

# IMF Working Paper

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## Modeling with Limited Data: Estimating Potential Growth in Cambodia

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## IMF Working Paper

Asia and Pacific Department

### Modeling with Limited Data: Estimating Potential Growth in Cambodia

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### Abstract

This paper proposes a framework to analyze long-term potential growth that combines a simple quantitative model with an investigative approach of ‘growth diagnostics’. The framework is used to forecast potential growth for Cambodia, and to conduct simulations about the main drivers of growth in that country. The main result is that Cambodia compares less favorably against other lower-income Asian economies in terms of its investment rate, which in turn is constrained by the poor quality of its infrastructure. Bridging this gap can lift Cambodia’s potential growth by more than one percentage point.

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## I. Introduction

Accurate estimates of potential growth have always been in high demand, in both advanced and lower-income economies. This is hardly surprising, since long-term potential growth is not only the core objective of development policy, but is also a key anchor of economic stability. However, applying standard quantitative methods to estimate potential output in lower-income economies is subject to severe limitations. In particular, poor data coverage and a lack of high-frequency economic indicators make more difficult the use of standard filtering techniques. Moreover, as low-income economies are often in the process of important structural changes, any model relying on stable macro/behavioral relationships can be a misleading guide about the future. Yet, it is far from clear that a judgment-based estimate will necessarily be a better alternative.

This paper's primary objective is to introduce a tractable quantitative framework to assess potential output growth in a lower-income economy. The framework is based on a small dynamic macroeconomic model that, by design, economizes on both the data and behavioral assumption requirements and also allows incorporating external assumptions and judgment calls. The paper will show that the model can be used alongside a more qualitative 'growth diagnostic' approach (introduced by Hausmann, Rodrik, and Velasco, 2005).

Cambodia's current macro backdrop makes it an especially interesting application for the proposed framework. The last decade was for the most part a fast-growing period for the Kingdom, which grew 9.8 percent on average over 1999 to 2007, doubling its standard of living in the process. The impressive growth performance was a result of a confluence of favorable factors, including the expansion of international trade, sustained investment, and improvements in productivity. Cambodia is, however, at an important crossroad. Its productivity growth is constrained by a lack of adequate infrastructure, notably in electricity and power sectors, which in turn is holding back investment. Overreliance on a narrow export market, notably the low-skilled garment industry, also means the external engine of growth is approaching its limit, unless the export sector moves up the value chain or diversifies into other products. Cambodia's growth potential will hinge on whether the Kingdom can successfully overcome these challenges in the coming years.

To assess the outlook for potential output growth in Cambodia, this paper proposes (i) a quantitative framework that accounts for the dynamics of fundamental drivers of growth, and (ii) an analytical diagnostics of the constraints to growth. The two parts of this strategy complement each other, with the model informing the analysis of growth impediments, and at the same time serving as a tool to assess different scenarios informed by the qualitative analysis.

The model proposed in this paper is an integration of several standard methods, which may be grouped into two main categories: (i) the production function approach, and (ii) the state space or statistical filtering approach. The first approach assumes an aggregate production function and estimates each of its components (factor inputs and total factor productivity, TFP). The approach works best in more advanced economies, where there are more data on factor inputs (such as capital stock, labor participation, hours worked, and utilization rates), as well as good proxies for TFP. For example, the Congressional Budget Office (CBO) and

the EU Commission use this method to estimate the potential growth in the United States and European Union, respectively (see Congressional Budget Office, 2001 and Roeger 2006).<sup>2</sup>

One drawback of the production function method, given its bottom-up philosophy, is that it does not exploit other macroeconomic predictions that can be useful for inferring potential output. In particular, macroeconomic theory suggests that if shocks are transitory potential output should be close to the smoother ‘trend’ of realized output. Moreover, according to the Phillips curve, potential output should be relatively low compared to actual output (i.e., output gap wider) when inflation is accelerating. The second category of estimates of potential growth attempts to exploit these macroeconomic relationships. Statistical filters that produce smoothed output series (such as HP and Bandpass filters) are the simplest example. A more structural example considers potential output as an unobserved variable within a structural macroeconomic model. An estimation procedure can then be performed to extract the sequence of potential output that is most consistent with the predicted relationship. For example, in a typical model, the likelihood of potential output being lower than actual output would increase with the observed inflation rate. For a recent example of this state space/filtering approach, see Benes and others (2010).

