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Mind the Gaps!

Financial-Cycle Output Gaps and Monetary-Policy-Relevant Output Gaps

Douglas Laxton, Asya Kostanyan, Akaki Liqokeli, Gevorg Minasyan, Armen Nurbekyan and Tamta Sopromadze

Mind the Gaps! Financial-Cycle Output Gaps and Monetary-Policy-Relevant Output Gaps[1] [2]

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Abstract

This paper develops measures of output gaps with a clear distinction between model concepts that are relevant for monetary policy and measures designed specifically for assessing financial-stability risks. It argues that failure to make a clear distinction between the two concepts can lead to misguided policies that could potentially result in central banks allowing long-term inflation expectations to ratchet downwards and possibly getting stuck in low interest rate traps with significant risks of deflation and financial instability. Moreover, the paper shows that the financial-cycle output-gap model (FCMOD) outperforms the traditional monetary-policy-relevant specification in predicting the medium-term projected level of GDP, so there is merit in using FCMOD forecasts as inputs into the monetary policy model (MPMOD) medium-term forecasts of potential output. The first measure, which goes to back to Arthur Okun in 1962 and is relevant for monetary policy, is used by inflation-forecast-targeting (IFT) central banks (CBs) to communicate how they are managing the short-run output-inflation trade-off. The second is a measure of the financial cycle and is based on a simple atheoretical model that incorporates information on the growth rates of real credit and real property prices. The paper develops empirical estimates for the U.S. and China (for the financial cycle). The estimates of the U.S. output gaps based on the financial-cycle concept are over *twice as large* before the global financial crisis (GFC) than the measures relevant for monetary policy. The estimates for China suggest that the financial-cycle output gap now is similar in magnitude to the U.S. estimates before the GFC.

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[1] The views expressed here are those of the authors and do not necessarily represent the views of Central Bank of Armenia (CBA) or National Bank of Georgia (NBG). No responsibility for them should be attributed to the CBA or NBG.

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I. INTRODUCTION

An important objective of this paper is to make a clear distinction between concepts of the output gap that are relevant for price and financial stability. This distinction is highly relevant for policy making and is closely related to the "leaning against the wind" (LAW) debate, which has been at the fore in recent years. The proponents of LAW argue that monetary policy should be focused on financial stability and should systematically react to the financial cycle to avoid costly crises (see, for example, Filardo and others, 2016; Juselius and others, 2016 and Borio, 2016). According to this logic, rather than cutting interest rates aggressively in response to contractionary shocks, central banks should be more flexible and plan to bring inflation back to their targets only gradually over time. There are two problems with the LAW argument. First, such a policy is inconsistent with central bank objectives of eliminating wasteful economic slack in the economy and efficiently managing the short-run unemployment-inflation tradeoff.[3] Secondly, and more importantly, such a policy can be completely counterproductive, because it may result in long-term inflation expectations ratcheting downwards and higher risks of getting stuck in a low inflation trap with a much more prolonged period of very low interest rates.[4] The LAW argument is based on a "lucky-fool" strategy, where policymakers hope that the economy will strengthen without monetary or fiscal policy action and dismiss the possibility that more contractionary shocks will arrive in the future that could potentially push economies into deflationary spirals with debt deflation.[5]

Importantly, we do not argue against the importance of financial stability, but rather emphasize that precisely because of its high importance it is critical to find the right set of policies to effectively deal with the risks and costs of financial instability; this is a better alternative to overburdening and risking the hard-fought credibility of existing monetary

[3] Saunders and Tulip (2019) and Svensson (2017) argue that such a policy would have insignificant benefits in terms of reducing the probability of a financial crisis.

[4] The analytical framework pushed by LAW proponents is based on an incorrect assumption that central banks can simply control real market interest rates and that higher interest rates would be successful in containing risks to financial stability. Central banks in the real world set a very short-term interest rate to influence long-term market interest rates and asset prices. In the standard framework for monetary policy the primary role of the central bank is to adjust this short-term interest rate to provide a nominal anchor for the economy and placing weights on other objectives must not be inconsistent with this objective (see Adrian, Laxton and Obstfeld, 2018). Real interest rates and asset prices are determined by the interactions of central banks and financial markets. For models with policies designed to deal with excessive credit expansions and asset prices see Benes, Kumhof and Laxton (2014a, b) and Benes, Laxton and Mongardini (2016).

[5] Central banks with established analytical frameworks, like the Czech National Bank, understood the risks associated with passive monetary policies based on lucky-fool strategies. They deployed their instruments aggressively to escape from a low-inflation trap and having achieved low unemployment and inflation slightly above target now enjoy significant policy space to deal with future contractionary shocks. See Al-Mashat and others (2018). We thank Tomas Holub (Czech National Bank Board Member) for his excellent presentation of the potential costs of following lucky-fool strategies. See www.douglaslaxton.org for links to his presentation at the 2019 Central Bank Modeling Workshop.

policy frameworks. Misguided policies based on weak analytical frameworks are potentially dangerous as demonstrated by the ample warnings before the GFC without providing sensible solutions. Indeed, proponents of LAW argue that interest rates should have been higher before the GFC pointing to evidence of large output gaps before the GFC (Taylor 2019).[6] By contrast, central banks such as the Czech National Bank (CNB) cut the policy rate in August 2008, before the September 2008 Lehman event and provided forward guidance that the impending slowdown in the global economy would require future cuts in interest rates. We argue that the advice to policymakers that is based on "lucky-fool" strategies is not robust and credible; we rather need to focus on policies, as the CNB has demonstrated, that could potentially be successful in reducing the risks and costs of financial crises.

We show that the monetary policy-relevant output gap is conceptually and quantitatively different from the financial cycle. Failure to make this distinction can lead to misguided policies that will result in central banks allowing long-term inflation expectations to ratchet downwards and potentially getting stuck in low interest-rate traps.

The first measure of the output gap, the monetary policy-relevant output gap, is the measure that is used by inflation-forecast-targeting central banks to communicate how they are managing the short-run output-inflation trade-off — see Clinton and others (2015) and Adrian, Laxton and Obstfeld (2018). The second measure, the financial-stability-relevant output gap or financial cycle, is based on a simple atheoretical model, which incorporates information on the growth rates of real credit and real property prices.

The monetary-policy output gap is constructed from a small Monetary Policy Model (MPMOD) that includes: a Phillips curve; a dynamic Okun's law equation; a monetary policy reaction function; a term-structure equation; and an equation that links the economy-wide output gap to measures of capacity utilization in the manufacturing sector. The exact model specification is based on a simplified version of a model presented in Alichi and others (2018).[7]

To construct the measures of the output gap relevant for financial-stability assessments, this paper develops a simple atheoretical model of the financial cycle. This involves specifying an atheoretical model that includes a cyclical and trend decomposition for output. Specifically, following Borio, Disyatat, Juselius (2013, 2014), we use information on real property price growth and real credit growth to help measure the lower-frequency cyclical component in US GDP. We refer to this simple atheoretical model as the Financial Cycle Model (FCMOD). For FCMOD, we use the term trend output to distinguish it clearly from the concept of

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[6] The measures of the equilibrium real interest rates and output gaps used by Taylor (2019) were based on a BIS paper by Hofman and Bogdanova (2012). The great deviation from the Taylor rule looks like it is simply a result of excessively high estimates of the equilibrium real interest rate and using the wrong concept of the output gap.

[7] See www.douglaslaxton.org for the details about the model including the IRIS code to replicate the results in this paper.

potential output, which is based on the notion of imbalances between aggregate demand and supply in the goods market. We emphasize that FCMOD is an atheoretical model, as there is no theoretical basis to support a structural link between deviations of aggregate demand and supply in the goods market and growth in these 2 financial variables.

While the resulting cyclical component of GDP from FCMOD is correlated with conventional measures of the output gap, the FCMOD output gaps were *over double the size* of the MPMOD output gaps before the GFC. This is consistent with the observation that financial imbalances were building up before the GFC with only modest increases in underlying inflationary pressures in the goods market.[8]

In addition to the importance for monetary and macroprudential policies, measures of sustainable output also have important implications for fiscal policy. Information about the sustainable or trend level of output is important to obtain measures of the medium-term sustainable tax base, a key input for fiscal policy. Using standard techniques for combining forecasts, this paper shows how to condition medium-term projections of actual and potential output on measures of trend output that can account for the financial cycle.

The remainder of the paper is organized in the following way. Section II summarizes MPMOD and the estimates developed in Alichi and others (2018).[9] Section III develops a simple atheoretical model of the financial cycle (FCMOD). Section IV compares the results from MPMOD and FCMOD with the HP filter and discusses the use of the HP filter in policymaking. Section V compares the real-time measures of the output gap from the two models as well as their out-of-sample medium-term forecasts. It also employs standard methods to combine the forecasts of the two models to obtain a measure of future potential output that incorporates information about the financial cycle. Section VI applies FCMOD to China and shows that the estimates of the China financial cycle in 2018 were similar in magnitude to the estimates derived for the U.S. before the GFC. Section VII provides some concluding remarks.

II. Measuring the Output Gap and Potential Output from MPMOD

The MPMOD is based on Alichi and others (2018), which describes the model and estimation results in detail.[10] The model is an extension of the simple multivariate filter presented in Alichi and others (2015). The basic idea behind the multivariate filter approach is to inform estimates of latent variables, such as the output gap, with theoretical

[8] Inflation in the US picked up before the GFC, but this was primarily due to high commodity prices.

[9] The code used to generate the results in this paper can be downloaded from www.douglaslaxton.org. The model is a simplified version of Alichi and others (2018). It has been simplified so that all the results can be easily replicated and updated by other researchers.

[10] The equations of the model are included in an appendix that can be downloaded from www.douglaslaxton.org.

relationships linking unobservable with observable variables. This is in sharp contrast to extracting measures of latent variables from purely statistical filters.

The original model included a Phillips curve, a dynamic Okun's law equation linking the unemployment gap to the output gap, and an equation that linked the output gap to the Fed's measure of capacity utilization in the manufacturing sector. The stochastic process for GDP included a persistent cyclical component as well as two shocks that could permanently change the level of potential output. The first shock to potential output accounts for simple level shifts, while the second shock can account for episodes when the growth rate of potential output deviates persistently from its long-term growth rate. The model has been extended to include a monetary policy reaction function and a model for 10-year bond yields. This allows us to estimate and project both the short-term equilibrium real interest rate, the 10-year term premium and 10-year bond yields.

The model is estimated with annual data covering the period from 1980 to 2018. We use annual data instead of quarterly data to avoid the problems with noise in high-frequency measures of inflation. The list of standard macro variables used in the model includes real GDP, the unemployment rate, CPI inflation, the Fed's survey of capacity utilization, as well as 1-year and 10-year government bond yields. We use long-term CPI forecasts from the Congressional Budget Office (CBO) as a measure of the perceived long-term inflation target. In addition, to avoid the uncertainty in the estimates at the beginning of the sample, we take the CBO's estimate of the NAIRU to be 6.2% in 1980. Unlike Alichi and others (2018), which used a regularized maximum-likelihood procedure to impose priors in the estimation procedure, we present results based on calibrated versions of the model. Conditional on these parameters, we use the Kalman filter to compute the most likely evolution of all the latent variables in the system. None of these modifications result in large changes to the results that were reported in Alichi and others (2018).

