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On the export-led growth hypothesis: the econometric evidence from China

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The export-led growth hypothesis is tested by estimating an augmented growth equation on the basis of times series data from China. The Granger no-causality procedure developed by Toda and Yamamoto (*Journal of Econometrics*, **66**, 1995) was applied to test the causality link between exports and economic growth in a VAR system. Three distinct features in this paper stand out compared to earlier studies on China: first, we have gone beyond the traditional two-variable relationship by building a VAR model in the production function context to avoid a possible specification bias; second, we follow Riezman, Whiteman and Summers (*Empirical Economics*, **21**, 1996) to test the export-led growth hypothesis while controlling for the growth of imports to avoid producing a spurious causality result; third, we test the sensitivity of causality test results under different lag structures along with the choice of optimal lags; in particular, the methodology developed by Toda and Yamamoto (1995) is expected to improve the standard F-statistics in the causality test process. The results indicate a bidirectional causality between exports and real industrial output in China in the 1987–1996 period. The export-led growth hypothesis, defined as a unidirectional causal ordering from exports to output, is therefore rejected in the case of China despite the positive contribution of exports on China's real output.

I. INTRODUCTION

The export-led growth hypothesis has been the subject of considerable research in the last two decades, yet the link between exports and economic growth which has been subjected to empirical scrutiny remains the subject of debate. The successful growth record of the so-called 'High-Performing Asian Economies' (HPAEs) has renewed interests in the export-led growth study[1] and often, exports is claimed as the 'engine of growth'. Three developments have added an additional twist to the literature on export-led growth study. First, the so-called 'new growth theory' has resulted in some reappraisal of the determinants of growth in modelling the role played by exports in the growth process; second, new developments in econometric theory, such as time series concepts of cointegration and causality testing, have further expanded the debate on the export-growth relationship; and finally, previous empirical studies have concentrated on the HPAEs and other developing economies, and most of them are smaller in size, so the question that whether the export-led growth model is valid in a large developing economy, such as China[2] was raised since rapid economic growth in China has been accompanied by persistent exports growth in last 10 years.

[1] The World Bank has concluded, in its several reports, that export growth and a trade-oriented policy are attributed to rapid economic growth in the HPAEs (World Bank, 1993).
[2] For example, see Xue (1995). Perkins and Syrquin (1989) pointed out some differences between large and small nations in adopting the export-led growth model, namely, (i) the larger the size of one country, the stronger the pressure on developing agriculture instead of foreign trade; (ii) the larger nations tend to have less need for overseas market for gaining economic efficiency; and (iii) the larger economies will have more variety of goods and services as well as a relatively more abundant resources thereby a lower requirement for trading with other nations.

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Therefore, was economic growth in China exports-led, or was it the other way around? The hypothesis can be further divided into three competing, although not mutualy exclusive, hypotheses: (1) the export-led growth hypothesis; (2) the growth-driven exports hypothesis; and (3) the two-way causal hypothesis, which is a combination of (1) and (2). The extent to which China fits into the above hypotheses is an issue we attempt to address in this paper.

This paper takes its motivations from these developments and contributes to the debate on the export-led growth hypothesis by constructing a six-variable Vector Autoregression (VAR) model for the Chinese economy. The study is based upon monthly time series data in a production function context. Three distinct features in this paper stand out compared to earlier studies on China: first, we have gone beyond the traditional two-variable relationship by building a VAR model in the production function context to avoid a possible specification bias; second, we follow Riezman *et al.* (1996) to test the export-led growth hypothesis while controlling for the growth of imports to avoid producing a spurious causality result; third, we test the sensitivity of causality test results under different lag structures along with the choice of optimal lags; in particular, the methodology by Toda and Yamomoto (1995) is expected to improve the standard F-statistics in the causality test process.

The paper progresses as follows: Section II provides the reader with a review of the empirical studies in the literature; Section III presents the model and data employed in this paper, Section IV offers the empirical results using the Granger no-causality test, and finally, Section V concludes.

II. A REVIEW

In an attempt to undertake an adequate review from an extensive empirical literature on the export-growth relationship, Table 1 presents a selective summary of the data, methodology and conclusions from a set of studies conducted between 1978 and 1996. A close look at Table 1 reveals some historical changes in previous studies in relation to the data set, econometric methodology and the theoretical foundations underlying the model that have been estimated.

