Toothless Tigers? East Asian Economic Growth from 1960-1990*

Robin Grier

I study East Asian economic performance relative to the experience of a sample of rich, industrialized countries. When I combine the coefficients from an augmented Solow model of growth for a sample of industrialized countries with the actual levels of factor accumulation in East Asia, I find no evidence that the region as a whole is over achieving. Only Hong Kong and Taiwan can be characterized as over achievers. Further, I show that Indonesia and Thailand (when income growth is measured in per-worker terms) are actually significant under achievers, growing slower than forecasted growth in every period.

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Abbreviations: TFP, GDP, OECD, OLS, MRW, GMM, RMSPE, PPP
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1. Introduction

Before the financial crisis of 1997, East Asian countries were roundly lauded as being economic ‘tigers,’ growth phenomenons, and even economic ‘miracles.’ Regional economic growth during the 1960-1995 period had far surpassed that of any other group of developing countries. While the crisis revealed economic and political problems in the region, and has tempered praise for the region to a certain extent, the economic transformation of these countries in the last forty years is undeniable. For example, per-capita income in Hong Kong and Singapore in 1960 was $2,247 and $1,658, respectively. In a 2001 ranking of real ppp-adjusted, per-capita GDP, Hong Kong and Singapore are the second and third most wealthy countries in the world (behind the United States and Japan). In addition, most countries in the region have seem to have rebounded from the financial crisis and experienced strong economic growth in the recent years (Economist, 2001, p. 201).

The East Asian growth phenomenon has created debate over the source of the region’s high growth rates. Some economists (Dahlman et al., 1987; Nelson and Pack, 1999) argue that the region has grown so fast because the individual countries have been able to rapidly assimilate new technology. Others (Collins and Bosworth, 1997; Krugman, 1994; Young, 1994, 1995) claim that growth was fueled almost totally by increased factor accumulation and that once the rate of accumulation slows down, income growth will slow to a rate more typical of developed countries.

Much work has been done on whether East Asian growth has been ‘miraculous’; that is, whether growth has been fueled by mere accumulation or is due to technological progress. The typical test in the literature involves choosing a production function with a specific functional form and coefficients, using growth accounting to ascribe what part of growth is due to input
growth, and measuring overall productivity growth (i.e., TFP growth) as the residual of this process. A large residual indicates that a country’s growth rate is not merely due to factor accumulation, but rather to high factor productivity growth.¹

In growth accounting, one must not only choose the production function coefficients that produce the Solow residual, but also judge which residuals are large enough to be considered a ‘miracle.’ Any attempt to characterize growth runs up against the question of: what is the relevant standard of comparison? Given that growth accounting is as much an art as a science, and that people on both sides of the debate use it to support their views, there is room for a different statistical approach.

In this paper, I investigate whether East Asian countries are over achievers relative to a representative industrialized country. Operationally, I use Mankiw, Romer, and Weil’s (1992) augmented Solow model as a functional form and estimate the model in growth form for a panel of rich, industrialized countries.² I take the coefficients from that model and the input accumulation of the East Asian countries to forecast per-capita and per-worker income growth in East Asia.³ I argue that if the model describing the rich world, when combined with the factor accumulation of East Asian countries, systematically under predicts income growth in a country, then we can characterize that economy as an over achiever, even though the results do not necessarily say anything about factor productivity growth.

While the technique is a simple one, it yields new and interesting results about East Asian growth not before reported in the literature. First, there is no evidence that the region is a monolithic block of over achievers. Only Hong Kong and Taiwan are over achievers, in the sense that they grew consistently faster than a representative wealthy country with equivalent
factor accumulation predicts. Second, I show that Indonesia (and Thailand when growth is measured in per-worker terms) are actually significant under achievers. That is, a representative wealthy country with the same level of factor accumulation would have grown considerably faster in every period than these countries did. So while most of the debate over East Asian growth has centered on which countries are productivity ‘miracles,’ I find that a sub-set of these countries are under performers.

