Trade and Productivity Growth: Dynamic Panel Study on Selected Asian Countries

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By

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Abstract

The paper studies the impact of trade variables of exports and imports on productivity growth in selected Asian countries using a dynamic panel VAR. The panel unit roots and co-integration techniques are utilized to determine the proper time-series properties of the model. As oppose to studies that suggest export-led productivity growth, we found significant import-led productivity growth in our panel of Asian countries. In fact, we found negative impact of exports on labor productivity. The result on the positive impact of imports on productivity growth is robust to both labor productivity and total factor productivity measures. This suggests that imports as opposed to exports play an important role in increasing productivity and transferring foreign technology onto the domestic economy. Further, we also found bi-directional effects of productivity on imports.

Key words: Total Factor Productivity, Labour Productivity, Trade, Short- and Long-run Causality
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1. Introduction

Recent survey by Rodriquez and Rodrik (1999) suggest that the controversy between the relationship of openness and economic growth has yet to be resolved. For instance the positive relationship openness and growth rate in GDP per capita is not very clear since "it is not one that immediately stands out in the data". In addition to the quality of the data, they also highlight the weakness of the various measures of openness used in the current empirical literature. In fact, this weakness of the openness measures such as the trade share is reflected by the endogenous problem between income and the effects from trade. For example, many studies have observed that countries with higher income, for reasons other than trade, tend to trade more (Frankel and Romer, 1999; Helpman, 1988; Rodrik, 1995). Frankel and Romer (1999) highlights the difficulty of isolating the impact of trade on growth rate of GDP per capital as most countries adopts free trade policies with free market policies. In this case the fiscal and monetary policies impact are difficult to isolate from the impacts of trade on output growth.

In this paper, we examined the relationship between exports, imports and productivity growth for 10 rapidly developing Asian countries in a dynamic panel VAR framework. Due to lack of long-time series for the productivity measures, most studies have focused on cross-country studies to study the effects of trade on productivity growth. Recent studies tend to highlight the weakness of the cross-country studies and suggest using the more flexible panel techniques to address the issues related to differences in technologies and market imperfections in the cross-country studies (Islam, 1995; Harrigan, 1996). In fact, panel estimation allows us to consider the heterogeneity that exist across the countries and at the same time address any spurious relationships that could exist in cross-country estimation. In our panel estimation, we carefully considered the stationarity of the series by using the panel unit-root test proposed by Im, Persaran and Shin (1997), which tends to be more robust than the traditional ADF test. The model is also tested for panel cointegration test as suggested by Pedroni (1998). After testing for stationarity and cointegration, we tested the model for any causal relationship between the trade variables of import and exports with productivity in a panel Vector-autoregressive model.

The paper address some of the above issues related to trade and growth by (a) using both the aggregate total factor productivity (TFP) growth and manufacturing labor productivity as measures to account for the impact of trade on growth, (b) use exports and imports as independent measures to account for their impact on the productivity growth in the domestic economy, and (c) taking account of the endogeniety problems by examining the causality between exports, imports and productivity growth in panel Vector-autoregressive model (VAR).

To isolate the productive impact of trade on output growth, we used the aggregate measure of TFP and manufacturing labour productivity. As oppose to GDP per capita, the productive impact of trade variables of exports and imports could be directly accounted by TFP, since the technology and efficient components of production could be easily isolated in the TFP measure. In addition to TFP, we also used the manufacturing labour productivity measure in our study. It is quite clear that the manufacturing is the sector that is driving trade activities in the domestic economy in most of the developing and Asian countries. As such the labour productivity measure at the manufacturing sector could directly account for the productive impact of trade on output growth.

The paper also studies the impact of imports and exports independently on output growth and conduct a panel test if there exist an export-led or import-led productivity growth in the panel of Asian countries under study. In most cases imports is only included as a component of total trade and not individually tested on its impact on productivity growth. As pointed out by Krishna et. al. (1999) that causality tests based on the trade shares suffers from the basic assumption that the coefficients of exports and imports are constrained to be constant. In fact, they show from their model specification test that output growth is best explained by models that include export and/or imports as independent variables for 70 percent of their sample countries. In order to provide a clear understanding on the impact of openness on productivity growth, we provide an independent test on the causal impact of imports and exports on productivity growth.

There are several reasons for independently studying the impact of exports and imports on productivity growth. The role of exports and imports will be different in the open economic system. In particular, Mckinnon (1964) states that in most developing countries the lack of technology is the main obstacles for growth and the "foreign exchange gap" impedes developing countries from financing the imports of these technologies. Exports of labour-intensive goods could fill in the "foreign exchange gap" and could finance the import of appropriate technology into the domestic economy. In this case, we could expect imports to have a greater impact on productivity growth than exports.

There are strong theoretical reasons to believe that imports could have greater impact on productivity than exports in an open economy. For instance, recent endogenous growth models suggest that importing is an important avenue for foreign technology and knowledge to flow into the domestic economy (Grossman and Helpman, 1991; Lee, 1995, Mazumdar, 2001). New technologies could be embodied in imports of intermediate goods like machines and equipments and in this case labour productivity could increase over time as workers acquire the knowledge to 'unbundle' the new embodied technology. We could also expect imports to increase competition in the domestic market, as imports of final and intermediate goods will force domestic producers to innovate and increase their efficiency to compete with the foreign imports (MacDonald, 1994).

