Exports, Growth and Causality:An Application of Co-Integration and Error-correction Modelling

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I. Introduction

The relationship between export expansion and economic growth has been examined extensively during the last two decades in the context of the suitability of the alternative development strategies. In particular, the academics and policy makers exhibited increased interest in the relative merits of export promotion versus import substitution development strategies. The decade of the 1970s witnessed an emerging consensus in favour of export promotion as development strategy. Such a consensus was based on the following facts. Firstly, higher export earnings working through alleviating foreign exchange constraints may enhance the ability of a developing country to import more industrial raw materials and capital goods which, in turn, may expand its productive capacity. Secondly, the competition in export markets abroad may lead to exploitation of economies of scale, greater capacity utilization, efficient resource allocation, and an acceleration of technical progress in production. Thirdly, given the theoretical arguments mentioned above, the observed strong correlation between exports and economic growth was interpreted as empirical evidence in favour of export promotion as development strategy.

The empirical evidence in favour of export promotion rests on the general approach where real growth is regressed on contemporaneous real export growth and the significance of the export growth coefficient support the proposition that export growth causes output growth. Balassa (1978), Feder (1982), Fosu (1990), Kavoussi (1984), Tyler (1981) and Ram (1985) have followed such approach.[1] Khan and Saqib (1993), on the other hand, examined the relationship between exports and economic growth by constructing a simultaneous equation model comprising of equations for exports and economic growth. They found a strong association between export performance and GDP growth for Pakistan and that more than 90 percent of the contribution of exports on economic growth was indirect in nature.

The above studies, though contribute significantly in explaining the relationship between exports expansion and economic growth, it would be inappropriate to characterize such finding as one in which export promotion has induced growth.[2] Such an answer can be found by examining the direction of causation between exports and economic growth. Discovering the direction of causation has important policy implications for development strategies. If a definite unidirectional causality running from exports expansion to economic growth is found, then it will lend credence to the export-led growth strategy. If the direction of causation is running from economic growth to exports then it would imply that higher level of economic activity is a prerequisite for developing countries to expand their exports. If the causation is of the bidirectional nature

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[1] Michaely (1977) and Balassa (1978) used simple Spearman rank correlation to measure the relationship between exports and economic growth.

[2] Jung and Marshall (1985) have pointed out that by specifying a structural model which contains all of the posited theoretical relationships one can obtain structural estimates of the various effects which will be more akin to discovering the direction of causation between exports and economic growth. Khan and Saqib (1993), to some extent, come closer to this view point.

then it would imply that exports and economic growth have a reciprocal relationship. Finally, if there is no causality between exports and economic growth then alternative strategies rather than export promotion may be needed to structurally transform the developing countries.[3]

Because of its direct relevance to the choice of alternative development strategies, Jung and Marshall (1985), Chow (1987), Hsiao (1987), and Bahmani-Oskooee et.al. (1991) have investigated, using the Granger or Sims procedure, the direction of causation between exports and economic growth for many developing countries as well as developed countries of the Far East region. Their findings have been mixed ranging from one-way causality from exports growth to output growth to no causality. These studies suffer from two major shortcomings. Firstly, none of these studies have examined the cointegrating properties of the variables involved. The standard Granger or Sims tests are valid if the original time series are not cointegrated. If the time series are cointegrated, then any causal inferences are invalid.[4] It is, therefore, essential to check for the cointegrating properties of the original time series before subjecting them to test for causality. Secondly, most economic time series exhibit non-stationary tendencies and regression of one against other is likely to lead to spurious regression results. In the past, the concept of first differencing the series has been used to transform a non-stationary series into a stationary one. However, first differencing filters out low frequency (long-run) information.[5] To remedy this problem, the cointegration and error-correction modeling are recommended try Engle and Granger (1987). Error-correction models try

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[3] See Chow (1987)

[4] See Granger (1986)

[5] See Miller (1991) and Khan Ali (1994)

to establish causality between two variables after reintroducing the low frequency information through the error-correction terms into the analysis. To the best of our knowledge, Bahmani-Oskooee and Alse (1993) have examined the relationship between exports growth and economic growth for less developed countries by using Granger approach, taking into account the two major shortcomings just discussed above.

