Institutions and Economies
Vol. 4, No. 2, July 2012, pp. 1-24

The Anatomy of the Asian Take-off

Jakob B. Madsen*
Department of Economics
Monash University, Australia
Email: jakob.madsen@monash.edu

Md. Rabiul Islam
Department of Economics
Monash University, Australia
Email: md.rabiul.islam@monash.edu

Abstract: This paper discusses the literature on sources and causes of growth among the Asian high growth performers since World War II (WWII). It is argued that the factor accumulation hypothesis cannot be used to explain the Asian growth miracle but that growth has been driven predominantly by R&D, the demographic transition and knowledge transfer from the developed countries. Furthermore, it is argued that due to scale effects in the ideas production function, the Asian high-growth economies are likely to grow at high rates in the future.

Keywords: Asian growth miracles, capital accumulation, growth accounting, Schumpeterian growth, technological progress

JEL classifications: *O11, O30, O40, O53*

1. Introduction

Over the last couple of decades researchers and policymakers have been consistently debating about whether factor accumulation or technological progress can explain rapid economic growth in the East Asian newly industrialized countries (NICs) during the early-1960s to the mid-1990s. The World Bank (1993) has dubbed this impressive growth 'The East Asian Miracle'. Theoretical as well as empirical debates on the sources of miraculous growth have been divided into two major strands, namely accumulation and assimilation. Based on the neoclassical growth framework, accumulationists argue that the factor inputs, particularly capital formation, are the main engines behind this outstanding growth. On the contrary, within the endogenous growth framework, assimilationists argue that the acquisition and mastery of foreign technologies are the major driving forces behind such spectacular growth. However, identifying the sources of rapid growth in miracle economies still remains an important area of research in order to replicate sustainable growth strategies in other regions in the light of East Asian experience.

Whether factor accumulation (labour and capital) or technological advancement can explain the Asian growth miracle has become a central question over the past two decades. Mankiw *et al*. (1992) argue that the differences in physical and human capital in an augmented Solow model can account for roughly 80 percent of the variations in cross-country income differences. This finding has been backed up by a series of papers by Young. Using a growth accounting framework Young (1994, 1995, 2003) and Collins and Bosworth (1996) argue that the higher rates of savings and investment are the major contributors to the rapid growth of the miracle economies and hence there have been little or no growth effects from the source of total factor productivity (TFP).

However, the Young hypothesis has not gone unchallenged. Klenow and Rodriguez-Clare (1997) find that TFP accounts for about 90 percent of the cross-country disparities in growth rates. Prescott (1998) shows that capital per worker cannot account for the huge observed differences in output per worker, instead technological changes or TFP increases labour productivity in the long run. Hall and Jones (1999) argue that differences in physical capital and educational attainment can only partially explain the variation in output per worker, and that a large amount of variation is driven by differences in the level of the Solow residual or TFP across countries. Easterly and Levine (2001) observe that the 'residual' rather than factor accumulation accounts for most of the income and growth differences (about 60 percent) across countries. Efficiency is at least as important as capital accumulation in explaining income differences across nations (Caselli, 2005).

Romer (1993) and Nelson and Pack (1999) suggest that the acquisition and assimilation of foreign technology and the capacity to put ideas into practice are the major driving forces behind the impressive growth rates in the Asian miracle economies. Radelet *et al*. (2001) argue that the potential for catching up foreign technology, favourable geographical and structural characteristics and demographic changes are the essential factors behind this stunning growth. R&D is not only an engine of growth, but also it plays a key role in the miracle economies' take-offs (Ang and Madsen, 2011). TFP growth driven by R&D, human capital and knowledge spillovers through the channel of imports are found to be the most important factors behind the rapid growth in Asian miracle economies (Madsen and Ang, 2010).

Although technological progress seems to play a leading role in such spectacular growth, these miracle economies have experienced significant changes in labour force participation rates, age structures, working hours, educational attainment and time preferences during the post-WWII period. Land has been an important factor of production for most of the Asian economies in their early stages of development and hence population growth was initially a growth drag due to diminishing returns introduced by land as a fixed factor of production. Demographic transition reduces population growth drag and age dependency ratios and enables a large fraction of women to enter the labour force. Also, increasing innovative activities has resulted in capital deepening. Therefore, the growth accounting framework should allow for demographic transition, increased female labour force participation, capital endogeneity, and particularly, the innovation and assimilation of new technologies in order to adequately explain the sources of miraculous growth in the Asian economies (Madsen and Ang, 2010).

In this paper we argue that factor accumulation alone would not have been the source of growth in the Asian miracle economies. We also argue that R&D, transfer of technology from abroad, reduced population growth, and reduced transaction costs have been the major sources behind the Asian Growth Miracle. In the next section we review the factor accumulation hypothesis and argue that it fails to explain the growth process and why Asia took off. Section 3 discusses the assimilation hypothesis showing that TFP has been the most important source of growth in Asian miracle economies. Section 4 concludes.

2. Accumulation Hypothesis

The neoclassical growth model of Solow (1956) and Swan (1956) considers exogenous technological progress as the main driving force for long run economic growth. Lower population growth allows for higher per capita savings and investment, which in turn increase per capita income by accumulating higher capital stock per worker. Technological improvement can facilitate sustained growth by offsetting diminishing returns to capital. However, if growth results exclusively from factor accumulation and there is no technical progress in the steady state, per capita growth must eventually cease.

Growth accounting is a popular method used to decompose labour productivity growth into its sources. It has been particularly popular for decomposing the sources of high growth in some Asian countries into technological progress, capital deepening (increasing K-L ratio), increased labour force participation, increasing educational attainment and so forth. The method is as follows. Consider the Cobb-Douglas production function:

$$Y = AK^{\alpha}L^{1-a} \tag{1}$$

where Y is output, A is knowledge or TFP, K is capital, α is capital's income share, and L is labour. Taking logs and total differentiating yields:

$$g_{Y/L} = g_A + \alpha g_{K/L} \tag{2}$$

where $g_{Y/L}$ is the growth in labour productivity, g_A is TFP growth and $g_{K/L}$ is the growth in the *K*-*L* ratio. While empirical data are generally available for growth rates in labour productivity and in capital deepening and capital's income shares, they are not available for technological progress. To overcome this problem technological progress is found residually from equation (2) as:

$$g_A = g_{Y/L} - \alpha g_{K/L} \tag{3}$$

Labour productivity growth in equation (2) has been decomposed into technological progress and capital deepening. This method can easily be extended to per capita income growth rates as the dependent variable and to allow for growth in educational attainment, changing labour force participation rates, changes in dependency rates (ratio of population and population of working age), and changes in annual hours worked.

