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IS THE EXPORT-LED GROWTH HYPOTHESIS VALID FOR INDUSTRIALIZED COUNTRIES?

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Abstract—This paper tries to establish whether a causal link between exports and productivity exists for four developed market economies based on cointegration and Granger-causality techniques. These techniques allow serious problems encountered in previous attempts to examine this relationship to be overcome, while recent trade theory suggests that the relationship between trade and productivity is fundamentally ambiguous. The findings of the econometric analysis suggest that an "outward-looking" regime favours the productivity performance of developed market economies as well as that of developing countries.

I. Introduction

CASUAL inspection of exports and productivity in developed market economies reveals that these two time series move together. Countries which do well in their export performance seem also to do well in their productivity performance and vice versa. What is the nature of this link? Does the comovement between exports and productivity reflect only a growth accounting identity—exports are a component of GDP—or a real causal link?

The paper tries to answer this question for four developed market economies (United States, Japan, United Kingdom, and Germany) based on the cointegration and causality approach recently developed. The former allows study of whether exports and productivity share a common trend so that they can be considered a long-run equilibrium relationship which holds except for a stationary stochastic error (short-run deviations). The causality analysis in turn allows examination of whether a causal link is present between these two variables. More specifically, the test is based on the criterion whether movements in exports help to predict movements in productivity, e.g., whether exports "Granger-cause" productivity.

The paper is divided in five sections. Section II states that the exports–productivity link requires reexamination in face of new developments in econometric techniques on the one hand and new insights in trade theory on the other. The new technique allows us to tackle the serious problems encountered in previous attempts to examine the relationship, while recent trade theory suggests the relationship between trade and productivity to be fundamentally ambiguous. Thus, the subject calls for more empirical evidence. Section III describes the methodology and characterizes the time trend and unit root properties of the data while in section IV the various causality tests are performed. Finally, section V summarizes the results and suggests a tentative policy conclusion.

II. Exports and Productivity

The idea that trade might influence productivity is not new. The hypothesis of "export-led growth" sees the growth of exports as having a stimulating influence across the economy as a whole in the form of technological spillovers and other externalities. Exports might exert these externalities because export industries are seen to be prime candidates to lead for various reasons: exposure to international markets calls for increased efficiency and provides incentives for product and process innovation, the increase in specialization allows the exploitation of economies of scale. The idea is that exports can be seen as economies of scale that are external to the firms in the non-export sector but internal to the economy as a whole. Larger exports will contribute to the stock of knowledge and human capital in the economy thereby benefiting all firms. Thus, the hypothesis predicts that the rate of export growth will cause economy-wide productivity gains.[1]

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[1] For the different types of economies of scale see Helpman/Krugman (1985). See also Romer (1986) who introduces external economies of scale in a neoclassic growth model through the externality of the economy's capital stock. In Romer's model the output level of an individual firm depends not only on its stock of capital, but on the economy's capital stock. The hypothesis of export-led growth can be thought of in a framework like Romer's but shifting the externality from capital to exports.

In spite of the fact that the export-led growth hypothesis has originally been put forward for developed market economies, previous studies have confined empirical testing of the hypothesis to countries with low or middle per capita income (see Balassa, 1978; Feder, 1982; Kormendi and Meguire, 1985).[2] Since there is no a priori reason why the relationship should be valid only for countries defined by some development criteria, I will look at developed market economies with Japan and Germany as cases of relatively favourable productivity and export growth rates and the United States and United Kingdom as countries with relatively less favourable records in export and productivity.

Previous attempts to examine the relationship were based on cross country correlations between exports and GDP (or productivity). This empirical approach involves, however, the problem that the correlation is not very informative since it is not clear whether the result reflects primarily that exports are a component of the product or a real causal link as is suggested by the hypothesis. Another empirical treatment is therefore required.[3]

Trade theory kept mostly silent until recently on the relationship between trade and technical efficiency (as opposed to allocative efficiency). In the "new" trade theory technical efficiency and trade becomes a central link.[4] Unfortunately, however, the effect of trade on technical efficiency is not conclusive in models of imperfect competition and increasing returns to scale. The trade effect will depend on the type of competition assumed on the domestic market, on whether entry and exit is relatively frictionless and on whether the market structure will change in response to a trade disturbance in a way that is conducive to improvements in productivity and technical efficiency. In order to see the crucial role of entry for the productivity outcome, consider the following case. Suppose firms produce with increasing returns to scale which result from the existence of fixed costs for product development. Firms producing differentiated goods engage in monopolistic competition under free entry so that domestic price equals average costs since firms cannot make excess profits. With increasing returns to scale, average costs are a declining function of firm-level output. In such an environment an export expansion (however brought about) will allow domestic firms to sell larger quantities at the initial price, making in turn an increase in prices and an expansion of production profitable. This means that activities which were operating at an inefficiently small scale have been expanded, thus increasing average productivity. However, increased profitability of home production increases the returns to product development thereby inducing entry into the market. Induced entry of firms producing additional varieties will reduce the demand of the incumbent firms thereby forcing them to contract output. Whether output per firm and thus productivity rises or declines will depend on which of the opposing forces dominates. One possible outcome is the co-existence of too many firms, producing too many varieties of products. Thus an export expansion might crowd in too many firms producing at too low levels of output which might dampen or reverse the original export induced productivity increase.[5]

