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Potential Growth: A Global Database

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Abstract

Potential growth—the rate of expansion an economy can sustain at full capacity and employment—is a critical driver of development progress. It is also a major input in the formulation of fiscal and monetary policies over the business cycle. This paper introduces the most comprehensive database to date, covering the nine most commonly used measures of potential growth for up to 173 countries over 1981-2021. Based on this database, the paper presents three findings. First, all measures of global potential growth show a steady and widespread decline over the past decade, with all the fundamental drivers of growth losing momentum over time. In 2011-21, potential growth was below its 2000-10 average in nearly all advanced economies and roughly 60 percent of emerging market and developing economies. Second, adverse events, such as the global financial crisis and the COVID-19 pandemic, contributed to the decline. At the country-level also, national recessions lowered potential growth even five years after their onset. Third, the persistent impact of recessions on potential growth operated through weaker growth of investment, employment, and productivity.

Keywords

Production function, filters, growth expectations, developing economies

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Potential Growth: A Global Database

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I. Introduction

The global economy headed into the COVID-19 pandemic and the Russian invasion of Ukraine after a decade of slowing growth. The pandemic-induced global recession of 2020 further deepened this slowdown and Russia's invasion of Ukraine in February 2022 has already left additional scars. These adverse shocks have reduced not just actual global output growth but have also dampened potential growth—the rate of increase of potential output, defined as the level of output an economy can sustain at full capacity utilization and full employment. Potential growth is a critical determinant of a wide range of macroeconomic and development outcomes. Sound fiscal and monetary policy decision about stimulus or austerity cannot be taken without being grounded in a firm understanding of potential growth.

Potential growth is of fundamental importance to short- and long-run macroeconomic analysis and policy but it is not directly observable. In an extensive literature, three main methods of estimating potential output growth have been employed, each of which has its advantages and disadvantages. Thus, measures of potential growth based on production function estimates make it possible to study the contributions of the fundamental drivers of growth—namely, the growth of the factors of production and technical progress—but involve assumptions that may be viewed as restrictive. A second method uses economic analysts' long-term (five-year-ahead) output growth forecasts, which may be assumed to incorporate their judgments. The third method obtains measures of potential growth from statistical filters of actual growth data; it may be best at ensuring consistency between estimates of potential growth and output gaps, on the one hand, and indicators of domestic demand pressures, on the other.

This study introduces the most comprehensive international database yet for the nine most commonly used measures of potential growth, based on these three methods, for the largest available sample of countries over the period 1981-2021. In addition, this study addresses the following questions. First, how has potential growth evolved in recent decades? Second, how have recessions and other adverse developments affected potential growth? Finally, through which channels have such developments affected potential growth?

The study makes several contributions to the literature. First, it introduces the first comprehensive database of the nine most commonly used measures of potential growth for the largest available country sample—of up to 173 economies (37 advanced economies and 136 emerging market and developing economies [EMDEs])—over 1981-2021. These measures comprise one based on the production function approach; five based on the application of univariate filters (Hodrick-Prescott, Baxter-King, Christiano-Fitzgerald, Butterworth, and Unobserved Components filters); one based on a multivariate Kalman filter; and two based on long-term growth forecasts. Previous studies have limited themselves to a single method of measuring potential growth, such as the production function approach (OECD 2014), or multivariate filters (ADB 2016; IMF 2015). This study builds on earlier work published before the pandemic that utilized several measures of potential growth (Kilic Celik, Kose, and Ohnsorge 2020; World Bank 2018).

Second, the study documents a broad-based and long-standing slowdown in potential growth.

All measures of potential growth show a decline in global potential growth in the decade before the pandemic and that it was internationally widespread. Earlier studies documented the decline for only a subset of measures (for example, Chalaux and Guillemette 2019; Kilic Celik, Kose, and Ohnsorge 2020).

Third, this study is the first to systematically compare the long-term damage to potential growth of short-term economic disruptions—such as recessions, banking crises, and epidemics—in a large set of countries. Thus far, only a few studies have estimated the effects of recessions on potential output growth, and they were confined to an OECD sample and the production function approach (Furceri and Mourougane 2012; Mourougane 2017). This study broadens the earlier research by estimating the effects of recessions, banking crises, and epidemics in a large sample of advanced economies and EMDEs and for a wide range of potential growth measures.

Fourth, this study estimates empirically, using a set of local projection models, the multiple channels through which short-term economic disruptions have dampened potential growth. Specifically, it estimates the effects of disruptions on the growth of the labor supply, the growth of investment, and the growth of total factor productivity (TFP) in a consistent framework. Previous studies have typically examined overall effects on growth or effects through individual channels.

The theoretical literature has analyzed, typically using DSGE models, several mechanisms through which short-term output disruptions (associated with recessions and other adverse events) may have longer-term effects. Weak aggregate demand during such disruptions may reduce the expected profitability of, and thus discourage, productivity-increasing research and development (Fatás 2000). It may similarly discourage investment in productivity-raising new technologies that would otherwise have improved productivity (Anzoategui et al. 2019). Investors who expect weak aggregate demand to persist will be reluctant to invest; reduced investment will tend to lower asset prices which, through wealth effects, will further depress consumption (Caballero and Simsek 2017). If aggregate demand weakness is accompanied by a financial crisis, financial market frictions can restrict firms' access to credit and start-up capital, further reducing investment and productivity growth.[2]

Damage to potential output from short-term disruptions can also result from productivity losses due to resource misallocation (Dieppe, Kilic Celik, and Okou 2021; Furceri et al. 2021); these may be partially offset by productivity gains stemming from the exit of low-productivity firms (Bloom et al. 2020). Finally, high unemployment that accompanies weak aggregate demand tends to lead to human capital losses and reduced job search activity among the long-term unemployed (Blanchard and Summers 1987; Lockwood 1991).

Empirical estimates have documented that some of these mechanisms were indeed at work during past recessions. An analysis of data for a large sample of countries during 1960-2018 found that financial crises, especially when accompanied by a rapid buildup of debt, were associated

[2] For details of these empirical findings involving financial markets, see Claessens and Kose (2017), Queralto (2013), and Wilms, Swank, and de Haan (2018).

with persistent productivity losses (Dieppe, Kilic Celik, and Okou 2021). Among a large sample of firms in six EMDEs in Europe, firms in sectors that faced the largest adverse demand shocks during the 2009 global recession reduced capacity most (Nguyen and Qian 2014). In a sample of 61 countries during 1954-2010, banking crises were followed by lower labor productivity growth, consistent with a loss of human capital during these crises (Oulton and Sebastia-Barriel 2016). Other studies found that the return of actual output growth or levels to pre-recession trends was non-linear and depended on the persistence, depth, and source of the recession and on whether it was accompanied by financial crises.[3] None of these studies, however, systematically examines the various channels through which short-term disruptions reduce potential growth.

The study reports the following key findings.

Trend decline in potential growth. An internationally widespread decline in average annual potential growth occurred between 2000-10 and 2011-21. This is shown by all estimates of potential growth, globally and for the main country groups—advanced economies and EMDEs. Global potential growth, as estimated using the production function approach, fell to 2.6 percent a year during 2011-21 from 3.5 percent a year during 2000-10; advanced-economy potential growth fell to 1.4 percent a year during 2011-21, 0.8 percentage point below its 2000-10 average; and EMDE potential growth fell to 5.0 percent a year during 2011-21 from 6.0 percent a year during 2000-10. The weakening of potential growth was highly synchronized across countries: during 2011-21, potential growth was below its 2000-10 average in 96 percent of advanced economies and 57 percent of EMDEs. This widespread decline reflected a multitude of factors. All the fundamental drivers of growth faded in 2011-21: TFP growth slowed, investment weakened, and labor force growth declined.

Persistent impact of recessions on potential growth. Recessions, even five years later, were associated, on average, with a decline of about 1.4 percentage points in potential growth. While the magnitude of the estimated decline in potential growth five years after a recession depended on the measure (with a range of 0.2-1.4 percentage points), it was always statistically significantly negative. The effect was somewhat stronger in EMDEs than in advanced economies: in EMDEs, potential growth was still, on average, 1.6 percentage points lower five years after the recession, whereas, in advanced economies, it was 1.3 percentage points lower.

Larger impact of recessions than other adverse events on potential growth. The longer-term effect of recessions on potential growth tended to be somewhat more severe than the effects of other adverse events. Banking crises were associated with initially larger falls in potential growth (peaking at 1.8 percentage point after two years) as a result of a collapse in investment. However, this tended to unwind quickly such that the fall in potential growth after five years was only 1.2 percentage point. Epidemics were associated with more modest, but still statistically significant, short- and medium-term declines in potential growth. These were more severe in EMDEs than in advanced economies, which may have been better able to limit the economic damage with fiscal

[3] For a discussion of the impact of financial crises on growth, see Ball (2014); Claessens, Kose, and Terrones (2009, 2012); Furceri and Mourougane (2012); and Haltmeier (2012).

and monetary stimulus.

Adverse effects through multiple channels. Recessions affected potential growth through multiple channels. Four to five years after an average recession, the annual growth of investment, employment, and productivity remained significantly lower than in "normal" years (by 3 percentage points, 0.7 percentage point and 0.7 percentage point, respectively). This contrasts with banking crises, which tended to be associated mostly with lasting losses of productivity growth, and epidemics, which were mainly associated with lasting employment losses, possibly reflecting economic shifts caused by behavioral responses to epidemics.

Different features of potential growth estimates. The comprehensive database also allows a comparisons across potential growth measures. Forecast-based estimates tend to be systematically higher than other estimates, and estimates based on univariate filtering techniques systematically lower. Estimates based on filtering techniques tend to be the most volatile and to track actual growth most closely, as expected. Estimates based on the production function approach tend to be the most stable and the least correlated with actual growth as they capture slow-moving drivers of potential growth.

The study proceeds as follows. Section II presents the database. Section III describes movements in potential growth around the world in recent decades. Section IV estimates the effects on potential growth of recessions. Section V documents the channels through which these operates. Section VI concludes.

II. Database

Three main methods of estimating potential growth estimates have been used in the literature, and several different measures can be derived using variants of them. The comprehensive database developed here allows a comparison of the behaviors of such measures.

The database includes nine measures of potential growth for up to 173 countries over periods as long as 1981-2021. The baseline measure of annual potential growth, estimated using the production function approach, is available for up to 30 advanced economies and 64 EMDEs for 1998-2021 (table 1, annex A). Six univariate and multivariate filter-based estimates of potential growth, which require quarterly data, are available for up to 37 advanced economies and 52 EMDEs for 1980Q1-2022Q1 (annexes B and C). IMF *World Economic Outlook*-based estimates of potential growth are available for up to 37 advanced economies and 136 EMDEs for 1990-2022 (annex D). Consensus forecast-based estimates of potential growth are available for up to 34 advanced economies and 44 EMDEs for 1990-2022.

The database also includes projections for a subset of measures. For the production function approach, projections are available for 2022-32. These projections and the methodology on which they are based are presented and analyzed in Kilic Celik, Kose, and Ohnsorge (2023). For the filter-based estimates, forecasts are available up to 2024Q4.

This study discusses aggregates for the global economy and for particular country groups. These aggregates are real GDP-weighted averages (at 2010-19 prices and market exchange rates) for a balanced sample of 30 advanced economies and 53 EMDEs for 2000-21, unless specified otherwise. The 53 EMDEs comprise 6 economies in East Asia and the Pacific (EAP), 9 economies in Europe and Central Asia (ECA), 16 economies in Latin America and the Caribbean (LAC), 5 economies in the Middle East and North Africa (MNA), 3 economies in South Asia (SAR) and 14 economies in Sub-Saharan Africa (SSA). Data for about half of EMDEs (mainly in ECA and SSA) are not available before 1998. Hence, to ensure broad country coverage, the sample period is restricted to 2000-21 when discussing international averages. However, when discussing the robustness of trends among different measures, the sample is restricted to those countries for which data are available for all measures.

II.1 Basic concepts

Three main methods of estimating potential growth have been employed in the literature, sometimes with different objectives. Some have been used to analyze short-term movements in potential growth, while others have focused on long-term developments (Basu and Fernald 2009). Estimates of movements in potential growth in the short term may be computed using time-series filtering techniques, including univariate or multivariate filters, while estimates of potential output growth over longer periods are usually based on structural models that include a production function or on long-term growth forecasts.

In the short term, when factors of production cannot be reallocated in response to shocks, potential growth may be viewed as the growth of output that can be sustained without putting pressure on given productive capacity and inflation (Okun 1962). Potential output growth can be buffeted in the short term by temporary disruptions and boosts to supply that may dissipate over the longer term. For example, a shift in the composition of demand may render part of the existing capital stock obsolete, effectively reducing potential output and its growth in the short-term. However, over the longer term, firms would be expected to adjust to the new structure of demand, returning potential output growth toward its previous path. The short-term measure is particularly relevant for demand management and monetary policy, since temporary supply constraints or upward demand shocks tend to reduce the effective slack in the economy, with implications for macroeconomic policy and the monetary policy rate. Central banks, in particular, need to focus on movements in potential growth in the short term as they gauge deviations of actual from potential output levels over the horizon of monetary policy transmission, around one to two years.

In the production function framework, potential output growth is a function of growth in the factors of production—the capital stock and the labor force, along with current technological progress (Solow 1962). Potential output growth in the long term thus depends on these fundamental drivers, an implicit assumption being that the factors of production are allocated to their most productive uses, regardless of temporary supply shocks. Finance and economy ministries often focus on potential growth over longer periods, aware that boosting it will promote fiscal sustainability over longer time horizons.

II.2 Measures of potential output growth

The literature has largely focused on three methods of estimating potential growth: a production function method, time-series filters, and analysts' growth forecasts**.**

Production function method. The production function approach represents potential output as a function of the fully utilized capital stock, fully employed labor force, and technology as measured by TFP. For analytical convenience, the production function is often assumed to have a particular form, known as Cobb-Douglas. Potential TFP growth is estimated as the predicted value of a parsimonious panel regression of five-year averages of trend TFP growth on lagged per capita income relative to the advanced-economy average (to proxy convergence-related productivity catchup), education and demographic indicators, and trend investment (annex A). Potential labor supply is estimated as the population-weighted aggregate of predicted values of age- and gender-specific labor force participation rates from regressions on policy outcomes and cohort characteristics, business cycles, and country effects. The potential capital stock is assumed to match the actual capital stock.

Time-series filtering methods. These methods employ univariate or multivariate filters. Univariate filters involve estimates of trend output using only GDP data series (annex B). Multivariate filters use the empirical relationship between GDP and other variables (such as inflation, unemployment rates, commodity prices or financial variables) to help distinguish short-run deviations of output from trends (annex C). The database in this study employs the following five univariate filters: the Hodrick-Prescott filter, the Baxter-King filter, the Christiano-Fitzgerald filter, the Butterworth filter, and a filter based on an unobserved components model. An additional multivariate filter uses financial variables and commodity prices, a Phillips curve relationship, a Taylor rule, and Okun's law.

Growth forecasts. This method is applied using two sets of long-term (five-years-ahead) growth forecasts, from Consensus Economics and the IMF's *World Economic Outlook* database (annex D). These forecasts are based partly on models used by the analysts and partly on the analysts' judgement. Judgment can play an important role during periods of major structural change, which models may not be well-equipped to capture.

Each approach comes with advantages and disadvantages (table 2). Even in data-poor environments, univariate filters are straightforward to implement. Multivariate filters utilize additional information that can ensure that the measure of potential output is better aligned with its determinants, as suggested by economic theory. In particular, the multivariate filter-based estimates can ensure that estimated output gaps in the short term are consistent with indicators of domestic demand pressures (such as inflation, unemployment, current account balances, and capacity utilization). All statistical filters, however, have drawbacks: in particular, they suffer from well-known "end-point" problems that tend to lead to large revisions as new data become available. The approach employed here includes forecasts of real GDP growth to minimize this problem. Since they capture high-frequency movements, measures of potential growth based on filtering techniques correlate strongly with actual output growth and with each other.

The production function approach has the advantage of taking into account the fundamental drivers of output on the supply side—factor inputs and technology—that dominate in the long run. While estimates of potential growth based on this approach are often consistent with long-term growth averages, they correlate less closely with actual growth in the short term. Potential growth measured by the production function approach is also only weakly correlated with potential growth estimates obtained from filtering techniques.

The production function approach has a number of drawbacks, however. It assumes a particular functional form of the relationship between factor inputs, technology, and output. Its application relies on imperfect measures of, or proxies for, the growth of potential TFP, labor supply, and the capital stock. And it is unable to capture cyclical shocks to capacity and supply that may cause short-term fluctuations in potential output. Finally, the approach provides measures of potential output *growth*, but derivation of potential output *levels* would require additional steps to identify an "anchor level" in which the output gap is closed.

Long-term growth forecasts generally incorporate analysts' judgment and, thus, capture factors that cannot be econometrically modelled. As a result, similar to estimates based on the production function approach, these forecasts are only weakly correlated with filter-based estimates of potential growth. However, in practice, forecasts can be sticky and, at times, difficult to interpret.

II.3 Comparison of different potential growth measures

The estimated potential growth rates resulting from the application of these methods differ in their levels and evolutions over time. This section briefly explores these differences.

First, differences among potential growth estimates were wider for advanced economies than EMDEs (figures 1.A and B). During 2000-21, potential growth estimated from forecasts was the highest among the nine measures in more than half the country-year pairs (figure 1.C). The lowest estimates were generally produced by the univariate filters. At the country level, the same pattern was found: forecast-based measures of potential growth tended to be the highest and measures from univariate filters the lowest, especially over the past decade.

Second, multivariate filter-based estimates of potential growth had narrower confidence bands than those based on univariate filters (figure 1.D). This likely reflects the use of additional demand pressure indicators in the multivariate filter that help identify the output gap more accurately. Confidence intervals cannot be computed for estimates based on the production function approach or analysts' forecasts.

Third, global, advanced-economy, and EMDE potential growth estimates based on univariate and multivariate filters typically have the highest variances, while those based on the production function approach have the lowest (figure 1.E). At the country level, univariate filter estimates have the largest variance (in about 75 percent of cases).

Fourth, univariate filter-based estimates have the least persistence, especially in advanced economies, while estimates from forecasts and the production function approach have the most persistence across all groups of countries (figure 1.F).[4] These findings are intuitively appealing, as filter-based estimates are designed to capture time-series variation, whereas the others rely on more persistent drivers of potential growth.

Fifth, estimates from different multivariate and univariate filters tend to be highly correlated, with a median within-country correlation coefficient above 85 percent (figure 2.A). However, they correlate only moderately with estimates from the production function approach and analysts' forecasts. Similarly, production function-based and forecast-based estimates correlate only moderately with each other, whereas estimates from the two sources of growth forecasts are highly correlated with each other.

Finally, as expected, estimates of potential growth based on filters derived from the unobserved components model most closely track actual growth, with an average correlation coefficient of 0.95 across the country sample, followed by estimates based on the multivariate filter and other univariate filters (figure 2.B). As expected, given its construction from slow-moving variables, the production function approach deviates more from actual growth (with a correlation of 0.45 with actual growth). The correlation is even lower for forecast-based measures of potential growth, which tend to change only when forecasters modify their views about long-term growth drivers.

III. Evolution of potential growth

This section first reviews the evolution of potential growth over the past two decades. It then focuses on potential growth during the last two global recessions, of 2009 and 2020. While both sub-sections rely mostly on the production function-based measures of potential growth, the findings are consistent with those from the other measures of potential growth.

III.1 Potential growth over time

Global potential growth, as estimated using the production function approach, fell to 2.6 percent a year over 2011-21 from 3.5 percent a year during 2000-10 (figure 3.A).[5] The weakening of potential growth was internationally widespread. Thus during 2011-21, potential growth was below its 2000-10 average in 96 percent of advanced economies and 57 percent of EMDEs. Economies with potential growth below its 2000-10 average accounted for about 80 percent of global GDP in 2022 (figure 3.B). Per capita potential growth estimates also show a trend decline over time, to 2.0 percent a year in 2011-21 from 2.7 percent a year during 2000-10 (figure 3.C). These estimates suggest a trend slowdown in global potential growth around the cyclical shocks that depressed actual growth below its elevated average in the early 2000s.

[4] The coefficient on lagged potential growth from a regression with one autoregressive term is taken to capture the degree of persistence here.

[5] Data for half the EMDEs (mainly in ECA and SSA) are not available before 1998. Hence, to ensure broad country coverage, the sample period is restricted to 2000-2021 for discussing country groups. However, when robustness of trends among different measures is discussed, the sample is restricted to those countries for which data are available for all measures.

The finding of a decline in potential growth is robust with respect to the measure used, although the magnitude of the slowdown differs across the measures. To ensure comparability, a smaller sample of 30 advanced economies and 25 EMDEs is used for which all nine measures are available. By all these measures, global potential growth slowed by 0.9-1 percentage point a year from its average in 2000-10, to 2.5-2.9 percent a year in 2011-21 (figure 3.D).

In advanced economies, the potential growth slowdown set in before the global financial crisis. After a sharp decline during 2008-10—the period of the global financial crisis and the start of the euro area sovereign debt crisis—potential growth stabilized in 2011-21 as investment growth recovered. However, at 1.4 percent a year over 2011-21, potential growth in advanced economies was 0.8 percentage point below its 2000-10 average (figure 4.A). As in the broader set of advanced economies, potential growth in the G7 economies (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States) was 1.5 percent a year on average in 2011-21, 0.5 percentage points below its 2000-10 average.

