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# Research Summaries

## An Exploration in the Deep Corners of the Oil Market

Rabah Arezki, Douglas Laxton, Armen Nurbekyan, and Hou Wang




*Oil prices have dropped dramatically focusing the attention on the short run. This article takes a longer view. It argues that the oil market is shaped by forces pertaining to demand and supply. A simple model integrating these forces is presented as a useful tool to explore likely scenarios. Notwithstanding the level of uncertainty surrounding the evolution of both demand and supply forces, simulations point to the emergence of supply shortages suggesting that available forecasts predicting persistently low oil prices may be too optimistic.*

Oil prices have fallen by over 50 percent since June 2014. Much has been written about what triggered this slump, and the relative role of supply and demand factors. Considering that price elasticities are extremely low in the short run,

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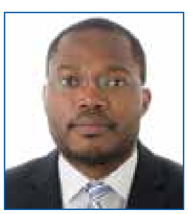
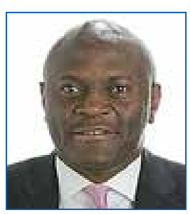
## The State Budget May Not Afford It All: Educate and Cure or Subsidize

Christian Ebeke and Constant Lonkeng Ngouana

*Energy subsidies have important fiscal, distributional, and environmental costs. They are often publicized by governments as sheltering the purchasing power of the less wealthy from high energy costs. But are they really a free-lunch? We attempt to provide an answer to this question in a large cross-section of emerging markets and low-income countries. To account for the fact that energy subsidies and public social spending may be jointly determined (e.g., at the time of the budget), we instrument energy subsidies in a given country by the subsidy intensity in neighbor countries. We find that public spending in education and health are on average lower by 0.6 percentage point of GDP in countries where energy subsidies are 1 percentage point of GDP higher. Moreover, the crowding-out is exacerbated in the presence of weak domestic institutions, narrow fiscal space,*

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## An Exploration in the Deep Corners of the Oil Market

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disturbances, such as the shift in strategy by OPEC, can result in sharp fluctuations in prices. Simple extrapolations of recent trends would give a very misleading picture of future oil prices over the longer term. The long-run price elasticities are considerably higher, as both consumers and producers change their behavior, and adopt new technologies, and underlying developments in demand and supply come to the fore. While there is uncertainty about the evolution of these developments, there are known elements such as geology on the supply side and demographics on the demand side. Technological innovation, responding to economic incentives (e.g., the advent of shale exploitation), and to policies aimed at reducing greenhouse gas emissions (e.g., the emergence of alternative energy sources) also will play a key role in shaping the oil market.

The present article discusses the relative strength of those forces and their interplay. It also presents exploratory simulations using a novel oil model developed at the IMF to study the implications of possible future trends in supply and demand. A simulated baseline path suggests that the oil price could reach US$80 (adjusted for inflation) per barrel in 2020 and US$100 in 2025. These projections should be seen as indicative of the underlying tendency of oil prices that would prevail, barring radical changes in the future path of technology and global economic growth. Of course, geopolitical disturbances or strategic maneuvering could cause short-term movements around any such path. However, the model does provide an analytical tool to explore the consequences of a variety of scenarios.

This article attempts to answer the following questions:
- What will drive demand forces?
- What will drive supply forces?
- Which model?
- What do model-based scenarios tell us?

### What Will Drive Demand Forces?

On the demand side, growth of the global economy, especially the main emerging markets will continue to drive demand for oil. By 2025, oil demand will likely grow by 9 to 12 million barrels per day (mb/d) from the current 91 mb/d—i.e., by 10 percent or more. This forecast accounts for continued efficiency gains in the use of oil. Efficiency in oil use has increased rapidly over the past decades through the adoption of energy saving technologies. The oil-consumption-to-world-GDP ratio declined by 60 percent between 1980 and 2013, with most of the decline accounted for by the advanced economies. Emerging markets are likely to experience similar efficiency gains in the future but of a more modest size, as energy intensive industries have migrated from advanced economies to emerging markets.

Petroleum product usage faces competition, particularly from natural gas, the cleanest source of energy among fossil fuels. Globally, in power generation, coal, nuclear power, and natural gas are major energy sources, and renewable resources have a growing presence—in part because of subsidies. The share of oil in global primary energy consumption has declined, from 50 percent in 1970 to about 30 percent today, whereas natural gas consumption has risen steadily, and now accounts for nearly 25 percent of consumption. Natural gas consumption is projected to increase strongly in the medium term according to the International Energy Agency, at the expense of oil, with emerging market and developing economies accounting for the bulk of the growth. Oil is expected to remain by far the most important source for transportation, but natural gas is expected to make inroads—e.g., use of liquefied natural gas in shipping.

