.9	5.53	5.53	8.85	8.85	7.82	7.82	11.6	11.6
c.v. rel.bias 5%		16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9
c.v. rel.bias 10%		10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3
c.v. rel.bias 20%		6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71
c.v. rel.bias 30%		5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34
Shea's adj.p.R2: ln(Yt/Yt-1)		0.34	0.34	0.311	0.311	0.245	0.245	0.487	0.487	0.511	0.511
		Italy		Japan		Norway		Sweden		United States	
		2sls	*liml*	*2sls*	*liml*	*2sls*	*liml*	*2sls*	*liml*	*2sls*	*liml*
ln(Yt/Yt-1)	*coeff*	0.968	0.972	0.912	0.965	0.948	1.017	0.966	1.213	0.734	1.229
	st. er.	0.068	0.07	0.075	0.1	0.254	0.331	0.134	0.335	0.222	1.036
ln(Pt-1/Pt-2)	*coeff*	0.46	0.46	0.177	0.152	0.41	0.397	0.272	0.124	-0.101	-0.565
	st. er.	0.095	0.096	0.137	0.152	0.14	0.148	0.158	0.23	0.279	1.031
ln(Yt-1/Yt-2)	*coeff*	-0.592	-0.592	-0.37	-0.378	-0.793	-0.82	-0.585	-0.595	-0.22	0
	st. er.	0.098	0.099	0.092	0.105	0.16	0.19	0.154	0.2	0.186	0.554
constant	*coeff*	0.002	0.002	0.006	0.006	0.004	0.004	0.008	0.008	0.01	0.008
	st. er.	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.006
Verdoorn	*coeff*	0.697	0.703	0.659	0.692	0.263	0.327	0.524	0.706	0.467	0.785
coefficient	*st. er.*	0.122	0.124	0.049	0.056	0.253	0.297	0.192	0.247	0.241	0.51
R-squared		0.891	0.89	0.831	0.801	0.545	0.498	0.746	0.586	0.505	.
N		39	39	41	41	39	39	36	36	39	39
Test of the	*Chi2/F*	0.635	0.211	3.48	1.07	0.823	0.262	6.36	1.71	3.76	0.731
overidifying restr.	*p-value*	0.888	0.888	0.323	0.375	0.844	0.852	0.0952	0.186	0.289	0.541
rk F statistic		6	6	5.43	5.43	1.06	1.06	3.78	3.78	1.07	1.07
c.v. rel.bias 5%		16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9
c.v. rel.bias 10%		10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3
c.v. rel.bias 20%		6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71	6.71
c.v. rel.bias 30%		5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34	5.34
Shea's adj.p.R2: ln(Yt/Yt-1)		0.366	0.366	0.275	0.275	-0.00668	-0.00668	0.15	0.15	-0.0333	-0.0333
Excluded Intruments:	ln(Yt-2), ln(Yt-3), ln(oil price_t), ln(export_t)										

Note: Reported 2SLS and LIML estimates are those obtained with allowing the option “robust” to account for possible heteroskedastic errors. The test of the overidentifying restrictions is the Sargan's (1958) and Basmann's (1960) Chi2 in the case of the 2sls estimator and the Basmann’s F in the case of the LIML. “rk F statistic” indicates the Kleibergen-Paap Wald rk F statistic. Below, c.v.rel.bias report Stock and Yogo’s critical values for Cragg-Donald F statistic and i.i.d. errors. 5%, 10%, 20% and 30% indicate the largest relative bias of the 2SLS estimator to OLS, that is acceptable. Such critical values only exist if the model is overidentified by at least two restrictions. Shea's adj.p.R2 that is for Shea's adjusted partial R-squared is a generalization of the first stage R-squared for the case of more than one endogenous variable. In the case of United States, all instruments are expressed as growth rates in place of levels. In the cases of Italy and Norway, the instruments oil price and exports are expressed as growth rates.