Figure 1 provides a summary of the MPMOD results over the historical range from 1980 to 2018 as well as the model's projected paths to 2028. To provide a benchmark, we also include the estimates of the output gap, potential output growth and the natural rate of unemployment (NAIRU) from the Congressional Budget Office (CBO, 2001, 2014). In contrast to our approach, the CBO uses a more disaggregated production function approach to estimate the potential output. Specifically, the CBO uses the Solow growth model for the following five sectors of the U.S. economy: nonfarm business; households and nonprofit institutions; government; farm; and the housing sector. This bottom-up approach includes detailed economic insights about the economy and, therefore, provides a credible methodology and a useful benchmark for measuring potential output.

The output gaps from MPMOD and the CBO are highly correlated, but the MPMOD estimates are higher, on average, by about 0.7 percentage points. Notably, the CBO output gap has almost never been positive. In contrast, the MPMOD estimates suggest that periods preceding increases in inflation and necessary hikes in the Fed fund's rate to control these inflationary pressures typically indicated excess demand. The estimates of potential growth are also highly correlated. Both measures are positively correlated with actual growth, with the CBO estimates pointing to larger increases in potential growth in the early 1980s and late 1990s. Estimates of the natural rate of unemployment both contain downward trends, but the CBO estimates also have a temporary 1 percentage point increase in the NAIRU during the GFC. This would be consistent with the view that there was significant hysteresis in the labor market — see Alichi and others (2019).

Figure 2 presents alternative estimates of the output gap and potential output growth that take the CBO estimates of the NAIRU as an observable variable. This does not have a large impact on the MPMOD results: in both cases, the output gap and potential output growth estimates are almost the same.

Detailed Results and Historical Narrative

Figure 3 provides the detailed historical data and estimates from 1980 to 2018 as well as the model's medium-term and long-term projections using MPMOD. These projections are not realistic forecasts, but rather show a smooth transition to the steady state; a professional forecast would obviously use considerable information outside the model to impose judgment on the near-term forecast. To condition the estimates on a plausible near-term forecast, it is assumed that in 2019 there is a modest degree of excess demand (0.5%) in the good's market.

To simplify the historical narrative, it is useful to divide the sample into three time periods. The first period (1980-1995) is characterized by disinflation and the process of anchoring long-term inflation expectations to around 2 percent. The second period (1996-2007) is characterized by anchored long-term inflation expectations and a large reduction in the variability of the output gap and inflation. Finally, the third period (2008-2018) includes the GFC and a prolonged period of economic slack, where conventional and unconventional policies are deployed very aggressively to support the economy and prevent long-term inflation expectations from ratcheting downwards.

Period I: Anchoring Long-Term Inflation Expectations (1980-1995)

The sample starts with the Volcker disinflation in 1980. In the early 1980s, facing double-digit inflation, the Fed increased and kept short-term interest rates high to generate sufficient economic slack to reduce inflation and anchor long-term inflation expectations to low levels. The output and unemployment costs of reducing inflation were substantial: the output gap fell below -5 percent and unemployment peaked at around 10 percent. The cumulative output gap from 1980 to 1987 was -14.9 percent. With inflation declining from 12.7 percent in 1980 to 3.5 percent in 1985, this was consistent with a "sacrifice ratio" of 1.6 [14.9/(12.7-

3.5)][11], a number that is broadly in line with other studies that focus on that particular period. As a result, inflation gradually fell to around 3 percent in mid-1980s (Figure 3).

After inflation bottomed out in 1985, in parallel with the recovering output gap and declining unemployment, inflation started to pick up, rising to about 5 percent in 1990. This was partly a result of an aggressive monetary policy response to the 1987 stock market crash, which was accompanied with a large injection of liquidity. These inflationary forces then required another disinflationary episode, where inflation was brought down to 3 percent by 1992. Long-term inflation expectations declined only gradually, as the buildup of confidence that inflation would remain low took time. Indeed, the MPMOD estimates suggest that the decline in long-term bond yields was a result of both lower levels of inflation expectations and inflation uncertainty. This is reflected in a gradual decline in the term premium and the expected path of short-term interest rates (Figure 3).

Period 2: The Great Moderation (1996-2007)

This is a period with much lower output and inflation variability; MPMOD's estimates show a dramatic reduction in the variability of the output gap. Indeed, the standard deviation of the output gap fell from 1.9 in the period 1980-1995 to 1.0 in 1996-2007. All other measures of macroeconomic variability were very low in this period including GDP growth, CPI inflation, unemployment, short-term and long-term interest rates. Using a structural model of the U.S. economy, Kumhof and Laxton (2007) show that the great moderation was a result of a combination of better demand-management policies, structural changes in the economy and smaller shocks.

Period 3: The Global Financial Crisis and Fighting Economic Slack (2008-2018)

The GFC erupted after the failure of Lehman Brothers on September 15, 2008. This resulted in a massive contraction in output followed by persistent economic slack and high unemployment. The cumulative size of the output gap is somewhat smaller than what followed the Volcker disinflation. There were also large downward adjustments in potential growth that were mainly a result of excessively optimistic expectations about sustainable output growth before the crisis (Figure 3) and the painful contractionary effects of the crisis on investment.

Due to the severity of the crisis, the G20 responded with a large fiscal expansion in 2009 and 2010 — see Freedman and others (2010). But after 2010 the Fed was left with the primary responsibility of fighting economic slack with unconventional monetary policies as the Fed fund's rate was constrained by the effective lower bound. The large expansion of the Fed's balance sheet ("quantitative easing") and forward guidance resulted in a dramatic reduction

[11] The "sacrifice ratio" shows the ratio of cumulative percentage output loss (due to disinflationary policy) to the reduction in inflation that is actually achieved.

in term-premia on long-term bonds and expectations that short-term interest rates would stay low for many years (Figure 3). The Fed was eventually successful in eliminating the large economic slack and reducing unemployment to low levels.[12] Inflation gradually increased to numbers that are roughly consistent with the Fed's 2 percent inflation target, which was announced in 2012.

III. A Simple Atheoretical Model of the Financial Cycle (FCMOD)

What is a financial cycle? This is a central question for macroeconomic policymakers, which, however, does not have a very clear answer. The notion of a financial cycle is generally understood as an excessive expansion in credit and asset prices, which is associated with a higher probability of a financial crisis. While the empirical literature about the characteristics of financial cycles has developed quite rapidly after the GFC (see, for example, Claessens, Kose and Terrones, 2011), the theoretical understanding of financial cycles and their relationship with business cycles, has evolved more slowly and has provided little practical advice for policymakers responsible for monetary and macroprudential policies.[13]

Against this background, this section develops a simple atheoretical model, the financial cycle model (FCMOD), to create measures of the financial cycle and trend GDP. Our approach is to build on empirical knowledge about financial cycles without taking a strong stance on an underlying theory, about which there is little consensus. More specifically, we use two main empirical findings in the literature — see, for example, Claessens, Kose and Terrones (2011) and Schularick and Taylor (2009):

- Financial cycles last much longer than business cycles.
- Financial booms are closely associated with booms in real credit growth and real property prices.

We use the same BIS measures of real credit growth and property prices (Table 1: Data Sources) that are used by Borio, Disyatat, and Juselius (BDJ, 2014).[14] There is, however, an important conceptual difference with BDJ — we do not refer to these estimates as measures of potential output, but instead use the terms trend or sustainable output. Unlike trend output, potential output is a well-defined theoretical construct and is based on balancing aggregate

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[12] In hindsight it would have been more efficient had fiscal policy responded more aggressively with high-multiplier instruments after 2010 to eliminate this economic slack faster. Indeed, Gaspar and others (2016) show that such policies can pay for themselves in the sense that they can result in lower levels of the government-debt-to-GDP ratio by raising nominal GDP sufficiently and not allowing inflation to decline systematically below the target. Similar arguments have been made recently by Agénor and da Silva (2019) to support the economy when monetary policy is constrained by the effective lower bond.

[13] For an example of a prototype model, which allows for financial crises in DSGE models, see Benes, Kumhof and Laxton (2014a, b) and Benes, Laxton and Mongardini (2016).

[14] The difference is that we use BIS annual data for property prices and credit to the non-financial sector while BDJ used quarterly BIS data.

demand and supply in the goods market.[15] There does not, however, exist a simple one-way causal link between financial variables, such as credit and property prices, and the difference between aggregate demand and supply in the goods market.

Indeed, in structural models, shocks to credit supply will cause both aggregate demand and supply to increase and will typically put upward pressure on property prices. The dynamic effects on inflation, though, will not be straightforward and will depend on how quickly aggregate demand and supply adjust. In a similar way, positive shocks to potential growth that are extrapolated into the future will drive property prices up, but may result in aggregate demand and supply increasing roughly together resulting in little inflationary pressures. These are both examples where financial the cycle can build up with little inflationary symptoms. This is why we refer to FCMOD explicitly as an atheoretical model and not a model of potential output. Potential and trend output, of course, are not totally disconnected — they both converge to the same levels in the long run, which is the only constraint that we use in the model. This underlines the idea that sustainable output is a very useful concept when thinking about the longer-term implications for the economy, but it is not the right concept for thinking about managing the short-run output-inflation tradeoff.

In a nutshell, we use the simplest possible statistical structure of MPMOD with two differences reflecting the empirical literature: trend output has lower volatility and there is a common shock in credit growth and house prices that drives the financial cycle. The three observable variables of the model are GDP, the growth rates of real property prices and real credit. In FCMOD the financial cycle output gap ($\hat{y}_t^{fc}$) is defined as the deviation of log real GDP (y_t) from its trend level ($\overline{y}_t^{fc}$):

(1) $$\hat{y}_t^{fc} = y_t - \overline{y}_t^{fc}$$

The stochastic process for trend output is comprised of three equations, (2)-(4), and are subject to four types of shocks:

(2) $$\overline{y}_t^{fc} = \overline{y}_{t-1}^{fc} + g_t^{fc} + \epsilon_{\overline{y}^{fc},t}$$

(3) $$g_t^{fc} = 0.1 g_{fc}^{ss} + (1-0.1) g_{t-1}^{fc} + \epsilon_{g^{fc},t}$$

(4) $$\hat{y}_t^{fc} = 1.0\hat{y}_{t-1}^{fc} - 0.2\hat{y}_{t-2}^{fc} + \epsilon_{\hat{y}^{fc},t} + 0.4\epsilon_{\hat{y}^{fc},t}$$

[15] In an earlier paper that maps out the proposed empirical methodology Borio, Disyatat and Juselius (2013) argue that inflation should not be used to help measure the output gap because there isn't a tight simple relationship between the output gap and inflation. Interestingly, the more successful central banks are at managing the short-run output inflation and eliminating the positive correlation between the output gap and inflation the more difficult it will be to find evidence that simple Phillips curves exist. Successful central banks have learned to deal with this uncertainty as well as other forms of uncertainty in the monetary transmission mechanism.

The level of trend output $\left(\overline{y}_t^{fc}\right)$ evolves according to trend potential growth $\left(g_t^{fc}\right)$ and a level-shock term $\left(\epsilon_{\overline{y}^{fc},t}\right)$. Potential growth is also subject to a shock $\left(\epsilon_{g^{fc},t}\right)$, whose impact fades away with a persistence parameter of 0.9. The output gap $\left(\hat{y}_t^{fc}\right)$ is a function of one and two-year lagged values of the output gap. The output gap incorporates a shock (ϵ_t^{fc}) with the weight 0.4, which is the common component of the shock driving both credit and property prices. The output gap is also subject to an idiosyncratic shock $\left(\epsilon_{\hat{y}^{fc},t}\right)$.

Real credit growth (Δrbc_t) and real house price growth (Δrph_t) are both modeled as autoregressive processes that gradually revert to their long-run steady-state rates $(\Delta rbc^{ss}$ and $\Delta rph^{ss})$, respectively. Each of the processes has two types of innovations: one idiosyncratic, i.e. specific to that equation ($\epsilon_t^{\Delta rbc}$ and $\epsilon_t^{\Delta rph}$, respectively), and one common component that enters both equations $\left(\epsilon_t^{fc}\right)$ capturing a positive cross-correlation between credit and house prices during financial cycles.