EMDEs**,** by contrast, enjoyed a short-lived pre-global recession surge in potential growth in the 2000s that subsequently faded. In the wake of the global financial crisis and associated global recession, a surge in public investment underpinned EMDE potential growth, offsetting softening growth of both TFP and labor supply. As EMDE policy stimulus was unwound and as investment growth plummeted in commodity-exporting EMDEs amid the oil price slide in 2014-2016, EMDE potential growth slowed sharply in 2015-19. A sharp investment growth slowdown during the 2010-19 also depressed potential growth in China whereas the slowdown was milder in other EMDEs where investment growth remained more robust and demographics were more favorable. Overall, at 5.0 percent a year, EMDE potential growth during 2011-21 fell 1.0 percentage point a year short of its average during 2000-10 (figure 4.B).

Across *EMDE regions*, potential growth fell furthest in those regions that had benefited from rapid per capita income convergence in the early 2000s or included many commodity-exporting EMDEs (figures 4.C.and D). The slowdown in potential growth in 2011-21 relative to its 2000-10 average was sharpest in MNA, where investment growth plunged amid the oil price drop of 2014-16 and conflict and policy uncertainty persisted in parts of the region.

In EAP, potential growth in 2011-21 was 1.4 percentage points a year lower than in 2000-10. This decline mostly reflected a slowdown in potential growth in China, partly as a result of policy efforts aimed at rebalancing growth away from investment towards more sustainable growth engines; adding to this was slower growth of both TFP and the working-age population.

In ECA and LCA, potential growth in 2011-21 was 0.5-0.6 percentage point a year lower than in 2000-10. The ECA region's previous two decades of rapid integration into European Union production networks, beginning in the 1990s, gradually diminished its potential for further catchup productivity growth. The region also hosts several energy-exporting countries (including Russia) which suffered recessions or slowdowns in the wake of the 2014-16 slump in oil prices. In LAC, potential growth suffered from weakened productivity growth, partly as a result of adverse terms-of-trade shocks and bouts of policy uncertainty, as well as less favorable demographics.

Potential growth in SSA also declined somewhat (by 0.2 percentage points a year in 2011-21 relative to 2000-10). A sharp slowdown in TFP growth was only partially offset by favorable demographics and rapid capital accumulation, which accelerated as resource discoveries were developed into operating mines and oil fields and governments undertook large-scale public infrastructure investments.

In 2011-21, potential growth in SAR remained broadly unchanged from 2000-10. Growth of the labor force benefited from a demographic dividend. The share of the population of working age rose by more than one-tenth between 2000 and 2021, reaching 67 percent in 2021. Capital and TFP also maintained their growth momentum in 2011-21. Growth in investment remained broadly robust over this period—growing faster than in the EMDE average—and the investment-GDP ratio rose by 5 percentage points of GDP between 2000 and 2021, to more than 28 percent of GDP in 2021.

III.2 Potential growth during global recessions

The 2000-21 period spans two global recessions—the 2009 recession that was triggered by the global financial crisis and the 2020 recession that was caused by the COVID-19 pandemic. These recessions disrupted fixed capital investment and caused widespread employment and output losses. In the case of the 2020 recession, disruptions of education systems caused by pandemic-induced reductions in social interaction also slowed down human capital accumulation.

By the production function-based measure of potential growth, global potential growth slowed by 1.2 and 1.3 percentage point from two years before the global recessions of 2009 and 2020, respectively, to the recession year itself (figure 5.A). The slowdowns in potential growth in EMDEs differed more between the two recessions (1.3 percentage points in 2007-09 and 1.7 percentage points in 2018-20) than the slowdowns in advanced economies (1.2 percentage points in 2007-09 and 1.1 percentage points in 2018-20; figures 5.B and C). The considerably smaller slowdown in EMDEs in the 2009 global recession largely reflected the investment-driven support for potential growth in China during the global financial crisis. In EMDEs excluding China, potential growth declined by 1.2 and 2.0 percentage points in the 2009 and 2020 recessions, respectively (figure 5.D).

In advanced economies, the slowdown in potential growth in the two global recessions reflected steep declines in investment and TFP growth, whereas in EMDEs it reflected mostly a decline in TFP growth (figures 6.A-D). In both country groups, slowing labor force growth also contributed. The steeper slowdown in potential growth in EMDEs in 2020 than in 2009 reflected the deeper collapse in investment but also the pandemic-induced fall in potential labor force participation.

Although both global recessions resulted in a slowdown in potential growth, they differed in the behavior of potential growth in the subsequent recoveries. The global financial crisis was followed by a decade of investment weakness and reduced productivity growth, leading to a failure of potential growth to return to pre-recession rates. In contrast, the 2020 global recession was followed by the swiftest first-year output rebound of any global recession over the past eight decades (World Bank 2021). This was accompanied by strong growth in investment, especially in advanced economies, and a productivity rebound, which together lifted potential growth to pre-recession rates globally, in advanced economies, and in EMDEs. However, the impact of this initial rebound in potential growth is likely to be temporary because of the persistent headwinds faced by the fundamental drivers of potential growth (Kilic Celik, Kose, and Ohnsorge 2023).

These estimated movements in potential growth around global recessions were similar for almost all measures of potential growth, except those based on forecasts. Potential growth declined in the two recession years globally, in advanced economies, in EMDEs, and in EMDEs excluding China.[6] On average across the eight measures that showed declines in the two recessions, global potential growth slowed by about 1.3 percentage points from two years before the recession to the year of the recession.[7] The slowdown was larger in EMDEs (1.5 percentage points) than in advanced economies (1.2 percentage points). The recession year in both episodes generally saw the trough in potential growth for all measures. The estimated decline in potential growth was smallest for production function-based measures and largest for measures obtained using univariate filters.

IV. The long-term effects of short-term shocks on potential growth

The COVID-19-induced output collapse of 2020 renewed concerns about the impact of recessions on the level and growth of potential output. A number of studies have documented the lasting effects of country-specific recessions and financial crises on the level or growth of actual or potential output (Cerra and Saxena 2008; Furceri and Mourougane 2012; Mourougane 2017). However, these studies have mostly focused on OECD countries using only production function-based estimates of potential growth.

This section broadens the scope of the earlier literature in three dimensions. First, it examines the effect of country-specific recessions on potential growth in a much larger sample of countries, including both advanced economies and EMDEs. Second, it employs all the measures of potential growth described above to obtain a better understanding of the linkages between recessions and potential growth. Third, in addition to recessions, it considers other adverse events, such as banking crises and epidemics, and compares their effects on potential growth.

IV.1 Methodology

A (country-specific) recession is defined as a period from a peak in output preceding a business cycle trough to the trough, with a trough defined as a year in which output growth is both negative and at least one standard deviation below its long-term (1995-2020) average (as in Huidrom, Kose, and Ohnsorge 2016). This definition yields up to 124 recessions in 37 advanced economies and up to 351 recessions in 101 EMDEs during 1980-2020.

[6] For the COVID-19-induced global recession of 2020, this is broadly consistent with the findings of persistently lower potential output levels by Bodnár et al. (2020) for the euro area and Fernald and Li (2021) for the United States.

[7] Measures based on consensus forecasts for long-term growth are not covered here because they have a much smaller country sample.

Almost half of such recessions at the country level occurred during global recession years (1975, 1982, 1991, 2009, 2020; figure 7.A). Recessions at the country level, on average, lasted 1.5 years and were associated with a contraction in actual output of 4.0 percent, on average (figure 7.B). In advanced economies, recessions were, on average, somewhat less severe than in EMDEs (with drops of 3.5 percent and 4.3 percent, respectively; figures 7.C and D). The duration of recessions was similar, at 1.5 years, in the two country groups.

A local projection method (LPM) is employed to estimate the evolution of potential growth following recessions (annex E). The model estimates the cumulative effect of recessions on potential growth, following Jordà (2005) and Teulings and Zubanov (2014). In impulse responses, the model estimates the effect of short-term shocks (the recession, banking crisis, or epidemic event) over a horizon *h* on potential growth while controlling for other determinants:

$$y_{i,t+h} - y_{i,t} = \alpha_h + \beta_h shock_{i,t} + \gamma_h \Delta y_{i,t\text{-}1} + fixed\ effects_i + \varepsilon_{i,t}\ ,$$

where $y_{\mathrm{i,t}}$ is potential growth. The model controls for country-fixed effects to capture time-invariant cross-country differences. The variable $shock_{i,t}$ is a dummy variable for a recession event (or banking crisis or epidemic), the main variable of interest. Lagged potential growth $y_{i,t\text{-}1}$ controls for the history of potential growth.

IV.2 Results

Long-term effect of recessions. Even five years after recessions, potential growth as measured by the production function approach is estimated, on average, to have been 1.4 percentage points lower than if a recession had not occurred (figure 8.A). Coefficient estimates for the recession dummy are statistically significantly negative for the first five years after a recession. The effect was somewhat stronger and more persistent for EMDEs, with 1.6 percentage points lower potential growth five years after a recession compared to 1.3 percentage points for advanced economies (figures 8.B.C).

These results are broadly robust to the choice of potential growth measure and the definition of recessions. Four to five years after recessions, potential growth as measured by most methods other than the production function approach is estimated to have been 0.2-1.3 percentage points lower than if a recession had not occurred (annex E).[8]

Recessions could alternatively be defined as years of negative output growth, regardless of the depth of the output decline. This alternative definition of events would yield 541 recessions events (151 events in 37 advanced economies and 390 events in 101 EMDEs), around 14 percent more than the baseline sample of 475 events.[9] Potential growth slowed statistically significantly

[8] The only exceptions are, for advanced economies, forecast-based estimates from the IMF World Economic Outlook database and, for EMDEs, multivariate filters and Hodrick-Prescott-filtered estimates. One possible reason for the unresponsiveness of some forecast-based measures might be that forecasters' perception of long-term growth is stickier for advanced economies than for EMDEs.

[9] By this alternative definition, the average recession is associated with an actual output contraction of 3.7 percent and lasts 1.6 years.

following recessions defined in this way also.

Long-term effect of other adverse events. The effects of banking crises and epidemics on potential growth are also examined and compared with those of recessions (annex E). The banking crises examined are those identified in Laeven and Valencia (2020). This yields a sample of 25 banking crises in 32 advanced economies and 41 banking crises in 91 EMDEs during the period 1990-2021. During the year of an average banking crisis globally, actual output rose by 0.7 percent—well below the average annual global output growth during the sample period of 1990-2021 (3.5 percent) and even further below average annual EMDEs output growth over this period (4.1 percent). The average crisis lasted less than 1 year.

The five recent epidemics examined are: SARS (2002-03), swine flu (2009), MERS (2012), Ebola (2014-15), and Zika (2015-16). They affected 96 countries—32 advanced economies and 64 EMDEs. On average, they were accompanied by close-to-zero output growth, compared to the average growth of 4.0 percent in these countries during the sample period outside these episodes.

Like recessions, both banking crises and epidemics have reduced potential growth, but the time profiles of their effects differed from those of recessions. Banking crises tended to have stronger short-term impacts than recessions but somewhat smaller long-term effects on potential growth.[10] Overall, 81 percent of banking crises were associated with recessions within three years (figure 8.D). Using estimates based on the production function approach, potential growth slowed more steeply in the first 1-2 years after banking crises than after recessions, but the initial decline in potential growth after banking crises was subsequently partly reversed, whereas the slowing effect of recessions strengthened over time (figures 8.A and 9.A). The long-term effects of banking crises on other potential growth measures are estimated to have been even weaker than the effect on measures based on the production function approach (annex E).[11] The effect of banking crises was stronger but shorter-lived in EMDEs than in advanced economies; five years after a banking crisis, the effect was no longer statistically significant in EMDEs but still significant in advanced economies (figures 9.B and C). The fading effect of banking crises on potential growth may in part reflect the lack of a lasting impact on the growth of employment and investment, especially in EMDEs, as the disruptions of banking crises were often followed by economic rebounds.

The strong initial impact of banking crises on potential growth, as well as their declining and highly heterogeneous longer-term effects, are in line with estimates of actual output losses reported in the literature. Candelon, Carare, and Miao (2016) document significant growth

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[10] Results for currency crises and debt crises suggest limited and short-lived impacts that are statistically significant only in the year of the event (currency crises) or up to two years after the event (debt crises).

[11] The exercise is repeated for banking crises that were followed by recessions within a three-year window. There were 20 such cases events in the sample used here. The results indicate statistically significant impacts of recessions combined with banking crises, with somewhat larger short-term effects but similar long-term effects to banking crises, but the difference between the responses of potential growth to banking crises with and without recessions is not statistically significant.

slowdowns in the first year following banking crises which become more muted in subsequent years. Similarly, Dwyer, Devereux, and Baie (2013) document wide heterogeneity in growth impacts five years after banking crises.[12] In a comprehensive review of the literature, Claessens and Kose (2018) also find that the duration of a recession depends on the features of the financial stress that accompanies it. In particular, house price busts, especially when combined with credit crunches, can prolong recessions, whereas a rapid recovery in housing and asset markets can accelerate the broader economic recovery from financial stress.

Epidemics, too, had somewhat more modest, but still statistically significant, negative long-term effects on potential growth than did recessions—larger in EMDEs than in advanced economies (figures 2.8.A and 2.9.D). Based on the production function measure, potential growth five years after an epidemics was 0.9 percentage point lower than it would otherwise have been (compared with declines of 1.2 and 1.4 percentage points after banking crises and recessions, respectively). One reason for the more muted effect of epidemics than of recessions is their more muted effect on productivity over the medium term. Experience since 2020, when the COVID-19 pandemic erupted, has shown how rapidly productivity can rebound when pandemic restrictions are lifted and disruptions are resolved.

V. How do short-term shocks affect potential growth?

The previous section established that recessions have been associated with significantly slower potential growth for several subsequent years. This section assesses three possible channels through which this process unfolded: employment, investment, and TFP growth. The literature provides ample evidence that all three channels suggested by the production function approach are likely to have been important in weakening potential growth following recessions and other adverse events.

V.1 Effects of recessions

Employment and labor supply. In a recession, unemployment generally rises significantly and remains elevated for a prolonged period. For example, in the sample of recessions examined here, unemployment remained 1.8 percentage points higher, on average, three years after the recession than would have been the case otherwise (annex E). Such a lasting effect is in line with other findings in the literature. In the United States, for example, a 1 percentage point increase in state-level unemployment during the 2007-09 recession was associated with 0.3 percentage point lower employment rates in 2015 (Yagan 2019). Following recessions, lingering uncertainty about future sales prospects may discourage firms from hiring (Baker, Bloom, and Davis 2016; Bloom 2009, 2014). Financial constraints may force the more indebted firms into greater job cuts in the event of demand drops (Giroud and Mueller 2017). Long spells of unemployment may

[12] Even if the effect of banking crises on output growth has been short-lived, their effect on output levels has been persistent. Cerra and Saxena (2008) showed this for actual output levels five to ten years after financial crises; Ollivaud and Turner (2014) showed this for potential output levels three to seven years after the global financial crisis.

discourage workers and erode the skills of the long-term unemployed (Ball 2009; Blanchard 1991; Blanchard and Summers 1987). Thus, the decrease in employment over a prolonged period after a recession tends to have adverse consequences for labor supply and potential output.

Investment and capital accumulation. Gross fixed investment typically falls more sharply in response to economic downturns than other components of GDP (Kydland and Prescott 1982). A recession can cause investors to reassess long-term growth prospects. A downgrade in growth forecasts could erode prospects of long-term returns on investment or risks around expected returns and, thus, discourage investment. Access to finance for investment may also become more restricted and discourage investment, especially for younger, more innovative, and riskier firms (Fort et al. 2013).[13] Reduced capital accumulation in a recession will directly reduce potential growth.

Total factor productivity. A collapse in investment growth not only directly reduces potential growth but also indirectly by slowing the adoption of productivity-enhancing embodied technologies and the reallocation of resources towards more productive uses (Dieppe, Kilic Celik, and Okou 2021; Syverson 2011). Workers losing their jobs during recessions may enter permanently lower-skilled career paths (Huckfeldt 2022). Skills mismatches between job market entrants and job requirements are larger during recessions than expansions and tend to be long-lasting, suggesting persistent productivity losses from such mismatches (Liu, Salvanes, and Sørensen 2016). Recessions are also likely to be associated with reduced spending on research and development, with negative consequences for the growth of TFP.

All three channels were at work during the recessions considered in this study (annex E). Five years after the average recession, TFP growth is estimated to have been 0.7 percentage point lower than it would have been without a recession and, in EMDEs, 0.9 percentage point lower (figures 10.A and 11.A). Investment growth declined steeply in the first year of the average recession and remained significantly lower five years later—3 percentage points below what it would have been without a recession, both globally and in EMDEs (figures 10.B and 11.B).

The effect was somewhat shorter-lived for employment. Four years after the average recession, employment growth was about 0.7 percentage point lower than what it would have been otherwise. However, for EMDEs, this effect was no longer statistically significant by the fifth year (figures 10.C and 11.C). The absence of a longer-lasting employment response in EMDEs is, in part likely to reflect the large, flexible informal economies that help these countries absorb shocks to labor markets.

V.2 Effects of banking crises and epidemics

The effects of banking crises on the growth of TFP, investment, and employment tended to be short-lived (figures 10.D-F and 11.A-F). Five years after the average banking crisis, neither investment growth nor employment growth were statistically significantly lower than otherwise;

[13] Similar lasting impacts of investment weakness have been shown for banking crises (Wilms, Swank, and de Haan 2018).

only TFP growth was still significantly lower. Epidemics were associated, even five years later, with statistically significantly lower TFP growth, investment growth, and—in contrast to recessions and banking crises—potential labor supply growth. The effect of epidemics on investment growth after five years was somewhat stronger, and the effect on TFP growth weaker, than the effects of recessions (figures 10.D-F).

Banking crises had larger long-term adverse effects on TFP growth, investment growth, and employment growth in advanced economies than EMDEs, possibly reflecting the larger role of finance in, and greater financial development of, advanced economies. Conversely, epidemics had larger long-term adverse effects on these variables in EMDEs than in advanced economies, in part perhaps because EMDE governments and central banks had less policy room to dampen the economic effects of epidemic disruptions (figures 11.A-F).

VI. Conclusions

Potential growth, the growth an economy can generate at full employment and full capacity, is critical for a sustained increase in living standards. It also anchors the calibration of macroeconomic policies. This study introduced the most comprehensive international database of potential growth, including the nine most widely used measures of potential growth for up to 173 countries over 1981-2021. At the global level, all measures point to a steady decline in potential growth in the past decade. This decline was internationally widespread, with potential growth in 2011-21 falling below its 2000-10 average in 70 percent of countries. The decline in potential growth between 2000-10 and 2011-21 was almost as large in advanced economies (0.8 percentage point per year) as in EMDEs (1.0 percentage point per year).

The study also presented an application of the new database by studying the effects of recessions and other adverse events on potential growth. Recessions, on average, have been followed, even five years later, by a drop of 1.4 percentage points in potential growth. The magnitude of this estimated decline varies somewhat among the possible measures of potential growth, but it is virtually always statistically significant. This lasting effect of recessions operates through the many channels: Four to five years after recessions, investment growth, productivity growth, and employment growth all remained statistically significantly lower. In addition, this study compared the effects of recessions with those of other adverse events, such as banking crises and epidemics. The long-term effect of recessions was somewhat deeper than that of banking crises and more broad-based than that of epidemics.

Understanding the behavior of potential growth is of fundamental importance to short- and long-run macroeconomic analyses and policy formulation. The new database will facilitate future research on a number of topics related to potential growth.

Role of human capital accumulation in driving potential growth*.* To improve estimates of potential growth based on the production function approach, broader measures of human capital could be constructed, using information beyond the education enrollment and completion metrics and life expectancy data used in this study. The COVID-19 pandemic demonstrated the critical importance of a broader measures of human capital that takes into account such factors as morbidity and the quality of schooling (Angrist et al. 2021; World Bank 2018). The World Bank's *Human Capital Index* offers one such measure but is thus far available only for very few countries and years (World Bank 2021). In addition, there is some evidence that increased human capital is more growth-enhancing in the presence of better institutions (Ali, Egbetokun, and Memon 2018). Future specifications could take into account such interaction effects.[14]

Effects of climate change-related weather events on potential growth. There is growing evidence that climate change-related weather events are causing increasingly frequent and severe damage to output and that they have consequences for potential growth. Some of these are associated with increased migration (Missirian and Schlenker 2017); shorter working hours in industries with widespread outdoor labor due to excessive heat (ILO 2019); falls in total factor productivity (Economides and Xepapadeas 2018); and increased economic volatility (Panton 2020). Overall, climate change has been shown to be associated with significant output losses (Cantelmo, Melina, and Papageorgiou 2019; Colacito, Hoffman, and Phan 2018; Kahn et al. 2019). Conversely, increased investment designed either to increase resilience to adverse climate events or to mitigate climate change could provide a boost to potential growth (IMF 2019). Some of these diverging forces are explored in Kilic Celik et al. (2023). In any event, it will be essential to analyze the implications of climate change for potential growth.

Role of natural resources in the measurement of potential growth. Particularly for countries that rely heavily on natural resources, production function-based estimates of potential growth could be improved by taking into account natural resources as a factor of production whose depletion can reduce potential growth. In addition, research could take into account the adverse implications of natural resources for other factors of production and productivity. For example, natural resources affect the growth benefits of foreign direct investment (Hayat 2018) and of aggregate investment (Gylfason and Zoega 2006). They can also have reduce productivity through rent-seeking behavior (Torvik 2002) and sectoral shifts (Stokke 2008).