Both standard approaches have advantages and drawbacks. The first method offers an appealing identification of the drivers of potential growth, which is useful for the analysis of growth impediments. However it requires detailed and granular data, a condition rarely met for lower-income countries. The second method can economize on the amount of data required by using restrictions from economic theory. Traditionally the filtering method is most often used to explain the cyclical fluctuations of output around the trend (that is, to assess the output gap), and does not allow a structural explanation of the sources of long-run growth.

This paper develops a hybrid model that combines the strengths of both traditional methods. A small-scaled structural macro model is proposed, which has a supply-side production function and thus is capable of explaining the dynamics of growth drivers. The model has a state-space structure, where unobserved variables are estimated using a Kalman filter. This eases the burden on data requirements, since not all variables need to be observed. Finally, the model has the demand-side equations, namely the processes governing output gap and Phillips curve, enabling the model to also utilize information from macroeconomic theory as in the standard filtering method.

The paper is organized as follows. First, the small structural macro model is laid out and estimated for Cambodia. The estimated model is used to project potential growth over the next decade, and serves as a platform to conduct quantitative growth simulation under different scenarios. The paper then proceeds to identify factors that may potentially be hindering growth, by examining a number of criteria according to which Cambodia may have

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<sup>2</sup> The production function approach can be motivated via an explicit microfoundation, as done in Willman (2002), another EU application. For developing economies, a simplified and reduced form of the method may instead be implemented. For example, Epstein and Macchiarelli (2010), using the case of Poland, focus on identifying the trend labor input in the production function (i.e. the natural rate of employment).

fallen behind other lower-income peers. This growth diagnostic is then used in combination with the growth model developed in the first part, to provide a quantitative assessment of the growth dividends, should the identified growth impediments be removed.

## II. Estimating Potential Growth from a Small Macro Model

### A. The Model

The potential output  $\bar{Y}_t$  is modeled as a simple Cobb-Douglas aggregate production function with Hicks-neutral productivity term:

$$\bar{Y}_t = A_t K_t^\alpha L_t^{1-\alpha} \quad (1)$$

where  $A_t$  is the productivity level,  $K_t$  is the physical capital stock,  $L_t$  is the labor input, and  $0 < \alpha < 1$ . The potential output is therefore determined by the supply side of the economy, with available factor inputs and technology dictating how much output the economy can potentially produce.

The capital stock evolves as a function of an exogenous saving rate,  $s_t$ :

$$K_t = (1 - \delta) K_{t-1} + s_t Y_t \quad (2)$$

where  $\delta$  is the depreciation rate, and  $Y_t$  is the level of actual output. The saving rate is fixed at its realized historical values over the estimation sample, while its future values are pinned by an assumption as part of a forecasting scenario. Since the modeled economy is open, the saving rate  $s_t$  is identical to the rate of total investment, both domestic and foreign. Labor input is determined by the demographics, growing exponentially at a constant rate  $l$ :

$$\log L_t = l + \log L_{t-1} + \varepsilon_t^L \quad (3)$$

with a white noise shock  $\varepsilon_t^L$ .

The productivity term  $A_t$  is an aggregate of three sub-components:

$$A_t = AO_t AG_t^{b_G} AM_t^{b_M} \quad (4)$$

where  $AG_t$ ,  $AM_t$  and  $AO_t$  represent productivities in the agricultural, manufacturing and other sectors respectively. The productivity in each sector is subject to disturbances but is expected to grow exponentially at a constant rate:

$$\log AG_t = c_G + \log AG_{t-1} + \varepsilon_t^{AG} \quad (5)$$

$$\log AM_t = c_M + \log AM_{t-1} + \varepsilon_t^{AM} \quad (6)$$

$$\log AO_t = c_O + \log AO_{t-1} + \varepsilon_t^{AO} \quad (7)$$

Demand shocks can cause the actual output to deviate from its potential level - for instance capital and labor may be under-utilized in recessions, causing actual output to fall below its potential level. These exogenous shocks are assumed not to have permanent effect on output, and thus the output gap  $gap_t \equiv \log(Y_t / \bar{Y}_t)$  narrows as the effect of shock disappears. The demand-side equation can be summarized in a reduced-form as

$$gap_t = \beta gap_{t-1} + \varepsilon_t^y \quad (8)$$

with  $\varepsilon_t^y$  being a white-noise demand shock.

Inflation dynamics depends on the output gap and is therefore, conditional on actual output, informative about the potential output. Inflation  $\pi_t$  is assumed to follow a canonical Phillips curve with a white-noise disturbance:

$$\pi_t = \gamma \pi_{t-1} + (1-\gamma)(gap_t + \bar{\pi}) + \varepsilon_t^\pi \quad (9)$$

In other words, inflation rises with the output gap, moves with inertia, and is subject to supply shocks such as energy and international food prices. In the long-run, inflation converges to a constant  $\bar{\pi}$ .