Broadly speaking, the studies on the export-growth relationship can be categorized into two groups: (i) those based on cross-country data, and (ii) those based on time series data. However, in recent years an increasing number of studies have relied on time series data, as opposed to the cross section data analysis (see, e.g., Marin, 1992; Ghartey, 1993; Sengupta and Espana, 1994; Jin, 1995; Xu, 1996; Paul and Chowdhury, 1995; Dutt and Ghosh, 1996; Riezman *et al.*, 1996).

The main arguments against cross section data analysis and in favour of times series analysis have been that cross-country studies implicitly impose or assume a common economic structure and similar production technology across different countries which is most likely not true, and further, economic growth of a country is influenced not only by exports and other factors inputs, but also by host of domestic policies such as monetary, fiscal and external policies. Despite some developments in cross-section data analysis to improve the power of the test based on cross section data (e.g. Burney, 1996), the significance of the conclusion drawing from cross section data is still subject to some debate in finding a long run causal relationship in the data (see, for instance, Levine and Renelt, Marin, 1992; Enders, 1995).

Among time series data analysis, many researchers have directed the export-led growth studies towards the use of the Granger no-causality testing[3] procedure. However, one problem with these studies is their arbitrary choice of the lag length (see, for example, Jung *et al.*, 1985; Chow, 1987; Darrat, 1987; Ghartey, 1993). Furthermore, most of the studies have applied F-test statistics for the causality test (see for example, Chow, 1987; Marin, 1992; Paul and Chowdhury, 1995; Jin and Yu, 1996; Riezman *et al.*, 1996; Xu, 1996). It is now well established in the literature of econometrics that the F-test statistic is not valid if times series are integrated (e.g., if they are $I(1)$ variables) as argued by Enders (1995), Gujarati (1995), Toda and Yamamoto (1995) and Zapata and Rambaldi (1997).

As far as the model specification is concerned, some studies have utilized a simple two-variable relationship (e.g., Chow, 1987; Xu, 1996); some other studies have applied an export-augmented neoclassical production function, incorporating the influence of the so-called 'new growth theory'[4] to include other variables, such as education, technological change and energy consumption. It should be pointed out that the approach of using a simple two-variable framework in the causality test may be subject to a possible specification bias. It is established in the literature of econometrics that causality tests are sensitive to model selection and functional form (Gujarati, 1995; Xu, 1996).

In particular, Riezman *et al.* (1996) have pointed out an important finding that 'standard methods of detecting export-led growth using Granger-causality tests may give misleading results if imports are not included' (Riezman *et al.*, 1996; p. 7). Using a sample of 9 countries, and subsequently 126 countries, they found that 'imports may play the role of a confounding variable in causal ordering (i.e.,

[3] Granger (1981, 1988a, b) has introduced the concept of causality in the framework of bivariate VAR, defining Y is said to be Granger-caused by X if the information in past and present X helps to improve the forecasts of the Y variable.
[4] Some of the similar treatments incorporating new growth theory are Tyler (1981), Ram (1985), Fosu (1990), Ukpolo (1994) and Burney (1996).

imports affect both income and exports)' (1996, p. 90), and omitting the imports variable can result in a spurious rejection of export-led growth hypothesis as well as a spurious detection of it.

Another problem that has often been ignored and/or has not been dealt with properly in the literature, yet is far more important, is that exports, via the national income acounting identity, are themselves a component of output. This problem, as argued by Greenaway and Sapsford (1994a, p. 160) is due to 'the endogeneity of the export growth variable within an output growth equation'. Therefore, any studies which do not consider the endogenous nature of the growth process, to a large extent, are subject to a simultaneity bias and hence will yield unreliable conclusions as to the export-growth hypothesis.

Finally, as far as the studies on China are concerned, the literature is limited, and available empirical studies are very much in a similar fashion to the studies surveyed earlier, and most of them have proved to be weaker in terms of econometric methodology. Table 2 presents some selective works since 1990. The noteworthy studies are by Kwan and Cotsomitis (1991) and Kwan and Kwok (1995), who are the first to adopt Granger no-causality method in the case of China and examine the endogeneity assumptions of exports growth variable in an output growth equation. They concluded that exports variable is exogenous in the output growth equation and a unidirectional causality is found from exports to growth. Therefore, they support the export-led growth hypothesis in the case of China. Other studies have also have reached the same conclusion (see Table 2).

However, except Kwan and Kwok (1995), these studies have used traditional OLS estimation without testing the time series properties for the data and thereby suffer from the problems of invalid causal inference or a 'spurious regression' problem as well as the simultaneity bias. While Kwan and Kwok (1995) have made some progress in the econometric methodology, they have used F-test statistic which is an inefficient estimation when time series are integrated.