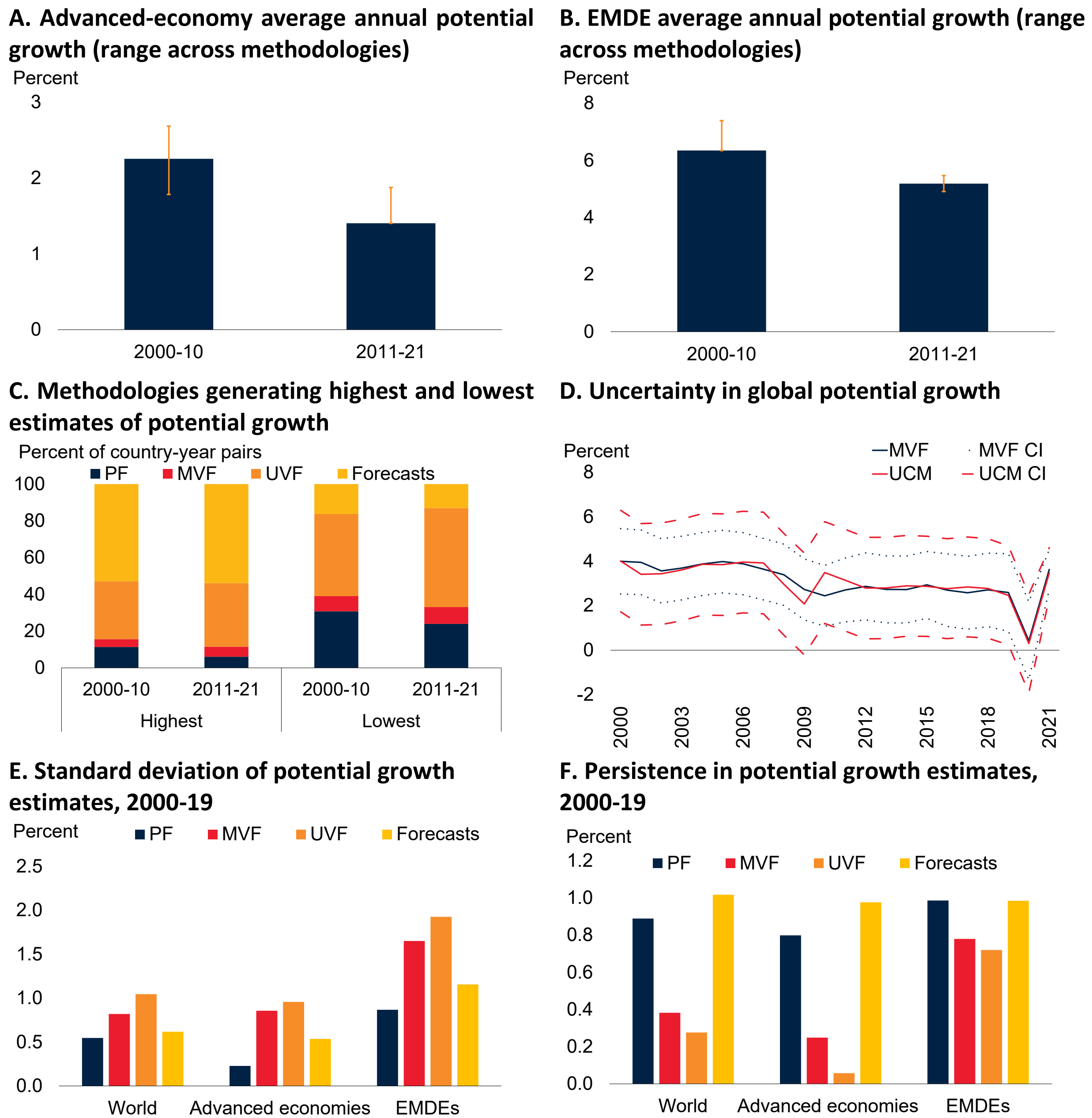
Implications of emerging trends in drivers of growth. Measures of TFP based on the production function approach could be refined to capture new developments. For example, the energy transition could generate large sectoral shifts, with consequences for TFP growth, and major investments (IMF 2021). The broadening use of digital technologies, the shift from trade in goods to trade in equipment services ("servitization"), and shifts in global value chains could change the patterns of cross-country technology transfers and hence affect productivity growth and foreign direct investment flows. Servitization and digitalization have been associated with productivity gains in the affected firms and industries (Cette, Nevous, and Py 2022; Gal et al. 2019). Conversely, concerns have been raised that friendshoring or nearshoring of global value chains may be associated with productivity losses (Moran and Oldenski 2016; Quian, Liu, and

[14] Loayza and Pennings (2022) have developed tools to model long-term growth. These include applications such as how public investment affects growth, the determinants of TFP, and the evolution of growth in resource-rich economies.

Steenbergen 2022).

Better measures of output gaps. Output gap estimates are important inputs into macroeconomic policy decisions, especially monetary ones. Hence, multivariate filter-based potential growth estimates could be tailored to capture more closely the relationship between domestic inflation and domestic monetary policy by controlling for additional external factors. These include global output gaps, global commodity price cycles, and global financial cycles. Especially for EMDEs, estimates could also be extended backwards in time and systematically tested, and adjusted, for major structural breaks.

FIGURE 1 Estimates of potential growth



Source: World Bank.

Note: "PF" stands for production function approach, "MVF" for multivariate filter, "UVF" for univariate filter, and "Forecasts" for five-year-ahead growth forecasts from the IMF World Economic Outlook. "EMDE" = emerging market and developing economies. Aggregates refer to weighted averages (constant real GDP weights at average 2010-19 prices and exchange rates).

A.B. Blue bars denote production function-based estimates. Orange whiskers indicate the range of eight estimates.

C. Graph shows the share of country year pairs during each period in which each methodology generates the highest or the lowest estimate of potential growth. Only country-year pairs are considered for which at least two methodologies are available. "UVF" stands for any of four univariate filters (Christiano-Fitzgerald filter, Baxter-King, Hodrick-Prescott, or Butterworth). Unbalanced sample of 30 advanced economies and 25 EMDEs for 1998-21.

D. "UCM CI" and "MVF CI" are 95 percent confidence bands of each methodology. Unbalanced sample of 30 advanced economies and 25 EMDEs for 2000-21.

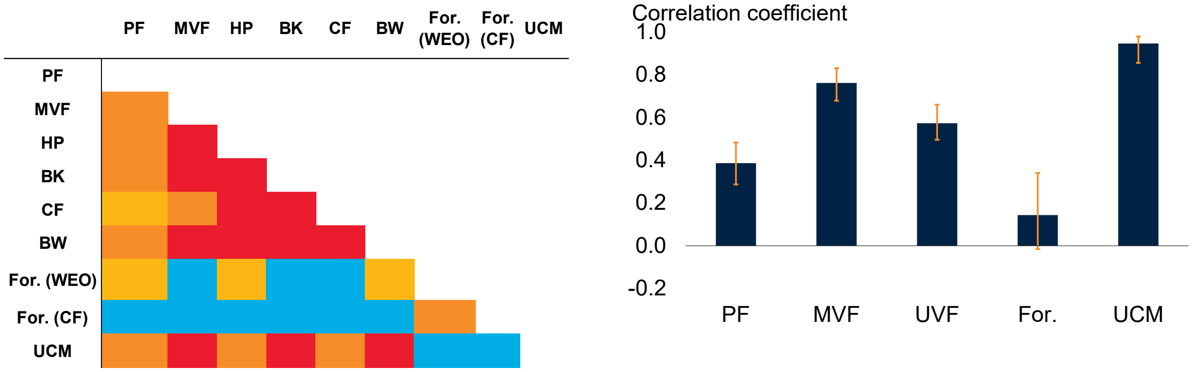
E. Standard deviation of potential growth estimates over 2000-2019. "UVF" is the maximum among the univariate filters. Unbalanced sample of 30 advanced economies and 40 EMDEs.

F. Coefficient estimates on lagged potential growth from an AR1 regression of global, advanced-economy, and EMDE potential growth for 2000-2019. "UVF" is the minimum among the univariate filters. Unbalanced sample of 30 advanced economies and 25 EMDEs for 2000-21.

FIGURE 2 Comparison of potential growth estimates

A. Correlation of potential growth, 2000-21

B. Correlation of potential growth estimates with actual growth, 2000-20



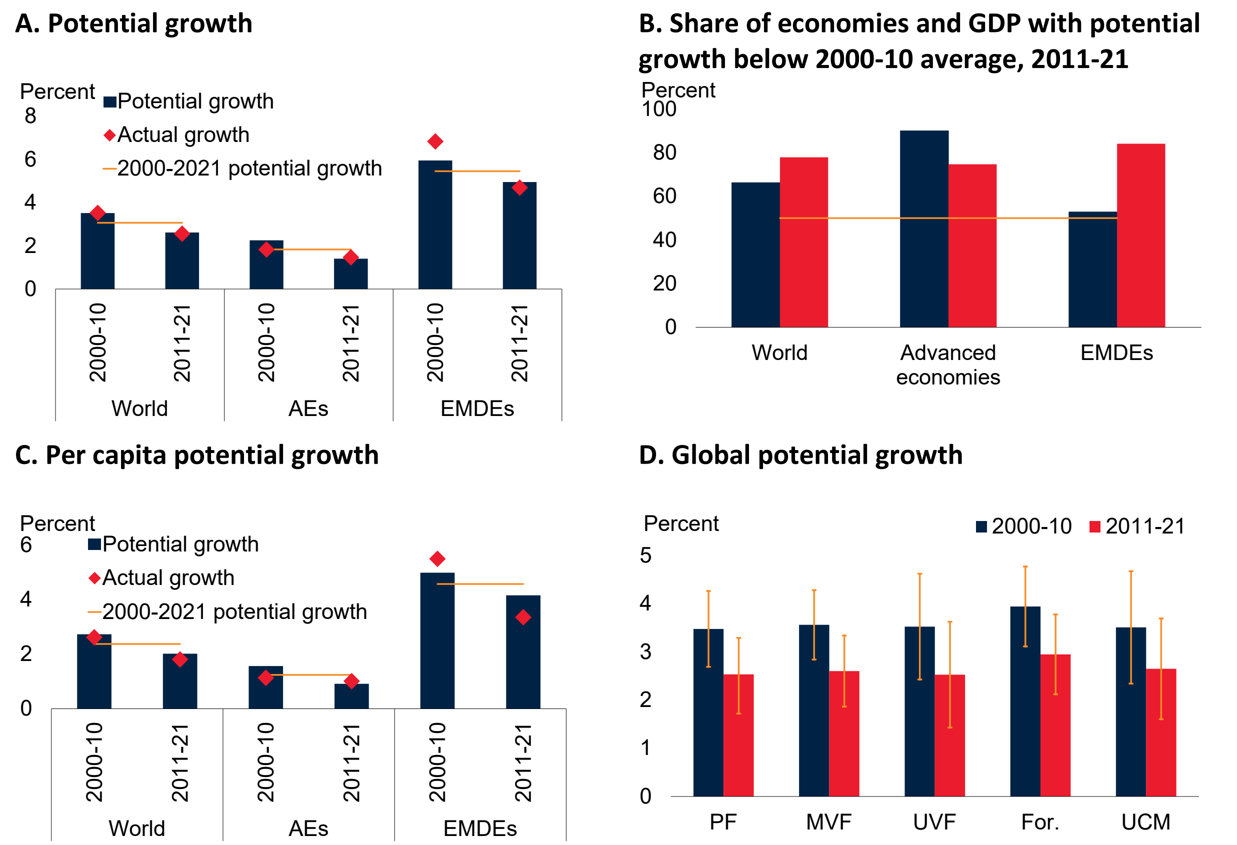
Source: World Bank staff estimates.

Notes: "PF" stands for production function approach; "HP" for Hodrick-Prescott filter; "BK" for Baxter-King filter; "MVF" for multivariate filter; "CF" for Christiano-Fitzgerald filter; "For. (WEO)" or "For." for five-year-ahead growth forecasts from the IMF World Economic Outlook database; "For. (CF)" for five-year-ahead growth forecasts from the Consensus Economics; "UCM" for Unobserved Components Model.

A. Figure shows the within-country correlation during 2000-20 between different measures of potential growth. Red represents greater than 80 percent, orange represents 60-80 percent, yellow represents 40-60 percent, and light blue represents 20-40 percent. Unbalanced sample of 37 advanced economies and 63 EMDEs for 2000-21.

B. Blue bars show the median of within-country correlation during 2000-20 between different measures of potential growth and actual growth. Orange whiskers represent the 25th and 75th percentiles of within-country correlation during the same period. Unbalanced sample of 37 advanced economies and 95 EMDEs for 2000-20.

FIGURE 3 Evolution of potential growth



Sources: World Bank, UN population statistics.

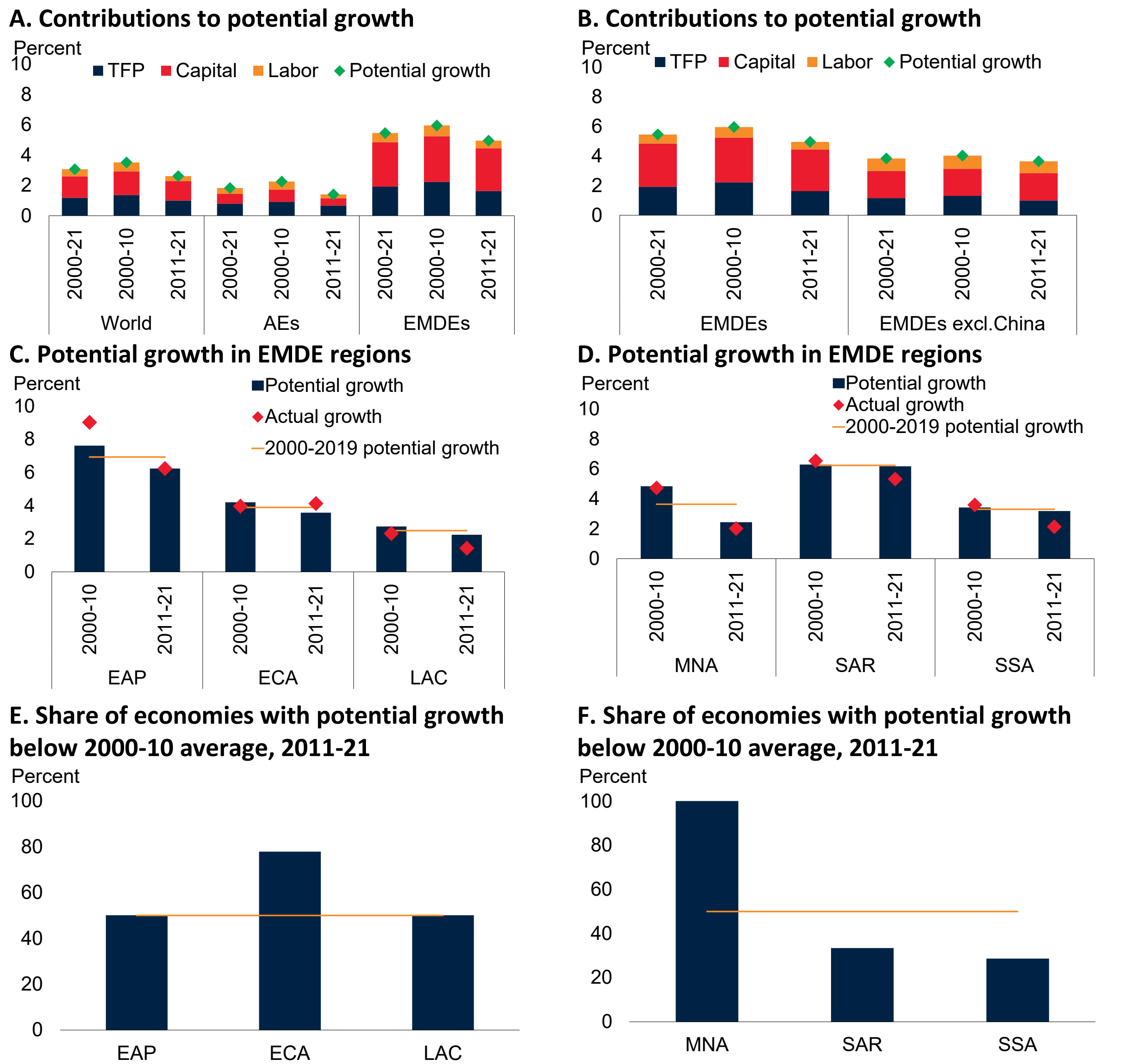
Note: AEs = advanced economies; EMDEs = emerging market and developing economies.

A.B.C. Based on potential growth derived using production function approach. GDP-weighted average. Sample includes 30 advanced and 53 emerging market and developing economies.

B. Number of economies and their share of global or group GDP with potential growth in each period below its 2000-10 average. Horizontal line indicates 50 percent. Unbalanced sample of 30 advanced economies and 53 EMDEs for 2000-21.

D. Based on common sample of 30 advanced economies and 25 EMDEs for 2000-21 to ensure consistency in samples across methodologies. Orange whiskers indicate range implied by GDP-weighted average of country-specific standard deviations of potential growth estimates for each approach.

FIGURE 4 Drivers of potential growth



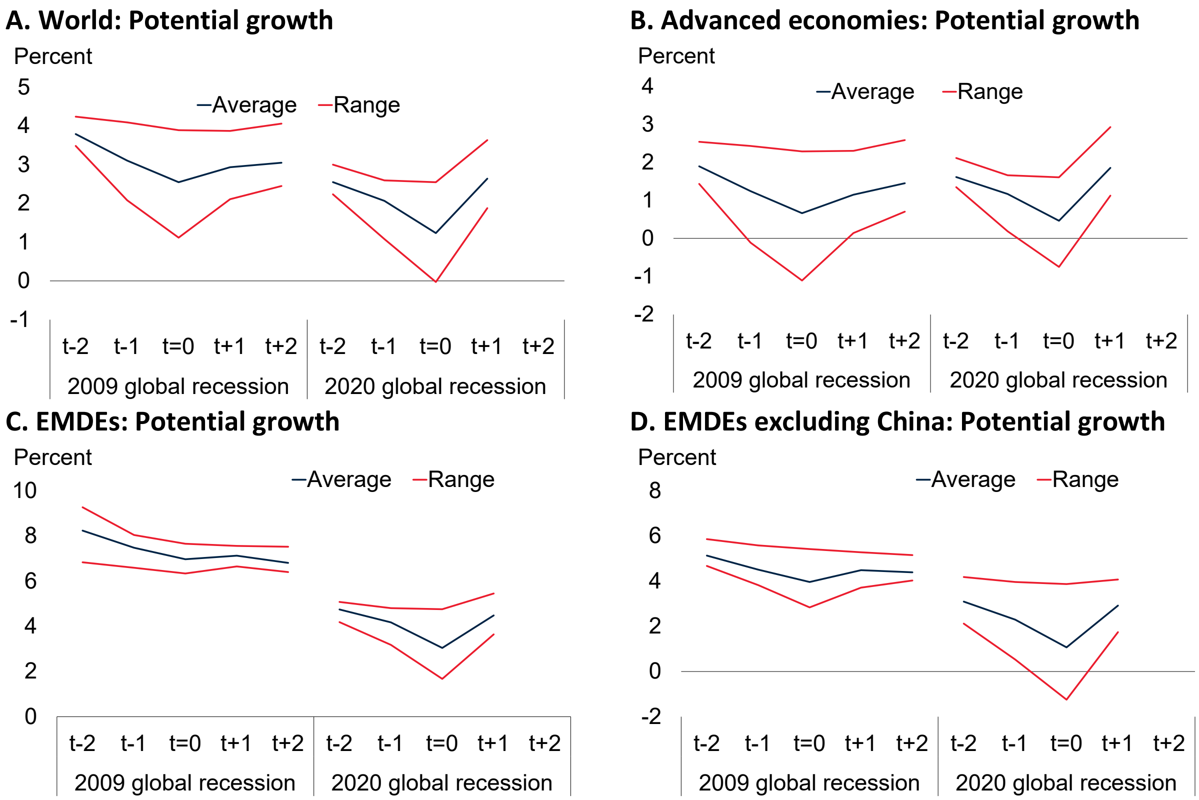
Source: World Bank staff estimates.

Note: GDP-weighted averages of production function-based potential growth estimates. TFP growth stands for total factor productivity growth. AEs = advanced economies; EMDEs = emerging market and developing economies.

A.-D. Sample of 30 advanced economies and 53 EMDEs.

E.F. Number of economies and their share of GDP in a region among 53 EMDEs with potential growth in each period below its 2000-10 average. Horizontal line indicates 50 percent. Regional samples include the largest available coverage for each region. EAP stands for East Asia and Pacific (6 countries), ECA stands for Europe and Central Asia (9 countries), LAC stands for Latin America and the Caribbean (16 countries), MNA stands for Middle East and North Africa (5 countries), SAR stands for South Asia (3 countries), and SSA stands for Sub-Saharan Africa (14 countries). In all MNA countries, potential growth was higher in 2000-10 than in 2011-21 (and higher than the full-period average) because of a commodities boom in the first decade of the 2000s that was followed by a commodity price plunge, political tensions, and conflict in the second decade of the 2000s.