Whether a trade expansion will enhance/retard productivity growth will also depend on the competitive conditions on the domestic market as can be seen by the following example. Suppose firms on the domestic market face oligopolistic competition and behave in a Bertrand (price setting) fashion. Incumbent firms could increase profits by committing themselves to lower sales, since some of their profits are wasted by "excessive" competition. One credible committment to less agressive behavior is the choice of outdated or costly technology. Collusion is facilitated by maintaining costs artificially high. The profits to the firms from a greater degree of collusion can outweigh the losses in productivity. How does an export expansion affect the technological choice in such a framework? As the level of exports increases, excess profits of domestic firms in-

[2] An exception in this is Helpman and Trajtenberg (1987) who find that exports influence the growth potential of countries regardless of their ranking in terms of per-capita income.

[3] Feder (1982) and Helpman and Trajtenberg (1987) use a fully specified growth equation, in which the role of exports is modelled explicitly so that in their analysis the export variable has a clear structural interpretation.

[4] See Helpman and Krugman (1985) for the integration of trade theory with increasing returns to scale.

[5] See Flam and Helpman (1987) for the conditions for output per firm to rise in response to industrial and trade policy. The importance of entry/exit for the quantitative welfare effects of trade liberalizations (restrictions) is also confirmed by simulation experiments (see Venables/Smith (1986), Baldwin/Krugman (1986)).

crease as well. This will, in turn, reemphasize the strategic motive for under-investment in technology, since the potential payoffs to a strategy of high costs rise. Thus, an export expansion will lead to lower productivity growth, as long as a firm's strategic behavior is conducive to an increase in costs. The export-productivity result is, however, not robust to changes in competitive behavior, since it relies on the assumption that firms compete "too agressively." The productivity outcome will be reversed if firms behave in a Cournot (quantity setting) fashion. Then strategic incentives will work to enhance productivity. There will be over-investment in technology as firms would like to precommit themselves to a larger scale of output. By raising profits, an export expansion will reinforce the strategic motive for over-investment, thereby increasing productivity.[6] The example illustrates how the export induced productivity effect will depend on the type of competition assumed on the domestic market. It also shows how innovation might be related to market structure.[7]

To summarize, I conclude that the arguments given in this section suggest exports cause productivity. The sign of the causal impact is, however, ambiguous. Exports are supposed to cause productivity gains the smaller the country is and the less entry occurs. In small countries it is more likely that minimum efficient scale is large relative to the home market size, indicating that the potential for exports to allow the exploitation of economies of scale is large. Furthermore, productivity gains in response to an export disturbance are more likely if tougher competition induced by entry of new firms will on the one hand lead to the exit of uncompetitive firms and to an increase in X-efficiency and will create an incentive to invest in R&D on the other. Whether exports will cause productivity gains or losses can, in the end, only be decided empirically.

Empirical research on the new trade issues has proved to be a challenging exercise. Since data requirements are very demanding and the adequate data not yet easily available, econometric estimation and hypothesis testing have been precluded until now. Empirical studies have, therefore, employed calibration experiments. The method makes assumptions about economic behavior and uses econometric estimates and industry case studies to measure key behavioral parameters and then infers missing parameters by making the assumed behavior and one period's data mutually consistent (see Baldwin and Krugman (1986), Venables and Smith (1986), Cox and Harris (1985)).

I will take a quite different route in order to explore the export-productivity relationship. Based on aggregate data I will employ VAR techniques which are commonly used in applied macroeconomics (see Sims (1980), Stock and Watson (1987)). The VAR technique differs considerably in its philosophy from calibration methods. Calibration is theory-driven, while VAR is data driven. The theory-driven feature of calibration comes from maintaining economic behavior (such as, e.g., mark-up pricing) to be true for the purpose of the empirical analysis and making the data consistent with the assumed behavior. The data-driven feature of VAR comes from letting the data "speak" without imposing too many theory-induced a priori restrictions and then looking at whether or not the data are consistent with what the theory implies. One way theory comes in is in the choice of variables included in the time series analysis.[8] Both techniques seem not to be adequate for testing theories because the former assumes that the model is true and makes the data consistent with it, while in the latter many models might be consistent with the data.