## B. Potential Growth Estimate

The solution to equations (1)-(9) is characterized by a balanced growth path, with the potential output growth driven by productivity growth and factor accumulation. The model has a state space structure, where a subset of variables is observed, while others can be estimated from Kalman filtering. The observed variables are annual output  $Y_t$ , inflation  $\pi_t$ , labor input  $L_t$ , investment rate  $s_t$ , output gap  $gap_t$ , agricultural productivity  $AG_t$  and manufacturing productivity  $AM_t$ .<sup>3</sup> The full estimation period is 1986-2011, and any missing data points are treated as unobserved, to be recovered by the filter algorithm. Appendix A provides details of data source and available dates for each series.

The model is log-linearized, solved, and estimated by the Bayesian method.<sup>4</sup> In almost all cases, only loose priors about the parameter values are imposed to allow data ample room to speak, by setting large prior standard deviations and wide minimum-maximum bounds. Only in the case of  $\alpha$ , is the prior maximum value binding after the estimation. The detailed information of the parameter priors and estimation results are given in Appendix B.

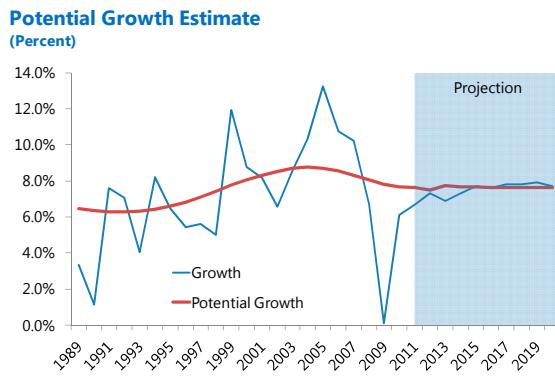
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<sup>3</sup> Past estimate of output gap is strictly speaking not required for the estimate of potential output. It is included here to ‘train’ the model to produce a smooth estimate of potential growth. If in the modeler’s view, the latent potential growth can fluctuate meaningfully, then the HP-filtered gap can be dropped from the list of observed variables.

<sup>4</sup> The procedure is implemented using an open source Matlab specialized toolbox, IRIS, developed by Jaromir Benes. See <http://code.google.com/p/iris-toolbox-project/>.

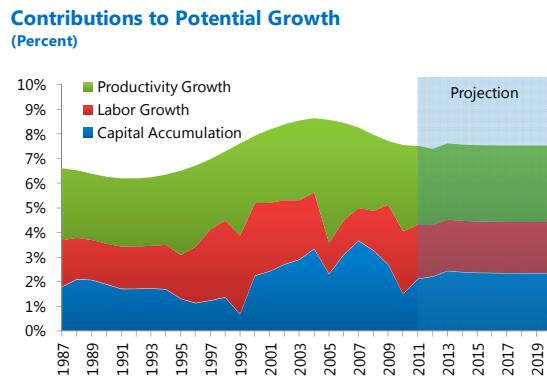
The estimated model is used to forecast all endogenous variables up to 2020. The baseline projection (Figure 1) assumes that Cambodia will be able to maintain investment at 20 percent of output in each year (similar to the 2000–10 average of 19.6 percent). The estimate for labor growth is 3 percent, whereas the productivity growth is 3 percent in agricultural sector, 15 percent in manufacturing sector, and 3 percent in other sectors. These growth assumptions are all close to their historical values.

**Figure 1**



Sources: The Cambodian authorities; and IMF staff estimates.

**Figure 2**



Sources: The Cambodian authorities; and IMF staff estimates.

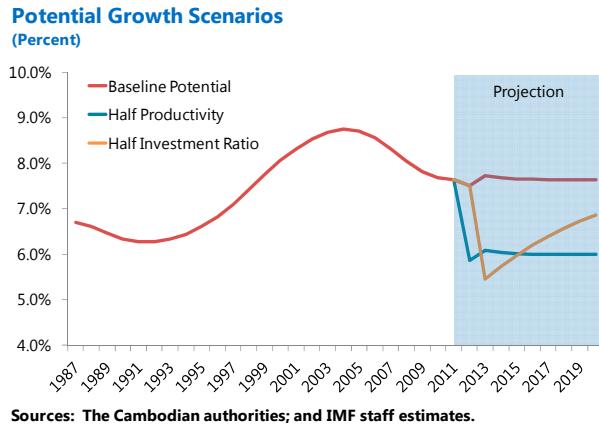
The baseline estimate shows that the potential growth has been declining gradually from the peak of 8.7 in 2004–05, but is expected to stabilize at around 7.5 percent from 2012 onwards without further shocks, provided investment rate remains at 20 percent. The estimated output gap is currently in negative territory but should gradually close as actual output growth catches up with the potential growth.