2. A Different Approach

I estimate a version of the augmented Solow model with data from a panel of 21 industrialized OECD countries for the years 1960-1990. I combine the coefficients from that model and the actual factor accumulation of East Asian countries to forecast per-capita (and per-worker) income growth in the East Asian region. I use industrialized economies as a benchmark for categorizing East Asian growth because industrialized economies are arguably closer to their steady states than developing ones. This is the only group of countries where economists have found clear evidence of conditional convergence. Thus, the Solow model ‘fits’ the industrialized world better than any other group of countries in the world. To maximize the efficiency of my estimator, I include as many industrialized countries as possible in the sample for estimating the augmented Solow model.

Specifically, I use the augmented Solow model developed in Mankiw, Romer, and Weil (1992, MRW hereafter). They begin with the Cobb-Douglas production function below:

\[ Y(t) = K(t)^{a} H^{b} (A(t)L(t))^{1-a-b} \quad a, b > 0 \quad 0 < a + b < 1 \quad (1) \]
In equation (1), \( Y \) is real output, \( K \) is the stock of physical capital, \( H \) is the stock of human capital, \( L \) is labor, and \( A \) is a measure of the level of technology. \( \theta \) and \( \psi \) are the respective shares of physical and human capital in total output. From this production function, MRW then derive the following cross-country growth regression:

\[
\ln(Y_{it}) - \ln(Y_{it-j}) = \frac{(1-e^{-8t})}{(1-\theta-\psi)} \ln(s_k) + \frac{(1-e^{-8t})}{(1-\theta-\psi)} \ln(s_h) - \frac{(1-e^{-8t})(\theta + \psi)}{(1-\theta-\psi)} \ln(n + g + d) - (1-e^{-8t}) \ln(Y_{i,t-j})
\]  

(2)

In this equation, \( s_k \) and \( s_h \) are the shares of income invested in physical and human capital, \( d \) is the depreciation rate, \( n \) is the population growth rate, and \( g \) is the growth of labor-augmenting technology. \( \theta \) represents the speed at which a country’s output converges to its steady-state level.

I depart from the MRW model in two ways. First, as is becoming customary in the growth literature, I estimate a growth model for a panel of 21 countries instead of a single cross section. I average the data into 5 year intervals, which allows me to capture information both in average cross country differences and in fluctuations over time. I include in my sample only industrialized OECD countries because they represent a group of developed, relatively homogenous set of countries that may be close to their long-run steady states and thus serve as a good benchmark from which to compare East Asian economic growth.

Second, it is now widely recognized that investment is unlikely to be an exogenous explanatory variable in a model of economic growth and that using OLS to estimate growth will produce inconsistent results (Barro and Lee, 1994b; Caselli et al., 1996). For that reason, I
estimate the model using a GMM estimator with two lags of investment as instruments for current investment. I also conduct statistical tests of the validity of my estimator and the validity of the augmented Solow model for describing the OECD data.7

3. Forecasting East Asian Growth

I begin by estimating equation (2) for a panel of 21 OECD countries from 1960-1990. The data for per-capita income, investment, and population growth come from the Summers and Heston’s (1991) Penn World Tables. The education variable, which is from Barro and Lee (1994a), measures the average years of secondary schooling of the population over 25.8

I assume, like MRW, that the sum of technology growth and depreciation is equal to .05, although the results of the paper do not change materially when \( g + d \) is assumed to be .06. One potential problem of assuming a constant rate of technical progress is that studies of the OECD (Maddison, 1987) find that post-1973 productivity growth is significantly lower than pre-1973 productivity growth. To address this issue, I use time dummies in the estimation, which may account for unmodelled changes in technological progress. Second, I test for parameter stability across the sample and find that, at the .05 level, I cannot reject the null hypothesis of parameter homogeneity across the two sub-samples (1960-1974 and 1975-1990).9

As noted above, I treat investment as an endogenous regressor in the model. I use a GMM estimator with a heteroskedasticity and autocorrelation consistent weighting matrix and two lags of investment to over identify the equation.10 Since GMM in this context minimizes a criterion function that is itself a function of the correlation between the instruments and the errors of the equation, we can construct a test of the overall validity of the over identifying
instruments.