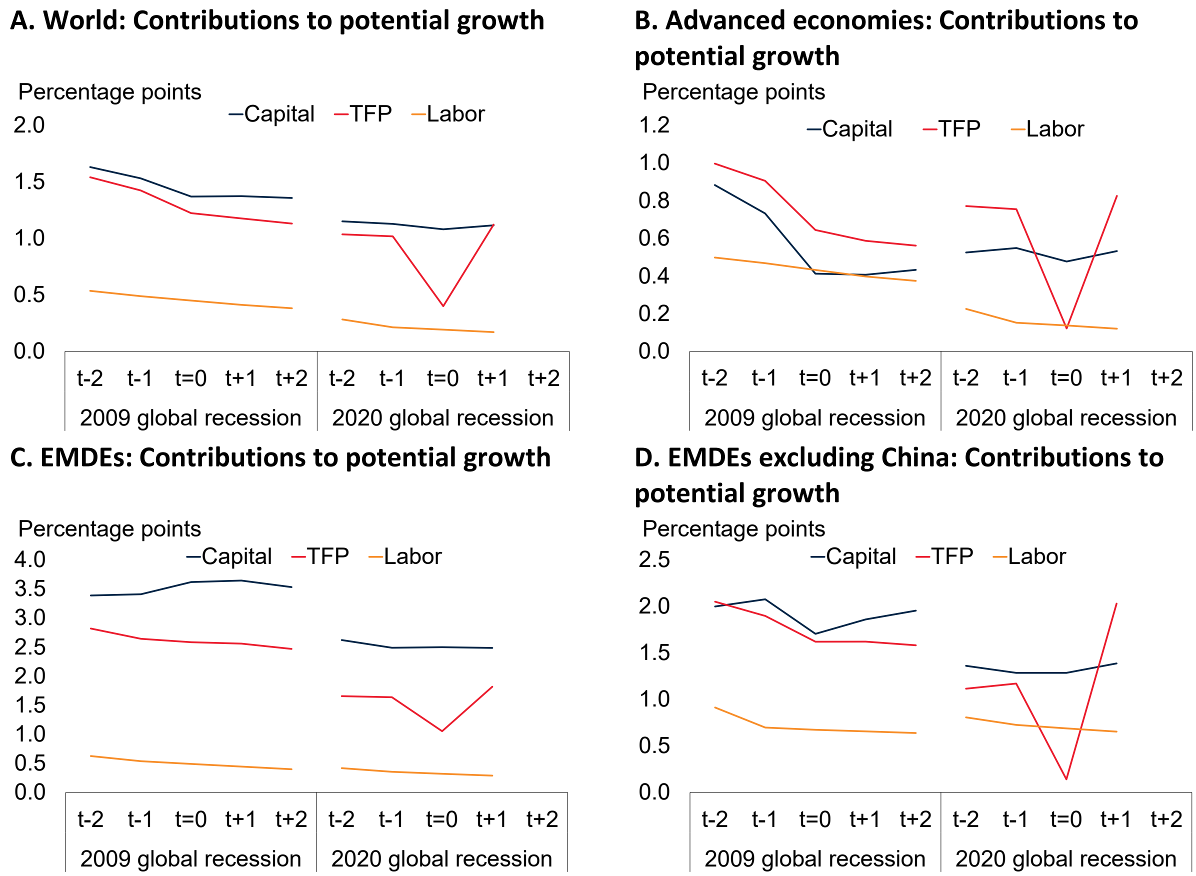
FIGURE 5 Potential growth around the global recessions of 2009 and 2020



Sources: World Bank; World Economic Outlook.

Note: EMDEs = emerging market and developing economies. "Average" is an unweighted average of seven potential growth measures (excluding expectations). "Range" reflects the maximum and minimum. Figures show potential growth around global recessions in t=2009 and t=2020. Unbalanced sample of 30 advanced economies and 25 EMDEs for 2007-21.

FIGURE 6 Drivers of potential growth around the global recessions of 2009 and 2020

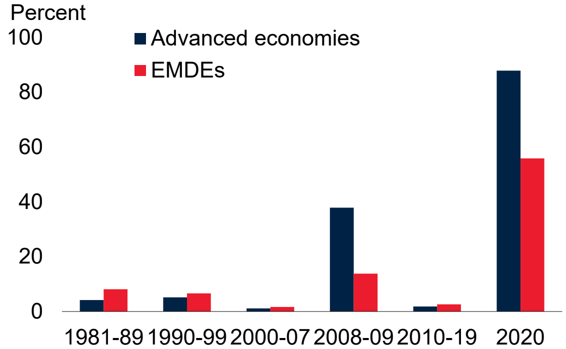


Sources: World Bank; World Economic Outlook.

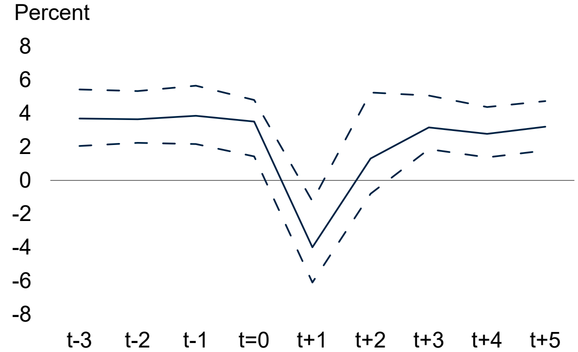
Note: EMDEs = emerging market and developing economies. Figures show the contributions of capital, total factor productivity (TFP), and labor to potential growth around t=2009 and t=2020. Unbalanced sample of 30 advanced economies and 25 EMDEs for 2007-21.

FIGURE 7 Characteristics of recessions

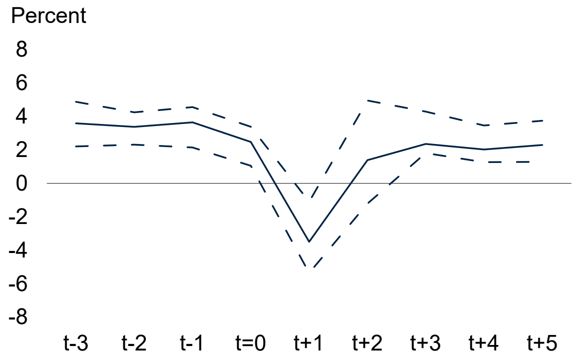
A. Share of countries with recessions



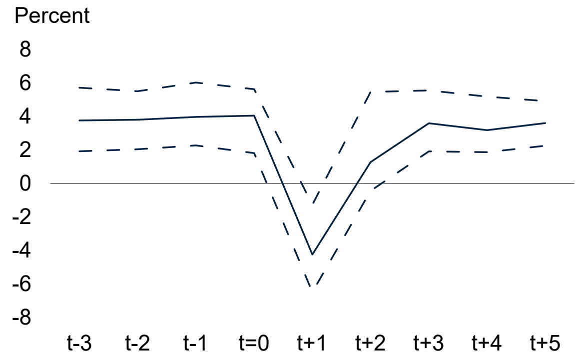
B. Actual growth during recessions: World



C. Actual growth during recessions: Advanced economies



D. Actual growth during recessions: EMDEs

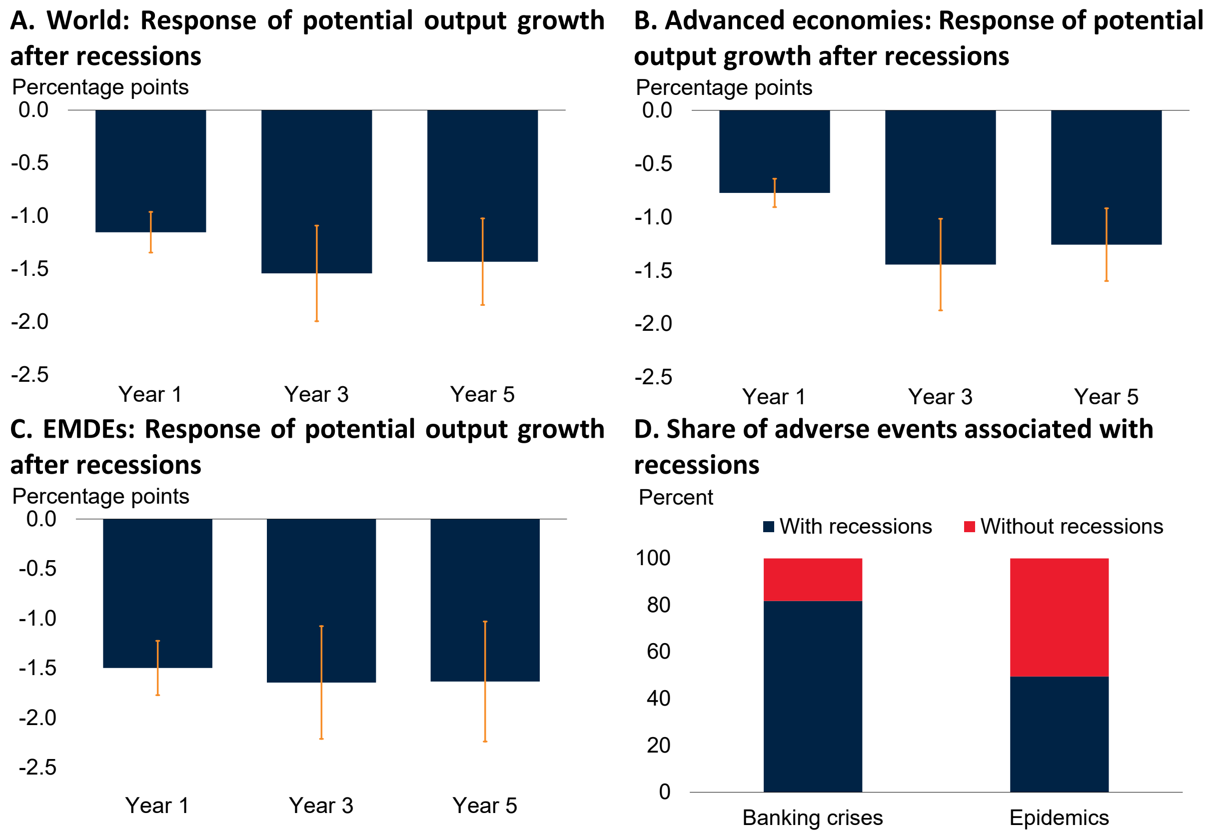


Source: World Bank.

Note: Recessions are defined as the period from the peak preceding a business cycle trough to the trough, with a trough defined as a year in which output growth is both negative and at least one standard deviation below its long-term average. Sample includes 91 recession events in 33 advanced economies and 190 recession events in 77 EMDEs during 1981-2020.

B. Unweighted averages of actual growth during recessions as defined in annex 2E denotes the peak year preceding the recession.

FIGURE 8 Effects of recessions on potential growth



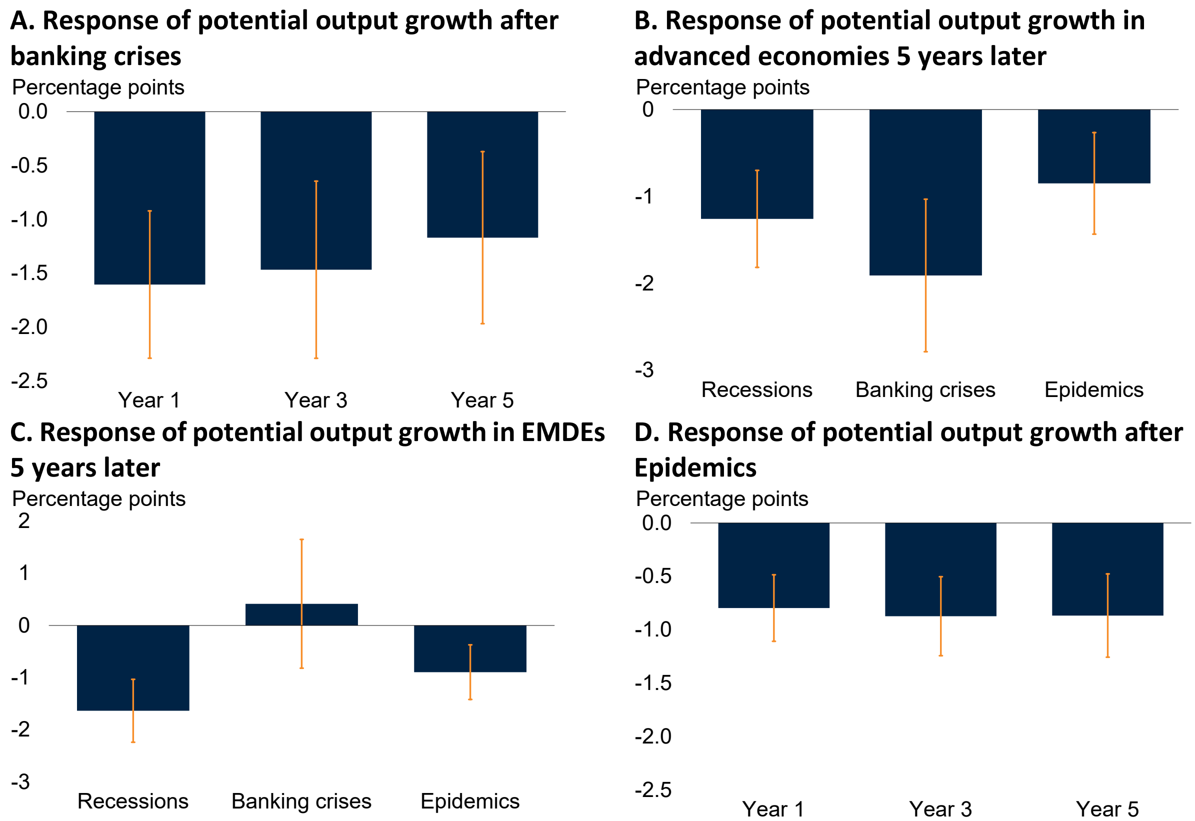
Source: World Bank.

Note: Recessions are defined as the period from the peak preceding a business cycle trough to the trough, with the troughs defined as years in which output growth is both negative and one standard deviation below the long-term average. Banking crises are identified as in Laeven and Valencia (2020). Epidemics include SARS (2003), swine flu (2009), MERS (2012), Ebola (2014), and Zika (2016).

A.-C. Blue bars are coefficient estimates from local projections model. Orange whiskers indicate 90 percent confidence interval. Methodological details are in annex E. Sample includes unbalanced panel of 28 advanced economies 50 EMDEs for 1998-2020.

D. Share of events associated with recessions is the share of events that coincide with a recession in a 3-year window, out of the total number of events. Sample includes unbalanced panel of 33 advanced economies and 98 EMDEs for 1981-2020.

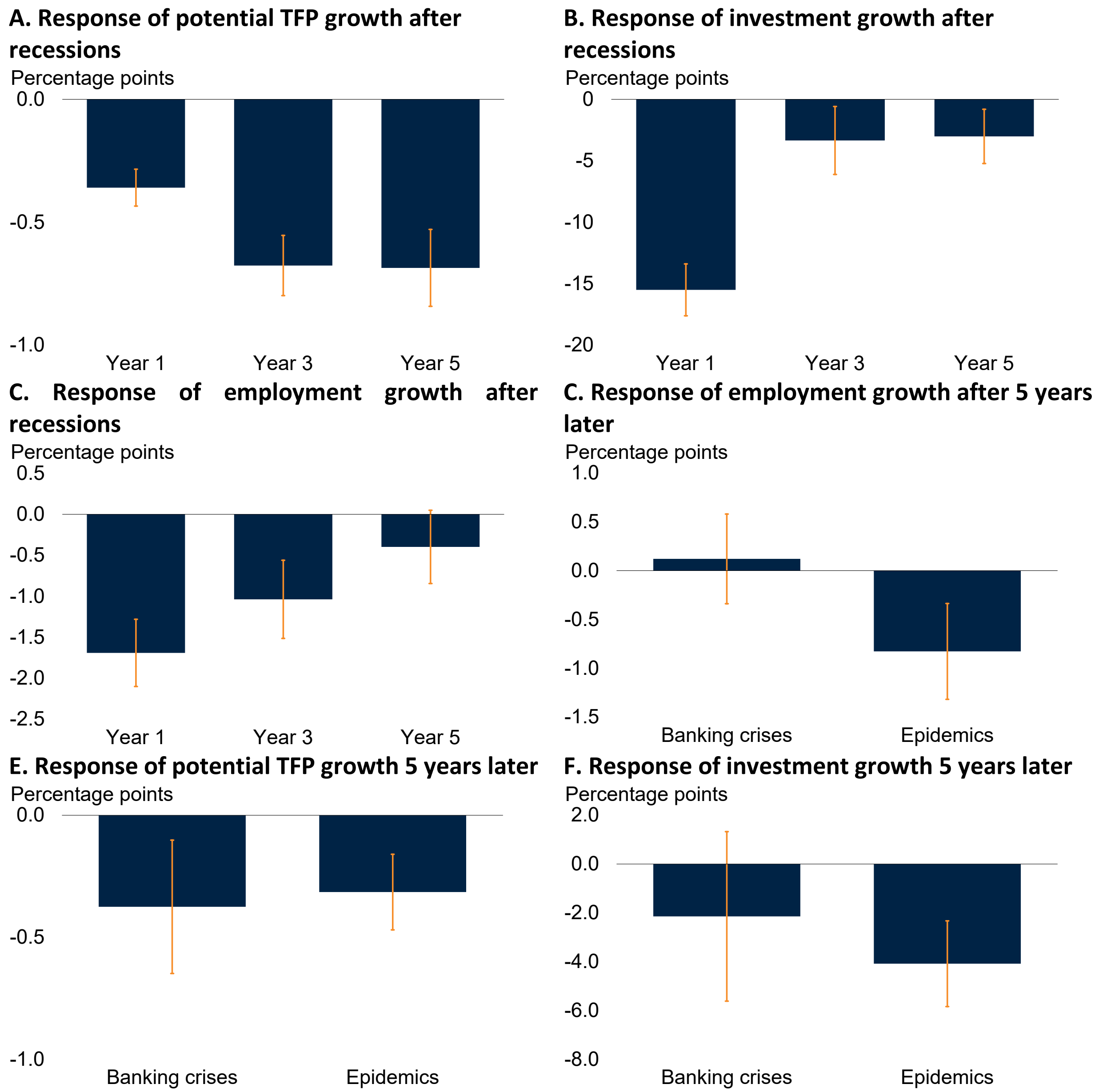
FIGURE 9 Effects of banking crises and epidemics on potential growth



Source: World Bank.

Note: Blue bars are coefficient estimates from local projections model. Orange whiskers indicate 90 percent confidence interval. Methodological details can be found in annex E. Recessions are defined as the period from the peak preceding a business cycle trough to the trough, with the troughs defined as years in which output growth is both negative and one standard deviation below the long-term average. Banking crises are identified as in Laeven and Valencia (2012, 2018, 2020). Epidemics include SARS (2003), swine flu (2009), MERS (2012), Ebola (2014), and Zika (2016). Sample includes unbalanced panel of 32 advanced economies 97 EMDEs for 1981-2020.

FIGURE 10 Effects of adverse events on growth of employment, TFP, and investment

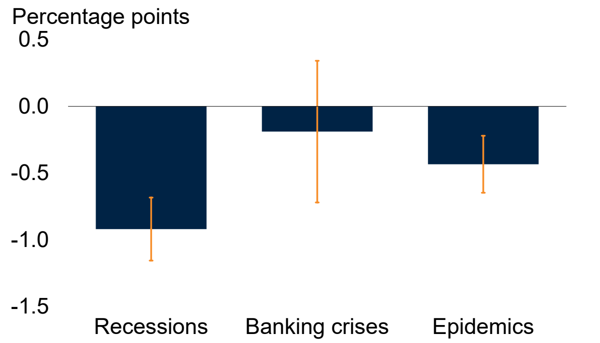


Source: World Bank.

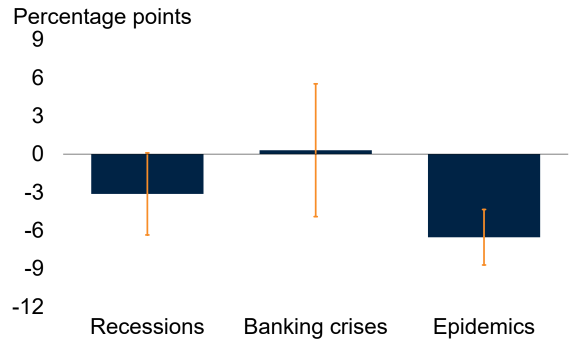
Note: Blue bars are coefficient estimates from local projections model. Orange whiskers indicate 90 percent confidence interval. Recessions are defined as the period from the peak preceding a business cycle trough to the trough, with the troughs defined as years in which output growth is both negative and one standard deviation below the long-term average. Banking crises are identified as in Laeven and Valencia (2020). Epidemics include SARS (2003), swine flu (2009), MERS (2012), Ebola (2014), and Zika (2016). Sample includes unbalanced panel of 32 advanced economies 97 EMDEs for 1981-2020.