III. Trend Properties of the Data

In order to explore the comovement of exports and productivity I begin by characterizing the time trend and unit root properties of the data included in the analysis since the neutrality and

[6] For the argument in the context of trade policy see Rodrik (1988).

[7] The relationship between market structure and innovation is one of the oldest concerns in the industrial organization literature. It deals with the question of whether more or less competition will be more conducive to R&D and innovation (see Kamien/Schwartz (1982)). Recently, there have been attempts to analyse the role of trade in this relationship (see Grossman and Helpman (1991)). In this literature openness to trade has an ambiguous effect on growth. Openness means that the monopoly profits of domestic firms are extended to a larger market creating an incentive to invest in R&D. But it also means fiercer foreign competition which may choke off domestic investment opportunities.

[8] The data-driven feature of VAR is controversial (see Leamer (1985) and Cooley/Le Roy (1985)).

TABLE 1.—TESTS FOR INTEGRATION
1960.1–1987.2

Series	Germany DF	Germany ADF	United Kingdom DF	United Kingdom ADF	United States DF	United States ADF	Japan DF	Japan ADF	DF	ADF
					A. Single Unit Root					
x	−1.6	−1.6	−0.29	−0.22	−0.86	−0.82	−2.9	−2.4		
pr	−1.3	−1.3	−1.5	−1.5	−0.15	−0.11	−1.9	−1.5		
tot	−1.8	−2.4	−1.2	−2.3	−0.94	−0.99	−1.3	−2.0		
q									−3.1	−2.1
					B. Second Unit Root					
Δx	−10.0	−5.4	−13.6	−3.8	−12.3	−3.3	−5.7	−3.9		
Δpr	−10.9	−5.0	−9.7	−3.7	−8.8	−4.2	−8.1	−5.6		
Δtot	−8.3	−4.7	−7.2	−5.3	−7.1	−5.2	−6.2	−5.2		
Δq									−4.7	−4.7

Notes: DF, ADF-Dickey-Fuller and Augmented Dickey Fuller Test: $\Delta z_t = \beta z_{t-1} + \Sigma_{j=1}^{p} \delta_j \Delta z_{t-j} + e_t$ with $p = 0$ for DF and $p = 4$ for ADF Critical values for the tests at the 1% and 5% significance level, respectively, are −4.07 (DF), −3.77 (ADF), and −3.37 (DF), −3.17 (ADF)

causality tests are sensitive to unit roots in the series (see Sims, Stock and Watson (1986)). The data consist of quarterly observations on the log of exports of manufacturing goods (x), the log of labour productivity (manufacturing output per employee) (pr), the log of the terms of trade (export unit value divided by import unit value for manufacturing goods in local currency (tot), and the log of OECD output at constant prices (q). Since all variables are treated as endogenous in a first stage, OECD output and the terms of trade are included in the time series analysis in order to control for export growth which results either from price competitiveness or from growth in the world economy. The terms of trade is also supposed to detect possible linkages of the real exchange rate (and possible effects of trade policy in the form of tariff and non-tariff barriers if they are reflected in the terms of trade) and productivity; a link much stressed by the literature on the "new" trade issues and by the "hysteresis" model of trade (see Baldwin and Krugman (1986)).

A. *Testing for Integration*

A key step in understanding the comovement of exports and productivity is to find out first whether each of the series contains a stochastic trend and second whether they share a common stochastic trend. The former is called a test of whether a series is integrated of order d $I(d)$, while the latter refers to a test of whether two or more variables are cointegrated.

A variable is said to be integrated of order one $I(1)$ if it must be differenced one time to be stationary.[9] To test for integration the following regression is formed:

$$\Delta z_t = \beta z_{t-1} + \sum_{j=1}^{p} \delta_j \Delta z_{t-j} + e_t \qquad (1)$$

where p is selected to be large enough to ensure that the residual e_t is empirically white noise. The test statistic is the ratio of $\hat{\beta}$ to its calculated standard error obtained from an OLS regression. The null hypothesis is H_0: $z_t \sim I(1)$, that is, z_t is not stationary in levels. The null is rejected if β is negative and significantly different from zero. The test statistic does not have a t-distribution under the null, because of the theoretically infinite variance of z_t, but tables of significance levels have been provided by Fuller (1976).