It has been shown that the minimized value of the GMM criterion function times the sample size is distributed as a $P^2$ with degrees of freedom equal to the number of over identifying restrictions. If the instruments are invalid because I am using lagged investment as an instrument and the error term of the equation is serially correlated, or because lagged investment belongs directly in the estimated equation, then the calculated statistic would be large. In my sample, the calculated test statistic (variously called a J-test, Sargan test, or a Hansen test) is 1.41, which means that the null hypothesis that the over identifying restrictions are valid cannot be rejected even at the .10 level. Equation (3) presents the estimates.

$$\text{Avg. real per-capita income growth} = .14 - .03 \log(\text{initial per-capita income})$$

$$- .03 \log (n + g + d) + .02 \log(\text{investment}) + .005 \log (\text{avg. yrs sec. educ.})$$

$$t\text{-statistics in parentheses;}$$

$$N = 126; R^2=.625$$

Time dummies were estimated but not reported

The independent variables are all correctly signed and significant, except the education variable, which is only marginally significant with a $t$-statistic of 1.3. The coefficient on lagged per-capita income is negative and significant at the .01 level, indicating conditional convergence in the sample. Before using the above coefficients to forecast East Asian growth, I check the validity of the model in explaining OECD growth in two ways. First, the $R^2$ is over .6, indicating that the model explains more than one half of the variation in the growth rate. Second, equation (2) implies that the coefficients of investment, human capital, and $(n + g + d)$ should add up to
zero. I perform a Wald test of the null hypothesis that the coefficients sum to zero, and find that I cannot reject the null even at the .10 level.\textsuperscript{13}

I forecast per-capita GDP growth in East Asia by combining the coefficients from equation (2) with actual regional factor accumulation. Countries are characterized as over achievers if their forecasts are inaccurate, biased, and consistently lower than actual growth rates.\textsuperscript{14} To test the accuracy of the forecasts, I calculate the RMSPE of the forecasts, which is the root mean squared error expressed as a % of the mean value of the dependent variable. A high RMSPE means that the coefficients of the industrialized country model do not accurately predict East Asian growth. To test whether the forecasts are biased, I calculate the proportion of the forecast error that is due to systematic bias, \((U^M)\), the proportion that is due to differences in variation \((U^v)\), and the proportion due to covariance \((U^c)\).\textsuperscript{15} Pindyck and Rubinfeld (1991, p. 341) argue that “the ideal distribution of inequality over the three sources is \(U^m = U^v = 0\) and \(U^c = 1\)” A value of \(U^M\) and \(U^v\) above .1 or .2 indicates that the predicted and actual growth series have significantly different means and variability.

Finally, to determine if country growth rates are systematically and significantly above the model’s predicted rates, I plot actual and forecasted growth for each individual country. I characterize a country as an over achiever if the RMSPE of the forecast is above 30%, the proportion of the error due to bias is over 0.30, and the actual growth rate is systematically above the forecasted rate.

Using the coefficients from equation (3) to forecast growth in the overall East Asian sample, I find no evidence that the region is a monolithic block of over achievers. Forecasted growth in the region is relatively inaccurate (the RMSPE for the overall sample is nearly 50%),
but the proportion of this error that is due to systematic bias is very low (.02). As a group, these 7 countries do not grow consistently faster than their factor accumulation and the rich country coefficients would predict.

However, the results reported in Table 1 indicate that the low level of bias in the overall forecasts masks big biases in both directions on a country-by-country level. Calculating forecast statistics for the individual countries indicates great variation in the results. Both Hong Kong and Taiwan are over achievers, while Singapore comes very close.

Figures 1-7 plot expected and actual per-capita growth rates for each individual country. The results illustrate the fact that Hong Kong and Taiwan both grew consistently faster than what their input growth and the rich country augmented Solow coefficients predict. Average forecasted per-capita income growth in Hong Kong is 3.1%, when actual average annual growth was 6.3%. The model over predicts Taiwanese economic growth in the first two periods, but under predicts growth in the last twenty years. Average forecasted growth is 5.0%, while actual growth rates averaged 6.2% a year.