(5) $$\Delta rbc_t = 0.6^{\Delta rbc}\Delta rbc_{t-1} + (1.0 - 0.6)\Delta rbc^{SS} + \epsilon_t^{\Delta rbc} + \epsilon_t^{fc}$$

(6) $$\Delta rph_t = 0.6\Delta rph_{t-1} + (1.0 - 0.6)\Delta rbc^{SS} + \epsilon_t^{\Delta rph} + \epsilon_t^{fc}$$

The idea behind the common shock $\left(\epsilon_t^{fc}\right)$ is key in FCMOD. It appears in three equations in the model — output gap, real credit growth and real house price growth equations — creating a simple mechanism, which simultaneously generates a boom in output, credit and house prices. If a high growth rate of GDP is accompanied with a simultaneous rapid increase in credit and house prices, the model will deem part of the growth to be unsustainable. If, on the other hand, the idiosyncratic shocks explain the data better, that would point to lower systemic imbalances. This reflects one of the most robust empirical regularities about financial crises mentioned earlier.

To illustrate the importance of the common shock in explaining the US data, we conducted the following exercise. First, we exclude this shock from the output gap equation (4) and extract a measure of the shock driving the output gap $\left(\epsilon_{\hat{y}^{fc},t}\right)$. Figure 4 plots the resulting shock in the output gap equation $\left(\epsilon_{\hat{y}^{fc},t}\right)$ and the common shock $\left(\epsilon_t^{fc}\right)$ driving both real growth in credit and property prices. The FCMOD output gap shock is highly correlated with the common shock, underlining the importance of this mechanism for explaining the data. In addition, we also compared the medium and long-term forecasts of GDP to verify that the model with the financial variables forecasts better than the model without the financial variables.

Figure 5 depicts the FCMOD estimates of the financial cycle and trend output growth based on the sample period of 1980-2018. It can be observed that the financial cycle is more prolonged and has higher volatility compared to the MPMOD output gap. This comes as no surprise taking into account the stylized fact that financial cycles last longer than typical business cycles. In addition, financial variables incorporated into the FC output gap contribute to its more prolonged buildups and sharp drops.

Corresponding to the more volatile output gap, FCMOD trend output growth rate is much smoother compared to its MPMOD counterpart. As Borio (2013) claims, the main distinctive feature of finance-neutral trend output is sustainability. Even when output is at its non-inflationary path (which is captured in MPMOD as potential output), it might still be unsustainable as long as the financial imbalances are building up.

Figure 6 displays the real-time estimates and rolling forecasts of FCMOD trend output growth and the FCMOD output gap starting from 1995. Each colored circle is the real-time estimate and the colored lines are the real-time forecasts at each time period (i.e., using data only up to that time period). As the figure demonstrates, the real-time estimates of both variables remain close to the corresponding final two-sided estimates with no signs of any systematic bias. This indicates that the measures of the output gap and trend output growth obtained from FCMOD are reasonably reliable since they do not exhibit any significant revisions especially in pre-crisis periods.

IV. HP FILTER: TO USE OR NOT TO USE?

A long-standing debate, which has intensified after the GFC, is whether mechanical tools, such as the HP filter, are useful in policymaking.[16] Hamilton (2017) revived the debate with his provocatively titled paper "Why you should never use the Hodrick-Prescott filter" arguing that the resulting dynamic properties of the filtered series have no connection with underlying structural relationships. Drehmann and Yetman (2018) responded with "Why you should use the Hodrick-Prescott filter - at least to generate credit gaps" arguing that credit gaps resulting from the HP filter have good early-warning properties leading to financial crises.

To contribute to this debate, we compare the estimates of MPMOD with the results of the HP filter. We use two criteria for the comparison of these methodologies:

- How much do the real-time estimates change as new information arrives?
- How useful is it for policymakers to construct a consistent macroeconomic narrative?

[16] The problems associated with using the HP filter to measure potential output dates back at least 25 years (see Laxton and Tetlow, 1993). Unfortunately, in spite of these problems, the HP filter has been employed mechanically and extensively for many years in some policymaking institutions. See, for example, Turner and others (2016) for a discussion of the OECD methodology and the massive revisions in the OECD output gap estimates that were a result of mechanically updating estimates of the labor efficiency gap with the HP filter. For a discussion of the econometric pitfalls of prefiltering the data with the HP filter and doing empirical work with such estimates see Laxton, Shoom and Tetlow (1992) and Hamilton (2017). Unfortunately, some institutions still use univariate filters like the HP filter to measure the output gap and draw implications from these estimates for monetary policy. See, for example, Taylor (2019) that uses updated results from a BIS paper by Hofman and Bogdanova (2012) to argue that interest rates have been systematically lower than the Taylor rule.

We find that the multivariate filter approach developed in this paper produces more robust and sensible real-time estimates of potential output and the output gap compared to estimates from the HP filter. More importantly, the multivariate filter approach provides a structured economic framework that incorporates information on the labor market, capacity utilization and economic relationships such as Okun's Law and the Phillips Curve.

Figure 7 and Figure 8 highlight the advantages of the multivariate filter approach over the HP filter. They provide a comparison of the real-time estimates produced by MPMOD and the trend estimates of GDP derived from the HP filter. Figure 7 and Figure 8 also provide rolling forecasts from both models to better understand the problems with the HP filter. It clearly illustrates that the real-time MPMOD estimates track more closely the estimates that are based on all information in the sample. As a result, the historical revisions from the multivariate filter are considerably smaller than the HP filter.

To better understand the end-of-sample problems with the HP filter it is useful to understand the underlying statistical model that is consistent with estimates derived from the HP filter optimization problem. Real GDP (y_t) is defined as the sum of the HP trend ($\bar{y}_t$) and the output gap ($\hat{y}_t$).

(7) $y_t = \bar{y}_t + \hat{y}_t$

The underlying statistical process for the HP filter assumes that both the output gap and the second difference of trend GDP are white noise[17] (equation 8 and 9).

(8) $\hat{y}_t = \varepsilon_t^{\hat{y}}, \qquad \varepsilon_t^{\hat{y}} \sim iid\ (0, \sigma^2_{\varepsilon\hat{y}})$

(9) $\Delta\bar{y}_t - \Delta\bar{y}_{t-1} = \varepsilon_t^{\bar{y}}, \qquad \varepsilon_t^{\bar{y}} \sim iid\ (0, \sigma^2_{\varepsilon\bar{y}})$

(10) $\frac{\sigma^2_{\varepsilon\hat{y}}}{\sigma^2_{\varepsilon\bar{y}}} = \Lambda$

Figure 7 plots the historical real-time forecasts for GDP that are conditional on the HP filter ($\Lambda = 100$) real-time end-of-sample estimates of trend GDP. Since the output gap is assumed to be white noise, each forecast shows the output gap jumping back to zero and staying at zero. Trend growth at the end of the sample as well as future expected trend growth ratchets up and down with actual growth. This is a result of the HP model assumption that there is a unit root in trend growth. Therefore, a mechanical updating of the filter results in massive revisions in both the output gap and trend growth. The estimates of potential growth and the output gap from MPMOD are obviously still revised in response to new information (Figure 8), but not nearly to the same extent as with univariate filters such as the HP filter. More importantly, it provides a quantitative description of the U.S. economy and monetary policy that is consistent with the historical narrative (Section II).

[17] White noise is when the variables are independent and identically distributed with a mean of zero.

V. INCORPORATING FCMOD FORECASTS INTO MPMOD ESTIMATES

In this section we explore whether the GDP level predictions generated from FCMOD can improve the real-time consistency and forecasting accuracy of MPMOD framework. For this purpose, we generate 5-year-ahead GDP level forecasts in FCMOD for the sample period of 1995-2018. Next, we incorporate these forecasts into MPMOD. The underlying logic is that FCMOD-based GDP level forecasts combine information about the financial cycle which can help better identify the unobservable variables in MPMOD. The FCMOD-based GDP forecasts can adjust the model consistent expectations in MPMOD to enrich them with the information regarding financial vulnerabilities and other risks perceived by economic agents that are not directly captured in MPMOD structure. Indeed, this information can be very indicative of possible upswings and downfalls in economic activity.

The adjusted real-time estimates and rolling forecasts of MPMOD output gap incorporating 5-year-ahead FCMOD GDP level forecast are presented in Figure 9. As can be seen from the figure, although there is no significant improvement in the real-time estimates at the beginning of the sample, the real-time output gap estimate tracks a bit more closely to its two-sided counterpart in later periods. The predictions of the output gap also improve compared to the baseline MPMOD estimate as it can be observed in the second subplot of Figure 9.

For instance, the adjusted real-time output gap estimate coincides with the final two-sided estimate in 2009 during the downturn of GFC, while the real-time estimate in the baseline MPMOD specification was revised upwards in the two-sided estimate. Moreover, the adjusted output gap predictions in 2009 are more aligned with the developments of the corresponding two sided estimate.

Finally, in order to compare the MPMOD specifications discussed so far in terms of their forecast accuracy, we computed root-mean-squared errors (RMSE) for GDP level forecasts based on each specification across different prediction horizons. The results are summarized in Figure 10 and Figure 11. Figure 10 shows the RMSEs from FCMOD and the HP filter. Figure 11 depicts the RMSEs from MPMOD, FCMOD, and MPMOD, which incorporates 5-year-ahead GDP forecasts from FCMOD. It can be seen, that incorporating FCMOD-based predictions into MPMOD improves the forecast accuracy of the latter.

Interestingly, FCMOD outperforms every MPMOD specification for all forecast horizons in predicting GDP level. This suggests that FCMOD with much simpler structure relying solely on two financial indicators (real credit growth and real asset price dynamics) encompassed more relevant information for predicting the future developments of GDP. The reason behind this outcome for the medium-term projections is because of the different definitions of trend GDP between MPMOD and FCMOD. While the former defines potential output as non-inflationary, the latter makes use of finance neutral measure of output. It is likely that the latter is more successful in estimating the sustainable level of GDP which in turn helps generate more accurate medium-term forecasts.

Having considered the consistency of real-time output gap estimates and accuracy of GDP level forecasts across alternative MPMOD specifications, it can be concluded that incorporating 5-year-ahead forecasts from FCMOD into MPMOD demonstrated a superior performance. This specification gives a more consistent and reliable output gap estimate with small ex-post revisions. Moreover, this specification provides more accurate GDP level forecasts for both short and medium-term horizons, which is the main focus of interest for policymakers engaged in monetary and macro-prudential policy issues.

VI. Application of FCMOD to China

China's impressive economic growth record has been accompanied with a number of challenges in the financial sector, including increasing concerns about overheating in the housing sector, high credit growth, and the size of shadow banking activities. This section examines these questions using FCMOD.

Figure 12 shows the evolution of residential property prices and the credit-to-GDP ratio in China. Large swings in residential property prices have been accompanied by several policy tightening cycles. In addition, the government simultaneously implemented targeted measures to improve longer-term housing supply to contain rising house prices. Despite these policy interventions, prices have been rising rapidly — Eftimoski and McLoughlin (2019). Residential property prices on average have been growing nearly twice as fast as national income over the past decade, mainly driven by speculative demand and weak housing supply — Chen & Wen (2016).

The overheating of the housing sector was supported by booming credit and a deterioration of its efficiency — Chen and Kang (2018). The credit-to-GDP ratio (nonfinancial sector domestic sector), which was stable at around 125 percent before the GFC, peaked over the last decade at about 205 percent in 2018 (Figure 12b). Concerns had also been increasing regarding lending from non-bank institutions, which were not well regulated — Koss and Shi (2018).