Table 1 investigates the possibility that the series x, pr, tot, and q might have up to two unit roots for Germany, the United Kingdom, the United States, and Japan. The first block presents the Dickey-Fuller tests (with $p = 0$) and the Augmented Dickey-Fuller tests (with $p = 4$) for a single unit root. In no case is there significant evidence against the unit root hypothesis. Thus, the null hypothesis that the series are not stationary in levels cannot be rejected. The block *B*

[9] A time series random variable is said to be stationary if its distribution does not depend on time. A variable that is integrated is said to have a unit root in its autoregressive representation. Thus, the statements "z_t has a unit root" and "z_t is integrated of order one" are equivalent.

shows the results of the Dickey-Fuller (1979) tests for a second unit root, i.e., for a unit root in the first difference of the series, allowing for the alternative that the series are stationary in first differences. According to these tests, no series contains two unit roots. In other words, since all series for the four countries have significant test statistics, the null hypothesis that the series are not stationary in first differences has to be rejected. Thus, exports, productivity, the terms of trade and OECD output appear to be $I(1)$, i.e., to contain a stochastic trend over the 1960.1–1987.2 sample, a feature that they share with most macroeconomic time series.[10]

B. *Testing for Cointegration*

Since all series appear to contain a stochastic trend the question arises whether they contain a common stochastic trend. If that were the case, then changes in the "trend" of, e.g., productivity observed in the early seventies would appear as shifts in exports (and the terms of trade and world output) as well, indicating that exports and productivity move together in the long run. Testing for cointegration is a way of testing the long-term relatedness between time series that have individually a unit root.

Two variables are said to be cointegrated of order one $CI(1,1)$, if they are individually $I(1)$, but some linear combination of the two is $I(0)$ (see Engle and Granger (1987)). In our case we want to test if there exists a linear combination of x and pr (with or without the inclusion of tot and q)

$$u_t = x_t - \alpha pr_t \tag{2}$$

which reduces the number of unit roots, implying that the low frequency components of x_t and pr_t would virtually cancel out to produce the mean-reverting so-called "equilibrium error" u_t. Hence, in order to test for cointegration between x and pr a test is required for whether or not u_t is stationary. If u_t follows an integrated process of order zero $I(0)$, it can be concluded that a long-run equilibrium condition holds for x and pr ($x - \alpha pr = 0$), except for a stationary disturbance u_t with finite variance. In other words, deviations from the long-run equilibrium condition will show mean reversal, even if there is not such a tendency in exports and productivity. If x and pr are cointegrated, the long-run elasticity of productivity with respect to exports can be estimated without specifying any dynamics and without deciding a priori the direction of causality, since both variables are endogenous and can be treated symmetrically.

In order to test for cointegration the "cointegration regression" (equation (2)) is estimated using OLS.[11] The null hypothesis of no cointegration is tested based on the Durbin-Watson statistic (CRDW), but testing whether CRDW is significantly greater than zero. An alternative way is to perform the Dickey-Fuller tests (DF, ADF) for the estimated residual u_t, assuming that a first order model is correct. All three tests are reported in table 2. The CRDW and DF indicate that the data fail to reject the null of non-cointegration at any significance level below 10% (the critical value at 10% for 100 observations of the CRDW is 0.322 and of the DF -3.03 as tabulated by Engle and Granger (1987)). For the German and Japanese data the ADF accepts cointegration at the 5% level while for the United Kingdom and the United States the ADF does not reject the null even at the 10% level (critical values of ADF are -3.17 and -2.84 at the 5% and 10% significance levels, respectively).[12]

Since cointegration between x and pr alone fails to be accepted for the four countries (at least on the basis of DF and CRDW) I proceed by including the terms of trade (tot) in the cointegrating regression. Apart from the United Kingdom, tests for cointegration among these three variables now reject the null that the series are not cointegrated, suggesting that the trivariate specifications have less unit roots than variables. Since the cointegrating vector constitutes an equilibrium, the tests should not give different

[10] When variables contain stochastic trends, as most macroeconomic series do, the distinction between "trend" and "cycle" becomes blurred. Changes in growth trends seem to be associated with some of the shorter "cyclical" swings in the series suggesting that there is an important connection between them (see Nelson and Plosser (1982) and Campbell and Mankiw (1987), and with respect to the export-productivity relation see Marin 1989)).

[11] If variables are cointegrated, OLS gives a consistent and efficient estimate of the cointegrating coefficient, as has been shown by Stock (1987).

[12] For the parameter estimates of the cointegration regression see Marin (1990).