The present study examines the direction of causation between exports growth and economic growth in Pakistan using Granger Causality approach but at the same time taking care of the nonstationarity as well as cointegrating properties of the two series. To enrich our analysis we divide total exports into primary and manufactured exports and then examine direction of causation of these two categories of exports with economic growth separately. This study uses quarterly time-series data covering the period from 1972:II to 1994:II. As is well-known, the quarterly series for GDP are not available, therfore, these were calculated from the annual data by utilizing the methodology given in Khan and Raza (1989). The quarterly data for exports were taken from the various issues of International Financial Statistics of the IMF.

The rest of the paper is organized as follows: The methodology is discussed in section II and results are presented in section III. The final section contains concluding remarks.

II. Methodology

The traditional practice in testing the direction of causation between two variables has been to utilize the standard Granger (1969) framework. The notion of Granger causality is based upon the predictability of a time series. The basic idea is that if forecasts of Y using both past values of Y and past values of another variable X are better than forecasts obtained using past values of Y alone, then X is said to cause Y. More formally, if

$$\sigma^2 (Y/\bar{Y} , \bar{X}) \prec \sigma^2 (Y/\bar{Y})$$

then X is said to cause Y. The term $\sigma^2 (Y/\bar{Y},\bar{X})$ is the variance of the prediction error of Y based on the information set which includes past values of Y and X whereas $\sigma^2 (Y/\bar{Y})$ is the variance of the prediction error of Y based on the information set which includes past values of Y alone. Similarly if

$$\sigma^2 (X/\bar{X} ,\bar{Y}) \prec \sigma^2 (X/\bar{X})$$

then Y is said to cause X. Bidirectional causation occurs if the conditions:

$$\sigma^2 (Y/\bar{Y} ,\bar{X}) \prec \sigma^2 (Y/\bar{Y})$$

and

$$\sigma^2 (X/\bar{X} ,\bar{Y}) \prec \sigma^2 (X/\bar{X})$$

occur simultaneously. In this case causation is said to run bidirectional, i.e., from X to Y and from Y to X. The standard Granger causality test consist of estimating the following equations:

$$Y_t = \beta_0 + \sum_{J=1}^{m} \beta_J Y_{t-j} + \sum_{i=1}^{n} \alpha_i X_{t-i} + U_t \qquad ....(1)$$

$$X_t = \gamma_0 + \sum_{J=1}^{m} \gamma_J X_{t-j} + \sum_{i=1}^{n} \delta_i Y_{t-i} + V_t \qquad ....(2)$$

where U and V are mutually uncorrelated white noise series and t denotes the time period. Causality may be determined by estimating equations (1) and (2), and testing the null hypothesis that $\alpha_i = \delta_i = 0$ for all i's against the alternative hypothesis that $\alpha_i \neq 0$ and $\delta_i \neq 0$ for atleast some i's. If the coefficients α_i's are statistically significant but δ_i's are not, then Y is said to have been caused by X. The reverse causality holds if δ_i's are statistically significant while α_i's are not. But if both α_i and δ_i are significant, then causality runs both ways.

Recent developments in econometric techniques have highlighted atleast two major shortcomings to the application of the standard Granger causality test. First, the standard Granger causality test is valid if the original time series are not cointegrated. If the time series are cointegrated, then, as pointed out by Granger (1986), any causal inferences will be invalid. It is, therefore, essential to check for the cointegrating properties of the original time series before subjecting them to tests of causality. Hence, the conclusions reached by earlier studies using simple Granger causality test without taking into account the cointegrating properties are nullified. Second, most economic time series data such as exports and GDP, exhibit non-stationary tendencies and regression of one against other would lead to spurious regression results. In the past, the concept of first differencing the series has been used to transform non-stationary series into stationary. However, first differencing filters out low-frequency (long-run) information.[6] To remedy this problem, the cointegration technique and error-correction modelling are recommended [See Engle and Granager (1987)]. Error-correction models try to establish causality between two variables after reintroducing the low-frequency information through

[6] See Miller (1991) and Khan and Ali (1994)

the error-correction term into the analysis.