The combination of these factors gave rise to concerns about the possibility of bubbles forming in China's financial and housing sectors. The recent BIS estimates of credit gaps, which were based on a simple one-sided HP filter approach, confirmed these concerns for the period 2012-2016, with double-digit credit gaps. Interestingly, according to that methodology, these large gaps disappeared during last two years (Figure 13). This reflects the drawbacks of mechanical updating with the HP filter mentioned earlier, since financial imbalances of that magnitude can hardly disappear in two years in the absence of significant changes in fundamentals and macroeconomic policies.

To construct estimates of the financial cycle in a more consistent way, we apply FCMOD to China. We use the real growth rate of total credit to private non-financial sector and two alternative measures of real property price growth. The first measure is based on surveyed sales prices of newly constructed residential buildings in 70 medium and large-sized cities in China (based on BIS data). The second one is based on sales prices of residential buildings per square meter in 31 major cities of China (CEIC). The steady-state growth rates of real GDP and credit were assumed to be 5.0 and the real property price growth rate was assumed to converge to 0.5 percent in the steady state.

Figure 13 compares the FCMOD estimates of China's output gap that result from different FCMOD specifications and property price datasets. It clearly shows that estimates incorporating real credit and property price growth point to much larger financial imbalances compared to the estimates that do not use these financial variables. Importantly, the large differences between estimates based on BIS and CEIC data underline the importance of looking at a wide range of data and the details of housing price data in China.

Figure 14 depicts the FCMOD estimates of China's trend output based on the sample period of 2008-2018. Since 2008 trend output has been accelerating rapidly, but was still accompanied by a financial boom, which is very similar in magnitude to the estimates derived for the U.S. *before* the global financial crisis. According to an IMF's recent study, historical precedents of "safe" financial booms of such magnitude and speed are few and far from comforting — Chen and Kang (2018).

To further illustrate potential problems of using the HP filter when estimating the credit-to-GDP gap, we conduct a simple experiment. After obtaining the estimates of trend and credit-to-GDP gap for China, we generate a forecast up to 2050 using the last historical estimate of trend growth (Figure 15). We then apply the one-sided HP filter to obtain the trend-gap decomposition of the credit-to-GDP ratio. Figure 15 shows that, according to this methodology, the financial cycle is 0 all the way to the end of the sample despite the fact that the credit-to-GDP ratio is clearly unsustainable reaching 400 percent in 2050. This simple thought experiment illustrates the risks of mechanical applications of the HP filter for policymaking. Moreover, this is not merely a theoretical example, but reflects actual policy issues in emerging markets, which start from low levels of credit-to-GDP ratios and tend to extrapolate the high growth rate of sustainable credit too much into the future. This is why you should not use the HP filter – especially to generate credit gaps!

VII. CONCLUDING REMARKS

This paper provides two approaches for measuring the output gap. The first approach (MPMOD) is useful for communicating how efficiently central banks and the fiscal authorities are managing the short-run output inflation tradeoff. It is based on an extension of previous work applying simple multivariate filters to estimate potential output. We show that MPMOD produces more reliable real-time estimates compared to univariate filters such as the HP filter. The advantage of MPMOD is that it uses a structured economic framework that includes information about the labor market, capacity utilization and economic relationships such as the Phillips Curve and Okun's Law.

The second approach is developed to create measures of the financial cycle. It incorporates financial information on real house price growth and real credit growth to help measure the cyclical component of GDP. This approach provides estimates of output gaps that are more than twice as large before the GFC as output gap measures that are useful for conventional monetary policy analysis.

We show that models with financial considerations provide more accurate GDP level forecasts for all forecast horizons than MPMOD specifications. This suggests that FCMOD, with a much simpler structure relying solely on two financial indicators (real credit growth and real asset price dynamics), provides more robust estimates of medium-term potential output. We also demonstrate that incorporating FCMOD-based GDP forecasts in MPMOD improves its forecast accuracy and helps to provide more reliable output gap estimates.

We argue that understanding concepts such as potential output and distinguishing it from simple measures of trend output can be vital for analytical work designed to support policymaking. Consistent with this, we question the LAW argument that monetary policy should be focused on financial stability and should systematically react to the financial cycle to avoid costly crises. According to the LAW logic, rather than cutting interest rates aggressively in response to contractionary shocks, central banks should be more flexible and plan to bring inflation back to their targets gradually over time. There are two problems with the LAW argument. First, such a policy would be inconsistent with central bank objectives of eliminating wasteful economic slack in the economy and efficiently managing the short-run output-inflation tradeoff. Secondly, and more importantly, such a policy could be completely counterproductive if it resulted in long-term inflation expectations ratcheting downwards and increased the risks of getting stuck in a low inflation trap with a much more prolonged period of very low interest rates.

Our analysis shows that the proposed toolkit to measure financial cycles is much better suited for policymaking compared to mechanical approaches such as HP filters. This is true both in terms of real-time revision properties and the ability to construct a consistent macroeconomic narrative. Moreover, we illustrate that the mechanical approach can potentially lead to dangerous policy recommendations as exemplified by the application on China. In our future work we plan to expand on this issue for developing countries, where these problems can be substantial due to possible extrapolation of “safe” growth rates of credit-to-GDP ratios.

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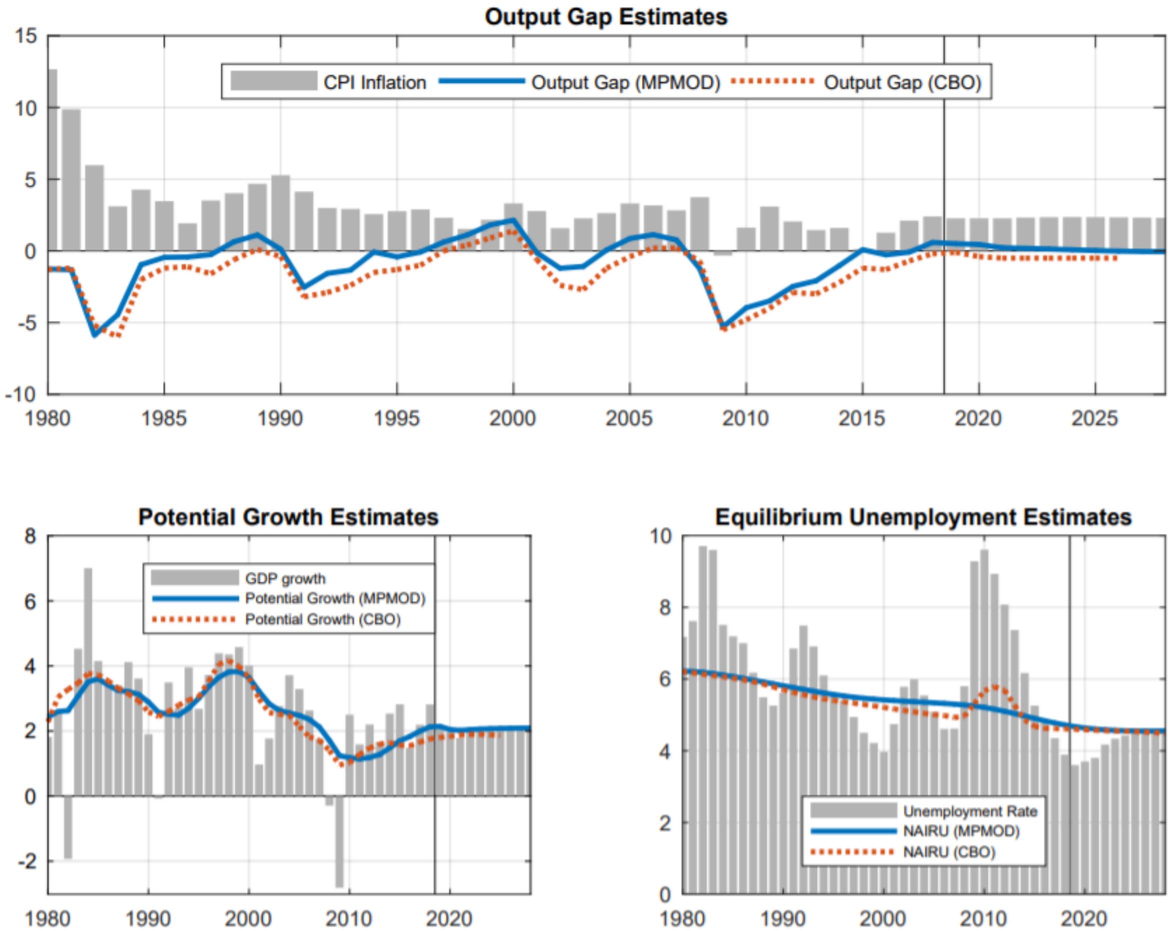
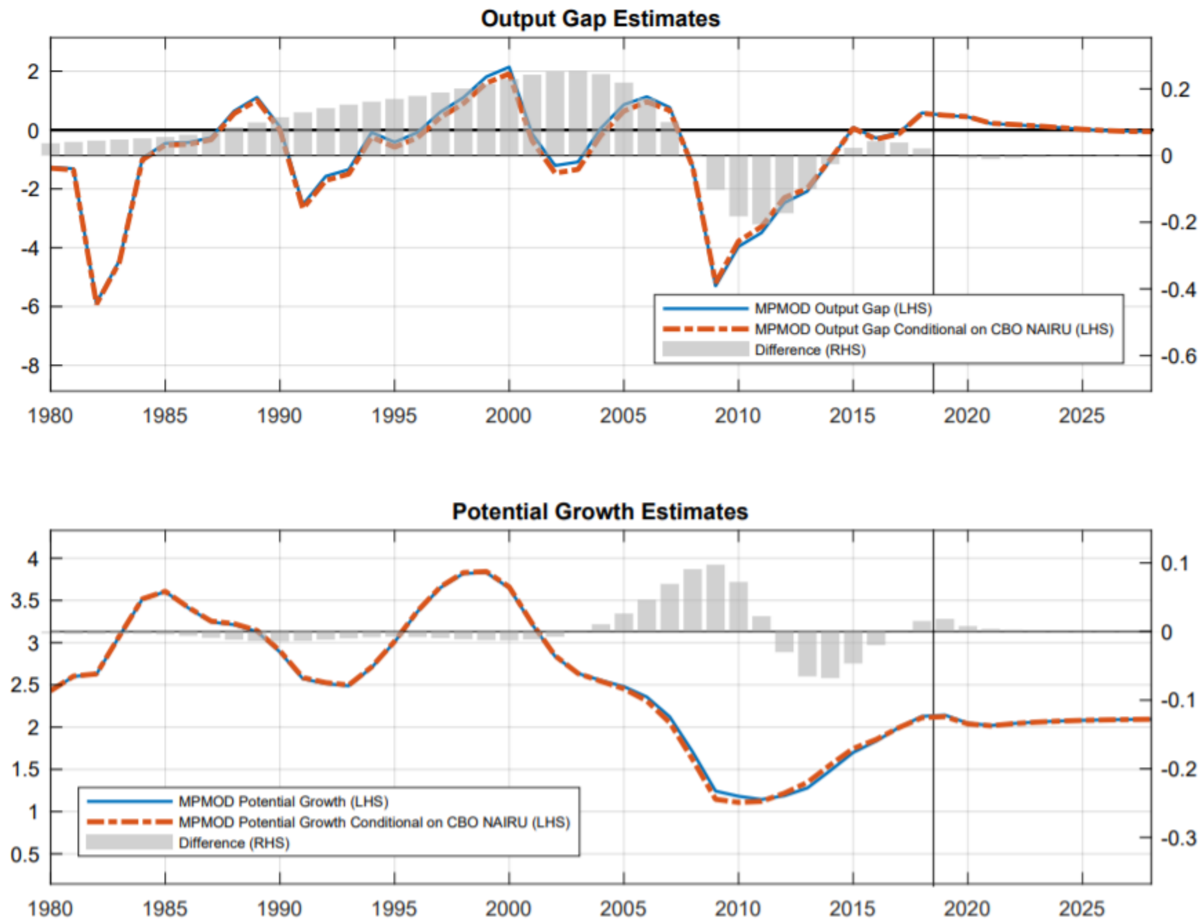
Figure 1: **Comparison of MPMOD Results with CBO Estimates**