TABLE 2.—TEST FOR COINTEGRATION
1960.1–1987.2

System	Unit Roots under Null and Alternative	DF	ADF	CRDW
	Germany			
x, pr	2 vs 1	−2.6	−3.2	0.25
x, pr, tot	3 vs 2	−2.9	−3.3	0.32
x, pr, tot, q	4 vs 3	−2.8	−3.3	0.30
pr, x	2 vs 1	−2.7	−3.3	0.25
pr, x, tot	3 vs 2	−3.0	−3.5	0.33
pr, x, tot, q	4 vs 3	−3.1	−3.8	0.44
	United Kingdom			
x, pr	2 vs 1	−1.4	−1.4	0.12
x, pr, tot	3 vs 2	−1.7	−1.7	0.14
x, pr, tot, q	4 vs 3	−1.6	−1.7	0.15
pr, x	2 vs 1	−1.2	−1.2	0.12
pr, x, tot	3 vs 2	−1.6	−1.6	0.15
pr, x, tot, q	4 vs 3	−1.5	−1.4	0.19
	United States			
x, pr	2 vs 1	−1.5	−2.5	0.09
x, pr, tot	3 vs 2	−4.0	−3.9	0.55
x, pr, tot, q	4 vs 3	−4.8	−5.2	0.71
pr, x	2 vs 1	−1.3	−2.5	0.09
pr, x, tot	3 vs 2	−3.4	−3.3	0.44
pr, x, tot, q	4 vs 3	−2.1	−2.2	0.24
	Japan			
x, pr	2 vs 1	−2.0	−3.8	0.16
x, pr, tot	3 vs 2	−3.1	−5.0	0.37
x, pr, tot, q	4 vs 3	−2.8	−4.6	0.31
pr, x	2 vs 1	−2.0	−4.0	0.16
pr, x, tot	3 vs 2	−3.1	−5.1	0.34
pr, x, tot, q	4 vs 3	−3.1	−4.6	0.33

Notes: CRDW-Cointegration Regression Durbin-Watson statistic, DF-Dickey-Fuller Test: $\Delta u_t = -\phi u_{t-1} + \epsilon_t$.

ADF-Augmented Dickey Fuller Test. $\Delta u_t = -\phi u_{t-1} + \Sigma_{j=1}^{4} b_j \Delta u_{t-j} + \epsilon_t$

Critical values for the tests in the 2 variable case at the 5% and 10% significance level, respectively, are 0.386, 0.322 (CRDW), −3.37, −3.03 (DF), −3.17, −2.84 (ADF), and in the 3 variable case 0.367, 0.308 (CRDW), −3.13, −2.82 (ADF)

results when the cointegrating equation is estimated in its different inversions. This is indeed confirmed by the data in the trivariate case, since the tests indicate cointegration (or fail to indicate as with UK data) independently of whether x or pr has been used as the dependent variable in the regression (see table 2).

The inclusion of OECD output q in the cointegration regression does not change the picture considerably. The DF, ADF, and CRDW tests have increased in some of the cases and declined in others. But again, the hypothesis that x, pr, tot and q are not a cointegrated vector has to be rejected for Germany, the United States and Japan, while it fails to be rejected for the United Kingdom. It is worth noting that in one of the cases (with U.S. data) the inversion of the regression failed to lead to consistent cointegration results. We nevertheless interpret that these four variables are cointegrated in the United States, since we could find at least one cointegrated vector.

Summarizing these results, all variables included in the analysis can be characterized as being $I(1)$, i.e., they have a single unit root. While pr and x alone do not share a common trend, (pr, x, tot) and (pr, x, tot, q) constitute a cointegrated vector in all countries except the United Kingdom. The sign of the long-run elasticities indicates that x, tot and q are positively related to productivity in the long run (not shown).[13]

IV. Causality Tests

Having characterized the trend properties of the data, we can now turn to their causal orderings. x is said to cause y if the forecast for y is improved (has a smaller mean square error) by using additionally the history of x than by using just the history of y alone (see Granger (1969)). This means that the hypothesis that x causes y can be examined by estimating

$$y_t = \left(\sum_{i=1}^{p} \theta_i L^i\right) y_t + \left(\sum_{j=1}^{z} \psi_j L^j\right) x_t + \epsilon_t \qquad (3)$$

and testing whether the $(\Sigma_{j=1}^{z} \psi_j L^j)$ are jointly significantly different from zero based on an F-test of the OLS regression.[14] The test requires that the disturbance term ϵ_t is close to being white noise which involves a careful choice of suitable values of p and z. The order of own lags (the value of p) has been estimated by the Bayesian information criterion (BIC), while 4 (6 or 8) lags have been included for the other variables in the VAR.[15] Besides the correct treat-

[13] For the long-run elasticities see Marin (1990).

[14] The concept of causality to which we refer is narrow, since it is based only on the zero restrictions in a VAR. For deeper interpretations of causality, predictability and exogeneity see Geweke (1984).

[15] BIC is defined as $\log \sigma_{pq}^2 + (p+q)\log T/\tau$ where σ_{pq}^2 is the estimated variance of the innovations in the ARMA process of order (p, q) and T is the sample size. The procedure searches over different values of p and q within a specified range until the criterion function is minimized.

ment of the lag structure the causality test requires mean zero stationary variables. Otherwise the F-statistics will have nonstandard distributions (see Sims, Stock and Watson (1986) who offer alternative test statistics when variables have unit roots).