The present paper takes into account the above shortcomings and uses the amended Granger causality test to detect the direction of causation between two variables. The amended Granger causality test allows for a causal linkage between two variables stemming from a common trend. Such a linkage characterizes the long-run equilibrium alignment that persist beyond the short-run adjustments. Specifically, it considers the possibility that the lagged level of a variable Y may help to explain the current changes in another variable X, even if past changes in Y do not. The understanding is that if Y and X have a common trend, then the current change in X is partly the result of X moving into alignment with the trend value of Y.[7] Such causality may not be detected by the standard Granger test, which only investigates whether past changes in a variable help to explain current changes in another variable. The standard test may report one-way, reverse or two-way causality or no causality; however, the amended test rules out the possibility of no causality when the variables share a common trend, i.e., they are cointegrated.

Cointegration not only takes into account stationary properties of the variables being considered, but also examines whether both variables, X and Y, move together in the long-run, allowing for short-run deviations.[8] Cointegration requires that all variables are of the same order of integration. If a series has a finite mean and variance it is called integrated of order zero, and is denoted as I(O). If the series needs to be differenced once to become stationary, I(O), it is then called integrated of order one and is denoted as I(1).

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[7] See Miller and Russek (1990)

[8] For a detailed, discussion on the theory of cointegration, see Muscatelli and Hurn (1992) and Perman (1991).

In general, a series that is required to be differenced d times to become stationary is called I(d). If two series are I(d) and there exist a linear combination of those series which is I(b) with b<d, then the series are said to be cointegrated, denoted as CI(d, d-b). However, cointegration occurs if there exist a constant λ such that:

$Z_t = X_t - \lambda Y_t$ *is* $I(O)$, meaning the residual series (Z_t) is stationary. The logic is that "if X and Y are I(1) but move together in the long-run, it is necessary that Z_t be I(O) as otherwise the two series will drift apart without bound" [See Granger (1986)]. If X and Y are cointegrated then λ, the cointegrating parameter, must be unique in a bi-variate context.

The estimation of amended Granger causality test involves four steps. Step I includes the determination of the order of integration of the variables under consideration. Cointegration regression is estimated with the help of the Ordinary Least Squares(OLS) Method in step II, using variables having the same order of integration. In step III the stationarity of residuals (Z_t) is tested and the residual so obtained is used as error-correction term in step IV when amended Granger causality equations are estimated.

Step I: Testing for Order of Integration: First step towards estimation of the amended Granger causality equations is to determine order of integration of the variables under consideration. Two prominent procedures to determine the order of integration are: (a) Dickey-Fuller (DF) test and (b) Augmented Dickey-Fuller (ADF) test. The DF test is based on the regression: $\Delta X_t = \mu + \beta X_{t-1} + \varepsilon_t$, where X_t denotes the variable of interest and Δ denotes the difference operator; μ and β are parameters to be estimated. The null hypothesis (H_o) is: X_t is not I(O). The ADF test is based on the regression: $\Delta X_t = \mu + \beta X_{t-1} + \sum_{i=1}^{\tau} \gamma_i \Delta X_{t-i} + \varepsilon_t$ where τ is selected such that ϵ_t is white noise; μ, β and γ_i are parameters to be estimated. The cumulative distribution of the DF and the ADF statistics are provided by Fuller (1976). The DF and the ADF statistics are calculated by dividing the estimates of β by its standard error. If the calculated DF and ADF statistics are less than their critical values from Fuller's table, then the null hypothesis (Ho) is rejected and the series are stationary or integrated of order one, i.e. I(1).

Step 2: Cointegration Regression: In the second step we estimate cointegration regression using variables having the same order of integration. Cointegration regression for two variables X_t and Y_t is given as

$$X_t = \psi + \delta\, Y_t + Z_t \qquad (3)$$

$$Y_t = \alpha + \beta\, X_t + Z_t \qquad (4)$$

where ψ and α are constants and δ and β and are cointegrating parameters. Equations (3) and (4) are estimated with the help of the OLS method.

