

## **The 2008 Financial Crisis and Potential Output in Asia: Impact and Policy Implications\***

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Monitoring the behavior of potential output helps policymakers implement appropriate policies in response to an economic crisis. In the short-run, estimates of the output gap will guide the timing of implementation and withdrawal of stimulus measures. In the medium- to long-term, these estimates will also provide the basis for gauging productive potential and hence guide policies to support the sustainable non-inflationary output growth. In this paper, we investigate the post-crisis behavior of potential output in emerging East Asian economies, by employing the Markov-switching model to account for structural breaks. Results show that after the 1997/98 Asian financial crisis, potential output in Hong Kong, China; Korea; Singapore; and Malaysia reverts to the level consistent with the trend prior to the crisis. While there is a permanent drop in potential output in Thailand and Indonesia, growth rates returned to the pre-crisis trend. PRC, Taipei, China, and the Philippines are special cases. Econometric estimates of a simple growth model show that the difference among economies can be attributed to the investment-GDP ratio, macroeconomic policies, exchange rate behavior, and

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productivity which is proxied by the level of technological activity. These results can guide policy after the 2008 crisis.

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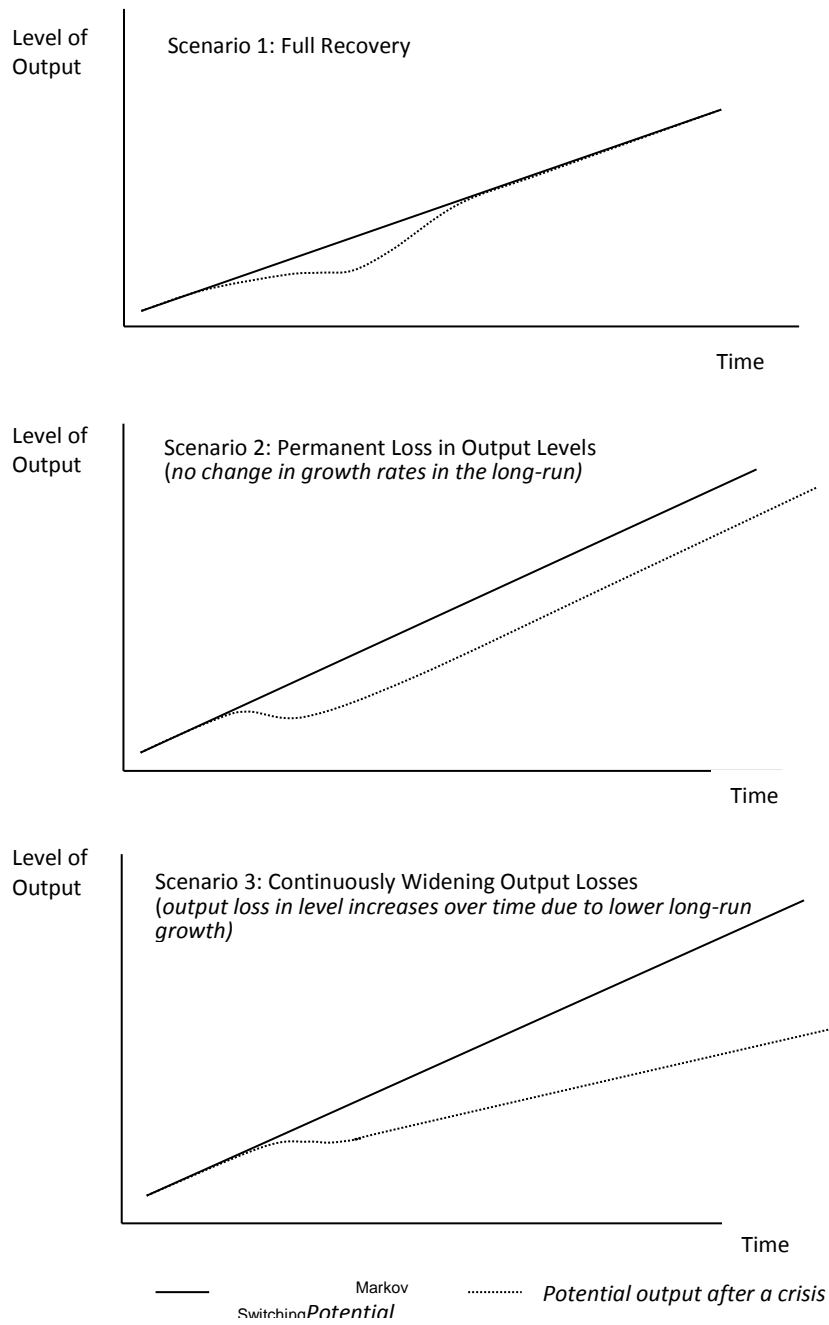
## 1. INTRODUCTION

Potential output is defined as the level of output consistent with price stability or, alternatively, the trend level of output around which the economy fluctuates over the business cycle. Deviations of actual from potential output lead to output gaps. The output gap is one of the main components of price determination based on the Phillips Curve and is often used as an argument in monetary policy reaction functions. As such it is an important consideration in an inflation-targeting framework.

Potential output can also be a useful indicator for policymakers in adopting appropriate measures in response to an economic crisis. The main issue is to what extent a particular crisis has an impact on potential output. To illustrate, a crisis can have three possible impacts on potential output depending on the nature of the economic downturn and subsequent policy responses (figure 1). Scenario 1 shows that potential output will revert to the level that was determined by its trend prior to the crisis. This implies that actual output growth will experience a jump when the economy returns to its path prior to the crisis. Meanwhile, output growth in Scenario 2 will only return to its pre-crisis trend but potential output will be at a lower level. The worst case scenario is depicted as Scenario 3 where output expansion will slow down even after the crisis dissipates.

Knowledge of the cyclical position — based on the estimates of potential output and the position of GDP in relation to its potential (i.e., the output gap) — is a key element in monetary and fiscal framework. First, the level of GDP relative to its potential has important implications for inflationary

**Figure 1 Possible Impacts of a Crisis on Output**



pressures in the economy. Consequently, the output gap is one of the main factors in monetary policy decisions, such as in the Taylor rule or in the inflation-targeting framework. Second, the size and sign of the output gap provides a good indicator of an economy's cyclical position, which is an important element in the estimation of the "structural fiscal balance." The structural fiscal balance is conceptually a non-cyclical component of the fiscal balance and an important gauge for assessing the fiscal stance.

Accordingly, it is important to be able to accurately decompose an economic downturn into a change in potential output and a change in the output gap. A change in output can be decomposed into a permanent ( $y^p$ ) and a transitory component ( $z$ ), such that:

$$\Delta y_t = \Delta y_t^p + \Delta z_t,$$

where  $y^p$  and  $z$  correspond to potential output and the output gap, respectively. For example, during a recession, if the change in  $y^p$  is dominant, then a restrictive monetary policy is called for. However, if it turns out that the transitory component is more prominent, then the restrictive monetary policy can choke off the recovery. It should be noted that real shocks (e.g., a rise in productivity due to new technology) are usually manifested in changes in  $y^p$  while nominal shocks (e.g., an increase in money supply) tend to affect the transitory component.

The major implication is that potential output should be estimated fairly accurately in order that appropriate policies can be implemented in response to a particular crisis. The second part of the paper presents various methodologies to estimate potential output, with emphasis on accounting for structural breaks in the data. This section includes a review of some applications in Asian countries. The third section of the paper discusses the various channels by which a financial crisis can affect potential output. Policy responses are highlighted. Empirical studies focused on the 1997/98 East Asian financial crisis are reviewed in this section. The fourth section deals with empirical results of the present study. This is the basis for policy

recommendations in response to the 2008 crisis which are outlined in the last section.

## 2. ESTIMATING THE POTENTIAL OUTPUT

Methodologies to estimate potential output and the output gap can be classified into three major categories. The first are statistical or atheoretical approaches, where actual data on output are used to construct an estimate of potential output. On the other hand, structural approaches apply economic theory to estimate potential output. Typically, data on employment and the capital stock are used to construct a production function. Given assumptions about the full-time equivalent of employment, productivity, and utilization of capital stock, measures of potential output can be estimated. However, this method cannot be applied to many developing countries due to lack of required data.

In this section, we will focus on the atheoretical approach, discussing the strengths and weaknesses of a few common methodologies employed in our empirical analyses.

### 2.1. Atheoretical Approach

The most popular atheoretical approach is suggested by Hodrick and Prescott (1997). The Hodrick-Prescott (HP) filter<sup>1)</sup> has a time-varying trend and estimates the potential component of output by minimizing the loss function, specified as follows:

$$L = \sum_{t=1}^n (y_t - y_t^T)^2 + \lambda \cdot \sum_{t=2}^{n-1} (\Delta y_{t+1}^T - \Delta y_t^T)^2,$$

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<sup>1)</sup> “Filtering” refers to a procedure by which a value is decomposed into two or more ex ante unknown quantities. The decomposition is based on set criteria.

where  $\lambda$  is the smoothing weight on potential output growth and  $n$  is the sample size.<sup>2)</sup>

The main advantage of the HP filter is that it produces an output gap that is stationary and it allows the trend to follow a stochastic process. One disadvantage though is that the selection of the smoothing weight is arbitrary and that this matters to the actual results.<sup>3)</sup> The HP filter is also sensitive to new data, which is the uncertainty associated with statistical revisions. It is useful to distinguish the latter from the uncertainty due to data revisions, which arise when historical GDP figures are changed. Studies have shown that the effect of statistical revisions is about an order of magnitude more important than published data revisions.<sup>4)</sup>

Another atheoretical approach is what is called the unobservable components method (UC). Typically, output is decomposed into a permanent ( $y^p$ ) and a transitory component ( $z$ ), such that:

$$y_t = y_t^p + z_t,$$

where  $y^p$  and  $z$  correspond to potential output and the output gap, respectively. Permanent output is assumed to follow a random walk with drift:

$$y_t^p = \mu^y + y_{t-1}^p + \varepsilon_t^y,$$

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<sup>2)</sup> Burns and Mitchell (1946) suggested that the cyclical components of the business cycle fall within a particular range of duration (typically between 1.5 to 8 years). The band pass filter extracts components of a time series with this range of periodicities, while filtering out components at lower and higher frequencies. Two popular methods employing this filter are the Baxter-King (1999) filter and the Christiano-Fitzgerald (CF) (2003) filter. In this report, the CF variant of the filter was used. The method is also atheoretical and has properties similar to the HP filter.