Before turning to the empirical results, it is worth noting two points. First, all four variables included in the analysis appear to have a unit root. Second, the four variables constitute a cointegrated vector (excluding the United Kingdom) so that they can be seen to have been generated by an "error-correction" model as described by Engle and Granger (1987). This has three implications for the causality tests. First, the appropriate way to detrend the series is to take first differences (in our case fourth differences in order to get rid also of possible seasonality in the data) and by doing so they become mean zero, stationary variables. Second, the standard asymptotic distribution theory can be used to interpret the F-tests in the causality procedure, since all variables are mean zero stationary. Third, an error-correction term has to be included in the VARs in those cases in which the variables have common stochastic trends, which captures the extent to which the system is out of equilibrium. Moreover, cointegration between two or more variables is already sufficient for the presence of causality at least in one direction. That cointegration already implies causality seems somewhat surprising, since cointegration is concerned with the long-run and equilibrium, whereas causality refers to short-run forecastability. The intuition behind it is that for two or more series to have an attainable long-run equilibrium, there must be some causation between them to provide the necessary dynamics. If the error-correction term is not included in the VAR when the series are cointegrated, on some occasions one would not detect causation when it is, in fact, present (see Granger (1988)).

The results of the causality tests are presented in table 3. Four different specifications of the causality tests have been performed: with and without an error-correction term (ec) taking into account that the series are cointegrated; with and without the inclusion of a deterministic time trend

TABLE 3.—EXPORT-PRODUCTIVITY CAUSALITY TESTS: F-STATISTICS AND P-VALUES

$$\Delta x_t = f(\Delta x_{t-j}, \Delta pr_{t-j}, \Delta tot_{t-j}, \Delta q_{t-j})$$

	Germany			United Kingdom			United States			Japan		
Specification	x, pr	x, tot	x, q	x, pr	x, tot	x, q	x, pr	x, tot	x, q	x, pr	x, tot	x, q
const; Δz_t	0.97	4.3	2.62	0.13	2.7	0.91	0.63	1.34	1.4	2.2	5.8	2.5
	(43.02)	(0.32)	(4.08)	(96.9)	(3.9)	(46.6)	(64.5)	(26.2)	(25.1)	(7.1)	(0.04)	(4.85)
const; Δz_t; t	0.91	4.3	1.84	0.67	3.6	1.89	0.61	1.3	1.2	2.4	5.4	1.8
	(45.2)	(0.32)	(12.8)	(61.4)	(1.0)	(12.3)	(65.4)	(27.2)	(30.1)	(6.0)	(0.07)	(14.4)
const; Δz_t; ec	1.01	3.9	1.9	0'.32	2.4	1.1	0.78	0.78	0.89	2.0	3.84	2.6
	(40.9)	(0.56)	(11.7)	(86.6)	(5.5)	(36.4)	(54.2)	(54.4)	(47.6)	(10.4)	(0.65)	(4.06)
const; Δz_t; ec; t	0.99	3.9	1.38	0.94	3.1	1.72	0.78	0.78	0.89	2.2	3.2	1.77
	(41.9)	(0.59)	(24.9)	(44.6)	(2.2)	(15.6)	(54.3)	(54.2)	(47.4)	(8.2)	(1.8)	(14.3)

$$\Delta pr_t = f(\Delta pr_{t-j}, \Delta x_{t-j}, \Delta tot_{t-j}, \Delta q_{t-j})$$

	Germany			United Kingdom			United States			Japan		
Specification	pr, x	pr, tot	pr, q	pr, x	pr, tot	pr, q	pr, x	pr, tot	pr, q	pr, x	pr, tot	pr, q
const; Δz_t	3.25	1.72	3.1	4.82	3.01	3.22	3.5	1.5	0.18	2.54	0.94	2.53
	(1.58)	(15.4)	(2.0)	(0.17)	(2.39)	(1.76)	(1.1)	(21.4)	(94.8)	(4.6)	(44.6)	(4.6)
const; Δz_t; t	2.8	1.7	2.5	4.7	3.5	4.2	3.3	1.6	0.44	2.43	0.80	1.68
	(3.0)	(16.0)	(4.9)	(0.21)	(1.2)	(0.46)	(1.5)	(19.2)	(77.8)	(5.4)	(53.1)	(16.2)
const; Δz_t; ec	3.2	1.9	3.9	5.3	3.1	3.95	3.1	1.45	0.19	2.8	1.1	2.1
	(1.7)	(12.7)	(0.96)	(0.09)	(2.0)	(0.6)	(2.1)	(22.3)	(94.5)	(3.1)	(35.4)	(9.2)
const; Δz_t; ec; t	2.9	1.5	2.4	4.7	3.1	3.89	2.7	1.42	0.47	2.65	0.91	1.53
	(2.6)	(22.3)	(5.9)	(0.21)	(2.2)	(0.68)	(3.7)	(23.5)	(75.6)	(3.9)	(46.4)	(20.2)