Table 3. Estimation results. Specification III

Dependent variable: ln(Pt/Pt-1)		Australia		Belgium		Denmark		Finland		France	
		2sls	*liml*	*2sls*	*liml*	*2sls*	*liml*	*2sls*	*liml*	*2sls*	*liml*
ln(Yt/Yt-1)	*coeff*	0.617	0.619	0.754	0.754	0.837	0.837	0.587	0.587	0.663	0.663
	st. er.	0.15	0.151	0.11	0.11	0.166	0.166	0.052	0.052	0.086	0.086
ln(Pt-1/Pt-2)	*coeff*	-0.285	-0.286	0.171	0.171	0.157	0.157	0.317	0.317	0.311	0.311
	st. er.	0.139	0.139	0.179	0.179	0.201	0.201	0.091	0.091	0.129	0.129
ln(Yt-1/Yt-2)	*coeff*	-0.211	-0.211	-0.39	-0.39	-0.407	-0.407	-0.569	-0.569	-0.458	-0.458
	st. er.	0.105	0.105	0.129	0.129	0.175	0.176	0.051	0.051	0.077	0.077
Oil price	*coeff*	-0.006	-0.006	0.008	0.008	0.003	0.003	-0.003	-0.003	0.003	0.003
	st. er.	0.007	0.007	0.004	0.004	0.007	0.007	0.004	0.004	0.003	0.003
Export	*coeff*	-0.012	-0.012	-0.013	-0.013	-0.004	-0.004	0.013	0.013	-0.001	-0.001
	st. er.	0.006	0.006	0.004	0.004	0.007	0.007	0.003	0.003	0.003	0.003
constant	*coeff*	0.143	0.143	0.141	0.141	0.047	0.047	-0.118	-0.118	0.021	0.021
	st. er.	0.066	0.066	0.042	0.042	0.075	0.075	0.029	0.029	0.032	0.032
Verdoorn	*coeff*	0.316	0.317	0.439	0.439	0.51	0.51	0.027	0.028	0.297	0.297
coefficient	*st. er.*	0.128	0.129	0.184	0.184	0.248	0.248	0.103	0.103	0.109	0.109
R-squared		0.331	0.33	0.858	0.858	0.574	0.573	0.889	0.889	0.756	0.756
N		41	41	39	39	40	40	40	40	40	40
Test of the	*Chi2/F*	0.24	0.239	0.00121	0.00121	0.0218	0.0218	0.0219	0.0219	0.00133	0.00133
overidifying restr.	*p-value*	0.625	0.628	0.972	0.972	0.883	0.884	0.882	0.883	0.971	0.971
rk F statistic		11.5	11.5	7.87	7.87	12.2	12.2	10.7	10.7	18	18
Shea's adj.p.R2: ln(Yt/Yt-1)		0.29	0.29	0.125	0.125	0.191	0.191	0.464	0.464	0.39	0.39
		Italy		Japan		Norway		Sweden		United States	
		2sls	*liml*	*2sls*	*liml*	*2sls*	*liml*	*2sls*	*liml*	*2sls*	*liml*
ln(Yt/Yt-1)	*coeff*	0.931	0.933	0.904	0.919	0.879	0.915	0.84	0.87	0.757	0.804
	st. er.	0.087	0.089	0.097	0.105	0.278	0.327	0.125	0.153	0.231	0.275
ln(Pt-1/Pt-2)	*coeff*	0.442	0.442	0.143	0.133	0.406	0.401	0.251	0.236	-0.203	-0.248
	st. er.	0.091	0.091	0.131	0.135	0.128	0.131	0.13	0.139	0.303	0.344
ln(Yt-1/Yt-2)	*coeff*	-0.57	-0.571	-0.355	-0.353	-0.779	-0.794	-0.6	-0.601	-0.168	-0.148
	st. er.	0.096	0.096	0.097	0.1	0.17	0.191	0.128	0.132	0.184	0.204
Oil price	*coeff*	-0.002	-0.002	-0.008	-0.008	0.004	0.003	0	0.001	-0.013	-0.012
	st. er.	0.006	0.006	0.004	0.004	0.008	0.009	0.006	0.006	0.009	0.01
Export	*coeff*	0.039	0.038	0.001	0.001	-0.056	-0.058	0.017	0.017	0.008	0.009
	st. er.	0.043	0.043	0.006	0.006	0.07	0.071	0.006	0.007	0.006	0.006
constant	*coeff*	0.002	0.002	0.011	0.007	0.005	0.005	-0.177	-0.174	-0.062	-0.064
	st. er.	0.001	0.001	0.065	0.068	0.002	0.002	0.07	0.072	0.05	0.054
Verdoorn	*coeff*	0.647	0.65	0.641	0.653	0.167	0.201	0.321	0.352	0.489	0.526
coefficient	*st. er.*	0.142	0.144	0.101	0.106	0.273	0.301	0.206	0.222	0.217	0.237
R-squared		0.894	0.894	0.839	0.831	0.567	0.547	0.811	0.803	0.492	0.419
N		39	39	41	41	39	39	36	36	39	39
Test of the	*Chi2/F*	0.152	0.152	0.746	0.728	0.279	0.273	1.33	1.3	0.396	0.371
overidifying restr.	*p-value*	0.697	0.7	0.388	0.399	0.597	0.605	0.249	0.263	0.529	0.547
rk F statistic		6.9	6.9	7.28	7.28	0.978	0.978	4.92	4.92	2.08	2.08
Shea's adj.p.R2: ln(Yt/Yt-1)		0.205	0.205	0.186	0.186	-0.0751	-0.0751	0.0831	0.0831	-0.0473	-0.0473
Excluded Intruments:	ln(Yt-2), ln(Yt-3)										