<sup>3)</sup> Hodrick and Prescott recommend a value of 1600 for quarterly data, which is based on the relative size of the variances of the shocks to permanent and transitory components of output. Changing the weight affects how responsive potential output is to movements in actual output. For example, as the smoothing factor approaches infinity, the loss function is minimized by penalizing changes in potential output growth, which is done by making potential output growth a constant, i.e., a linear time trend. Hence the time-trend method is a special case of the HP filter.

<sup>4)</sup> An assertion also contained in the 1999 Orphanides and van Norden study.

where  $\mu^y$  is a drift term and  $\varepsilon_t^y \sim N(0, \sigma_y^2)$ . The output gap is assumed to follow an AR(2) process:

$$z_t = \varphi_1 z_{t-1} + \varphi_2 z_{t-2} + \varepsilon_t^z,$$

where  $\varepsilon_t^z \sim N(0, \sigma_z^2)$  and the stationary conditions hold. Estimates of the parameters of the model and the unobserved state variables can be obtained through a maximum likelihood procedure using the Kalman filter. This approach has advantages and disadvantages similar to the HP filter.

The Beveridge and Nelson decomposition is yet another atheoretical method where the changes in output are modeled as an ARMA ( $p, q$ ) process,

$$\varphi(L)(\Delta y_t - \mu) = \theta(L)\varepsilon_t.$$

Standing at time  $t$ , the expectation of  $y_{t+k}$  conditional on data through  $t$  is

$$\hat{y}_t(k) = y_t + \sum_{j=1}^k \Delta \hat{y}_t(j).$$

The permanent or trend component of  $y_t$  is

$$y_t^p = y_t + \lim_{k \rightarrow \infty} \left[ \sum_{j=1}^k \Delta \hat{y}_t(j) - k\mu \right].$$

The second term of the equation's right hand side, which captures the momentum contained in  $y_t$  at time  $t$ , was interpreted by Beveridge and Nelson (1981) as the cyclical component of the series. In this paper, this method is applied using the Newbold (1990) implementation of the Beveridge-Nelson (BN) decomposition.<sup>5)</sup>

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<sup>5)</sup> Unlike the HP filter that imposes smoothness in the trend a priori, both the BN decomposition and the unobserved components method "let the data speak for themselves" (Morley *et al.*, 2003). However, it is well-known that the BN decomposition results in a

The UC method usually results in a smooth trend and large cycle. This is because the UC method (see e.g., Clark, 1987) forces the innovations in the trend and the cycle to be uncorrelated. When this restriction is relaxed, meaning that the covariance between the trend and the cycle innovations are not restricted to zero, the (unrestricted) unobserved components model results to a univariate representation and a trend-cycle decomposition that is identical to the BN decomposition (Morley *et al.*, 2003). Hence, in this study the BN decomposition is estimated instead of the (restricted) unobserved components method.

## 2.2. Accounting for Structural Breaks

A common disadvantage of the atheoretical methodologies is that they do not account for structural breaks in the time series. Model instability and structural breaks from one sub-period to another is an important consideration that needs to be taken into account. Early methods (e.g., Chow, 1960) dealt with the issue by dating the parameter shifts in cases where the changes are known — or are determined — by the researcher. Later methods incorporated strategies for detecting parameter switches when the dates of the turning points are unknown; in these methods, the structural change is modeled endogenously. The most popular of these is Hamilton's (1989) Markov-switching (MS) model, which allows for the probability of the shift to depend explicitly on the regime that is in effect (Kim and Nelson, 1999a provide an exposition of these models).

In MS models, since the evolution of the variable capturing the changes in the regime,  $S_t$ ,  $t=1, 2, \dots, T$ , is not known, it needs to be estimated — as an unobserved variable — together with the parameters of the model. These Markov regime-switching models can be applied to account for both shocks to potential output and breaks from trend that lead to unusually large contractions. Hamilton (1989) developed a method to analyze economic

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decomposition where much of the GDP variation is in the trend component, while the temporary component is small.



fluctuations as the outcome switches from one state to another, with the change in state being governed by an unobserved first-order Markov process.<sup>6)</sup> Lam (1990) extended the original Hamilton model to enable the modeling of processes whose autoregressive component need not have a unit root. Meanwhile, Kim (1994) reworked Lam's specification using state space techniques enabling the application of a Kalman filter.

The generalized Hamilton model assumes that the MS occurs in the permanent part of output but not in the cyclical component. It thus assumes that recessions have a permanent impact on real GDP. Another set of models that attempt to capture business cycle asymmetry, albeit fundamentally very different in approach from Hamilton's model, assume that recessions are transitory "plucks" from output. That is, recessions are those episodes when output is disturbed by negative temporary shocks, but that following a recession, a rapid recovery phase — labeled as the "bounce-back" or "peak-reversion" effect—ensues. This is the model advocated by Friedman (1964, 1993), and formalized in MS framework by Kim and Nelson (1999b).

A body of empirical work followed either of these types of business cycle asymmetry (Hamilton- and Friedman-types) separately. Kim and Piger (2002) generalize these business cycles models by adopting a unified framework capable of capturing both types and asymmetric together and therefore allows one to decompose one type of asymmetry from the other, and evaluate which of the two types are significant. Similar to Stock and Watson (1989, 1991, and 1993), Kim and Piger adopted a multivariate framework, but incorporating MS in their framework. In their model, output

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<sup>6)</sup> Potential output is specified as:

$$y_t^p = \mu_0 + y_{t-1}^p + \mu_1 s_t + \varepsilon_t^y.$$

Potential output is a random walk with a drift that evolves according to a two-state Markov process. The binary variable  $s_t$  represents either a high or a low growth state of the economy in period  $t$ . The probability that state  $j$  follows state  $i$  is given by the transition probabilities,

$$p_{ij} = \Pr(s_t = j | s_{t-1} = i) \text{ where } \sum_j p_{ij} = 1 \text{ and } i, j = 0, 1.$$

and investment (but not consumption) are affected by shocks to the common stochastic trend, a common transitory portion, and transitory shocks that are idiosyncratic in nature.

Kim and Piger (2002) applied their model to cointegrated data, and assumed that both types of asymmetry are propelled by the same state variable. This implies that each recession is forced to contain both permanent and transitory common factor. A related approach was utilized by Kim and Murray (2002) using non-cointegrated data, this time utilizing two different state variables to capture the Hamilton-type and the Friedman-type asymmetries, with the state variables' duration and timing permitted to vary across recessions. This allows for the possibility that recessions can emanate from more than one source, either as a change in the common transitory component or a shift in the common permanent component. Otherwise stated, this approach permits one to isolate whether a particular recession is driven by a regime change in the permanent component or in the transitory component.

Kim and Piger (2002) and Kim and Murray (2002) therefore improve upon Hamilton (1989), Lam (1990), and Kim (1994) in that unlike the latter, their methods are able to capture the peak-reversion feature that the Hamilton model is unable to capture. Moreover, their methods are more general, in that using specific coefficients in their equations can reproduce the results by the Hamilton model.

In estimating the business cycle co-movement and asymmetry in the context of Asian economies, it would be better to use to Kim and Piger (2002), which uses only one state variable rather than the more complex, two-state approach adopted in Kim and Murray (2002).<sup>7)</sup> The reason is that unlike the US, for which these business cycles methods were originally developed, Asian economies in general have less episodes of boom and bust cycles. Most of the economies we studied have only about one or two

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<sup>7)</sup> This advice was given by Professor Chang-Jin Kim in a phone conversation on 16 November 2009. Unfortunately, the algorithm generously provided by Professor Jeremy Piger would not converge when applied to data from East Asian economies. The algorithm can be provided upon request.

episodes of recessions at the most. Thus, for Asian economies, it would be more difficult to obtain the averaging required to estimate the state probabilities for the computer algorithm to converge. The less complex model will hold a better chance of having the probability estimates converge, if at all either of the methods could be used to generate the numbers for Asian economies.

### **3. IMPACT OF FINANCIAL CRISES ON POTENTIAL OUTPUT IN ASIA**

#### **3.1. Theory and Policy Responses**

There are various channels through which the crisis can impact potential output.

First, a crisis discourages firms from investing in capital as a fall in demand and uncertain economic outlook increase uncertainty on the returns on investment. Moreover, a financial crisis tends to worsen funding conditions for the firms new investment due to higher risk premia, tighter lending standards, and thus higher real cost of capital due to limited credit supply. Second, a crisis weakens the labor market situation. Especially when the labor market is rigid, a temporary reduction in employment could become persistent even as the economic conditions improve. Third, a crisis may lead to a drop in productivity due to decreased capital spending. For instance, a reduction in R&D spending can lower total factor productivity.