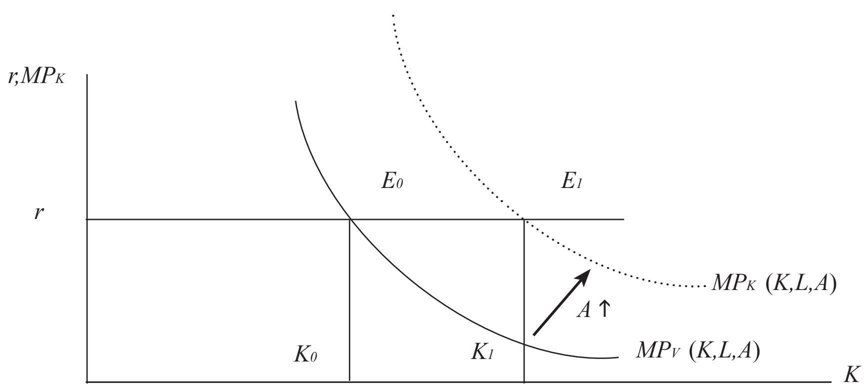
Using the growth accounting method for four East Asian Tigers (Hong Kong, Singapore, South Korea, and Taiwan) Young (1995) finds that their spectacular growth rates since 1960 have predominantly been due to factor accumulation such as capital deepening, increased labour force participation rates and enhanced schooling. Technological progress played only a secondary role. This observation corroborates earlier studies by Young (1992, 1994), Krugman (1994) and Kim and Lau (1994) where it is argued that the rapid growth in Asian newly industrialized countries (NICs) is driven by extraordinary growth in labour and capital inputs rather than technological progress. In a subsequent study, Young (2003) finds a similar contribution from factor accumulation to China's post-1978 growth experience, implying that rising labour force participation rates, improving educational attainment, and transferring labour out of the agricultural sector account for most of the recent Chinese growth.

Decomposing growth into factor accumulation and productivity gains in the period 1960-1994 for 88 developing and industrial countries (focusing on seven East Asian economies, namely, Indonesia, South Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand), Collins and Bosworth (1996) obtain empirical results similar to Young's (1995) showing that the success of East Asian countries is due to high rates of saving and investment. TFP plays a surprisingly small role in the success because technology transfer remains limited at the early stage of development and hence physical and human capital accumulation take the lead in such impressive growth. Higher capital accumulation results from increasing national savings, especially in Singapore, which had a mandatory savings program throughout the period of accelerating growth.

Krugman (1994) is certainly right in his argument that input-driven growth cannot be sustained due to diminishing marginal returns. East Asian NICs should provide more resources for innovation and research and development (R&D) to attain a positive rate of productivity growth and to catch up with the industrialized nations. They also need to improve the quality of their investment in human capital and to upgrade their software to exploit the full potential of the technology developed at the frontier (Kim and Lau, 1994). Therefore, growth can only be sustained if R&D and human capital continue to improve the technology as discussed in Section 3.

Based on the growth accounting exercises, the accumulation hypothesis explains the miraculous growth of Asian NICs as a result of excessive capital accumulation, improved educational attainment and increased female labour force participation. Therefore, the development strategy is pretty straightforward: encourage savings, subsidise schooling and encourage women to join the workforce. However, the accumulation hypothesis has a number of shortcomings. First, it assumes that the state of knowledge is embodied in new machinery and codified in blueprints and that technology adopted at the technology frontier can readily be adapted to the local environment and operated by the indigenous population regardless of skills. Second, individuals with higher education need not be more productive than the uneducated, as individuals with high education are often employed unproductively in government sectors. Third, capital deepening is endogenously explained by technological progress along the balanced growth path. To see how technological progress leads to capital deepening consider Figure 1.

Figure 1: Technological progress and capital deepening



Source: Authors

An increase in technological progress or stock of knowledge (A), as shown in Figure 1, shifts the marginal product of capital upward from MP_K to MP_K^1. It will in turn increase the return on capital and hence investment and the capital stock will also go up. Barro (1999) and Barro and Sala-i-Martin (2004) argue that capital accumulation responds endogenously to technological progress. An improvement in technology should lead to rates of return to capital exceeding the required returns among investors, thus initiating capital accumulation.

King and Rebelo (1993) argue that the transitional dynamics in the neoclassical model of capital accumulation cannot account for some important parts of sustained cross-country differences in rates of economic development. Their findings point to endogenous models such as Romer (1986) and Lucas (1988) as being more suitable for research on the process of economic growth. King and Levine (1994) investigate the role of investment and physical capital accumulation in economic growth and development. They find that capital accumulation is not a fundamental cause but rather a feature of economic growth. Again, the growth accounting exercise demonstrates that the four Asian Tigers realized the highest TFP growth in a sample of 87 countries during 1960-1989 (World Bank, 1993). Using standard cross-country growth regressions, Kawai (1994) and Pack and Page (1994) find that the extraordinary growth in high-performing East Asian countries is mainly productivity-driven.

Asian Tigers accumulated capital and labour force participation at a much faster rate than other countries in the world during 1960-1990 (Sarel, 1996). With the exception of Singapore, a large fraction of higher than average growth in Japan, Korea, Taiwan and Hong Kong is attributed to technological progress (Drysdale and Huang, 1997). While Singapore's productivity growth is less impressive, it is still well above the world average. Disembodied technical progress is probably more important during the early stage of economic development. However, productivity estimates are sensitive to a number of external factors, for example, the process of technological transfer, the external trading environment, the level of economic growth, and the distortions and biases in the measurement of capital and labour (Dowling and Summers, 1998).

Stiglitz (1998) does not believe that the high rates of savings and investment are the major driving forces behind the East Asian growth miracle. Any visitors to the cities and factories in East Asian countries are impressed to see the unprecedented technological progress over the last two decades. The Young (1995) result in favour of capital accumulation is simply not very robust. During a rapid capital accumulation process, small changes in the capital share estimates can result in a large shift in the TFP estimates. The imperfectly competitive Asian labour and product markets might render basing income shares on actual income shares highly problematic. Measurement of physical and human capital is also difficult. Technology is both cause and consequence of investment and hence without continuous technological progress, investment cannot be sustained in the long run due to its diminishing marginal returns. Therefore, it becomes difficult to assess the growth effects of factor accumulation in a growth accounting framework.

3. Assimilation Hypothesis and Endogenous Growth

The assimilation and the endogenous growth hypotheses reject the thesis that the spectacular Asian growth rates are driven predominantly by factor accumulation. The advocates of these hypotheses do not deny that increasing saving rates, labour force participation rates and lower age dependency rates have been influential for growth. However, they view such factors as not standing alone, but as outcomes of other fundamental factors that lead to the demographic transition and the increasing propensity to save. Furthermore, endogenous growth theory stresses that growth along the balanced growth path is driven by R&D and human capital.

