EXPORT-LED GROWTH, GROWTH-DRIVEN EXPORT, BOTH OR NONE? GRANGER CAUSALITY ANALYSIS ON OECD COUNTRIES

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Abstract

This paper investigates the possibility of export-led growth and growth-driven export by testing for Granger causality between the logarithms of real exports and real GDP in twenty-five OECD countries. Two complementary testing strategies are applied. First, depending on the time series properties of the data, causality is tested with Wald tests within finite-order vector autoregressive (VAR) models in levels and/or in first-differences. Then, with no need for pre-testing, a modified Wald procedure is used in augmented level VAR systems. In both cases we experiment with alternative deterministic trend degrees. The results indicate that there is no causality between exports and growth (NC) in Luxembourg and in the Netherlands, exports cause growth (ECG) in Iceland, growth causes exports (GCE) in Canada, Japan and Korea, and there is two-way causality between exports and growth (TWC) in Sweden and in the UK. Although with less certainty, we also conclude that there is NC in Denmark, France, Greece, Hungary and Norway, ECG in Australia, Austria and Ireland, and GCE in Finland, Portugal and the USA. However, in the case of Belgium, Italy, Mexico, New Zealand, Spain and Switzerland the results are too controversial to make a simple choice.

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1. Introduction

Since the early 1960s policy makers and scholars alike, have shown great interest in the possible relationship between exports and economic growth. The motivation is clear. Should a country promote exports to speed up economic growth or should it primarily focus on economic growth, which in turn will generate exports? There are basically four propositions. According to the so called export-led growth hypothesis export activity leads economic growth. Trade theory provides several plausible explanations in favour of this idea. Besides others, the positive impact of an outward oriented trade policy on technological change, labour productivity, capital efficiency and, eventually, on production can be mentioned.

The second proposition, the growth-driven exports hypothesis, postulates a reverse relationship. It is based on the idea that economic growth induces trade flows. It can also create comparative advantages in certain areas leading to specialisation and facilitating exports. These two approaches certainly do not exclude each other; therefore the third notion is a feedback relationship between exports and economic growth. Finally, there is also potential for a simple contemporaneous relationship between these two variables.

There is a vast empirical literature on this issue. The most recent and most comprehensive survey of this literature is due to Giles and Williams (2000a) who review more than one hundred and fifty export-growth applied papers published between 1963 and 1999. These papers fall into three groups.

The first group of studies is based on cross-country rank correlation coefficients, the second applies cross-sectional regression analysis, and the third uses time series techniques on a country-by-country basis. Two thirds of the papers belong to this third group, and more than seventy of these are based on the concept of Granger causality and on various tests for it. Our work also fits into this stream. There are forty-five studies surveyed by Giles and Williams (2000a) which test for Granger causality between exports and economic growth in one or several OECD countries. Most of them consider at most two countries, but the most extensive studies, Afxentiou and Serletis (1991), Pomponio (1996) and Riezman *et al*. (1996), investigate sixteen, fifteen and twenty-eight countries, respectively.

The conclusions are fairly mixed and often contradict one another. For example, within a bivariate framework, in the case of the USA, Afxentiou and Serletis (1991) find evidence of two-way causality (TWC), while Pomponio (1996) finds support only for exports causing growth (ECG) and Riezman *et al*. (1996) conclude that there is no causality (NC) between exports and growth. In the case of Canada, Afxentiou and Serletis (1991) and Pomponio (1996) conclude that growth is causing exports (GCE), but Riezman *et al*. (1996) reject both ECG and GCE. For Australia, Riezman *et al*. (1996) reach the conclusion of GCE, while Pomponio (1996) find NC. For the UK, Riezman *et al*. (1996) again conclude GCE, but Afxentiou and Serletis (1991) find NC.