Policy responses and private restructuring efforts following the crisis also influence the trajectory of output. Policy responses to cushion the economic downturn can sometimes have long-term effects. For example, an increase in public spending, which is used to build physical and social infrastructure, may help boost potential output. On the other hand, stabilization policies could introduce distortions in markets, thus creating long-term side effects. A financial crisis also provides an impetus for reforms and corporate

restructuring. Successful implementation of structural reforms and corporate restructuring could enhance productivity, thus eventually lifting potential output even higher than its original path. Overall, the crisis impacts on productivity beyond the short-term, thus the impact on potential growth remains highly uncertain. For example, Japan has suffered substantial and persistently widening output losses following the banking crisis. But, Mexico and Norway have eventually achieved the level of output and even exceeded what the pre-crisis trend growth had suggested (Haugh *et al.*, 2009).

A priori, the impact of a crisis on potential output is uncertain; hence it is important to investigate the sources of a decline in output following a crisis. It is very difficult to determine the path of potential output in the event of a crisis. However, identifying the sources of the output loss — for example, a temporary rise in the unemployment rate or a decline in productivity — has important implications for the output gap and the appropriate policy responses. If the output loss is largely associated with the output gap — a temporary deviation from potential output — stabilization policies would be sufficient. However, if the loss is induced from a change in potential output, the appropriate policy response would require more fundamental reforms which can address structural problems (see Cerra and Saxena, 2005).

In addition, a financial crisis can change potential output through indirect effects. Indeed crises usually trigger policy responses from public authorities to cushion the economic downturn. Stabilization policies can sometimes have long-term effects. On the one hand, investment in infrastructure is likely to boost potential output. On the other hand, other policies can be detrimental to long-term growth when they introduce distortions or encourage excessive risk-taking. At the same time, temporary fiscal measures can lead to permanent increase in government size and in debt levels, which in turn will have negative effects on growth. Finally, the final impact of policies depends on the nature and the design of the specific measures. Financial crises can also foster the implementation of structural reforms that can in turn enhance potential output by moderating political opposition to reforms.

### 3.2. Evidence from Earlier Crises

Many studies looked into the impact of financial crises including the effect of the 1997 financial crisis on potential output in Asia. Past experiences show that financial crises tend to cause substantial and persistent output losses, although there are significant country variations. The patterns of medium-term output performance following financial crisis have attracted much attention recently. Several studies have examined the medium-term behavior of output in the crisis-affected countries. Some stylized facts about the crisis-driven recessions have emerged as follows:

- Financial crises, especially the ones involving banking crises, tend to have a negative and persistent effect on potential output. Furceri and Mourougane (2009) estimate that financial crises lower potential output by around 1.5 to 2.4% on average for the OECD economies. The magnitude of the effect increases with the severity of the crisis. Abiad, Balakrishnan, Brooks, Leigh, and Tytell (2009) also find that output tends to be depressed substantially and persistently following banking crises, after investigating 88 banking crises that occurred over the past four decades across a wide range of economies. Their finding was based on the comparison of the medium-term level of output<sup>8)</sup> with the level it would have reached following the pre-crisis trend.
- Following financial crises, output does not return to its original trend path on average over the medium-term. Growth does, however, eventually return to its pre-crisis rate for most economies, suggesting the pattern of medium-term output performance following financial crisis is best described by Scenario 2 in figure 1.
- The depressed output path tends to result from long-lasting reductions of roughly equal proportion to the employment rate, the capital-to-

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<sup>8)</sup> The medium term was defined as seven years after the crisis in this paper.

labor ratio, and total factor productivity (see Abiad *et al.*, 2009).

- Initial conditions and policy responses have a strong influence on the size of the output loss. What happens to short-term output is also a good predictor of the medium-term outcome. Interestingly, post-crisis output losses are not significantly related with the level of income.

In Asia, one of first cross-country estimates of the output gap in the aftermath of the 1997 crisis was undertaken by Bautista (2003). By applying the generalized Hamilton model as modified by Lam (1990) and Kim (1994), he addressed the problem created by structural breaks. One interesting result was that the stochastic output gap estimates obtained from the modified Hamilton model were on average smaller than estimates of the linear-quadratic output gap. The reason is that shocks to potential output partly account for the fluctuations in GDP. This is clear evidence that the crisis had an adverse impact on potential output. The downturn in the Philippines and Thailand, however, could not be classified as recessions and instead appeared as slowdowns. The different experiences of each country could likely be attributed to different policy responses.

A similar approach was applied by Cerra and Saxena (2005) but with the asymmetry applied also to the output gap. They used a two-common-factor model with regime switching in each of the factors. Real GDP, investment, and private consumption were used to identify the common transitory and stochastic trends. Their results indicate some amount of permanent output loss in all the six economies that were part of the study. The recovery phase is predominantly characterized by a return to the normal growth rate of an expansion, rather than a higher-than-normal growth rate. This is akin to Scenario 2 of figure 1. Thus the level of output is permanently lower than its initial trend path.

Cerra and Saxena also determine that the impact of the 1997 crisis was milder in the Philippines, a result that is consistent with Bautista. The cumulative output loss in the Philippines for the period 1997-1999 was only 1.5%, compared to 22.3% in Indonesia, 10.3% in Republic of Korea (Korea),

and 19% in Malaysia. Unfortunately, Thailand was not included in the study due to lack of data.

## 4. EMPIRICAL RESULTS

### 4.1. Results from Atheoretical Methods

Three relatively simple atheoretical methods were initially applied to determine the variation in the empirical results. The economies that were included in the estimation are: People's Republic of China (PRC); Hong Kong, China; India; Indonesia; Japan; Korea; Malaysia; the Philippines; Singapore; Taipei, China; and Thailand. In addition, estimates were applied to the US and aggregate Europe.<sup>9)</sup> The data used are described in the appendix. The end-point problem of the HP filter is addressed by extending the data up to the fourth quarter of 2010 by applying ADB forecasts. The results are summarized in tables 1-3.

All three methods — HP, band pass (BP)-CF, and BN — suggest a noticeable drop in the potential output growth for both (a) the countries affected by the 1997/98 Asian financial crisis (e.g., Malaysia, Indonesia, Thailand), and (b) all regions and countries (with the possible exception of PRC) for the 2008 global crisis. In general, among the three methods used, the BN decomposition registers the largest reduction in potential GDP growth during both crisis periods. This result is expected because, as previously explained, the BN methodology results in a decomposition where much of the GDP variation is in the trend and stochastic component.

For the 1997/98 crisis, all three methods suggest large and substantial reduction in potential output growth for Indonesia, Malaysia, and Thailand. BN is also capturing a relatively large potential output growth reduction for Korea; Hong Kong, China; and Singapore, while BP-CF is capturing the

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<sup>9)</sup> Includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and United Kingdom.

**Table 1 Potential Output Growth Rates<sup>1)</sup> (Using HP Filter)**

	1985Q1- 1989Q4	1990Q1- 1994Q4	1995Q1- 1997Q2	1997Q3- 1999Q4	1997/98 Crisis Reduction in Potential Growth	2000Q1- 2004Q4	2005Q1- 2007Q4	2008Q1- 2009Q2	2008/09 Crisis Reduction in Potential Growth
	(1)	(2)	(3)	(4)	(5)=[ave(1:3)]-(4)	(6)	(7)	(8)	(9)=[ave(6:7)]-(8)
China, People's Republic of	9.6	10.7	10.2	8.5	<b>1.7</b>	9.4	10.8	9.7	<b>0.2</b>
Hong Kong, China	7.4	5.3	3.0	1.7	<b>3.9</b>	4.0	5.1	2.7	<b>1.7</b>
India	5.4	5.5	6.3	5.8	<b>-0.3</b>	6.5	8.4	7.6	<b>-0.4</b>
Indonesia	7.2	8.1	4.1	0.4	<b>6.5</b>	3.5	5.7	5.5	<b>-1.2</b>
Korea, Republic of	9.3	7.8	5.5	4.3	<b>3.7</b>	5.0	3.9	2.5	<b>2.1</b>
Malaysia	5.9	9.6	6.9	3.8	<b>3.7</b>	4.9	5.0	3.3	<b>1.7</b>
Philippines	1.8	2.9	3.8	3.4	<b>-0.8</b>	4.5	5.1	4.1	<b>0.6</b>
Singapore	7.1	9.2	7.5	5.1	<b>2.9</b>	5.1	5.6	2.6	<b>2.7</b>
Taipei, China	9.0	7.4	6.3	5.0	<b>2.8</b>	3.9	3.4	1.2	<b>2.5</b>
Thailand	9.2	9.1	3.5	0.5	<b>7.5</b>	4.3	4.4	2.3	<b>2.0</b>
Europe <sup>2)</sup>	2.9	1.9	2.3	2.7	<b>-0.4</b>	2.2	1.5	0.2	<b>1.7</b>
Japan	4.9	2.5	1.0	0.6	<b>2.6</b>	1.3	1.1	-0.5	<b>1.7</b>
United States	3.5	2.6	3.7	3.9	<b>-0.7</b>	2.9	2.0	0.8	<b>1.8</b>

Notes: 1) Each period uses average year-on-year growth rates. 2) Includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and United Kingdom.

Sources: OREI staff calculations using gross domestic product (GDP) figures from Oxford Economics and forecast GDP growth rates from ADB's Asian Development Outlook Update 2009.



