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Revisit Export and GDP Nexus in China and Taiwan: A Rolling Window Granger Causality Test

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Abstract. *This paper re-examines the causal link between export and economic growth for both, China and Taiwan, using a rolling window Granger causality test over the 1980Q1-2013Q3 period. Our empirical results based on full-sample Granger causality test find evidence of feedback between export and economic growth for both China and Taiwan. However, results from our parameter stability test indicate that there is instability in our VAR model. We doubt these results might be misleading due to instability in our VAR model and these motivate us to use the bootstrap rolling window estimation to investigate the export and economic growth nexus which accounts for the time varying causal link between these two variables. Our empirical results from rolling window Granger causality test indicate that export growth did Granger cause economic growth in some certain periods, 1984Q4-1985Q2 and 1989Q2-1990Q1 for China and no relationship for Taiwan. On the contrary, economic growth also Granger cause export growth in some periods, 1987Q4-1988Q1, 1989Q1-1989Q2, 2009Q3, and 2013Q2-2013Q3 for China and 1984Q4-1985Q1, 1989Q4, and 2008Q3 for Taiwan. Our empirical results have important policy implications for both China and Taiwan.*

Keywords: Export Growth; Export Growth; Rolling Window Granger Causality Test; China; Taiwan.

JEL Classification: C32; C53; E32; F43; O51; O52.

1. Introduction

Over the past several decades, empirical studies have devoted increasing attention to the relationship between exports and economic growth. Whether exports promotes or is neutral with respect to economic growth is central to the debate about their relationship. However, despite voluminous research, empirical results remain mixed and inconclusive, making impossible to generalize the relationship across countries and over time.

There are at least four views regarding the nature of the relationship between exports and economic growth. The first is the export-led-growth hypothesis, which implies a one-way Granger causality from exports to economic growth, where exports can promote economic growth. If there is a unidirectional Granger causality from exports to economic growth, with increases in exports leading to increased economic growth, then the effect of exports on economic growth is positive, as exports may stimulate economic growth through Keynesian-type aggregate demand effects. Specifically, an increase in demand generated by higher exports can provide foreign exchange that allows for more imports of intermediate goods, which in turn raises capita formation, higher employment, and profits. This further increase in higher investment will further stimulate economic growth (Krueger, 1978; Ram, 1985). The second hypothesis regarding the relationship between economic growth and exports proposes the opposite causality, running from economic growth to exports, with economic growth inducing increased exports rather than the other way round. If causality running from economic growth to exports and this means that with increases in economic growth will cause increases in exports. This growth-led-exports hypothesis is argued by economists like Krugman (1984) and Lancaster (1980); who advocate that economic growth leads to enhancement of skills and technology, and with this, increased efficiency, thereby creating a comparative advantage for the country that facilitates exports. The third view is the feedback hypothesis, which propose a two-way Granger causal relationship between exports and economic growth and thus that exports and economic growth are mutually determined. Such interdependence suggests that policies that limit the growth of exports may negatively affect economic growth and, conversely, that a reduction in economic growth can be negatively transmitted back to exports. The reason for a feedback is that exports may rise from the realization of economies of scale due to productivity gains; the rise in exports may further enable cost reductions, which may result in further productivity gains (Helpman and Krugman, 1985). The fourth view is the neutrality hypothesis of no causality in either direction between exports and economic growth. This view implies that increased exports may not affect economic growth and both exports and economic growth may be determined by other unrelated variables (for example, investment) in the economic system (Pack, 1988). As these four different hypotheses have different policy implications, knowledge of the causal relationship between exports and economic growth is crucial to devising appropriate exports strategies and policies. As noted by Lim and Ho (2013) that trade theory does not provide definitive guidance on the causal relationship between exports and economic growth. Also, it remains as unsolved problem for policy makers that should promote exports to speed up economic growth or should focus on economic growth to create more exports?

This study revisits the causal link between exports and economic growth for both China and Taiwan over the period of 1980Q1 to 2013Q3, using a rolling window Granger causality test. To the best of our knowledge, this is the first study that uses a rolling window Granger causality test to study the relationship between exports and economic growth for both Taiwan and China. While previous studies using time series VAR model without taking into account the possibility of parameters instability, the results might be misleading due to the ignorance of structural breaks. Our paper makes a contribution to the existing literature by taking into account the time variation in the causal links between exports and economic growth with bootstrap Granger non-causality test and rolling-window sub-sample estimation. Empirical literature examining causality between these two time series may suffer from inaccurate results when the underlying full-sample time series have structural changes as pointed by both Balcilar et al., (2010) and Balcilar and Ozdemir (2013). In the presence of structural changes, the dynamic links between the two series will show instability across different sub-samples (Balcilar et al., 2010; Balcilar and Ozdemir, 2013). We can address this by allowing the causal relationship between the two series to be time-varying instead of using full-sample data that assumes the single causality holds in every time period. The time-varying nature that may exist in the causal link between exports and economic growth for both China and Taiwan has been taken fully into consideration in this paper by using bootstrap sub-samples rolling window estimations. Instead of just testing for causality on the full-sample which assumes a permanent causal relationship, we also test for causality on the rolling sub-sample with a fixed-size window, thus allowing us to capture structural changes in the model and the evolution of causality between sub-periods. In light of this, our paper is starkly different from the existing literature which, in general, only considers full-sample causality, and unlike our study is susceptible to misleading results and conclusions in the presence of parameter instability due to structural breaks in the relationships. Finally, we hope that this study can bridge the gap of the current literature in export and economic growth.

The plan of this paper is organized as follows. Section 2 briefly describes the data used in this study. Section 3 outlines the econometric methodology employed. Section 4 reports our empirical findings and some major policy implications are also reported. Finally, Section 5 is devoted to concluding remarks.