Contradictions like these might be partly due to the different methods, variable selections, time frames and frequencies, but some of the results surveyed by Giles and Williams (2000a) can also be challenged on the ground that, prior to testing for causality, the uni- and multivariate properties of the data had not been properly investigated.[2]

In this paper we study the possibility of Granger causality between the logarithms of real exports and GDP in twenty-five OECD countries, between 1960 and 1998. In order to re-enforce the results two complementary strategies are applied. On the one hand, depending on the time series properties of the data, causality is tested with Wald tests within finite-order vector autoregressive (VAR) models in levels and/or in first-differences. The disadvantage of this strategy is that the final outcome might heavily depend on preliminary test results which, themselves, are often uncertain and

[2] About the most important aspects and problems of time-series causality studies see Giles and Williams (2000a) and (2000b).

misleading. In order to reduce the impact of pre-testing on the conclusions regarding causality, the modified Wald (MWald) procedure of Toda and Yamamoto (1995) is also used which is valid even under uncertainty about integration and cointegration.[3]

However, this method is based on an augmented VAR system in levels, and in relatively small samples the extra, redundant regressors may lead to costly losses in power and efficiency. These two approaches might or might not lead to the same conclusions. If they confirm each other, we have more conviction in the results, if they contradict each other, we readily accept that the statistical methods and/or data used do not allow firm answers.

Our focus is on bivariate systems, though we briefly consider a trivariate model, as well. In this model the third variable is the logarithm of openness, defined as the proportion of the total real trade flows to GDP. It is important to acknowledge, however, that in the trivariate system our analysis is partial and experimental, at best, for two reasons.

Firstly, openness is treated as an auxiliary variable. Consequently, the analysis can handle only direct, one-period-ahead causality between exports and economic growth disregarding the possibility of indirect causality at longer time horizons.

Secondly, at the sample sizes and lag structures we work with, the trivariate system has too many unknown parameters making their estimation unreliable. Our study illustrates how sensitive the Granger causality test results can be to different methods and model specifications. This fact casts doubt on studies relying solely on one particular approach or specification and should warn applied researchers to take extreme care when interpreting their results. With this limitation in mind, our final conclusion is that there is no causality between exports and growth (NC) in Luxembourg and in the Netherlands, exports cause growth (ECG) in Iceland, growth causes exports (GCE) in Canada, Japan and Korea, and there is two-

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[3] Dolado and Lütkepohl(1996) propose a similar technique.

way causality between exports and growth (TWC) in Sweden and in the UK. Although with less certainty, we also conclude that there is NC in Denmark, France, Greece, Hungary and Norway, ECG in Australia, Austria and Ireland, and GCE in Finland, Portugal and the USA. However, in the case of Belgium, Italy, Mexico, New Zealand, Spain and Switzerland the results are too controversial to make a simple choice. The rest of this paper is organized as follows. The data used in this study is briefly discussed in Section 2. Section 3 presents the Granger causality test results. The concluding remarks can be read in Section 4.

2. The data and its properties

All data utilised in this study are from *EconData, World Bank World Tables*. The data set comprises annual measures on 25 OECD countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea Rep., Luxembourg, Mexico, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, UK and USA.[4]

The sample period is 1960-1997 for all countries, except Hungary (1970-1998), Korea and Mexico (1960-1998). The variables are GDP in 1995 $US million (GDP), exports of goods and services in 1995 $US million (EXP), imports of goods and services in 1995 $US million (IMP) and openness (OPEN), defined as (EXP+IMP)/GDP. GDP, EXP and OPEN have been transformed in natural logarithms and the resulting variables are denoted as LNGDP, LNEXP and LNOPEN.

The unit-root and cointegration analysis are reported in Kónya (2004).[5] In most cases the results are ambiguous. For example, there

[4] At the moment the OECD has 29 members. However, only those countries are considered in this study for which the World Bank´s *World Tables* provide at least twenty observations for each variable. Consequently, four countries, the Czech Republic, Germany, Poland and Turkey have been disregarded

[5] For brevity, the unit-root and cointegration tests results and also some

are only two countries (Iceland and the Netherlands) for which cointegration between LNGDP and LNEXP can be established without ambiguity, and only four countries (Australia, Belgium, Canada and Hungary) for which the results clearly indicate no-cointegration between these variables. For the other nineteen countries the various unit-root and cointegration tests lead to contradicting conclusions.