3.1 Extension of Growth Accounting Framework

Growth accounting is not simply a matter of decomposing sources of growth into capital and labour. The transformation from a low-income agricultural society to a modern growth regime reflects the joint forces of demographic transition, increased female labour force participation, increased thriftiness, and, particularly, the adaptation and development of new technologies (Galor, 2005). Growth accounting needs to allow for all these factors to provide an adequate account of the forces that have shaped the transformation of the Asian economies from the post-Malthusian to the modern growth regimes. To that end, we can extend the framework used by Mankiw *et al*. (1992) to allow for changes in working hours, labour force participation, demographics, and land as a separate factor of production. The effects of R&D, knowledge spillovers and human capital on growth can also be incorporated in this framework. The framework builds on Madsen (2010).

Consider the following constant returns to scale Cobb-Douglas production function:

$$Y = AK^{\alpha}T^{\beta}H^{1-a-\beta} \qquad (4)$$

where Y is output, A is technology, K is capital, T is land and H is quality adjusted labour. This production function exhibits constant returns to scale in K, T and H, holding the stock of knowledge constant. However, there are increasing returns to scale in K, T, H and A together.

Quality adjusted labour input consists of human capital per worker (h), annual hours worked (X) and raw labour (L), as follows:

$$H = hXL \tag{5}$$

where h is computed following the Mincerian approach:

$$h = exp\,(\theta s) \tag{6}$$

where s is educational attainment, defined as the average years of schooling among the population of working age, and θ is the returns to schooling.

Using Eq. (5), Eq. (4) can be written in terms of per worker employed:

$$\frac{Y}{L} = A^{1/(1-\alpha)}\left(\frac{K}{Y}\right)^{\alpha/(1-\alpha)} T^{\beta/(1-\alpha)}\, h^{(1-\alpha-\beta)\,(1-\alpha)}\, X^{(1-\alpha-\beta)\,(1-\alpha)}\, L^{-\beta(1-\alpha)} \tag{7}$$

Taking logs and differentiating Eq. (7) in combination with Eq. (6) yields the labour productivity growth rate ($g_{Y/L}$):

$$g_{Y/L} = \frac{1}{1-\alpha} g_A + \frac{\alpha}{1-\alpha} g_{K/Y} + \frac{\beta}{1-\alpha} g_T + \frac{1-\alpha-\beta}{1-\alpha}\,\Delta(\theta s) + \frac{1-\alpha-\beta}{1-\alpha} g_X - \frac{\beta}{1-\alpha} n \tag{8}$$

where g_A is the knowledge growth rate, $g_{Y/K}$ is the growth rate in the capital-output ratio, g_T is the growth rate in land area, g_x is the growth rate in annual hours worked and n is the employment growth rate. This equation shows the sources of labour productivity growth once endogeneity of capital has been allowed for.

We have several comments on Eq. (8). First, we have followed Mankiw *et al*. (1992) by allowing growth accounting to be in terms of the *K*-*Y* ratio to filter out technology-induced capital deepening, which is attributed only to capital deepening under the conventional growth accounting exercises (see also King and Levine, 1994). Technological progress generates capital deepening because it increases the expected per unit earnings of capital and, through the channel of the stock market, this brings Tobin's q in excess of its steady-state value. This initiates a capital deepening process that terminates when Tobin's q reaches its steady-state equilibrium (for an exposition, see Madsen and Davis, 2006). Hence Eq. (8) is more meaningful than the traditional growth accounting framework in which capital-induced growth is explained by K alone.

Second, the model does not give insight into the factors that shape the *K*-*Y* ratio outside the balanced growth path. Madsen and Davis (2006) show that the *K*-*Y* ratio is driven by various corporate taxes and tax credits and the required stock returns, which are in turn driven by time preferences. A reduction in the required returns, for example, increases the present value of earnings and therefore Tobin's q. An increase in Tobin's q induces capital deepening and, due to diminishing returns to capital, this leads to an increase in the *K*-*Y* ratio. Saving ratios are, in that sense, reflected in the *K*-*Y* ratio. Various taxes that increase the effective acquisition costs of capital change the optimal *K*-*Y* ratio and this also gives rise to transitional dynamics.

Third, population growth is a drag on per capita growth because of diminishing returns introduced by land as a semi-fixed factor of production. In contrast to reproducible capital, land usage cannot easily be expanded in response to higher returns to land induced by population growth. When a factor of production is inelastic in supply, it is not the quantity of the factor that responds to higher demand but its price in the steady state. Reproducible capital will automatically respond to population growth through the Tobin's *q* mechanism so that the *K*/*L* ratio remains unaffected by population growth along the balanced growth path. In an Agrarian economy, population growth will reduce per capita output provided that additional labour is not channelled into the R&D sector. As the economy develops, β approaches zero and population growth becomes unimportant for growth. For Singapore, β has been virtually zero, but it was quite high in China, Japan and Korea during their early stages of development.

Fourth, human capital is treated exogenously in the model. Since the return to schooling is a positive function of expected growth, human capital may be endogenous. There are, however, reasons to expect government policies to have been more important for schooling decisions than private optimization at the primary and secondary levels in the, often highly regulated, Asian miracle economies. Schooling has been compulsory up to lower secondary level for a majority of the Asian miracle economies in most of the period considered and only limited discretion can be exercised for upper secondary and tertiary levels. Furthermore, credit constraints have prevented individuals from optimizing inter-temporally.

Thus far we have not made any distinction between output per capita and output per hour worked since they are identical along the balanced growth path. However, since labour force participation and age dependency rates have changed substantially in Asia during the transitional period, it is useful to decompose per capita output as follows:

$$\frac{Y}{Pop} \equiv \frac{Y}{L} \cdot \frac{L}{Pop_{Wa}} \cdot \frac{Pop_{Wa}}{Pop} \tag{9}$$

where *Pop* is the size of the population and Pop_{Wa} is the population of working age. Log differentiating yields the per capita growth rate:

$$g_{Y/pop} = g_{Y/L} - g_{Lfp} + g_{Age} \tag{10}$$

which shows that per capita income growth ($g_{Y/pop}$) (is the sum of the labour productivity growth rate ($g_{Y/L}$), the growth in the labour force participation rate (g_{YfL}), and the growth in the fraction of the population of working age (g_{Age}). This decomposition of per capita productivity growth is useful in the Asian miracle context. It can be shown below that increasing labour force participation rates and reduced age dependency rates have been contributing factors to growth in the Asian miracle economies.

Combining Eqs. (8) and (10) yields the complete growth equation that can be used in the growth accounting exercise, as follows:

$$g_{Y/Pop}=\frac{1}{1-\alpha}g_{A}+\frac{\alpha}{1-\alpha}g_{K/Y}+\frac{\beta}{1-\alpha}g_{T}+\frac{1-\alpha-\beta}{1-\alpha}\Delta(\theta s)+\frac{1-\alpha-\beta}{1-\alpha}g_{X}-\frac{\beta}{1-\alpha}n+g_{Lfp}+g_{Age} \tag{11}$$

where per capita income growth ($g_{Y/pop}$) is the result of TFP growth (g_A), growth in the *K*-*Y* ratio ($g_{K/Y}$), growth in land area under cultivation (g_T), change in schooling ($\Delta(\theta s)$), growth in annual hours worked (g_X), population (employment) growth drag (n), growth in labour force participation (g_{Lfp}), and growth in the fraction of the working age population (g_{Age}).