Note: Reported 2SLS and LIML estimates are those obtained with allowing the option "robust" to account for possible heteroskedastic errors. The test of the overidentifying restrictions is the Sargan's (1958) and Basmann's (1960) Chi2 in the case of the 2sls estimator and the Basmann's F in the case of the LIML. "rk F statistic" indicates the Kleibergen-Paap Wald rk F statistic. Shea's adj.p.R2 that is for Shea's adjusted partial R-squared is a generalization of the first stage R-squared for the case of more than one endogenous variable. In the model for United States all instruments and controls are expressed as growth rates in place of levels. In the cases of Italy and Norway, the control variables oil price and exports are expressed as growth rates.

Table 4. Estimation results. Specification IV

Dependent variable: ln(Pt/Pt-1)		Australia		Belgium		Denmark		Finland		France	
		2sls	liml	2sls	liml	2sls	liml	2sls	liml	2sls	liml
ln(Yt/Yt-1)	coeff	0.539	0.582	0.862	0.981	0.703	0.925	0.934	2.61	0.759	0.743
	st. er.	0.234	0.314	0.088	0.146	0.159	0.412	0.434	9.161	0.138	0.171
ln(Pt-1/Pt-2)	coeff	-0.369	-0.365	0.531	0.531	0.177	0.124	0.559	1.723	0.246	0.237
	st. er.	0.13	0.147	0.209	0.282	0.146	0.191	0.347	6.359	0.185	0.199
ln(Yt-1/Yt-2)	coeff	-0.089	-0.158	-0.689	-0.726	-0.322	-0.303	-0.886	-2.551	-0.423	-0.421
	st. er.	0.167	0.26	0.166	0.249	0.126	0.15	0.429	9.037	0.123	0.129
ln(W_t/W_t-1)	coeff	0.008	0.192	0.392	0.585	-0.291	-0.294	0.387	2.188	-0.195	-0.302
	st. er.	0.344	0.622	0.226	0.398	0.247	0.427	0.444	9.755	0.428	0.604
ln(I_t/Y_t)	coeff	-0.232	-0.252	-0.028	-0.065	0.059	0.112	-0.043	0.085	0.037	0.068
	st. er.	0.115	0.147	0.052	0.09	0.061	0.108	0.048	0.735	0.153	0.209
Verdoorn	coeff	0.329	0.311	0.369	0.544	0.463	0.71	0.109	-0.082	0.446	0.422
coefficient	st. er.	0.118	0.132	0.261	0.314	0.174	0.363	0.229	0.823	0.173	0.222
R-squared		0.353	0.207	0.785	0.706	0.603	0.397	0.676	.	0.627	0.551
N		35	35	35	35	40	40	40	40	44	44
Test of the	Chi2/F	1.99	0.611	7.93	2.26	9.03	2.51	3.43	0.306	0.527	0.483
overidifying restr.	p-value	0.574	0.614	0.0475	0.105	0.0289	0.077	0.33	0.821	0.468	0.491
rk F statistic		0.878	0.878	3.66	3.66	5.06	5.06	0.266	0.266	0.553	0.553
c.v. rel.bias 5%		12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	.	.
c.v. rel.bias 10%		7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.77	.	.
c.v. rel.bias 20%		5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	.	.
c.v. rel.bias 30%		4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	.	.
Shea's adj.p.R2: ln(Yt/Yt-1)		0.275	0.275	0.364	0.364	0.208	0.208	-0.161	-0.161	0.176	0.176
		-0.0646	-0.0646	0.314	0.314	0.332	0.332	-0.173	-0.173	-0.0634	-0.0634
		0.611	0.611	0.521	0.521	0.723	0.723	0.376	0.376	0.067	0.067
		Italy		Japan		Norway		Sweden		United States	
		2sls	liml	2sls	liml	2sls	liml	2sls	liml	2sls	liml
ln(Yt/Yt-1)	coeff	1.026	1.07	0.88	0.882	0.767	1.037	0.934	0.994	1.089	1.29
	st. er.	0.148	0.193	0.08	0.081	0.3	1.076	0.156	0.207	0.532	0.868
ln(Pt-1/Pt-2)	coeff	0.493	0.524	0.339	0.343	0.452	0.47	0.386	0.41	-0.577	-0.76
	st. er.	0.135	0.166	0.13	0.134	0.137	0.199	0.171	0.195	0.677	0.969
ln(Yt-1/Yt-2)	coeff	-0.612	-0.646	-0.46	-0.465	-0.725	-0.924	-0.721	-0.776	-0.101	-0.029
	st. er.	0.137	0.168	0.118	0.121	0.254	0.852	0.18	0.224	0.322	0.436
ln(W_t/W_t-1)	coeff	0.207	0.285	0.304	0.316	-0.055	0.228	0.353	0.435	-0.339	-0.437
	st. er.	0.292	0.387	0.243	0.26	0.326	1.185	0.197	0.261	0.385	0.613
ln(I_t/Y_t)	coeff	-0.095	-0.118	-0.078	-0.08	0.02	0.01	-0.385	-0.418	0.31	0.338
	st. er.	0.115	0.14	0.068	0.072	0.019	0.046	0.124	0.157	0.342	0.441
Verdoorn	coeff	0.817	0.892	0.635	0.636	0.077	0.213	0.347	0.37	0.626	0.716
coefficient	st. er.	0.3	0.404	0.095	0.097	0.255	0.573	0.184	0.21	0.294	0.379
R-squared		0.864	0.844	0.884	0.883	0.594	0.196	0.71	0.662	.	.
N		39	39	44	44	37	37	36	36	36	36
Test of the	Chi2/F	1.06	0.332	0.322	0.32	1.31	0.347	1.31	0.608	0.559	0.446
overidifying restr.	p-value	0.786	0.803	0.571	0.575	0.726	0.792	0.52	0.551	0.454	0.509
rk F statistic		0.616	0.616	1.27	1.27	0.285	0.285	2.27	2.27	0.43	0.43
c.v. rel.bias 5%		12.2	12.2	.	.	12.2	12.2	9.53	9.53	.	.
c.v. rel.bias 10%		7.77	7.77	.	.	7.77	7.77	6.61	6.61	.	.
c.v. rel.bias 20%		5.35	5.35	.	.	5.35	5.35	4.99	4.99	.	.
c.v. rel.bias 30%		4.4	4.4	.	.	4.4	4.4	4.3	4.3	.	.
Shea's adj.p.R2: ln(Yt/Yt-1)		0.132	0.132	0.389	0.389	-0.104	-0.104	0.0984	0.0984	-0.0851	-0.0851
Shea's adj.p.R2: ln(Wt/Wt-1)		-0.0121	-0.0121	0.254	0.254	-0.172	-0.172	0.0366	0.0366	0.291	0.291
Shea's adj.p.R2: ln(It/Yt)		0.459	0.459	0.0764	0.0764	0.647	0.647	0.238	0.238	0.0672	0.0672
Excluded Intruments	ln(Yt-2), ln(Yt-3), ln(It-1/Yt-1), ln(Wt-1/Wt-2), ln(oil price_t), ln(export_t)										

