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Growth, Exports and Cointegration: An Empirical Investigation

By

Peter Kugler

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I. Introduction

Export growth is often considered to be a main determinant of production and employment growth of an economy. This so-called hypothesis of export-led growth is, as a rule, substantiated by the following four arguments. First, export growth leads by the foreign trade multiplier to an expansion of production and employment. Second, the foreign exchange made available by export growth allows to import capital goods which, in turn, increase the production potential of an economy. Third, the volume of and the competition on export markets causes economies of scale and an acceleration of technical progress in production. Fourth, given the theoretical arguments mentioned, the observed strong correlation of export and production growth is interpreted as empirical evidence in favour of the export-led growth hypothesis.

Most of these arguments are, however, not convincing. The first two arguments are based on a short-run macro model of the Keynesian type, which is by its demand orientation not suitable to explain economic growth. Economies of scale and acceleration of technical change by international trade is a potentially important source of economic growth. The treatment of labour supply and technical progress as exogenous is not very convincing in neoclassical growth models. Thus, recent work on neoclassical models with endogenous growth is of major importance. These developments are especially interesting in our context because there are interesting links between these growth models and static models developed in the field of international trade [Helpman, 1988]. On the one hand, we have to mention the growth model of Romer [1986] and Lucas [1988]. The former approach postulates economies of scale, external to the firm but internal to the industry. These external economies of scale allow a compen-

sation of the negative effect of capital accumulation on the marginal product of capital on the firm level and lead to an endogenous growth process. The latter model replaces exogenous labour supply growth by a human capital accumulation process. On the other hand, we have, e.g., the static model of economies of scale in the production of internationally traded intermediate goods as formulated by Eithier [1982], which is related to Romer's approach. In addition, we may see a relationship between the theory of acquired comparative advantage and the theory of human capital accumulation. Of course, these links have to be analyzed further on a theoretical level.

However, they point to a causal relationship of international trade and exports to economic growth. Finally and crucially, for the purpose of this paper, the strong correlation of export and GDP growth rates has nothing to say about a relationship between the export and the GDP trend development, as it may arise from a pure short-run relationship.[1] In order to test for the existence of a long-run or trend relationship between GDP and exports, the theory of cointegration developed recently by Engle and Granger [1987], Johansen [1988] and Stock and Watson [1988] among others has to be applied. This is the purpose of this paper. To this end, we analyze quarterly data for six countries (USA, Japan, Switzerland, West Germany, France and the UK), using the multivariate cointegration approach proposed by Johansen [ibid.]. In this frame, we test for a long-run relationship between GDP, consumption and investment on the one hand and exports on the other hand.

II. Testing for a Common GDP-Export Trend

The real macroeconomic variables GDP, consumption, investment and export are denoted by Y_t, C_t, I_t and X_t, respectively. The logarithms of these series are collected in a vector.

$$Z_t' = [z_{1t}\, z_{2t}\, z_{3t}\, z_{4t}] = [y_t\, c_t\, i_t\, x_t]\,.$$

[1] Empirical work addressing the export-GDP relationship uses country cross-section data or time series data for a single country. For a recent overview and results, the reader is referred to Jung and Marshall [1985]. As a rule, country cross-sections point to a strong interrelationship of GDP or GNP and export growth rates. There are many reasons to doubt the econometric specifications adopted in these studies. We will mention only two problems: First, export growth is considered to be weakly exogenous. Second, the level of technology, which is presumably different across countries, is not properly accounted for.

We assume that the elements of Z_t' are integrated of order one, denoted by I(1). This notation, introduced by Engle and Granger [1987], means that they have to be differenced once in order to get a series with a stable and invertible ARMA representation. Thus, the changes in y_t, c_t, i_t and x_t, which are approximately growth rates, are stochastic variables with a constant mean. The variables follow stochastic trends which may be different across series. By contrast, if we adopt the concept of a deterministic trend, all series follow the variable t and have the same trend behaviour besides a different coefficient of the variable t. Using the concept of a stochastic trend, we may ask whether our series are driven by common trends [Stock and Watson, 1988] or equivalently whether they are cointegrated [Engle and Granger, 1987]. This amounts to testing for the existence of linear independent so-called cointegrating relationships:

$$\sum_{j=1}^{4} \beta_{ji} z_{jt} = \varepsilon_{it}, \qquad i = 1, \ldots, r \tag{1}$$

The ε_{it} are I(0) series, although the z_{jt} are I(1) variables. Given the I(0) characteristic of ε_{it}, it is evident that the long-run behaviour of $z_{jt} (j = 1, \ldots, 4)$ is determined by $4 - r$ common trends.