Madsen and Ang (2010) decompose per capita income growth into its components following Eq. (11) for six Asian economies over the period from 1953 to 2006. Estimated results are presented in Table 1, where TFP is found to have contributed the largest share of per capita income growth in all the sample countries considered, particularly China, Japan and Taiwan (on average 4 percentage points). In other words, TFP has contributed approximately 63% of the average per capita income growth rate over the sample period. Non-TFP induced capital deepening, as represented by the increasing *K*-*Y* ratios, has contributed about 21% of the average per capita growth rate. The reduction in agricultural land use has hardly affected growth. However, this is not surprising given that land use has not changed much over time. Increasing educational attainment has, on average, accounted for about 0.4 percentage points of the annual growth rate. Population (employment) growth rates have been a drag (on average -0.05 percentage points) on all the sample economies throughout the whole period. Declining annual hours worked has reduced the annual growth rate by, on average, 0.18 percentage points.

Table 1: Sources of Growth in Asian Economies: 1953-2006

	China	India	Japan	Korea	Singapore	Taiwan
$g_{Y/pop}$	6.054	2.283	4.385	5.306	4.663	5.607
g_A	4.147	1.268	3.313	2.065	2.386	4.590
$g_{K/Y}$	0.814	1.087	0.743	1.528	1.144	0.604
g_T	0.039	0.005	-0.004	-0.004	-0.002	-0.010
$\Delta(\theta s)$	0.415	0.272	0.379	0.534	0.391	0.443
g_X	-0.196	0.004	-0.236	-0.050	-0.156	-0.450
n	-0.117	-0.127	-0.007	-0.039	-0.001	-0.018
g_{Lfp}	0.509	-0.410	0.142	0.753	0.370	-0.123
g_{Age}	0.442	0.185	0.055	0.519	0.529	0.570

Note: The data are annualized geometric growth rates.
Source: Madsen and Ang (2010).

The contribution of changing labour force participation rates to per capita income growth varies significantly across nations. Increasing participation rates have contributed positively to growth in China, Japan, Korea and Singapore (on average 0.4 percentage points). The contribution has been negative for India and Taiwan (-0.4 and -0.1 percentage points, respectively). On average, the labour force participation rate has been increasing moderately and contributed about 4% of the average per capita growth rates. The reduced age dependency has positively influenced growth. The contribution has been approximately 0.5 percentage points for China, Korea, Singapore and Taiwan. The reduced fertility has, temporarily, resulted in a reduction in age dependency. Adding the reduced negative growth drag effects of population growth over the entire sample period, demographic transition has been influential for growth, and it has often been as important a source of growth as the increase in the *K*-*Y* ratio (Madsen and Ang, 2010).

3.2 Endogenous Growth

The decomposition in Table 1 showed that TFP growth was a main source of economic growth over the last half of the century in Asia. This begs the question as to what sources have been driving TFP growth and whether the momentum in TFP growth will continue. Endogenous growth theories can account for the endogeneity of technological change and hence balanced growth results exclusively from the technological progress that takes place through innovations, in the form of new products, processes and markets (Romer, 1986; Lucas, 1988). The first-generation endogenous growth model captures the endogenous technological movement by assuming a positive relationship between the level of R&D and the TFP growth (Romer, 1990; Aghion and Howitt, 1992). The proportional relationship between them indicates that an increase in the size of the population, other things remaining unchanged, on average could raise the number of R&D personnel and thus activities in R&D might increase, which may lead to increased TFP and output growth.

However, the critical scale effect of R&D was not found to be consistent empirically and thus the semi-endogenous model (the first variant of the second generation endogenous growth model) came up with the idea that there could be a positive association between R&D *growth* and TFP growth (Jones, 1995a, b). As a response to Jones' critique, another variant of this second generation growth model appeared as the Schumpeterian model, where the first generation model has been modified by assuming that TFP growth varies proportionately with R&D intensity, not with the level of R&D (Aghion and Howitt, 1998; Ha and Howitt, 2007; Madsen, 2008).

The two leading second-generation models have quite different implications for growth. Schumpeterian theory predicts that TFP is growing proportionally with research intensity, where research intensity is measured by real R&D divided by real income. R&D is divided by income to allow for product proliferation and increasing complexity of new innovations as TFP increases (Ha and Howitt, 2007). Growth can still be sustained in the Schumpeterian framework if R&D is kept at a fixed proportion of the number of product lines, which is in turn proportional to the size of the population in steady state. As such, to ensure sustained TFP growth, R&D has to increase over time to counteract the increasing range and complexity of products that lower the productivity effects of R&D activity. Similarly, the Schumpeterian model of Vandenbussche *et al*. (2006) predicts that TFP growth is proportional to the log of educational attainment, which implies that the growth rate will remain positive as long as the labour force has some education and that growth is proportional to educational attainment. Semi-endogenous growth theory, by contrast, abandons scale effects in ideas production. This implies that TFP growth is proportional to the growth rate in R&D and educational attainment. Under this framework, levels of R&D and educational attainment have no permanent growth effects.

To distinguish between different endogenous growth models, we can use the following knowledge production function (see, e.g., Ha and Howitt, 2007; Madsen, 2008):

$$g_A = \frac{\dot{A}}{A} = \lambda\left(\frac{X}{Q}\right)^{\sigma} A^{\phi-1},\ 0 > \sigma \leq 1,\ \phi \leq 1 \qquad (12)$$

$$Q \propto L^{\beta} \text{ in steady state}$$

where, g_A is TFP growth, A is the knowledge stock, λ is the research productivity parameter, X is innovative activity, Q is a measure of product variety, σ is the duplication parameter (zero if all innovations are duplications and 1 if there are no duplicating innovations), ϕ is the returns to scale in knowledge, L is employment or population, and β is the coefficient of product proliferation. X is measured as R&D inputs (semi-endogenous growth models) or productivity-adjusted R&D inputs (Schumpeterian growth models) (*R&D/A*), where the productivity adjustment allows for the increasing complexity of innovations. Thus, the growth enhancing effect of R&D input is counterbalanced by the negative effect of product variety (Ha and Howitt, 2007). The ratio between X and Q is referred to as research intensity. Semi-endogenous theory assumes $\phi < 1$ under the assumption of diminishing returns to knowledge and the absence of product proliferation effects ($\beta = 0$). Schumpeterian theory maintains constant returns to knowledge ($\phi = 1$) and the presence of a product variety effect ($\beta = 1$). First-generation endogenous growth models assume constant returns to knowledge ($\phi = 1$) and the absence of product proliferation effects ($\beta = 0$).