It is clear from the literature that the export-growth study should overcome the problems of simultaneity bias in a well-defined economic model and test the hypothesis using more recent econometric methodology.

III. THE MODEL AND DATA

The data

To undertake the analysis, we use Chinese time series data. Monthly seasonally adjusted data[5] over the period 1978:5–1996:5 ($T = 102$) was collected, in logarithm, for exports (*Exp*), industrial output (*Ind*), energy consumption (*En*), labour force (*Lab*), imports (*Imp*) and capital expenditure (*Inv*). Industrial output and capital expenditure were inflation-adjusted using CPI index. The data source is *China Monthly Statistics*, published by China Statistical Bureau and is detailed in Appendix A.

The model

Following the developments of the 'new growth theory', the export-growth relationship is to be tested by including exports, energy consumption and imports as arguments, besides other factor inputs, in the agregate production function, so:

$$Ind_t = f(Inv_t, Lab_t, En_t, Exp_t, Imp_t) \qquad (1)$$

where Ind_t, is real industrial output, Int_t, Lab_t, En_t, Exp_t, and Imp_t, respectively are capital, labour, energy inputs, exports and imports. Note that we have used real industrial output to approximate real GDP growth to avoid the income identity problem between GDP and exports as suggested by Greenaway and Sapsford (1994a).

We apply the Granger no-causality test methodology, developed by Toda and Yamamoto (1995) which was interpreted and expanded by Rambaldi and Doran (1996) and Zapata and Rambaldi (1997), to test the hypothesis that 'industrial output is Granger-caused by exports', versus the alternative hypothesis that 'industrial output has driven exports in China'.

The advantage of using Toda and Yamamoto's (1995) method of testing for Granger causality lies in its simplicity and the ability to overcome many shortcomings of alternative econometric procedures: some studies have applied the cointegration technique by Johansen and Juselius (1990). However, this method involves transforming the suggested relationship into an Error Correlation Model (ECM) and identifying the parameters associated with the causality. If the case involves more than two cointegration vectors, this is not practically simple. Further, there is growing concern among applied researchers that the cointegration likelihood ratio (LR) tests of Johansen (1988) and Johansen and Juselius (1990) have often not provided the degree of empirical support that might reasonably have been expected for a long run relationship. Furthermore, using a Monte Carlo experiment, Bewley and Yang (1996) argue that the power of LR tests is high only when the correlation between the shocks that generate the stationary and nonstationary components of typical macroeconomic series is sufficiently large and also that the power of LR tests deteriorates rapidly with over-specification of the lag length. This concern has also been supported by the simulation studies of Toda (1994) and Ho and Sorensen (1996).

[5] The data were originally in level forms and showed some seasonal trend and hence was deseasonalized following the method suggested by Pindyck and Rubinfeld (1991). The process is detailed in Appendix 1.

Table 1. *A selection of empirical studies on the export-led growth hypothesis*

		Methodology				
Study	Data set	Eco. growth	Export growth	Technique	Other variables	Conclusions
Balassa (1978)	Cross-section, 10 contries	GNP growth	Export growth or real export growth	Rank correlation, OLS Production function	Labour force growth domestic investment and foreign investment/output	Support for the hypothesis
Tyler (1981)	Cross-section 55 countries	GDP growth	Export growth	OLS, Production function	Labour force growth, investment/growth	Support for the hypothesis, Threshold efect
Feder (1983)	Cross-section 31 countries	GDP growth	Export growth or export change	OLS	Labour force growth, investment/output	Support for the hypothesis
Kavoussi (1984)	Cross-section 73 countries	GDP growth	Export growth	Rank corelation, OLS, production function	Labour growth, capital growth	Support for the hypothesis. Threshold effect
Balassa (1984)*	Cross-section 10 countries	GNP growth	Export growth	OLS, Production function	Labour force growth ratio to output of domestic investment	Suport for export-led growth hypothesis
Jung, Peton and Marshall (1985)	Time series 1950–81 37 countries	Real GNP (or GDP) growth	Lagged real export growth	Max. likelihood simultaneous linear functions Granger causality	Lagged GNP (GDP) growth	Little support for export growth causing economic growth
Moschos (1989)	Cross-section	Real GDP growth	Real export growth	OLS, production function	Labour force growth, real domestic investment growth	Support for export growth hypothesis threshold effect
Salvatore and Hatcher (1991)	Time series 1963–73, 1973–85; 26 countries	Real GDP growth	Real export growth	OLS, production function	Labour input growth, capital input growth and industrial growth	Support for export growth hypothesis
Ram (1985)	Cross-section 73 countries	Real GDP growth	Real export growth	OLS tests, allowed for heteroscedasticity	Labour force growth Investment growth	Suport for export growth hypothesis. Threshold effect
Darratt (1987)	Time series 4 countries 1955–82	Read GDP growth	Real export growth and lagged real export growth	OLS white test for causality	None	Rejection of the export-led growth hypothesis in 3 out of 4 cases
Kunst and Marin (1989)	Time series 1965(2)–85(4)	Labour productivity (manufacturing)	Nominal export	*F*-test for Granger causality in VAR system	Terms of trade, OECD ouput growth	Rejection of export growth hypothesis
Bahmani and Alse (1993)	Time series 1973(1)–88(4) 9 developing economies	Real GDP growth	Real export growth	ADF tests for cointegration *F*-test for Granger causality	None	Bidirectional causality between export growth and GDP growth
Ghartey (1993)	Time series 1960(1)–90(2) US, Taiwan, Japan	Nominal GNP	Nominal export	WALD-test for Hsiao's version of causality	Capital stock terms of trade in Japan's model. None for US and Taiwan	Rejection in US and Japan; support for the hypothesis in Taiwan