The one-sector neoclassical growth model predicts [2] that y_t, c_t and i_t are driven by one common trend representing labour supply growth and technical progress. Thus, we have two cointegrating relationships under this model, namely, $c_t - y_t = \varepsilon_{1t}$ and $i_t - y_t = \varepsilon_{2t}$.

It may be worthwhile to mention that we have to make no assumption about the direction of causality in the cointegrating relationships. In addition, the neglecting of variables having a transitory influence on y_t, c_t, i_t and x_t does not bias the results obtained asymptotically as they only give rise to stationary deviation from the co-integrating relationships, which are captured by the ε's. Thus, the approach applied accounts for additional shortcomings of the empirical work described in Section II. Besides that, it does not restrict the attention to growth rates, but concentrates on trends in level series.

Hypotheses on the number of cointegrating relationships and certain linear restrictions on β_{ji} can be tested using the approach proposed by Johansen [1988] and Johansen und Juselius [1990]. This method is based on a vectorautoregressive representation of the level

[2] For a recent overview of the basic neoclassical growth model and its extensions, the reader is referred to King et al. [1988a, b].

series:

$$Z_t = \mu + \sum_{\tau=1}^{k} \Pi_\tau Z_{t-\tau} + e_t, \tag{2}$$

where e_t is $N(0, \sigma^2 V)$ distributed. It is useful to convert the system to a first-difference model

$$\Delta Z_t = \mu + \sum_{\tau=1}^{k-1} \Gamma_\tau \Delta Z_{t-\tau} + \Gamma_k Z_{t-k} + e_t, \tag{3}$$

where $\Gamma_\tau = -\mathrm{I} + \Pi_1 + \ldots + \Pi_\tau$.

The rank of Γ_k is equal to the number of cointegrating vectors. Thus, we can write this matrix as

$$-\Gamma_k = \alpha \beta', \tag{4}$$

where β is the $p \times r$ matrix of cointegrating vectors and α is a corresponding coefficient matrix. It is easily seen that the $-\Gamma_k$ is the impact matrix determining the long-run multipliers in (3). Of course, if Z_t is I(0), $-\Gamma_k$ can be inverted to get a stationary long-run equilibrium. According to (1), this corresponds to four cointegrating relationships.

The approach of Johansen is based on maximum likelihood estimation of (3). In this framework, we can test hypotheses for the number of cointegrating vectors r as well as certain linear restrictions for these cointegrating vectors. Thereby, we have to note that the matrix of cointegrating vectors β is not identified. However, the space spanned by the columns of β can be estimated. Thus, we can test whether β can be represented as a linear combination of at least r known vectors spanning a space of dimension p. In our context, we are mainly interested in whether export x_t can be excluded from the cointegrating relationships. This amounts to the following representation of β:

$$\begin{bmatrix} \beta_{11} \ldots\ldots \beta_{1r} \\ \beta_{21} \ldots\ldots \beta_{2r} \\ \beta_{31} \ldots\ldots \beta_{3r} \\ \beta_{41} \ldots\ldots \beta_{4r} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \phi_{11} \ldots\ldots \phi_{1r} \\ \phi_{21} \ldots\ldots \phi_{2r} \\ \phi_{31} \ldots\ldots \phi_{3r} \end{bmatrix}. \tag{5}$$

Of course, (5) incorporates r restrictions, namely $\beta_{4i} = 0$ $(i = 1, 2 \ldots, r)$. The likelihood ratio test statistic for (5) derived by Johansen follows a standard χ^2 distribution with r degrees of freedom. By contrast, the distribution test statistic for hypotheses on r is non-standard and is tabulated by Johansen [1988] and Johansen and Juselius [1990]. The

latter contains selected fractiles for the case $\mu = 0$. In our application, we assume non-zero mean growth rates and therefore have to use the fractiles given in the paper of Johansen and Juselius [ibid.].

III. Empirical Results

The empirical analysis outlined above was applied to seasonally-adjusted quarterly data for the USA, Japan, Switzerland, West Germany, the UK and France for the years 1970–87. Details on the data series and their sources are given in the Appendix. Briefly, consumption covers private expenditures on durables, non-durables and services. Investment is business-fixed investment and exports covers goods and services. First of all, we have to test for the order of integration of the series involved. The results of augmented Dickey-Fuller unit root tests for the levels and first differences of the four variables considered are reported in Table 1. The test is run in its augmented form, with one- and six-lagged differences. In general, the results indicate that the series are I(1). For some first-difference series, the unit root hypothesis cannot be rejected in the six-lag augmented test. However, these results seem to be brought about by an over-parametrization of the test, as the included additional difference terms are not statistically significant at conventional levels.