3. Testing for Granger causality

The concept of Granger causality, by which we actually understand *precedence*, is based on the idea that a cause cannot come after its effect.[6] More precisely, variable X is said to Granger-cause another variable, Y, if the current value of Y (y_t) is conditional on the past values of X (x_{t-1}, x_{t-2}, ... , x_0) and thus the history of X is likely to help predict Y. Note, that this is causality for one period ahead. This concept is generalized by Dufour and Renault (1998) to causality h periods ahead, and to causality up to horizon h, where h is a positive integer that can be infinite. They show that in a bivariate system no-causality for one period ahead implies no-causality at, or up to, any horizon. This is a clear advantage of a bivariate system over a trivariate system, (X, Y, Z) for example, where causality between X and Y can arise via the auxiliary variable Z. Namely, X might cause Z one period ahead, which in turn might cause Y at a subsequent period. This indirect, two-period ahead causality might exist even if there is no direct, one-period ahead causality between X and Y. However, if there is no causality between X and Y for two periods ahead then there is no causality between them at, or up to, longer horizons either. This difference between bivariate and trivariate systems implies that they require different strategies to test for causality at horizons beyond one period.

In this section we study the possibility of Granger causality between LNGDP and LNEXP. Since apart from the pure existence of

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details of the Granger-causality tests are not reported in this paper. The interested reader can find them in Kónya (2004).

[6] From now on "causality" always refers to "Granger causality".

a causal link between these variables, we are also interested in the nature of this relationship, we test for causality in both directions. We start with a simple bivariate system, but later we augment the information set with a third variable, LNOPEN. This third variable is treated as auxiliary in the sense that it is not directly involved in the causality test. Therefore, the possibility of indirect causality is ignored, though two-step causality may arise when LNGDP cause LNEXP and/or LNEXP cause LNGDP indirectly, via LNOPEN.

In order to re-enforce the Granger-causality test results, we apply two complementary strategies. The first one, let us call it indirect approach, assumes that the variables are stationary or can be made stationary by differencing. It makes use of pre-testing for unit roots and cointegration and, depending on the outcomes, testing for causality is undertaken within VAR models of different specifications.

When both series are deemed I(0), case *a*, a VAR model in levels is used. When one of the series is found I(0) and the other one I(1), case *b*, VAR is specified in the level of the I(0) variable and in the first difference of the I(1) variable.

When both series are determined I(1) but not cointegrated, case *c*, the proper model is VAR in terms of the first differences. Finally, when the series are cointegrated, case *d*, we can use a vector error correction (VECM) model or, for a bivariate system, a VAR model in levels.

Obviously, the weakness of this strategy is that incorrect conclusions drawn from preliminary analyses might be carried over onto the causality tests. In the light of the unit-root and cointegration test results, this possibility must be taken seriously. The ambiguities of pre-testing might have great impact on the final conclusions regarding Granger-causality, unless different VAR specifications lead to the same results.

The second strategy, let us call it direct approach, is free of this problem. It is based on the procedure of Toda and Yamamoto (1995) which does not rely so heavily on pre-testing, though some knowledge of the maximum order of integration and of the lag structure is still required. We start with the indirect approach, and thereafter we employ the direct approach.

Indirect Approach with Wald tests

Case a requires the estimation of a VAR model in levels. A standard VAR model is a set of unrestricted, reduced form regression equations where each left-hand-side variable is determined by the same set of predetermined variables, namely, by its own past values and by past values of the other left-hand-side variables. Accordingly, a bivariate VAR system of order *mlag* looks like

$$\begin{aligned} y_t &= \alpha_1 + \sum_{i=1}^{mlag} \beta_{1i} y_{t-i} + \sum_{i=1}^{mlag} \gamma_{1i} x_{t-i} + \varepsilon_{1t} \\ x_t &= \alpha_2 + \sum_{i=1}^{mlag} \beta_{2i} y_{t-i} + \sum_{i=1}^{mlag} \gamma_{2i} x_{t-i} + \varepsilon_{2t} \end{aligned} \quad (1)$$

where it is assumed that y_t and x_t are stationary and that ε_{1t} and ε_{2t} are white-noise disturbances. If necessary, (1) can be augmented with a deterministic linear or quadratic trend, and additional auxiliary variables might be also considered. The proper augmentation might prove to be crucial since a deterministic trend might substitute for left-out trending variables. In any case, due to the fact that the same right-hand-side variables appear in both equations, this system might be over-parameterized. On the other hand, it is relatively simple to estimate since OLS on individual equations is as efficient as system wide methods, even if the error terms in different equations are contemporaneously correlated (Enders, 1995, p. 301).