Eq. (12) can not only be used to discriminate between various endogenous growth models, it can also be used to explain TFP growth. Madsen (2008) shows that semi-endogenous and Schumpeterian growth models imply the following R&D-driven growth model:

$$\Delta lnA_{it} = \beta_0 + \beta_1 \Delta lnX_{it} + \beta_2 ln\,(X/Q)_{it} + \varepsilon_{it} \qquad (13)$$

Semi-endogenous growth models predict that $\beta_1 > 0$ and $\beta_2 = 0$ whereas Schumpeterian growth theory predicts that $\beta_2 > 0$. Since R&D has transitional growth effects in Schumpeterian growth models, a positive β_1 may also be consistent with Schumpeterian growth theory.

Ang and Madsen (2011) estimate the TFP growth equation (Eq. 13) in five year intervals for six Asian countries (China, India, Japan, Korea, Singapore and Taiwan) over the period from 1953 to 2006. Their estimated results in Table 2 shed light on the second-generation endogenous growth models by investigating the role of R&D in explaining cross-country productivity growth.

Columns 1 and 2 show the regression results related to semi-endogenous growth theory. The estimated coefficient of the growth in domestic innovative activity is found to be positive and statistically significant when research inputs are measured by R&D expenditure. However, the significance disappears when research inputs are measured by number of R&D workers. Hence the results are found to be mixed for semi-endogenous growth theory.

Table 2: TFP Growth Regressions (5-year estimates of Eq. 13)

	Semi-Endogenous		Schumpeterian				Both Models			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ΔlnR_{it}	0.08^{a}						0.07^{b}	0.08^{a}		
	(0.00)						(0.03)	(0.00)		
ΔlnN_{it}		0.05							0.04^{c}	0.03
		(0.11)							(0.07)	(0.15)
$ln(R/Y)_{it}$			2.43^{b}				2.97^{b}			
			(0.02)				(0.03)			
$ln(R/AL)_{it}$				1.33^{b}				1.63^{a}		
				(0.02)				(0.00)		
$ln(N/L)_{it}$					1.93^{a}				2.37^{a}	
					(0.00)				(0.00)	
$ln(N/hL)_{it}$						1.38^{a}				1.46^{a}
						(0.00)				(0.00)

Notes: R = real R&D expenditure; N = R&D labour; Y = real GDP; A = TFP; L = labour force; h = educational attainment. Constant, country and time dummies are included but not reported to conserve space. The numbers in parentheses are p-values. Variables in first-differenced form provide estimates in five-year differences whereas those in levels give five-year moving averages. ^{a}, ^{b} and ^{c} signify 1%, 5%, and 10% levels of significance, respectively. Source: Ang and Madsen (2011).

Columns 3 to 6 demonstrate regression results related to Schumpeterian growth theory. The estimated coefficients of domestic research intensity are found to be positive and statistically significant in all four cases, regardless of how research intensity is measured. The results are found to be similar when the semi-endogenous and Schumpeterian growth theories are combined in an integrated framework (columns 7-10).

The empirical results in Table 2 have important implications for economic growth as well as endogenous growth theories. In the regressions where both R&D growth and research intensity are significant, or where only research intensity is significant, productivity growth is governed by research intensity in the long run. An R&D-induced increase in research intensity leads to TFP growth in the short and medium run that exceeds the steady-state TFP growth due to the growth effects of R&D. TFP growth is kept at a constant rate that is driven by research intensity in the steady state. Growth in that sense is Schumpeterian, and not semi-endogenous, along the balanced growth path (Ang and Madsen, 2011). These results are consistent with a number of recent studies that have found empirical evidence in favour of the Schumpeterian growth models, for example: Ha and Howitt (2007) for USA; Madsen (2008) for 21 OECD countries; Madsen, Ang *et al*. (2010) for the UK; and Madsen, Saxena *et al*. (2010) for India, among others. Therefore, growth can be sustained if R&D is kept at a fixed proportion of the number of product lines.

In a recent study, Madsen and Ang (2010) argue that TFP growth has been the major driving force behind rapid economic growth for China, India, Japan, Korea, Singapore and Taiwan during 1953-2006. Using an extended growth accounting framework, they show that the demographic transition, increasing capital-output ratio, increasing labour force participation rates, and the direct effects of increasing educational attainment have been responsible for about a third of the growth in these economies. However, increasing reliance on knowledge derived from investment in human capital and R&D combined with knowledge spillovers have been the main engine of rapid growth. The positive effects of research intensity and the level of human capital on knowledge-driven growth confirm that growth will remain positive, but not miraculous in those countries. As the miracle economies move closer to the technology frontier, TFP growth rates will slow down and they will converge to the OECD rate in due course. However, China and India may take some time as they have many years of convergence ahead of them.

The endogenous hypothesis is only an approximate cause of take-off – it does not explain where R&D comes from in the first place. Differences in capital accumulation, productivity and output per worker are basically related to social infrastructure – institutions and government policies – that encourage capital accumulation, skill acquisition, innovation and technology transfer (Hall and Jones, 1999). Intellectual property right such as 'patent protection' is important for R&D because it encourages innovators to work on risky projects where the potential return is higher and reduces uncertainty about possible appropriation. Coe *et al*. (2009), for example, find that strong patent protection is associated with higher levels of total factor productivity, higher returns to domestic R&D, and larger international R&D spillovers. 'Effectiveness of legislature' and 'effective executive' are also important for R&D because they express the quality of legislative and political institutions (Madsen, Islam *et al*., 2010).

Although many countries have adopted good patent protection frameworks, they can be far from being effective in protecting innovators because of weak legislative and political systems. The ability of a country to implement a law depends on the quality of government agencies such as the judiciary as well as political stability. The higher the efficiency of the judicial system the better the patent protection framework and the higher is the incentive to innovate (Madsen, Islam *et al*., 2010). Political stability, accountability of government, and low corruption should also be positively related to patent rights and consequently to innovative activity. For example Mauro (1995) shows that investment and innovation are negatively related to corruption and bureaucratic inefficiency. A one standard deviation improvement in the corruption index increases investment by 2.9 percent of GDP. Quality of institutions may override geography and trade openness in explaining cross-country variations in income levels (Rodrik *et al*., 2004). East Asian countries are significantly different from each other in terms of initial conditions, government policies and institutional quality and hence there is no single recipe for East Asian success (Rodrik, 1997).

3.3 Assimilation Hypothesis

Technological knowledge is often tacit and circumstantially specific and hence it is very difficult to transplant without sufficient capabilities to exploit it. Countries that are far from the world technology frontier may have greater potential for growth than more advanced countries (Gerschenkron, 1962), mainly because of their lower effective costs in creating new and better products (Howitt, 2000). However, backwardness does not automatically translate into higher growth. Although countries may be endowed with different abilities in adopting new technologies, more investment in domestic R&D and human capital may generally increase their capacity to effectively absorb foreign technology (Nelson and Phelps, 1966; Griffith *et al*., 2004). While the accumulation hypothesis focuses on increasing investment, the assimilation hypothesis stresses innovation and learning to master modern technologies that are new to a country, but not to the world. Therefore, development does not follow if a country does not innovate and learn technologies already developed elsewhere. Lucas (1993) argues that the growth externalities from human capital through learning by doing are the main source of growth behind the Asian miracles. Physical capital plays an important but absolutely subsidiary role. Human capital accumulation takes place in schools, in research organizations, and in the course of producing goods and engaging in trade.