### What Will Drive Supply Forces?

On the supply side, it is important to distinguish between different sources to understand the underlying trends. Conventional oil production, accounting for 80 percent of current production is depleting rapidly. The very large investments in the development of known reserves that have taken place over the past decade will help only to stabilize conventional production. On the unconventional front, we should distinguish between the low-cost tight (shale) oil versus higher-cost sources, including deep water and oil sands. The latter is economical at relative prices above US$80 to US$90, while new deep water wells can be economical above US$50 to US$60.

Depletion of conventional oil is estimated at 6 percent a year, which would mean a reduction in supply of about 20 mb/d over the next 10 years. There are however 17 mb/d of known oil reserves in the process of being developed. Shale oil has been growing in importance, and has enjoyed rapid efficiency gains during the early stage of the investment cycle. Shale oil has the potential to increase to 12 mb/d production from the current level of 5 mb/d. Oil sands and deep water sources could each provide an additional 4 mb/d.

Over time, the balance between supply and demand forces will tend to lead to upward pressure on oil prices, up to a point where higher-cost oil sources become economical. Shale oil is likely to provide a price ceiling in the short to medium term, because of the fast improving cost structure and potential.

## Which Model?

The model is based on an extension of Benes and others (2012).[1] The world oil supply equation captures both depletion and technological developments. The world oil demand function includes the real price of oil, and world GDP.

The depletion forces are captured by the so-called Hubbert linearization, where annual production is approximated by the logistic curve:

$$q_t = \alpha_s Q_t \frac{Q-Q_t}{\bar{Q}} \quad \Leftrightarrow \quad \frac{q_t}{Q_t} = \alpha_s - \beta_1 Q_t.$$ [2]

$q_t$ represents annual world oil production at time t, $Q_t$ represents cumulative production until time t, and represents ultimately recoverable resources (URR) (assumed in the most simplistic case to be a geological constant). This specification entails that oil is harder and harder to extract as cumulative production increases. Production peaks at the point where half of the URR has been extracted. Benes and others (2012) show that this view about peak oil can be strongly rejected by the data compared to a more flexible model where supply also responds to the price of oil.

The logistic curve is augmented by the present and past prices:

$$\frac{q_t}{Q_t} = \alpha_s - \beta_1 Q_t + \beta_2 p_t^{\vartheta} + \beta_3 \frac{1}{3} \sum_{k=4}^{6} p_{t-k}^{\vartheta} + \varepsilon_t.$$

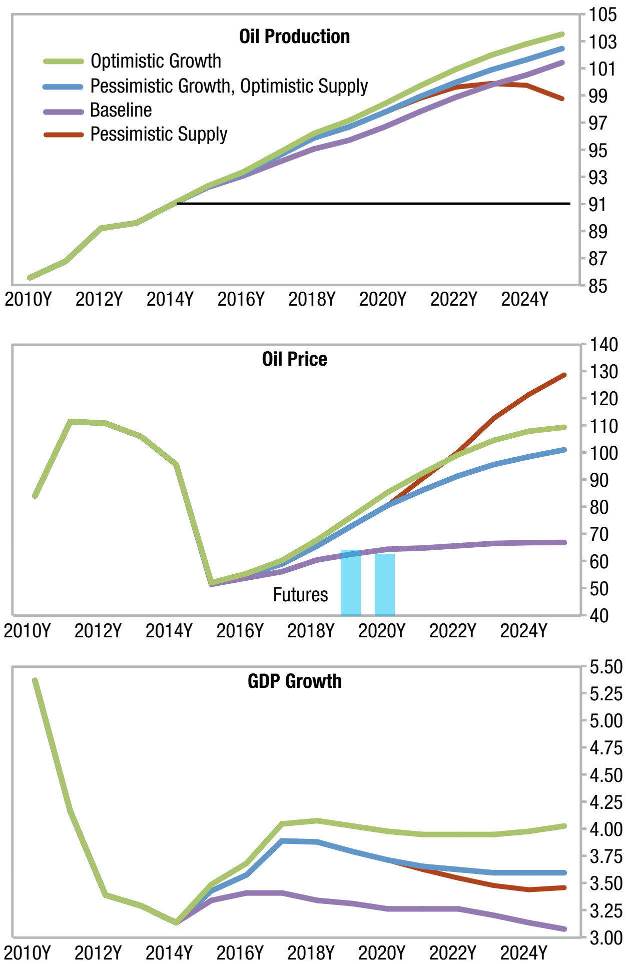
An increase in prices encourages producers to speed up production from existing fields. Over the medium run (in practice 4 years or more) higher prices lead to more intensive development of known fields, new exploration, and/or better technologies—hence the additional, 4–6 year, lagged response.