**Table 2 Potential Output Growth Rates<sup>1</sup> (Using BN Decomposition)**

	1985Q1- 1989Q4	1990Q1- 1994Q4	1995Q1- 1997Q2	1997Q3- 1999Q4	1997/98 Crisis Reduction in Potential Growth	2000Q1- 2004Q4	2005Q1- 2007Q4	2008Q1- 2009Q2	2008/09 Crisis Reduction in Potential Growth
	(1)	(2)	(3)	(4)	(5)=[ave(1:3)]-(4)	(6)	(7)	(8)	(9)=[ave(6:7)]-(8)
China, People's Republic of	11.6	6.6	10.1	8.2	<b>1.1</b>	7.8	9.9	12.0	<b>-3.4</b>
Hong Kong, China	7.2	5.5	3.8	-0.7	<b>6.5</b>	4.4	6.8	0.3	<b>5.0</b>
India	5.5	4.8	7.2	5.8	<b>-0.3</b>	5.9	9.3	7.1	<b>0.0</b>
Indonesia	6.5	8.1	7.5	-4.2	<b>11.5</b>	4.5	5.9	5.6	<b>-0.6</b>
Korea, Republic of	9.1	7.8	7.6	1.7	<b>6.6</b>	5.5	4.7	0.8	<b>4.4</b>
Malaysia	4.7	9.2	9.7	0.7	<b>6.8</b>	5.6	5.6	2.7	<b>3.0</b>
Philippines	2.8	1.9	5.3	2.1	<b>0.8</b>	4.7	5.8	2.9	<b>2.3</b>
Singapore	6.4	9.1	7.9	4.2	<b>3.6</b>	5.0	7.8	-1.2	<b>7.3</b>
Taipei, China	9.0	7.0	6.5	5.4	<b>2.2</b>	3.7	4.6	-0.9	<b>4.9</b>
Thailand	8.6	9.0	7.0	-3.5	<b>12.0</b>	5.1	4.9	1.5	<b>3.5</b>
Europe <sup>2)</sup>	3.0	1.6	2.3	2.7	<b>-0.4</b>	2.2	2.5	0.6	<b>1.7</b>
Japan	5.1	2.3	2.3	-0.7	<b>4.1</b>	1.5	2.0	-2.4	<b>4.1</b>
United States	3.8	2.3	3.4	4.5	<b>-1.4</b>	2.7	2.6	-0.1	<b>2.7</b>

Notes: 1) Each period uses average year-on-year growth rates. 2) Includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and United Kingdom.

Sources: OREI staff calculations using gross domestic product (GDP) figures from Oxford Economics and forecast GDP growth rates from ADB's Asian Development Outlook Update 2009.

**Table 3 Potential Output Growth Rates<sup>1)</sup> (Using BP-CF)**

	1985Q1- 1989Q4	1990Q1- 1994Q4	1995Q1- 1997Q2	1997Q3- 1999Q4	1997/98 Crisis Reduction in Potential Growth	2000Q1- 2004Q4	2005Q1- 2007Q4	2008Q1- 2009Q2	2008/09 Crisis Reduction in Potential Growth
	(1)	(2)	(3)	(4)	(5)=[ave(1:3)]-(4)	(6)	(7)	(8)	(9)=[ave(6:7)]-(8)
China, People's Republic of	9.3	10.6	11.1	8.4	<b>1.8</b>	8.9	11.5	9.8	<b>0.1</b>
Hong Kong, China	7.8	5.2	3.7	1.0	<b>5.0</b>	4.1	5.4	2.5	<b>2.0</b>
India	6.7	4.5	7.4	5.9	<b>0.1</b>	6.0	9.1	7.8	<b>-0.7</b>
Indonesia	6.7	8.8	4.0	0.0	<b>7.0</b>	3.5	6.1	5.1	<b>-0.6</b>
Korea, Republic of	9.4	8.0	5.4	3.9	<b>4.1</b>	5.3	3.7	2.4	<b>2.2</b>
Malaysia	5.3	10.2	7.0	3.2	<b>4.4</b>	4.9	5.3	2.9	<b>2.2</b>
Philippines	2.0	2.7	4.0	3.9	<b>-1.2</b>	4.1	5.8	3.9	<b>0.9</b>
Singapore	7.3	9.0	8.6	4.4	<b>3.8</b>	4.9	6.0	2.8	<b>2.5</b>
Taipei, China	9.8	6.8	7.5	4.5	<b>3.6</b>	3.8	3.7	1.3	<b>2.5</b>
Thailand	8.7	10.0	3.3	-0.6	<b>8.7</b>	4.8	4.4	1.5	<b>3.2</b>
Europe <sup>2)</sup>	3.4	1.5	2.7	2.8	<b>-0.4</b>	2.2	1.6	0.2	<b>1.7</b>
Japan	5.4	2.3	1.0	0.4	<b>2.9</b>	1.4	1.2	-0.6	<b>2.0</b>
United States	4.0	2.2	4.4	3.8	<b>-0.5</b>	2.9	2.0	0.7	<b>1.9</b>

Notes: 1) Each period uses average year-on-year growth rates. 2) Includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and United Kingdom.

Sources: OREI staff calculations using gross domestic product (GDP) figures from Oxford Economics and forecast GDP growth rates from ADB's Asian Development Outlook Update 2009.

same for Singapore. Indonesia has either the highest reduction or second highest reduction. It is well known that Indonesia suffered the most from the 1997 crisis.

For the 2008/09 crisis, for all three methods, Singapore and Hong Kong, China register the largest potential output growth reductions. This can be explained by their large dependence on exports and foreign capital flows. All three methods likewise registered low potential growth reduction for PRC, Indonesia, and India. PRC was able to inject a large fiscal stimulus package while India is not as export dependent compared with East Asian economies.

#### **4.2. Accounting for Structural Breaks Using Markov Switching**

To account for structural breaks, the Markov switching model as generalized Hamilton model and modified by Lam (1990) and Kim (1994) was applied to nine East Asian economies.<sup>10)</sup> The resulting level of potential output is then compared to the estimates obtained from the HP filter. This is shown from Figures 2a to 2i. Generally the results from the MS regime methodology and the HP filter do not deviate significantly from each other. However, there are distinct differences.

The MS results are more “jagged” which is to be expected since the methodology is sensitive to breaks in the data and the HP is a smoothing procedure. In only one economy is the difference between the two estimates relatively large: Malaysia. The authors unfortunately cannot offer a credible reason for this. Figure 2d shows that from 1984 to 1991 the HP estimates were consistently below the MS estimates while the reverse is true between 1991 and 2007.

The difference between the two methodologies shows up more clearly in the estimates of the output gap (Figures 3a to 3i). Except for Malaysia and Singapore, the output gap estimates for MS are smaller than those from the HP filter. This is to be expected since in the MS methodology the switch in

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<sup>10)</sup> We are grateful to Carlos C. Bautista for providing us a copy of the GAUSS algorithm to estimate potential output using this method. The algorithm can be provided upon request.