Another interesting result of Table 1 is the finding that Indonesia is an under achiever, in the sense that the country consistently grows slower than its factor input growth and the wealthy country coefficients predict. As Figure 3 demonstrates, predicted per-capita income growth is larger than the actual growth rate in Indonesia for every period. Average growth is forecasted at 6.3% a year, when real growth “only” averaged 3.8% a year.

Singapore is a borderline case, in that the proportion of the forecast error due to systematic bias is 27% (which is below my 30% cut-off). Figure 4 shows clearly though that, after the first period from 1961-1965, Singapore has grown consistently faster than a
representative wealthy country would have with the same factor input growth. In fact, actual
growth averaged 6.5% a year, while average forecasted growth was only 4.9%.

In sum, when I combine the coefficients from an augmented Solow model of growth for a sample of industrialized countries with the actual levels of factor accumulation in East Asia, I find that Hong Kong and Taiwan can be characterized as over achievers. Further, I show that Indonesia is actually a significant under achiever, growing slower than forecasted growth in every period.

Discussion

In this section, I discuss my findings in relation to other results in the literature. In doing so, it is important to note that my empirical method is significantly different (and may rest on different assumptions) than the traditional studies of growth accounting in the literature, and the results may not be directly comparable. For example, my model rests on the assumption of Harrod-neutral (that is, labor augmenting) technological progress. As Nelson and Pack (1999) point out, results based on capital-augmenting technological change (Young, 1995) are not comparable with those based on the assumption of labor-augmenting technological progress. However, it is still interesting to investigate whether the countries I identify as over achievers correlate with those countries considered to be productivity ‘miracles’ in the literature.

The countries most commonly identified as ‘miracle’ economies are South Korea, Taiwan, Hong Kong, and Singapore (although there is much debate about the latter). For example, Nelson and Pack (1999) argue that high factor accumulation cannot explain the high growth rates in these four countries, while Klenow and Rodriguez-Clare (1997) make the same
argument for the first three.

I show that only Hong Kong and Taiwan are over achievers, in the sense that they grow consistently faster than a representative OECD country would with the same level of factor accumulation. Singapore comes close to satisfying the requirements I outlined for being an over achiever. South Korea, which grew at a faster average rate than any other country in the East Asian sample (at 6.66% a year), however, did not grow consistently faster than a representative rich country would have with equivalent factor accumulation.

I also find evidence that Indonesia is a significant under achiever. While Indonesia certainly grew faster than most of the developing world during the sample period, actual growth was consistently below that forecasted by the coefficients of the industrialized countries. This result is new in the literature, in that it shows at least one economy in the region that seems to be using resources inefficiently. While the finding is merely suggestive, it may support the argument that crony capitalism is a serious problem in Indonesia, resulting in a less than maximally productive allocation of resources (Woronoff, 1997).19

Per-worker results

Young (1994) argues that output per-worker is a better measure of productivity than output per-capita because the East Asian economies have all experienced rising labor participation rates after World War II. Replacing output per-capita with output per-worker in a TFP analysis, Young finds that capital augmenting productivity growth in East Asia has only been exceptionally high in Hong Kong. In the next section, I test whether my results change when income growth is measured in per-worker terms.
In equation (3b), I re-estimate the rich country augmented Solow model using the growth in per-worker income, the growth of the labor force (instead of population growth), and lagged per-worker (instead of per-capita) income. As before, I estimate the regression with GMM, treating investment as an endogenous variable, and using two lags of the investment variable as instruments for current investment. I test the null hypothesis that the over identifying restrictions are valid and find I cannot reject the null even at the .10 level.20

\[
\text{Avg. real per-worker income growth} = 0.18 - 0.03 \log(\text{initial per-worker income}) \quad \text{(3b)}
\]

\[
-0.03 \log (n + g + d) + 0.016 \log(\text{investment}) + 0.003 \log (\text{avg. yrs sec. educ.})
\]

\[N = 126; \quad R^2 = 0.727\]
\[t\text{-statistics in parentheses;}
\]
\[\text{Time dummies were estimated but not reported}\]