Marin (1992)	Time series UK, US, Japan and Germany 1960(1)–87(2)	Labour productivity growth (manufacturing)	Export growth (manufacturing)	ADF test for cointegration *F*-test for Granger causality	Terms of trade, OECD output	Support for the hypothesis
Sengupta and Espana (1994)	Time series Korea 1961–86	Real GDP growth	Real export growth	Engle and Granger causality augmented production function function with a two-section version	Labour force growth	Support for the hypothesis.
Ukpolo (1994)	Time series 1969–88 (annual data)	Manufacturing growth	Fuel export growth	Extended production function OLS regresion	Capital growth; Labour growth; Non-fuel prod. growth; C_p, C_p^*	Limited support for the hypothesis.
Greenaway and Sapsford (1994a)	Time series 14 countries (most are LDCs)	Real GDP growth excluding export	Real export growth	OLS regression 3 versions of production function	Capital growth Labour growth	Rejection of the hypothesis.
Jin (1995)	Times series 1976(2)–1993(2); 'four small dragons'**	Real GDP	Real exports	*F*-test for Granger causality with IRF[a], and VDC[b]; Engle and Granger cointegration; *ad hoc* VAR model	Real exchange rate; foreign price shock; foreign output shock	Bidirectional causality in SR and no cointegration in LR
Amirkhalkhali and Dar (1995)	Time series 1961–1990 23 LDCs	Output growth	Export	OLS; GLS production function	Input-output ratio; labour force growth	Support for the hypothesis***
Dutt and Ghosh (1996)	Time series 1953–91; 14 countries	Real GDP	Real exports	Engle and Granger cointegration; Two-variable relationship	None	Only 1/3 sample countries support for the hypothesis
Jin and Yu (1996)	Time series 1959(1)–92(3) US	Real GDP	Real exports	*F*-test for Granger causality with IRF and VDC; Engle and Granger cointegration; *ad hoc* VAR model	Real capital growth; labour growth; real exchange rate and foreign output stock	Rejection of the hypothesis
Xu (1996)	Times series 32 countries	Real GDP	Real exports	Engle and Granger cointegration; Two-variable relationship	None	Only 1/2 sample countries support for the hypothesis
Burney (1996)	Cross-section by income groups; continents 1965–90	GDP growth	Export growth	OLS and RC[c]; augmented production function	Labour growth; capital growth; energy consumption growth	Limited support for the hypothesis.
Riezman, *et al.* (1996)	Time series, 126 countries	Income growth	Export growth	Forecast error variance decomposition	Imports growth, human capital and investment growth	Limited suport for the hypothesis
Bodman (1996)	Time series Australia and Canada	Productivity growth	Export growth	Johansen's cointegration; two-variable relationship	None	Support for hypothesis.

Note: * Private consumption and government consumption respectively ** H. K, Taiwan, Korea and Singapore; *** their results are ambiguous since they found that there is no major difference between inward-orientated and outward-orientated economies. (a) Impulse response function; (b) Variance decomposition; (c) Random coefficients estimation.
Source: Greenaway and Sapsford (1994a), plus additions from the author.