The model was estimated using non-linear Bayesian techniques, with fairly tight priors based on previous studies for oil demand, and GDP variables. For the supply equation, where there is almost no guidance from previous studies, very loose priors are used within a nonlinear technique (the extended Kalman filter). The model is estimated as a system. Because it contains an endogenous breakdown of output into trend and gap components, a diagonal covariance matrix is imposed as an identifying assumption. The posterior distributions of parameters are obtained using an adaptive random-walk algorithm.

## What Do Model-Based Scenarios Tell Us?

We present a baseline scenario, and two alternatives, for the next decade. The alternative simulations use different assumptions about supply and demand, to emphasize the importance of uncertainty, and the crucial role of underlying assumptions about long-term factors.

Figure 1. Oil Production, Oil Price, and World GDP Growth

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[1] A more detailed discussion will be presented in a forthcoming IMF working paper.

[2] The analysis here is adapted from Deffeyes (2005).

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In the baseline scenario shown in Figure 1, medium-term world GDP growth is assumed to be 3.6 percent. Production expands strongly, reaching 102.5 mb/d in 2025. But the oil price moves up gradually to around US$100 in 2025, to allow higher cost production to become economical. Tight (shale) oil production can provide only about 7 mb/d of additional supply in 2025, not enough to meet additional 11.5 mb/d demand. The remainder of the production increase comes from higher cost resources such as deep sea and oil sands.

The first alternative scenario assumes 4 percent world GDP growth. Higher growth leads to larger increase in oil demand, and oil production reaches 103.5 mb/d in 2025. Oil price increases to US$110 in real terms in 2025 to get the additional production.

The second alternative assumes that the higher cost oil resources, namely deep sea and oil sands, are impossible to extract, due to, for example, environmental concerns. Production increases to 100 mb/d in 2023, when tight oil production reaches its potential. As higher cost resources cannot be extracted, production peaks at that point. Thereafter, because of depletion, production declines to 98.8 mb/d in 2025, and prices reach US$130 in real terms. GDP growth is lower than in the baseline decreasing to 3.4 percent.

These scenarios are intended to be illustrative, to show the enormous uncertainty around the fundamental forces at play. One could come up with a wide range of possible alternatives, using different assumptions along many dimensions. These include energy efficiency, substitution from oil to other energy sources, and climate change policies. As can be seen in Figure 1, the outlook for oil prices in the futures market would be consistent with some very optimistic assumptions about future oil supply and some very pessimistic assumptions about world growth.

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Deffeyes, K. 2005. *Beyond Oil: The View from Hubbert's Peak*. Hill and Wang: New York.

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*and among the net oil importers. Finally, consistent with our empirical findings, we show that high energy subsidies and low public social spending can emerge as equilibrium of a political game between the elite and the middle-class when the delivery of public goods is subject to bottlenecks, reflecting weak domestic institutions.*

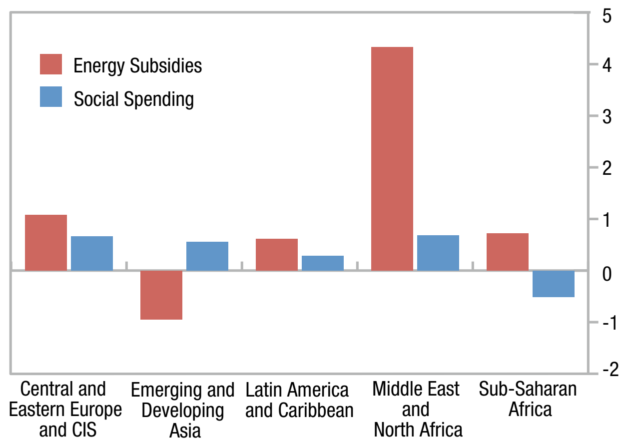
International agencies have warned governments around the globe on the fiscal cost and environmental damage of energy subsidies (e.g., IEA, 2011; IMF, 2013; World Bank, 2010; Parry and others, 2014). A comprehensive assessment by Clements and others (2013) suggests that pre-tax energy subsidies amounted to 0.7 percent of global GDP in 2011. The figures are even more alarming when the negative externalities from energy consumption are factored-in—the authors evaluated post-tax energy subsidies to 2.9 percent of global GDP in 2011, equivalent to 8.5 percent of total government revenues. In addition, generalized energy subsidies have important distributional effects—they accrued mostly to upper-income groups, given their high energy consumption (see Arze Granado and others, 2012, for a survey of micro-based evidence).