In an influential paper, Nelson and Pack (1999) argue that capital accumulation might be an important component of growth, but its productive assimilation was the major driving force behind the miraculous success in a number of Asian economies between 1960 and 1996. They denote their views as 'assimilation' theories that stress entrepreneurship, innovation and learning. Investment in human and physical capital is necessary, but far from sufficient for the assimilation process. Low TFP growth found in the East Asian Tigers by Young (1995) could be a result of a downward measurement bias due to the failure to allow for the possibility that the bias in technical change is labour augmenting and the elasticity of substitution is below unity. Therefore, the observed capital share is prevented from declining in East Asia by the acquisition and assimilation of modern technology and change in the industrial structure. The success stories of Asian Tigers underlie significant investment efforts coupled with learning processes, orientation to the world market and innovative entrepreneurship.

The more backward a country's technology, the greater is the potential for that country to grow more rapidly than the technologically leading countries, provided that the former has sufficient social capabilities to exploit the latter's technology (Abramovitz, 1986). If a technology is already developed and efficiently used in industrialized countries, firms in developing nations can adopt that without any uncertainty at relatively low cost. Being far away from the technology frontier, Asian NICs did not have any experience in advanced western technology during the 1960s and hence they started to invest in mastering those technologies during the 1970s and 1980s. For example, the production of electronic goods in Taiwan was almost nil in 1960, whereas it accounted for approximately 21 percent of exports of manufacturing goods by 1990. High rates of investment in physical and human capital were required to absorb those technologies from advanced countries. Risk taking entrepreneurship and good management were also involved to develop new sets of skills and new ways of organizing economic activity in order to learn to use new technologies more effectively (Nelson and Pack, 1999).

Successful entrepreneurship and technology diffusion in the NICs were facilitated by the growing supply of relatively well trained factory workers, technicians, engineers, and managers. An increasing level of education helped those countries to identify new opportunities and to learn new things effectively. Again, the extraordinary rise in manufacturing exports stimulated the learning process in the NICs in two ways (Pack and Westphal, 1986). First, managers and engineers had to pay attention to world standards to compete in the global market. Second, most of the export contracts were made with firms in Japan and the USA, who provided technical support to facilitate supply of high performance products. Hence effective innovation and learning to master modern technologies were the key to successful industrial development in Asian NICs (Nelson and Pack, 1999). This finding is consistent with a recent study by Hobday (2003) who shows that a common factor behind such impressive growth in NICs is large investments in training and R&D to adapt technologies that have already been developed in more advanced countries.

In an important paper, Radelet *et al*. (2001) provide an extensive analysis of Asia's growth experience in a broad historical and international perspective for 78 sample countries over the period 1965 to 1990. Considering a wide variety of policy and structural variables that affect economic growth, their cross-country empirical results suggest that the East Asian countries grew faster than the rest of the world for four key reasons: (i) significant potential for catching up, (ii) favourable geographical and structural characteristics, (iii) constructive post-war demographic changes, and (iv) helpful economic policies and strategies to maintain sustained growth. In addition, positive trends in literacy and education, key demographic developments, favourable public health policies to raise life expectancy, government concern for agricultural development, higher level of government savings, protection of private property rights, supporting natural harbours, proximity to major sea lanes, and favourable economic institutions and policies are also supportive for their rapid economic growth.

Countries with lower initial incomes grew faster than more advanced countries after controlling for social, economic, political and geographical factors that influence the long run level of income. For example, average income in the four Asian tigers was one-sixth of the US level in 1965, but the catch up factor enhanced their growth rates by 3.5 percentage points relative to the US every year from 1965-1990. Countries with abundant natural resources had a tendency to grow slower than others. Hence the resource poor Asian tigers grew faster by turning their focus towards the manufacturing sector more quickly. Rising shares of working age population, higher government savings, controlled government expenditure, larger budget surpluses and greater productive interactions between the government and the market helped most of the East Asian countries to grow faster. However, countries that were landlocked, or whose populations had relatively little access to the sea, or that were located in the tropical region all experienced significantly lower growth rates over the whole sample period (Radelet *et al*., 2001).

Trade openness helped Asian NICs to grow faster by allowing them to undertake more specialized production processes, providing a means to earn foreign exchange to purchase capital goods imports, facilitating technology transfer from advanced industrialized nations, and providing competitive pressure to enhance productivity and efficiency. Most of the fast growing Asian countries significantly reduced import tariffs and export taxes, abolished quantity restrictions on trade, and lowered the barriers to international flows of capital. The successful Asian nations connected multinational production technologies to domestic production process by facilitating foreign direct investment, licensing agreements, duty exemption systems, joint ventures, own-equipment manufacturing arrangements, export processing zones, and bonded warehouses. Hence promoting labour intensive manufacturing exports remains at the heart of the East Asia's success (Radelet *et al*., 2001). This finding corroborates an earlier study by Crafts (1999) where it is argued that the spectacular success in most of the NICs results from managed development approaches focusing on massive export oriented manufacturing and industrialization.

Besides technological improvement, East Asian NICs have experienced a significant demographic transition and institutional development and therefore the role of these additional factors in explaining miracle growth has currently gained interest among researchers. Rodrik (1997) investigates the role of institutional quality on economic performance for eight East Asian countries using an institutional quality index originally constructed by Easterly and Levine (1997) from Knack and Keefer's (1995) data on quality of bureaucracy, rule of law, risk of expropriation and repudiation of contracts by government.

The combined index is scaled from 1 to 10, with high values indicating good institutions. While ranking East Asian institutions, significant variations have been found across nations, for example: high grade institutions are found in Japan (9.37), Singapore (8.56), and Taiwan (8.24); intermediate grade institutions in Malaysia (6.90), Korea (6.36), and Thailand (6.26); and low grade institutions in Indonesia (3.67) and the Philippines (2.97). Using cross-country growth regressions Rodrik (1997) argues that institutional quality, initial income and initial education can account for virtually all of the variations in East Asian growth performance. The coefficient on the institutional quality index indicates that a one point increase on the scale of institutional quality is associated with a 0.8 percent increase in the long-run growth of GDP per worker. Institutional quality increases with income but decreases with ethno-linguistic fragmentation. Institutions are related to cultural heritage and historical development of an economy and hence they cannot be borrowed from outside. High-quality institutions contribute to economic growth irrespective of a government's stance on policy interventions (Rodrik, 1997).