Note: Reported 2SLS and LIML estimates are those obtained with allowing the option “robust” to account for possible heteroskedastic errors. The test of the overidentifying restrictions is the Sargan's (1958) and Basmann's (1960) Chi2 in the case of the 2sls estimator and the Basmann’s F in the case of the LIML. “rk F statistic” indicates the Kleibergen-Paap Wald rk F statistic. Below, c.v.rel.bias report Stock and Yogo’s critical values for Cragg-Donald F statistic and i.i.d. errors. 5%, 10%, 20% and 30% indicate the largest relative bias of the 2SLS estimator to OLS, that is acceptable. Such critical values only exist if the model is overidentified by at least two restrictions. Shea's adj.p.R2 that is for Shea's adjusted partial R-squared is a generalization of the first stage R-squared for the case of more than one endogenous variable. Regressions for France, Japan and United States were estimated without oil price and export variables as excluded instruments and have one overidentifying restriction. In the model for United States all instruments are expressed as growth rates in place of levels. In the cases of Italy and Norway, the instruments oil price and exports are expressed as growth rates.

Table 5. Chow Test: Years 1973-1986 and 1987-2006. Specifications I, III and IV

		Australia	Belgium	Denmark	Finland	France
Specif. I	*Chow*	1.125	8.329	1.543	3.336	2.554
	p-value	0.36	0.01	0.21	0.02	0.05
Specif. III	*Chow*	1.467	2.9	3.265	1.039	1.56
	p-value	0.23	0.03	0.02	0.41	0.2
Specif. IV	*Chow*	0.438	4.284	0.919	1.678	2.472
	p-value	0.85	0.01	0.5	0.16	0.04
		Italy	**Japan**	**Norway**	**Sweden**	**US**
Specif. I	*Chow*	1.919	1.579	0.995	2.265	0.712
	p-value	0.13	0.2	0.42	0.09	0.59
Specif. III	*Chow*	0.438	1.784	0.642	0.521	1.721
	p-value	0.82	0.15	0.7	0.76	0.16
Specif. IV	*Chow*	1.657	1.659	1.762	1.27	1.561
	p-value	0.16	0.16	0.15	0.31	0.19

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