Notes. p-values appear in parentheses. The p-value indicates the probability of obtaining an F-ratio at least as large as the test statistic under the null. A p-value smaller than 5 indicates rejection of the null of no causality at the 5% level.

allowing for the possibility that some of the series are stationary in first differences around a linear time trend.[16] Focusing first on the productivity equation at the lower part of table 3, exports appear to "Granger-cause" productivity in all four countries (independently of specifications) at either the 1% or 5% significance level. Thus, the inclusion of past information on x improves the forecast for pr. However, the quantitative impact of exports on productivity seems to be negligible as the sum of the coefficients of lagged exports in the productivity equations indicate. They range between -0.13 and 0.03 with positive signs for Germany and negative ones for the three other countries (not shown).[17]

The predictive role of the terms of trade for productivity finds support only for the U.K. data with improvements in the terms of trade (an increase in the real exchange rate) dampening productivity. The sum of the estimated coefficients vary between -0.15 and -0.22 depending on specifications. That increases in the real exchange rate retard productivity growth seems also to be the case in the other countries, although the effect is not statistically significant below the 10% level (the p-values range between 12.7 and 53.1 depending on specification and country).

Looking at the relation between pr and q, the null hypothesis of no causality has to be rejected except for the United States and possibly Japan. While the sum of the coefficients of lagged OECD output is positive in Germany and Japan, the sign is negative for the United Kingdom and the United States. That there is an independent causal linkage between OECD output and productivity not mediated via exports, might be an indication of international increasing returns to scale as described by Ethier (1979) in which productivity of an industry depends on the size of the world market rather than the domestic market as long as middle products are traded.

Focusing next on the export equations at the upper part of table 3, one finds a predictive role of the terms of trade (price competitiveness) for exports (x, tot) in all countries except the United States at either the 1% or 5% significance level. Productivity is Granger causing exports (x, pr) only in Japan (at the 10% level), and the inclusion of lagged OECD output improves the forecast of exports (x, q) in Japan only.

It is worth noting that the specification does matter for the causality test results. The inclusion of the error-correction terms and/or the time trend have changed the p-values and F-statistics considerably in most cases, although the basic results do not depend on the specification. It almost never happened that one specification rejected the null of no causality, while another specification failed to do so (except for (x, q), (pr, q) in Germany and Japan).

Since export disturbances might take some time until they affect productivity as the productivity effect is supposed to take place via changes in market structure, I have increased the number of lags of export growth from four to eight (for the U.S. and Japanese data) and from four to six (for the U.K. and German data) in order to account for longer-term influences. In all countries, upon increasing the number of lags of exports, the sum of the estimated coefficients $\Sigma\hat{\beta}_{zz}$ remains more or less the same (shown in the bottom part of table 4). In contrast, increasing the export lag length sharply changes the Granger causality F-tests.[18] Now, exports Granger cause productivity only at the 10% level in Germany and Japan, while the F-statistics have become much larger for U.S. data and have remained the same only for the United Kingdom. Thus, the general result that exports cause productivity remains valid. Focusing on the terms of trade–productivity link, it appears that, besides the United Kingdom, the terms of trade has become now a predictive role for productivity in the United States as well (even at the 1% significance level). The causal linkage between OECD output and productivity has become weaker in Germany (but still remains significant somewhat around the 5% level) and has become stronger in Japan (it is now significant at the 5% level).[19]

[16] When regressing the first difference of each of the series against a constant, time and four of its own lags the t-statistics on the time trend have been significant for OECD output and Japanese exports suggesting that q and x-Japan may be well described by a single unit root and a quadratic time trend.

[17] For the neutrality tests as measured by the sum of the coefficients see Marin (1990).

[18] Different results for longer-term influences based on a subset model approach were obtained by Kunst/Marin (1989).

[19] The stronger causality results for some of the variables when the lag length of exports is increased stand in contrast to the money-income causality results obtained by Stock and Watson (1987).

