A Panel Data Approach to the Contribution of Trade to the Growth of Selected East Asian Countries

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Abstract

Panel data methods are used to estimate the contribution of openness of trade to the long term or the steady state rate of growth of output (*SSGR*) of selected East Asia countries viz., Singapore, Malaysia, Thailand, Hong Kong, Korea and the Philippines. Since *SSGR* is unobservable, its estimates are derived by estimating modified production functions and by imposing the equilibrium conditions of the Solow (1956) growth model. Panel cointegration tests showed that there is a well defined long run relation between output, trade ratio and capital. Growth accounting exercise showed that factor accumulation is the dominant contributor to the *SSGR* of this region. Openness of trade, however, has made a significant contribution to *SSGR* by 1999-2003.

Keywords: Panel unit root and cointegration tests, Trade Openness, Total Factor Productivity and East Asian Countries.

JEL: N1, O1, O4, O11

1. Introduction

The relative importance of factor accumulation versus technological progress (*TFP*) for the growth of the East Asian countries has started in the late 1980s and 1990s with Amsden (1989) and Young (1995). This is also known as the accumulation versus assimilation controversy. Nelson and Pack (1999), in their reassesment of this controversy, have noted that it is important to take into account the effects of some variables on total factor productivity (*TFP*) in estimating the production functions instead of conducting growth accounting exerciseses by assuming that *TFP* is exogenous. When this modification is made the relative importance accumulation and assimilation may significantly change. Among the many factors that may have improved *TFP,* openness of trade (*TRA*) is generally considered to be an important factor for the East Asian countries.[1] In this paper we shall conduct a simple growth accounting exercise, using the parameters of a modified production functions that allows for the effects of *TRA* on *TFP* to analyse the accumulation versus assimilation controversy. We shall estimate the effects of *TRA* with three panel data methods developed for the non-stationary variables viz., Pedroni (2000, 2001 and 2004), Mark and Sul (2003) and Breitung (2006). Our panel of countries consists of six East Asian countries viz., Hong Kong, Malaysia, Korea, the Philippines, Singapore and Thailand.

We shall also examine a few other neglected issues in the empirical literature on growth models. Firstly, although several works state that their aim is to estimate the long run growth equations, they do not make a distinction between the observable actual growth rate and the unobservable long run equilibrium growth rate i.e., the steady state growth rate (*SSGR*) of the theoretical models. Secondly, a few specification problems and the derivation of the unobserved *SSGR* from the estimated growth equations are also need attention. We argue that *SSGR* should be derived from the estimates of modified production functions after imposing the steady state equilibrium

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[1] Hoover and Perez (2004) have pointed that more than 80 growth enhancing variables have been identified in the empirical literature. It is hard to say which of these variables are more important because their relative importance may change between countries and periods. Furthermore, many are trended and it is hard to introduce more than one or two such variables into the growth equations because of multi-colinearity. Nelson and Pack have examined the effects of structural changes in the manufacturing sector on the total factor productivity (*TFP)* in Taiwan, Hong Kong, Korea and Singapore and concluded that assimilation is important for the East Asian growth miracle.

conditions. Thirdly, panel data methods are difficult to use with a small number of countries because panels consisting of variables averaged over 5 or more years will reduce significantly the sample size. However, we shall justify the use of annual observations in the panel methods of growth equations.

To limit the length of this paper we shall not review the accumulation versus assimilation controversy because our main purpose is to show that estimates of the unobservable *SSGR* can be derived with the panel data methods with a small cross-sectional dimension.[2] Next, we use the standard techniques based on the first generation Pedroni's (2000, 2001 and 2004) cointegration tests. However, our cointegrating equations are estimated with the Pedroni Group-Mean Panel Fully-Modified Ordinary Least Squares (GMPFMOLS) method and two other recent methods developed by Mark and Sul (2003) and Breitung (2006).

The outline of this paper is as follows. Section 2 is on the specification issues, Section 3 presents empirical results and Section 4 concludes.