From a political economy standpoint, governments' repeated argument that energy subsidies shelter the purchasing power of the poor against high energy costs would fade out, if energy subsidies, owing to budget constraints, come at the cost of lower public social spending. This is precisely because the high energy subsidies and low social spending mix is likely to have a net negative impact on lower-income groups who can hardly afford alternative market-provided services.

Against this backdrop, we assess whether or not energy subsidies crowd-out public social spending, defined narrowly (for the purpose of our analysis) as public expenditures in education and health. Our focus on public social spending is motivated by three factors. First, in contrast to energy subsidies, public social spending is less likely to be regressive, given the relatively limited access of poor households to (costly) private schools and hospitals. Second, because it is "less visible," public social spending is likely to generate a relatively low political premium and might be more prone to crowding-out in the budgetary process. Third, and perhaps most importantly, public social spending is likely to improve human capital and productivity, thereby boosting the economy's growth potential.

Figure 1 provides some insights into our question. The facts are quite striking: while subsidies did decrease in developing and emerging Asia between the two identified sub-periods (2002–2006 and 2007–2011), they did increase in Sub-Saharan Africa. Interestingly, social spending moved in opposite directions in and across both regions, pointing to a potential trade-off between subsidies and social spending. In contrast, social spending did not move much in the resource-rich Middle East and North Africa (MENA), despite the sharp increase in energy subsidies, suggesting that countries' endowment or resource space may condition the crowding-out.

**Figure 1: Energy Subsidies and Social Spending — Change Between the First and Second Sub-periods**
(in percent of GDP)[1]




[1] The first (second) sub-period covers 2002–06 (2007–11). Averages are considered for each sub-period. CIS refers to the Commonwealth of Independent States.
Source: Clements and others (2013), World Development Indicators (2013), and authors' calculations.

Figure 2 provides a more disaggregated picture (at the country level) and paints a quite similar story: (i) Although energy subsidies rose around the globe between the two identified sub-periods (most countries in the sample are on the right of the vertical axis), especially in resource-rich countries, the evolution of social spending was uneven (countries are almost equally split below and above the horizontal axis); (ii) some resource-rich countries were somewhat able to afford higher energy subsidies without slashing public social spending (in nominal terms), and even when public social spending did decrease in resources-rich countries, the

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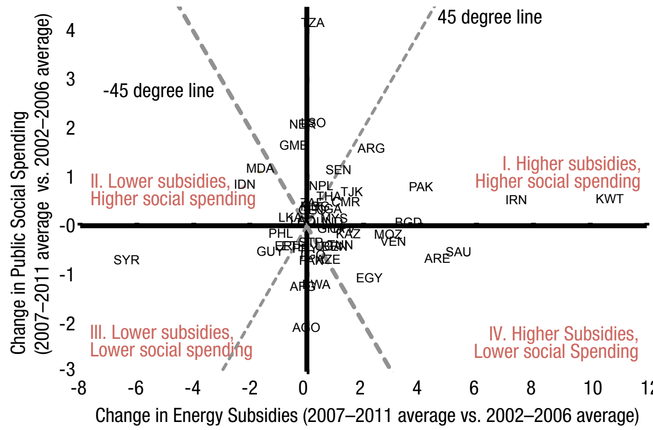
decline was much lower than the increase in subsidies (above the 45 degree line); and (iii) in general, where social spending did increase, the increase was lower than the increase in subsidies (below the 45 degree line). Consequently, only very few countries went through the virtuous cycle of lower energy subsidies and higher public social spending (second quadrant); Moldova and Indonesia are notable exceptions.