Table 2. *A selection of empirical studies on the export growth study for China*

Study	Data set	Methodology				Conclusions
		Growth	Export	Technique	Other variables	
Zuo (1994)	Time series 1980–1993	Real GDP growth	Real export growth	Rank corelation, *ad hoc* model	None	Support for the hypothesis.
Kwan and Cotsomitis (1991)	Time series 1952–1985	Income growth (per capita)	Export share in GDP	Granger causality, *F*-test	None	Support for the hypothesis.
Lee (1994)	Time series 1984–1990	Income growth (per capita)	Export growth	OLS *ad hoc* model	Time trend, FDI and lagged income	Support for the hyp. while indicating regional difference
Xue (1995)	Time series 1980–1994	GNP growth	Export growth	Rank corelation, *ad hoc* model	None	Support for the hypothesis
Kwan and Kwok (1995)	Time series 1982–1985	Income growth	Export growth	Engle-Hendry Richard causality, OLS	Labour force, Investment/output ratio	Support for the hypothesis

Source: Author's survey.

Testing for Granger no-causality in multiple times series has been the subject of considerable recent research in the literature of econometrics. It has been argued that the traditional F-test in a regression context for determining whether some parameters of the model are jointly zero, e.g. in the form of a causality test (in a stable VAR model), is not valid when the variables are integrated and the test statistic does not have a standard distribution (see for example, Gujarati, 1995). Therefore, several alternative procedures have been developed attempting to improve the size and power of the Granger no-causality test (see for example, Mosconi and Giannini 1992, Toda and Phillips, 1993). Unfortunately, these tests are considerably cumbersome and 'the simplicity and ease of application have been largely lost' (Rambaldi and Doran, 1996, p. 1).

The procedure developed by Toda and Yamamoto (1995) utilizes a modified WALD test for restrictions on the parameters of a VAR(k), or MWALD procedure (where k is the lag length in the system). This test has an asymptotic χ^2 distribution when a VAR($k + d_{max}$) is estimated (where d_{max} is the maximal order of integration suspected to occur in the system). A Monte Carlo experiment which included the above three alternative test procedures, presented in Zapata and Rambaldi (1997), provides an evidence that the MWALD test has a comparable performance in size and power to the LR and WALD tests if (i) the correct number of lags for estimating $k + d_{max}$ is identified and (ii) no important variables are omitted, provided a sample of 50 or more observations is available.

Rambaldi and Doran (1996) have proved that the MWALD method for testing Granger no-causality can be computationally simple by using a Seemingly Unrelated Regression (SUR) which routinely can be computed by several of the available econometric packages, such as Shazam. We have therefore built the following six-variable VAR system in a SUR form:

$$\begin{bmatrix} Ind_t \\ Exp_t \\ Lab_t \\ Imp_t \\ Inv_t \\ En_t \end{bmatrix} = A_0 + A_1 \begin{bmatrix} Ind_{t-n} \\ Exp_{t-n} \\ Lab_{t-n} \\ Imp_{t-n} \\ Inv_{t-n} \\ En_{t-n} \end{bmatrix} + \begin{bmatrix} \varepsilon_{ind} \\ \varepsilon_{exp} \\ \varepsilon_{lab} \\ \varepsilon_{imp} \\ \varepsilon_{inv} \\ \varepsilon_{en} \end{bmatrix} \qquad (2)$$

The advantage of this procedure, as argued by Zapata and Rambaldi (1997), is that it does not require the knowledge of cointegration properties of the system. It has a normal standard limiting chi-square distribution and usual lag selection procedure to the system can be applied even if there is no cointegration and/or the stability and rank conditions are not satisfied 'so long as the order of integration of the process does not exceed the true lag length of the model' (Toda and Yamamoto, 1995, p. 225).

It should be added that, by using a VAR model, we can compromise between the theory-driven and the data-driven approaches,[6] since we have included the relevant set of variables in our VAR system following the recent literature of 'new growth theory', and at the same time, the simultaneity bias can be overcome by the VAR model. Gujarati (1995) points out that the VAR model is a truly simultaneous system in that all variables are regarded as endogenous considering the feedback effects in the system.

To examine the first causality (from exports to growth), we should test whether exp_{t-n}, appears in the first equation of the VAR system.

$$H_0\colon \alpha_{12}^{(1)} = \alpha_{12}^{(2)} = \alpha_{12}^{(3)} = \ldots = \alpha_{12}^{(n)} = 0$$

where: $\alpha_{12}^{(i)}$ are the coefficients of exports for 1, ... the nth lags in the first equation of the system (2).

