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Endogenous Credibility and Economic Modeling: *Adapting the Forecasting and Policy Analysis System to Modern Challenges*

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Endogenous Credibility and Economic Modeling: *Adapting the Forecasting and Policy Analysis System to Modern Challenges*[*]

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Abstract

This paper introduces the Forecasting and Policy Analysis System (FPAS) Mark II, which incorporates Mervyn King's imperative for economic models to reflect the endogenous nature of central bank credibility based on policy actions. The original FPAS, predominantly utilized by inflation-targeting central banks, has been constrained by its focus on baseline projections and local approximations. These limitations hinder its capacity to accurately reflect the evolving credibility of central banks in response to their policy choices. Credibility specifically refers to how anchored are long term inflation expectations in bond markets and by wage and price setters but also a broader consideration is whether long-term real interest rates and the exchange rate operate as shock absorbers. FPAS Mark II integrates "Monetary Policy as Risk Management" (MPRM), enhancing the framework's ability to address significant uncertainties and adapt to changing economic conditions. This new approach advocates a shift from a baseline projection to a scenario-based strategy that attempts to anticipate a diverse range of economic outcomes including non-linear such as time-varying policy credibility. By doing so, FPAS Mark II not only adheres to King's vision by embedding endogenous credibility into the fabric of monetary policy but also equips policymakers to navigate complex financial landscapes more effectively, avoiding potential pitfalls and better managing periods of uncertainty.

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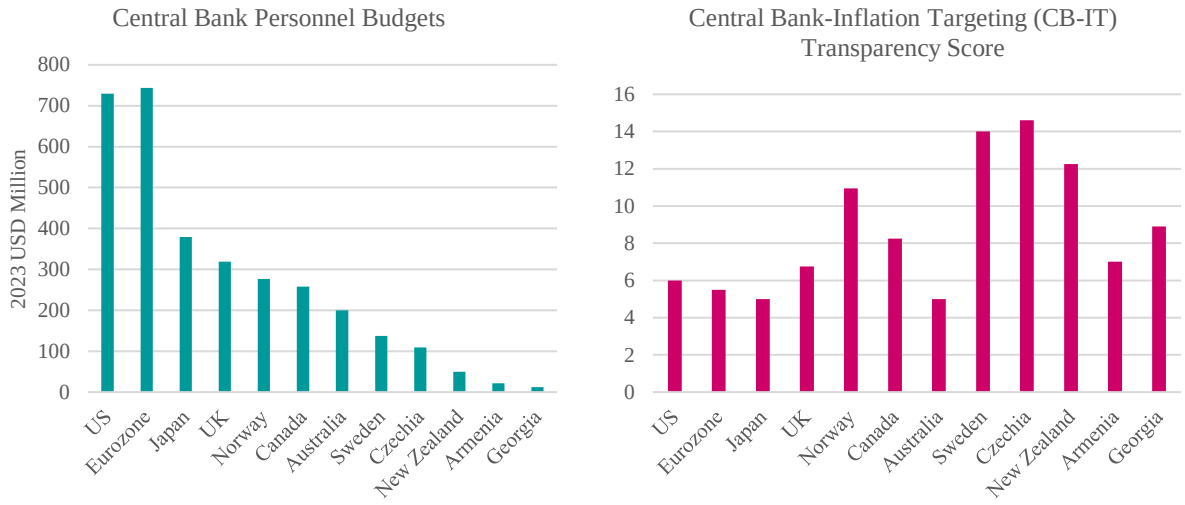
I. Introduction