The empirical evidence on the relationship between productivity and export growth is rather mixed. Studies at the firm level by Kruger and Tuncer (1982) conclude that export growth is positively related with productivity growth. In a more recent study on Taiwan's electronics industry, Aw and Hwang (1995) found exporting firms tends to have higher productivity growth than non-exporting firms. In contrast, a recent study by Clerides, Saul, and Tybout (1998) found no evidence of any effects from export market participation on productive performance of firms for Colombia, Mexico and Morocco. In United States Bernard and Jensen (1999) found that exporting does not contribute to the plant productivity growth. However, their evidence shows positive effect of productivity on plant level exports.

There are several papers that explore the causal relationships between exports and productivity growth in time series analysis (Kunst and Marin, 1989; Marin, 1992; Xu, 1996; Yamada, 1998). For major OECD countries, Marin (1992) found positive relationship from exports to labour productivity growth. However, the recent paper by Yamada (1998) re-examined this causal relationship for the same OECD countries and found no evidence of causality from exports to productivity growth.

Our results in a panel VAR indicate that exports and imports have qualitatively different impact on labour productivity and TFP growth across the Asian countries under study. We found robust evidence of import-led productivity growth for the Asian countries under study. There are strong bi-directional causality between imports and productivity growth in our results. This result is robust to both labour productivity and TFP growth. However, we do uni-directional causality from exports to labour productivity growth and thus some evidence of export-led productivity growth. However, this result is not robust to the use of TFP growth as the productivity measure. This suggests that trade has important impact on productivity and output growth in the economy, however it is imports that provides the important virtuous link between trade and output growth.

The paper is organised as follows. Section 2 provides the data sources and trend properties. Section 3 discusses the Vector Error-Correction Model and the empirical results. The conclusion is given in section 4.

2. Data and Trend Properties

2.1 Data

The study covers the rapidly growing Asian countries of Hong Kong, India, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand. The data for the study was collected from the World Data and World Development Indicators, World Bank[1]. The productivity measure used in the study is labour productivity, which is

[1] The price deflators are collected from the respective countries' Statistical Yearbooks, if it is not available in the World Data or the World Development Indicators.

defined as real manufacturing value-added divided by the number workers in the manufacturing sector, which is also used in the time series study on export and productivity growth by Marin (1992) and Yamada (1998). All variables were adjusted to US$ and at constant 1987 domestic prices. The manufacturing value-added is adjusted to 1987 prices using the manufacturing price deflators. If the manufacturing price deflators are not available, we used the GDP deflators to adjust the manufacturing value-added. The exports and imports[2] are also adjusted to the US$ and at constant 1987 domestic prices using their respective export and import price indices. The annual data for the labour productivity study covers the period from 1960 to 1996 and all the variables are expressed in the log form.

In addition to manufacturing labour productivity, we also used total factor productivity growth measure to analyse the impact of trade on productivity growth. The data sources for the TFP measurements for the Asian countries are given in the *Measuring Total Factor Productivity: TFP Survey, APO*. Since we derived the TFP measurement by growth rates, we did not adjust the output to a common currency for the panel study. The exports and imports series in the TFP models are in constant 1987 domestic prices. Due to lack of data, we are only able to derive the TFP measure consistently across countries and over time from 1980. Thus, for the analysis with TFP growth, we used the annual data from 1980 to 1996.

The trend of labour productivity, share of exports to GDP and share imports of GDP are shown in Table 1. Across the Asian countries, growth rate in labour productivity

[2] Since the data on imports of intermediate inputs are not available for all the countries in the sample, total import is used in the analysis. In addition, the imports of varieties of final goods could be an important source for domestic firms and producers to unbundled new technology embodied in final goods.

does not show any similar trend. In 1990, Malaysia has the highest labour productivity growth of 24 percent rising from 5.7 percent in 1970. In contrast, Thailand has a productivity growth of 7.2 percent in 1970 but it decline to 1.2 percent in 1990. The data clearly shows the dependency of these countries on exports and imports for their sustainable growth. As compared to labour productivity growth, there is an upward trend for exports and imports from 1970 to 1990 across all the Asian countries under study. In particular, the share of exports to GDP increased two-fold for India, Indonesia, Korea, Malaysia, Singapore, Taiwan, and Thailand. Conversely, the share of imports to GDP also increased nearly two-fold for India, Malaysia, and Thailand. The growth rate in TFP across the selected Asian countries shows different trends. There is an upward trend for all the Asian countries from 1980 to 1990, except for Singapore.