2. Specification Issues

Many panel data studies of growth equations use short panels of 3 to 5 years and a large number of countries. They treat the average growth rates from such short panels as if they were good proxies for the long term growth rate or the *SSGR*. However, simulations with the closed form solutions show that an economy typically takes more than 3 or 4 decades to reach its steady state equilibrium even after small perturbations; see Sato (1963), Jones (2000) and Rao (2006). Therefore, the dependent variable in many panel data studies is not a good proxy for *SSGR* and suffer from misspecification biases. Commenting on such specification weaknesses Easterly, Levine and Roodman (2004) have observed that "This literature has the usual limitations of choosing a specification without clear guidance from theory, which often means there are more plausible specifications than there are data points in the sample." Rao (2008) has argued that what can be estimated with annual and short panel data, at best, is a production function and not equations for the long run rate of growth or *SSGR*. *SSGR,* conceptually, is similar to the natural

[2] An excellent survey of this controversy is provided by Sarel (1995).

rate of unemployment. Both are unobservable and their estimates should be derived by imposing the steady state conditions on the estimated short run dynamic equations with observable variables. The effects of some growth enhancing variables, such as *TRA*, can then be derived from the estimates of extended production functions in which the effects of variables like *TRA* on the *SSGR* are taken into account. For this purpose, we extend the constant returns Cobb-Douglas production function in the Solow (1956) growth model and use its steady state conditions to estimate *SSGR* because the Solow model is simple to estimate. *TFP,* which is assumed to be exogenous in the Solow model, can be endogenised with the assumption that *TFP* is a function not only of time but also other growth improving variables like *TRA*. The Solow model, extended in this manner, is not a full-fledged endogenous growth model and it may be called as the Solow model with an endogenous framework.[3]

Let the standard Cobb-Douglas production function in per worker output (y) and per worker capital (k) with constant returns and the Hicks neutral technical progress be:

$$y = A_0 e^{gT} k^{\alpha} \qquad (1)$$

where T is time trend and A_0 is the initial stock of knowledge. It is well known that in the standard Solow model, where *TFP* is autonomous, in the steady state *SSGR* equals g. Two alternative specifications, where *TFP* is assumed to dependent on *TRA* i.e., $g = g(T, TRA)$ in a linear and non-linear form are as follows.

$$y_t = \left[A_0 e^{(g_1 + g_2 TRA_t)T} \right] k_t^{\alpha} \qquad (2)$$

$$y_t = \left[A_0 e^{(g_3 + g_4 TRA_t + g_5 TRA_t^2)T} \right] k_t^{\alpha} \qquad (3)$$

The terms in the square brackets are the assumed relationship for the evolution of the stock of knowledge, for example, in (2) it is assumed that

[3] There is no clear cut evidence that the endogenous growth models are better than the exogenous Solow (1956) model. Parente (2000) and Jones (1995) discuss this in some detail. Endogenous growth models are also difficult to estimate and need nonlinear dynamic methods. Greiner, Semler and Gong (2004) explain these procedures.

$$A_t = A_0 e^{e^{(g_1 + g_2 TRA_t)T}} \quad (4)$$

Equation (3) allows us to test for a variety of nonlinear effects of *TRA* as *TRA* increases. Its effects on *TFP* may remain constant or accelerate or increase at first and then decline, depending on the signs and values of g_4 and g_5. The Solow model implies that *SSGRs* with the modified production functions in (2) and (3), respectively, are $g_1 + g_2 TRA_t$ and $(g_3 + g_4 TRA_t + g_5 TRA_t^2)$.[4]

The specification for the panel method with the cross section (*i = 1….6*) and time series (*t=1…..34*) dimensions of equation (2) in our sample of 6 countries and the period 1970-2003, for example, is:

$$y_{it} = A_{i0} e^{(g_1 + g_2 TRA_{it})T} k_{it}^{\alpha} \quad (5)$$

Similar equation can be specified for (3).

3. Empirical results

First, the order of the logarithms of the variables viz., *ln(y)* and *ln(k)* and the level of *TRA* are tested with the standard panel data unit root tests and the results are in Table 1.[5] With the

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[4] The derivatives of the exponents of the modified production functions are:

$$SSGR = g_1 + g_2 (TRA + \Delta TRA)$$

$$SSGR = g_3 + g_4 (TRA + \Delta TRA \times T) + g_5 (TRA^2 + 2TRA \times \Delta TRA \times T)$$

If the changes in *TRA* is zero in the steady state (like the change in the state variable capital per worker) then *SSGR* are as given in the text.

[5] The tests are: Levin, Lin and Chu (2002), (LLC), Im, Pesaran and Shin (2003) (IPS), Maddala-Wu (1999) (MW), Breitung (2000) (BR) and Hadri (2000) (HA). To conserve space, only the tests based on common unit root process (LLC, BR and HA) are reported. Test results based on the individual unit root process (not reported) are also similar.

exception of Breitung-t test for capital, other tests show that these variables are I(1) in levels and I(0) in their first differences.