2. Data

This empirical study uses quarterly data for both China and Taiwan over the period 1980Q1-2013Q3. The variables in this study include total real export (*REX*) and real GDP (*RGDP*). RGDP and REX are expressed in terms of billions of Chinese Yuan for China (2005=100) and millions of New Taiwan dollars for Taiwan (2006=100). The source of the data is from the AREMOS Database, Ministry of Education of Taiwan. Summary statistics of both RGGDP (growth rate) and REX (growth rate) for both China and Taiwan are reported in Table 1. We can see that China has higher growth rate for both RGDP (0.003148) and REX (0.004864) than those of Taiwan (0.001452 and 0.000944, respectively for REX and RGDP). The Jarque–Bera (J-B) normality test results indicate that the growth rate of both RGDP and REX for both China and Taiwan are approximately no-normal.

Table 1. *Summary Statistics of China and Taiwan data (Percentage change on previous period (LN%))*

Countries	China Export	China GDP	Taiwan Export	Taiwan GDP
Mean	0.004864	0.003148	0.001452	0.000944
Median	0.004335	0.002906	0.001304	0.000881
Maximum	0.039829	0.014524	0.013738	0.003894
Minimum	-0.021741	-0.00476	-0.01356	-0.00347
Std. Dev.	0.009524	0.002529	0.003102	0.001197
Skewness	0.346816	1.087037	-0.34327	-0.34773
Kurtosis	4.665071	9.118572	7.598706	4.088208
Jarque-Bera	18.16586	235.413	120.7086	9.312159
Probability	0.000	0.000	0.000	0.000

Note: The sample period is from January 1980:Q1 to 2013:Q3 .China Export and GDP (in Billions of Chinese Yuan) and Taiwan Export and GDP (in Millions of New Taiwan Dollar).

3. Methodology

3.1. Unit Root Test and Cointegration Test

Many macroeconomic time-series contain unit roots (dominated by stochastic trends) (see Nelson and Plosser, 1982). Unit root tests are important in examining the stationarity of a time series because the presence of nonstationary regressors invalidates many standard hypothesis tests. Granger and Newbold (1974) have found by simulation that the F-statistic calculated from a regression involving nonstationary time-series data does not follow the standard distribution. The actual distribution is nonstandard and, compared to the standard distribution, has a substantial rightward shift under the null hypothesis of no causality. Consequently, the significance of the test is overstated and a spurious result is obtained. The presence of a stochastic trend is determined by testing the presence of unit roots in time-series data. Several tests for the presence of unit roots in time-series data have appeared in literature (see, for example, Dickey and Fuller, 1979, 1981; Phillips and Perron, 1988, and Kwiatkowski et al. 1992). In this study, unit roots are tested for using both the Augmented Dickey–Fuller (ADF) and the Kwiatowski et al. (KPSS) tests. In order to fully investigate the stationary property of each variable, we first apply three conventional unit root tests –ADF, PP and KPSS tests to examine the null of a unit root in both RGDP and REX for China and Taiwan. We select the lag order of the test on the basis of the recursive t-statistic, as suggested by Perron (1989).

Once a unit root has been confirmed for a data series, the question is whether there exists some long-run equilibrium relationship among variables. If this is the case, then estimating a multivariate time-series model using only first differences of the series could result in a serious misspecification since important level terms will have been omitted (Engle and Granger, 1987 and Engle and Yoo, 1987). The existence of a long-run equilibrium relationship among economic variables is referred to literature as cointegration. Johansen and Juselius (1990) propose two test statistics for evaluating the number of cointegrating vectors: the trace (Tr) and the maximum eigenvalue (L-max) statistics. It is well known that the JJ cointegration tests are very sensitive to the choice of lag length. The Schwartz Criterion (SC) is used to select the number of lags required in the cointegration test. A VAR model is first fit to the data to find an appropriate lag structure.

3.2. Granger Causality Test based on Full Sample

The purpose of our study is to analyze the causal relationship between exports and economic growth for both China and Taiwan. We thus make use of the Granger non-causality test in the bivariate VAR framework proposed by Balcilar et al. (2010). In general terms, standard causality test statistics for joint restriction and standard asymptotic properties include the Wald, Likelihood Ratio (LR) and Lagrange Multiplier (LM) statistics. However, according to Sims et al. (1990) and Toda and Phillips (1993, 1994), when the underlying time series data in levels estimation of VAR models is non-stationary, these test statistics may not have standard asymptotic distributions. Toda and Yamamoto (1995) propose a modified Wald test by estimating an augmented VAR model with I (1) variables to obtain standard asymptotic distribution for the Wald test. However, Shukur and Mantolos (1997b) use Monte Carlo simulations to show that the modified Wald test does not have correct size in small and medium size samples. Nevertheless, Shukur and Mantalos (1997a) suggest that improvement (in terms of power and size) can be achieved by using the residual based bootstrap (RB) method critical values. Moreover, the excellent performance of the RB method over standard asymptotic tests, regardless of cointegration or not, has been confirmed in a number of Monte Carlo simulations studies (Mantalos and Shukur, 1998; Shukur and Mantalos, 2000; Mantalos, 2000; Hacker and Hatemi-J, 2006; Balcilar et al., 2010). Especially, Shukur and Mantalos (2000) prove that small sample corrected LR tests exhibit relatively better power and size properties, even in small samples. As a consequence, based on these findings, this paper resorts to the RB based modified-LR statistic to examine causality between exports and economic growth for both China and Taiwan.