As regards causality within this system, there is one-way causality running from *X* to *Y* if not all γ_{1i}'s are zero but all β_{2i}'s are zero (i = 1, ... , *mlag*), there is one-way causality from *Y* to *X* if not all β_{2i}'s are zero but all γ_{1i}'s are zero, there is two-way causality between *Y* and *X* if neither all β_{2i}'s nor all γ_{1i}'s are zero, and there is no Granger causality between Y and X if all β_{2i}'s and γ_{1i} 's are zero. These parameter restrictions can be tested by F, Wald or likelihood ratio tests.

Prior to testing for causality, there is an important issue to be addressed. Since the lag length is typically unknown, it has to be specified in one way or in another. This is a crucial step since too few lags might result in omitted variable bias, while too many lags waste observations; decrease the degrees of freedom and the precision of the results.

There are several possible approaches. Lütkepohl (1993, p. 306) suggests linking the lag length (*mlag*) and the number of endogenous variables in the system (m) to the sample size (T) according to the $m\square mlag = T^{1/3}$ formula. At a sample size of 38 this rule implies a maximal lag length of 1-2 periods for a bivariate VAR system.

As an alternative, one can rely on some formal model specification criteria, like e.g. the Akaike Information Criterion (AIC) or the Schwarz Bayesian Information Criterion (SBIC). Occasionally, these two criteria select different lag lengths.

Since the sample sizes are relatively small, we prefer the lag structures which are the more parsimonious, but still long enough to whiten the residuals. If, however, the Granger-causality test proves to be very sensitive to the lag structure, preference is given to the more frequent outcome.

On the basis of the preliminary test results, we estimate (1) with X = LNEXP, Y = LNGDP and various deterministic trends for Austria, Denmark, France, Luxembourg, Portugal and Sweden. We experiment with four different lag lengths (*mlag* = 1, 2, 3, 4) over the same sample. The $\gamma_{1,1} = ... = \gamma_{1,mlag} = 0$ and $\beta_{2,1} = ... = \beta_{2,mlag} = 0$ parameter restrictions are tested with Wald tests which, under the null hypotheses, have a limiting χ^2 distribution with *mlag* degrees of freedom.

The results, shown in Table 1, indicate one-way Granger causality running from LNGDP to LNEXP for Austria and Portugal, and two-way causality between LNGDP to LNEXP for Sweden.

Granger causality in either direction is necessary for the export-led growth (ELG) or growth-driven exports (GDE) hypotheses. However, since these hypotheses imply positive overall effects, the nature of the causal relationship is also important.

The impact of past LNEXP values on current LNGDP and the impact of past LNGDP values on current LNEXP can be assessed by the estimates of γ_{1i} and β_{2i} (i = 1,..., *mlag*), respectively. Their sums,

$$\Gamma_1 = \sum_{i=1}^{mlag} \gamma_{1i} \quad \text{and} \quad \mathrm{B}_2 = \sum_{i=1}^{mlag} \beta_{2i}$$

are 'returns-to-scale' type parameters. Γ_1 measures the change in LNGDP in period t due to one unit rises in LNEXP in each of the previous *mlag* periods, while B_2 measures the change in LNEXP in period t due to one unit rises in LNGDP in each of the previous *mlag* periods. In the vein of the ELG and GDE hypotheses, both of them are expected to be positive.

According to our findings, Γ_1-hat is positive for Sweden (0.1409), meaning that if real exports increase by 1% in years t-1, t-2, and t-3, real GDP increases by 0.1409% in year t. Similarly, B_2-hat is positive for Austria (0.9589), meaning that if real GDP increases by 1% in years t-1 and t-2, real exports increase by 0.9589% in year t. On the other hand, B_2-hat is negative for Portugal (-1.1013) and Sweden (-0.6793), suggesting that higher values of LNEXP induce lower LNGDP values in the future. Clearly, these conclusions do not support the GDE hypothesis.