**Figure 2 Potential Output (local currency, billion)**

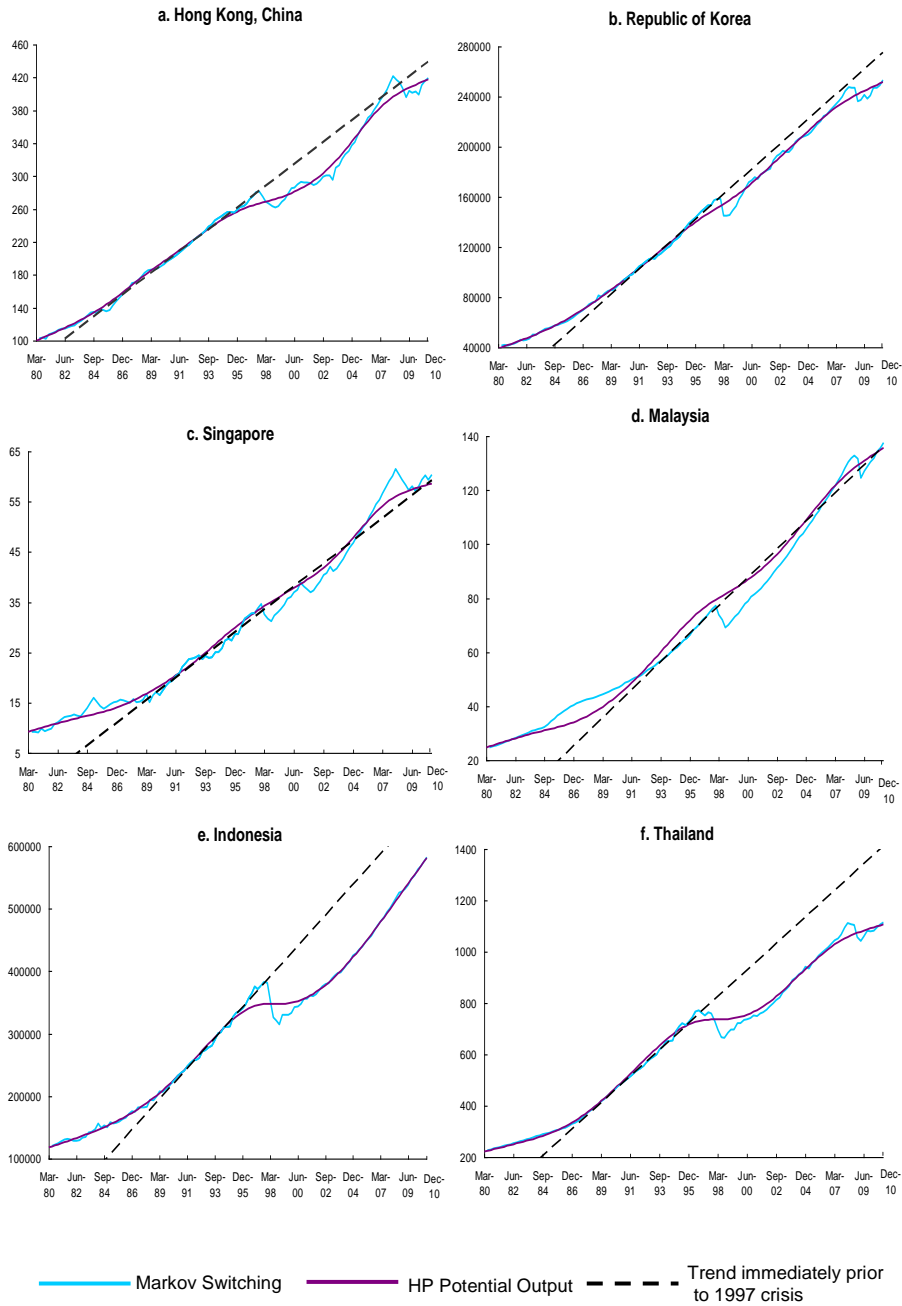
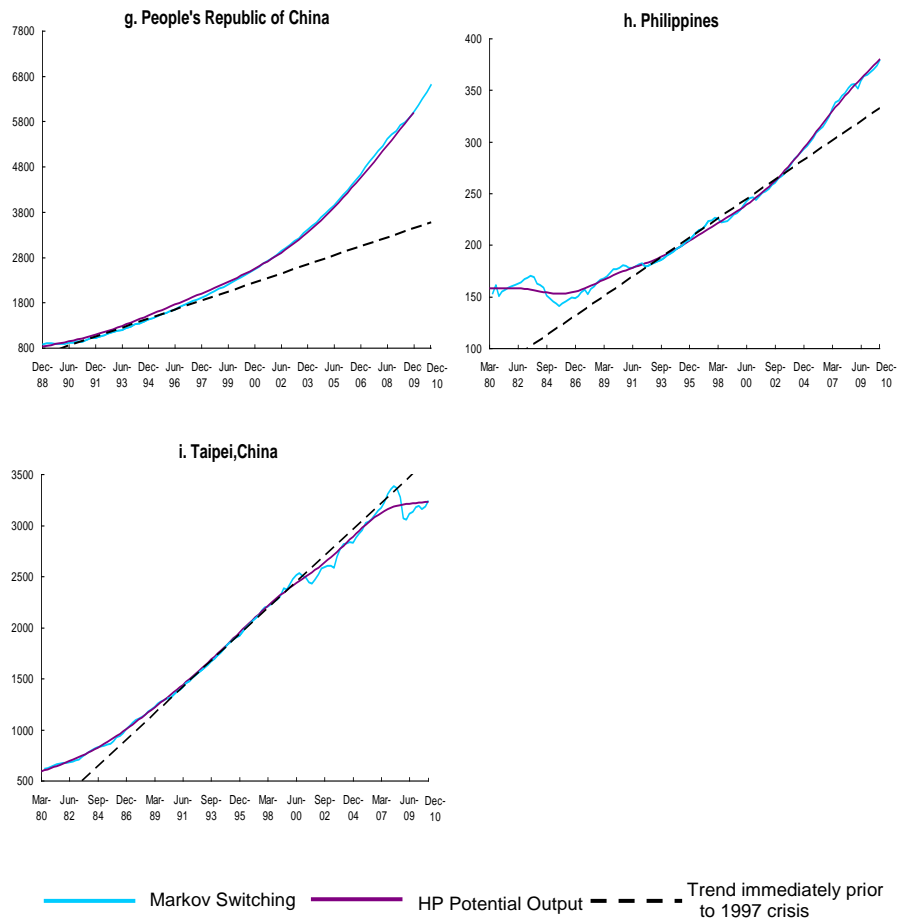
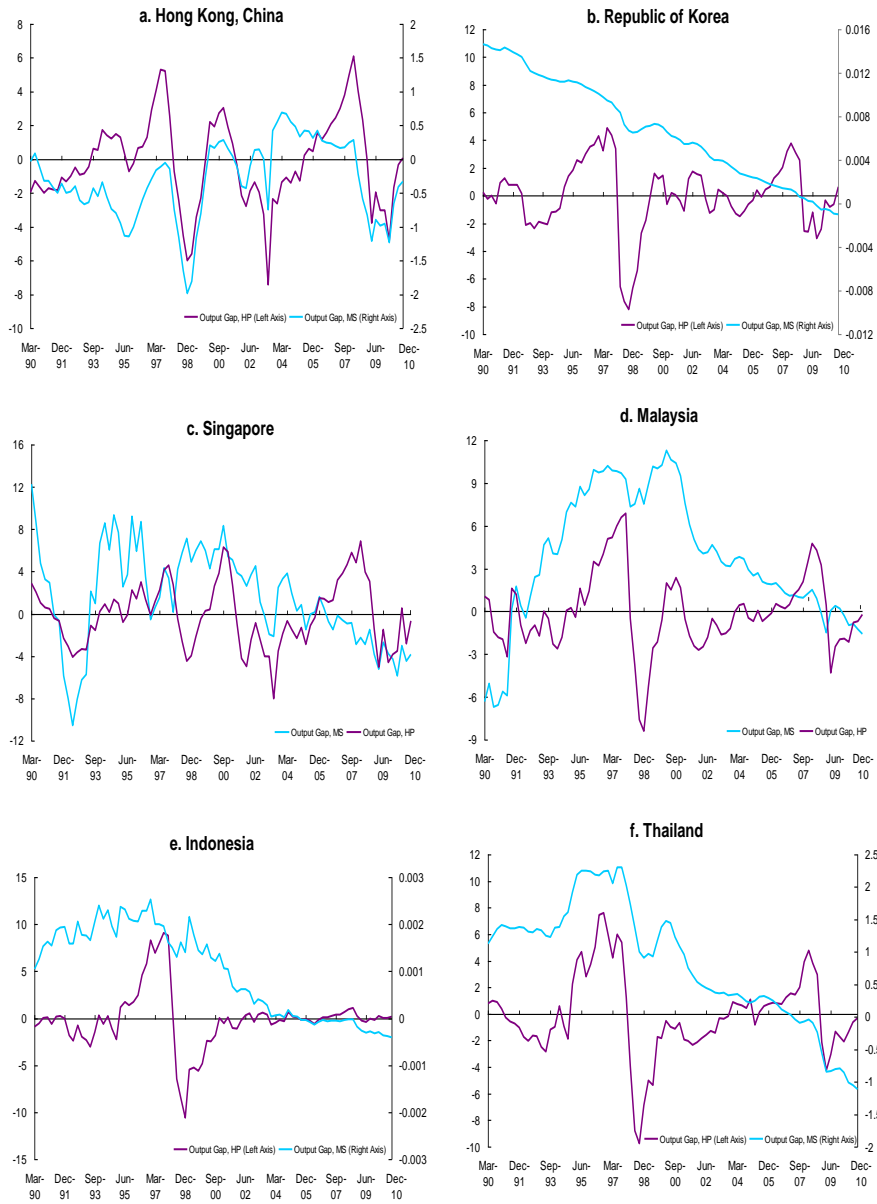


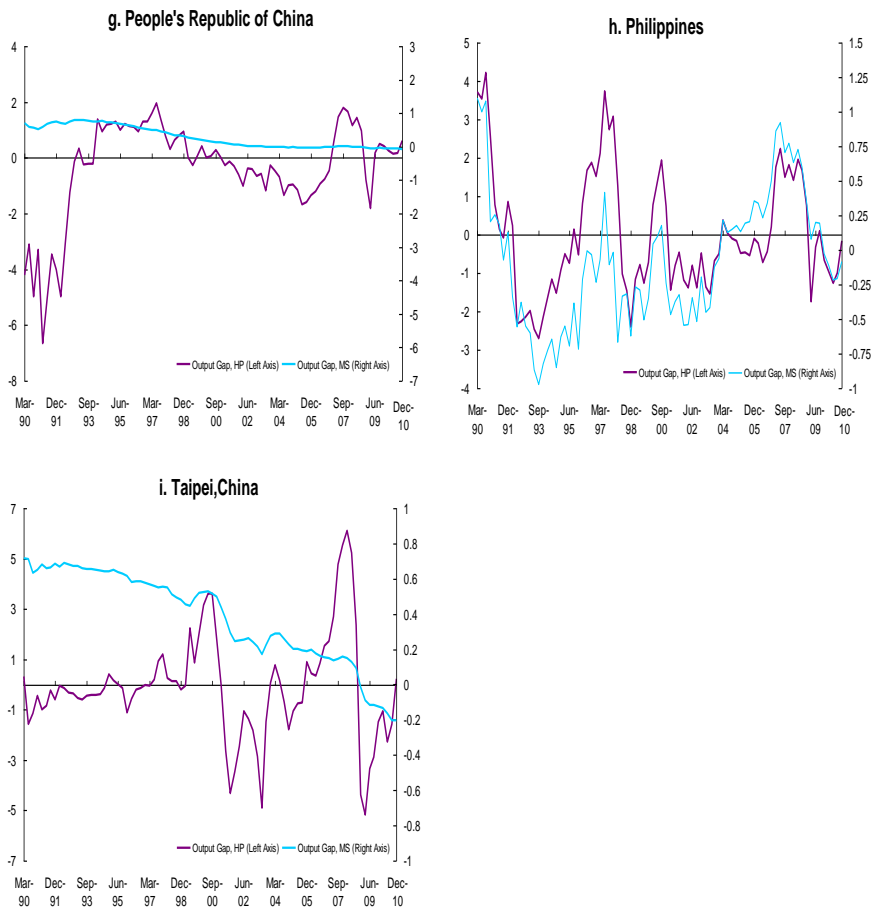
Figure 2: continued



Source: Authors calculations using gross domestic product (GDP) data sourced from Oxford Economics and forecast GDP growth rates from the *Asian Development Outlook 2009 Update*.