To demonstrate this *RB* based modified-*LR* causality test, we can consider the following bivariate VAR (p) process as:

$$y_t = \phi_0 + \phi_1 y_{t-1} + ... + \phi_p y_{t-p} + \varepsilon_t, \text{ t=1, 2,.....T} \quad (1)$$

Where: $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t})'$ is a white noise process with zero mean and covariance matrix Σ. The optimal lag length p is determined by the Schwarz Criteria (*SC*) in this study. If $y_t = (y_{1t}, y_{2t})'$ is split into two sub-vectors, y_{1t} (economic growth) and y_{2t} (exports), the equation (1) can accordingly be represented as:

$$\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} \phi_{10} \\ \phi_{20} \end{bmatrix} + \begin{bmatrix} \phi_{11}(L) & \phi_{12}(L) \\ \phi_{21}(L) & \phi_{22}(L) \end{bmatrix} \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \quad (2)$$

Where: y_{1t} and y_{2t} indicates the economic growth and exports, respectively. In the empirical section, $\phi_{ij}(L) = \sum_{k=1}^{p+1} \phi_{ij,k} L^k$, $i, j = 1,2$ and L is the lag operator defined as $L^k x_t = x_{t-k}$.

Based on *Eq.* (2), the null hypothesis that exports does not Granger cause economic growth is tested by imposing the restriction, $\phi_{12,k} = 0$ for $k = 1,2,....., p$. Similarly, the null hypothesis that economic growth does not Granger cause exports is tested by imposing the restriction, $\phi_{21,k} = 0$ for $k = 1,2,....., p$. As discussed, the full-sample causality tests in this paper are relied upon *RB* based *p*-values and modified-*LR* statistics. If the fist null hypothesis, $\phi_{12,k} = 0$ for $k = 1,2,....., p$ is rejected, then there is a significant causality running from exports to economic growth in Taiwan. This means that export development can promote economic growth in Taiwan. In the same manner if the second null hypothesis, $\phi_{21,k} = 0$ for $k = 1,2,....., p$ is rejected, we can say that exports is caused by economic growth in Taiwan.

3.3. Stability Test

Because the full-sample causality tests usually assume that parameters of the VAR model used in testing are constant over time. However, when the underlying full-sample time series have structural changes, the assumption is probably violated. The results from the full-sample causality tests would become invalid and hence the causal links between series would show instability (Balcilar and Ozdemir, 2013). Granger (1996) stresses the issue of parameter non-constancy as one of the most challenging issues faced by recent empirical studies. As a result, tests for short-run and long-run parameter stability should be conducted in our study.

In the presence of structural changes, parameters in our VAR models estimated using full-sample data from both China and Taiwan will shift with time. The causal relationship between exports and economic growth will accordingly be unstable. Therefore, the full-sample causality tests with assumptions of parameter constancy and a single causal relationship across the whole sample period are no longer reliable, and the ensuing results turn to be meaningless (Zeileis *et al.*, 2005). For this reason, this paper proceeds to test for parameter stability and to determine whether structural changes exist. We uses the *Sup-F, Mean-F* and *Exp-F* tests developed by Andrews (1993) and Andrews and Ploberger (1994) to investigate the temporal stability of parameters in the above VAR models formed by the export and economic growth. The L_c test of Nyblom (1989) and Hansen (1992) is also used to test for all parameters in the overall VAR system.

As we have used the *Sup-F, Mean-F* and *Exp-F* tests developed by Andrews (1993) and Andrews and Ploberger (1994) to investigate the short-run parameters stability of our VAR model. Nevertheless, it is noted that when the underlying variables in levels are cointegrated, the VAR model in first differences is misspecified unless it allows for error-correction. Hence, it is very essential to test for parameter stability of the long-run relationship. This is achieved based on different structural changes and parameter stability tests on the long-run relationship estimated using the Fully Modified ordinary least squares (*FM-OLS*) estimator of Phillips and Hansen (1990). Here, the L_c test proposed by Nyblom (1989) and Hansen (1992) is mainly applied to investigate the long-run parameters stability.

3.4. Sub-Sample Rolling Window Granger Causality Test

Structural changes can be identified beforehand and incorporated into the estimation using several techniques such as sample splitting and the use of dummy variables. However, these techniques impose a disadvantage of pre-test bias. In order to overcome the parameter non-constancy and avoid pre-test bias, this study is therefore proposed by using the rolling-window sub-samples Granger causality test based on the modified bootstrap estimation. Two important reasons justify the use of the rolling estimation. First, the rolling window agrees with the fact that the causal relationship between variables changes over time. Second, the rolling estimation can observe instability across different sub-samples due to the presence of structural changes.

Following Balcilar et al. (2010), the rolling window technique is based on fixed-size sub-samples rolling sequentially from the beginning to the end of the full-sample. Specifically, given a fixed-size rolling window including l observations, the full-sample is converted to a sequence of T-l sub-samples, that is, τ-l+1, τ-l, ..., T for τ= l, l+1, ..., T. The *RB* based modified-*LR* causality test is then applied to each sub-sample, instead of estimating a single causality test for full sample. Possible changes in the causal links between exports and economic growth for China and Taiwan are intuitively identified by calculating the bootstrap *p*-values of observed *LR*-statistic rolling through T-l sub-samples. More importantly, the magnitude of the effect of exports on economic growth as well as that of economic growth on exports is also assessed in this study. The impact of exports on economic growth is defined as the average of the entire bootstrap estimates deriving from the formula $N_b^{-1}\sum_{k-1}^{p}\hat{\phi}_{21,k}^{*}$, with N_b representing the number of bootstrap repetitions; in similar manner, the impact of economic growth on exports is obtained from the formula $N_b^{-1}\sum_{k-1}^{p}\hat{\phi}_{12,k}^{*}$. Both $\hat{\phi}_{21,k}^{*}$ and $\hat{\phi}_{12,k}^{*}$ are bootstrap estimates from the VAR models in *Eq.* (2). The 90-percent confidence intervals are also computed, where the lower and upper limits equal 5 and 95 quantiles of each of the $\hat{\phi}_{21,k}^{*}$ and $\hat{\phi}_{12,k}^{*}$ respectively (Balcilar et al., 2010).