The breakdown of potential growth into contributions from factor accumulation and productivity gain is shown in Figure 2. Growth in productivity contributes about 3 percent to potential growth on average, and has been a relatively stable source of growth for Cambodia. Factor accumulation contributes about 4 percent to potential growth on average, with roughly equal contribution from capital and labor accumulation over 1987–2011. However, during 2000–09, a rapid accumulation of the capital stock contributed about 3 percent to growth, and was a key driver of the potential growth during this high-growth period. As factor accumulation slows going forward, growth is projected to moderate from the last decade, supported foremost by a continued gain in productivity, followed by sustained capital accumulation and labor growth.

### C. Adverse Growth Scenarios

Clearly, if Cambodia fails to sustain its investment or productivity improvement, the potential growth can be adversely affected. But by how much? Figure 3 compares the baseline potential growth with potential growth under the scenarios that (i) the productivity in each sector grows at only half the rate as in the baseline, and (ii) the investment-to-output ratio  $s_t$  is halved relative to baseline to 10 percent.

**Figure 3**



Sources: The Cambodian authorities; and IMF staff estimates.

A reduction in productivity growth by half immediately reduces potential growth by over 1.5 percentage points, and lowers potential growth permanently by 1.7 percentage points in the long run. A fall in the investment rate by half, on the other hand, will reduce potential growth by nearly 2 percentage points immediately, before sustained productivity gain begins to lift potential growth. The boost from productivity only raises potential growth gradually however, and the growth rate after 10 years still falls short of the baseline by more than 1 percentage point. In both cases, there will be substantial gaps between the *levels* of potential output compared with the baseline, and the gaps are still diverging after 10 years.

The possibility of highly nonlinear dynamics not captured by the model must be considered when using the model to analyze adverse scenarios. For a small open economy such as Cambodia, there can be a significant positive feedback between investment and productivity, in ways not captured by the model. Higher productivity lowers production costs and raises profit margins, which helps attract foreign direct investment and accelerates capital accumulation. On the other hand, foreign investment brings technical know-how and is an important boost to productivity. Falling short of sustaining either investment or productivity may therefore risk starting a vicious anemic-growth cycle.

What policy lessons can be drawn from the exercise so far? One clear policy priority is to continue improving the quality of the factors of production via investment in education and skills of labor, and speed up the diffusion of technology to improve the productive efficiency for existing industries. Investment in infrastructure to lower energy costs will also provide a significant boost to productivity, especially for the manufacturing sector. The next step is to promote sectors that have a greater room to benefit from productivity growth. In the manufacturing sector, this means moving up the value-chain of the dominant garment industry, or a diversification into other sectors. The low-skilled garment industry has less

room for productivity improvement, and its contribution to potential growth may inevitably decline in the longer term.<sup>5</sup>

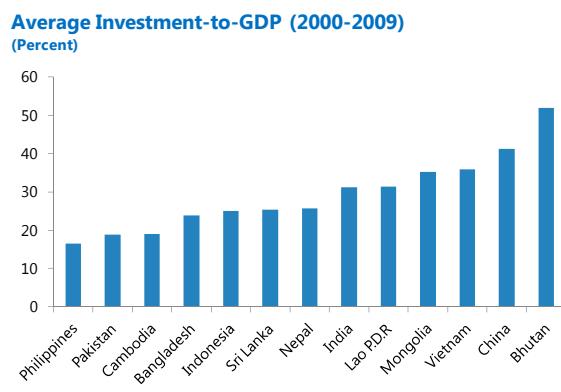
### III. Growth Diagnostic via Cross-Country Comparison

What are the major growth-hindering factors in Cambodia? What can be done to alleviate these impediments and what is the likely effect on growth potential? This section aims to identify constraints to growth drivers through a ‘growth diagnostic’ exercise relying on cross-country comparison.<sup>6</sup> Impediments to growth drivers, namely investment and productivity, are now discussed in turn.