**Figure 3 Output Gap**





regimes is loaded into the potential component of output. Another consequence of this bias in “loading” is that the output gap for the MS methodology becomes positive after the 1997 crisis for many key economies: Indonesia, Malaysia, Singapore, Thailand, and Korea. This counterintuitive result implies that the crisis caused a fall in potential output that is larger than the fall in actual output. This weakness in the original MS methodology was supposed to have been addressed by the algorithm of Kim and Piger (2002) and Kim and Murray (2002).

## 5. POST-CRISIS TRENDS IN POTENTIAL OUTPUT

### 5.1. Explaining Behavior of Potential Output

For the purposes of this study, what is important is to see whether or not estimated potential outputs — using both the MS and HP methods — for the nine economies will follow the same general pattern after the 1997 crisis. To determine the applicable scenario — i.e., whether Scenario 1, 2, or 3 — the trend of potential output immediately prior to the 1997 crisis was estimated from data obtained from the MS method. A simple linear trend was estimated — mostly based on the period from the first quarter of 1990 to the second quarter of 1997 — and extended. This is shown as a black dashed line in the graphs.<sup>11)</sup>

While it is still too early to tell how the 2008/09 crisis will affect medium-term output performance, the path of potential output following the 1997/98 crisis can provide valuable insights. Output declined for most economies in emerging East Asia<sup>12)</sup> in the wake of the 1997/98 crisis. While the causes and impacts of the crisis are well documented, an extensive analysis of the recovery process is still limited. In particular, the behavior of potential output over an extended period of time has not been adequately studied for emerging East Asian economies. Of particular interest is which scenario — Scenario 1, Scenario 2, or Scenario 3 in figure 1 — materialized for each economy. The different outcomes could be traced to the set of policies implemented to cope with the crisis.

The patterns of post-1997/98 crisis recoveries differ significantly across borders, particularly between three groups of economies. The first group comprises Singapore; Hong Kong, China; Korea; and Malaysia. The second group includes Indonesia and Thailand and the third group covers PRC, the Philippines, and Taipei, China. The first group generally follows Scenario 1

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<sup>11)</sup> A similar analysis will result if the trend is based on the HP estimate of potential output.

<sup>12)</sup> Throughout this paper, “emerging East Asia” refers to nine selected economies of developing Asia: PRC; Hong Kong, China; Indonesia; Republic of Korea; Malaysia; the Philippines; Singapore; Taipei, China; and Thailand.



and the second groups follow Scenario 2. In the case of the third group, potential output did not seem to be affected by the 1997/98 crisis and eventually exceeded the level consistent with the pre-crisis trend.

In Hong Kong, China; Korea; Singapore; and Malaysia, the level of potential output reverted to a level consistent with the pre-crisis trend after an initial drop in the wake of the crisis. Hong Kong, China experienced the largest fall and longest recovery period, about 10 years. The absence of currency flexibility may have contributed to this situation. Unlike the other economies, Hong Kong, China saw the Hong Kong dollar appreciate in real effective terms in 1997 and 1998. The real effective exchange rate of the Hong Kong dollar did not return to its 1996 level until 2003.

Greater openness seemed to be one of the major factors that allowed this group to ride out the crisis. According to some studies,<sup>13)</sup> the sharp currency depreciation was one of the main contributors to the quick recovery of economies in the region. The resulting increase in exports helped them to stage a quick and strong recovery from the crisis. Their export orientation also helped maintain the pace of technological progress as measured by total factor productivity (TFP). Estimates of TFP growth confirm that TFP growth collapsed during the crisis, but also suggest that TFP growth has since reverted to earlier trends. Other estimates show that Korea, Singapore, and Taipei, China have a higher level of TFP than the ASEAN-4<sup>14)</sup> many years after the 1997/98 crisis.<sup>15)</sup> Data from UNCTAD show that the Group 1 economies plus Taipei, China have a higher index of technological activity (table 4). This technological advantage helped the newly industrialized economies (NIEs)<sup>16)</sup> and Malaysia return to a level of potential output that is consistent with their pre-crisis trend.

In the case of Indonesia and Thailand, the 1997/98 crisis shifted the potential output path downward from the pre-crisis trend level, although growth

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<sup>13)</sup> Park and Lee (2002).

<sup>14)</sup> ASEAN-4 covers Indonesia, Malaysia, Philippines, and Thailand.

<sup>15)</sup> APO (2004) as cited by ADB (2007) reports estimated TFP growth until 2000. Kisdorn (2008) shows that in 2004 the level of TFP of the NIEs was higher than the ASEAN4.

<sup>16)</sup> NIEs includes Hong Kong, China; Republic of Korea; Singapore; and Taipei, China.

**Table 4 Technological Activity Index**

	Rank (out of 117 Countries)	Country	1995 Index	Rank (out of 117 Countries)	Country	2001 Index
High Innovation	3	Japan	0.949	5	Japan	0.935
	10	Taipei, China	0.89	7	Taipei, China	0.902
	18	Singapore	0.803	12	Singapore	0.875
	24	Korea, Republic of	0.762	20	Korea, Republic of	0.812
Medium- high Innovation	37	Hong Kong, China	0.613	33	Hong Kong, China	0.632
	61	Malaysia	0.401	55	Malaysia	0.446
	63	China, People's Republic of	0.39	58	China, People's Republic of	0.417
	67	Thailand	0.34	61	Thailand	0.361
	76	Philippines	0.264	80	Philippines	0.265
85	Indonesia	0.203				
Low Innovation				93	Indonesia	0.175

Note: Each component of the Index has equal weights, the Index value being the simple average of the normalized value of the three variables: R&D manpower, patents in the United States and scientific journal articles.

Source: UNCTAD, World Investment Report, 2005.

growth eventually recovered to the pre-crisis rate. The impact of financial crises on the level of potential output tends to be long-lasting for these two countries. Abiad *et al.* (2009) find that the path of output tends to be depressed substantially and persistently following the crisis as a result of reductions in the employment rate, the capital-to-labor ratio, and TFP in roughly equal proportions after analyzing 88 cases of financial crises over the past four decades. They also argue “capital and employment tend to suffer enduring losses relative to the pre-crisis trends.” In emerging East Asia, Park and Lee (2002) and ADB (2007) find that the main cause of the decline in potential output was the sharp contraction in investment and lower capital accumulation afterwards. Some argue that the drop in investment and capital stock in the pre-crisis period might be overestimated, if an investment boom preceded the crisis and investment was at unsustainable levels prior to the

crisis. Nevertheless, the crisis seems to have reduced incentives to invest in capital and slow capital accumulation.<sup>17)</sup>

The output path in PRC, Taipei, China, and the Philippines seem fairly unaffected by the 1997/98 crisis, albeit for the reasons that are completely different. PRC's strong growth momentum continued with its relatively closed economic and financial systems unaffected by the crisis. Prior to the 1997/98 crisis, PRC boasted huge foreign reserves, low external debt, and sound economic fundamentals, which allowed it to ride out and counter speculative attacks against its currency. Also, the slow pace of financial liberalization meant little exposure and opportunity for foreign speculators to tap the domestic capital market. This lessened the magnitude of uncontrolled capital movement. In the Philippines, potential output languished in the 1980s and the momentum of its recovery seems to have dominated adverse impacts of the 1997/98 crisis (see figure 2h). In fact, the level of potential output at a certain point during the 1997/98 crisis is estimated to have exceeded the level consistent with the pre-crisis trend. Moreover, the Philippines did not benefit as much from capital inflows compared with the other economies and therefore was not as severely affected by the abrupt withdrawal of capital from the region.

Apart from its technological advantage, Taipei, China's relatively good performance immediately after the 1997/98 crisis is attributed to several factors. For one, the country's huge foreign reserves, low external debt, and sound economic fundamentals allowed it to ride out and counter speculative attacks against its currency. The slow pace of financial liberalization meant little exposure and opportunity for foreign speculators to tap the domestic capital market. This lessened the magnitude of uncontrolled capital movement. Taipei, China likewise adopted a moderately loose monetary policy that kept the price range within reasonable levels.

Strictly speaking, Taipei, China belongs to the first group since the economy experienced a recession in 2001 and figure 2i depicts a Scenario 1 pattern. The recession was brought about by the downturn in the global

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<sup>17)</sup> Furceri and Mourougane (2009).

electronics market, the increase in the number of bad loans in the financial sector, and the continued migration of Taipei, China's manufacturers to PRC to take advantage of cheaper costs there for land and labor. However, since the fall in potential output was mild and not related to the 1997 crisis, Taipei, China is included in the third group.

Differences in initial conditions, country-specific reasons, and policy responses exerted significant influence on the patterns of the post-crisis recovery. The cross-country comparison of the post-crisis recoveries suggests three important elements for a healthy recovery. First is initial conditions. Economies with relatively sound economic fundamentals stand better chance in dealing with a shock. Second, continued openness together with currency flexibility allowed the economies to tap external demand when domestic demand slackened. Luckily, a favorable external environment during the 1997/98 crisis helped the region in the recovery process. Third, swift policy responses to mitigate the initial crisis impact proved beneficial not only in the short-term, but also later in the medium- to long-term by minimizing disruptions in asset allocation, such as a rise in unemployment and a deterioration in capital stock. Finally, the crisis prompted corporate restructuring and structural reforms in many emerging East Asian economies. The medium-term output performance reflects the success of these reforms.

## **5.2. Econometric Evidence**

A simple growth model was estimated to provide econometric evidence for the arguments in the previous section (Appendix 1). The results indicate that the investment-GDP ratio exerts a positive and significant impact on per capita growth of potential output. Policy variables represented by government consumption and money supply also affect the dependent variable significantly.