FIGURE 11 Effects of adverse events on growth of employment, TFP, and investment in advanced economies and EMDEs

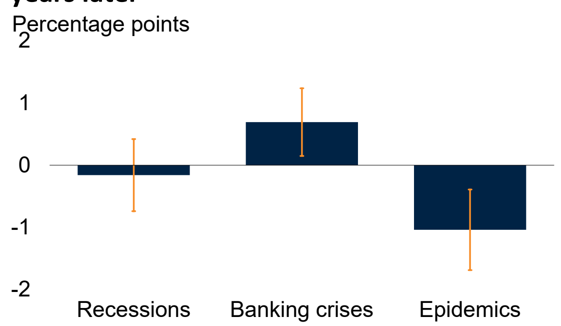
A. EMDEs: Response of potential TFP growth 5 years later



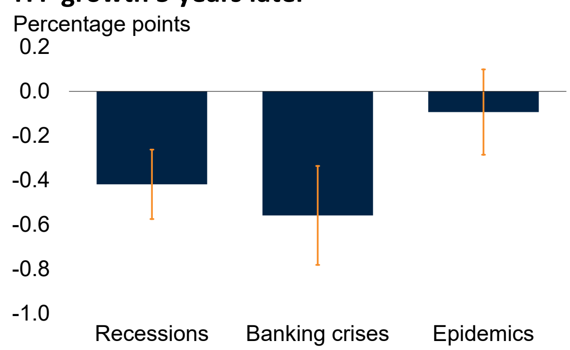
B. EMDEs: Response of investment growth 5 years later



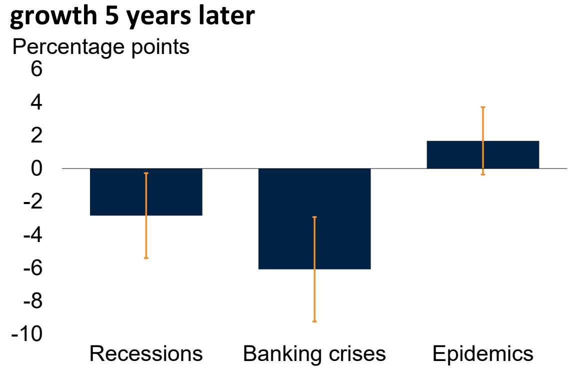
C. EMDEs: Response of employment growth 5 years later



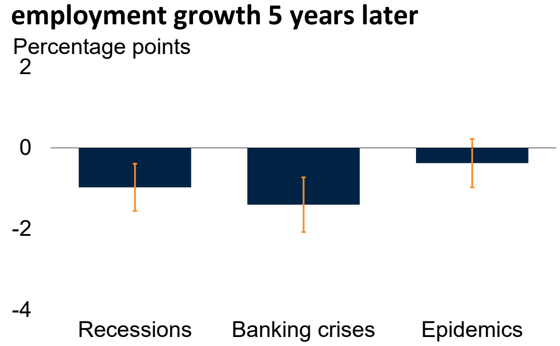
D. Advanced economies: Response of potential TFP growth 5 years later



E. Advanced economies: Response of investment growth 5 years later



F. Advanced economies: Response of employment growth 5 years later



Source: World Bank.

Note: Blue bars are coefficient estimates from local projections model. Orange whiskers indicate 90 percent confidence interval. Recessions are defined as the period from the peak preceding a business cycle trough to the trough, with the troughs defined as years in which output growth is both negative and one standard deviation below the long-term average. Banking crises are identified as in Laeven and Valencia (2012, 2018, 2020). Epidemics include SARS (2003), swine flu (2009), MERS (2012), Ebola (2014), and Zika (2016). Sample includes unbalanced panel of 32 advanced economies 97 EMDEs for 1981-2020.

ANNEX A Production function approach

The production function approach assumes that potential output can be captured by a Cobb-Douglas production function with constant returns to scale (Solow 1957):[15]

$Y_t = A_t K_t^{a} L_t^{(1-a)}$,

where Y_t is potential output, A_t is potential total factor productivity (TFP), K_t is the potential capital stock, and L_t is potential employment. To extend the sample beyond 2019—the latest available data from Penn World Tables—TFP was recalculated as the Solow residual of output, employment (extended using data from *Haver Analytics*) and capital (extended using investment data from *Haver Analytics* and the perpetual inventory method; table 3). Labor and capital shares are the within-country averages of those reported in *Penn World Tables*. Human capital is not separately accounted for in the production function approach but affects TFP growth and labor supply growth, as described below.

Two of the three components of potential output—potential TFP and potential employment—are proxied by the fitted values from panel regression estimates. The third component, the contribution of capital to potential growth, is assumed to be the same as the contribution of capital to actual growth, as shown in the *Penn World Tables* (and extended using data from *Haver Analytics*). This approach yields an unbalanced panel dataset for 30 advanced economies and 64 EMDEs for 1998-2021 (table 4). The same approach, using appropriate assumptions, can be used to project potential growth into the future. These assumptions and the approach for projections for 2022-32 are detailed in Kilic Celik, Kose, and Ohnsorge 2023.

Capital stock data from Penn World Tables 10.0 is used until the latest available year in the dataset (2019 for most countries in the sample). For 2020-21, investment data are compiled from national statistical agencies and Haver Analytics, while the capital stock is estimated from investment data by the perpetual inventory method using historical average depreciation rates.[16]

Potential TFP growth is defined as the fitted value of a panel fixed effects regression for 33 advanced economies and 92 EMDEs for 1983-2020 of Hodrick Prescott-filtered trend of actual TFP growth (the Solow residual) on determinants of productivity. These include GDP per capita relative to advanced economies, education (secondary school completion rate), the working-age share of the population, and the five-year moving average real investment growth (as in Abiad, Leigh, and Mody 2007; Bijsterbosch and Kolasa 2010; Feyrer 2007; Turner et al. 2016).[17] To allow for nonlinearities in the productivity dividends from education, schooling is interacted with a

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[15] The potential growth estimates may be biased if the assumption of constant returns to scale is not valid (Dribe et al. 2017). For a detailed discussion of drawbacks of growth accounting, see Dieppe and Kilic Celik (2021). That said, the approach is widely used for its conceptual simplicity and ease of interpretation.

[16] Implicitly, this approach does not account for the possibility that inefficient investment is written off during downturns. Hence, it may overstate the capital stock during downturns.

[17] The results are robust to using GDP per capita instead of GDP per capita in percent of advanced-economy GDP per capita. GDP per capita relative to a frontier (advanced economies) is used here to proxy the catch-up effect highlighted in the literature on stochastic frontier analysis (Growiec et al. 2015).

dummy for schooling in the bottom two-thirds across the sample. A dummy is included for commodity exporters during the period 2003-07. This dummy is intended to capture the impact of the exceptionally large commodity price boom that temporarily lifted commodity exporters' growth during this period. Potential TFP is thus:

$\Delta tfp_{i,t} = \alpha_0 + \alpha_1 \, GDP\ per\ capita_{i,t} + \alpha_2 \, wap_{i,t}$,

$+ \alpha_3 \, education_{i,t} + \alpha_4 \, education_{i,t} * D_{edu}$,

$+ \alpha_5 \, D_{cebi,t} + \alpha_6 \, \Delta inv_{i,t} + \varepsilon_{i,t}$,

where $\Delta tfp_{i,t}$ is the logarithmic first difference of trend TFP, $GDP\ per\ capita_{i,t}$ is GDP per capita in percent of advanced-economy per capita GDP, $wap_{i,t}$ is the working-age share of the population, $education_{i,t}$ is the percent share of the population who completed secondary school, $\Delta inv_{i,t}$ is the five-year moving average of real investment growth, D_{edu} is a dummy variable taking the value of 1 if the secondary completion rate is in the bottom two-thirds of the distribution, and $D_{cebi,t}$ is a dummy variable for the period 2003-07 taking the value 1 if the country is a commodity exporter.[18]

The data were compiled using a wide range of sources: UN Population Statistics (for population growth, the working-age share of the population); Barro and Lee (2013) (for secondary school completion); the World Development Indicators (for secondary school completion and GDP per capita relative to the advanced economies); and Haver Analytics (for investment).

The regression results are broadly in line with the previous literature (table 5). TFP growth slows as per capita incomes converge toward advanced-economy levels (Barro and Sala-i-Martin 1997). A better-educated population and accelerated investment growth are associated with higher TFP growth. However, the impact of education diminishes as education levels rise toward advanced-economy levels (Benhabib and Spiegel 1994, 2005; Coe, Helpman, and Hoffmaister 1997; Kato 2016). As a result, the coefficient on secondary school completion rates is only significant for countries with completion rates below the top third.

The results are broadly robust to a number of alternative specifications (tables 5 and 6). Two different methodologies are used to estimate trend TFP growth (a linear-quadratic trend and 3, 5, and 7-year moving averages) instead of the HP-filtered trend. The 3- and 7-year rolling averages of investment growth are used. In most specifications, the coefficient estimates remain significant and retain their signs; however, the working-age population share became insignificant in some specifications. The inclusion of R&D spending, which is available only for a

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[18] This approach is similar to Abiad, Leigh, and Mody (2007) and Bijsterbosch and Kolasa (2010). Abiad, Leigh and Mody (2007) estimate five-year non-overlapping averages of TFP growth as a function of per capita GDP, schooling, population growth, trade openness and a nonlinear function of current account deficits and FDI for a sample of 22 European countries for 1975-2004. Bijsterbosch and Kolasa (2010) estimate five-year non-overlapping averages of labor productivity growth as a function of relative productivity levels (which here is proxied with relative per capita GDP), the share of high-skilled workers in employment, and investment in percent of value added for sectoral data for eight European countries for 1996-2005.

much smaller sample, and urbanization also do not materially change the results.

Potential labor supply is defined as the product of the working-age population and the fitted value of age- and gender-specific regressions of labor force participation rates ($lfpr_{a,g,t}$) in percent on their structural determinants ($X_{a,g,t}$) and controlling for cohort effects, fixed effects, and the state of the business cycle—defined as the deviation of the logarithm of real GDP from the Hodrick-Prescott-filtered trend. The vector $X_{a,g,t}$ includes gender-specific education outcomes (secondary and tertiary completion rates in percent of the population over the age of 25 and enrollment rates in percent of population of the age group that officially corresponds to the level of education, age-specific fertility rates (births per woman), and life expectancy (in years). These are interacted with a dummy variable D_{emde} which takes the value of 1 for EMDEs. The vector $C_{a,g,t}$ includes all the control variables:[19]

$$lfpr_{a,g,t} = \alpha_{a,g} + \beta_{a,g} X_{a,g,t} + \gamma_{a,g} X_{a,g,t} * D_{emde} + \delta_{a,g} C_{a,g,t} + \varepsilon_{a,g,t}.$$

Data on the working-age population comes from the UN Population Statistics Database. Data for age- and gender-specific labor force participation rates are available from Key Indicators of the Labor Market (KILM) of the ILO Population Statistics Database for 1990-2019, which is spliced by Labour Force Statistics of the OECD for 1960-2020 for 33 advanced economies and 16 EMDEs. This produces data for age- and gender-specific labor force participation rates for 1960-2020 for up to 38 advanced economies and 142 EMDEs.[20] Completion rates of secondary and tertiary education are from Barro and Lee (2013) and the World Bank's World Development Indicators; age-specific fertility rate and life expectancy are from the UN's World Population Projections database; gender-specific secondary and tertiary school enrollment rates are from the World Development Indicators. The regression sample includes up to 35 advanced economies and 133 EMDEs for 1987-2020.[21]

The regression results are broadly in line with findings in the previous literature (table 7).

First, among teenage and younger women, fertility rates are associated with higher labor force participation as mothers are more likely to discontinue their education and participate in the labor force, especially in advanced economies (Azevedo, Lopez-Calva, and Perova 2012; Fletcher and Wolfe 2009; Herrera, Sahn, and Villa 2016). This effect is more muted in EMDEs, potentially reflecting an earlier average age of marriage, which tends to be associated with lower female

[19] This approach combines those by Fallick and Pingle (2007) and Goldin (1994). For the United States, Fallick and Pingle (2007) estimate labor force participation by age group and gender as a function of cohort and age fixed effects as well as business cycle fluctuations. Goldin (1994) models aggregate labor force participation rates as a function of country-level variables such as female schooling. The regression used here incorporates both cohort effects and country-level variables modelling human capital and other factors driving labor force participation.

[20] This is an unbalanced sample because some of the exogenous variables are not available for the full period for all countries. However, the regression results are robust to restricting the sample to the balanced panel with fully available data.

[21] Since UN data for life expectancy is only available for five-year periods, historical life expectancy data from the World Developing Indicators database is used. For projection years or missing data, UN World Population Statistics are spliced with data from World Development Indicators database.

labor force participation (United Nations 2012).

Second, for relevant age groups, educational attainment is associated with higher participation rates, except for young men and women aged 20-24. The positive correlation between completion rates and labor force participation may partly reflect higher compensation for more educated workers. For young men, higher tertiary educational attainment is associated with lower labor force participation. This might reflect the lack of demand for employment in sectors where these educated workers would expect to be employed, discouraging them from labor force participation (Klasen and Pieters 2013). However, for men aged 50-64 and all workers aged 65 years and older, education becomes an insignificant determinant of labor force participation (as in Fallick and Pingle 2007). Tertiary enrollment rates in all relevant age groups are associated with lower labor force participation rates, as students devote time to completing their degree (Kinoshita and Guo 2015; Linacre 2007; and Tansel 2002).

Third, life expectancy is one of the main determinants of participation for workers aged 50 and above (Fallick and Pingle 2007). For the younger ones among them, between the ages of 50-64, higher life expectancy is associated with higher labor force participation, possibly reflecting the need to accumulate savings for a longer retirement period or the positive association between better health among older workers and higher incomes (Haider and Loughran 2001). Among those aged 65 years or older, higher life expectancy is associated with higher labor force participation in advanced economies, but does not significantly change participation in EMDEs. Life expectancy may be a weak proxy for a healthy old age in EMDEs with less-developed health care systems or where differences in life expectancy might mostly reflect differences in infant mortality (Eggleston and Fuchs 2012).

Fourth, labor force participation is procyclical—albeit less so in EMDEs than in advanced economies—in most age groups until the age of 50. Labor force participation rises when real GDP is above its HP-filtered trend and declines when real GDP is below its HP-filtered trend.[22] As the age increases, the sensitivity to cyclicality decreases and participation eventually becomes countercyclical (Balakrishnan et al. 2015; Duval, Eris, and Furceri 2011). This may reflect greater ability of more experienced workers to remain employed or return to employment after spells of unemployment during recessions (Elsby, Hobijn, and Şahin 2015; Shimer 2013). However, participation becomes pro-cyclical again (although not statistically significant) for workers aged 65 and above as they become eligible to retire and may be readier to drop out of the labor force in a weaker economy. This result is broadly robust to defining the business cycle as deviations of real GDP from the 10-year moving average or from a linear-quadratic trend (tables 8, 9).

[22] In several instances, there were no statistically significant differences between advanced economies and EMDEs in the cyclicality of their labor force participation. Hence, the interactions were omitted from the regressions.

ANNEX B Univariate filters

Univariate statistical filters decompose a series y_t into trend, cyclical, and noise components. The trend component is used as a proxy for potential output. Although they are all essentially weighted moving averages of the series y_t, they differ in their weights.

Five univariate filters are applied to estimate potential output: filters based on Hodrick and Prescott (1997), three band-pass filters (Baxter and King 1999; Butterworth 1930 and Gomez 2001; Christiano and Fitzgerald 2003), and a filter based on an Unobserved Components Model. The measures are estimated for 37 advanced economies and 52 EMDEs for 1980Q1-2022Q1 (table 10). Forecasts from the *Global Economic Prospects* report provide data to 2024. A smaller sample is used in comparisons with other approaches, to ensure consistency of samples (tables 11 and 12).

Hodrick-Prescott filter

The Hodrick-Prescott (HP) filter minimizes deviations of a series y_t from its trend τ_t, assuming a degree of smoothness λ of the trend. The HP filter chooses the trend τ_t that minimizes:

$$\sum_{t=1}^{T}(y_t-\tau_t)^2+\lambda\sum_{t=2}^{T-1}\left[(\tau_{t+1}-\tau_t)-(\tau_t-\tau_{t-1})\right]^2,$$

where T is the sample size. A larger λ indicates a smoother trend. For λ=0, the trend is equal to the actual series and for λ>+∞ the trend is a linear time trend with a constant growth rate. Typically, the value of λ is set at 1600 for quarterly data. The trend is estimated based on past values as well as projected values of the series y_t.

Band-pass filters

The three band-pass filters aim to isolate fluctuations in a time series which lie in a specific band of frequencies. They eliminate slow-moving components (trend) and very high frequency components (noise) and define the intermediate components as the business cycle. Specifically, the three band-pass filters differ in their approximations of the optimal linear filter (also known as the "ideal" band-pass filter) to deal with finite time series.

The *Baxter and King (BK) filter* is a moving average of the data with symmetric weights on lags and leads. Therefore, it loses observations in the beginning and towards the end of the sample. It is particularly well-suited when the raw series follows a near-independent and identically distributed process (Christiano and Fitzgerald 2003). Specifically, the BK filter is given by:

$$\hat{c}_t = b(L)y_t,$$

where *b(L)* is the lag polynomial given by:

$$b(L)=\sum_{j=-k}^{k} b_j^k L^j,$$

with $b^k_j = b^k_{-j}$. Note that k observations will be lost in both ends of the sample. The higher k, the closer the filter is to the ideal filter but also the higher are the number of lost observations. The default business cycle frequencies used here (required for estimation) are between 1.5 to 8 years.

The *Christiano and Fitzgerald (CF) filter* is a one-sided moving average of the data with weights that minimize the distance between the approximated and the "ideal" filter. Since the filter is one-sided, it does not lose observations towards the end of the sample. It is most suitable for random-walk series. The optimal cycle at time *t* is given by:

$$\hat{c}_t = \sum_{j=-f}^{p} b_j^{p,f} y_{t-j} ,$$

where are the optimal weights of the CF filter that solve:

$$\underset{b_j^{p,f}}{Min}\, E\left[(\hat{c}_t - c_t)^2 \left| y \right.\right] ,$$

and c_t is the filtered series under the "ideal" (infinite sample) band-pass filter. By default, the CF filter business cycle frequencies are set between 1.5 to 8 years.

The *Butterworth (BW) filter*—widely used in electrical engineering for signal extraction—isolates only low-frequency fluctuations, not high-frequency ones. Pollock (2000) proposes the use of this filter for macroeconomic time series filtering as an alternative to the traditional linear filters such as the Hodrick-Prescott filter. The low-pass BW filter is characterized by two parameters λ and *n* and can be specified as:

$$b(L) = \frac{\lambda(1+L)^n(1+L^{-1})^n}{(1+L)^n(1+L^{-1})^n + \lambda(1-L)^n(1-L^{-1})^n} ,$$

where *L* is a lag operator, λ is the smoothness parameter and *n* is the degree of the filter.

Unobserved Components Model

Most univariate filters can be nested into the Unobserved Components Model.[23] In contrast to other univariate filters, the Unobserved Components Model does not impose specific parameter assumptions about the degree of smoothing, lead and lag windows, or business cycle frequencies. Instead, it relies on assumptions about the underlying process followed by output gaps and potential growth, and is estimated using the Kalman filter (Harvey 1990):

$LY_t = L\bar{Y}_t + Y_{GAPt}$, *(*1)

[23] For example, if the trend and cyclical components are uncorrelated white noise, the unobserved components model coincides with the Hodrick-Prescott filter if the noise-to-signal ratio matches the Hodrick-Prescott filter's smoothing parameter (Hamilton 2018).

$$L\bar{Y}_t = L\bar{Y}_{t-1} + G_t + \varepsilon_{\bar{Y}t} \quad , \qquad (2)$$

$$G_t = (1 - \tau)G_{ss} + \tau\, G_{t-1} + \varepsilon_{Gt} \quad , \qquad (3)$$

$$Y_{GAPt} = \beta_1 Y_{GAPt-1} + \beta_2 Y_{GAPt-2} + \gamma_t Y_{GAP} \quad , \qquad (4)$$

where LY is the log of seasonally adjusted quarterly real GDP, $L\bar{Y}$ the log of potential output, Y_{GAP} the output gap, G_t potential output growth, G_{ss} the steady state level that growth is assumed to converge to over the long term, and ε_Y and ε_G are independently and identically distributed disturbances. Note that the shock ε_Y shifts the level of potential output whereas ε_G is a shock to potential output growth. Equation (3) assumes that potential growth converges (at a speed of convergence τ) to its steady level G_{ss} after a shock. The output gap follows a commonly used second-order autoregressive process (equation 4). The Kalman filter algorithm yields (posterior) time-varying variance-covariance matrices for the smoothed estimates of the unobserved state variables, potential growth and the output gap. The standard deviation of potential growth is used to calculate the 95 percent confidence band around estimated potential growth.

ANNEX C Multivariate filters

The unobserved components model can be expanded to include additional indicators of domestic demand pressures to help identify the output gap (Benes et al. 2010). The most commonly used indicators are inflation and the unemployment rate. Specifically, the univariate model (1-4) is further augmented with a Phillips Curve relationship between inflation and output gaps (equation 5), an Okun's Law relationship between unemployment rates and output gaps (equations 6-9), a relationship between capacity utilization and output gaps (equations 10-13), and a set of equations describing the Taylor rule (equations 14-17).

Given the large variation in available data across economies, switches are employed to add selected equations to each country model based on the country's specific dataset. If house prices or the unemployment rate data is not available for a specific country, the relevant equations would not be included. At minimum, all countries have output, inflation, and commodity price data.[24]

Model components

The *Phillips Curve* relates inflation to the output gap, controlling for the impact of supply side shocks such as import prices on domestic inflation.

$$\pi_t = \rho\, \pi_{t-1} + (1-\rho)\pi_{t+1} + \alpha_1 Y_{GAPt} + \lambda_1 \pi_{mt} + \varepsilon_{\pi}\ , \qquad (5)$$

where π_t is annualized quarter-on-quarter inflation at time *t*, π_{mt} is import price inflation at time *t*, and Y_{GAPt} is the output gap at time *t*. Expectations are assumed to be an average of adaptive and rational expectations, weighted by ρ. Inflation expectations are linked to fixed horizon forecasts of inflation from Consensus Economics where available.[25]

Okun's Law relates the unemployment gap U_{GAPt} (defined as the difference between the actual unemployment rate U_t and the equilibrium, or natural, unemployment rate $\bar{U}_t$ in equation 6) to the output gap (in equation 7) as:

$$U_{GAPt} = U_t - \bar{U}_t\ , \qquad (6)$$

$$U_{GAPt} = \gamma U_{GAPt-1} - \alpha_2 Y_{GAPt} + \varepsilon_{tUGAP}\ . \qquad (7)$$

Following Blagrave et al. (2015), the equilibrium unemployment rate process is specified in deviation from steady state. Equation (8) specifies the process for U_t . It implies that following a shock, the non-accelerating inflation rate of unemployment (NAIRU) $\bar{U}_t$ converges back to its steady state value U_{ss} according to the parameter τ_1 and has a trend component G_U which has an autoregressive process (9):

[24] Three economies—Lesotho, Namibia, and Tanzania—have only output, inflation, and commodity price data.