#### A. Identifying Impediments

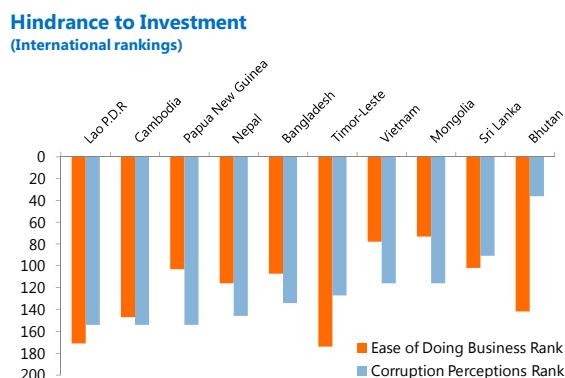
Although investment has contributed significantly to Cambodian growth over the past decade, investment as a percentage of GDP in Cambodia remains one of the lowest among lower income economies (Figure 4). A simple cross-country regression over 2000-2009 shows that a 10 percent higher investment rate is associated with a 1.3 percent higher GDP growth.<sup>7</sup> Meanwhile, a simulation based on the above macro model suggests that a 10 percent increase in investment can raise potential growth immediately by as much as 2 percent, and the positive growth effect can persist even after a decade (see Section III.B below). Investment therefore has a significant untapped potential as a key driver of future growth for Cambodia.

**Figure 4**



Sources: IMF, World Bank.

**Figure 5**



Sources: WDI, World Bank, and Transparency International.

<sup>5</sup> The link between productivity in the traded goods ('export sophistication') and economic growth is documented by Hausmann, Hwang, and Rodrik (2007). They also highlight the difficulties in transitioning from low to high sophistication markets without policy support, owing to the presence of network externalities.

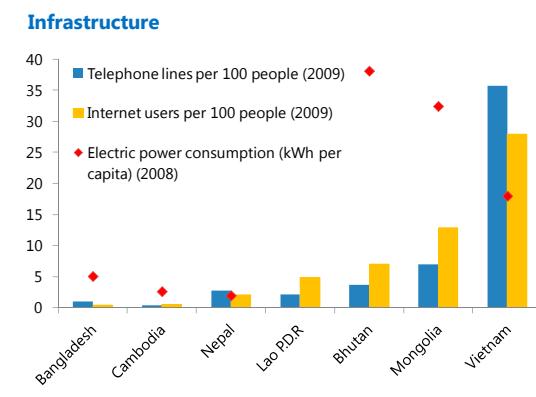
<sup>6</sup> See Hausmann, Rodrik, and Velasco. (2005).

<sup>7</sup> The estimated cross-sectional equation is  $y=1.03+0.13x$  with  $R^2=0.38$ , where  $y$  denotes real GDP growth per capita averaged over 2000-2009, and  $x$  is the gross fixed capital formation as a percentage of GDP averaged over 2000-2009. The sample countries include Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Lao P.D.R., Mongolia, Nepal, Pakistan, the Philippines, Sri Lanka and Vietnam.

A combination of factors is, however, currently holding back investment, and mitigating these constraints will be an important first step towards unleashing investment. According to the latest *Doing Business 2012* report by the World Bank, investors have found it harder to start a business, obtain a construction permit, and have contracts enforced in Cambodia than in many other countries. Cambodia, thus, only ranks 147 in the overall ease of doing business, trailing behind most of its lower income peers (Figure 5). Meanwhile, the Kingdom also scores poorly in terms of corruption perception, according to Transparency International. Such rent seeking can deter private investment, cause misallocation of resources that compromise investment efficiency, and ultimately hurt growth. As Figure 5 shows, Cambodia is currently ranking among the lowest in both categories relative to the lower income peer group.

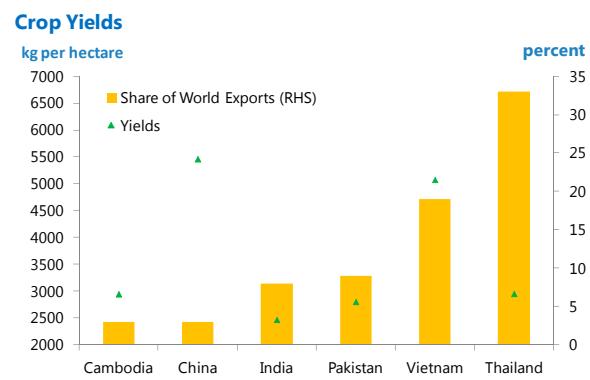
A lack of adequate infrastructure is also restraining investment, as well as hampering total factor productivity. As Figure 6 shows, Cambodia compares less favorably against its peers in basic indicators such as available telephone lines and internet users. Meanwhile, prohibitively expensive power has been a binding obstacle for Cambodia, constraining power consumption per capita, which is currently low relative to other lower-income countries. The newly built hydropower plants will likely help ease some constraints on investment and growth, but should be supplemented by wider measures to improve other basic infrastructure. There is robust evidence that factors such as the ease of doing business and basic infrastructure are important determinants of private investment in Asia (IMF (2010)).