The results of Equation 3b are very similar to those of Equation 3, insofar as all of the independent variables are correctly signed and significant, except for schooling, which is correctly signed but only marginally significant. The \( R^2 \) is .727, indicating that the model explains a large amount of the variation in real per-worker income growth. I perform a Wald test of the null hypothesis that the coefficients on investment, schooling, and \( (n + g + d) \) sum to zero, and find that I cannot reject the null even at the .20 level.21

Using the coefficients of the industrialized model and the real factor inputs of the 7 East Asian countries to forecast regional growth, I again find no evidence that the region as a whole is over achieving. Table 2 indicates that while the RMSPE of the forecasts is still high (at almost 50%), the proportion of this forecasting error that is due to systematic bias is almost zero
(.00003). As a group, the East Asian countries do not grow any faster than their factor accumulation and the rich country augmented Solow model coefficients predict.

Table 2 also shows that the overall regional forecast masks big differences between the individual countries. Hong Kong and Taiwan continue to easily meet my criteria of over achievers, while Indonesia still looks like an under achiever. Again, Singapore comes close to being characterized as an over achiever. The criteria for deciding which countries qualify as miracles is not carved in stone, and the results indicate that Singapore is not as easily classified as some of the other countries.

One difference between these results and those in Table 1 is that growth in Thailand, which was estimated with little bias using the coefficients from equation (3), is now forecasted with a high level of bias (.53). Measuring income growth in per-worker terms places Thailand in the same category as Indonesia, where growth is systematically below what would be predicted by the country’s input accumulation and the industrialized country augmented Solow coefficients.

4. Can Macro Policy Explain the Over and Under-Achievers?

In the results reported above, I find that Hong Kong and Taiwan grew faster, and Indonesia and Thailand grew slower, than a representative industrialized country with identical factor accumulation would predict. In this section, I test whether macroeconomic policy choices can help to explain the economic performance of these four countries.

While there is a large literature showing that policy is important in explaining differences in growth rates across countries, it is important to note that no one explanation serves to explain
growth in all of East Asia. The phenomenal growth rates in East Asia set the economies apart from other developing countries, but their individual policy experiences are very different from one another. Harris (1986, p.68) cautions against generalizing the East Asian experience; “If a neutral state is required to explain Hong Kong’s growth (as the neoclassicists would have it), it does not explain the performances of the other three, where there was consistent state intervention. South Korea, Taiwan, and Singapore are triumphs of state capitalism, but Hong Kong and Singapore are also triumphs of free trade” (Booth, 1999; Perkins, 1994).

Having said that, there are some commonly agreed upon macro policy variables which are thought to be important to growth in all countries. I estimate a Barro-style regression of per-capita (and per-worker) income growth for the industrialized-country sample, including the growth of government consumption expenditures (as a % of GDP), average inflation, and the standard deviation of inflation as measures of fiscal and monetary policy. All three variables were constructed with data from Summers and Heston’s (1991) Penn World Tables.

Grier and Tullock (1989) find that the growth of government consumption spending (as a % of GDP) is negatively and significantly correlated with real GDP growth. While inflation and output are positively related in traditional models of the Phillips curve, many recent papers argue that inflation has a damaging effect on new investment and economic growth. Pindyck and Solimano (1993) provide theoretical and empirical support for the argument that high inflation lowers growth by increasing economic instability. Investors may want to defer new investments during periods of high inflation because the inflation signals the unsustainability of government policies, or because high inflation is associated with a more volatile marginal profitability of capital (Fischer, 1993; Fischer and Modigliani, 1978).
I also include a measure of trade openness that is created with data from Sachs and Warner (1995), although, as Rodrik and Rodriguez (1999) have shown, the effect of openness on growth is controversial. The variable is the number of years in the last five years a country has had an open trade policy, as defined by Sachs and Warner.