The accuracy and performance of rolling window estimation depends on the increment interval of each regression and the window size l. Small intervals such as one are recommended as they provide more detailed transition since it maximizes the total number of rolling regressions. The window size l is the parameter that controls the number of observations covered in each sub-sample and also the precision of estimates. A large window size may improve the accuracy of estimates but may reduce the representativeness especially in the presence of heterogeneity. However, a small window size reduces heterogeneity and improves the representativeness of parameters but may reduce parameter accuracy by increasing the standard errors of estimates. Consequently, the window size should be set to balance the trade-off between representativeness and accuracy.

No consistent criterion is available for us to select the window size in rolling window estimation (Balcilar et al., 2010). Pesaran and Timmerman (2005) assess the window size under structural change according to root mean square error. They show that the optimal window size depends on persistence and size of the break. Based on their Monte Carlo simulations, they argue that the bias in autoregressive (AR) parameters are minimized with a window size as low as 20 when there are frequent breaks. Two conflicting demands have been taken into account when we choose the suitable window size. First, the degree of freedom that relates to the precision of parameter estimates requires for a larger window size; second, the presence of multiple structural changes that possibly increases the risk of including some of these multiple shifts in the windowed sample claims for a smaller window size. Therefore, a small window size of 18 quarters is chosen in this study (this excludes the observations required for lags and hence is the actual number of observations in the VAR) for both China and Taiwan. As for the issue of inaccurate estimates as a result of the selected small window size, it can be addressed by the bootstrap technique employed in the rolling estimation for better precision.

4. Empirical Results and Policy Implications

4.1. Empirical Results from both Unit Root Test and Cointegration Test

The empirical results for ADF, PP and KPSS tests are presented in Tables 2 (test without trend) and 3 (test with trend) clearly indicate that both ADF and PP tests fail to reject the null of non-stationary in both two variables for both China and Taiwan. KPSS also give us similar results as those of ADF and PP tests. However, the results for first difference indicate a strong rejection of the null hypothesis for both two variables. These results show that both exports and real GDP in both China and Taiwan are non-stationary. Based on these results, we proceed to test whether these two variables are cointegrated using the cointegration test of Johansen and Juselius (1990, hereafter JJ) for both China and Taiwan.

Table 2. *Unit Root Tests (ADF, PP and KPSS) for China and Taiwan (without Trend)*

Countries	Levels			First Difference		
	ADF(k)	PP(k)	KPSS(k)	ADF(k)	PP(k)	KPSS(k)
China Export	0.062(0)	0.028(3)	1.442[9] ***	-11.279(0)***	-11.288(4)***	0.160[3]
China GDP	-0.373(0)	-0.378(3)	1.451[9] ***	-6.618(1)***	-13.624(2)***	0.050[3]
Taiwan Export	-1.231(0)	-1.471(11)	1.434[9] ***	-9.693(0)***	-9.789(11)***	0.188[10]
Taiwan GDP	-2.563(0)	-2.682(5)	1.423[9] ***	-10.210(0)***	-10.206(1)***	0.646[1]

Notes: The number in parenthesis indicates the lag order selected based on the recursive t-statistic, as suggested by Perron (1989). The number in the brackets indicates the truncation for the Bartlett Kernel, as suggested by the Newey and West (1994). *** denotes the significance levels at 1%.

Table 3. *Unit Root Tests (ADF, PP and KPSS) for China and Taiwan (with Trend)*

Countries	Levels			First Difference		
	ADF(k)	PP(k)	KPSS(k)	ADF(k)	PP(k)	KPSS(k)
China Export	-2.464(0)	-2.464(0)	0.149[9]**	-11.237(0)***	-11.247(4)***	0.149[3]
China GDP	-3.424(5)	-2.564(2)	0.054[9]	-6.594(1)***	-13.581(2)***	0.044[3]
Taiwan Export	-2.967(1)	-2.138(7)	0.226[9]***	-9.756(0)***	-10.442(13)***	0.049[11]
Taiwan GDP	-0.534(0)	-0.534(4)	0.360[9]***	-10.688(0)***	-10.760(6)***	0.053[5]

Notes: The number in parenthesis indicates the lag order selected based on the recursive t-statistic, as suggested by Perron (1989). The number in the brackets indicates the truncation for the Bartlett Kernel, as suggested by the Newey and West (1994). ** and *** denotes the significance levels at 5% and 1%, respectively.

Johansen and Juselius (1990) propose two test statistics for evaluating the number of cointegrating vectors: the trace (Tr) and the maximum eigenvalue (L-max) statistics. It is well known that the JJ cointegration tests are very sensitive to the choice of lag length. The Schwartz Criterion (SC) is used to select the number of lags required in the cointegration test. A VAR model is first fit to the data to find an appropriate lag structure. The Schwartz Criterion (SC) suggests 4 lag for our VAR model for both China and Taiwan. Table 4 reports JJ results indicate that both the trace (Tr) and the maximum eigenvalue (L-max) statistics point out that there exist no cointegration between exports and real GDP for both China and Taiwan over the period of 1980Q1-2013Q3.