The existence of the causality from exports to growth can be established by rejecting the null hypothesis, $\alpha_1 = \alpha_2 = \ldots = \alpha_n = 0$ (i.e. exports does not Granger-cause industrial output) which requires finding the significance of the MWALD statistic for the group of the lagged independent variables identified above.

The similar restrictions and the testing procedure can be applied to examine the second causality (i.e. growth to exports). This involves testing the following linear restrictions in the VAR system:

$$H_0\colon \alpha_{21}^{(1)} = \alpha_{21}^{(2)} = \alpha_{21}^{(3)} = \ldots = \alpha^{(n)} = 0$$

where: $\alpha_{21}^{(i)}$ are the coefficients of exports for 1 ... the nth lags in the second equation of the VAR system.

Thus we shall test whether Ind_{t-n}, appear in the second equation (the exp. equation). The existence of the causality from growth to exports can be established by rejecting the hypothesis of 'industrial output does not Granger-cause exports' which requires finding the significance of the MWALD statistic for the *group* of the lagged independent variables identified above.

IV. EMPIRICAL RESULTS

Prior to testing for a causality relationship between the time series, it is necessary to test for their order of integration and establish that they are integrated of the same order. To this end, Augmented Dickey-Fuller test (ADF) and Phillips-Perron test (PP) were carried out on the time series in undifferenced and differenced forms. The ADF tests involved two tests, namely the test including constant and trend and the test including constant but no trend. The number of the lags included was determined using Akaike Information Criteria (AIC) and Schwartz Criteria (SC).[7] The results are presented in Table 3 and they suggest that the time series are $I(1)$ variables at the 95% confidence level.[8]

After ADF test, we proceeded to the Granger causality test. The results are presented in Table 4 and they suggest that both null hypotheses of 'Granger no-causality from exports to growth' and 'from growth to exports' can be rejected at the 95% level, with a p-value of 0.048 and 0.0001 respectively in VAR(8) system for MWALD statistic(s). The sums of lagged coefficients for exports and growth are 0.03 and 0.02 respectively with the positive signs, indicating economic growth and exports affect each other positively[9] in the Chinese economy. These results suggest that there is a feedback effect in the system, or a bidirectional causality was found for the export-growth relationship in China. Therefore, the results reported here cannot offer the support, in the sense of a unidirectional causal ordering from exports to output for the export-led growth hypothesis.

Even though we have chosen AIC and SC to help in aiding the choice of the lag length,[10] we have estimated the model using several lag lengths to ensure that the results are not sensitive to the choice of the lag length. As Pindyck and Rubinfeld (1991, p. 217) point out that 'it is best to run the test for a few different lag structures and make sure that the results are not sensitive to the choice of m (lag length)'. Ghartey (1993) and Bahmani-Oskooee and Alse (1993, p. 540) have also warned of the danger of arbitrary choice of lag length, and one must 'select a strategy for choosing the optimum number of lags on each other when there is more than one independent variable' in a VAR model.

Table 4 indicates that the results are consistent with each other for different lag, thus we conclude that our results are robust or *sturdy*, in a similar sense of Leamer's Extreme Bound analysis (EBA),[11] avoiding a *fragile* statistical inference.

[6] There is a debate on choosing the theory-driven or the data-driven approach as the appropriate methodology in the literature of econometrics (see Cooley and Le Roy (1985) and Leamer, 1985). Marin (1992) argues that both techniques seem not to be adequate for testing theories, since 'the former assumes that the model is true and makes the data consistent with it; while in the latter many models, ..., let the data 'speak' themselves' (1992, p. 690).

[7] Not reported in this paper.

[8] The ADF results on the first differences of the variables (not reported here) indicate that an $I(2)$ specification at the 95% confidence level in all classes can be rejected.

[9] The coefficients are reference figures only as one must interpreted them carefully when a lengthy lag structure is involved in the VAR system as argued by Gujarati (1995).

[10] Both AIC and SC criterion are minimized for the 7th lag structure (i.e. the VAR order = 8).

[11] Leamer (1978, 1983) has discussed the importance of the model selection and model search in his EBA analysis in which, he distinguishes between *free* and *doubtful* variables. He suggested the construction of a range or a bound for the estimates from a set of different combinations of free and doubtful variables. The smaller the bound, the more robust for the estimates or a *fragile* inference will arise.