Step III: Testing Stationarity of the Residuals (Z_t): The residuals from the cointegration equations are recovered to perform stationarity test based on the following equations.:

$$(DF) \qquad \Delta\varepsilon = \phi_0 + \phi_1 \varepsilon_{t-1} + V_t \qquad (5)$$

$$(ADF) \qquad \Delta\varepsilon = \phi_0 + \phi_1\varepsilon_{t-1} + \sum_{t-1}^{K}\phi_j\Delta\varepsilon_{t-i} + V_t \quad ..(6)$$

where ϵ_t is the residual (Z_t) from the cointegration regressions (3) and (4). The null hypothesis of nonstationarity stands rejected if ϕ is negative and the calculated DF or ADF statistics is less than the critical value from Fuller's table. In other words, the existence of a long-run stable equilibrium relationship between the two variables are confirmed

Step IV: Amended Granger Causality Test: After establishing the fact that the two variables are cointegrated, the question as to which variable causes the other can be taken up. In this connection the standard Granger causality test is amended to incorporate the error-correction terms which are derived from the cointegration regressions. The amended Granger causality test is given as follows:

$$(1 - L)\, X_t = a_o + b_o\mu_{t-1} + \sum_{i-1}^{m} C_{oi}\,(1 - L)\, X_{t-i} + \sum_{i-1}^{n} d_{oi}\,(1 - L)\, Y_{t-i} + e_t \quad ...(7)$$

$$(1 - L)\, Y_t = \alpha_1 + b_1\acute{\mu}_{t-1} + \sum_{i-1}^{m} C_{li}\,(1 - L)\, Y_{t-i} + \sum_{i-1}^{n} d_{li}\,(1 - L)\, X_{t-i} + \acute{e}_t \quad ...(8)$$

where L is the lag operator and the error-correction terms μ and $\acute{\mu}$ and are the stationary residuals from cointegration equations (3) and (4) respectively. The error-correction terms in equations (7) and (8) introduce an additional channel through which causality can be detected. For example, in equation (7), Y is said to cause X not only if the d_{oi}'s are jointly significant, but also if b_o (the coefficient of error-correction term) is significant. Thus, in contrast, to the standard Granger test, the amended Granger causality test allows for the result that Y causes X, as long as the error-correction term bears a significant coefficient even if the d_{oi}'s are not jointly significant.[9]

III. Results

As stated earlier, the estimation of amended Granger causality test to determine direction of causation between exports and economic growth involves four steps as outlined earlier and the results are presented in the same order; except that the results of steps 2 and 3 are discussed together.

Testing for the Order of Integration: The degree of integration of each variable involved in our analysis is determined using both the DF and the ADF class of unit root tests. The results are reported in Table 1. In the level form both the DF and the ADF test statistics present mixed results and as such nothing definite can be said about the stationary properties of the variables involved in the analysis.

However, both the DF and the ADF test statistics reject the null hypothesis of non-stationarity for all the variables to be used in the amended Granger causality test at the 5 percent level only when the first differenced variables are used. This indicates that all the series are stationary in the first difference and are integrated of order 1, i.e. I(1).

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[9] See Granger (1988)

Table 1: Test for the Order of Integraton

Variables	Dickey-Fuller (DF)		Augmented Dickey-Fuller (ADF)	
	Without Trend	With Trend	Without Trend	With Trend
Log Y	0.05	-1.81	0.05 [1]	-1.84 [1]
Log X	-3.62*	-6.49*	-3.08 [1]	-6.90 [1]*
Log PX	-5.10*	-5.85*	-3.27 [1]	-3.60 [1]*
Log MX	-1.99	-7.65*	-0.81 [1]	-4.21 [1]*
(1-L) Log Y	-9.14*	-9.09*	-6.42 [1]*	-6.38 [1]*
(1-L) Log X	-10.88*	-10.82*	-10.51 [1]*	-10.44 [1]*
(1-L) Log PX	-15.92*	-15.87*	-8.92 [1]*	-8.97 [1]*
(1-L) Log MX	-18.08*	-17.98*	-8.02 [1]*	-7.98 [1]*

Note: Y = GNP in real terms
X = Total exports in real terms
PX = Primary exports in real terms
MX = Manufactured exports in real terms

- Critical value of DF and ADF statistics from the Fuller's tables are -2.89 and -3.46 respectively at the 5% level of significance

- Figures in parenthesis are the number of Lags used in the ADF test

* Signifiance at the 5% level.