Table 1. Wald tests for Granger causality - VAR(*mlag*) in levels of I(0) variables

Country-Model	H_{01}			H_{02}		
	mlag	Γ_1-hat	χ^2-statistic	mlag	B_2-hat	χ^2-statistic
At-3	1	0.089	0.898	2	0.958	6.638^b
Dk-3	1	-0.097	0.729	1	0.147	1.281
Fr-3	1	-0.069	1.293	2	0.386	1.486
Lu-2	1	0.010	0.013	2	0.223	2.773
Lu-3	1	-0.039	0.156	2	0.087	2.953
Pt-4	3	0.032	4.361	3	-1.013	8.963^b
Se-3	1	0.140	9.503^a	1	-0.679	12.676^a

Note: 1) Γ_1-hat and B_2-hat are the sums of the estimated γ_{1i}, and β_{2i} coefficients, respectively 2) ^{a}: significant at the 1% level; ^{b}: significant at the 5% level; ^{c}: significant at the 10% level. 3) Model 1 - VAR(*mlag*) without deterministic terms; Model 2 - VAR(*mlag*) with constant; Model 3 - VAR(*mlag*) with linear trend; Model 4: VAR(*mlag*) with quadratic trend. 4) At the 10% level the Breusch-Godfrey LM and the Ljung-Box portmanteau tests did not detect autocorrelation (of order 1-4) in the residuals. 5) H_{01} : LNEXP does not cause LNGDP; H_{02} : LNGDP does not cause LNEXP.

Case b requires the estimation of (1) using the level of the I(0) variable and the first difference of the I(1) variable. Therefore, depending on the preliminary test outcomes, X = ΔLNEXP and Y = LNGDP or X = LNEXP and Y = ΔLNGDP, where Δ is the first-difference operator. Otherwise, the specification and estimation of the model, and also the Granger-causality tests, are performed the same way as before.

The results are shown in Tables 2 and 3. They indicate one-way causality running from LNEXP to ΔLNGDP for Denmark, from ΔLNGDP to LNEXP for Korea, from ΔLNEXP to LNGDP for

Austria and Portugal, from LNGDP to ΔLNEXP for Canada, Finland, France, Greece, Italy, Japan and the USA, while two-way causality is detected for Sweden.

As regards the Γ_1-hat and B_2-hat statistics, the first-difference operator, Δ, alters their interpretations, but their logical sign is still positive. In this sense the ELG hypothesis is supported only for Austria, Portugal and Sweden, and the GDE hypothesis is supported only for the USA.[9]

Table 2. Wald tests for Granger causality - VAR(*mlag*) in mixed terms, ΔLNGDP and LNEXP

Country-Model	H_{01}			H_{02}		
	mlag	Γ_1-hat	χ^2-statistic	mlag	B_2-hat	χ^2-statistic
Dk-3	1	-0.184	2.876[c]	1	0.026	0.017
Ko-2	1	-0.006	2.554	1	-0.979	3.714[c]
NZ-3	1	0.013	0.009	4	0.011	5.072
Pt-4	3	0.049	3.612	2	0.425	0.379
Ch-2	1	-0.012	1.274	4	-0.516	3.688

Note: See Table 1, Notes 1-4. 5) H_{01} : LNEXP does not cause ΔLNGDP; H_{02} ΔLNGDP does not cause LNEXP.

[9] Note that $\Delta LNGDP_t$ and $\Delta LNEXP_t$ are approximate growth rates.

Table 3. Wald tests for Granger causality - VAR(*mlag*) in mixed terms

Country-Model	H_{01}:			H_{02}		
	mlag	Γ_1-hat	χ^2-statistic	mlag	B_2-hat	χ^2-statistic
At-2	1	0.130	3.342[c]	1	-0.041	2.480
Ca-2	1	0.078	1.289	3	-0.068	7.754c
Fi-4	3	-0.080	0.632	2	-1.315	24.680[a]
Fr-2	1	0.067	1.062	1	-0.047	3.126[c]
Gr-2	1	-0.057	1.194	1	-0.103	5.879[b]
It-2	1	0.058	0.673	1	-0.067	4.696[b]
Jp-3	2	0.069	0.700	2	-0.112	10.283[a]
Mx-2	1	0.118	1.962	1	0.024	0.791
Pt-2	1	0.078	2.909[c]	2	0.021	0.842
Se-2	1	0.196	11.512[a]	3	-0.085	11.165[b]
USA-3	2	-0.080	1.253	2	0.280	4.837[c]

Note: See Table 1, Notes 1-4. 5. H_{01} : ΔLNEXP does not cause LNGDP; H_{02} : LNGDP does not cause ΔLNEXP.