Table 4. *Panel A: JJ Cointegration Rank Test base on Maximum Likelihood Ratio*

China Export vs. China GDP	Trace test	Critical Value	L-Max test	Critical Value Lag =2
$H_0 : r \le 0$	6.507946	15.49471	6.205846	14.26460
$H_0 : r \le 1$	0.302100	3.841466	0.302100	3.841466
Panel: B JJ Cointegration Rank Test base on Maximum Likelihood Ratio				
Taiwan Export vs. Taiwan GDP	Trace test	Critical Value	L-Max test	Critical Value Lag =2
$H_0 : r \le 0$	9.525360	15.49471	7.510320	14.26460
$H_0 : r \le 1$	2.015040	3.841466	2.015040	3.841466

Note:
1. The computed Ljung-Box Q-statistics indicate that the residuals are white noise.
2. *indicates singni_cance at the 5% level.
3. Schwartz Bayesian Criterion (SBC) was used to select the number of lags required in the cointegrating test.

4.2. Empirical Results from Granger Causality Test based on Full Sample

The purpose of our paper is to analyze the causal relationship between exports and economic growth for both China and Taiwan. We thus make use of the Granger non-causality test in the bivariate VAR framework proposed by both Balcilar et al. (2010) and Balcilar and Ozdemir (2013).

Since we find no cointegration exists between export and real GDP for both China and Taiwan, therefore, the restriction are tested by using a VAR (p) model in difference variables to test causal relationship between exports and economic growth are for both China and Taiwan. Based on Schwartz criteria (SC), a VAR (4) model was selected for our testing models. By means of the *RB* based modified-*LR* causality tests, the full-sample causality results are reported in Table 5 for China and Table 6 for Taiwan. Based on the bootstrap *p*-values, the null hypotheses are rejected in either direction for both China and Taiwan, indicating presence of full-sample causal links between exports and economic growth (a feedback exits) for both China and Taiwan.

Table 5. *Full-Sample Granger Causality Tests - China*

	H0: GDP Growth does not Granger cause Export Growth		H0: Export Growth does not Granger cause GDP Growth	
	Statistics	P value	Statistics	P value
Bootstrap LR Test	10.829	0.006***	7.922	0.0185**
Bootstrap Wald Test	10.829	0.006***	7.922	0.0185**

Table 6. *Full-Sample Granger Causality Tests - Taiwan*

	H0: GDP Growth does not Granger cause Export Growth		H0: Export Growth does not Granger cause GDP Growth	
	Statistics	P value	Statistics	P value
Bootstrap LR Test	13.886	0.072*	26.278	0.002***
Bootstrap Wald Test	14.818	0.072*	29.751	0.002***

4.3. Empirical Results from Stability Test

In the presence of structural changes, parameters in our VAR models estimated using full-sample data from both China and Taiwan will shift with time. The causal relationship between exports and economic growth will accordingly be unstable. Therefore, the full-sample causality tests with assumptions of parameter constancy and a single causal relationship across the whole sample period are no longer reliable, and the ensuing results turn to be meaningless (Zeileis et al., 2005). To this reason, this paper proceeds to test for parameter stability and to determine whether structural changes exist. We uses the *Sup-F, Mean-F* and *Exp-F* tests developed by Andrews (1993) and Andrews and Ploberger (1994) to investigate the temporal stability of parameters in the above VAR models formed by exports growth and real GDP growth. The L_c test of Nyblom (1989) and Hansen (1992) is also used to test for all parameters in the overall VAR system.

The corresponding results are reported in Table 7 for China and Table 8 for Taiwan. The *Sup-F* tests under the null hypothesis of parameters constancy against a one-time sharp shift in parameters are reported in Tables 7 and 8. The results suggest that a one-time sharp shift exists in both exports growth and real GDP growth equations of both China and Taiwan data. The *Mean-F* and *Exp-F* tests under the null hypothesis that parameters follow a martingale process against the possibility that the parameters might evolve gradually are also reported in Tables 7 and 8, respectively, for both China and Taiwan. The results show that parameters in the real GDP growth equation and VAR (4) system formed by both China and Taiwan data evolve gradually with time. The L_c statistics test against the alternative that the parameters follow a random walk process proposed by Gardner (1969), indicative of parameters non-constancy in the overall VAR models estimated using the full-sample data of both China and Taiwan. As a consequence, these results provide robust evidence that the parameters of the estimated VAR models using full-sample data show short-run instability for both China and Taiwan data.

Table 7. *Short-Run Parameter Stability Tests - China*

	GDP Growth Equation		Export Growth Equation		VAR(2) System	
	Statistics	Bootstrap P value	Statistics	Bootstrap P value	Statistics	Bootstrap P value
Mean-LR	11.54	0.01***	31.36	0.01***	33.54	0.01***
Exp-LR	59.33	0.01***	35.88	0.01***	64.32	0.01***
Sup-LR	127.77	0.01***	80.58	0.01***	137.76	0.01***

Table 8. *Short-Run Parameter Stability Tests - Taiwan*

	GDP Growth Equation		Export Growth Equation		VAR(4) System	
	Statistics	Bootstrap P value	Statistics	Bootstrap P value	Statistics	Bootstrap P value
Mean-F	9.81	0.03**	18.80	0.01***	27.20	0.01**
Exp-F	14.79	0.01***	28.04	0.01***	16.91	0.01***
Sup-F	38.35	0.01***	64.94	0.01***	41.04	0.01***

Since we find no cointegration between exports and real GDP for both China and Taiwan and we suspect these results might be due to structural change, therefore, we tests for parameters stability of the long-run relationship for both China and Taiwan in the following step. Specifically, the *FM-OLS* estimator is used to estimate cointegration and the *Sup-F, Mean-F* and *Exp-F* tests, as well as the L_c test are used to test parameters stability of the long-run relationship. The empirical results are presented in Table 9 for China and Table 10 for Taiwan. Based on the bootstrap *p*-values, the L_c statistics reject the null hypothesis of cointegration at 1 percent significance level, and meanwhile the *sup-F, mean-F, and Exp-F* statistics also reject the null hypothesis of parameters constancy at 1 percent significance level. This significant evidence of a one-time shift in the long-run relationship and hence no reliable cointegration between exports and real GDP for both China and Taiwan can be obtained from the *sup-F, mean-F, and Exp-F* and L_c tests.