The null hypothesis in the first two tests in Table 1 is that the variable is I(1) against the alternative of I(0). In the Hadri test the null is that the variable is I(0) against the alternative I(1). Lags for the tests are selected automatically by EViews 6. Asterisk and double asterisk denote rejection of the null at the 5% and 10% levels. Intercept and trend are included in the levels but only the intercept in the first test difference equations.

Since the results in Table 1 show, with the exception of the Breitung – t test for *ln(k),* that the variables are I(1) in levels and I(0) in first differences, we proceed further and used Pedroni's cointegration tests to test for cointegration between the variables in equations (1), (2) and (3). These results are in Table 2. Four of these tests are panel tests and three are group tests. They take into account the cross sectional and time series information and posses higher power. These 7 tests are: (1) panel υ–statistic, (2) panel ρ -statistic, (3) panel *pp*-statistic, (4) panel-*ADF* statistic, (5) group ρ -statistic, (6) group-*pp*-statistic and (7) group-*ADF* statistic. The null in these tests is no cointegration against the alternative of cointegration. The test statistics have the standard normal distribution.

It can be seen that the panel υ -statistic is insignificant in the four equations and the panel and group *ADF* statistics are insignificant in equations (1) and (3). All other test statistics are insignificant in the remaining equations. In particular tests for equation (2) in which *TRA* has linear effects on *SSGR* and equation (3) where *TRA* has nonlinear effects are impressive and imply that robust long run relationships between output, openness and capital exist.

EViews 6 is used for these tests and the manual has some useful information on these tests; see also Murthy (2007) for an easy to understand exposition of panel unit root and cointegration tests.

Table 1: Panel Unit Root Tests

(Based on the Common Unit Root Process)

Series	LLC	Breitung – t	Hadri – Z
ln(y)	-0.091 (0.46)	-0.264 (0.40)	2.511 (0.00)
ln(TRA)	-0.605 (0.27)	1.020 (0.85)	2.806 (0.00)
ln(k)	0.413 (0.66)	5.450 (0.00)*	6.346 (0.00)
Δ ln(y)	-6.942 (0.00)	-5.059 (0.00)	-0.221 (0.59)
Δ ln(TRA)	-7.951 (0.00)	-7.567 (0.00)	0.431 (0.33)
Δ ln(k)	0.590 (0.72)	-1.544 (0.06)**	5.119 (0.00)

Notes: Probability values are in the parentheses.

Table 2: The Pedroni Panel Cointegration Tests: Equations (1) to (3)

	Equation (1) (Solow Model)	Equation (2) (Modified Solow Model)	Equation (3) (Modified Solow Model)
Panel υ-statistic	-0.987	-1.209	-0.399
Panel σ-statistic	2.185*	2.626*	1.975*
Panel $\rho\rho$-statistic	2.365*	3.017*	1.981*
Panel ADF-statistic	1.455	1.975*	1.378
Group σ-statistic	2.727*	3.12*	2.726*
Group $\rho\rho$-statistic	2.832*	3.404*	2.613*
Group ADF-statistic	1.530	1.893**	0.869

Since these cointegration tests are favourable, we have estimated these 3 cointegrating equations with three methods viz., the Pedroni Group Mean Panel Fully Modified OLS (GMPMOLS), Mark and Sul (2003) and Breitung (2006) methods, with and without the common time dummies.[6] To conserve space we shall not report all these estimates and the parameters for the individual countries. Estimates without the common time dummies performed far better in these three methods implying that autonomous *TFP* is somewhat low or perhaps insignificant for these countries. In the estimates with the common time dummies, the coefficients of *TRA* became insignificant in all the three methods. This may also be due to the colinearity between trend and

[6] RATS 7.0 is used for the cointegration tests and for the estimates of the cointegrating equations with the Pedroni method. GAUSS 8.0 is used for the Mark and Sul and Breitung estimation methods.

$TRA \times T$. However, in all equations the share of capital has been always significant.[7] Estimates of the coefficients in the cointegrating equations are shown in Table 3.