TABLE 4.—EXPORT-PRODUCTIVITY CAUSALITY AND NEUTRALITY TESTS
$\Delta pr_t = f(\Delta pr_{t-j}, \Delta x_{t-j}, \Delta tot_{t-j}, \Delta q_{t-j})$

6 or 8 lags of x and 4 lags of tot and q

Specification	Germany			United Kingdom			United States			Japan		
	pr, x	*pr, tot*	*pr, q*	*pr, x*	*pr, tot*	*pr, q*	*pr, x*	*pr, tot*	*pr, q*	*pr, x*	*pr, tot*	*pr, q*
					A. Causality Tests: *F*-statistics and *P*-values							
const; Δz_t	1.81	1.12	2.49	4.05	3.78	3.78	3.74	3.72	0.60	1.67	0.88	3.28
	(10.77)	(35.25)	(4.98)	(0.17)	(0.82)	(0.82)	(0.10)	(0.80)	(66.64)	(11.92)	(47.95)	(1.55)
const; Δz_t; *ec*	1.99	0.84	2.65	3.76	2.9	3.40	3.64	3.85	0.57	1.85	0.99	2.59
	(7.77)	(50.41)	(5.48)	(0.30)	(2.78)	(1.42)	(0.12)	(0.66)	(68.31)	(8.94)	(42.02)	(4.32)
					B. Neutrality: $\Sigma\hat{\beta}_{zz}$							
const; Δz_t	0.01	−0.02	0.18	−0.14	−0.19	−0.01	−0.12	−0.22	−0.09	0.01	−0.03	0.28
const; Δz_t; *ec*	−0.08	−0.01	0.20	−0.14	−0.23	−0.01	−0.13	−0.21	−0.10	0.01	−0.04	0.25

Notes. For the United States and Japan 8 lags of Δx and for the United Kingdom and Germany 6 lags of Δx have been included $\Sigma\hat{\beta}_{zz}$ denotes the sum of the 8, 6 and 4 lags, respectively, of the estimated coefficients

Summarizing these results, in all countries, labour productivity is Granger-caused by exports, independent of specification and lag length. The sum of coefficients of lagged exports is, however, not much different from zero (between −0.14 and 0.01), indicating that the quantitative effect of exports on productivity is not great. Causality from the terms of trade to productivity has been identified for the United Kingdom and the United States (depending on lag length of exports) with deteriorations in the terms of trade (devaluations of the real exchange rate) favouring productivity (the sum of coefficients of lagged *tot* is around −0.20). With the exception of the United States, in all other countries a direct causal link from OECD output to productivity has proved to be statistically significant (independently of specification and lag length) with increases in OECD output improving productivity in Japan and Germany (with the sum of coefficients of lagged q ranging between 0.09 and 1.09 depending on specification and lag length) and tending to retard productivity in the United Kingdom (sum of coefficient estimates between −0.1 and −0.5). Additionally, price competitiveness Granger caused exports in all countries except the United States, OECD output in Japan and Germany only, while productivity Granger caused exports in Japan only.

V. Summary and Conclusions

This paper investigates the relationship between exports, productivity, the terms of trade and world output for four OECD countries based on the cointegration and causality concept. The findings of the econometric analysis can be summarized as follows. Exports, productivity, and the terms of trade (with and without the inclusion of world output) share common trends, i.e., they move together in the long run in all countries except the United Kingdom. Furthermore, the causality *F*-tests suggest that exports Granger-cause productivity in all four countries. Based on these results, I conclude that the hypothesis of export-led growth cannot be rejected for the United States, Japan, United Kingdom and Germany. An "outward looking" regime seems to favour productivity performance of developed market economies as well and seems, therefore, not to be restricted to developing countries only as commonly asserted. The findings might also be an explanation for the favourable productivity performance in Japan and Germany and the relatively poor one in the United States and United Kingdom. Exports seem to have played a role here.

Moreover, the positive long-run relation between the terms of trade and productivity, and the significant causal link from the terms of trade to productivity in the United States and United Kingdom suggest that the terms of trade (the real exchange rate) has mattered for the productivity performance in these two countries. Interpreting this result, increases in the real exchange rate might have induced entry of foreign low-cost producers into the British and U.S. market leading to the exit of high-cost domestic producers giving rise to improvements in average productivity. If the number of firms declines as a result, the productivity effect might work via two channels: first, through the exit of low-productivity firms; second, through the scale effect of production, since the market share of the exiting firms is taken by the incumbent firms which might lead to increased output per firm. Output per firm will increase only, however, if price elasticities of exports are sufficiently low preventing overall output from declining substantially due to reduced exports. The story is consistent with the data. Whether it is, in fact, the right one cannot be decided on the basis of the empirical evidence presented.

Given these results for the United Kingdom and United States, the exchange rate might play a productivity enhancing role in two different ways. Either through devaluations of the real exchange rate boosting productivity via exports (the terms of trade as a proxy for price competitiveness has, however, a significant causal impact on exports in the United Kingdom only, but not in the United States), or through revaluations of the real exchange rate improving productivity through the rationalization of production of the import competing sector at the disadvantage of the export sector.[20]

And finally, world output proved to Granger cause productivity independently of exports in all countries except the United States which might be an indication of international increasing returns to scale in which productivity of an industry depends on the size of the world market rather than the domestic market.

[20] For inferences about policy effectiveness from the results of Granger-causality tests see Buiter (1984), Granger (1988).

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