In ***Case c***, LNGDP and LNEXP are both I(1), but not cointegrated. Since *X* and *Y* are supposed to be I(0) in (1), this time causality can be tested using VAR in first differences and the resulting Wald statistic has an asymptotic χ^2 distribution with *mlag*-1 (*mlag*>1) degrees of freedom (Lütkepohl and Reimers, 1992, p. 265). The results, shown in Table 4, indicate one-way causality from ΔLNEXP to ΔLNGDP for Italy and New Zealand, from ΔLNGDP to ΔLNEXP for Australia, Canada, Finland and Korea, and two-way causality is likely in the case of the UK.

Table 4.Wald tests for Granger causality-
VAR(*mlag*) in first differences

Country-Model	H_{01}			H_{02}		
	mlag	Γ_1-hat	χ^2-statistic	mlag	B_2-hat	χ^2-statistic
Au-2	2	0.152	2.575	4	0.188	7.780[c]
Be-3	2	0.169	3.653	2	0.137	0.119
Ca-3	2	0.093	0.726	2	-1.560	6.430[b]
Fi-2	2	0.156	2.216	2	-1.021	7.549[b]
Fi-3	2	0.155	2.520	4	-2.912	25.114[a]
Gr-3	2	-0.081	1.973	2	0.381	0.278
Hu-2	2[#]	0.227	0.816	2	0.271	0.097
Ir-2	2	0.340	3.960	2	0.216	0.722
It-3	2	0.205	6.342[b]	2	-1.110	3.327
Ko-3	2	-0.011	0.415	2	-0.822	5.469[c]
Lu-2	2	-0.097	0.425	2	0.277	0.751
Mx-3	2	0.164	2.669	2	0.809	3.887
NZ-2	3[#]	0.333	7.291[c]	1	0.026	4.036
No-2	2	0.006	0.290	2	-0.337	0.613
Ch-3	2	-0.004	2.646	3	-0.420	2.803
UK-2	2	0.173	7.758[b]	2	0.178	15.069[a]
USA-2	2	-0.152	3.649	2	0.928	2.398

Note: See Table 1, Notes 1-3. 4) H_{01} : ΔLNEXP does not cause ΔLNGDP. H_{02} : ΔLNGDP does not cause ΔLNEXP. [#]: Autocorrelation has been detected at the 10% level.

Apart from three cases (Canada, Finland and Korea) the Γ_1-hat and B_2-hat are positive, supporting the ELG and GDE hypotheses.

Finally, when LNGDP and LNEXP are cointegrated, ***Case d***, they have an attainable long-run equilibrium and there must be causality between them at least in one direction (Granger, 1988).

In cointegrated systems, however, the usual Wald test for linear restrictions may have a non-standard asymptotic distribution that depends on nuisance parameters. For this reason, causality is preferably tested within a vector error correction (VEC) framework instead of a first-difference VAR model. Yet, the Wald test in a level VAR still has a χ^2 distribution asymptotically when cointegration is 'sufficient' in the sense of Toda and Phillips (1993).

Although, it is usually not an easy task to figure out whether this condition holds, it is assured in bivariate cointegrated systems. Apart from causality inference, another advantage of the VEC framework might be that it provides additional information about the speed the system responds to disequilibrium.

Since we are not concerned with this adjustment process, in order to keep the analysis as simple as possible, similarly to *Case a*, we conduct Wald tests for Granger causality in level VAR models. The results can be seen in Table 5.

Apparently, there is support for one-way causality from LNEXP to LNGDP in the case of Australia, Iceland, Ireland, Italy, Mexico and Norway, one-way causality in the opposite direction, i.e. from LNGDP to LNEXP, seems to exist in Japan and Korea, and causality is likely in both directions in the UK. With the exception of Korea and Mexico, Γ_1-hat and B_2-hat are positive, justifying the ELG and GDE hypotheses.