Estimates of the basic production function in (1) are in the first 3 rows of Table 3. The share of profits (α), which is highly significant, is about 0.5 in the three methods. These are plausible estimates although higher than the stylised value of one third used in many growth accounting exercises.[8] The actual average growth rates of capital ($\Delta \ln k$) and output ($\Delta \ln y$), respectively, are 5.34 and 3.37. These values are used in our growth accounting exercise. The higher estimates for the share of profits may be due to the absence of the time trend to capture *TFP* due to some trended variables and as Nelson and Pack (1999) have hinted may give higher importance to factor accumulation in the growth process. Estimates of growth due to factor accumulation and *TFP,* implied by these estimates of the profit share, are shown in the first three rows of Table 4 where the estimate of *TFP* is computed as the Solow residual i.e., $TFP = \Delta \ln y - \alpha \Delta \ln k$. These estimates imply that, on the average, factor accumulation is the dominant contributor to growth of these six East Asian countries. The contribution of factor accumulation to growth, implied by our estimates, is about 80 percent.

Estimates of the two modified production functions, where *TFP* is made a function of *TRA,* are in rows 4 to 9 of Table 3. In the estimates of equation (2), with linear effects of *TRA,* all the coefficients are significant at the 5% level. However, in the estimates of equation (3), with non-linear effects for *TRA,* the squared *TRA* is insignificant, implying that the nonlinear effects of *TRA* are insignificant. The most noteworthy feature in these six equation is that the estimates of the share of profits are close to the stylised value of one third. This implies that the importance of factor accumulation in the growth process is perhaps somewhat overestimated in the unmodified production function in equation (1).

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[7] When we introduced trend as an additional explanatory variable the generalized symmetric matrix could not be inverted and RATS gave an error message.

[8] Recently Bosworth and Collins (2008) have assumed 0.4 for the value of the share of profits in their growth accounting exercise for China and India.

Table 3: Panel Group Estimates: Equations (1) to (3)

	lnk	$TRA \times T$	$TRA^2 \times T$
Basic Solow Model Pedroni: Equation 1	0.501 (50.93)*		
Basic Solow Model Mark-Sul: Equation 1	0.514 (51.90)*		
Basic Solow Model Breitung: Equation 1	0.512 (50.29)*		
Modified Equation (2) Pedroni	0.362 (18.46) *	4.230 E^{-3} (6.59) *	
Modified Equation (2) Mark-Sul	0.372 (19.21) *	4.546 E^{-3} (3.94) *	
Modified Equation (2) Breitung	0.347 (17.24) *	4.121 E^{-3} (4.56) *	
Modified Equation (3) Pedroni	0.377 (7.65) *	3.672 E^{-3} (3.47) *	-0.801E^{-3} (-1.02)
Modified Equation (3) Mark-Sul	0.347 (19.20) *	3.173 E^{-3} (2.08) *	-0.797 E^{-3} (-0.86)
Modified Equation (3) Breitung	0.356 (22.89) *	3.709 E^{-3} (2.20) *	-0.660 E^{-3} (-0.94)

Notes: t-ratios are in the parantheses below the coeffcients. * stands for significance at the 5% level. ln(k) and *TRA* are scalled to get estimates up to 3 digits in RATS.

Using the estimates for equation (2), we performed a simple growth accounting exercise and the results are in rows (4) to (6) of Table 4.[9] These results imply that the importance of factor accumulation to growth, although still dominant, is reduced from 80 percent to between 55 to 60 percent. The importance of *TFP* almost doubled from about 20 to 40 percent. Therefore, our results support the Nelson and Pack (1999) suggestion to include some determinants of *TFP* in the estimates of the production function for growth accounting exercises.

In column (4) of Table 4 the contribution of *TRA* to *TFP* is shown using the average values of *TRA* for 1970-1974, which is the beginning of our sample period, and also for 1999-2003 which is the end of the sample period. In column (5) *TFP* due to factors other than *TRA* is shown as a residual for these two periods. From these results it can be seen that *TRA*'s contribition to *TFP* has doubled from about 10 percent from the early 1970s to about 20 percent in the early 2000s in the three estimates. Therefore, *TRA* seems to have played an increasing role in enhancing *TFP* in the East Asian countries. The failure of our nonlinear equation (3) to capture this effect may be

[9] Estimates of equation (3) are ignored because there is no evidence for the nonlinear effects of *TRA*.

due to its inadequacy to capture a more complex nonlinear process or due to the differences in the nonlineasr effects between these countries. Therefore, a country specific study would be useful to understand these nonlinear effects.