**Figure 6**



Sources: WDI, World Bank.

**Figure 7**

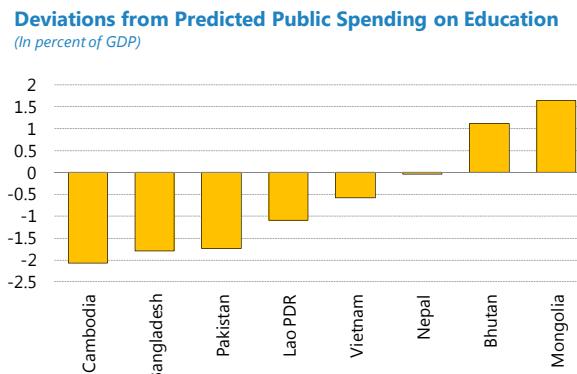


Sources: WDI, World Bank.

While productivity gains have been a key driver of growth in Cambodia in the past, not all sectors have witnessed a surge in productivity. Growth in the agricultural sector, for example, has partly been helped by expansion in total harvested area, whereas crop yields remain similar to the less productive competitors in the international market (Figure 7). As crop area inevitably stops expanding and with export market power still limited, the sector will need to rely on improving the level of yield in order to continue growing and increase its competitiveness in the global market. Improving yield via greater use of physical capital such as machinery is one option, and is another example where investment and productivity have complementary effects.

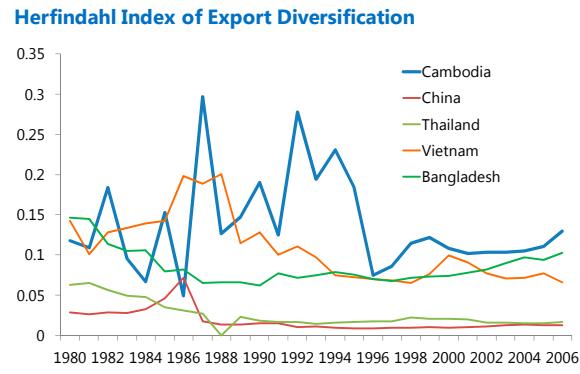
Another important source of growth is labor productivity. According to World Bank data, the school enrollment rate at primary level was close to 90 percent in 2007. However, the secondary enrollment is much lower at 34 percent, while the tertiary enrollment is only 5 percent. As the economy climbs up the technology ladder, shortage of qualified labor will become an even more binding growth constraint. There is therefore an urgent need to speed up investment in human resource. However, the public expenditure on education as a share of GDP in Cambodia is one of the lowest compared to peers (Figure 8).

**Figure 8**



Source: IMF staff estimates.

**Figure 9**



Sources: World Bank and UN Comtrade.

Although the manufacturing and export sectors have probably been major beneficiaries of productivity gains in the past, relying exclusively on a garment-led growth model alone may be more challenging going forward. While Cambodia has made efforts to diversify to more destination markets, the diversification in the product (as opposed to market) space is limited. As Figure 9 illustrates, the Herfindahl index of export diversification (lower number indicates more diversification) for Cambodia has been higher than many of its neighboring exporters. Countries such as China and Thailand, which have enjoyed a long period of sustained export-led growth, are highly diversified in the products that they export. Vietnam has also been diversifying. Only Bangladesh and Cambodia seem to have stalled in the progress towards greater diversification. The recent trend if anything points towards less diversification in Cambodia, indicating that the Kingdom is following a different development path from a typical developing country.<sup>8</sup>

Conceptually, there are benefits and costs to both diversification and specialization, but in the case of Cambodia, a number of factors currently point towards increasing net benefits from export diversification. First, the uncertain global economic backdrop highlights the need for diversifying risks, across both markets and products. Second, following years of rapid growth, Cambodia is now better positioned to start investing more in a wider range of

<sup>8</sup> Imbs and Wacziarg (2003) document robust cross-country evidence that economies typically diversify until a certain income level is reached (typically around \$7000-\$9000 per capita), after which sectoral concentration resumes again. Thus, the Herfindahl index typically decreases with income at an early stage of development, before rising later in a U-shaped pattern. Cambodia, on the other hand, has not followed this pattern, and has not increased its diversification despite low per capita GDP, \$830 as of 2010.

sectors, and promote greater extensive margin trade.<sup>9</sup> Third, export diversification is an essential part of export discoveries, which in turn can lead to a renewed wave of productivity growth much needed by Cambodia. Finally, Cambodia's low labor costs and stable environment have started to attract foreign investors beyond the dominant garment sector, providing an opportunity to diversify its export industry.