Table 5. Wald tests for Granger causality - VAR(*mlag*)
in levels of CI(1,1) variables

Country-Model	H_{01}			H_{02}		
	mlag	Γ_1-hat	χ^2-statistic	mlag	B_2-hat	χ^2-statistic
Au-2	1	0.083	6.798[a]	1	0.098	0.485
Ic-2	2	0.103	21.452[a]	1	0.308	1.981
Ir-2	2	0.123	5.359[c]	1	-0.039	0.047
It-3	1	0.076	3.331[c]	1	-0.243	1.902
Ja-2	2	0.068	1.552	1	0.529	8.270[a]
Ko-3	1	0.022	1.228	2	-0.158	5.981[c]
Me-3	3	-0.091	9.955[b]	2	0.038	0.552
Ne-3	2	0.074	1.937	2	0.345	1.362
No-2	1	0.067	3.112[c]	4	-0.207	3.780
Sp-2	3	0.068	5.073	1	-0.169	0.829
UK-2	3	0.039	7.395[c]	3	0.366	18.616[a]

Note: See Table 1.

Direct Approach with MWald tests

The test proposed by Toda and Yamamoto (1995) is a modified Wald (MWald) test for linear restrictions on some parameters of an augmented VAR(*mlag*+*d*) in levels, where *d* is the highest order of integration suspected in the system, usually at most two. The test statistic does not depend on any nuisance parameter and under the null hypothesis it has an asymptotic χ^2 distribution with the usual degrees of freedom, granted that *d*#*mlag*. The last *d* lags are not considered explicitly in the Wald test, but they are necessary to ensure the asymptotically χ^2 sampling distribution of the test statistic.

This test procedure has three advantages. First of all, it can be used in possible integrated and cointegrated systems, without pre-testing for cointegration. Secondly, Rambaldi and Doran (1996) have shown that computationally the MWald test is very simple, since it can be run in a seemingly unrelated regression. Thirdly, according to the Monte Carlo experiments on bivariate and trivariate models performed by Zapata and Rambaldi (1997), despite the intentional over-fitting, the MWald test performs as well as similar but more complicated test procedures in samples of size fifty at least.

This time, unfortunately, we work with shorter time series, and the extra, redundant regressors may lead to costly losses in power and efficiency. Nevertheless, it is worth to apply this procedure and compare the outcomes to the results obtained via the indirect approach.

First we use the MWald test on the LNGDP-LNEXP bivariate system. We assume that the maximal order of integration is one, i.e. $d = 1$, and experiment with $mlag + d = 2, 3, 4, 5$. For each country the preferred *mlag* value is selected on the basis of AIC, SBIC statistics from VAR(*mlag*) estimated by OLS over the same sample. When these statistics choose different *mlag* values, preference is given to the one which produces non-autocorrelated, or at least 'whiter', residuals.

The results (see Kónya, 2004) suggest one-way causality from LNEXP to LNGDP in the case of Australia (*Model 2*), Austria (*Model 2*), Belgium, Hungary (*Model 3*), Iceland, Ireland, Spain and Switzerland, from LNGDP to LNEXP in Canada, Finland (*Model 4*), Italy, Japan, Korea, Mexico (*Model 2*), New Zealand (*Model 3*), Portugal and the USA (*Model 2*), and two-way causality seems to be likely in Denmark (*Model 3*), Finland (*Models 2, 3*), New Zealand (*Model 2*), Sweden and the UK. In each of these cases but one (UK - *Model 3*) Γ_1-hat is positive, while B_2-hat has unexpected sign in six cases (Canada, Finland, Italy, Korea - Model 3, New Zealand, Portugal and Sweden).

Bivariate systems, like the ones we have used so far, are often criticised as incomplete, omitting potentially important variables. For this reason, we consider a trivariate system as well, namely LNGDP-LNEXP-LNOPEN, where openness is expected to appraise the sensitivity of GDP and exports to each other. We use $d = 2$ uniformly on all countries. This choice is safe, but not parsimonious since according to the unit-root test results a second unit root in LNOPEN is an unlikely option for almost all countries. The MWald test requires $mla \exists d$, so we experiment with $mlag + d = 4, 5, 6$.

It is important to realise, however, that in the trivariate system our analysis is partial and experimental, at best, for two reasons. Firstly, openness is treated as an auxiliary variable, i.e. it is not directly involved in the MWald tests.