Table 1: Trend of Labor Productivity, Exports and Imports for Asian Countries from 1970 to 1990

	Labor Productivity Growth			Total Factor Productivity Growth		
	1970	1980	1990	1970	1980	1990
Hong Kong	2.8	2.2	3.5	-	-	-
India	0.9	1.8	7.6	-	-8.11	5.70
Indonesia	6.9	18.7	9.5	-	5.91	5.70
Japan	8.6	-3.5	1.4	-	2.96	2.95
Korea	-4.0	-3.8	4.2	-	-8.34	1.49
Malaysia	5.7	12.0	24.7	-	-1.80	2.91
Philippines	24.5	13.3	8.0	-	4.60	-0.50
Singapore	0.6	11.7	8.8	-	2.04	0.37
Taiwan	14.3	-10.1	7.8	-	1.64	3.27
Thailand	7.2	5.7	1.2	-	-1.02	2.89
	Exports (% of GDP)			Imports (% of GDP)		
Hong Kong	94.6	89.9	134.3	86.9	90.8	125.8
India	3.7	6.5	7.7	4.4	10.1	10.6
Indonesia	13.5	34.2	26.1	15.0	20.2	23.7
Japan	10.8	13.7	10.7	9.5	14.6	10.0
Korea	14.1	33.9	29.7	23.8	41.3	30.3
Malaysia	42.0	57.5	76.4	37.8	55.0	74.3
Philippines	21.6	23.6	27.5	21.0	28.5	33.3
Singapore	105.6	213.4	197.5	126.0	224.2	188.8
Taiwan	20.2	36.2	44.1	22.3	33.1	39.1
Thailand	15.0	24.1	34.1	19.4	30.4	41.7

3. Methodology

3.1 Panel Unit Root Tests

Levin and Lin (1992), Quah (1994), and Im, Pesaran and Shin (1997) extended the standard unit-root test of Augmented Dickey-Fuller (ADF) test for single stationary series to a panel unit-root test with various degrees of heterogeneity. As opposed to the standard ADF test, which lacks power in small samples, the power of the panel unit-root test increases with the number of panel series.[3]

The differences in panel unit-root test across Levin and Lin (1992) (henceforth LL), Quah (1994) and Im, Pesaran, and Shin (1997) (henceforth IPS) is in the specification of the alternative hypothesis. In the above panel unit-root tests, the null-hypothesis is that in each series in the panel contains a unit root and thus difference stationary. In Quah (1994) and LL, the alternative hypothesis is proposed as that all the component series in the panel are stationary. In IPS, the alternative hypothesis is that at least one of the component series is stationary.

The LL model and IPS model could be illustrated with the following models. The LL model only allows for heterogeneity in the intercept and is given by

$$\Delta y_{it} = \mu_i + \beta y_{it-1} + \sum_{k=1}^{p} \varphi_k \Delta y_{it-k} + \gamma t + \varepsilon_{it} \text{, i=1,2,…,N, t=1,2,…,T.} \quad (1)$$

The null and the alternative hypothesis are given by $H_0 : \beta = 0, \quad H_1 : \beta < 0$. The model (1) is estimated using the within estimator or the LSDV estimator and the LL test

[3] These panel unit root tests have been employed in recent empirical studies such as Purchasing Power Parity (MacDonald, 1996; Oh, 1996; Wu, 1996; Coakley and Fuertes, 1997; Papel, 1997), panel unit root

statistic is based on the usual t-statistic: $t_\beta = \frac{\hat{\beta}}{\hat{\sigma}_\beta}$. LL suggested two transformations of the t-statistic t_β that are asymptotically normally distributed as both N and $T \to \infty$.

As opposed to LL model, IPS model allows for the common dynamics between the various components of the series to be relaxed. The heterogeneous panel data model as proposed by IPS is given by

$$\Delta y_{it} = \mu_i + \beta_i y_{it-1} + \sum_{k=1}^{p_i} \varphi_k \Delta y_{it-k} + \gamma_i t + \varepsilon_{it}, \text{ i=1,2,…,N, t=1,2,…,T.} \quad (3)$$

The maintained hypothesis of common dynamics is relaxed and the relevant hypotheses are redefined as $H_0 : \beta_i = 0, \quad H_1 : \exists i \quad st\ \beta_i < 0$. Based on the IPS model, each individual component of the panel could be estimated separately by OLS and the test statistics are obtained as (studentized) averages of the test statistics for each equation. The t-bar statistic proposed by IPS is defined as the average of the individual Dickey-Fuller τ statistics:

$$\bar{t} = \frac{1}{N}\sum_{i=1}^{N} \tau_i, \text{ where } \tau_i == \frac{\hat{\beta}}{\hat{\sigma}_\beta} \quad (4)$$

The standardized t-bar statistic proposed by IPS under the assumption that the cross-sections are independent is given by

$$\Gamma_i = \frac{\sqrt{N}\left(\bar{t} - E(\tau_i \mid \beta_i = 0)\right)}{\sqrt{\operatorname{var}(\tau_i \mid \beta_i = 0)}} \quad (5)$$

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properties of inflation rate (Culver and Papel, 1997), health care expenditure and GDP (McCoskey and Selden, 1998).

The means $E(\tau_i \mid \beta_i = 0)$ and the variances $\text{var}(\tau_i \mid \beta_i = 0)$ are obtained by Monte Carlo simulations and are tabulated in IPS. IPS conjecture that the standardized t-bar statistic Γ_i converges weakly to a standard normal distribution as N and $T \to \infty$.