We estimate the impact of energy subsidies on public social spending more systematically in a large cross-section of emerging markets and low income countries.[1] Because subsidies and social spending are jointly determined (e.g., in the budget process), naïve ordinary least squares (OLS) estimates would be biased. To address this simultaneity bias and other potential sources of endogeneity, we instrument energy subsidies in a given country by subsidy intensity in neighbor countries.[2] Our instrumental variable estimations indeed suggest a causal relationship running from energy subsidies to public social spending. More specifically, we find that public expenditures in education and health are on average 0.6 percentage point of GDP lower in countries where energy subsidies are 1 percentage point of GDP higher. Moreover, the crowding-out is stronger when the fiscal space is narrow, rising to about 0.8 when the debt-to-GDP ratio reaches 70 percent, and among the net oil importers. Also, consistent with a central prediction of our theoretical model, weak domestic institutions exacerbate the crowding-out effect, estimated to be almost one-to-one in countries with government ineffectiveness above the 75th percentile of the sample distribution.[3]

**Figure 2: Energy Subsidies and Social Spending Across Countries: What Happened?**




Source: Clements and others (2013), World Development Indicators (2013), and authors' calculations.

A natural question is, therefore, why the poor would support energy subsidies—a form of redistribution that disproportionally benefits upper income groups—in equilibrium. Or put differently, under which conditions high energy subsidies and low public social spending could occur in equilibrium? We show that high energy subsidies and low public social spending may emerge as an equilibrium outcome of a political game between the elite and the middle-class when the delivery of the public good is subject to bottlenecks, reflecting weak domestic institutions. Intuitively, the poor support that equilibrium because energy subsidies provide a small but certain benefit to consumption, whereas the delivery of public spending is subject to important leakages (e.g., in the form of corruption or lack of commitment by the politician). The elite, internalizing this, set a subsidy rate that is sub-optimally high, crowding-out public social spending, especially when the fiscal space is narrow. The model also implies that resource wealth limits the severity of the crowding-out, as the size of the pie is bigger. In addition, we show that the energy subsidy and public social spending mix could be improved endogenously if the rich have more skin in the game. This would for instance be the case if the social contract is such that energy subsidies are financed using additional income taxation or if the public good represents a worthwhile alternative to market-provided services.

Our findings have important policy implications. On the one hand, they suggest that non-resource-rich countries with a narrow fiscal space would have to move expeditiously with subsidy reform in order to relax the constraints weighting on public social spending. On the other hand, it will

[1] The choice of the cross-sectional econometric approach over a panel specification is motivated by three main factors: (i) the relatively short time period for which subsidies data are available (2000–11); (ii) the dominance of the between-country variation in the subsidies-to-GDP ratio over the within-country changes; and (iii) the inertia in public social spending and some of its determinants (demographics, institutions, urbanization, natural resource dependency, etc.), which implies that fixed-effects would absorb most of the variations in panel estimations.

[2] Energy subsidies in neighboring countries are found to explain about one-quarter of the variations in subsidies across the 109 countries in our sample, and half of the variation among net oil exporters. We also find that the constraints on the executive condition the level of energy subsidies in a country.

[3] We also control for traditional determinants of social spending such as demographics (dependency ratio, urbanization rate), macroeconomic conditions (output volatility), and the size of the government.

prove challenging to resource-rich economies to keep energy subsidies at their current high levels moving forward, in view of mounting social spending pressures, including from the youth, given the volatile nature of resource revenues. The recent sharp drop in global oil prices seems to vindicate this point. Indeed, in line with our conceptual framework and empirical findings, resource-rich countries were somewhat able to afford high energy subsidies with relatively limited crowding-out of public social spending, thanks to their large fiscal space at a time when oil prices were relatively high and on the rise. Those subsidy regimes will clearly be harder to sustain at much lower international oil prices, as existing fiscal buffers get eroded.

On the positive side, energy subsidy reform is likely to pose less political headache when global oil prices are relatively low. Governments around the world—resource-rich and non-resource-blessed alike—are therefore presented with a golden opportunity to reform energy subsidy at this juncture of high energy subsidies and low global oil prices. In that vein, depoliticizing domestic energy pricing, for instance by adopting an automatic pricing mechanism (see Coady and others, 2012), seems to be a good transition toward fully-deregulated energy prices.