Table 9. *Parameter Stability Tests of the Long-Run Relationship - China*

	Sup-F	Mean-F	Exp-F	L_c
$LRGDP = \alpha + \beta * LEXPT$	68.59	37.01	30.44	6.17
Bootstrap p value	0.01***	0.01***	0.01***	0.01***

Table 10. *Parameter Stability Tests of the Long-Run Relationship - Taiwan*

	Sup-F	Mean-F	Exp-F	L_c
$LRGDP = \alpha + \beta * LEXPT$	296.77	134.84	143.84	9.55
Bootstrap p value	0.01***	0.01***	0.01***	0.01***

4.4. Empirical Results from Sub-Sample Rolling Window Granger Causality Test

Based on the above parameters stability tests, we found both the short-run and long-run parameters in the VAR models estimated using full-sample data show instability due to structural changes and hence the result of feedback at full-sample between exports and economic growth for both China and Taiwan might be misleading and meaningless. Therefore, the VAR models in *Eq*. (2) can serve as a basis framework in which we continue to perform the rolling-window causality test with sub-sample data. The employed rolling-window estimation takes structural changes into account and allows the causal links between variables to be time-varying across different sub-samples, which greatly differ from the existing literature.

We utilize the *RB* based modified-*LR* causality tests with the null hypothesis that exports does not Granger cause economic growth and vice versa, the bootstrap *p*-values of *LR*-statistics are estimated from the VAR models in *Eq*. (2) using the rolling sub-sample data including 18-quarters observations. Besides, the magnitude of the effect of economic growth on exports growth and that of exports growth on economic growth are also calculated for both China and Taiwan. All the rolling estimates for each sub-sample are plotted in Figures 1.a, 1.b, 2.a and 2.b for China and 3.a, 3.b, 4.a and 4.b for Taiwan. After trimming 18-years observations from the beginning of the full sample, these rolling estimates move from 1983Q2 to 2013Q3 for both China and Taiwan.