The individual unit root LM statistic, LM_i, for testing hypothesis that $\beta_i = 0$ for series i is defined as

$$LM_i = \frac{T\Delta y_i' P_i \Delta y_i}{\Delta y_i' M_i \Delta y_i} \tag{6}$$

where $M_i = I - Q_i(Q_i' Q_i)^{-1} Q_i'$, $P_i = M_i y_{i,-1}(y'_{i,-1} M_i y_{i,-1})^{-1} y'_{i,-1} M_i$, $Q_i = (\lambda, t, \Delta y_{i,-1}, ..., \Delta y_{i,-p})$ and λ is a vector of ones. IPS propose to base the test on the standardized cross-section average:

$$\overline{LM} = \frac{1}{N}\sum_{i=1}^{N} LM_i \tag{7}$$

and have the individual LM statistics:

$$\Gamma_{\overline{LM}} = \frac{\sqrt{N}\left(\overline{LM} - E(LM_i \mid \beta_i = 0)\right)}{\sqrt{Var(LM_i \mid \beta_i = 0)}} \tag{8}$$

where the moments $E(LM_i \mid \beta_i = 0)$ and $Var(LM_i \mid \beta_i = 0)$ are obtained from Monte Carlo simulations and IPS show that the standardized LM-bar statistics converges weakly to a standard normal distribution as N and $T \to \infty$.

3.1.1 Panel Unit Root Test Results

In the first panel, we employ the test for labor productivity, exports and imports for 10 Asian countries from 1960 to 1996. All the series on our analysis are in logs. The t-bar and LM-bar test statistics based on the IPS model are reported in Table 1. As given in equation (3), we performed the panel unit-root test with following conditions:

a) constant but no trend and b) constant and heterogeneous trend in the test regression. The number of lags for the individual ADF test statistic is justified by AIC criteria.[4]

Table 1: Panel Unit Root Test Results with Labor Productivity, Exports and Imports for Panel of Selected Asian Countries

	Sample	Constant		Constant & Trend	
		t-bar	LM-bar	t-bar	LM-bar
Labor Productivity	N=10, T=37	-0.43 (0.99)	2.79 (0.49)	-1.70 (0.97)	3.58 (0.92)
Exports	N=10, T=37	-0.09 (0.99)	3.76 (0.12)	-1.85 (0.90)	4.24 (0.73)
Imports	N=10, T=37	-0.07 (0.99)	2.19 (0.80)	-2.07 (0.74)	4.51 (0.61)
D(Labor Productivity)	N=10, T=36	-3.98 (0.0001)	13.78 (0.0001)	-4.53 (0.0001)	13.72 (0.0001)
D(Exports)	N=10, T=36	-3.41 (0.0001)	11.79 (0.0001)	-4.48 (0.0001)	13.41 (0.0001)
D(Imports)	N=10, T=36	-3.69 (0.0001)	11.29 (0.0001)	-4.39 (0.0001)	13.20 (0.0001)

Note: i. Labor productivity, Exports and Imports are in logarithmic form
ii. Parenthesized values are the p-values obtained by stochastic simulation of 100000 replications

Given that in our model there are only 10 countries as cross-sectional components, instead of using the standardized t-bar and LM-bar statistics given in IPS, we stochastically simulated the model with 100,000 replications to obtain the small sample critical values for both t-bar statistic and LM-bar statistic. The t-bar and LM-bar test results reported in Table 1 show that all 3 variables are I(1) process, that is they are non-stationary processes at the levels but are stationary after first differencing.

[4] The general results did not alter when we use the other criteria such as SC.

In the second panel, we used TFP growth, Exports and Imports for 9 Asian countries over the period from1980 to 1996. The t-bar and LM-bar test statistics reported in Table 2 are obtained by applying the IPS unit root test for the TFP growth, logarithm of Exports and Imports. The test results reported in Table 2 show that TFP growth is an I(0) process and both exports and imports are I(1) process. Since the two trade variables are I(1) and TFP growth variable is I(0), we formulate the panel vector autoregressive model in terms of the growth rates of TFP, exports, and imports.

Table 2: Panel Unit Root Test Results for TFP Growth, Exports and Imports for Panel of Selected Asian Countries

	Sample	Constant		Constant & Trend	
		t-bar	LM-bar	t-bar	LM-bar
TFP Growth	N=9, T=17	-2.84 (0.0001)	5.76 (0.0001)	-3.72 (0.0001)	7.73 (0.0001)
Exports	N=9, T=17	-0.05 (0.99)	3.52 (0.11)	-1.54 (0.98)	2.03 (0.79)
Imports	N=9, T=17	-0.04 (0.99)	2.08 (0.77)	-2.01 (0.69)	3.91 (0.66)
D(Exports)	N=9, T=16	-3.38 (0.0001)	6.37 (0.0001)	-3.53 (0.0001)	7.44 (0.0001)
D(Imports)	N=9, T=16	-3.15 (0.0001)	7.16 (0.0001)	-3.01 (0.0001)	6.65 (0.0001)

Note: i. Exports and Imports are in logarithmic form
ii. Parenthesized values are the p-values obtained by stochastic simulation of 100000 replications

The next stage of our analysis is to determine if the 3 variables are cointegrated. It should be noted that in the absence of co-integration and in order to avoid the spurious regression problem we can only difference the data and estimate the model for variable changes (see Garcia-Mila et al.(1996) and Picci (2000)); however, if the variables of interests are co-integrated a model in differences is misspecified, since it ignores the long run information. In the next section, we examine the co-integration properties between labor productivity, exports and imports.