To explain the sources of growth in miracle economies, Bloom and Williamson (1998) stress the demographic transition – a change from high to low rates of mortality and fertility – that has been more dramatic in East Asian countries during the twentieth century than in any other region or in any other period. The East Asian demographic transition resulted in its working age population growing at a much faster rate than its dependent population and consequently accelerating per capita productive capacity. For example, between 1965 and 1990, the working age population in East Asia grew about 2.39 per cent a year, whereas the entire population and the dependent population grew about 1.58 and 0.25 per cent a year, respectively. Population growth is found to have transitional effects on economic growth and hence East Asia's social, economic and political institutions and policies help them to realize the growth potential that emerged from this transition. Using data from 78 Asian and non-Asian countries for the period 1965-1990, Bloom and Williamson (1998) argue that an increase of 1 percent in the growth rate of the working-age population is associated with an increase of 1.37 to 1.87 per cent in the growth rate of GDP per capita in the East Asian region. As much as one-third of growth of the East Asian miracle economies can be explained by population dynamics. Demographic transition not only drives the labour force but it also raises savings as well as investment. A one percent increase in the growth rate of the total population reduces the per capita GDP growth rate by 0.92 per cent. However, overall population growth is not the mechanism driving East Asian economic performance. Rather, age distribution is the most effective channel through which demographic transition influences economic growth across nations (Bloom and Williamson, 1998).

It is important to note that R&D and human capital may help an economy to create new knowledge or imitate technologies that are developed elsewhere. Using panel data analysis for the period 1970-2004, Madsen, Islam *et al*. (2010) investigate whether technology transfer, research intensity, human capital and the ability to exploit foreign technology can explain income differences across 23 OECD and 32 developing countries. The estimated results show that the growth effects of R&D are through innovation in OECD countries, whereas the growth effects of R&D arise mainly through imitation in developing countries. Technological backwardness does not automatically translate into higher growth. Developing countries that are far behind the technology frontier should invest in R&D in order to exploit technology already developed at the frontier. The positive effect of research intensity on TFP growth in OECD countries implies that growth will continue at the present rates for countries at or close to the technology frontier, provided that R&D is kept to a fixed fraction of the number of the product lines. However, positive growth effects of the interaction between research intensity and distance to the technology frontier ensure that developing countries that invest in R&D will continue to grow further.

4 Conclusions

Whether factor accumulation or technological progress can adequately explain sources of miraculous growth in the East Asian NICs has been of great importance in both theoretical and applied studies over the last couple of decades. Despite spectacular growth in capital stocks, the degree of TFP growth remains a subject of academic and policy debate across this region. TFP cannot be measured directly and hence it is generally calculated as the left over that cannot be explained by increases in labour and capital inputs. This may raise significant measurement issues in TFP estimation. A proper understanding of the underlying growth success of these miracle economies can provide valuable lessons for other developing countries to implement sustained growth strategies in the light of the East Asian experience.

This paper discussed the current state of the literature on factor accumulation and technology assimilation to investigate their relevance and applicability to explain sources of rapid economic growth in the Asian miracle economies. The findings of this research show that TFP growth has been the main driving force behind outstanding growth across these nations. Traditional growth accounting cannot accommodate fundamental sources of this miraculous growth and hence we should extend growth accounting frameworks to allow for technology-induced capital deepening, population growth drag, changes in age structure and annual hours worked. The real engine behind the Asian growth miracle has been an increasing reliance on knowledge created through investment in R&D and human capital. Capital accumulation may be helpful at the early stage of development, however, as countries move forward TFP contributes more to economic growth. Improvement in educational attainment and research intensity will certainly help those miracle economies to continue their positive TFP growth.

Notes

* Corresponding Author.

References

Abramovitz, M. (1986) "Catching Up, Forging Ahead, and Falling Behind", *Journal of Economic History*, 46(2): 385-406.

Aghion, P. and Howitt, P. (1992) "A Model of Growth through Creative Destruction", *Econometrica*, 60(2): 323-351.

Aghion, P. and Howitt, P. (1998) *Endogenous Growth Theory*, Cambridge: MIT Press.

Ang, J.B. and Madsen, J.B. (2011) "Can Second-Generation Endogenous Growth Models Explain the Productivity Trends and Knowledge Production in the Asian Miracle Economies?", *Review of Economics and Statistics,* 93(4): 1360-1373.

Barro, R. (1999) "Notes on Growth Accounting", *Journal of Economic Growth*, 4(2): 119-137.

Barro, R. and Sala-i-Martin, X. (2004) *Economic Growth*, Cambridge: MIT Press.

Bloom, D.E. and Williamson, J.G. (1998) "Demographic Transitions and Economic Miracles in Emerging Asia", *World Bank Economic Review*, 12(3): 419-455.

Caselli, F. (2005) "Accounting for Cross-Country Income Differences", in Aghion, P. and Durlauf, S.N. (eds), *Handbook of Economic Growth*, Elsevier, 1(A): 679-741.

Coe, D.T., Helpman, E. and Hoffmaister, A.W. (2009) "International R&D Spillovers and Institutions", *European Economic Review*, 53(7): 723-741.

Collins, S.M. and Bosworth, B.P. (1996) "Economic Growth in East Asia: Accumulation versus Assimilation", *Brookings Papers on Economic Activity*, 1996(2): 135-203.

Crafts, N. (1999) "East Asian Growth Before and After the Crisis", *IMF Staff Papers*, 46(2): 139-166.

Dowling, M. and Summers, P.M. (1998) "Total Factor Productivity and Economic Growth – Issues for Asia", *Economic Record*, 74(225): 170-185.

Drysdale, P. and Huang, Y. (1997) "Technological Catch-Up and Economic Growth in East Asia and the Pacific", *Economic Record*, 73(222): 201-211.

Easterly, W. and Levine, R. (1997) "Africa's Growth Tragedy: Policies and Ethnic Divisions", *Quarterly Journal of Economics*, 112(4): 1203-1250.

Easterly, W. and Levine, R. (2001) "It's Not Factor Accumulation: Stylized Facts and Growth Models", *World Bank Economic Review*, 15(2): 177-219.

Galor, O. (2005) "The Demographic Transition and the Emergence of Sustained Economic Growth", *Journal of the European Economic Association*, 3(2-3): 494-504.

Gerschenkron, A. (1962) *Economic Backwardness in Historical Perspective*, Cambridge: Belknap Press of Harvard University Press.

Griffith, R., Redding, S. and Van Reenen, J. (2004) "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries", *Review of Economics and Statistics*, 86(4): 883-895.

Ha, J. and Howitt, P. (2007) "Accounting for Trends in Productivity and R&D: A Schumpeterian Critique of Semi-Endogenous Growth Theory", *Journal of Money, Credit and Banking*, 39(4): 733-774.

Hall, R.E. and Jones, C.I. (1999) "Why Do Some Countries Produce So Much More Output per Worker than Others?", *Quarterly Journal of Economics*, 114(1): 83-116.