Figure 1.a. *Export Growth Granger GDP Growth in China*

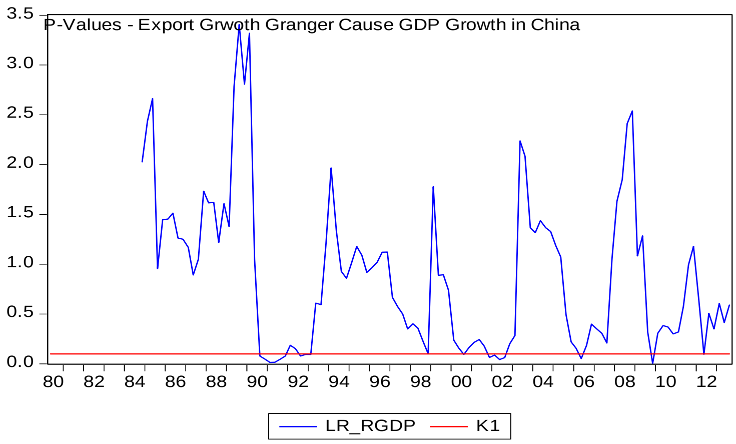

Figure 1.b. *Export Growth Granger GDP Growth in China – Coefficients Plots*

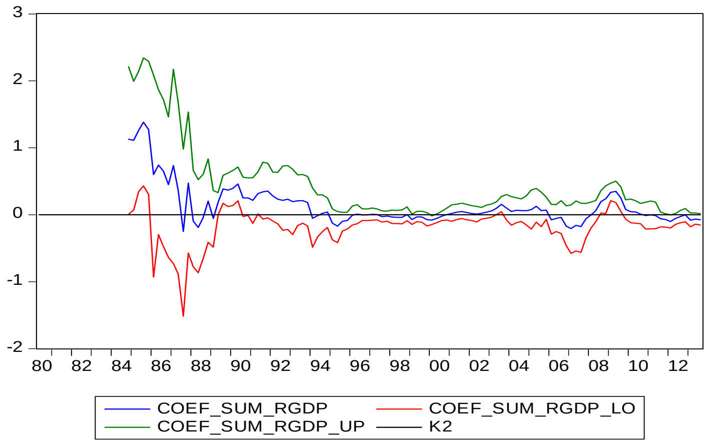

Figure 2.a. *GDP Growth Granger Export Growth in China*

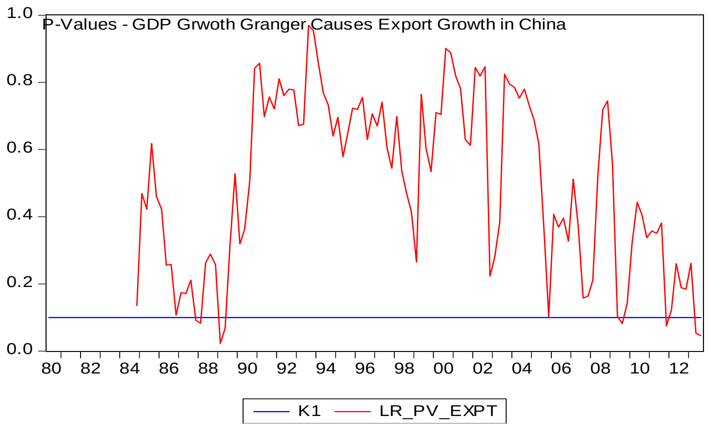

Figure 2.b. *GDP Growth Granger Export Growth in China – Coefficients Plot*

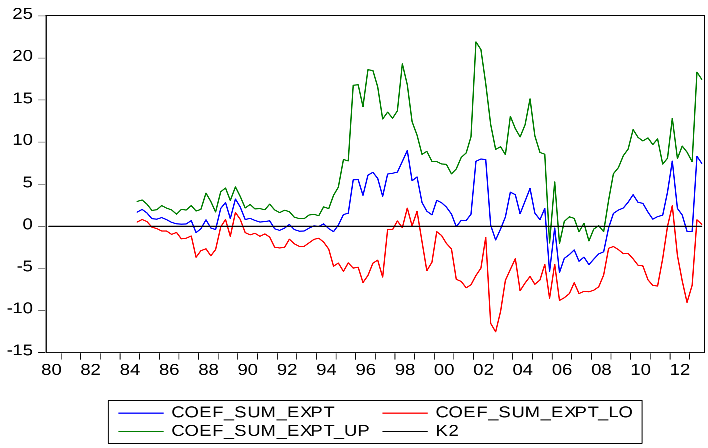

Figure 3.a. *Export Growth Granger GDP Growth in Taiwan*

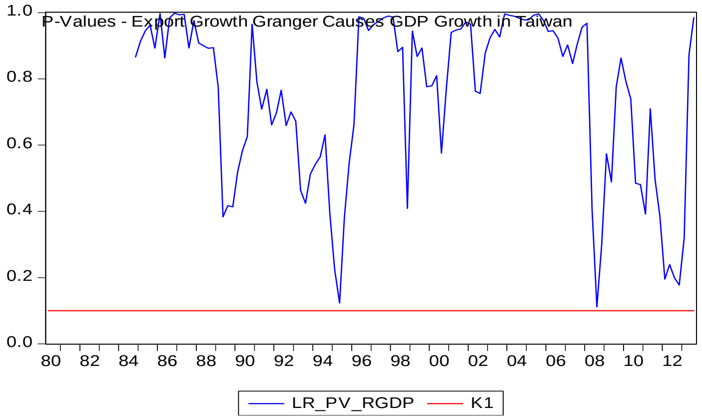

Figure 3.b. *Export Growth Granger GDP Growth in Taiwan – Coefficients Plot*

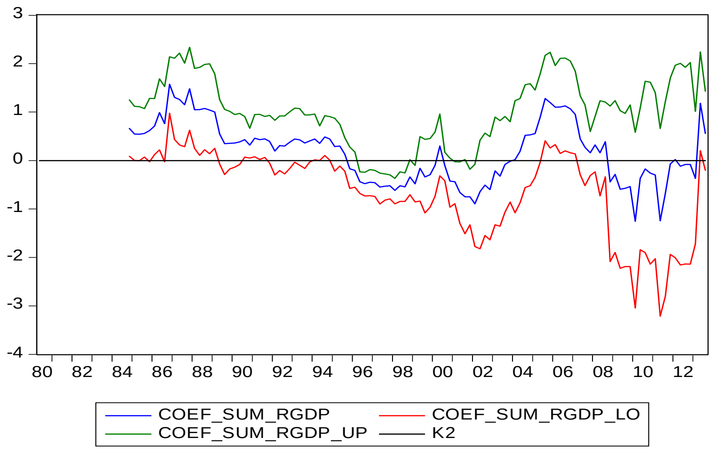

Figure 4.a. *GDP Growth Granger Export Growth in Taiwan*

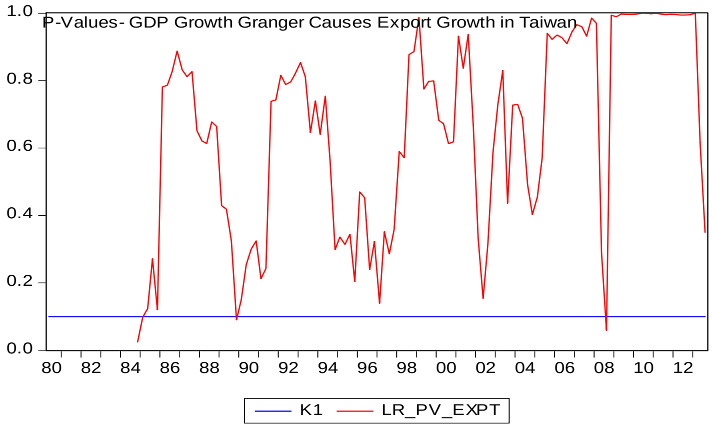

Figure 4.b. *GDP Growth Granger Export Growth in China – Coefficients Plot*

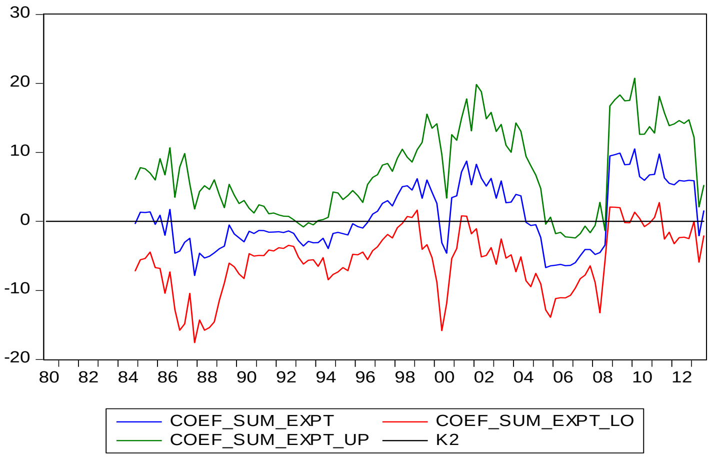

Figure 1.a presents the rolling bootstrap *p*-values of *LR*-statistics estimated using sub-samples data. The null hypothesis that exports growth does not cause economic growth can be rejected at 10 percent significance level for China during 1984Q4-1985Q2 and 1989Q2-1990Q1 two periods. Therefore, the p-values greater than 0.1 (the part above the red line) are ignored to protect against low power results. Figure 1.b gives the bootstrap estimates of the sum of the rolling window coefficients for the impact of exports growth on economic growth in China. Figure 1.b, shows that in the two periods of 1984Q4-1985Q2 and 1989Q2-1990Q1, exports growth has a significantly positive impact on economic growth. Overall, the bootstrap sub-sample rolling estimates in Figures 1.a and 1.b indicate that the exports growth has quite a weak effect on economic growth in China. The movements in exports growth have low power in explaining the economic growth for China over the past 3 decades (except for those of 1984Q4-1985Q2 and 1989Q2-1990Q1 two periods). Figure 2.a reports the rolling bootstrap *p*-values of *LR*-statistic with the null hypothesis that economic growth does not Granger cause export growth in China. Figure 2.b presents the rolling estimates of the magnitude of the effect that economic growth has on exports growth. Based on the finding from Figure 2.a, the null hypothesis is rejected at 10 percent significance level mainly in the periods of 1987Q4-1988Q1, 1989Q1-1989Q2, 2009Q3, and 2013Q2-2013Q3 for China. Moreover, as shown in Figure 2b, economic growth in China has a significantly positive impact on exports growth in those periods of 1987Q4-1988Q1, 1989Q1-1989Q2, 2009Q3, and 2013Q2-2013Q3 for China. Based on the result from Figures 1a, 1b, 2a, and 2b, we can conclude that exports and economic growth has a weak feedback relationship exits in China.

Figure 3.a presents the rolling bootstrap *p*-values of *LR*-statistics estimated using sub-samples data. The null hypothesis that exports growth does not cause economic growth can not be rejected at 10 percent significance level in any period for Taiwan. Because all the p-values are greater than 0.1 (see the part above the red line). Figure 3.b gives the bootstrap estimates of the sum of the rolling window coefficients for the impact of

exports growth on economic growth in Taiwan. Figure 3.b shows that exports growth has positive impacts on economic growth in most of the sample periods (though it is not significant). Overall, the bootstrap sub-sample rolling estimates in Figures 3.a and 3.b indicate that exports growth has no effect on economic growth in Taiwan. The movements in exports growth have no power in explaining the economic growth in Taiwan over the entire sample period.