3.2 Panel Co-integration Test

Pedroni (1995, 1997, 1999) provides the cointegration tests for panel analysis. By carefully studying the properties of spurious panel regressions, Pedroni (1999) proposed a panel co-integration test in which the null hypothesis is defined that each individual components of the series are not cointegrated, as opposed to the alternative hypothesis that there is a single cointegrating vector which differs across the individual components. The main purpose of the panel cointegration is to pool information to determine the common long-run relationship and at the same time allow for heterogeneity across the individual components in the panel. Therefore, an important feature of the panel cointegration tests is to introduce the dynamics into the tests by allowing the fixed effects to differ across the individual components under the alternative hypothesis.

Pedroni (1999) constructs the tests for the null of no co-integration in heterogeneous panels based on the regression residuals from the hypothesized co-integrating regression. The regression, in general, takes the following form

$$y_{it} = \alpha_i + \delta_{it} t + \beta_{1i} x_{1it} + \beta_{2i} x_{2it} + ... + \beta_{Mi} x_{Mit} + e_{it} \quad (9)$$

for t = 1,2, …, T; i = 1,2,…,N

where T refers to the number of observations over time, N refers to the number of individual members in the panel, and M refers to the number of regression variables. Since there are N different members of the panel, one can formulate N different equations, each of which has M regressors. The parameter α_i is the member-specific intercept (fixed-effects parameters) and the slope coefficients $\beta_{1i}, \beta_{2i}, ..., \beta_{Mi}$ are permitted to vary across individual members of the panel. The term $\delta_i t$ captures individual deterministic trends, which can be omitted depending on the presence of deterministic trend components in the data. However, in general, inclusion of member-specific intercepts or the member specific trends will affect the asymptotic distributions and the corresponding critical values just as in the conventional time series case.

Pedroni (1997) derives the asymptotic distributions and explores the small sample performances of seven different statistics[5] for testing null-hypothesis of no-cointegration. Panel v -Statistic, Panel ρ -Statistic, Panel *t*-Statistic (non-parametric) and Panel *t*-Statistic (parametric) are commonly referred to as *within*-dimension or panel cointegration test. The remaining three test statistics - Group ρ -Statistic, Group *t*-Statistic (non-parametric) and Group *t*-Statistic (parametric), are based on pooling along what is commonly referred to as between-dimension or group mean panel statistics.[6] For the within-dimension statistics, the test for the null-hypothesis of no co-integration is implemented as a residual-based test of $H_0 : \gamma_i = 1 \, \forall i$, versus the alternative hypothesis $H_1 : \gamma_i = \gamma < 1 \, \forall i$. In this case it presumes a common value for $\gamma_i = \gamma$, where γ_i is the estimated autoregressive parameter of the estimated residuals obtained from equation (9). On the other hand, for the between-dimension statistics the null-hypothesis of no co-integration is implemented as a residual-based test of $H_0 : \gamma_i = 1 \, \forall i$, versus the alternative hypothesis $H_1 : \gamma_i = \gamma < 1 \, \forall i$. Here it does not presume a common value for $\gamma_i = \gamma$ under the alternative hypothesis. Pedroni (1999) proposed that the standardized test statistics for the above-mentioned seven statistics, which asymptotically follows standard normal distribution and is given as:

[5] See Pedroni (1999), pp 659-662 for the testing procedure and the complete formulation of test statistics.

$$\aleph^{*}_{N,T} = \frac{\aleph_{N,T} - \mu\sqrt{N}}{\sqrt{v}} \Rightarrow N(0,1) \qquad (10)$$

where $\aleph_{N,T}$ is the non-standardized test statistics, μ and v are the mean and variances obtained by stochastic simulations (see Pedroni (1999), Table 2 for the details).

3.2.1 Testing for co-integration

The panel co-integration test is carried out for the following equation:

$$y_{it} = \alpha_i + \delta_i t + \beta_{1i} X_{it} + \beta_{2i} M_{it} + e_{it} \qquad (11)$$

where y_{it} , X_{it} , and M_{it} are the logarithm of labor productivity, exports and imports respectively. The panel co-integration test is conducted with and without the deterministic heterogeneous trends.