Table 4 Growth Accounting for Estimates of *TFP*

	(1)	(2)	(3)	(4)	(5)
	Total growth ($\Delta \ln y$)	Growth due to factor accumulation (proportion in parantheses)	Growth due to *TFP* (proportion in parantheses)	Contribution of ΔTRA to *TFP* (proportion in parantheses)	Contribution of other trended factors to *TFP* (proportion in parantheses)
With Basic Solow Model: Equation (1)					
Pedroni	3.371	2.676 (0.80)	0.902 (0.20)		
Mark and Sul	3.371	2.745 (0.81)	0.750 (0.19)		
Breitung	3.371	2.735 (0.81)	0.792 (0.19)		
With Modified Production Function: Equation (2)					
Pedroni	3.371	1.898 (0.56)	1.473 (0.44)	(1970-1974) 0.135 (0.09)	(1970-1974) 1.339 (0.91)
				(1999-2003) 0.302 (0.21)	(1999-2003 1.171 (0.79)
Mark and Sul	3.371	1.987 (0.59)	1.384 (0.41)	(1970-1974) 0.145 (0.10)	(1970-1974) 1.276 (0.90)
				(1999-2003) 0.325 (0.23)	(1999-2003 1.096 (0.77)
Breitung	3.371	1.853 (0.55)	1.518 (0.45)	(1970-1974) 0.131 (0.09)	(1970-1974) 1.421 (0.91)
				(1999-2003) 0.294 (0.19)	(1999-2003) 1.275 (0.81)

4. Conclusion

This paper has used three panel data methods for nonstationary variables to estimate production functions and then derive the *SSGR* for a panel of six East Asian countries. Two production functions are modified where *TFP* is made a function of *TRA*. Firstly, it is argued that in the estimates of growth equations, where the variables are averaged over short panels, the depended variable is not a good proxy for the unobservable *SSGR* of the theoretical models. Therefore, it is suggested that the effects of growth enhancing variables, such as *TRA,* should be derived by imposing the steady state conditions on the estimates of the underlying nonsteady state equations of the growth model. Since annual observations can be used to estimate these nonsteady state equations, it is possible to increase the sample size and use panel data methods with smaller cross-sectional dimensions. This is especially important because it is not known how the averaging process in many panel data studies may distort their estimates and results.

Secondly, we have used in our estimates the Solow (1956) growth model for its simplicty and demonstrated how the permanent growth effects of *TRA* can be estimated and used in the growth accounting exercises. We found that it is important to allow for the effects of growth enhancing variable like *TRA* on *TFP,* and therefore on the *SSGR,* because estimates with the unmodified production function may underestimate the significance of growth improving variables. Our results show that although factor accumulation is more dominant in the growth process, its significance has declined from about 80 percent to 55 percent when the modified production function is used for estimation. Furthermore, we found that *TRA* has contributed up to 20 percent to *TFP. TRA* increases by another 25 percent than its mean value during 1999-2003, its contribution to *TFP* increases from 20 to 30 percent.

There are some limitations in this paper. Our estimates of *TFP* are based on the Solow residual since we could not estimate it from the production function because estimates with the common time dummies did not yield satisfactory estimates. However, usinging the Pedroni estimates in Table 4, *SSGR* which is equal to *TFP* is about 1.5 percent. Of this 1.2 percent is due to other trended variables and 0.3 percent is due to *TRA*. If *TRA* is increased by another 25 percent over the next 5 years, assuming that *TFP* due to other factors remains constant at 1.2 percent, the additional *TFP* due to the improvement in *TRA* will be another 0.15 points i.e., *TFP,* hence

SSGR, will increase from 1.5 percent to 1.7 percent. Although this is a small magnitude, it will make a significant difference to the level of income over longer periods.[10] Another limitations of our study is that we have included only one growth enhancing variable, which is essentially of the mana from the heaven type, although there are several other potential determinants of *TFP*. However, some of these potential factors, e.g., human capital and expenditure on R & D etc., need additional resources which means that it is necessary to estimate additional equations on how households and firms determine these expenditures. This is beyond the scope of the present paper. Nevertheless, in spite these limitations, we hope that our methodology would be useful to other researchers to estimate improved models with the panel data and country specific time series methods.

[10] Over a 25 years per worker income will be 5 percent higher.

Data Appendix

Y is the real GDP at constant 1990 prices (in millions and in US$). Source: UN National accounts database (2008).

L is employment or the labour force (within 15-64 age goup) whichever is availiable. Source: World Development Indicators (2005).

K is real capital stock estimated with the perpetual inventory method with the assumption that the depreciation rate is 4%. The initial capital stock is 1.5 times the real GDP in 1969 (in millions of US$). Source: the UN National accounts database (2008).

TRA is the ratio of exports plus imports of goods and services to GDP. Source: UN national accounts and International Financial Statistics, IMF (2005).

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