Pursuing greater export diversification will be a function of the extent to which Cambodia succeeds in sustaining investment. Acemoglu and Zilibotti (1997) suggest that higher incomes make possible the diversification of indivisible risky projects, and consequently countries should voluntarily choose to diversify more as their incomes grow, leading to a U-shape pattern in sectoral concentration. The fact that Cambodia is not diversifying more rapidly may therefore be another symptom that investment is being hindered. Removing these constraints and related market failures will not only boost investment which is an important engine for growth in itself, but will also lead to greater export discoveries and diversification, which will bring fresh productivity gains that will be a backbone for sustained growth over the next decade.

In sum, despite Cambodia's strong record of growth in the past, the underlying fundamentals for sustained growth on many fronts can be significantly strengthened before they are comparable to the standards of the peers. Implementing structural reforms to improve infrastructure and promote investment and total factor productivity will therefore be necessary to ensure robust growth over the next decade.

## B. Quantifying Growth Dividends

How much additional growth can such structural reforms promote? Specifically, if the reforms were to succeed in bridging the gaps between infrastructure quality in Cambodia and peers, how much would Cambodia's potential growth increase as a result? Estimates of investment elasticity to various measures of infrastructure quality have been computed by IMF (2010), and are reproduced in the second column of Table 1. Gaps between the corresponding infrastructure quality of Cambodia and the average of peers are shown in the first column; in all cases, gaps are positive, indicating that Cambodia lags behind peers. If these gaps were to be closed, the estimated extra investment rate would be as in the third column. The calculation suggests that the effect of improved infrastructure can boost investment by up to 5 percent of GDP.

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<sup>9</sup> Extensive margin trade refers to increased exports of new products (which 'extends' the frontier of exported product space). By contrast, intensive margin trade refers to growth in exports of existing products. Hummels and Klenow (2005) find that extensive margin accounts for around 60 percent of the greater exports of richer economies.

**Table 1**

	Gap with peers	Investment elasticity	Extra investment rate
Electric power consumption (kWh per capita) <sup>1</sup>	618	2.2	4.0
Telephone lines per 100 <sup>2</sup>	8	1.4	4.4
Road per squared meters <sup>3</sup>	0.5	4.0	4.8

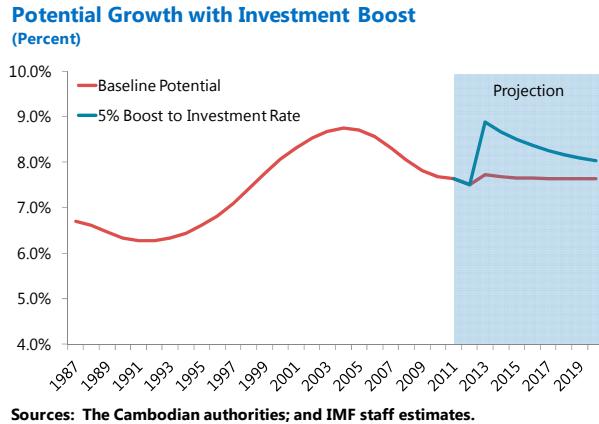
Sources: WDI, World Bank, IMF staff estimates

<sup>1</sup> Based on 2008 data; Peers include Bangladesh, Bhutan, Mongolia, Nepal, Timor-Leste, and Vietnam.

<sup>2</sup> Based on 2009 data; Peers include Bangladesh, Bhutan, Lao P.D.R., Mongolia, Nepal, and Vietnam.

<sup>3</sup> Based on 2004 data; Peer is Vietnam.

Supposing that the infrastructural improvement indeed raises investment rate permanently by 5 percent of GDP, then the impact on potential growth based on the macro model will be as shown in Figure 10. The immediate effect on potential growth is about 1.2 percent, and the effect persists even after a decade. After 10 years, the potential growth, despite declining from diminishing returns to physical capital, would still be 0.4 percentage points higher than without improvement in infrastructure. Thus, the growth impact is both substantial and long lasting. The cumulative effect of these growth dividends would lift the aggregate income level by more than 7 percent after 10 years.