Table 3. *Unit root tests*

Variable	*ADF*[1] test 1[a]	*ADF*[1] test 2[b]	*PP*[2]	Order of integration
Industrial output	− 1.45(5)	− 2.99(5)	− 11.6(6)	$I(1)$
Exports	− 1.63(6)	− 2.34(6)	− 10.5(6)	$I(1)$
Imports	− 1.89(6)	− 2.25(6)	− 11.2(6)	$I(1)$
Investment	− 1.73(6)	− 3.06(6)	− 9.98(6)	$I(1)$
Labour force	− 1.68(5)	− 3.25(7)	− 11.9(5)	$I(1)$
Energy consumption.	− 1.72(7)	− 3.25(7)	− 11.9(5)	$I(1)$
Critical values[3] (at the 5% level)	− 3.45		− 18.2	

Notes: (1) The augmented Dickey-Fuller test; (2) The Phillip-Perron tests; (3) The critical values (for 100 observations) for the ADF tests are taken from Enders (1995, table A); The critical values for the Phillip-Perron tests are taken from Davidson and Mackinnon (1993). The numbers in parentheses for the ADF tests represent the number of lags included in the test regression to ensure white noise and the numbers in parentheses for the PP rests represent the choice of truncational lag length in the test. (a) The ADF test includes constant and trend; (b) the ADF test includes constant but no trend.

Table 4. *Results of Granger causality test*

H_0:	*Exp* does not cause *Ind*		*Ind* does not cause *Exp*	
Optimal lag (VAR order)	7(8)		7(8)	
P-values	0.048		0.0001	
Sum of lagged coeff.	0.03		0.02	
R^2	0.9455		0.9455	
Test statistic				
Lag structure (VAR order)	*P*-value	MWALD statistic	*P*-value	MWALD statistic
4 (5)	0.00895	11.585	0.0910	8.004
5 (6)	0.0353	10.159	0.1171	7.370
6 (7)	0.0501	10.010	0.0004	22.308
7 (8)	0.0480	10.102	0.0001	27.144
8 (9)	0.0060	12.013	0.0074	11.513
9 (10)	0.0121	14.785	0.0401	10.923

Note: *Ind* = Industrial output in real terms; *Exp* = Exports; *Lab* = labour force; *Inv* = total capital expenditure, *Imp* = import and *En* = total energy consumption. *Optimal lag length* is determined by AIC and SC. The results for other equations are not reported for the simplicity; VAR order = $k + d_{max}$, where: k is the lag length used in the system; d_{max} is the maximum order of integration in the system in our system, it is $I(1)$.

The finding that a bidirectional causality between growth and exports in the case of China, to some extent, is coincident with the conclusion of Ghartey (1993) that economic growth causes exports growth in a country if it is relatively close (measured by DOP-import share in GNP) and is endowed with abundant natural resource (measured by arable land given in hectares per 1000 persons, ANR). China's import share in GNP has been between 10%–20% in the 1980s to 1990s,[12] its natural resource was 816 in 1995.[13] These figures are very similar to those in the USA (16% for DOP and 876 for ANR[14]) where a two-way causality was found in the study by Ghartey (1993)

[12] Xue, (1995, p. 198).
[13] Based on *China Statistical Bureau* (1995, p. 4 and 1995, p. 59).
[14] Ghartey (1993, p. 1148).

Table 5. *Results of Granger causality test: comparison*

H_0:	P-values for MWALD (optimal VAR order)
Exp does not cause *Ind*	0.0465 (8)
Lab does not cause *Ind*	0.0325 (6)
Inv does not cause *Ind*	0.0103 (6)
Imp does not cause *Ind*	0.0389 (8)
En does not cause *Ind*	0.0105 (8)

Note: Variable definitions are the same as in Table 4.

compared to Taiwan where DOP was 47% and ANR was 58.88 in 1989. This is an indication that the direction of exports-growth causality is influenced by the degree of economic development and other demographic factors as argued in the literature.

Further, in order to test the exogeneity assumptions of export variable in the system, we chose to use the 'block exogeneity' concept suggested by Enders (1995). This involves testing the coefficients for all lags of exports variable being restricted to be equal to zero in the system (2); that is to test H_0: $\alpha_{ij} = 0$, where $i = 1, \ldots,$ nth equations; $j = 1, \ldots, n$th lags of exports variable. P-value for the hypothesis of 'block exogeneity' was 0.002 for MWALD statistic (15.231),[15] indicating that the hypothesis can be strongly rejected at 99% significance level. Therefore, this suggests that exports variable is not exogeneous in the VAR model and hence has reinforced the rejection of the export-led growth hypothesis that have been made earlier.