Consequently, we can study only direct, one-period-ahead causality between exports and economic growth, disregarding the possibility of indirect causality at longer time horizons. Since, unlike in a bivariate system, in a trivariate system no-causality for one period ahead does not imply no-causality for two or more periods ahead; the bivariate and trivariate causality test results are not really comparable. Secondly, having at most 39 observations for each variable and a maximal lag length of 6 years, the usable sample size is only 33, while each equation of the trivariate VAR has 19-21 unknown parameters.[10]

For these reasons, the results (see Kónya, 2004), must be treated with great care and we can draw only tentative conclusions from them. Nevertheless, it is worth to mention, that in the case of thirteen countries (Australia, Austria, Canada, Denmark, Hungary, Iceland,

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[10] There are 3×6=18 slope parameters belonging to the lagged LNGDP and LNEXP terms, a constant and, depending on the order of the time trend, the slope parameters of t and t^2.

Ireland, Japan, Norway, Portugal, Spain, Switzerland and the USA) the MWald test in the trivariate system provides definitely more support to causality between LNGDP and LNEXP than in the bivariate system, and there are only two examples (Belgium and Korea) for the opposite. This is a surprising outcome since, due to the potentially important omitted variables; the bivariate system is expected to produce more spurious causality.

4. Concluding remarks

In this paper we aimed to explore whether in the last three and a half decades the OECD countries experienced export-led-growth or growth-driven-export, maybe both or none. We did so by studying Granger causality between economic growth, measured by the logarithm of real GDP, and the logarithm of real exports. In order to re-enforce the results, two complementary strategies were used.

First, we studied the uni- and bivariate time-series properties of the data and, building on these characteristics, employed Wald tests on appropriate parameter restrictions in bivariate VAR models in levels and/or first differences. The obvious weakness of this approach is its dependence on pre-testing. Unfortunately, in practice different unit-root and cointegration tests, and also different model specifications, can lead to contradicting results. This shortcoming certainly does not come to light when applied researchers, without any serious reason, place all their faith in a single method or model. However, we used five unit-root and three cointegration tests, on various specifications.

As expected, the results were often ambiguous, so testing for causality in a single model was unjustified. We distinguished four cases, namely when LNGDP and LNEXP are I(0)-I(0), I(0)-I(1) or I(1)-I(0), I(1)-I(1) but not CI(1,1), and CI(1,1). For most of the countries we considered at least two of these possibilities and experimented with different deterministic trends. Following this indirect approach, we also applied the modified Wald test of Toda and Yamamoto (1995) which does not rely so heavily on pre-testing, but performs better in larger samples.

There are only eight countries where different methods and specifications lead to unanimous conclusions. They are Canada (GCE), Iceland (ECG), Japan (GCE), Korea (GCE), Luxembourg (NC), the Netherlands (NC), Sweden (TWC) and the UK (TWC). For all other countries the causality test results are mixed. This is partly due to the fact that in most cases the true time-series properties of the data could not be discovered beyond doubt. Still, this fact would not cause much difficulty, if the causality test results were invariant to the methods applied. However, in many cases, different strategies delivered different outcomes.

The other reason for ambiguity is the uncertainty regarding the deterministic trend degree. What type of a deterministic trend should be included and what is its impact on Granger causality? For example, models with and without a linear time trend often produce different causality test results. Although one could expect a time trend to act as a proxy for omitted economic variables, thus decreasing the chance of spurious causality, there are counterexamples as well. All things considered, it is clear that the causality results are usually not robust to method and specification, so their interpretation calls for great care.

In the light of this limitation, we can arrive at the following conclusions. We are confident to claim that there is NC between exports and growth in Luxembourg and in the Netherlands, ECG in Iceland, GCE in Canada, Japan and Korea, and TWC in Sweden and in the UK. There is probably NC also in Denmark, France, Greece, Hungary and Norway, ECG in Australia, Austria and Ireland, and GCE in Finland, Portugal and the USA. However, contrary to the spirits of the ELG and GDE hypotheses, some of the revealed causal relationships imply a negative delayed impact from exports to growth or from growth to exports. Finally, in the case of Belgium, Italy, Mexico, New Zealand, Spain and Switzerland the results are too controversial to make a simple choice.

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