Source: Authors' Estimates and Congressional Budget Office (CBO) Estimates of the NAIRU

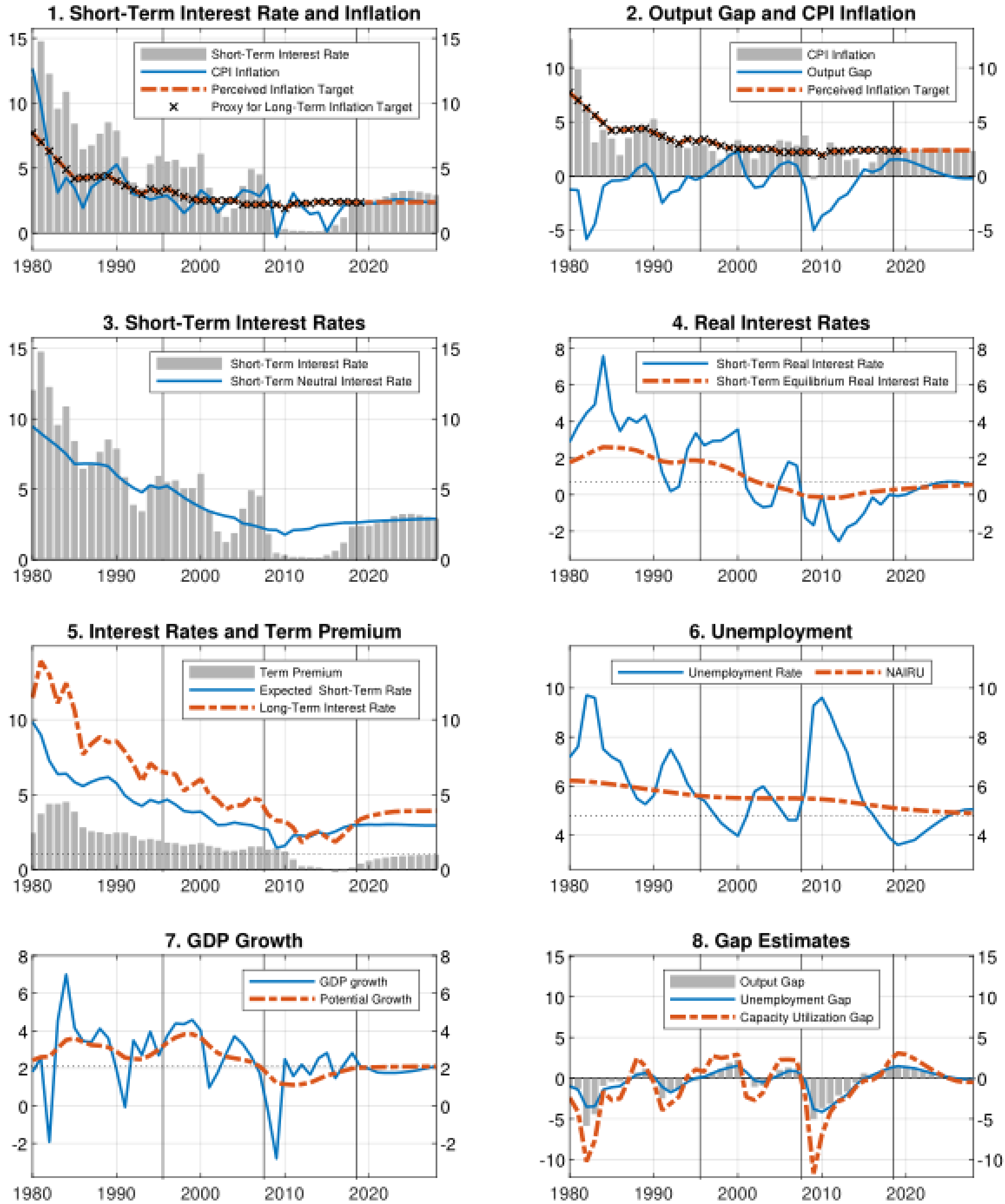
Figure 2: MPMOD Estimates Conditional on CBO NAIRU



Source: Authors' Estimates

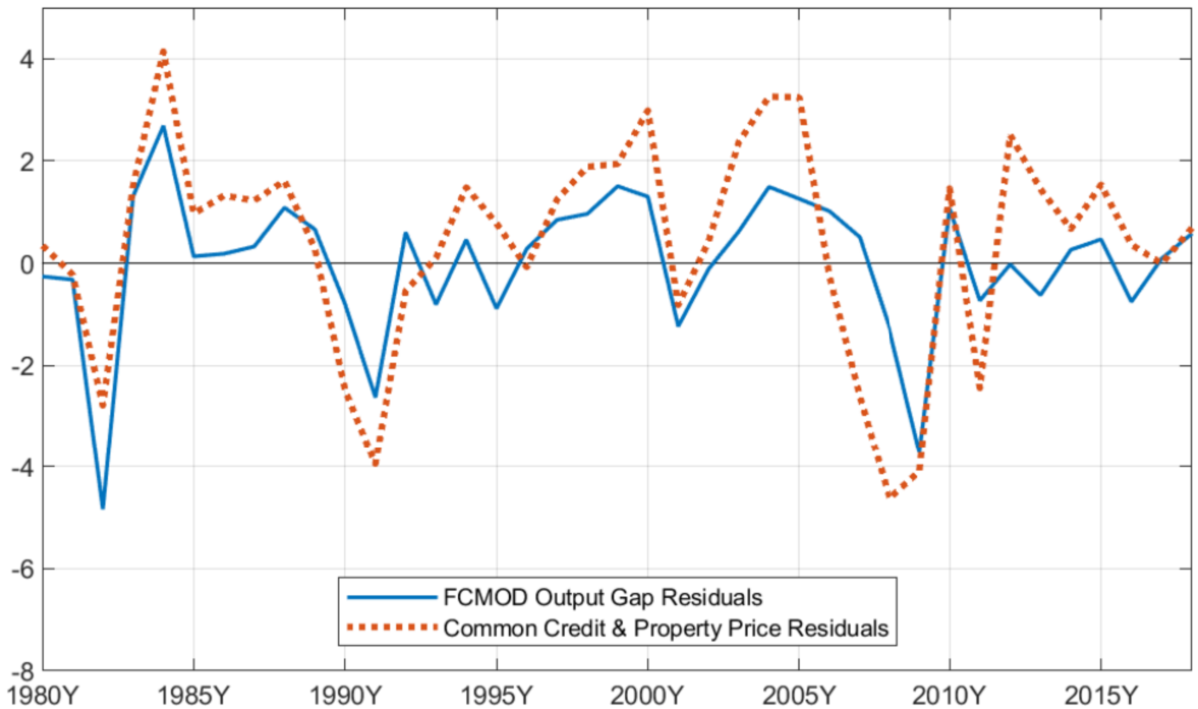
Figure 3: MPMOD Detailed Results

1980-1995 – Period 1. Anchoring Long-Term Inflation Expectations
1996-2007 – Period 2. The Great Moderation
2008-2018 – Period 3. The Global Financial Crisis and Fighting Economic Slack
2019-2029 – Forecast