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Q&A

# Seven Questions on Potential Output

Pau Rabanal

*Potential output is a crucial benchmark for policymakers because it measures the output level or path an economy can sustain over the medium term. It is typically defined as the level of non-inflationary real gross domestic product (GDP). Since it is a counterfactual object, assumptions are needed to estimate it. This article discusses old methodologies, empirical challenges, and new developments in the estimation of potential output.*

## Question 1. What is potential output, and why is it different from actual output?

Macroeconomists examine hundreds of statistics, but the most important indicator they look at when they study a given country is output. Output is measured using the real gross domestic product (GDP), i.e., the value of all goods and services produced in an economy, adjusted for changes in prices. Typically, countries want to increase the level and the rate of growth of real GDP because of its close relationship to the level of income and wealth and, ultimately, of welfare. In addition, economists and policymakers may also want to understand whether observed (or actual output) is at the level where it "should be," given the country's economic environment. Potential output tries to measure precisely where the economy "should be." If there is a difference between where the economy "is" (actual output) and where it "should be" (potential output), then economic policy might be able to close the gap between the two (which is the output gap).

A reliable measure of potential output is a critical benchmark for economic policy. Potential output (or GDP) is often defined as the level of output that an economy can sustainably produce over the medium term making normal use of its resources. Yet, this is a concept that is not straightforward to implement in practice because economies rarely operate at normal capacity and undistorted for long. In reality, a barrage of overlapping shocks tends to move real GDP one way or the other, leaving policymakers to decide whether these changes are due to lasting capacity shifts, transitory demand jitters, or simply statistical noise.

## Question 2. Why does potential output matter?

Potential output is closely related to inflation, and the definition from the Congressional Budget Office (2001) makes this clear: "… it is a measure of maximum sustainable output—the level of real GDP in a given year that is consistent with a stable rate of inflation." Central banks manage demand (i.e., actual output) through changes in monetary conditions and interest rates. When actual output exceeds potential output, inflationary pressures emerge. On the other hand, output below the potential level (a negative output gap) implies that there is underemployment (excess supply) of capital and labor, which would motivate a looser policy stance.

But potential output is also important for other areas of policymaking. In the absence of further shocks and when price and wage adjustment is complete, actual output converges to potential output. Hence, the potential growth rate of the economy determines its long-run position. Structural reforms, such as removing inefficiencies in labor and goods markets, might help increase the potential growth rate. The fiscal accounts are also affected by the difference between actual and potential output. For instance, if the economy is growing faster than its potential rate and the output gap is positive, tax revenues would tend to be higher than in normal times because of strong profits, wages, and asset prices. At the same time, expenditures are likely to be lower because of lower unemployment benefits and other social spending. If the fiscal accounts are not corrected by the cycle, policymakers might incorrectly conclude that the fiscal outlook is more favorable and further increase government spending, thereby increasing the debt bias.

## Question 3. What is the simplest way to compute potential output?

There are several methods to compute potential output. A simple and popular method is to assume that potential output is a smooth trend around which actual output fluctuates. The widely used Hodrick and Prescott (HP, 1997) filter computes potential output as a two sided moving average of actual output. However, the HP filter has important shortcomings. It can be sensitive to statistical choices (e.g., the degree of smoothing), and it suffers from the problem of reverting to actual GDP at the start and end of the sample. This may lead to close-to-zero estimates of the output gap in real time, which then get revised when new data becomes available. By construction, the HP filter does little to foster our understanding of what actually drives potential output. Finally, the assumption of a smooth trend might be at odds with large shocks, such as a banking or financial crisis, hitting the economy.

### Question 4. How is potential output estimated using supply-side measures?

Production function models construct potential output bottom-up from the supply side of GDP based on available labor and capital inputs, as well as measures of total factor productivity and utilization rates of labor and capital. This is the method applied by the European Commission and the Congressional Budget Office, among others. However, the approach requires timely access to micro-level data as well as filtering to eliminate short-term fluctuations from these variables—for example, to determine the "potential" level of labor, capital and total factor productivity available for production—creating problems very similar to the univariate filtering approach.

### Question 5. What other macroeconomic variables can be useful to estimate potential output?

Structural multivariate approaches use relationships derived from economic theory to help identify potential output (see Laubach and Williams 2003; and Benes and others 2010). Multivariate filters take advantage of the information contained in selected observable macroeconomic variables such as consumer price index (CPI) inflation, which is related to the output gap through the Phillips curve relationship (see Clarida, Galí, and Gertler 1999). Another variable to consider is unemployment, which is linked to output through the relationship known as Okun's law (see Ball, Leigh, and Loungani 2013). Including these additional variables adds to the usefulness of estimates of potential output for guiding policy decisions. At the same time, the results are often quite sensitive to the specification and estimation of the underlying partial-equilibrium relationships. In addition, the necessary assumptions about the smoothness of potential output require judgment quite similar to the selection of the smoothness of univariate filters.