Finally, we have also conducted the tests for the causality between the factor inputs other than exports (i.e. investment, labour force, energy consumption and imports) and industrial output, in order to compare the significance of each pair of the causality. The results reported in Table 5 indicate that the causalities between energy and output, labour and output, and finally, between investment and output are stronger than the causality between exports and output since the P-values for MWALD for these causalities are higher (with the 1% significant level) than the causality between exports and output (with the 5% significance level). In fact, a closer look at the causality between imports and output reveals that the causality is also more significant than that between exports and output. Without going in to further details due to the scope of this paper, two points quickly come to mind: first, considering the Chinese economy is more labour-intensive with low capital utilization and hence inefficiency and low productivity in the Chinese industries (Wu, 1996), it would not be surprising that the results reported here suggest that the contributions of labour, energy consumption and investment to industrial output in China are much more significant than other factor inputs; second, the share of exports in GDP in China is lower than that in the countries such as NICs.

V. CONCLUDING REMARKS

This paper has used the time series concepts of causality test developed by Toda and Yamamoto (1995) to examine the causality link between exports and economic growth in China in the context of the export-led growth hypothesis. The test was based upon time series data for the period 1987:5 to 1996:5 in China. After an extensive survey of empirical literature on this topic, a VAR system incorporating an augmented growth equation was applied to overcome the problems of simultaneity bias and weak theoretical foundations underpinning the models that previous studies have suffered from.

The results indicate a bidirectional causality between exports and real industrial output in China because a feedback effect was found within the VAR system. So, the export-led growth hypothesis, defined as a unidirectional causal ordering from exports to industrial output, is rejected in the case of China. This casts some doubts about whether the model of exports-led growth can be applied to a large developing economy such as China. However, it does not mean that exports does not play an important role in the Chinese economy, it was merely saying both exports and industrial output contribute positively to each other in the course of economic development. Instead of saying exports in an 'engine of the growth', we would argue, in the case of China, that growth is also 'the engine of exports'.

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[15] P-values with different lag structures are not reported, although they were all significant at 5% significant level.

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APPENDIX A. DATA

Monthly data, seasonally adjusted flow variables[16] on exports, imports, industrial output, labour force, total investment and energy consumption, were collected, in log form, for the period 1987:5 to 1996:5 from various issues of *China Monthly Statistics* (CMS) of China Statistical Bureau (China Statistical Information and Consultancy Service Centre). The details of each series are as follows: Total Industrial output value (*Ind*): Table 2.1 series in various issues of CMS; Exports (*Exp*) value and imports (*Imp*) value: Table 7.1 series in CMS; Labour Force (*Lab*): Table 14.1 series in CMS; Total Investment (*Inv*): It was obtained by adding 'Total Capital Construction Investment' and 'Total Technical Updating and Transformation Investment'. They are from Table 4.1 and 4.2 series in CMS; CPI data are from Table 7.1 series in CMS. Energy Consumption (EN): Table 3.5 series measured in Standard Coal Equivalents (SCEs) from CMS.

APPENDIX B. THE SEASONALITY ADJUSTMENT

The plots of the original time series for the Chinese data reveal some seasonal trends in the data as expected in the time series. Two common methods, among others, were suggested in econometric theory to remedy the problem, namely, deseasonalization of the data as suggested by Pindyck and Rubinfeld (1991) and the use of dummy variables[17] (Gujarati, 1995). We followed the suggestion by Pindyck and Rubinfeld, since the use of dummy variables in the case of monthly data will reduce quickly the degrees of freedom as suggested in the literature (see, for example, Gujarati (1995)).

The steps to deseasonalize time series, as suggested by Pindyck and Rubinfeld (1991), are first to generate an average index series by dividing original series using a 'yearly average' each year (i.e. $z_t/y_t/y$ bar, where y_t = original series; y bar is yearly average each year, and z_t = average series index). This average index was then added by corresponding month for a total of nine years (i.e. $z_t = z_{\mathrm{Jan}} + z_{\mathrm{Feb}} + \ldots + z_{\mathrm{Dec}}$ for 1987–1996) to generate a seasonal index. The deseasonalized data was then obtained by dividing original series using the seasonal index.

[16] See Appendix 1 for the details of seasonality adjustment.
[17] Gujarati (1995, p. 517). Other methods include 'rank-relative methods', 'percentage-of-annual-average' and 'ratio-to-moving-average' methods.