The significant impact of the growth rate of major industrialized economies implies that greater openness and favorable global economy support expansion of potential output. However, the impact of the real

effective exchange rate is ambiguous as explained in Appendix 1. The econometric results, however, do not refute the need for a depreciation that will restore external balance.

An interesting result is the positive and significant impact of the level of technological activity in the random-effects version of the econometric results. While the variable is insignificant in the fixed-effects model, the study presents enough evidence to support policies that enhance an economy's technological capability.

## **6. IMPLICATIONS FOR RESPONSES TO THE 2008/09 CRISIS: OUTPUT GAP, EXIT STRATEGIES AND MEDIUM-TERM POLICIES**

Output losses associated with crises are significant, but appropriate policy responses can shape the post-crisis recovery and help contain medium-term output losses. The forecast-adjusted simple HP filtered estimates and the MS estimates suggest a drop in potential output growth for emerging East Asian economies.<sup>18)</sup> Consistent with earlier studies, potential output is likely to be reduced by the 2008/09 crisis. However, the drop is generally milder during this crisis compared to the 1997/98 crisis. The previous crisis experience also shows large variations in the post-crisis recovery patterns of individual economies. The key challenge for policymakers is therefore to implement policies that will close the output gap and at the same time stem the decline in potential output.

An integral part of the recovery process is the policy adjustments at the macroeconomic level. A critical difference between the 1997/98 crisis and the 2008/09 crisis is the size and promptness of monetary and fiscal responses. Short-run monetary and fiscal policy stimuli have been effective

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<sup>18)</sup> The output gaps derived from HP estimates are used for the analysis in this section. The MS output gaps are relatively small and have a counterintuitive sign particularly after the 1997 crisis. As explained earlier this is because the switch in regimes is loaded into the potential component of output.

in dealing with immediate crisis effects.<sup>19)</sup> Output gaps (see figures 3a to 3i) show that many economies have reached the troughs already in the first quarter of 2009, only one quarter after the crisis created negative output gaps. This can be attributed to timely and sizeable policy support. In contrast, during the 1997/98 crisis, the output gaps were largely negative for nearly two years from the first quarter of 1998. Recent studies also find that short-run expansionary macroeconomic policies are positively correlated with smaller output and growth losses (see Abiad *et al.*, 2009).

While expansionary macroeconomic policies have been moderately successful in narrowing the negative output gap, careful monitoring of the output gaps is important to avoid risks of mistimed exits. In the wake of the crisis, the first order of business was to design and implement fiscal stimulus packages and loosen monetary policy. The swift policy responses have been moderately successful as GDP growth was generally higher in the second and third quarters of 2009 compared with the first quarter. However, fiscal policy has to be consolidated and monetary policy has to be tightened in due time otherwise the recovery will be snuffed by inflationary pressures. Output gaps can be a useful guide in timing the exit strategy. For majority of the region's economies, the forecast adjusted simple HP-filtered estimates suggest that output gaps remain negative. Although a declining trend is detected, the negative output gap suggests that talks of any exit strategies are still premature. The exceptions to this are PRC and Indonesia, where output gaps are turning positive.

The region's policymakers need to look into instituting more structural measures designed to counter the permanent effects of crisis on output. It is important for policy makers to be able to determine whether the downturn in GDP during crisis years is associated more with the cyclical components or a reduction in the potential output. Cyclical downturns might be countered with fiscal and monetary countercyclical policy. On the other hand, a permanent reduction in potential output growth is better addressed with more structural changes (such as policies to reduce the structural rate of

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<sup>19)</sup> This is also supported by the econometric evidence presented in Appendix 1.

unemployment). The estimated results using the forecast adjusted simple HP-filter and the MS methodology suggest that for some countries and regions, both the 1997/98 and 2008/09 crises reduced potential output growth, suggesting that the crisis will again lead to either Scenario 2 or Scenario 3, rather than Scenario 1. Economies that did experience a Scenario 1-type pattern, the importance of productivity-retaining measures was underscored. This again makes further structural reforms a priority. The exit strategy from the stimulus measures to policies that focus more on medium-term economic growth is therefore quite important.

A major policy consideration is how to lift potential output to minimize medium-term output losses while sustaining the recovery momentum. The crisis provides incentives and catalysts for structural reforms. Economies that seized the opportunity were often able to grow faster and achieved higher potential output even after the crisis. Although necessary structural reforms are country-specific, many of these structural policies are medium-term in nature (e.g., education and R&D). Hence there should be investment programs in the pipeline as the stimulus measures are withdrawn. Additional key actions that can contribute to national economic recovery include the strengthening of the banking sector, an equal strengthening of the financial market, control of inflation, and the timely provision of fiscal stimuli. Measures to reduce unemployment have also been largely successful although the larger numbers work in the informal sector in many developing countries.

## **APPENDIX: ECONOMETRIC MODEL AND EMPIRICAL RESULTS**

### **A1. Model**

To guide policymakers and provide econometric evidence for the arguments laid out in the text, a simple growth model is estimated. Instead of

actual GDP growth being the dependent variable, per capita growth rate of potential output is used. The estimated model is as follows:

$$GR_{it} = f\left(\frac{I}{GDP_{i,t-k}}, GC_{i,t-l}, REER_{i,t-m}, MS_{i,t-n}, GR_{USJAP EU}, GDP_{t,0}, TA_{it}\right).$$

$GR_{it}$  is per capita growth rate of economy  $i$  at time  $t$ ,  $I/GDP_{i,t-k}$  is the investment-GDP ratio of economy  $i$  lagged  $k$  periods;  $GC_{i,t-l}$  is government consumption growth y-o-y in real terms for economy  $i$  lagged  $l$  periods;  $REER_{i,t-m}$  is the y-o-y percentage in the real effective exchange rate for economy  $i$  lagged  $m$  periods, with positive value indicating an appreciation;  $MS_{i,t-n}$  is y-o-y money supply growth in real terms for economy  $i$  lagged  $n$  periods;  $GR_{USJAP EU}$  is the weighted average of the y-o-y real GDP growth rate of the US, Japan, Europe, with weights fixed at 42%, 14%, and 44%, respectively;  $GDP_{t,0}$  is the per capita income of economy  $i$  in 1990 in PPP\$; and  $TA_{it}$  is the level of technological activity for economy  $i$  as reported in table 4, with the 1995 figure being applied to 1990-1999 and the 2001 figure being applied to 2000-2009.

The growth model is patterned after Park and Lee (2002) since the economy's behavior after the 1997/98 crisis is of interest in this study. The investment-GDP ratio indicates the rate at which the capital stock is augmented. Data on the latter variable is not available for all economies hence  $I/GDP$  is used instead. Differences in initial conditions could affect future growth rates and also the pattern of adjustment to a crisis. In growth theory, an economy with a lower initial per capita GDP is in a more favorable position for future growth. The fundamental idea is that the gap in existing capital and technology between the current and steady-state levels provides an opportunity for "catching up" via high rates of capital accumulation as well as diffusion of technology from more advanced economies. This is the rationale for the variable  $GDP_0$ .

Meanwhile, macroeconomic and structural reform policies implemented by the government for crisis management can influence the behavior of both



actual and potential output. Fiscal policy can shore up domestic demand while monetary policy usually plays a crucial role in determining consumption and investment. While the major concern of policymakers would be short-term output growth, implementing appropriate stimulus measures has repercussions on medium- and long-term output growth. For example, if government does not compensate for a sharp drop in private sector demand, there may be a permanent loss of employment.

An important variable in the adjustment process is the exchange rate. The large real exchange rate depreciation in many economies of East Asia after the crisis restored their external balance. This helped facilitate the quick recovery in the economies. The favorable global environment at the time of the 1997 crisis also supported the current account balance through sustained export demand.

Following the importance of technology in endogenous growth models, a variable representing technological activity is included in the model. Unfortunately, there is no measure of technological capability at the country level on a regular basis (Archibugi and Coco, 2005). What is used in the econometric model is a technological activity index reported by UNCTAD but only for two years. The rankings of the level of technological activity, however, reflect the degree of recovery of the nine economies from the 1997 crisis.

## **A2. Estimation Procedure**

Since a combination of time series and cross section data is used, a traditional fixed-effects model was estimated in order to determine the optimal number of lags. After this, the possibility of improving the estimation to account for nonstationary and heterogeneous behavior was considered. This was done by using the mean-group estimator of Pesaran and Smith (1995) and Pesaran, Shin, and Smith (1998) which involves assuming that given the dependent variable  $Y$  and explanatory variables,  $X_s$ , there is a short-run and long-run behavior of the “cointegrating” variables:

$$\Delta y_{it} = \varphi^* (y_{i,t-1} - \beta x_{i,t}) + \sum_{j=1}^p \alpha_j \Delta y_{i,t-j} + \sum_{j=1}^q \gamma_j \Delta x_{i,t-j} + \varepsilon_{it},$$

where  $\varphi$  is the error correction speed of adjustment parameter to be estimated;  $\beta$  is a  $k \times 1$  vector of parameters;  $\alpha$  and  $\gamma$  are parameters to be estimated;  $x_{it}$  is a  $(1 \times k)$  vector of covariates; and  $\varepsilon_{it}$  is the error term.

The model was estimated using Stata but results indicated that the log likelihood function was non-concave. One possible reason was that the dependent variable — per capita growth of potential output — or some or all of the covariates are stationary. This was a logical deduction since many of these variables are percent changes thereby inherently involve differencing. Panel unit root tests developed by Im-Pesaran-Shin confirmed this.