### Question 6. Do financial variables contain useful information to estimate potential output?

From a more practical perspective, CPI inflation appears to have been a less informative variable to compute the output gap in recent years (see Bayoumi and others 2014; and IMF 2013). Despite major recessions in advanced economies in recent years, deflation was lower than that predicted by Phillips curve models. In addition, in the build up to the recent global financial crisis, CPI inflation was not particularly out of target in most advanced economies. However, inflationary pressures did show up in other price measures outside the definition of the CPI: most notably, in house prices. With hindsight, the severe credit and housing busts that followed suggest actual GDP growth significantly outpaced potential during the boom years.

More generally, the empirical literature on credit booms and busts (Claessens and others 2012) provides a strong case for including financial variables to inform potential output estimates. The multivariate filter approach can be extended to include credit, house, and asset prices. If wide swings in output tend to occur along with wide swings in credit, the approach will ignore the former when determining the level of potential output. In a recent paper, Borio and others (2014) have shown that estimated output gaps that were taking into account financial variables were indeed pointing at more overheating before the crisis, and a more negative gap afterwards, than a conventional HP-filter approach would suggest. This means that once financial variables are included in the analysis, potential output moves more steadily.

### Question 7. How useful are fully specified dynamic stochastic general equilibrium models for estimating potential output?

As we have discussed, univariate and multivariate filters aim at extracting potential output as a smooth trend, potentially taking into account information from other relevant sources. However, some of the parameters used in these filters are reduced-form and do not have an economic interpretation, making it difficult to understand what are the channels of transmission. Dynamic stochastic general equilibrium (DSGE) models overcome some of these shortcomings by modeling both the demand and the supply side of the economy. Hence, they can identify GDP fluctuations driven by all shocks that matter for potential output over the longer term. These models also narrow down explicitly the definition of potential output to the output level that would be available if the economy could operate in the absence of

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price and wage rigidities, but taking into account the reality of real frictions (such as adjustment costs to investment or employment) that demand policies cannot overcome. The latest generation of estimated DSGE models incorporates labor frictions (see Galí, Smets, and Wouters 2011), and financial frictions (see Furlanetto, Gelain, and Taheri Sanjani 2014), with promising results. However, the findings are sensitive to the underlying assumptions and different models can produce different output gaps, so more work is needed to take into account model uncertainty.

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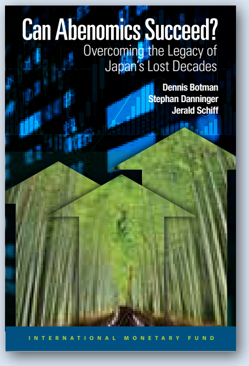


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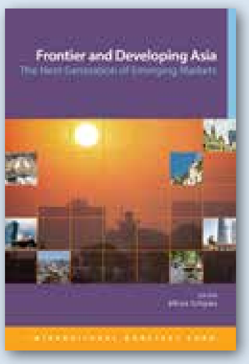


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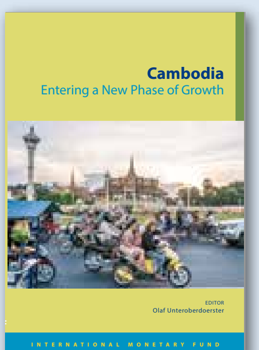


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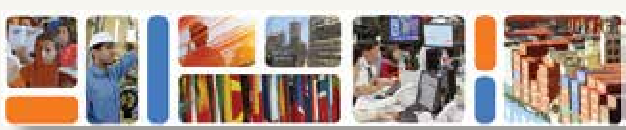

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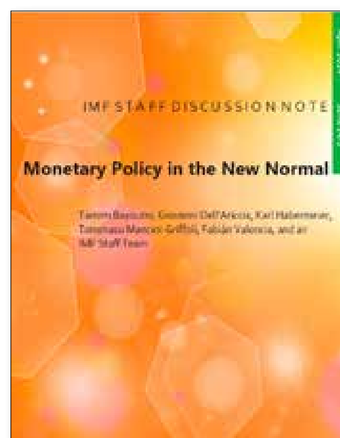


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