Table 3 reports the test results ($\aleph_{N,T}$ and $\aleph^{*}_{N,T}$) for all the seven test statistics. It should be noted that under the alternative hypothesis, the panel-v statistics diverges to a positive infinity, and consequently the right tail of the normal distribution is used to reject the null hypothesis. Therefore in the panel-v statistic a large positive value implies that the null of no co-integration is rejected. For each of the other six test statistics, the test statistics diverges to a negative infinity under the alternative hypothesis, and consequently the left tail of the normal distribution is used to reject the null hypothesis. In this case, for any of these six test statistics, a large negative value implies that the null of no co-integration is rejected. The main draw back in using the standardized test statistic

[6] The with-in dimension statistic are constructed by summing numerator and denominator terms over the N dimension in the test statistic separately, whereas the between-dimension statistics are constructed by dividing the numerator by denominator prior to summing over N dimension.

$\aleph^*_{N,T}$ is that the simulated moments μ and v reported in Pedroni (1999) are based on T = 1000. But in our empirical work we have only T = 36. To overcome this problem, we conducted the Monte Carlo simulations to get the exact critical values for the non-standardized test statistics, $\aleph_{N,T}$, for our empirical sample size of N = 10 and T = 36.

The panel cointegration test results reported in Table 3 suggest that we cannot reject the null hypothesis of no-cointegartion between labor productivity, exports and imports. The panel cointegration test clearly shows that in the given panel there is no long run relationship between the variables and the panel VAR have to be modeled in the first differenced form.

Table 3: Panel Co-integration Results: Testing Co-integration between Labor Productivity, Exports and Imports

	No-trend but constant		Heterogonous trend	
	Non-standardized, $\aleph_{N,T}$	Standardized, $\aleph^*_{N,T}$	Non-standardized, $\aleph_{N,T}$	Standardized, $\aleph^*_{N,T}$
Panel v-stat	28.79 (0.99)	-0.82	44.89 (0.99)	-1.74
Panel rho-stat	-19.97 (0.99)	1.72	-30.44 (0.99)	1.73
Panel pp-stat	-5.22 (0.99)	1.69	-7.43 (0.99)	1.13
Panel adf-stat	-5.46 (0.99)	1.45	-7.53 (0.99)	1.01
Group rho-stat	-25.27 (0.99)	2.18	-37.05 (0.98)	2.19
Group pp-stat	-6.11 (0.99)	2.09	-8.16 (0.98)	1.24
Group adf-stat	-6.55 (0.99)	1.53	-8.40 (0.98)	0.92

Note: Parenthesized values are the p-values obtained by stochastic simulation of 100000 replications

4. Causal Relationship Between Trade and Productivity in a Panel VAR Estimation

The key interest in our study is to determine if causality exist between trade and productivity for a panel of Asian countries. The panel cointegration test clearly shows that the three variables are not co-integrated and that there do not exist any long run relationships between labor productivity, exports and imports. In order to establish the causal linkages between labor productivity, exports and imports, we formulate the model in the differenced form. On the other hand, the causal linkages between the TFP growth and trade are established by constructing the tri-variate VAR with TFP growth, exports growth and imports growth[7].

The empirical model is given by

$$\begin{pmatrix} \Delta y_{it} \\ \Delta X_{it} \\ \Delta M_{it} \end{pmatrix} = \begin{pmatrix} \alpha_{1it} \\ \alpha_{2it} \\ \alpha_{3it} \end{pmatrix} + \begin{pmatrix} \varphi_{11}^{(1)} & \varphi_{12}^{(1)} & \varphi_{13}^{(1)} \\ \varphi_{21}^{(1)} & \varphi_{22}^{(1)} & \varphi_{23}^{(1)} \\ \varphi_{31}^{(1)} & \varphi_{32}^{(1)} & \varphi_{33}^{(1)} \end{pmatrix} \begin{pmatrix} \Delta y_{it-1} \\ \Delta X_{it-1} \\ \Delta M_{it-1} \end{pmatrix} + \ldots + \begin{pmatrix} \varphi_{11}^{(p)} & \varphi_{12}^{(p)} & \varphi_{13}^{(p)} \\ \varphi_{21}^{(p)} & \varphi_{22}^{(p)} & \varphi_{23}^{(p)} \\ \varphi_{31}^{(p)} & \varphi_{32}^{(p)} & \varphi_{33}^{(p)} \end{pmatrix} \begin{pmatrix} \Delta y_{it-p} \\ \Delta X_{it-p} \\ \Delta M_{it-p} \end{pmatrix} \quad (12)$$

where Δy_{it} - Labor productivity Growth or TFP Growth, ΔX_{it} - Exports Growth, and ΔM_{it} - Imports Growth. The model also allows for sufficient dynamics across the individual components in the panel through the fixed effects (α_{1it}). The estimated parameters for the above models are reported in the Appendix I. The optimal lag length p is determined by both AIC and SC criteria. The results indicate that there is a robust estimation with both labor productivity and TFP growth. Most of the group dummies were statistically significant indicating sufficient dynamics in the model is captured in our estimation. In fact, the estimation with TFP provides a better and robust fit as compared to the result with labor productivity.