[25] Fixed-horizon forecasts transform the fixed-event forecasts (for example, for 2022 and 2023) provided by Consensus Economics to be one year-ahead forecasts (in other words, at a fixed horizon in the future). See Bordo and Siklos (2017) and Siklos (2013) for details.

$\bar{U}_t - U_{ss} = \tau_1(\bar{U}_{t-1} - U_{ss}) + G_{Ut} + \varepsilon_{Ut}$, (8)

$G_{Ut} = \tau_u G_{Ut-1} + \varepsilon_{Gt}$, (9)

Since *capacity utilization* C_t is highly pro-cyclical, it can help identify the cyclical component of output even when other indicators (such as, say, a stable unemployment gap during jobless recoveries or stable inflation in highly open economies) do not signal cyclical upturns. Equations (10)-(13) describe the relation between capacity utilization and output gaps and the exogenous process for capacity utilization, where   is the steady state of capacity utilization rate, C_{GAPt} is the capacity utilization gap, defined as the difference between actual and non-inflationary capacity utilization C_t, and G_{Ct} is the growth of capacity utilization:

$$C_{GAPt} = q\ C_{GAPt-1} + \alpha_3 Y_{GAPt} + \varepsilon_{CGAPt} \quad (10)$$

$$C_t = C_{GAPt} + \overline{C}_t \quad (11)$$

$$\overline{C}_t - \overline{C}_{ss} = \tau_2(\overline{C}_{t-1} - \overline{C}_{ss}) + G_{Ct} + \varepsilon_{Ct} \quad (12)$$

$$G_{Ct} = \tau_c G_{Ct-1} + \varepsilon_{Gt} \quad (13)$$

A *Taylor rule* describes monetary policy in economies where short-term policy interest rates are used as an instrument of monetary policy:

$$i_t = \tau_i i_{t-1} + (1-\tau_i)(r_t^* + \pi_t^* + \gamma_\pi(\pi_{t+4} - \pi_t^*) + \gamma_{YGAP} Y_{GAPt}) + \varepsilon_{it} , \quad (14)$$

where i_t is the nominal policy interest rate that responds to forecast inflation from its target (π_t^*) and the output gap. The *ex ante* real interest rate is defined using the Fisher equation as:

$r_t = i_t - \pi_{4t+1},$ (15)

where π_{4t+1} is the year-on-year change in consumer prices. The neutral real interest rate is modelled as in Laubach and Williams (2003):

$$r_t^* = cG_t + Z_t , \quad (16)$$

$$Z_t = Z_{t-1} + \varepsilon_{Zt} , \quad (17)$$

An *output gap* process closes the model. Inflation and unemployment might fail to capture all domestic demand pressures, such as credit or asset price growth or commodity price cycles.[26] This may lead to an underestimation of the output gap and an overestimation of potential output, especially at the peak of the cycle. Instead of assuming that the output gap process is exogenous, as in the traditional multivariate Kalman filter, three additional indicators are included in the output gap equation: house price, credit, and commodity price growth:

[26] See Borio (2013, 2014) and Summers (2014) for advanced economies, Jesus et al. (2015) for Latin America and the Caribbean, Kemp (2015) for South Africa, and Enrique et al. (2016) for East Asia and the Pacific. The cyclical component of copper prices helps explain mining sector output gaps in Chile (Blagrave and Santoro 2016).

$$Y_{GAPt} = \beta_1 Y_{GAPt-1} + \beta_2 hpr_{t-1} + \beta_3 compr_{t-1} + \beta_4 cr_{t-1} + \beta_5 (r_t - r_t^*) + \varepsilon_{YGAPt} \quad , (18)$$

where cr_t, hpr_t, and $compr_t$ are cyclical components of year-on-year private sector credit growth deflated by consumer price inflation, quarterly seasonally-adjusted house prices, and export-weighted real average commodity prices, respectively, and r_t-r_t^* is the deviation of the real policy rate from its equilibrium level.

Estimation

The model uses the Kalman filter algorithm and Bayesian techniques on quarterly data covering 1980Q1-2022Q2 for up to 36 advanced economies and 54 EMDEs. A key parameter determining the shape of potential output is the variance of the output gap relative to potential growth innovations. The variance of the innovations ε_{YGAPt} and ε_{Gt} are set such that their ratio equals the typically used smoothness parameter of the Hodrick-Prescott filter.

The prior for the elasticity of output gap with respect to commodity price β_3 (the central bank's response to deviations of inflation from target) and the coefficient on potential growth in the neutral real interest rate follows a normal distribution in the case of commodity prices to allow for a potentially negative impact of commodity price increases in commodity importers. The prior distributions for all standard deviations are inverse gamma distributions. All other estimated priors follow a beta distribution.

The standard deviations of ε_{CGAPt} and ε_{UGAPt} are set as the OLS standard errors of equations (5) and (9) based on Hodrick-Prescott-filtered data. Steady state values of growth, unemployment, and capacity utilization are calibrated to the sample means of their corresponding HP-filtered series. Estimates of potential growth from the Multivariate Filter Model and the Unobserved Components Model used in this paper are based on $L\bar{Y}_t$ and include both level and growth shocks to potential growth.

As in the case of the Unobserved Components Model, the Kalman filter algorithm yields (posterior) time-varying variance-covariance matrices for the filtered estimates of all unobserved state variables, including potential growth. From this matrix, the standard deviation of potential growth is used to calculate the 95 percent confidence band around estimated potential growth.

Data

Based on the univariate and multivariate filters, output gaps and potential growth are estimated for up to 37 advanced economies and 52 EMDEs for as long a period as 1980Q1-2024Q4 (table 10). A smaller sample is used in comparisons with other approaches, to ensure constant samples (tables 11 and 12). GDP, inflation, unemployment rates, private sector credit growth, and capacity utilization rates are from Haver Analytics. House price growth is from Bank for International Settlements, commodity prices are from the World Bank's *Pink Sheet*, and export weights are from the UN *Comtrade* database. Country-specific output gaps are aggregated using real GDP weights at 2010-19 exchange rates and prices.

ANNEX D Long-term growth expectations

Expectations of output growth over long horizons capture forecasters' assessment of long-term sustainable growth since they are stripped of unpredictable short-term shocks. Two sources of expectations are used: the International Monetary Fund's *World Economic Outlook* (WEO) database, published twice a year, and Consensus Economics, published on a quarterly basis. Since the longest available forecast horizon is 5-years for IMF's WEO, 5-year-ahead forecasts are selected for both sources for consistency across these two measures. The IMF's WEO provides five-year-ahead forecasts for up to 173 countries (37 advanced economies, 136 EMDEs) for 1990-2021. Consensus forecasts are available for up to 78 countries (34 advanced economies and 44 EMDEs) for 1990-2022 and the database includes the April vintages.

ANNEX E Local projection estimation

A local projection estimation is used to explore the evolution of potential growth, employment growth, potential TFP growth, and investment growth following recessions, banking crises, and epidemics. The model estimates the cumulative impact of recessions, following Jordà (2005) and Teulings and Zubanov (2014).[27]

In impulse responses, the model estimates the effect of short-term shocks (the recession, banking crisis, or epidemic event) over a horizon *h* on potential growth while controlling for other determinants:

$$y_{i,t+h} - y_{i,t} = \alpha_h + \beta_h\, shock_{i,t} + \gamma_h\, \Delta y_{i,t-1} + fixedeffects_i + \varepsilon_{i,t},$$

where $y_{i,t}$ is potential growth. The model controls for country-fixed effects to capture time-invariant cross-country differences.[28] The variable $shock_{i,t}$ is a dummy variable for a recession event (or banking crisis or epidemic), the main variable of interest. Lagged potential growth $y_{i,t-1}$ controls for the history of potential growth.

For channels, the same specification is used, where $y_{i,t}$ is employment growth, potential TFP growth, or investment growth. This model also controls for country-fixed effects to capture time-invariant cross-country differences. Lagged potential growth $y_{i,t-1}$ controls for the history of employment growth, potential TFP growth, or investment growth. Banking crises are defined as in Laeven and Valencia (2018) and the ones corresponding to the potential growth measures are listed in table 13. Epidemics include SARS (2003), swine flu (2009), MERS (2012), Ebola (2014), and Zika (2016) and affected countries are listed in table 14.

Results for the impact of recessions, banking crises, and epidemics on alternative measures of potential growth are shown in tables 15-18. Results for the impact of recessions, banking crises, and epidemics on employment, total factor productivity, and investment growth are shown in tables 19-20.

[27] Plagborg-Møller and Wolf (2021) show that vector autoregression (VAR) and LPM estimations yield the same impulse response functions but Li, Plagborg-Møller and Wolf (2022) show that LPM estimators have larger variance (but lower bias), especially for the medium- and long-term horizons, than VAR estimators.

[28] A dummy for time effects is not necessary because the time variable t refers to the time since the start of the event and pertains to different years for different countries.

TABLE 1 Methodology time and country coverage

Methodology	Time coverage*	Advanced economies	EMDEs
Production function approach	1998-2032	**30** (AUS, AUT, BEL, CAN, CHE, CYP, DEU, DNK, ESP, EST, FIN, FRA, GBR, GRC, HKG, HRV, IRL, ISR, ITA, JPN, KOR, LTU, LVA, NLD, NOR, PRT, SVK, SVN, SWE, USA)	**64** (ALB, ARG, ARM, BDI, BEN, BGD, BGR, BOL, BRA, BRB, CAF, CHL, CHN, CMR, COL, CRI, DOM, ECU, EGY, GAB, GTM, HND, HUN, IDN, IND, IRN, IRQ, JAM, JOR, KAZ, KEN, KGZ, LAO, LSO, MAR, MDA, MEX, MNG, MOZ, MRT, MUS, MYS, NAM, NER, NIC, PAK, PER, PHL, POL, PRY, QAT, ROU, RWA, SDN, SEN, SRB, TGO, THA, TJK, TUN, TUR, URY, VNM, ZAF)
Multivariate filter	1981-2024	**37** (AUS, AUT, BEL, CAN, CHE, CYP, CZE, DEU, DNK, ESP, EST, FIN, FRA, GBR, GRC, HKG, HRV, IRL, ISL, ISR, ITA, JPN, KOR, LTU, LUX, LVA, MLT, NLD, NOR, NZL, PRT, SGP, SVK, SVN, SWE, TWN, USA)	**52** (ALB, ARG, AZE, BGR, BHR, BLZ, BOL, BRA, BWA, CHL, CHN, CMR, COL, CRI, DOM, ECU, EGY, GEO, GTM, HND, HUN, IDN, IND, IRN, JOR, KAZ, KEN, KWT, LSO, MAR, MEX, MKD, MNG, MYS, NAM, NGA, NIC, PAN, PER, PHL, POL, PRY, ROU, SAU, SLV, THA, TUN, TUR, TZA, URY, VNM, ZAF)
Univariate filters	1980Q1-2024Q4	**37** (AUS, AUT, BEL, CAN, CHE, CYP, CZE, DEU, DNK, ESP, EST, FIN, FRA, GBR, GRC, HKG, HRV, IRL, ISL, ISR, ITA, JPN, KOR, LTU, LUX, LVA, MLT, NLD, NOR, NZL, PRT, SGP, SVK, SVN, SWE, TWN, USA)	**52** (ALB, ARG, AZE, BGR, BHR, BLZ, BOL, BRA, BWA, CHL, CHN, CMR, COL, CRI, DOM, ECU, EGY, GEO, GTM, HND, HUN, IDN, IND, IRN, JOR, KAZ, KEN, KWT, LSO, MAR, MEX, MKD, MNG, MYS, NAM, NGA, NIC, PAN, PER, PHL, POL, PRY, ROU, SAU, SLV, THA, TUN, TUR, TZA, URY, VNM, ZAF)
WEO five-year ahead expectations	1990-2022	**37** (AUS, AUT, BEL, CAN, CHE, CYP, CZE, DEU, DNK, ESP, EST, FIN, FRA, GBR, GRC, HKG, HRV, IRL, ISL, ISR, ITA, JPN, KOR, LTU, LUX, LVA, MLT, NLD, NOR, NZL, PRT, SGP, SVK, SVN, SWE, TWN, USA)	**136** (AFG, AGO, ALB, ARE, ARG, ARM, ATG, AZE, BDI, BEN, BFA, BGD, BGR, BHR, BHS, BIH, BLZ, BOL, BRA, BRB, BRN, BTN, BWA, CAF, CHL, CHN, CMR, COD, COG, COL, COM, CPV, CRI, DJI, DMA, DOM, DZA, ECU, EGY, ERI, ETH, FSM, GAB, GEO, GHA, GIN, GMB, GNB, GNQ, GRD, GTM, GUY, HND, HTI, HUN, IDN, IND, IRN, IRQ, JAM, JOR, KAZ, KEN, KGZ, KHM, KIR, KNA, KWT, LAO, LBN, LBR, LBY, LCA, LSO, MAR, MDA, MDG, MDV, MEX, MKD, MLI, MMR, MNG, MOZ, MRT, MUS, MWI, MYS, NAM, NER, NGA, NIC, NPL, OMN, PAK, PAN, PER, PHL, PNG, POL, PRY, QAT, ROU, RWA, SAU, SDN, SEN, SLB, SLV, SOM, SRB, SSD, STP, SUR, SWZ, SYC, SYR, TCD, TGO, THA, TJK, TLS, TON, TUN, TUR, TZA, UGA, URY, UZB, VCT, VNM, VUT, WSM, YEM, ZAF, ZMB)

Source: World Bank.

Note: Country codes are available at https://www.iban.com/country-codes.

TABLE 2 Methods to estimate potential growth

Methodology	Advantages	Disadvantages
Production function approach	Produces estimates that help explain the movement of potential output in terms of its inputs. Low correlation with actual output growth.	Relies on proxies for potential productivity and labor supply growth and capital accumulation that could be subject to measurement errors. Relies on assumption of specific functional form.
Time-series filters	Univariate filters are straightforward to implement, even in data-poor environments.	"End-point" problems can lead to large revisions as new data become available.[37]
	Multivariate filters produce output gaps that are consistent with indicators of domestic demand pressures (inflation, unemployment, current account deficits, capacity utilization).	Strong correlation with actual output growth, which could reflect short-term shocks to potential growth or, alternatively, are associated with cyclical movements.
Long-term growth expectations	In principle, incorporate judgment and, thus, capture factors that cannot be modelled during periods of high volatility.	In practice, tend to be sticky and, at times, in ways that are challenging to interpret.

Source: World Bank.

TABLE 3 Variable list

Variable	Units	Source	Sample
GDP in U.S. dollars	Millions of U.S. dollars, at market exchange rates	IMF World Economic Outlook database	194 countries, 1980-2021
Real GDP in local currency	Millions of local currency	Haver Analytics	93 countries, 1980Q2-2021Q4
GDP per capita	U.S. dollars at market exchange rates	IMF World Economic Outlook database; UN population statistics	182 countries, 1980-2021
Population, by age and gender	Number	UN population statistics and projections	184 countries, 1950-2035
Labor force, by age and gender	Number	ILO, Key Indicators of the Labour Market (KILM) database; OECD Labour Force Statistics	180 countries, 1960-2020
Investment growth	Percent	Haver Analytics	187 countries, 1961-2021
Secondary education completion rate	Percent of population that completed secondary education in percent of population in relevant age group	Barro and Lee (2013); World Development Indicators	179 countries, 1960-2020
Tertiary education completion rate	Percent of population that completed tertiary education in percent of population in relevant age group	Barro and Lee (2013); World Development Indicators	174 countries, 1960-2020
Secondary education enrolment rate	Percent of population of the age group corresponding to the level of education	World Development Indicators	193 countries, 1970-2020
Tertiary education enrolment rate	Percent of population of the age group corresponding to the level of education	World Development Indicators	192 countries, 1970-2020
Life expectancy	Years	UN population statistics; UN population projections	181 countries, 1985-2035
Fertility rate	Number of births per 1,000 women	UN population statistics; UN population projections	175 countries, 1960-2095
Employment	Number	Penn World Table	181 countries, 1950-2019
Urban population	Share of total population	World Development Indicators	194 countries, 1960-2020
R&D spending	In percent of GDP	World Development Indicators	144 countries, 1996-2019
Consumer price inflation	Percent	Haver Analytics	93 countries, 1980Q1-2021Q4
Inflation expectations	Percent	Consensus Economics	74 countries, 1980Q1-2021Q4
Unemployment rate	Percent of labor force	Haver Analytics	66 countries, 1980Q1-2021Q4
Capacity utilization rate	Percent of capacity	Haver Analytics	31 countries, 1980Q1-2021Q4
Import price inflation	Percent	Haver Analytics	74 countries, 1980Q1-2021Q4
Private credit growth	Percentage points of GDP	Haver Analytics	57 countries, 1980Q1-2021Q4
Average commodity export price	Index	World Bank; Federal Reserve Bank of St. Louis; UN Comtrade	93 countries, 1980Q1-2021Q4
Monetary policy rates	Percent	Haver Analytics	80 countries, 1980Q1-2021Q4
House prices		Bank for International Settlements	55 countries, 1980Q1-2021Q4

TABLE 3 Variable list (*continued*)

Variable	Units	Source	Sample
WEO real GDP growth forecasts	Percent	IMF World Economic Outlook database	175 countries, 1990-2021
Consensus real GDP growth forecasts	Percent	Consensus Economics	78 countries, 1990-2022

Source: World Bank.

TABLE 4 Coverage for production function-based estimates of potential growth

Economy	Sample period	Economy	Sample period	Economy	Sample period
Australia	1998-2032	**Europe and Central Asia**		**Middle East and North Africa**	
Austria	1998-2032	Albania	1998-2032	Egypt, Arab Rep.	1998-2032
Belgium	1998-2032	Armenia	1998-2032	Iraq	2001-2019
Canada	1998-2032	Bulgaria	2000-2032	Iran, Islamic Rep.	1998-2032
Cyprus	1998-2032	Hungary	1998-2032	Jordan	1998-2032
Croatia	1998-2032	Kazakhstan	1998-2032	Morocco	1998-2032
Denmark	1998-2032	Kyrgyz Republic	2000-2032	Qatar	1998-2016
Estonia	1998-2032	Moldova	2013-2032	Tunisia	1998-2032
Finland	1998-2032	Poland	1998-2032		
France	1998-2032	Romania	1998-2032	**South Asia**	
Germany	1998-2032	Serbia	1998-2032	Bangladesh	1998-2032
Greece	1998-2032	Tajikistan	1998-2032	India	1998-2032
Hong Kong SAR, China	1998-2032	Turkey	1994-2030	Pakistan	1998-2032
Iceland	1998-2032				
Israel	1998-2032	**Latin America and Caribbean**		**Sub-Saharan Africa**	
Italy	1998-2032	Argentina	1998-2032	Benin	1998-2032
Japan	1998-2032	Barbados	1998-2016	Burundi	1998-2032
Korea	1998-2032	Bolivia	1998-2032	Cameroon	1998-2032
Latvia	1998-2032	Brazil	1998-2032	Central African Republic	1998-2019
Lithuania	2000-2032	Chile	1998-2032	Gabon	1998-2032
Netherlands	1998-2032	Colombia	1998-2032	Kenya	1998-2032
Norway	1998-2032	Costa Rica	1998-2032	Lesotho	1998-2032
Portugal	1998-2032	Dominican Republic	1998-2032	Mauritania	2000-2032
Slovak Republic	1998-2032	Ecuador	1998-2032	Mauritius	1998-2032
Slovenia	1998-2032	Guatemala	1998-2032	Mozambique	1998-2032
Spain	1998-2032	Honduras	1998-2032	Namibia	1998-2032
Sweden	1998-2032	Jamaica	1998-2032	Niger	1998-2032
Switzerland	1998-2032	Mexico	1998-2032	Rwanda	2000-2016
United Kingdom	1998-2032	Nicaragua	1998-2032	Senegal	1998-2032
United States	1998-2032	Paraguay	1998-2032	South Africa	1998-2032
		Peru	1998-2032	Sudan	1998-2019
East Asia and Pacific		Uruguay	1998-2032	Togo	1998-2032
China	1998-2032				
Indonesia	1998-2032				
Malaysia	1998-2032				
Mongolia	1998-2032				
Philippines	1998-2032				
Thailand	1998-2032				
Vietnam	2013-2021				

Source: World Bank.

Note: Methodology and assumptions underlying projections for 2022-32 are detailed in Kilic Celik, Kose and Ohnsorge (2023).

TABLE 5 Regression results for total factor productivity

Dependent variable: TFP growth	Baseline HP-trend	3-year moving average	5-year moving average	7-year moving average	Linear-quadratic trend
GDP per capita rel. to advanced economies	-0.06***	-0.07***	-0.07***	-0.06***	-0.06***
	(0.000)	(0.001)	(0.002)	(0.002)	(0.001)
Working-age population	4.16*	3.05	4.70	6.86**	3.13
	(0.100)	(0.326)	(0.143)	(0.044)	(0.321)
Secondary completion rate	0.003	0.003	0.010	0.009	-0.029***
	(0.701)	(0.807)	(0.375)	(0.397)	(0.002)
Secondary completion rate (bottom two-thirds)	0.009*	0.012*	0.009	0.004	0.004
	(0.061)	(0.068)	(0.142)	(0.466)	(0.464)
Investment growth (five-year moving average)	0.088***	0.178***	0.185***	0.169***	0.118***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Commodity exporters credit boom dummy	0.592***	1.094***	0.778**	0.664**	1.001***
	(0.000)	(0.002)	(0.035)	(0.040)	(0.000)
Number of observations	706	694	692	687	706
Number of countries	125	125	125	125	125
Within R-square	0.26	0.27	0.29	0.29	0.25

Source: World Bank.