This outcome ruled out the Pesaran-Smith model. Instead improvements on the fixed effects model were obtained by testing for cross-sectional dependence, i.e., whether the residuals from the fixed effects model are correlated across entities. The test results indicate the presence of cross sectional dependence and following Hoechle (2007), adjustments are applied by estimating the model with Driscoll-Kraay standard errors. The results are shown in table A1.

Meanwhile, a standard random-effects model was estimated using generalized least squares taking into account heteroscedasticity and contemporaneous correlation among the variables. The results are shown in table A2. Estimates from a random-effects model are generally more efficient than those from a fixed-effects model. However, the latter always yields consistent estimates. Moreover, since choice of the economies in the study is pre-determined, the fixed-effects model is theoretically more appropriate.

### A3. Data

Quarterly real GDP data series for the nine emerging East Asian economies, Japan, US, and aggregate Europe were constructed for the period from 1980 to 2010. Data from 1980Q1 to 2009Q2 were sourced from

**Table A1 Regression with Driscoll-Kraay Standard Errors**

	Coef.	Std. Err.	<i>t</i>	P>  <i>t</i>	95% Conf. Interval	
Pesaran's Test of Cross Sectional Independence=8.664, Pr=0.0000						
Average Absolute Value of the Off-diagonal Elements=0.223						
Time Period: 1990:1 to 2009:2						
Number of Obs=702						
Method: Fixed-effects Regression Number of Groups=9						
Group Variable (i): Country F(16, 8)=106.12						
Maximum Lag: 3 Prob > F=0.0000						
within R-squared=0.5020						
	Coef.	Std. Err.	<i>t</i>	P>  <i>t</i>	95% Conf. Interval	
gr_opc	44.30594	11.34307	3.91	0.005	18.14877	70.46311
<i>I/GDP</i> <sub><i>i,t-1</i></sub>	1.766473	13.11754	0.13	0.896	-28.48262	32.01557
<i>I/GDP</i> <sub><i>i,t-2</i></sub>	-11.73668	11.00396	-1.07	0.317	-37.11184	13.63849
<i>I/GDP</i> <sub><i>i,t-3</i></sub>	-35.71371	9.817551	-3.64	0.007	-58.35303	-13.0744
<i>REER</i> <sub><i>i,t-1</i></sub>	0.0493613	0.0185593	2.66	0.029	0.0065636	0.0921591
<i>REER</i> <sub><i>i,t-2</i></sub>	0.0566701	0.0151829	3.73	0.006	0.0216583	0.0916819
<i>REER</i> <sub><i>i,t-3</i></sub>	-0.0057716	0.0137737	-0.42	0.686	-0.0375339	0.0259906
<i>REER</i> <sub><i>i,t-4</i></sub>	-0.0312023	0.0091777	-3.40	0.009	-0.0523661	-0.0100386
<i>MS</i> <sub><i>i,t-1</i></sub>	0.0277273	0.0337377	0.82	0.435	-0.050072	0.1055266
<i>MS</i> <sub><i>i,t-2</i></sub>	0.1160739	0.0331892	3.50	0.008	0.0395395	0.1926083
<i>GC</i> <sub><i>i,t-1</i></sub>	0.0204435	0.0176002	1.16	0.279	-0.0201426	0.0610297
<i>GC</i> <sub><i>i,t-2</i></sub>	0.0430097	0.0188366	2.28	0.052	-0.0004276	0.086447
<i>GR_US_JAP_EU</i>	0.7960337	0.1319575	6.03	0.000	0.4917391	1.100328
<i>TA</i> <sub><i>it</i></sub>	-.138649	12.81787	-0.09	0.931	-30.6967	28.4194
<i>GDP</i> <sub><i>i,0</i></sub>	0.0004438	0.0014232	0.31	0.763	-0.0028381	0.0037257
Crisis	-4.0994	1.146849	-3.57	0.007	-6.744039	-1.45476
_cons	(omitted)					

**Table A2 Cross-sectional Time-Series FGLS Regression,  
Random Effects**

	Coef.	Std. Err.	<i>t</i>	P>  <i>t</i>	95% Conf. Interval	
Coefficients: Generalized Least Squares						
Panels: Heteroskedastic						
Correlation: No Autocorrelation						
Pesaran's Test of Cross Sectional Independence=10.209, Pr=0.0000						
Estimated Covariances=9			Number of Obs=702			
Estimated Autocorrelations=0			Number of Groups=9			
Estimated Coefficients=17			Time Periods=78			
Wald Chi2(16)=965.06						
Prob > Chi2=0.0000						
<i>gr_opc</i>	60.89181	9.454518	6.44	0	42.36129	79.42232
<i>I/GDP<sub>i,t-1</sub></i>	3.132636	13.37797	0.23	0.815	-23.0877	29.35297
<i>I/GDP<sub>i,t-2</sub></i>	-16.2035	13.39094		0.226	-42.44925	10.04225
<i>I/GDP<sub>i,t-3</sub></i>	-39.66735	9.476735	-4.19	0	-58.24141	-21.09329
<i>REER<sub>i,t-1</sub></i>	0.0527876	0.0142222	3.71	0	0.0249126	0.0806627
<i>REER<sub>i,t-2</sub></i>	0.0505705	0.0175188	2.89	0.004	0.0162344	0.0849067
<i>REER<sub>i,t-3</sub></i>	-0.0029573	0.0170837	-0.17	0.863	-0.0364407	0.0305262
<i>REER<sub>i,t-4</sub></i>	-0.0319757	0.0141286	-2.26	0.024	-0.0596672	-0.0042842
<i>MS<sub>i,t-1</sub></i>	0.0343035	0.0311144	1.1	0.27	-0.0266796	0.0952866
<i>MS<sub>i,t-2</sub></i>	0.0914888	0.0314566	2.91	0.004	0.0298349	0.1531427
<i>GC<sub>i,t-1</sub></i>	0.0383344	0.0164303	2.33	0.02	0.0061316	0.0705373
<i>GC<sub>i,t-2</sub></i>	0.054322	0.0163228	3.33	0.001	0.0223298	0.0863142
<i>GR_US_JAP_EU</i>	0.7037246	0.0744424	9.45	0	0.5578202	0.8496289
<i>TA<sub>it</sub></i>	3.414927	0.723703	4.72	0	1.996495	4.833358
<i>GDP<sub>i,0</sub></i>	-0.0001203	0.0000401	-3.00	0.003	-0.0001989	-0.0000417
Crisis	-3.624811	0.3724092	-9.73	0	-4.35472	-2.894902
<i>_cons</i>	-2.149762	0.4873421	-4.41	0	-3.104935	-1.194589

Oxford Economics. Figures from 2009Q3 to 2010Q4 were derived from the quarterly pattern of Oxford Economics forecasts using the annual GDP growth rate forecasts from the Asian Development Outlook Update 2009. Data for the emerging East Asian economies on real private consumption (from 1980-2010), real total fixed investment (from 1980-2010), government consumption expenditures in current prices (from 1980-2009), and money supply (M2 and M3, from 1980-2009) were also sourced from Oxford Economics.<sup>20)</sup> All data not seasonally adjusted at the source were adjusted using Eviews 6, X12 Census method. Money supply and government consumption were deflated using CPI data obtained from Oxford Economics.<sup>21)</sup>

Population data used in the model was from the World Economic Outlook Database October 2009 and the Technology Activity Index for 1995 and 2001 was lifted from the UNCTAD World Investment Report 2005. Data on the real effective exchange rate was sourced from Bloomberg with the exception of PRC data which was obtained from the IMF's International Finance Statistics database.

#### **A4. Results**

Estimated coefficients generally conform to expectations and those that do are statistically significant. The main difference from the fixed-effects model (table A1) and the random-effects model (table A2) is the sign and significance of initial GDP and the variable representing technological activity. These two variables carry the correct sign and are significant in the random-effects model.

The investment-GDP ratio is significant when it is lagged one and four periods. The coefficient of the former carries the expected positive sign

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<sup>20)</sup> However, M3 data for Indonesia and Taipei, China are missing while figures for the Philippines from 1982Q1 to 1986Q3 were estimated based on data from the Central Bank of the Philippines.

<sup>21)</sup> CPI data for the nine emerging East Asia economies were obtained from Oxford Economics, with the exception of data for Hong Kong, China which was downloaded from CEIC.

while the variable lagged four periods negatively affects per capita growth of per capita GDP, a counter-intuitive result. The combined coefficients, however, yields a net positive impact confirming the role of investment in driving potential output.

The policy variables are also significant, with the fixed-effects model showing significant coefficients for government consumption and money supply when they are lagged two periods. In the case of random-effects, government consumption lagged one period is also significant. This conforms to conventional wisdom that fiscal policy — while normally longer to design and implement — has a quicker impact on economic activity.

The only problematic variable is the real effective exchange rate (*REER*). The expected sign is negative since an undervalued currency is more supportive of economic growth. The coefficient of the percentage change of *REER* is negative and significant when the variable is lagged four periods. However, it is positive and significant when lagged one and two periods. Moreover, combining the coefficients yields a net positive value. Most likely the time period involved does not capture the long-term dynamics of exchange rate behavior and economic growth. Another possible reason is that the percentage change in *REER* does not capture the degree of over-valuation or under-valuation of a particular currency, which is the important concept in explaining economic growth.

Meanwhile, the combined economic growth of industrialized economies yields a positive and significant coefficient. The dummy variable representing the 1997/98 crisis and its aftermath carries a negative coefficient. As mentioned earlier, the fixed-effects model and random-effects model yield contrasting results for the technology variable and the variable representing initial conditions. Nevertheless, this is an indication that both variables are important in explaining the behavior of potential output.

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