I find that controlling for macro policy variables increases the accuracy of the per-capita and per-worker growth forecasts for Taiwan.\textsuperscript{22} Per-capita growth in Taiwan is forecasted relatively accurately (RMSPE is 32\%) and with very little bias (a $U^m$ of .016). Forecasts of per-worker income growth yields similar results (a $U^m$ of .06 and RMSPE of 40\%).\textsuperscript{23} Hong Kong, on the other hand, continues to be a significant over achiever. Forecasted growth is both inaccurate and has a high degree of systematic bias (a $U^m$ of .50 and RMSPE of 87\% in the per-capita forecasts and a $U^m$ of .27 and RMSPE of 88\% in per-worker terms).

Indonesia and Thailand continue to be under achievers even when controlling for macro policy differences. Forecasts of per-capita growth in Indonesia are inaccurate (the RMSPE is 124\%) and biased (a $U^m$ of .435). Forecasts of per-worker income growth are also biased and inaccurate (a $U^m$ of .496 and RMSPE of 161\%). Per-capita income growth in Thailand, which was forecasted with little bias with the coefficients of equation (2), is now both inaccurate and systematically biased (RMSPE is 40\% and the $U^m$ is .682). Per-worker growth forecasts are similarly biased and inaccurate (RMSPE is 67\% and the $U^m$ is .85). Thus, controlling for macro policy choices makes Thailand look more like an under achiever and does nothing to explain the under achieving of Indonesia.

5. Conclusion
Studies of East Asian growth typically use growth accounting techniques to determine how much of income growth is due to factor input growth, and measures factor productivity growth as the residual of this process. Determining whether a Solow residual is large enough to reflect miraculous growth is largely subjective. A country may have the largest residual in the sample and still have relatively slow productivity growth. In this paper, I investigate whether East Asian countries can be characterized as over achievers relative to the performance of a representative wealthy country. Over achiever countries are ones that consistently faster than an industrialized country with the same factor accumulation.

This new technique yields several interesting results. I find no evidence that the East Asian region is a monolithic block of over achievers. In fact, the industrialized country augmented Solow coefficients, combined with East Asia’s factor accumulation, forecasts regional growth with very little bias. On a country by country basis, I show that Hong Kong and Taiwan are over achievers. They both grow systematically faster than their factor accumulation and the rich country coefficients predict. Singapore, which almost satisfies the over achieving criteria, also grows faster than the model predicts.

Actual per-capita (and per-worker) GDP growth in Indonesia is consistently less than a representative wealthy country with equivalent factor accumulation forecasts, which may lend support to the criticisms of the Indonesian economy being an extreme example of ‘crony capitalism.’ Thailand joins Indonesia as an under achiever when growth is measured with real per-worker GDP. In sum, in all countries except Hong Kong and Taiwan, income growth was largely explained by factor accumulation and the coefficients of the industrialized country Solow model. This result should be relatively encouraging for other developing countries. While the
other five countries in the sample did not systematically outperform the forecasts of the
industrialized-country model (and some even under performed), they did have considerably
higher growth rates than most of the developing world. This indicates that increased factor
accumulation can go a long way in fueling high growth rates and economic development, even
with less than a fully efficient usage of inputs.
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Table 1: Forecasting per-capita growth in East Asia
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<td>Region</td>
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<td>Thailand</td>
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Table 2: Forecasting per-worker growth in East Asia
References


Fischer, Stanley and Franco Modigliani, “Towards an Understanding of the Real Effects and


Figure 1. Actual and predicted per-capita income growth in Hong Kong
Figure 2. Actual and predicted per-capita income growth in Taiwan
Figure 3. Actual and predicted per-capita income growth in Indonesia
Figure 4. Actual and predicted per-capita income growth in Singapore
Figure 5. Actual and predicted per-capita income growth in Malaysia
Figure 6. Actual and predicted per-capita income growth in South Korea
Figure 7. Actual and predicted per-capita income growth in Thailand
Notes