The main focus of this study is to establish the causal linkages between productivity, exports and imports. We conduct the traditional Granger causality test within panel VAR framework. For example, testing Granger non-causality from exports growth to productivity growth involves testing restrictions that $\varphi_{12}^{(1)} = \varphi_{12}^{(2)} = ... = \varphi_{12}^{(p)} = 0$ against the alternative that $\varphi_{12}^{(i)} \neq 0$ for some i. We employ Wald test to establish the short-run causality between these variables, which follows χ^2 distribution with p degrees of freedom. Further, we could also distinguish between a positive and negative causal effect by the sign of the sum of the estimated coefficients, for example, the causality from exports growth to productivity growth is determined by the sign of $\sum_{i=1}^{p} \hat{\varphi}_{12}^{(i)}$.

The test results are reported in Table 4 and Table 6.

Table 6: Granger Causality Test (Wald Test) for Selected Asian Countries with the Growth rate of Labor Productivity, Exports, and Imports

Effect (→) Cause (↓)	ΔLP	ΔX	ΔM
ΔLP	-	1.12 (0.57	0.53 (0.77
ΔX	7.45** (0.02) (Positive)	-	15.20*** (0.000) (positive)
ΔM	8.07** (0.018) (Positive)	78,23** (0.016) (Positive)	-

Note: Parenthesized values are the probability of rejection of Granger non-causality

[7] The model with growth rate of TFP, exports and imports were not tested for cointegration, since total factor productivity growth is defined in terms of growth rate. Therefore we only tested the model for the short-run causal relationship.

The results for the model with labor productivity, there is evidence of export-led and import-led productivity growth in the selected Asian countries. However, there is no evidence of any feedback from labor productivity to the trade activities of export and imports. As compared to labor productivity, the result with TFP reveals that imports is the only trade variable that has statistically significant impact on productive performance in the selected countries in our sample. As oppose to export-led productivity growth, we observe TFP growth have statistically significant impact on export. This supports the observation by Bernard and Jensen (1999) and Clerides, Lach, and Tybout (1998) that there is positive effect from productivity to exports in United States and Latin American Countries.

Table 7:Granger Causality Test (Wald Test) for the Growth rate of TFP, Exports, and Imports for Selected Asian Countries

Effect (→) Cause (↓)	ΔTFP	ΔX	ΔM
ΔTFP	-	32.28*** (0.000) (Positive)	15.60*** (0.000) (Positive)
ΔX	3.298 (0.19)	-	15.44*** (0.000) (Positive)
ΔM	9.824*** (0.007) (Positive)	7.988** (0.018) (Positive)	-

Note: Parenthesized values are the probability of rejection of Granger non-causality

The results from our models clearly indicate that trade has important impact on productive performance of the selected Asian countries, however, it is imports that is the key component in the Openness strategy to have significant impact on output growth. In fact, the result clearly indicates that the selected Asian countries are experiencing import-led rather than export-led productivity growth.

5. Conclusion

The results in our study suggest that trade has important impact on output growth, however, this only occurs through imports rather than exports. As opposed to the accepted view that export-led productivity growth exists in most of the Asian countries, our panel VAR analysis suggests that imports have more statistically significant impact on productivity growth as oppose to exports. In fact, there is cumulative causality between imports and productivity growth that suggest that imports have a “virtuous” cyclical impact on output growth in the long-run. This result is observable in the estimation with both labor productivity and total factor productivity. We do not see such feedback effects between exports and the productivity measures used in our study. This clearly indicates that there is import-led productivity growth in the selected Asian countries.

References:

Asian Productivity Organization, "Measuring Total Factor Productivity: TFP Survey Report." *Asian Productivity Organization, 2001.*

Arellano, M., "On the testing of correlated effects with panel data." *Journal of Econometric*s, **5**9, 87–97, 1995.

Arellano, M., and Bond, S. R., "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations." *Review of Economic Studie*s, **5**8, 277-297, 1991.

Arellano, M., and Bover, O., "Another look at the instrumental variables estimation of error-components models." *Journal of Econometric*s, **6**8, 29–51, 1995.

Aw, B. Y. and A. R. Hwang, "Productivity and the Export Market: A Firm-Level Analysis." *Journal of Development Economics*, **47**, 313-332, 1995.

Bernard, A. B. and J. B. Jensen, "Exporting and Productivity." NBER working paper No: 7135, Cambridge, MA, 1999.

Clerides, S., Saul Lach and James Tybout, "Is Learning-by-Exporting Important." *Quarterly Journal of Economics*, 903-948, August 1998.

Dickey, D.A., and W.A. Fuller, "Distribution of the Estimators for Autoregressive Time Series with a Unit Root." *Journal of American Statistical Association*, **74**, 427-431, 1979.

Edwards, S., "Openness, Trade Liberalization, and Growth in Developing Countries." *Journal of Economic Literature*, **31**, 1358-93, 1998.

Frankel, J. A. and D. Romer, "Does Trade Cause Growth?" *American Economic Review,* **89**, 379-399, 1999.

Granger, C.W.J., "Some recent developments in a concept of causality." *Journal of Econometrics*, **39**, 199-211, 1998.

Grossman, G.M. and E. Helpman, *Innovation and Growth in the Global Economy*, MIT Press, Cambridge, 1991.

Harrigan, J., "Estimation of Cross-Country Differences in Industry Production Functions." *Journal of International Economics*, **47**, 267-293, 1999.