Table 2 contains the results obtained by the application of Johansen's procedure.[3] Thereby, the lag length k of the level VAR system was determined by minimizing the Akaike Information Criterion (AIC). Now, let us turn first to the test concerning the number of cointegrating vectors r. As a rule, the results support the existence of one or two cointegrating relations. The exception is the UK for which no statistically significant cointegration relation is found. In this case, the existence of *any* trend relationship between the variables is doubtful. Second, consider the result of the hypothesis that exports can be excluded from the r cointegrating relations. This hypothesis must not be rejected for three out of five countries,[4] namely the USA, Japan and Switzerland. It is, however, clearly rejected at all reasonable significance levels for West Germany and France. In sum, our empirical analysis provides us with mixed evidence concerning the impor-

[3] This analysis was performed using a RATS procedure kindly provided by Klaus Neusser of the University of Vienna.

[4] We calculated modified likelihood ratio statistics replacing the number of observations T by the number of degrees of freedom $T-p-1$.

Table 1 – *Univariate Unit Root Tests, Dickey-Fuller t-Statistics*

$$\Delta Z_t = \alpha + \gamma Z_{t-1} + \sum_{\tau=1}^{m} \Delta Z_{t-\tau} + \xi_t$$

Variable		Levels		First-differences	
		$m=1$	$m=6$	$m=1$	$m=6$
USA	y	−0.46	−0.38	−4.05***	−3.01**
	c	−0.30	−0.26	−4.27***	−2.94**
	x	−2.83*	−2.61*	−4.07***	−3.05**
	i	−1.54	−1.33	−3.33**	−2.67*
Japan	y	−0.72	−0.62	−4.70***	−3.46**
	c	−2.16	−2.15	−5.85***	−2.92*
	x	−1.48	−1.65	−4.51***	−3.21**
	i	0.58	0.93	−3.93***	−3.02**
Switzerland	y	0.058	−0.33	−4.68***	−2.74*
	c	−0.48	−0.54	−6.52***	−2.27
	x	−0.85	−0.75	−5.26***	−3.27***
	i	0.59	−0.94	−5.72***	−1.88
W. Germany	y	−1.13	−1.06	−5.80***	−2.82*
	c	−1.18	−0.46	−6.49***	−2.08
	x	−1.67	−1.81	−5.26***	−3.44**
	i	−0.36	−0.98	−6.46***	−2.23
UK	y	−0.13	−0.035	−6.32***	−2.66*
	c	1.36	1.00	−5.18***	−1.75
	x	−0.87	−0.82	−7.14***	−4.03***
	i	0.061	0.11	−5.75***	−2.81*
France	y	−1.98	−2.12	−4.31***	−2.84*
	c	−1.96	−1.90	−5.07***	−3.18**
	x	−3.10**	−2.53	−3.67***	−2.38
	i	−0.52	−0.40	−5.49***	−3.61***

Note: *, ** and *** indicate significance at the 10, 5 and 1 per cent levels, respectively. Critical values are provided by Fuller [1976].

tance of exports for GDP, consumption and investment trends. Statistical significant links are only found in two out of six countries considered.

IV. Conclusions

In this paper, the approach proposed by Johansen is used in order to test for a long-run or cointegrating relation between GDP, consumption and investment on the one hand, and exports on the other

Table 2 – *Multivariate Unit Root Tests: Johansen Test for Cointegration*

$$\Delta Z_t = \mu + \sum_{\tau=1}^{k-1} \Gamma_\tau \Delta Z_{t-\tau} + \Gamma_k Z_{t-k} + e_t$$

$$-\Gamma_k = \Pi = \alpha\beta'$$

β: matrix of cointegration vectors

$$\beta' = \begin{bmatrix} \beta_{11} \cdots \beta_{p1} \\ \vdots \quad \vdots \\ \beta_{1r} \cdots \beta_{pr} \end{bmatrix} \qquad \alpha = \begin{bmatrix} \alpha_{11} \cdots \alpha_{1r} \\ \vdots \quad \vdots \\ \alpha_{p1} \cdots \alpha_{pr} \end{bmatrix}$$