We welcome the Oxford Review of Economic Policy (OxREP) and its project on rebuilding macroeconomic theory. These types of retrospectives are a good way for the profession to get its bearings and provide important direction. The OxREP 2018 issue was an excellent accounting of macroeconomics from a variety of venerable economists. However, we viewed it largely from an academic perspective, although there was one contributor, Hendry and Muellbauer, that took the perspective of policy modeling at central banks. We want to present from the point of view of a central bank practitioner but one that has established a formal Forecasting and Policy Analysis System (FPAS), a project spearheaded by the IMF the past two decades and has become part of its official technical assistance handbook (2022). The FPAS is designed to support central banks to credibly achieve their output and inflation objectives while maintaining high levels of analytical transparency and accountability. The central banks that have established an FPAS tend to be small open economy central banks with limited resources (Figure 1) but nonetheless have pursued excellence and deserve a tremendous deal of respect from the international monetary policy community. They decided to not merely be passengers in the success of Inflation Targeting over the past 30 years, but in many cases have pushed the frontiers of monetary policymaking in important ways which has partially been documented in the IMF book by Adrian, Laxton, and Obstfeld (2018).

Figure 1: Big Budgets, Low Transparency



Source: Taken from the latest central bank annual reports. Some central banks such as the Bank of England have itemized costs to get core policy functions while others such as the Norges Bank are total staff costs. CB-IT scores are based on Kostanyan, Laxton and Romero (2022) and Kostanyan et al (2023). Note: End-of-period exchange rate taken to convert into USD

This paper will first present some of the ways that smaller central banks have differentiated themselves from the Big 4 (Fed, ECB, BoJ, BoE), namely a formal adoption of an FPAS. Then provide a high-level overview of FPAS Mark 1 and how some central banks are developing a Mark II version which tries to better embody the principles of risk management. Then briefly discuss how different types of macroeconomic modeling fit within an FPAS framework and briefly review whether they are fit-for-purpose. Then finish with a description of a semi-structural model with endogenous policy credibility as one of the policy models that can help central banks explore important non-linearities and construct strategies for managing the type of uncertainty that threaten their objectives.

II. What is the difference between the Big 4 central banks and those we would consider best practices?

In many respects, the Big 4 central banks could learn a thing or two from the smaller central banks. For instance, some old arguments that continue to get airtime within strategy discussions among the Big 4 have long been tested and debunked from the perspective of smaller best practice central banks. For instance, the issue of publishing a projection of the policy rate or even the exchange rate for that matter continues to be a topic of debate among the Big 4. This has caused confusion about what exactly is *good* forward guidance and why Adrian, Laxton, and Obstfeld (2018) and Laxton and Rhee (2022) found it necessary to distinguish between conventional forward guidance as practiced by the Czech National Bank or the Riksbank among others who have high levels of analytical transparency versus unconventional forward guidance as practiced by the Big 4 which are opaquer.

The best practice of conventional forward guidance is a full-fledged model-based macroeconomic projection for real GDP, inflation, interest rate and the exchange rate given its importance in the transmission of monetary policy. Model-based does not mean model-only, judgment and satellite models are important and discussed later. We consider this best practice because this type of forward guidance, policymakers have everything they need to communicate to financial markets a credible narrative for the economy and how monetary policy must be adjusted to achieve their output and inflation goals. Because of high levels of transparency, financial markets in these countries understand the underlying assumptions that go into the projection and that they are conditional. There is no issue in this setup of forward guidance to get misconstrued as a commitment or cornering policymakers into a particular view.

Whereas unconventional forward guidance is piecemeal, includes some variables but not all, tends to be more qualitative or threshold-based communication. This style of unconventional forward guidance is susceptible to miscommunication and just plain ineffective at times. A review of the Fed's Green and Tealbooks during the post-Global Financial Crisis (GFC) period reveal how it took years for the Fed to finally successfully communicate to financial markets of a lower for longer policy path along the effective lower bound (ELB). The costs of this communication strategy are well documented by Engen, Laubach and Reifschneider (2015) which show that had the Fed been more transparent they could have sped up the post-GFC recovery. Under conventional forward guidance it should have been clear how big the negative demand shock was and how serious the Fed was to stimulate the economy and close the output gap which meant interest rates at the ELB for longer than financial markets were anticipating.