1. While Rodrik (1997) argues that the high levels of factor accumulation in East Asia are just as remarkable a phenomena as high productivity rates, high productivity growth (i.e., a large Solow residual), and not high levels of accumulation, is traditionally thought of as ‘miraculous.
2. Similarly, Nelson and Pack (1999) list the coefficients from Levine and Renelt’s (1992) cross-country estimation of 121 countries and calculate the difference between actual and predicted GDP growth for a sample of developing countries with high investment rates.
3. As Mankiw (1997, p.105) puts it, “By allowing the data to choose the parameters, we ..are allowing the model to take its best shot.”
4. The 21 countries included in the industrialized country sample are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Norway, New Zealand, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States. The 7 East Asian countries are: Hong Kong, Indonesia, Malaysia, Singapore, South Korea, Taiwan, and Thailand.
5. Narrowing the sample of representative industrialized countries to only the G-7 does not significantly change the findings. The results are available upon request.
6. Quah (1993) argues that cross sectional regressions of time averaged data are uninformative because of possible trend breaks and variance changes in the individual country time series.
7. Collins and Bosworth (1996, p. 139) argue that one of the benefits of growth accounting is that it “...avoids some of the problems associated with cross-country regression analyses..such as simultaneity, multicolinearity, and limited degrees of freedom.” I eliminate the problem of limited degrees of freedom by estimating a regression with a panel of data instead of a single cross section. To deal with the possibility that investment is not an exogenous regressor, I use two lags of investment as instruments for current investment.

9. I estimate the model with OLS and conduct a log-likelihood ratio test. The calculated $P^2$ statistic is 12.14.

10. The resulting estimates are robust to general forms of heteroskedasticity and autocorrelation. I weight the autocovariances with a Bartlett kernel and select a fixed bandwidth of 4 using Newey and West’s (1987) formula. All estimations in this paper are done in Eviews 3.0.

11. As a direct check for first-order serial correlation in the error term, I estimated a version of the model using least squares and calculated a common autocorrelation coefficient for each of the 21 6-observation time series of the estimated errors. The value of this coefficient was .016, which indicates that first order autocorrelation is probably not a problem in these data.

12. The number of overidentifying restrictions is one, so the critical value at the .10 level is 2.71. See Greene (2000, p. 302) for a good description of the J-test.

13. The Wald statistic is distributed as a $P^2$ with degrees of freedom equal to the number of restrictions. I calculate a statistic of 1.72 while the critical value at the .10 level with one restriction is 2.71.

14. If forecasted growth is extremely accurate, then the question of bias becomes relatively unimportant. If the level of bias is small, but the forecasts are extremely inaccurate, then there is no possible significant pattern of over achievement. Even if the forecast is both inaccurate and biased, it is necessary to plot actual and forecasted growth to distinguish between countries which systematically over perform and under perform relative to the forecasts.

15. Pindyck and Rubinfeld (1991) describe the Theil inequality coefficient, which is separated into three parts: the proportion of the simulation error due to systematic bias, differences in variance, and unsystematic error. It is worrisome to have large values of the first two proportions as they signify systematic differences between the actual series and the simulated
16. It is possible that analyzing the forecasts at the country by country level over interprets the results. To investigate this further, I use the coefficients from equation (3) to forecast growth for the individual OECD countries and find that the model is an unbiased predictor of growth for almost every country in the sample. Only Canada, Japan, and the United States satisfy my three criteria of an over achiever, a finding not at odds with conventional wisdom.

17. Boskin and Lau (1990) argue that technological progress is capital augmenting in the G-5 and East Asian countries, and that traditional tests of the Solow growth model are thus mis-specified. However, the Solow model has broad explanatory power, and, as shown above, the main empirical predictions of the model are not rejected for my sample of industrialized countries.

18. Klenow and Rodriguez-Clare (1997) argue that Singapore has had high productivity growth, while Young (1994) and Huff (1999) argue that productivity growth has been close to zero.

19. To be fair, many of the East Asian economies are criticized for tolerating ‘crony capitalism’, although Indonesia is often argued to be the worst case in the region.

20. The calculated statistic is .873 and the critical value at the .10 level with one overidentifying restriction is 2.71.

21. The calculated test statistic is .159, while the critical value at the .10 level with one restriction is 2.71.

22. The specifics of the regressions estimated here are available upon request by the author.

23. While controlling for these policy choices helps to explain Taiwanese growth, it does not negate the fact that Taiwan may have had serious policy problems in other areas which were subsequently revealed in the 1997 crisis.