Figure 4.a reports the rolling bootstrap *p*-values of *LR*-statistic with the null hypothesis that economic growth does not Granger cause exports growth in Taiwan. Figure 4.b presents the rolling estimates of the magnitude of the effect that economic growth has on exports growth. Based on the finding from Figure 2.a, the null hypothesis is rejected at 10 percent significance level mainly in the periods of 1984Q4-1985Q1, 1989Q4, and 2008Q3 for Taiwan. Moreover, as shown in Figure 4, economic growth in Taiwan has a significantly positive impact on exports growth in the periods of 1984Q4-1985Q1, 1989Q4, and 2008Q3. Based on the result from Figures 3a, 3b, 4a and 4b, we can conclude that Granger causality running from economic growth to exports growth in Taiwan.

Several findings and policy implications can be concluded here. First of all, a feedback exits between real exports and economic growth in China. This result indicates that exports and economic growth reinforce each other. This result is consistent with the view of Helpman and Krugman (1985) and Bhagwati (1988) that exports may arise from the realization of economies of scale due to productivity gains; the rise in exports may further enable cost reductions, which may result in further productivity gains. On the other hand, increased trade (irrespective of cause) produces more income, which leads to more trade, and so on. Second, one-way Granger causality running from economic growth to exports was found in Taiwan, the major policy implications of this finding is that growth-driven export model is support here. This means that increasing in economic activity through human capital and technology improvements stimulates export growth because producers need new foreign markets to absorb the subsequent increase in supply. The major policy implication of this finding is that exports can not be used a driven-engine for economic growth in Taiwan.

5. Conclusions

This paper re-examines the causal link between exports and economic growth for both China and Taiwan, using a rolling window Granger causality test over the 1980.Q1-2013.Q3 period. Our empirical results based on full-sample Granger causality test find evidence of feedback between exports and economic growth for both China and Taiwan. However, results from our parameter stability test indicate that there is instability in our VAR model. We doubt these results might be misleading due to instability in our VAR model and these motivate us to use the bootstrap rolling window estimation to investigate the export and economic growth nexus which accounts for the time varying causal link between these two variables. Our empirical results from rolling window Granger causality test indicate that exports growth did Granger cause economic growth in some certain periods, 1984Q4-1985Q2 and 1989Q2-1990Q1 for China and no relationship for Taiwan. On the contrary, economic growth also Granger cause exports growth in some periods, 1987Q4-1988Q1, 1989Q1-1989Q2, 2009Q3, and 2013Q2-2013Q3 for China and 1984Q4-1985Q1, 1989Q4, and 2008Q3 for Taiwan. Our empirical results have important policy implications for both China and Taiwan.

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