Im, K.S., M.H. Pesaran, Y. Shin, "Testing for Unit Roots in Heterogeneous Panels." Mimeo, Department of Applied Economics, University of Cambridge, UK, 1997.

Islam, N., "Growth Empirics: A Panel Data Approach." *Quarterly Journal of Economics,* **110**, 1127-70, 1995.

Kruger, A. O. and B. Tuncer, "Growth of Factor Productivity in Turkish Manufacturing." *Journal of Development Economics*, **16**, 177-206, 1992.

Krishna, K., A. Ozyildirium, and N.R. Norman, "Trade, Investment, and Growth: Nexus, Analysis, and Prognosis." NBER working paper no: 6861, Cambridge, MA, 1999.

Kunst, R.M. and D. Marin, "On Exports and Productivity: A causal analysis." *Review of Economics and Statistics*, **71**, 669-703, 1989.

Lee, J.W., "Capital Goods Imports and Long-Run Growth." *Journal of Development Economics,* **48(1)**, 91-110, 1995.

Levin, A. and C.F. Lin, "Unit Root Tests in Panel Data: Asymptotic and Finite Sample Properties," unpublished manuscripts, University of California, San Diego, 1993.

MacDonald, J.M., "Does Import Competition Force Efficient Production?" R*eview of Economics and Statistics*, **76 (4)**, 721-727, 1994.

Marin, D., "Is the export-led growth hypothesis valid for industrialized countries?" *Review of Economics and Statistics*, **74**, 678-688, 1992.

Mazumdar, Joy, "Imported machinery and growth in LDCs." *Journal of Development Economics*, **65**, 209-224, 2001.

Miller, Stephen and M. Upadhyay, "The effects of openness, trade orientation, and human capital on total factor productivity." *Journal of Development Economics*, **63**, 399-423, 2000.

Pedroni, P., "Panel Cointegration, Asymptotic and Finite Sample Properties of Pooled Time Series Tests, with Application to the PPP Hypothesis: New Results." Working Paper, Indiana University, 1997.

Pedroni, P., "Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors." *Oxford Bulletin of Economics and Statistics*, **61**, 653-79, 1999.

Quah, D. (1994), "Exploiting Cross-Section Variations for Unit Root Inference in Dynamic Data." *Economics Letters*, **44**, 9-19.

Rodrigues, F. and D. Rodrik, "Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence." NBER working paper no: 7081, Cambridge, MA, 1999.

Rodrik, D., "Getting Interventions Right: How South Korea and Taiwan Grew Rich." *Economic Policy,* **20,** 53-99, 1995.

Yamada, Hiroshi, "A note on the causality between export and productivity: an empirical re-examination." *Economic Letters*, **61**, 111-114, 1998.

Xu, Z., "On the causality between export growth and GDP growth: An empirical investigation." *Review of International Economics*, **4**, 172-184, 1996.

Appendix I

Table A1: Panel VAR: Labor Productivity Growth, Exports Growth and Imports Growth for Selected Asian Countries

	ΔLP_t	ΔX_t	ΔM_t
ΔLP_{t-1}	0.28**	-0.004	0.01
ΔLP_{t-2}	0.19***	0.19	0.09
ΔX_{t-1}	0.001	0.40***	0.32***
ΔX_{t-2}	0.08***	0.13*	0.23**
ΔM_{t-1}	0.10***	0.24***	0.37***
ΔM_{t-2}	-0.01	-0.09*	-0.17***
Constant	0.01***	0.02***	0.02***
G2	-0.01**	0.000	0.001
G3	0.002***	0.002***	0.002***
G4	0.002***	0.003***	0.003***
G5	0.000	0.003***	0.003***
G6	-0.03*	0.001	0.002
G7	0.007**	0.002	0.001
G8	0.006**	0.003	0.001
G9	0.003***	0.004***	0.004***
R-Square	0.18	0.23	0.29

*, ** and *** represents the significance at 10%, 5% and 1% respectively

Table A2: Panel VAR : Total Factor Productivity Growth, Exports Growth and Imports Growth for Selected Asian Countries

	ΔTFP_t	ΔX_t	ΔM_t
ΔTFP_{t-1}	0.638***	0.492**	0.601*
ΔTFP_{t-2}	0.108*	-0.130	-0.226
ΔX_{t-1}	0.012	0.357***	0.269***
ΔX_{t-2}	0.033	0.170***	0.259***
ΔM_{t-1}	0.033*	0.226***	0.351***
ΔM_{t-2}	0.063***	-0.084**	-0.175***
Constant	0.033***	0.038***	0.043***
G2	0.028***	0.013***	0.014***
G3	0.003***	0.002***	0.003***
G4	0.007***	0.010**	0.012*
G5	-0.010***	-0.002	-0.002
G6	-0.018***	-0.007***	-0.008**
G7	0.006***	0.005***	0.006**
G8	0.014***	0.008***	0.008***
G9	-0.004***	0.002***	0.002**
R-Square	0.53	0.56	0.61

*, ** and *** represents the significance at 10%, 5% and 1% respectively