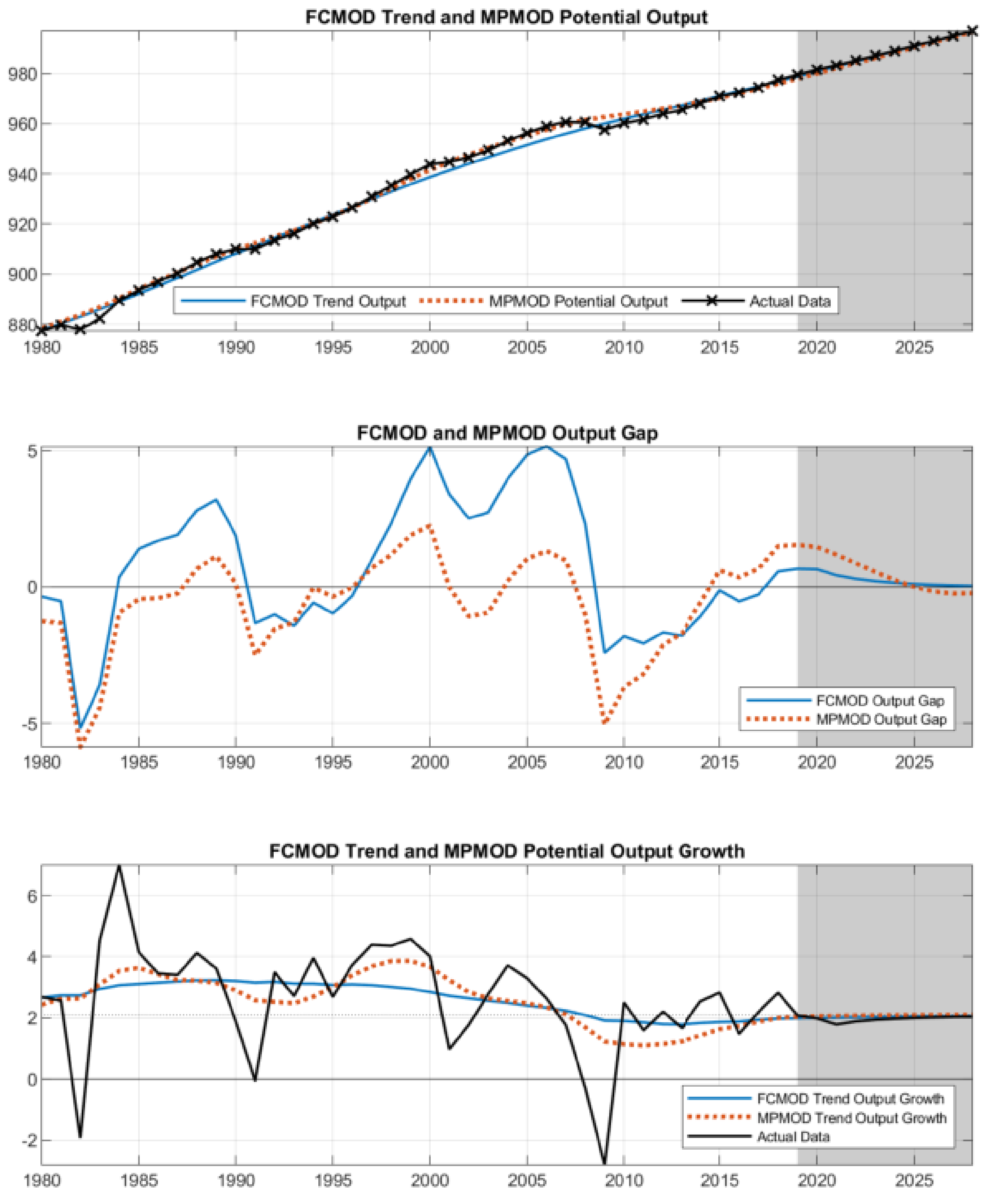
Source: Authors' Estimates

Figure 4: FCMOD Output Gap Residuals and Common Component of Shocks



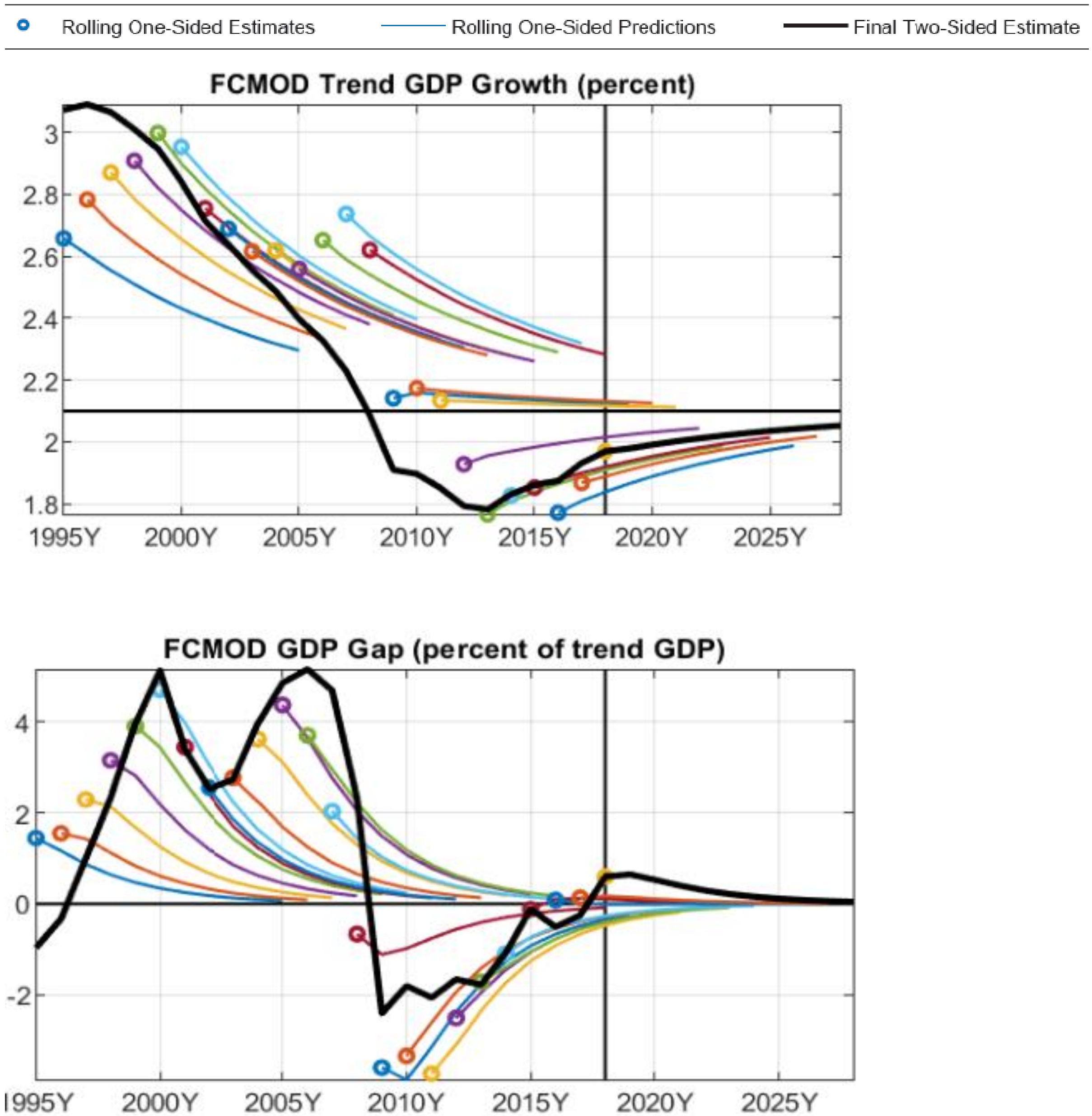
Source: Authors' Estimates

Figure 5: FCMOD Estimates of Output Gap and Trend Output Growth



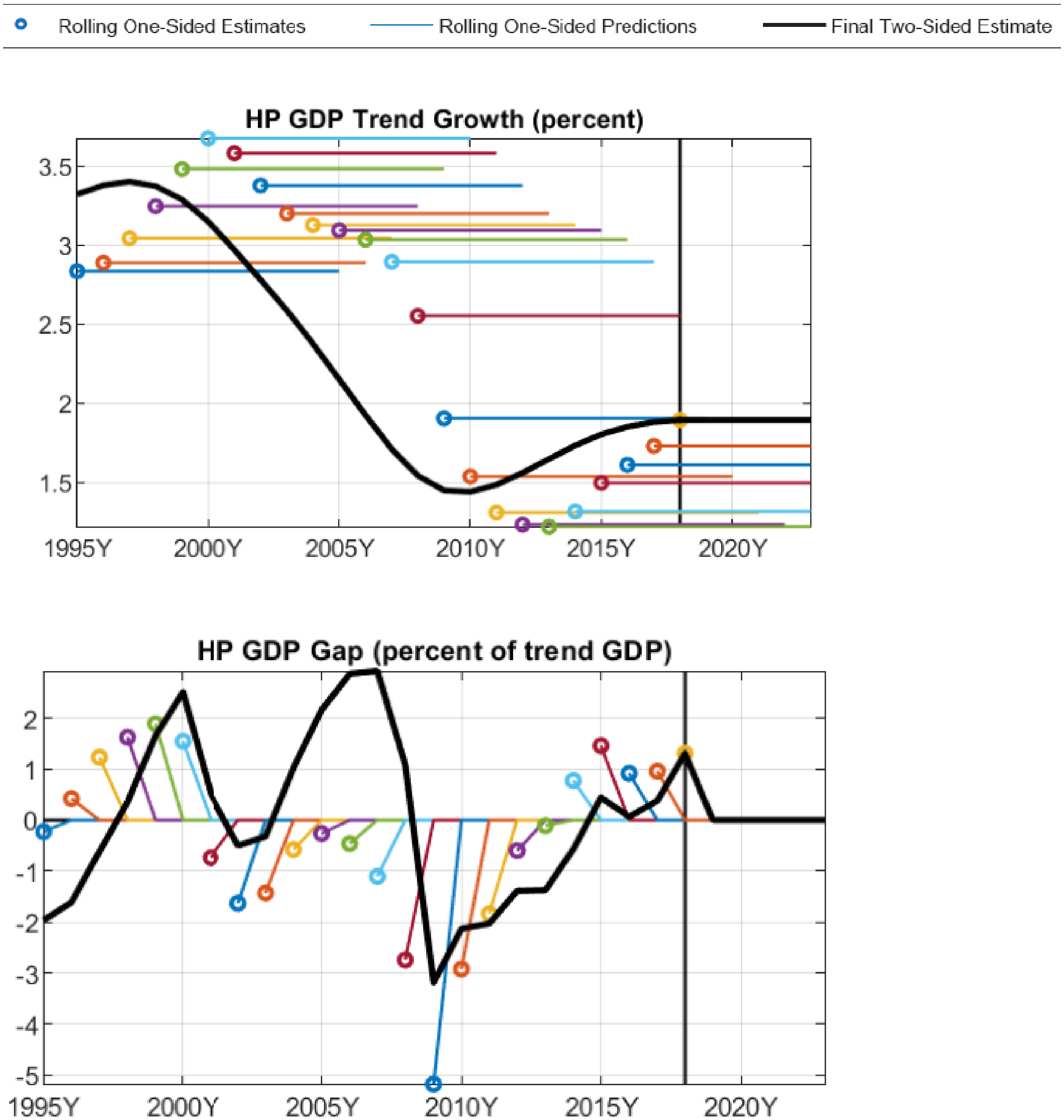
Source: Authors' Estimates

Figure 6: FCMOD Real-Time Estimates and Rolling Forecasts



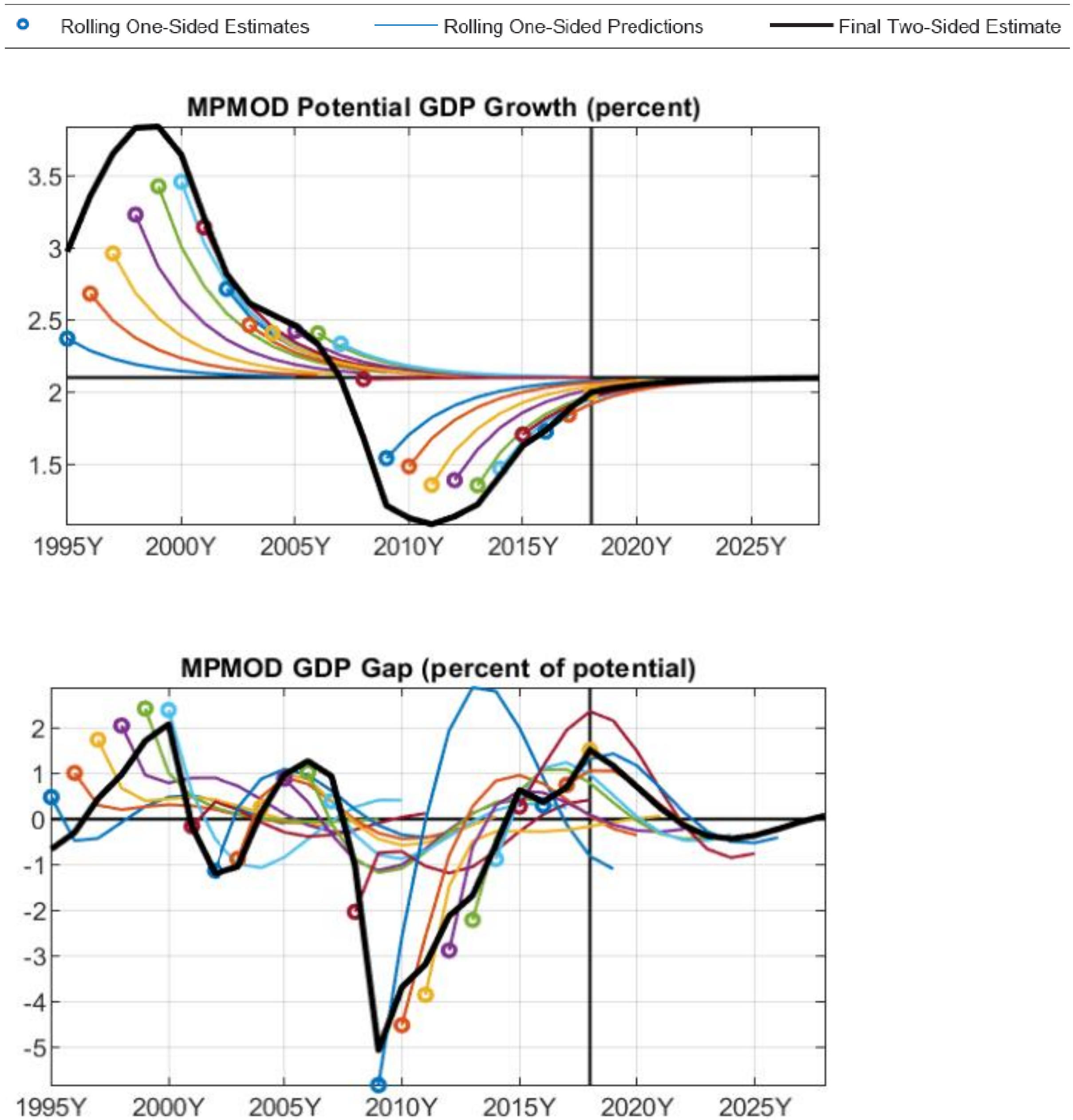
Source: Authors' Estimates

Figure 7: HPMOD Real-Time Estimates and Rolling Forecasts



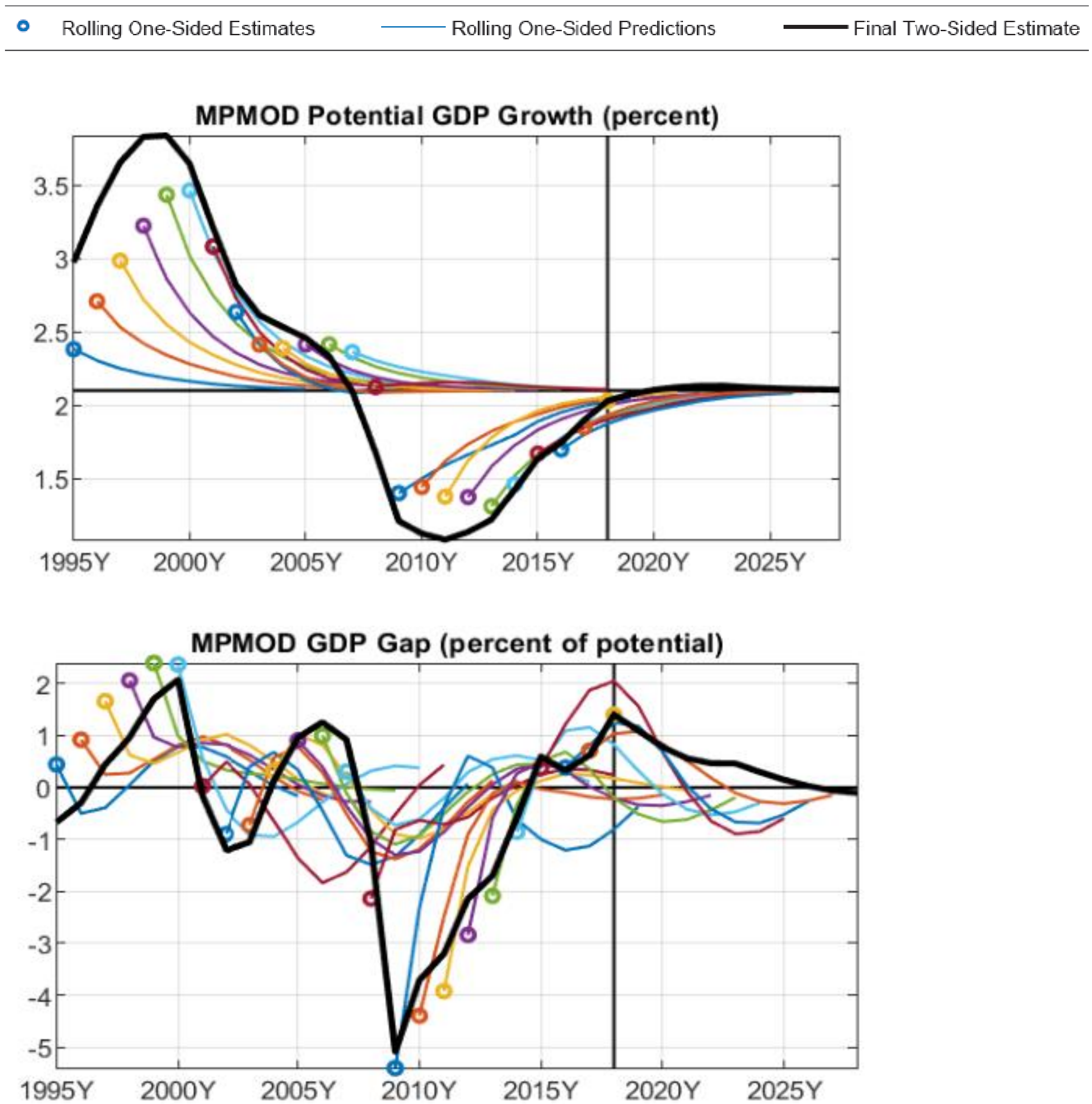