Testing for Cointegration: The variables which have been tested for the order of integration and found to have the same order, are used to estimate cointegration regression both ways with the help of the OLS. Table 2 reports the results of the DF and the ADF tests applied to the residuals of the cointegration equations. Table 2 also reports the slope coefficients of the cointegration regression as well as Cointegration Regression Durbin-Watson (CRDW) statistic to be used in the discussion that follows. Table 2 shows that the calculated DF or ADF statistic for all the residuals except one, is less than its critical value at the 5 percent level. Therefore, with the exception of equation where real income is regressed against primary exports all the series are cointegrated which suggest that there exists a two way stable long-run equilibrium relationship between exports (and manufactured exports) and economic activity. However, in the case of primary exports a one way stable long-run equilibrium relation from economic activity to primary exports is found.

Table 2: Test for Cointegration

Cointegration equation	Slope	t-Statistics of Slop	R^2	CRDW	DF	ADF
Log X = f(log Y)	1.34	11.22	0.59	1.32	-6.51*	-6.87 [1]*
Log Y = f(log X)	0.44	11.22	0.59	0.79	-4.65*	-4.57 [1]*
Log PX = f(log Y)	0.72	5.57	0.26	0.97	-5.81*	-3.56 [1]*
Log Y = f(log PX)	0.37	5.57	0.26	0.26	-2.21	-1.07 [1]
Log MX = f (log Y)	1.88	25.58	0.88	1.55	-7.38*	-4.00 [1]*
Log Y = f(log MX)	0.47	25.58	0.88	1.37	-6.70*	-3.66 [1]*

Note: Y = Real GNP
X = Total real exports
PX = Real Primary Exports
MX = Real Manufactured Exports

- The Critical values at the 5% level of significance for the DF and the ADF statistics from the Fuller's Tables are -2.84 and -3.41 respectively.

* indicates the existence of cointegration relationship.

There is yet another way to check the stationarity of the residuals from the cointegration equations. Although Engle and Granger (1987) have recommended the use of the ADF test for its superiority yet for quick check they have also recommended the CRDW statistic. For the residuals to be stationary the CRDW must be significantly different from zero. If it approaches zero, the residuals are non-stationary. Table 2 shows that all the CRDW statistics are higher than the critical values at the 5 percent level with the exception of one.[10] Thus, the CRDW test confirms the stationarity of the residuals consistent with the DF and the ADF test. The positive signs of all the slope coefficients suggest that exports and GDP are positively related with each other. An increase in exports stimulates output which, in turn, increases exports. Because of the long-run stable relations that exist between these two variables the policy suggestion that stems out is that export promotion policies should contribute to higher economic growth in Pakistan.

Amended Granger Causality Test: As have already established that there exist a two way long run equilibrium relation between exports and output the question that remains to be answered is which variable Granger causes the other and provides the short-run dynamic adjustment toward the long-run equilibrium. In other word, the issue of the direction of causation is still remains to be answered. The answer, as discussed earlier, is provided by the estimates of the amended Granger causality test. The Granger causality test is implemented on first differences of the variable as stationarity is achieved in first differences of the actual data.

It is important to note that Granger causality test is highly sensitive to the choice of lag-length. In most cases, such lag lengths are arbitrarily assigned. We, however, follow Oxley (1994) and Giles et al. (1993) and determine the optimum lag length with the help of Akaike's Final Prediction Error (FPE).[11] The optimal lag selection involves

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[10] The critical value of the CRDW statistic in the vicinity of 50 observations is 0.78 at the 5 percent level. See Engle and Yoo (1987), table 4 for such statistics

[11] The FPE is defined as

$$FPE(n) - [(T + n + 1) / (T - n -1] [SSR/T]$$

where T is the number of observations, SSR is the sum of squared residuals, and n is the number of lags. If FPE (n+1) > FPE(n), then the n+1 lag is dropped from the model.

two steps. In the first step, one dimensional autoregressive process of, say X, is performed and the optimum lag length (n) is determined so that the FPE value is minimum. In the second step, keeping the lag length selected in the first step (n) constant, the other variable say Y is being manipulated and the optimum lag length is chosen on the minimum FPE value. The optimum lag length for each variable is reported in the square bracket of Table 3.