Note: *** indicates significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level. Estimations are based on standard errors clustered around countries. The methodology is defined in annex.3. Sample includes unbalanced panel of 33 advanced economies 92 EMDEs for 1983-2020. p-statistics are shown in parentheses.

TABLE 6 Regression results for total factor productivity

Dependent variable: TFP growth	HP-trend	HP-trend	HP-trend	HP-trend
GDP per capita relative to advanced economies	-0.06***	-0.06***	-0.06***	-0.05***
	(0.000)	(0.000)	(0.000)	(0.000)
Working-age population	5.96**	4.70	6.54**	6.13**
	(0.024)	(0.115)	(0.038)	(0.047)
Secondary completion rate	-0.002	-0.001	0.013	0.000
	(0.770)	(0.847)	(0.139)	(0.968)
Secondary completion rate (bottom two-thirds)	0.007	0.011**	0.012**	0.006
	(0.125)	(0.028)	(0.013)	(0.255)
Investment growth (three-year moving average)	0.009			
	(0.672)			
Investment growth (five-year moving average)			0.084***	0.111***
			(0.000)	(0.000)
Investment growth (seven-year moving average)		0.007		
		(0.763)		
Commodity exporters credit boom dummy	0.953***	0.924***	0.557***	0.902***
	(0.000)	(0.000)	(0.000)	(0.000)
Urban population share			-0.066**	
			(0.031)	
R&D spending as percent of GDP				-0.092
				(0.752)
Number of observations	778	698	706	497
Number of countries	125	125	125	109
Within R-square	0.15	0.15	0.28	0.34

Source: World Bank.

Note: *** indicates significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level. Estimations are based on standard errors clustered around countries. Sample includes unbalanced panel of 33 advanced economies and 92 EMDEs for 1983-2020. p-statistics are shown in parentheses.

TABLE 7 Regression results for labor force participation rates, baseline

	15-19 years old		20-24 years old		25-49 years old		50-64 years old		65+ years old	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Fertility	0.734***		0.057*		0.000					
	(0.000)		(0.000)		(0.945)					
Secondary enrollment	0.197***	0.127***								
	(0.000)	(0.000)								
Tertiary enrollment			-0.114***	-0.180***						
			(0.000)	(0.000)						
Completion of tertiary education			0.039	-0.023	0.235***	0.130***	0.406***	0.063		
			(0.249)	(0.394)	(0.000)	(0.000)	(0.000)	(0.221)		
Completion of tertiary education			0.158**	-0.099*	0.323***	0.313***	0.486**	0.426**		
			(0.002)	(0.045)	(0.000)	(0.000)	(0.003)	(0.002)		
Life expectancy							0.569***	-2.679**	0.101***	0.227***
							(0.000)	(0.003)	(0.000)	(0.000)
Cycle	16.14***	21.43***	1.04	11.54***	1.504	-0.591**	0.590	-2.329**	1.435	21.76
	(0.000)	(0.000)	(0.144)	(0.000)	(0.182)	(0.008)	(0.495)	(0.008)	(0.394)	(0.399)
Cycle * life expectancy									-0.031	-0.192
									(0.216)	(0.584)
Fertility * EMDE	-0.669***		-0.066**							
	(0.000)		(0.006)							
Secondary enrollment * EMDE	-0.337***									
	(0.000)									
Completion of secondary education * EMDE			-0.027	-0.038						
			(0.495)	(0.238)						
Completion of tertiary education * EMDE			-0.127	0.153*						
			(0.056)	(0.000)						
Life expectancy * EMDE									-0.143***	-0.608***
									(0.000)	(0.000)
Secondary enrollment * EMDE	-0.337***									
	(0.000)									
Completion of secondary education * EMDE			-0.027	-0.038						
			(0.495)	(0.238)						

TABLE 7 Regression results for labor force participation rates, baseline (*continued*)

	15-19 years old		20-24 years old		25-49 years old		50-64 years old		65+ years old	
	Female	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
Completion of tertiary education * EMDE			-0.127	0.153*						
			(0.056)	(0.000)						
Life expectancy * EMDE									-0.143***	-0.608***
									(0.000)	(0.000)
Cycle * EMDE	-17.90***	-24.21***		-11.72***	-1.456*					16.46
	(0.000)	(0.000)		(0.000)	(0.038)					(0.526)
Cycle * life expectancy * EMDE										0.039
										(0.912)
Coefficient of fertility in EMDEs	0.065***		-0.009							
	(0.000)		(0.234)							
Coefficient of secondary enrollment in EMDEs	-0.133***									
	(0.000)									
Coefficient of secondary education in EMDEs			-0.012	-0.058***						
			(0.570)	(0.000)						
Coefficient of tertiary education in EMDEs			0.031	-0.063						
			(0.478)	(0.189)						
Coefficient of cycle in EMDE	-0.145**	-2.78**		-0.18	0.048**					
	(0.008)	(0.001)		(0.801)	(0.009)					
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort fixed effects	No	No	No	No	No	No	Yes	Yes	Yes	Yes
County-cohort fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age fixed effects	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	4432	4484	3741	3789	21382	21654	12239	12261	5111	5111
Number of countries	163	165	151	154	158	160	145	145	168	168
Adjusted R-square	0.997	0.997	0.999	0.999	0.997	0.999	0.986	0.993	0.998	0.999

Source: Barro and Lee 2013; Key Indicators of the Labor Market (KILM), International Labour Organization; Labour Force Statistics, Organisation for Economic Co-operation and Development (OECD); UN Population Prospects; World Development Indicators, World Bank; and World Bank staff estimations.

Note: Business cycles defined as deviation of real GDP from Hodrick-Prescott-filtered trend. Sample includes unbalanced panel of 35 advanced economies and 133 EMDEs for 1987-2020. p-statistics are shown in parentheses.

TABLE 8 Regression results for labor force participation rates, robustness test: 10-year moving average

	15-19 years old		20-24 years old		25-49 years old		50-64 years old		65+ years old	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Fertility	0.706***		0.076**		0.004**					
	(0.000)		(0.009)		(0.002)					
Secondary enrollment	0.202***	0.149***								
	(0.000)	(0.000)								
Tertiary enrollment			-0.112***	-0.171***						
			(0.000)	(0.000)						
Completion of secondary education			0.022	0.030	0.252***	0.149***	0.341***	-0.014		
			(0.540)	(0.296)	(0.000)	(0.000)	(0.000)	(0.786)		
Completion of tertiary education			0.167**	-0.070	0.354***	0.335***	0.570***	0.145		
			(0.002)	(0.166)	(0.000)	(0.000)	(0.000)	(0.265)		
Life expectancy							0.621***	1.127***	0.101***	0.227***
							(0.000)	(0.000)	(0.000)	(0.000)
Cycle	26.37***	34.46***	5.54***	19.59***	0.336	0.663	-2.63*	-0.789	1.74	51.62
	(0.000)	(0.000)	(0.000)	(0.000)	(0.832)	(0.077)	(0.042)	(0.566)	(0.826)	(0.127)
Cycle * life expectancy									-0.023	-0.594
									(0.574)	(0.193)
Fertility * EMDE	-0.664***		-0.067**							
	(0.000)		(0.005)							
Secondary enrollment * EMDE	-0.332***									
	(0.000)									
Completion of secondary education * EMDE			-0.023	-0.057						
			(0.565)	(0.080)						
Completion of tertiary education * EMDE			-0.127	0.153*						
			(0.056)	(0.000)						
Life expectancy * EMDE									-0.143***	-0.608***
									(0.000)	(0.000)

TABLE 8 Regression results for labor force participation rates, robustness test: 10-year moving average (*continued*)

	15-19 years old		20-24 years old		25-49 years old		50-64 years old		65+ years old	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Cycle * EMDE	-17.83***	-23.82***		-11.46***	-2.51*					-17.04
	(0.000)	(0.000)		(0.000)	(0.033)					(0.526)
Cycle * life expectancy * EMDE										0.057
										(0.876)
Coefficient of fertility in EMDEs	0.070***		-0.008							
	(0.000)		(0.251)							
Coefficient of secondary enrollment in EMDEs	-0.133***									
	(0.000)									
Coefficient of secondary education in EMDEs			-0.015	-0.046***						
			(0.470)	(0.000)						
Coefficient of tertiary education in EMDEs			-0.035	0.047						
			(0.450)	(0.322)						
Coefficient of cycle in EMDE	-1.69*	-2.09*		0.220	-1.00**					
	(0.033)	(0.039)		(0.745)	(0.006)					
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort fixed effects	No	No	No	No	No	No	Yes	Yes	Yes	Yes
County-cohort fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age fixed effects	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes

Source: Barro and Lee 2013; Key Indicators of the Labor Market (KILM), International Labour Organization; Labour Force Statistics, Organisation for Economic Co-operation and Development (OECD); UN Population Prospects; World Development Indicators, World Bank; and World Bank staff estimations.

Note: Sample of countries is balanced across gender and age specific regressions. Business cycles defined as deviation of real GDP from Hodrick-Prescott-filtered trend. Sample includes balanced panel of 34 advanced economies and 104 EMDEs for 1987-2020. p-statistics are shown in parentheses.

TABLE 9 Regression results of labor force participation rates, robustness check: linear-quadratic trend

	15-19 years old		20-24 years old		25-49 years old		50-64 years old		65+ years old	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Fertility	0.697***		0.059*		0.000					
	(0.000)		(0.011)		(0.922)					
Secondary enrollment	0.202***	0.125***								
	(0.000)	(0.000)								
Tertiary enrollment			-0.113***	-0.180***						
			(0.000)	(0.000)						
Completion of secondary education			0.040	-0.013	0.236***	0.1340***	0.403***	0.064		
			(0.233)	(0.642)	(0.000)	(0.000)	(0.000)	(0.218)		
Completion of tertiary education			0.158**	-0.100*	0.321***	0.311***	0.490**	0.431**		
			(0.002)	(0.041)	(0.000)	(0.000)	(0.003)	(0.001)		
Life expectancy							0.571***	0.972***	0.101***	0.229***
							(0.000)	(0.000)	(0.000)	(0.000)
Cycle	15.11***	24.22***	0.281	12.72***	3.24**	0.156	-1.56	-2.12*	1.45	17.01
	(0.000)	(0.000)	(0.684)	(0.000)	(0.003)	(0.470)	(0.101)	(0.014)	(0.512)	(0.491)
Cycle * life expectancy									-0.027	-0.118
									(0.275)	(0.348)
Fertility * EMDE	-0.630***		-0.067**							
	(0.000)		(0.005)							
Secondary enrollment * EMDE	-0.342***									
	(0.000)									
Completion of secondary education * EMDE			-0.029	-0.048						
			(0.482)	(0.133)						
Completion of tertiary education * EMDE			-0.126	0.155*						
			(0.058)	(0.014)						
Life expectancy * EMDE									-0.145***	-0.620***
									(0.000)	(0.000)

TABLE 9 Regression results of labor force participation rates, robustness check: linear-quadratic trend (*continued*)

	15-19 years old		20-24 years old		25-49 years old		50-64 years old		65+ years old	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Cycle * EMDE	-16.77***	-25.50***		-12.11***	-3.91**					-16.58
	(0.000)	(0.000)		(0.000)	(0.001)					(0.504)
Cycle * life expectancy * EMDE										0.073
										(0.829)
Coefficient of fertility in EMDEs	0.067***		-0.008							
	(0.000)		(0.285)							
Coefficient of secondary enrollment in EMDEs	-0.138***									
	(0.000)									
Coefficient of secondary education in EMDEs			0.011	-0.164***						
			(0.556)	(0.000)						
Coefficient of tertiary education in EMDEs			0.032	-0.083						
			(0.472)	(0.253)						
Coefficient of cycle in EMDE	-1.66**	-1.28		0.35	-0.667*					
	(0.007)	(0.103)		(0.740)	(0.063)					
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort fixed effects	No	No	No	No	No	No	Yes	Yes	Yes	Yes
County-cohort fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age fixed effects	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	4428	4480	3741	3789	21382	21654	12239	12261	5107	5107
Number of countries	163	165	151	154	158	160	145	145	168	168
Adjusted R-square	0.997	0.997	0.999	0.999	0.997	0.999	0.986	0.993	0.998	0.999

Source: Barro and Lee 2013; Key Indicators of the Labor Market (KILM), International Labour Organization; Labour Force Statistics, Organisation for Economic Co-operation and Development (OECD); UN Population Prospects; World Development Indicators, World Bank; and World Bank staff estimations.

Note: Business cycles defined as deviation of real GDP from linear-quadratic trend. Sample includes unbalanced panel of 35 advanced economies and 133 EMDEs for 1987-2020. p-statistics are shown in parentheses.

TABLE 10 Coverage for univariate and multivariate filter-based estimates

Economy	Sample period	Economy	Sample period	Economy	Sample period
Australia	1981-2024	**East Asia and Pacific**		Paraguay	1994-2024
Austria	1995-2024	China	1992-2024	Peru	1998-2024
Belgium	1995-2024	Indonesia	2001-2024	Uruguay	1997-2024
Canada	1981-2024	Malaysia	2005-2024	**Middle East and North Africa**	
Croatia	2000-2024	Mongolia	2010-2024	Bahrain	2008-2024
Cyprus	1995-2024	Philippines	1998-2024	Egypt, Arab Rep.	2007-2024
Czech Rep.	1996-2024	Thailand	1993-2024	Iran, Islamic Rep.	2012-2024
Denmark	1991-2024	Vietnam	2008-2024	Jordan	1992-2024
Estonia	1995-2024	**Europe and Central Asia**		Kuwait	2010-2024
Finland	1981-2024	Albania	2008-2024	Morocco	1998-2024
France	1981-2024	Azerbaijan	2001-2024	Saudi Arabia	2010-2024
Germany	1981-2024	Bulgaria	2000-2024	Tunisia	2000-2024
Greece	1995-2024	Georgia	2003-2024	**South Asia**	
Hong Kong SAR, China	1990-2024	Hungary	1998-2024	India	1997-2024
Iceland	1995-2024	Kazakhstan	1996-2024	**Sub-Saharan Africa**	
Ireland	1995-2024	North Macedonia	2000-2024	Botswana	1994-2024
Israel	1995-2024	Poland	1996-2024	Cameroon	1999-2024
Italy	1981-2024	Romania	1995-2024	Kenya	2009-2024
Japan	1981-2024	Turkey	2001-2024	Lesotho	2007-2024
Korea	1981-2024	**Latin America and Caribbean**		Namibia	2000-2024
Latvia	1995-2024	Argentina	2004-2024	Nigeria	2010-2024
Lithuania	1995-2024	Belize	1994-2024	South Africa	1981-2024
Luxembourg	1995-2024	Bolivia	1990-2024	Tanzania	2010-2024
Malta	2000-2024	Brazil	1990-2024		
Netherlands	1981-2024	Chile	1996-2024		
New Zealand	1988-2024	Colombia	2000-2024		
Norway	1981-2024	Costa Rica	1991-2024		
Portugal	1995-2024	Dominican Republic	2007-2024		
Singapore	1981-2024	Ecuador	2001-2024		
Slovak Republic	1995-2024	El Salvador	1990-2024		
Slovenia	1995-2024	Guatemala	2001-2024		
Spain	1995-2024	Honduras	2000-2024		
Sweden	1981-2024	Mexico	2000-2024		
Switzerland	1981-2024	Nicaragua	2006-2024		
Taiwan	1982-2024	Panama	2007-2024		
United Kingdom	1981-2024				
United States	1981-2024				

Source: World Bank.

Note: Forecasts for 2022Q2-2024Q4 are based on the lag structure of the estimation.

TABLE 11 Coverage for production function approach, filter-based, and expectations-based estimates: Advanced economies

Economy	Production function approach	Univariate and multivariate filters	WEO expectations
Advanced economies			
Australia	1998-2032	1981-2024	1990-2022
Austria	1998-2032	1995-2024	1990-2022
Belgium	1998-2032	1995-2024	1990-2022
Canada	1998-2032	1981-2024	1990-2022
Croatia	1998-2032	2000-2024	1994-2022
Cyprus	1998-2032	1995-2024	1990-2022
Denmark	1998-2032	1991-2024	1990-2022
Estonia	1998-2032	1995-2024	1993-2022
Finland	1998-2032	1981-2024	1990-2022
France	1998-2032	1981-2024	1990-2022
Germany	1998-2032	1981-2024	1990-2022
Greece	1998-2032	1995-2024	1990-2022
Hong Kong SAR, China	1998-2032	1990-2024	1990-2022
Ireland	1998-2032	1995-2024	1990-2022
Israel	1998-2032	1995-2024	1990-2022
Italy	1998-2032	1981-2024	1990-2022
Japan	1998-2032	1981-2024	1990-2022
Korea, Rep.	1998-2032	1981-2024	1990-2022
Latvia	1998-2032	1995-2024	1993-2022
Lithuania	2000-2032	1995-2024	1993-2022
Netherlands	1998-2032	1981-2024	1990-2022
Norway	1998-2032	1981-2024	1990-2022
Portugal	1998-2032	1995-2024	1990-2022
Slovak Republic	1998-2032	1995-2024	1994-2022
Slovenia	1998-2032	1995-2024	1994-2022
Spain	1998-2032	1995-2024	1990-2022
Sweden	1998-2032	1981-2024	1990-2022
Switzerland	1998-2032	1981-2024	1990-2022
United Kingdom	1998-2032	1981-2024	1990-2022
United States	1998-2032	1981-2024	1990-2022

Source: World Bank.

Note: Forecasts for filter-based estimates for 2022Q2-2024Q4 are based on the lag structure of the estimation. Forecasts for production function-based estimates are derived as described in Kilic Celik, Kose, and Ohnsorge (2023). Univariate filters: Hodrick-Prescott, Baxter and King, Christiano and Fitzgerald, Butterworth, and unobserved component model.

TABLE 12 Coverage for production function approach, filter-based, and expectations-based estimates: EMDEs

Economy	Production function approach	Univariate and multivariate filters	WEO expectations
EMDEs			
Albania	1998-2032	2008-2024	1993-2021
Argentina	1998-2032	2004-2024	1990-2021
Bolivia	1998-2032	1990-2024	1990-2021
Brazil	1998-2032	1990-2024	1990-2021
Bulgaria	2000-2032	2000-2024	2000-2021
Cameroon	1998-2032	1999-2024	1990-2021
Chile	1998-2032	1996-2024	1990-2021
China	1998-2032	1992-2024	1990-2021
Colombia	1998-2032	2000-2024	1990-2021
Costa Rica	1998-2032	1991-2024	1990-2021
Dominican Republic	1998-2032	2007-2024	1990-2021
Ecuador	1998-2032	2001-2024	1990-2021
Egypt, Arab Rep.	1998-2032	2007-2024	1990-2021
Guatemala	1998-2032	2001-2024	1990-2021
Honduras	1998-2032	2000-2024	1990-2021
Hungary	1998-2032	1998-2024	1990-2021
India	1998-2032	1997-2024	1990-2021
Indonesia	1998-2032	2001-2024	1990-2021
Iran, Islamic Rep.	1998-2032	2012-2024	1990-2021
Jordan	1998-2032	1992-2024	1990-2021
Kazakhstan	1998-2032	1996-2024	1993-2021
Kenya	1998-2032	2009-2024	1990-2021
Lesotho	1998-2032	2007-2024	1990-2021
Malaysia	1998-2032	2005-2024	1990-2021
Mexico	1998-2032	2000-2024	1990-2021
Mongolia	1998-2032	2010-2024	1993-2021
Morocco	1998-2032	1998-2024	1990-2021
Namibia	1998-2032	2000-2024	1994-2021
Nicaragua	1998-2032	2006-2024	1990-2021
Paraguay	1998-2032	1994-2024	1990-2021
Peru	1998-2032	1998-2024	1990-2021
Philippines	1998-2032	1998-2024	1990-2021
Poland	1998-2032	1996-2024	1990-2021
Romania	1998-2032	1995-2024	1993-2021
South Africa	1998-2032	1981-2024	1990-2021
Thailand	1998-2032	1993-2024	1990-2021
Tunisia	1998-2032	2000-2024	1990-2021
Turkey	1998-2032	2001-2024	1990-2021
Uruguay	1998-2032	1997-2024	1990-2021
Vietnam	2013-2032	2008-2024	1990-2021

Source: World Bank.

Note: Includes only countries with available data from 2001. Forecasts for filter-based estimates for 2022Q2-2024Q4 are based on the lag structure of the estimation. Forecasts for production function-based estimates are derived as described in Kilic Celik, Kose, and Ohnsorge (2023). Univariate filters: Hodrick-Prescott, Baxter and King, Christiano and Fitzgerald, Butterworth, and unobserved component model.