Source: Authors' Estimates

Figure 8: MPMOD Real-Time Estimates and Rolling Forecasts



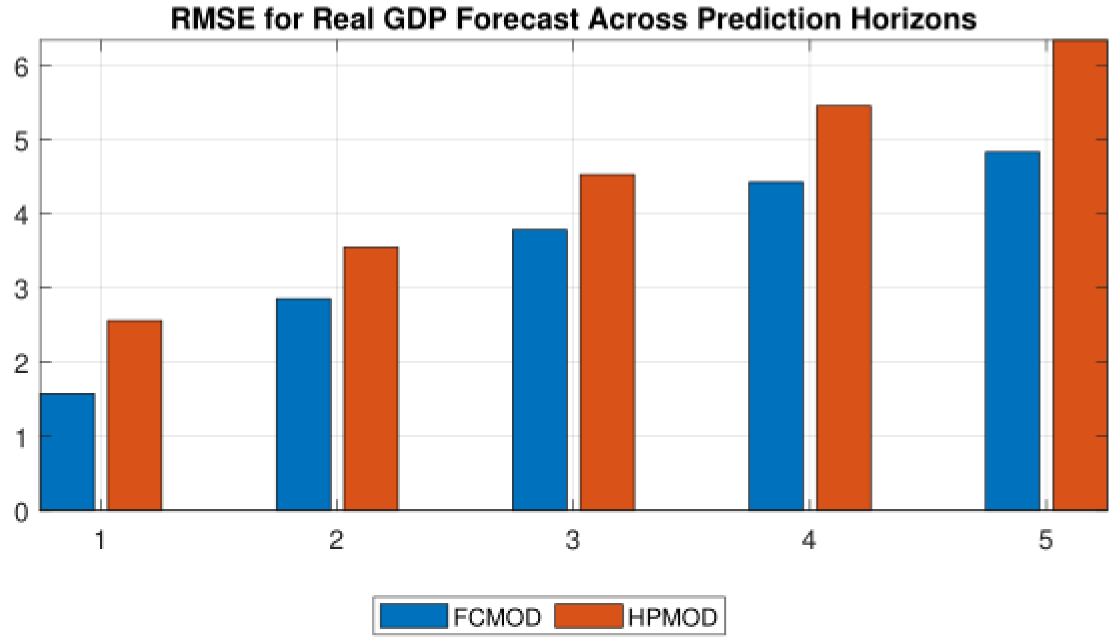
Source: Authors' Estimates

Figure 9: MPMOD Incorporating 5-Year-ahead FCMOD Forecast of GDP Level Real-time Estimates and Rolling Forecasts



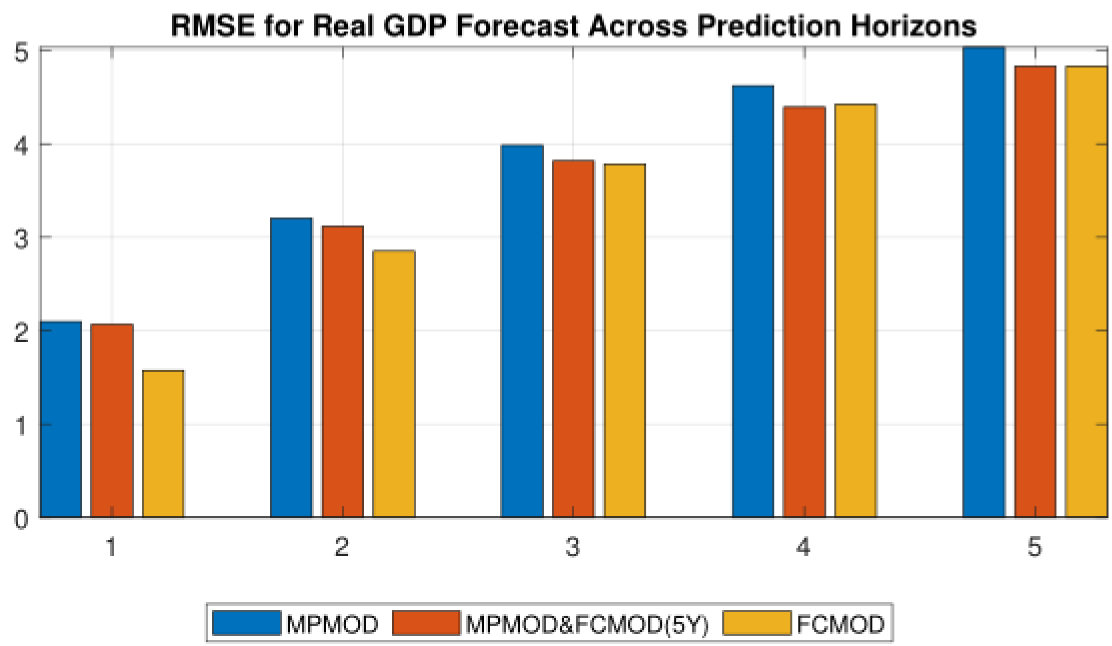
Source: Authors' Estimates

Figure 10: FCMOD and HPMOD Comparison of GDP Level (log) Forecast Accuracy



Source: Authors' Estimates

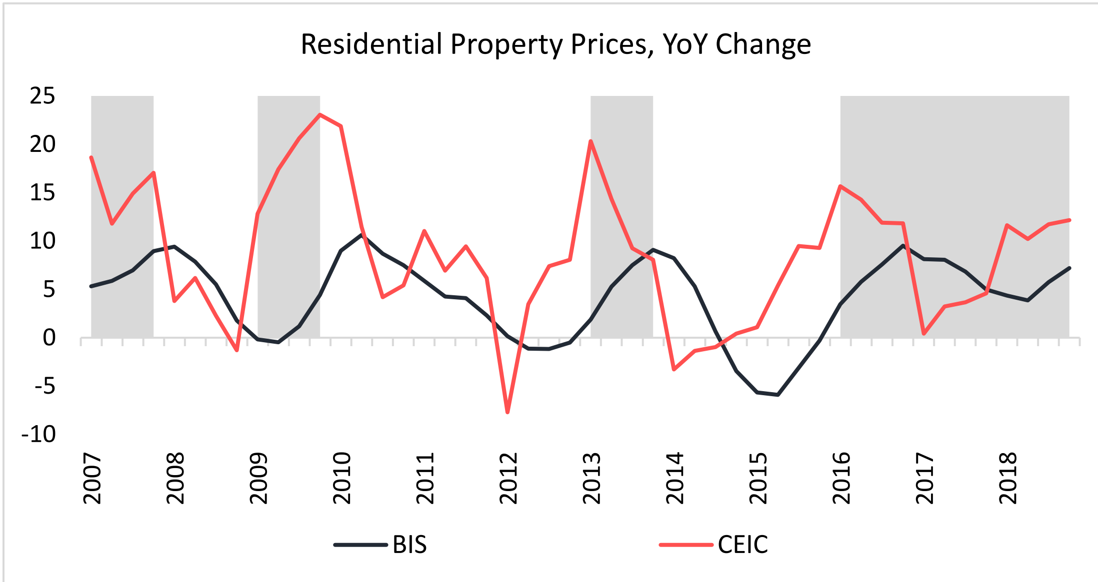
Figure 11: Different Model Specifications Comparison of GDP Level (log) Forecast Accuracy