Among the Big 4, the Fed is the only one that publishes a quantitative forward-looking view of the policy path, but the anonymous Dot plots circumvent the fundamental purpose of why central banks would publish a state-contingent projection of the policy rate. The model-based projections provide a *coherent* macroeconomic narrative linking the current and forecast settings of the interest rate instrument to the goal variables of inflation and output while the anonymity of the Dot plots is naturally incoherent. To solve the incoherence and communication struggles could be as simple as publishing the Tealbook on the day of the decision instead of its current 5-year moratorium. The Tealbook provides a multitude of model-based policy scenarios produced by the staff using the Fed's semi-structural macroeconomic model, FRB/US. Financial markets and the public cannot only get a better sense of the monetary policy reaction function of the Fed

but also the risks the Fed staff have identified and prepared for the policymakers. A very modest change that kills many birds with one stone.

The ECB and the BoJ provide inflation and real GDP forecasts but do not provide a policy path that is consistent with these forecasts. The failure to present a credible monetary policy strategy for achieving its objectives could be at the root of why both these institutions have historically struggled more than others to escape a low inflation trap. In the case of Japan, the situation is dire where on one hand current conditions look like Japan is on the precipice of finally escaping its low inflation trap but the moment that they try to raise interest rates to contain inflation they quickly run into debt sustainability concerns. The Eurozone is dealing with similar issues but to a lesser extent. The ECB will be the subject of a brief case study under endogenous credibility later in the paper where we explore how low central bank credibility heading into the COVID-19 pandemic caused a breakdown in the monetary policy transmission mechanism, something that should keep any central banker up at night.

Lastly, the BoE is unique, but the presentation of an inflation forecast in their Monetary Policy Report that assumes a constant interest rate path, and a market-implied interest rate path illustrate an active disregard for macroeconomic consistency and the role of central banks to present a credible narrative for achieving its output and inflation goals. The constant interest rate path condition is perhaps the more benign of the two because there is no pretense that the BoE is attempting to provide anything useful. Meanwhile, the market-implied assumption is worse since it is suggestive that the BoE is providing a dynamic interest rate path that is consistent with its objectives. However, at the end of the day, this practice is still an exogenous interest rate path and omits the story of how the BoE views the underlying forces in the economy and how it intends to anchor the system considering these forces, a fundamental precept of a credible Inflation Targeting regime. If the BoE were to take the advice of Mervyn King and pursue models with endogenous credibility, they should first establish an analytical framework that is experienced at publishing projections with an endogenous interest rate. Then they can move to scenarios where inflation is not assumed to return to the target without monetary policy intervention.

The adoption of Inflation Targeting with instrument independence and the regular presentation of a state-contingent and endogenous interest rate path is a basic function for central banks to be included in the FPAS Mark I club. Central banks that choose to omit this element in their analysis open themselves to unnecessary attacks on their credibility and could be a key factor moving forward that could differentiate the performance of central banks to successfully return inflation sustainably to target by say 2025. While a discussion about analytical frameworks and communication may seem tangential to modeling, it is an important path to take because it underlies the way we evaluate the use value of models for central banks.

III. What is an FPAS Mark I central bank?

The FPAS was designed to answer 3 essential questions for policymakers and provide the basis for conventional state-contingent forward guidance:

- ***Question 1:*** Where is the economy today? This question seeks to understand the latest data since the previous projection round.
- ***Question 2:*** What are the underlying forces in the economy? This question seeks to explore different interpretations of the data and challenge some of the underlying assumptions that are present in modern macroeconomic models i.e. the stars and bars.
- ***Question 3:*** What do we need to do with our instruments to achieve our objectives under these conditions? This question seeks to provide a path for the policy rate that is state contingent based on the analysis of questions 1 and 2.

These questions typically get addressed in the form of a monetary policy report that is published on the day of the policy decision. Historically, successful FPAS Mark I central banks have used a baseline macroeconomic projection that satisfies these 3 questions. Almost all central banks in the world answer the first question by devoting most of their monetary policy report to updating and assessing the latest data. We refer to this as elevator economics i.e. inflation is up or down on account of x, y and z but offers little insight other than maybe one-step ahead forecasting. The type of content you can get from journalists.