Using the optimum lag structure the amended Granger causality test is conducted and the relevant statistics are reported in Tables 3. A Cursory look at Table 3 is sufficient to see that bidirectional causality between exports growth and economic growth is found through both channels. What this result suggest is the fact that an increase in output growth will increase exports growth which, in turn, will increase output growth. Similar results are found i the case of manufactured exports growth and output growth. In the case of primary exports, though bidirectional causality is found through equation (3) the result is not as strong as in the cases of total and manufactured exports. Thus, a strong bidirectional causality between exports growth and economic growth is found in the case of Pakistan. We also found from Table 2 that there exists a long-run stable positive relationship between real exports and real GDP in both direction. The most important policy implications that stem out from our analysis are that export promotion policy must be vigorously pursued and that more emphasis should be given to manufactured exports to increase economic (output) growth in the country. These findings and policy implications are consistent with Khan and Saqib (1993) and Khan and Khanum (1994).

Table 3: Results of Amended Granger Causality Test

Equations	Dependent Variable	t-Statis. for EC_{t-1}	F-Statis. for $\Sigma(1-L)\log X_{t-i}$	F-Statis. for $\Sigma(1-L)\log PX_{t-i}$	F-Statistics for $\Sigma(1-L)\log MX_{t-i}$	F-Statistics for $\Sigma(1-L)\log Y_{t-i}$	Direction of Causation
$TEXP_t = f(TEXP_{t-i}, GNP_{t-i}, EC_{t-1})$	$(1-L)\log X_t$	-0.74 (-3.99)*	3.23 [3]*			2.22 [4]*	$Y \rightleftarrows X$
$GNP_t = f(GNP_{t-i}, TEXP_{t-i}, EC_{t-1})$	$(1-L)\log Y_t$	-0.64 (-2.89)*	3.16 [4]*			4.50 [3]*	$X \rightleftarrows Y$
$PEXP_t = f(PEXP_{t-i}, GNP_{t-i}, EC_{t-1})$	$(1-L)\text{Log } PX_t$	-0.20 (1.90)*		3.82 [4]*		5.77 [5]*	$Y \rightleftarrows PX$
$GNP_t = f(GNP_{t-i}, PEXP_{t-i}, EC_{t-1})$	$(1-L)\log Y_t$	-0.0014 (-0.51)		0.39 [5]		2.62 [4]*	$Px \nrightarrow Y$
$MEXP_t = f(MEXP_{t-i}, GNP_{t-i}, EC_{t-1})$	$(1-L)\log MX_t$	-0.53 (2.80)*			4.18 [7]*	5.53 [5]*	$Y \rightleftarrows MX$
$GNP_t = f(GNP_{t-i}, MEXP_{t-i}, EC_{t-1})$	$(1-L)\log Y_t$	-0.61 (2.69)*			5.04 [8]*	4.85 [4]*	$MX \rightleftarrows Y$

Note: EC denotes the error-correction term and numbers inside the parentheses are t-statistics
Numbers in square-brackets are the number of lags
*significant at the 5% level
TEXP = Total Exports (X)
PEXP = Primary Exports (PX)
MEXP = Manufactured Exports (MX)
GNP = Gross National Product (Y)

IV. Concluding Remarks:

The purpose of this paper has been to investigate the direction of causation between exports growth and economic growth. This issue has been widely investigated in the past in the context of the suitability of export promotion versus import substitution as development strategies. The traditional practice has been to utilize Granger causality test to examine the direction of causality. Recent developments in econometric techniques have highlighted atleast two shortcomings to the application of the standard Granger causality test. These include stationary properties of the series and cointegration of variables included in the analysis.

The present paper, while investigating the direction of causation between exports growth and economic growth using Granger causality test, has taken into account these two shortcomings. The paper finds a stable long-run two way relationship between exports (as well as manufactured exports) and output while one way stable relationship between output and primary exports. Furthermore, the paper also finds a bidirectional causation between exports (both primary and manufactured as well) growth and economic growth. Based on these findings it is recommended that export promotion policy with major emphasis on manufactured exports must be vigorously pursued to achieve a higher rate of economic growth.

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