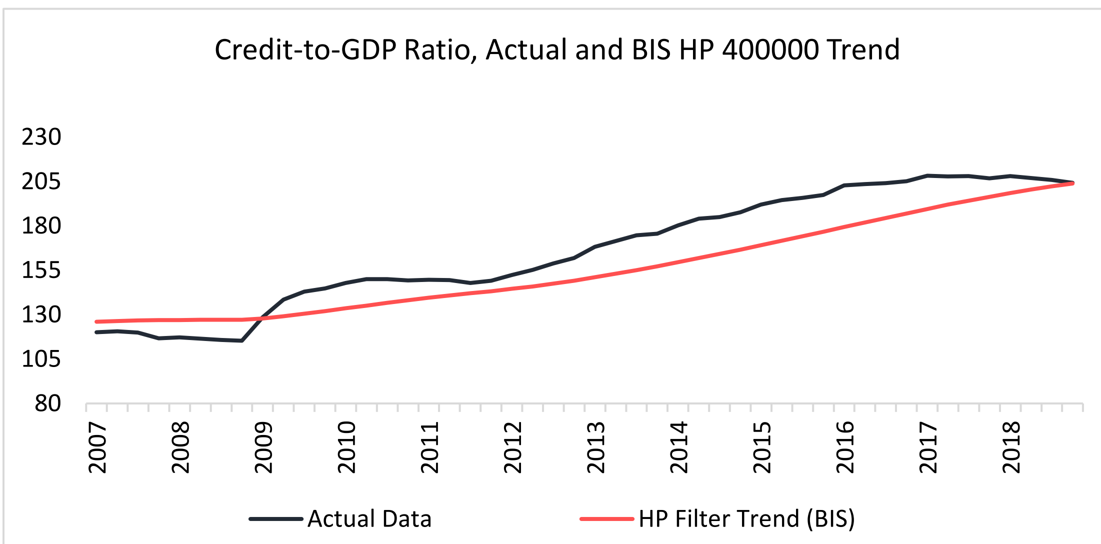
Source: Authors' Estimates

Figure 12: Property Price Growth and Credit-to-GDP Ratio in China

a)

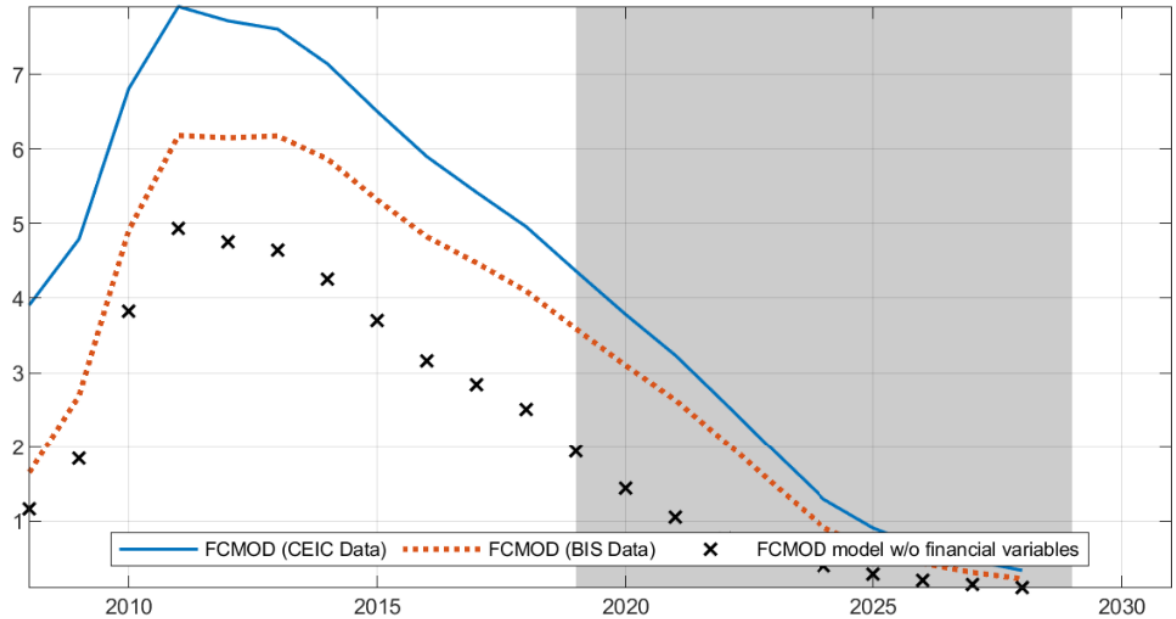


b)



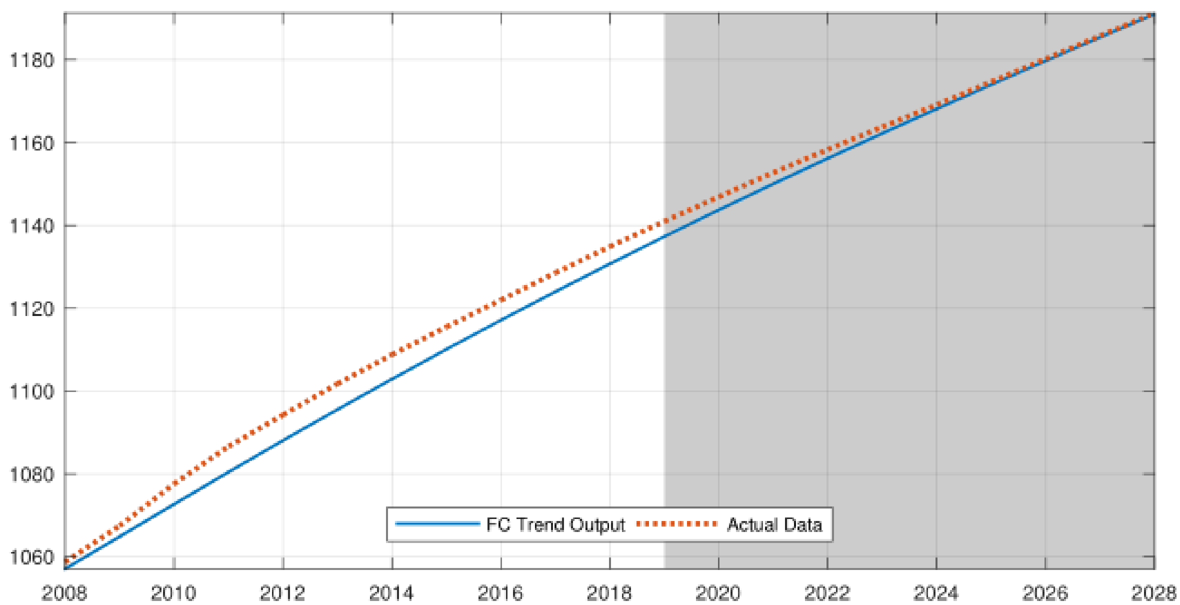
***Shaded areas signify periods of policy tightening**
Source: BIS, CEIC, Authors' Estimates

Figure 13: China: FCMOD Output Gap with and without Financial Variables using Data from BIS and CEIC



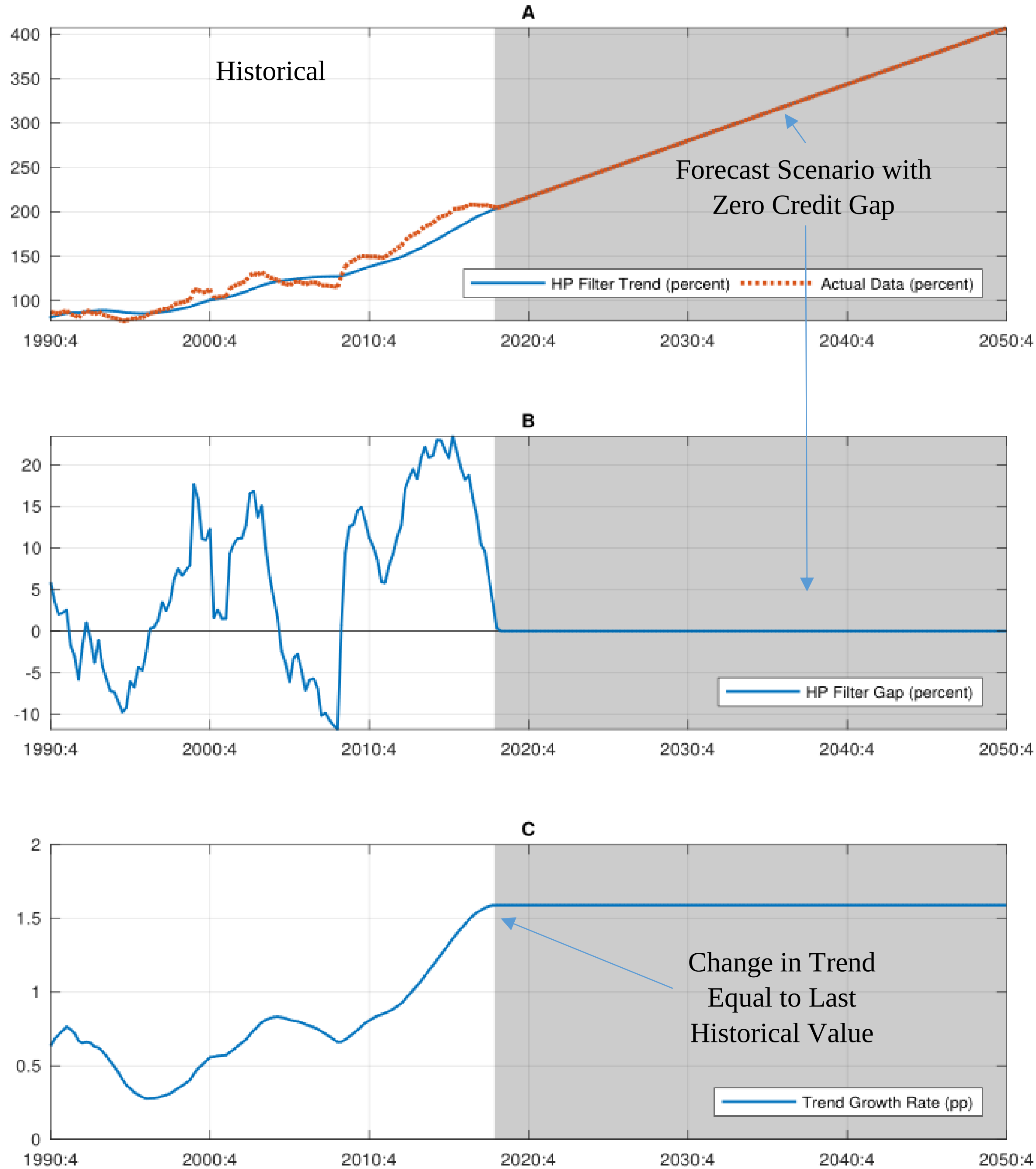
Source: Authors' Estimates

Figure 14: China: Actual and FCMOD Trend Output



Source: Authors' Estimates

Figure 15: China: Credit-to-GDP Ratios: Actual and Trend



Source: Authors' Estimates

Table 1: Data Sources

Indicator	Source
Inflation Expectations US	CBO
Gross Domestic Product (Constant Prices) US	U.S Bureau of Economic Analysis
CPI Inflation US	U.S Bureau of Labor Statistics
Unemployment Rate US	U.S Bureau of Labor Statistics
Capacity Utilization US	Federal Reserve
1 Year Treasury Constant Maturity Rate US	Federal Reserve
10 Year Treasury Constant Maturity Rate US	Federal Reserve
House Prices US	Bank for International Settlements
Credit Growth US	Bank for International Settlements
Gross Domestic Product (Constant Prices) China	World Economic Outlook, IMF
GDP Deflator China	World Economic Outlook, IMF
House Prices China	Bank for International Settlements
House Prices China	CEIC Data
Credit Growth China	Bank for International Settlements

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