$Z_t = [y_t, c_t, i_t, x_t]$, $p = 4$

Country	k	r	$H_0: \Pi = \alpha\beta'$ Johansen-Statistic[a] value	95% fractile	$H_0: \beta = H\phi$ $H = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix}$ $\chi_r^{2\,b}$
USA	5	≤ 3	0.29	4.0	
		≤ 2	14.02*	15.2	1.34
		≤ 1	29.29*	29.5	
		≤ 0	48.07**	47.2	
Japan	5	≤ 3	0.36	4.0	
		≤ 2	15.17*	15.2	1.34
		≤ 1	34.29***	29.5	
		≤ 0	59.08***	47.2	
Switzerland	5	≤ 3	0.49	4.0	
		≤ 2	13.70*	15.2	4.01
		≤ 1	36.61***	29.5	
		≤ 0	68.34***	47.2	
W. Germany	6	≤ 3	1.34	4.0	
		≤ 2	6.35	15.2	19.11***
		≤ 1	33.08***	29.5	
		≤ 0	74.44***	47.2	
UK	3	≤ 3	1.97	4.0	
		≤ 2	6.62	15.2	
		≤ 1	16.12	29.5	
		≤ 0	39.13	47.2	
France	5	≤ 3	1.77	4.0	
		≤ 2	8.98	15.2	6.20**
		≤ 1	27.99*	29.5	
		≤ 0	70.27***	47.2	

[a] Under H_0, this statistic has a (non-standard) distribution, which is tabulated in Johansen and Juselius [1990] (process with drift). – [b] Under H_0, this statistic is χ^2-distributed with r degrees of freedom. – *, ** and *** indicate significance at the 10, 5 and 2.5 per cent levels, respectively.

hand. Using quarterly data for six countries (USA, Japan, Switzerland, West Germany, UK and France), we arrived at the conclusion that in four cases considered, the hypothesis that exports do not enter the cointegrating relations between the other three variables cannot be rejected. Only for France and West Germany, there seems to be a strong interrelationship of the trend movement of exports and the other three key macroeconomic variables. Thus, there is only weak empirical evidence supporting the view of export-led growth.

How can we explain this pattern of results? As the links between West Germany and France are stronger than that between the four other countries considered here, we may conjecture that this is the reason for the result obtained. This conjecture has to be analyzed further. This could be done by analyzing aggregated data for West Germany and France or for the entire EC. This would also enable us to see whether the long-run relationship of exports and GNP, consumption and investment originates in the trade inside or outside a country block. In addition, the frame of analysis of this paper should be applied to data for different industries. This would make it possible to check whether an aggregate production/export relationship is also found at the industry level. This, in turn, indicates whether an aggregate relationship is causal from export to production or simply the result of the fact that strongly growing industries experience strong export growth as their production exceeds domestic demand.

Appendix: The Data and Their Sources

The data series are all seasonally adjusted at source (with the exception of Germany whose data are seasonally adjusted by BAK). Y_t is GDP (with the exception of the USA, where it is GNP). C_t is total private consumption and I_t is gross fixed business investment with the exception of Switzerland, where investment covers only equipment. Exports include goods and services (x_t). The following list gives the units and the source of data series:

USA	– bill. 1982 $; OECD, Quarterly National Accounts
Japan	– bill. 1980 yen; OECD, Quarterly National Accounts
West Germany	– bill. 1980 DM; OECD, Quarterly National Accounts
UK	– bill. 1985 £; OECD, Quarterly National Accounts
France	– bill. 1980 French franc; OECD, Quarterly National Accounts
Switzerland	– bill. 1970 Swiss franc; Basler Arbeitsgruppe für Konjunkturforschung (BAK)

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Zusammenfassung: Wachstum, Exporte und Ko-Integration. Eine empirische Untersuchung. – In diesem Aufsatz wird Johansens multivariate Ko-Integrationsanalyse auf vierteljährliche Daten für das BIP, den Konsum, die Investitionen und die Exporte von sechs Ländern angewandt. Es zeigt sich, daß in vier Fällen der Export keine ko-integrativen Beziehungen zu den anderen drei Variablen eingeht. Demgemäß gibt es keine starke empirische Evidenz für die Hypothese vom exportinduzierten Wachstum.

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Résumé: Accroissement, exportation et co-intégration: une analyse empirique. – L'application de l'analyse de co-intégration multivariate de Johansen aux données trimestrielles du produit national brut, de la consommation, de l'investissement et de l'exportation de six pays industrialisés indique qu'en quatre cas l'exportation n'influence pas les relations de co-intégration entre les trois autres variables. Par conséquence, l'évidence empirique ne supporte pas fortement l'hypothèse que la croissance économique soit stimulée par l'exportation.

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Resumen: Crecimiento, exportaciones y cointegración: una investigación empírica. – La aplicación del análisis de cointegración multivariado de Johansen al PBI trimestral, al consumo, a la inversión y a las exportaciones de seis países industrializados indica que en cuatro casos las exportaciones no forman parte de las relaciones de cointegración entre las tres otras variables. Por ello, no se obtiene evidencia empírica importante en favor de la hipótesis del crecimiento dirigido por las exportaciones.