TABLE 13 List of banking crises

Regions	Countries
Advanced economies	AUT (2008), BEL (2008), CHE (2008), CYP (2011), CZE (1996), DEU (2008), DNK (2008), ESP (2008), FIN (1991), FRA (2008), GBR (2007), GRC (2008), HRV (1998), IRL (2008), ISL (2008), ITA (2008), JPN (1997), KOR (1997), LTU (1995), LUX (2008), LVA (1995), LVA (2008), NLD (2008), NOR (1991), PRT (2008), SVK (1998), SVN (2008), SWE (1991), SWE (2008), USA (2007)
Emerging market and developing economies	ALB (1994), ARG (1995), ARG (2001), ARM (1994), AZE (1995), BDI (1994), BFA (1990), BOL (1994), BRA (1990), BRA (1994), CAF (1995), CHN (1998), CMR (1995), COD (1991), COD (1994), COG (1992), COL (1998), CPV (1993), CRI (1994), DJI (1991), DOM (2003), DZA (1990), ECU (1998), GIN (1993), GNB (1995), GNB (2014), GUY (1993), HTI (1994), HUN (1991), HUN (2008), IDN (1997), IND (1993), JAM (1996), KAZ (2008), KEN (1992), KGZ (1995), LBN (1990), LBR (1991), MDA (2014), MEX (1994), MNG (2008), MYS (1997), NGA (1991), NGA (2009), NIC (1990), NIC (2000), PHL (1997), POL (1992), PRY (1995), ROU (1998), STP (1992), TCD (1992), TGO (1993), THA (1997), TUN (1991), TUR (2000), UGA (1994), URY (2002), VNM (1997), YEM (1996)

Sources: Laeven and Valencia 2018; World Bank.

Note: The list of banking crises corresponding to the sample of potential growth measures. Country codes are available at https://www.iban.com/country-codes.

TABLE 14 List of countries affected by epidemics

Epidemics	Countries
SARS (2003)	CAN, CHN, FRA, MYS, PHL, SGP, THA, VNM, ZAF, HKG, TWN.
Swine flu (2009)	AFG, ALB, ARE, ARG, ARM, AUS, AZE, BGD, BGR, BHR, BHS, BIH, BLR, BMU, BOL, BRA, BRB, BRN, CAN, CHE, CHL, CHN, COL, CRI, CUB, CZE, DEU, DOM, DZA, ECU, EGY, ESP, EST, FRA, GBR, GEO, GHA, GRC, GTM, HND, HRV, HUN, IDN, IND, IRL, IRN, IRQ, ISL, ISR, ITA, JAM, JOR, JPN, KHM, KOR, KWT, LAO, LBN, LBY, LKA, LTU, LUX, LVA, MAR, MDA, MDG, MDV, MEX, MHL, MLT, MNE, MNG, MOZ, MUS, MYS, NAM, NGA, NIC, NLD, NOR, NPL, NZL, OMN, PAK, PAN, PER, PHL, POL, PRY, PYF, QAT, ROU, RUS, SAU, SDN, SGP, SLB, SLV, SRB, SUR, SVK, SVN, SWE, SYR, THA, TON, TUN, TUR, TZA, UKR, URY, USA, VNM, WSM, YEM, ZAF.
MERS (2012)	ARE, AUT, DEU, DZA, FRA, GBR, GRC, IRN, JOR, KOR, KWT, MYS, OMN, QAT, SAU, TUN, TUR, YEM.
Ebola (2014)	MLI, NGA, GIN, LBR, SLE.
Zika (2016)	BOL, BRA, COL, DOM, GLP, MTQ, PRI, SUR, USA.

Source: World Bank.

Note: Country codes are available at https://www.iban.com/country-codes.

TABLE 15 Impulse responses of potential growth to recessions

		Recessions: Baseline definition			Recessions: Alternative definition		
Definition of potential output	**h**	**World**	**AEs**	**EMDEs**	**World**	**AEs**	**EMDEs**
Production-function approach	0	-0.042	0.066	-0.138	-0.046	0.042	-0.123
	1	-1.153***	-0.773***	-1.499***	-1.123***	-0.792***	-1.414***
	2	-1.573***	-1.407***	-1.738***	-1.432***	-1.402***	-1.454***
	3	-1.542***	-1.444***	-1.645***	-1.401***	-1.432***	-1.371***
	4	-1.521***	-1.421***	-1.639***	-1.348***	-1.386***	-1.308***
	5	-1.431***	-1.257***	-1.635***	-1.244***	-1.193***	-1.296***
Multivariate filter	0	-0.355***	-0.354***	-0.352***	-0.348***	-0.342***	-0.352***
	1	-2.082***	-1.782***	-2.465***	-2.014***	-1.709***	-2.419***
	2	-1.298***	-1.485***	-0.947***	-1.215***	-1.372***	-0.91***
	3	-0.734***	-1.033***	-0.192	-0.647***	-0.848***	-0.272
	4	-0.442*	-0.699**	0.06	-0.356*	-0.488**	-0.103
	5	-0.133	-0.215	0.025	-0.123	-0.143	-0.089
Expectations (WEO)	0	-0.058	-0.06	-0.057	-0.04	-0.037	-0.042
	1	-0.208**	0.055	-0.356***	0.08	0.128*	0.052
	2	-0.33**	-0.143	-0.425**	-0.036	-0.042	-0.032
	3	-0.315*	-0.144	-0.403	-0.282	-0.08	-0.395
	4	-0.251	-0.072	-0.348	-0.282**	-0.022	-0.433**
	5	-0.262*	-0.125	-0.336	-0.269**	-0.078	-0.378*
Unobserved component model	0	-0.208***	-0.215***	-0.2***	-0.215***	-0.238***	-0.184***
	1	-1.83***	-1.605***	-2.102***	-1.794***	-1.597***	-2.037***
	2	-0.638***	-0.711***	-0.532***	-0.599***	-0.67***	-0.497***
	3	-0.279***	-0.256**	-0.316*	-0.275***	-0.217**	-0.362**
	4	-0.3***	-0.298**	-0.301**	-0.297***	-0.262**	-0.358***
	5	-0.198*	-0.143	-0.288***	-0.19**	-0.118	-0.314***

Source: World Bank.

Note: *** indicates significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level. "Recessions: Baseline definition" are defined as the period from the peak preceding a business cycle trough to the trough, with the troughs defined as years of output growth that is both negative and one standard deviation below the long-term average (as in Huidrom, Kose, and Ohnsorge 2016). "Mild Recessions: Alternative definition" are defined as years of negative output growth only, regardless of the depth of the output decline. Sample includes unbalanced panel of 33 advanced economies and 77 EMDEs for 1981-2020.

TABLE 16 Impulse Responses of Potential Growth to Recessions (Other Measures)

		Recessions: Baseline definition			Recessions: Alternative definition		
Definition of potential output	h	World	AEs	EMDEs	World	AEs	EMDEs
Expectations (CF)	0	0.004	0.04	-0.056	0.012	0.041	-0.04
	1	-0.084	-0.024	-0.189**	-0.087*	-0.058	-0.139*
	2	-0.157**	-0.127	-0.207*	-0.135**	-0.13	-0.145
	3	-0.114	-0.07	-0.171	-0.077	-0.083	-0.067
	4	-0.215**	-0.134*	-0.361	-0.241***	-0.224***	-0.272
	5	-0.19**	-0.187*	-0.203	-0.214**	-0.26**	-0.124
Hodrick-Prescott filter	0	-0.165***	-0.194***	-0.128***	-0.16***	-0.181***	-0.132***
	1	-0.212***	-0.337***	-0.046	-0.2***	-0.298***	-0.066
	2	-0.493***	-0.664***	-0.224	-0.412***	-0.512**	-0.264
	3	-0.32	-0.544*	0.056	-0.232	-0.35	-0.053
	4	-0.146	-0.321	0.17	-0.072	-0.132	0.006
	5	0.058	-0.047	0.249	0.089	0.089	0.055
Christiano-Fitzgerald filter	0	-0.691***	-0.575***	-0.8***	-0.673***	-0.524***	-0.826***
	1	-0.809***	-0.937***	-0.61***	-0.798***	-0.867***	-0.67***
	2	-1.299***	-1.572***	-0.795**	-1.193***	-1.304***	-0.956**
	3	-1.233***	-1.563***	-0.608	-1.061***	-1.215***	-0.749*
	4	-1.029***	-1.419***	-0.257	-0.887***	-1.062***	-0.548
	5	-0.685**	-0.833*	-0.406	-0.598**	-0.579	-0.666
Baxter-King filter	0	-2.161***	-1.983***	-2.388***	-2.113***	-1.932***	-2.351***
	1	-4.197***	-4.099***	-4.327***	-4.08***	-3.983***	-4.216***
	2	-3.413***	-3.607***	-3.071***	-3.132***	-3.295***	-2.843***
	3	-1.589***	-1.799***	-1.2**	-1.42***	-1.512***	-1.254**
	4	-1.469***	-1.614***	-1.166**	-1.303***	-1.281***	-1.353***
	5	-1.333***	-1.298***	-1.396***	-1.167***	-1.047***	-1.417***
Butterworth filter	0	-0.703***	-0.562***	-0.744***	-0.693***	-0.544***	-0.726***
	1	-1.507***	-1.27***	-1.672***	-1.461***	-1.212***	-1.626***
	2	-1.419***	-1.493***	-1.078***	-1.29***	-1.307***	-1.01***
	3	-1.103***	-1.017***	-1.05**	-0.979***	-0.813***	-1.044***
	4	-0.792***	-0.75**	-0.784*	-0.679***	-0.554**	-0.834**
	5	-0.443**	-0.433	-0.425	-0.378**	-0.293	-0.51*

Source: World Bank.

Note: *** indicates significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level. "Recessions: Baseline definition" are defined as the period from the peak preceding a business cycle trough to the trough, with the troughs defined as years of output growth that is both negative and one standard deviation below the long-term average (as in Huidrom, Kose, and Ohnsorge 2016). "Mild Recessions: Alternative definition" are defined as years of negative output growth only, regardless of the depth of the output decline. Sample includes unbalanced panel of 33 advanced economies and 77 EMDEs for 1981-2020.

TABLE 17 Impulse Responses of Potential Growth to Banking Crises and Epidemics

		Banking crises			Epidemics		
Definition of potential output	**h**	**World**	**AEs**	**EMDEs**	**World**	**AEs**	**EMDEs**
Production-function approach	0	-0.574***	-0.538*	-0.763**	-0.731***	-0.846***	-0.68***
	1	-1.605***	-1.508**	-1.865***	-0.796***	-1.035***	-0.649***
	2	-1.75***	-1.979***	-1.402***	-0.77***	-0.911***	-0.655***
	3	-1.467***	-1.958***	-0.451	-0.872***	-1.057***	-0.77**
	4	-1.286***	-1.929***	0.031	-1.083***	-1.126***	-1.062***
	5	-1.169**	-1.908***	0.416	-0.866***	-0.849**	-0.895***
Multivariate filter	0	-0.349**	-0.406**	-0.209	-0.229**	-0.247	-0.214
	1	-0.746***	-0.981***	-0.119	-0.021	-0.198	0.12
	2	-0.724**	-1.25***	0.743	0.195	0.169	0.215
	3	-0.27	-0.81**	1.176**	0.305	0.531*	0.127
	4	0.127	-0.279	1.183*	0.232	0.63**	-0.081
	5	0.4	0.052	1.339*	0.335	0.874**	-0.121
Expectations (WEO)	0	-0.025	-0.044	-0.019	-0.421***	-0.173	-0.525***
	1	-0.08	0.065	-0.155	-0.334***	-0.287***	-0.358**
	2	0.028	-0.035	0.076	-0.313*	-0.176	-0.374
	3	0.276	0.088	0.394	-0.479***	-0.175	-0.609***
	4	0.174	0.141	0.199	-0.519***	-0.19	-0.661***
	5	0.142	0.071	0.199	-0.623***	-0.208	-0.808***
Unobserved component model	0	-0.573***	-0.736***	-0.278	-0.664***	-0.792***	-0.564***
	1	-1.399***	-1.731***	-0.806**	0.139*	0.133	0.146
	2	-0.364**	-0.67***	0.18	0.075	0.083	0.066
	3	-0.133	-0.48***	0.488***	-0.075	-0.059	-0.085
	4	-0.356**	-0.796***	0.43**	-0.198	-0.028	-0.335*
	5	-0.299**	-0.553***	0.152	0.005	0.191	-0.156

Sources: Laeven and Valencia 2018; World Bank.

*Note: *** indicates significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level. Sample includes unbalanced panel of 33 advanced economies and 98 EMDEs for 1981-2020.*

TABLE 18 Responses of Potential Growth to Banking Crises and Epidemics (Other Measures)

		Banking crises			Epidemics		
Definition of potential output	**h**	**World**	**AEs**	**EMDEs**	**World**	**AEs**	**EMDEs**
Expectations (CF)	0	0.046	0.093**	-0.046	-0.081	-0.105	-0.062
	1	-0.33**	-0.144	-0.753***	-0.005	-0.148*	0.179
	2	-0.192	-0.163	-0.266	0.077	-0.082	0.275**
	3	-0.094	0.186	-0.632***	-0.056	-0.142**	0.027
	4	-0.212*	-0.102	-0.4	0.003	-0.063	0.082
	5	-0.285*	-0.161	-0.5	-0.104	-0.141	-0.039
Hodrick-Prescott filter	0	-0.132**	-0.229***	0.113	0.065**	0.163***	-0.01
	1	-0.177	-0.431***	0.456	0.297***	0.546***	0.104
	2	0.002	-0.39	0.979	0.499***	0.878***	0.199
	3	0.258	-0.224	1.453*	0.554***	1.037***	0.17
	4	0.497	-0.006	1.747*	0.509**	1.097***	0.042
	5	0.761*	0.299	1.913*	0.456*	1.146***	-0.124
Christiano-Fitzgerald filter	0	-0.485***	-0.53***	-0.253	-0.451***	-0.444***	-0.421***
	1	-1.034***	-1.365***	-0.005	-0.396***	-0.21	-0.513**
	2	-1.096***	-1.612***	0.338	0.032	0.284	-0.151
	3	-0.757	-1.481***	1.181	0.364	0.673**	0.12
	4	-0.344	-1.083**	1.512	0.214	0.57*	-0.086
	5	0.166	-0.501	1.825	0.604**	1.091***	0.174
Baxter-King filter	0	-2.288***	-2.64***	-1.31*	-0.666***	-0.739**	-0.614***
	1	-3.877***	-4.73***	-1.525	0.415	0.492	0.341
	2	-2.149***	-2.975***	0.125	0.677**	0.833**	0.539
	3	-0.921	-1.768***	1.427	0.173	0.428	-0.031
	4	-1.198**	-1.993***	1.001	0.02	0.407	-0.284
	5	-0.875*	-1.59***	1.114	0.249	0.88*	-0.269
Butterworth filter	0	-0.899***	-0.739***	-0.597	-0.45	0.03	-0.553*
	1	-1.382***	-1.429***	-0.515	0.196	0.665***	0.116
	2	-0.892**	-1.085***	0.249	0.295	0.876***	0.095
	3	-0.476	-0.745**	0.782	0.117	0.803***	-0.204
	4	-0.212	-0.619*	1.073	0.214	0.809***	-0.164
	5	0.117	-0.278	1.262	0.212	0.922**	-0.318

Sources: Laeven and Valencia 2018; World Bank.

*Note: *** indicates significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level. Sample includes unbalanced panel of 33 advanced economies and 98 EMDEs for 1981-2020.*

TABLE 19 Channels: Impulse Responses of TFP, Investment, Employment and Actual Growth Rates to Recessions

		Recessions: Baseline definition			Recessions: Alternative definition		
Definition of potential output	h	World	AEs	EMDEs	World	AEs	EMDEs
TFP	0	-0.066**	-0.019	-0.108**	-0.064**	-0.041**	-0.087*
	1	-0.359***	-0.228***	-0.471***	-0.353***	-0.251***	-0.443***
	2	-0.626***	-0.476***	-0.743***	-0.577***	-0.495***	-0.64***
	3	-0.676***	-0.495***	-0.819***	-0.635***	-0.527***	-0.723***
	4	-0.759***	-0.497***	-0.985***	-0.69***	-0.519***	-0.842***
	5	-0.686***	-0.418***	-0.919***	-0.619***	-0.425***	-0.793***
Investment	0	-1.842**	-2.913***	-1.151	-2.469***	-3.515***	-1.7*
	1	-15.501***	-12.809***	-17.097***	-15.483***	-12.99***	-17.006***
	2	-7.689***	-10.231***	-6.265**	-7.37***	-9.332***	-6.151**
	3	-3.348**	-4.079**	-2.936	-2.963*	-3.696***	-2.484
	4	-2.947*	-2.897	-2.976	-1.814	-2.478*	-1.414
	5	-3.017**	-2.838*	-3.13	-3.601***	-2.588**	-4.216**
Employment	0	-0.432***	-0.309	-0.497**	-0.446***	-0.435***	-0.444**
	1	-1.691***	-2.898***	-1.247***	-1.723***	-2.845***	-1.248***
	2	-1.29***	-3.4***	-0.471	-1.331***	-3.13***	-0.549*
	3	-1.038***	-1.592***	-0.819**	-1.025***	-1.509***	-0.817**
	4	-0.717***	-1.046***	-0.586*	-0.631***	-0.964***	-0.482
	5	-0.398	-0.975***	-0.16	-0.393	-0.86***	-0.179
Unemployment	0	-0.039	-0.077	-0.017	-0.048	-0.055	-0.044
	1	1.326***	1.555***	1.21***	1.281***	1.588***	1.126***
	2	1.88***	3.424***	1.15***	1.78***	3.417***	1.048***
	3	1.786***	3.457***	1.002***	1.698***	3.515***	0.897***
	4	1.689***	3.257***	0.902***	1.577***	3.234***	0.803**
	5	1.656***	3.34***	0.811**	1.464***	3.112***	0.695**
Actual growth	0	0.019	-0.887***	0.419	-0.02	-0.986***	0.446
	1	-8.809***	-7.157***	-9.597***	-8.474***	-6.843***	-9.305***
	2	-4.992***	-4.506***	-5.197***	-4.649***	-3.94***	-4.979***
	3	-1.399**	-2.503**	-0.957	-1.337**	-2.112**	-0.988
	4	-2.349***	-2.539***	-2.28**	-2.095***	-2.012***	-2.144**
	5	-1.124**	-1.609**	-0.903	-0.886*	-1.209**	-0.719

Source: World Bank.

*Note: *** indicates significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level. "Recessions: Baseline definition" are defined as the period from the peak preceding a business cycle trough to the trough, with the troughs defined as years of output growth that is both negative and one standard deviation below the long-term average (as in Huidrom, Kose, and Ohnsorge 2016). "Mild Recessions: Alternative definition" are defined as years of negative output growth only, regardless of the depth of the output decline. Sample includes unbalanced panel of 32 advanced economies and 79 EMDEs for 1981-2020.*

TABLE 20 Channels: Impulse Responses of TFP, Investment, Employment and Actual Growth Rates to Banking Crises and Epidemics

		Banking crises			Epidemics		
Definition of potential output	**h**	**World**	**AEs**	**EMDEs**	**World**	**AEs**	**EMDEs**
Total factor productivity	0	-0.177***	-0.119***	-0.279**	-0.235***	-0.241***	-0.223***
	1	-0.559***	-0.419***	-0.771***	-0.276***	-0.307***	-0.248***
	2	-0.627***	-0.566***	-0.748***	-0.296***	-0.306***	-0.278***
	3	-0.562***	-0.619***	-0.531**	-0.394***	-0.389***	-0.388***
	4	-0.54***	-0.655***	-0.446	-0.524***	-0.358***	-0.606***
	5	-0.375**	-0.558***	-0.189	-0.315***	-0.093	-0.434***
Investment	0	-4.451*	-4.119	-4.576	-12.522***	-9.658***	-13.252***
	1	-14.031***	-16.744***	-12.31***	-3.487**	-1.575	-4.275**
	2	-1.649	-11.541***	4.509	-2.762*	2.696**	-4.803**
	3	3.182	-2.718	6.846*	-3.202***	0.203	-4.575***
	4	0.507	-6.409***	4.781*	-3.442**	-0.446	-4.772**
	5	-2.145	-6.08***	0.303	-4.085***	1.671	-6.537***
Employment	0	-0.223	-0.677*	-0.03	-1.662***	-2.784***	-1.167***
	1	-1.196***	-3.444***	-0.358	-0.951***	-1.419***	-0.764*
	2	-0.501	-2.528***	0.243	-0.866***	-0.584**	-1.009**
	3	-0.166	-1.511***	0.339	-0.574*	-0.897***	-0.44
	4	-0.198	-1.551***	0.316	-0.926***	-0.662*	-1.021**
	5	0.12	-1.403***	0.692**	-0.828***	-0.377	-1.039***
Unemployment	0	0.382**	0.473**	0.355	0.869***	1.881***	0.465***
	1	1.592***	2.81***	0.909***	1.063***	2.516***	0.497**
	2	1.891***	3.574***	0.928***	1.089***	2.402***	0.599**
	3	1.828***	3.822***	0.663**	1.151***	2.701***	0.592**
	4	2.1***	4.494***	0.694**	1.316***	2.841***	0.742***
	5	2.156***	4.684***	0.661**	1.033***	2.401***	0.51*
Actual growth	0	-0.629	-2.113**	0.026	-3.956***	-4.161***	-3.76***
	1	-2.026	-5.123***	-0.64	-0.362	0.903	-0.871
	2	0.967	-0.462	1.609	-0.128	0.491	-0.403
	3	1.809**	0.055	2.596**	-1.124***	-0.51	-1.379***
	4	1.859**	-1.334	3.292***	-1.137***	-0.287	-1.491***
	5	1.66*	-0.419	2.603**	-1.081***	0.183	-1.731***

Source: Laeven and Valencia 2018; and World Bank.

Note: *** indicates significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level. Sample includes unbalanced panel of 32 advanced economies and 100 EMDEs for 1981-2020.

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