Hobday, M. (2003) "Innovation in Asian Industrialization: A Gerschenkronian Perspective", *Oxford Development Studies*, 31(3): 293-314.

Howitt, P. (2000) "Endogenous Growth and Cross-Country Income Differences", *American Economic Review*, 90(4): 829-846.

Jones, C.I. (1995a) "Time Series Tests of Endogenous Growth Models", *Quarterly Journal of Economics*, 110(2): 495-525.

Jones, C.I. (1995b) "R&D-Based Models of Economic Growth", *Journal of Political Economy*, 103(4): 759-784.

Kawai, H. (1994) "International Comparative Analysis of Economic Growth: Trade Liberalization and Productivity", *Developing Economies*, 32(4): 373-397.

Kim, J. and Lau, L.J. (1994) "The Sources of Economic Growth of the East Asian Newly Industrialized Countries", *Journal of the Japanese and International Economies*, 8(3): 235-271.

King, R.G. and Levine, R. (1994) "Capital Fundamentalism, Economic Development, and Economic Growth", *Carnegie-Rochester Conference Series on Public Policy*, 40(1): 259-292.

King, R.G. and Rebelo, S.T. (1993) "Transitional Dynamics and Economic Growth in the Neoclassical Model", *American Economic Review*, 83(4): 908-931.

Klenow, P.J. and Rodriguez-Clare, A. (1997) "The Neoclassical Revival in Growth Economics: Has It Gone too Far?", in Bernanke, B.S. and Rotemberg, J.J. (eds), *NBER Macroeconomics Annual*, 12: 73-114, MIT Press.

Knack, S. and Keefer, P. (1995) "Institutions and Economic Performance: Cross-Country Tests Using Alternative Institutional Measures", *Economics and Politics*, 7(3): 207-227.

Krugman, P. (1994) "The Myth of Asia's Miracle", *Foreign Affairs*, 73(6): 62-78.

Lucas, R.E. (1988) "On the Mechanics of Economic Development", *Journal of Monetary Economics*, 22(1): 3-42.

Lucas, R.E. (1993) "Making a Miracle", *Econometrica*, 61(2): 251-272.

Madsen, J.B. (2008) "Semi-Endogenous versus Schumpeterian Growth Models: Testing the Knowledge Production Function Using International Data", *Journal of Economic Growth*, 13(1): 1-26.

Madsen, J.B. (2010) "The Anatomy of Growth in the OECD since 1870", *Journal of Monetary Economics*, 57(6): 753–767.

Madsen, J.B. and Ang, J.B. (2010) "Endogenous Growth Accounting and the Asian Growth Miracle", mimeo.

Madsen, J.B., Ang, J.B. and Banerjee, R. (2010) "Four Centuries of British Economic Growth: The Roles of Technology and Population", *Journal of Economic Growth*, 15(4): 263-290.

Madsen, J.B. and Davis, P. (2006) "Equity Prices, Productivity Growth and 'The New Economy'", *Economic Journal*, 116(513): 791-811.

Madsen, J.B., Islam, M.R. and Ang, J.B. (2010) "Catching Up to the Technology Frontier: The Dichotomy between Innovation and Imitation", *Canadian Journal of Economics*, 43(4): 1389–1411.

Madsen, J.B., Saxena, S. and Ang, J.B. (2010) "The Indian Growth Miracle and Endogenous Growth", *Journal of Development Economics*, 93(1): 37-48.

Mankiw, G., Romer, D. and Weil, D.N. (1992) "A Contribution to the Empirics of Economic Growth", *Quarterly Journal of Economics*, 107(2): 407-437.

Mauro, P. (1995) "Corruption and Growth", *Quarterly Journal of Economics*, 110(3): 681-712.

Nelson, R.R. and Pack, H. (1999) "The Asian Miracle and Modern Growth Theory", *Economic Journal*, 109(457): 416-436.

Nelson, R.R. and Phelps, E.S. (1966) "Investment in Humans, Technological Diffusion, and Economic Growth", *American Economic Review*, 56(1/2): 69-75.

Pack, H. and Page, J.M. (1994) "Accumulation, Exports, and Growth in the High-Performing Asian Economies", *Carnegie-Rochester Conference Series on Public Policy*, 40(1): 199-236.

Pack, H. and Westphal, L.E. (1986) "Industrial Strategy and Technological Change: Theory versus Reality", *Journal of Development Economics*, 22(1): 87-128.

Prescott, E.C. (1998) "Needed: A Theory of Total Factor Productivity", *International Economic Review*, 39(3): 525-551.

Radelet, S., Sachs, J. and Lee, J-W. (2001) "The Determinants and Prospects of Economic Growth in Asia", *International Economic Journal*, 15(3): 1-29.

Rodrik, D. (1997) "TFPG Controversies, Institutions, and Economic Performance in East Asia", NBER Working Paper No. 5914.

Rodrik, D., Subramanian, A. and Trebbi, F. (2004) "The Primacy of Institutions over Geography and Integration in Economic Development", *Journal of Economic Growth*, 9(2): 131-165.

Romer, P.M. (1986) "Increasing Returns and Long-Run Growth", *Journal of Political Economy*, 94(5): 1002-1037.

Romer, P.M. (1990) "Endogenous Technological Change", *Journal of Political Economy*, 98(5): S71-S102.

Romer, P.M. (1993) "Idea Gaps and Object Gaps in Economic Development", *Journal of Monetary Economics*, 32(3): 543-573.

Sarel, M. (1996) "Growth in East Asia: What We Can and What We Cannot Infer from It", *IMF Economic Issues*, No. 1: 237-259.

Solow, R.M. (1956) "A Contribution to the Theory of Economic Growth", *Quarterly Journal of Economics*, 70(1): 65-94.

Stiglitz, J.E. (1998) "Sound Finance and Sustainable Development in Asia", Keynote Address to the Asia Development Forum, Manila, the Philippines, March 12, 1998.

Swan, T.W. (1956) "Economic Growth and Capital Accumulation", *Economic Record*, 32(2): 334-361.

Vandenbussche, J., Aghion, P. and Meghir, C. (2006) "Growth, Distance to Frontier and Composition of Human Capital", *Journal of Economic Growth*, 11(2): 97-127.

World Bank (1993) *The East Asian Miracle*, Washington DC: World Bank.

Young, A. (1992) "A Tale of Two Cities: Factor Accumulation and Technical Change in Hong Kong and Singapore", in Blanchard, O.J. and Fischer, S. (eds), *NBER Macroeconomics Annual*, 7: 13-64, MIT Press.

Young, A. (1994) "Lessons from the East Asian NICS: A Contrarian View", *European Economic Review*, 38(3-4): 964-973.

Young, A. (1995) "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience", *Quarterly Journal of Economics*, 110(3): 641-680.

Young, A. (2003) "Gold into Base Metals: Productivity Growth in the People's Republic of China during the Reform Period", *Journal of Political Economy*, 111(6): 1220-1261.