**Figure 10**

Sources: The Cambodian authorities; and IMF staff estimates.

This simulation does not capture the direct effect of infrastructural improvement on total factor productivity, nor the positive feedback between investment and productivity gains, both of which can be significant albeit harder to measure. At the same time, to the extent that structural reforms may have an adverse effect on some sectors (for example, cheaper electricity may render old production technology obsolete and lower demand for low-skilled labor), the net effect on growth may also be smaller. Notwithstanding these interaction effects, the magnitude of growth dividends from improved infrastructure according to the model estimate is significant, and likely to be of first-order importance.

#### **IV. Conclusion**

A key advantage of the proposed framework is that the quantitative model complements the investigative approach (growth diagnostics, as adopted in this paper) in important ways. The latter identifies key constraints to future growth and potential sources of structural breaks, and thus closes the gap left by the model. The model can then be used to simulate the identified potential breaks, to obtain a quantitative assessment that would otherwise not be available. Another advantage is that, since the model has a state space structure, the data availability issue is of less concern, since missing or delayed data for some series over some periods can be estimated by the filter.

Given these advantages, the framework can also be useful for other lower-income economies. The details of the model and the investigative research design are flexible, and can be suitably adjusted to fit the country application. For example, for countries with more stable macro relationships, the model may be extended to include an Euler equation that endogenizes saving/investment. For countries with fully independent monetary policy, a policy rule can be added. If less is known about the sectoral productivities, modeling aggregate TFP alone will suffice. As the growth diagnostic exercises differ from case to case, the model structure can also be tailored according to the focus of the analysis.

Regarding Cambodia's potential growth, the main findings are: (i) the potential growth has indeed moderated from its 2004-2005 peak, but the medium-term outlook of 7.5 percent remains relatively robust, (ii) the baseline outlook is, however, conditional on Cambodia's ability to maintain its productivity growth and the rate of investment, which are currently constrained by a number of structural impediments, (iii) mitigating some of these hindrance factors, for example, by closing the infrastructural gaps between Cambodia and other lower-income peers, would translate into a significant boost to investment and corresponding growth dividend.

## Appendix

### A. Data

**Table 1A. Data for Observed Variables and Sources<sup>1</sup>**

Variables	Data	Period Covered	Sources
$Y_t$	Real GDP at 2000 prices	1986–2011	NIS, IMF
$gap_t$	Deviation of $Y_t$ from the HP-filtered trend	1986–2011	NIS, IMF
$\pi_t$	CPI inflation (Phnompenh)	1995–2011	NIS, IMF
$L_t$	Total labor force	1994–2009	WDI
$S_t$	Gross fixed capital formation to GDP	1995–2011	NIS, IMF
$AG_t$	Cereal yield (kg per hectare)	1994–2009	WDI
$AM_t$	Electricity production (kWh)	1995–2008	WDI

<sup>1</sup> NIS is National Institute of Statistics of Cambodia; WDI is World Development Indicators 2011, the World Bank.

## B. Parameters

**Table 2A. Priors and Posterior Estimates of Parameters**

Parameters	Prior		Posterior	
	Mode	Dispersion	Mode	Dispersion
$\alpha$	0.2	0.9	0.3	NA
$b_G$	0.05	0.9	0.042	0.0002
$b_M$	0.05	0.9	0.013	0.0005
$c_G$	0.03	0.9	0.033	0.0004
$c_M$	0.03	0.9	0.150	0.0003
$c_O$	0.03	0.9	0.027	0.0000
$\delta$	0.05	0.9	0.078	0.0006
$\beta$	0.9	0.9	0.494	0.0279
$\gamma$	0.9	0.9	0.424	0.0346
$\bar{\pi}$	0.07	0.5	0.061	0.0003
$l_g$	0.03	0.5	0.029	0.0000
$\sigma_{\varepsilon^{AG}}$	0.01	0.9	0.099	1.8437
$\sigma_{\varepsilon^{AM}}$	0.01	0.9	0.073	0.9984
$\sigma_{\varepsilon^{AO}}$	0.01	0.9	0.006	0.0068
$\sigma_{\varepsilon^L}$	0.01	0.9	0.011	0.0236
$\sigma_{\varepsilon^Y}$	0.01	0.9	0.040	0.3100
$\sigma_{\varepsilon^\pi}$	0.01	0.9	0.053	0.5314
$\sigma_{\varepsilon^s}$	0.001	0.9	0.042	0.3365

Source: IMF staff calculations.

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