The second question tends to refer to analysis around the so-called stars and bars i.e. the NAIRU, potential output, equilibrium real interest rate, equilibrium real exchange rate and inflation expectations. Despite high levels of uncertainty around the stars and bars, under or overestimating them by a large margin can have a significant impact on central bank performance. Many central banks conduct this type of analysis internally; however, few central banks are transparent in this regard. While it is true that there is substantial uncertainty around these unobserved variables, that is more reason for higher levels of analytical transparency rather than less. Regular communication around such variables, in our view, better positions a central bank to adjust quickly if large structural changes were to occur. A history of analyzing and communicating potential output among FPAS central banks has shown their advantages during times when the economy is severely affected by supply-side factors during the COVID-19 pandemic.

Even fewer central banks provide an answer to the third question, which is perhaps the most essential since it provides the analytical basis for central bank credibility: anchored long-term inflation expectations in bond markets and by wage and price setters. When a central bank states a commitment to achieving an inflation objective, it better have a compelling case to back it up otherwise they are susceptible to periodic attacks on its credibility in the form of "inflation scares" as defined by adverse movements in long-term inflation expectations inconsistent with the inflation goal which can colloquially be discerned in real-time when the long-end of the yield curve shifts higher in response to inflationary data (Goodfriend, 1993). A higher long-end of the yield curve in response to inflation data suggests financial markets question the central bank's commitment to its target.

IV. What is an FPAS Mark II central bank?

> "Uncertainty is not just an important feature of the monetary policy landscape; it is the defining characteristic of that landscape. Consequently, the conduct of monetary policy in the United States at its core involves crucial elements of risk management, a process that requires an understanding of the many sources of risk and uncertainty that policymakers face and the quantifying of those risks when possible." (Greenspan 2003)

This section briefly describes the motivation behind developing a new monetary policy analytical framework that attempts to formalize the risk management approach to monetary policy that also brings central bank credibility to the forefront of the policy analysis. FPAS Mark II is an attempt to build on the success of FPAS Mark I by officially codifying to the extent that it is possible the principles and ideas embedded in the risk management approach to monetary policy that was famously espoused by Alan Greenspan in his 2003 Jackson Hole speech on Monetary Policy under Uncertainty. To this day, Fed board members have continued to express the idea of risk management as an important part of their analytical decision-making process. Some recent examples include:

> Powell in January 2024: "We're really in a risk management mode"
> Waller in February 2024: "data that we received validates the careful risk management approach"
> Mester in February 2024: "Risk management will be the hallmark of monetary policy decisions going forward"

While there have been many descriptions of what a risk management approach to monetary policy looks like on a personal level from different Fed board members (Evans 2011, Bullard 2021) there has not been a formal description or transparent implementation of this approach on an institutional level. The Central Bank of Armenia has published several papers on the components of FPAS Mark II that seeks to formalize the risk management approach to monetary policy into a publicly available set of documents (Archer, Galstyan and Laxton 2022, Galstyan et al 2024, etc.). The new approach has several components, here are a few:

- Scenarios-based approach to monetary policy analysis and communication.
- Stress on policies of least regret when relevant as the risk-manager of the economy.
- Doing judgment-heavy policy analysis and communication.

(i) Scenarios-based approach to monetary policy analysis and communication

> "A policy action calculated to be optimal based on a simulation of one particular model may not, in fact, be optimal once the full extent of uncertainty is taken into account. It is entirely possible that different policies will exhibit different degrees of robustness with respect to the true underlying structure of the economy. For example, **policy A** might be judged as best, conditional on a particular model of the economy, but might also be seen as having relatively severe adverse consequences if the true structure of the economy

> turns out to be other than the one assumed. On the other hand, **policy B** might be somewhat less effective in advancing the policy objectives under the assumed baseline model but might be relatively benign in the event that the structure of the economy turns out to differ from the baseline." (Greenspan 2003)

To address a communication strategy that is centered around this type of uncertainty and to inoculate the central bank staff from false precision of baseline forecasts, FPAS Mark II utilizes an adversarial collaborative case study approach. The staff are tasked to come up with alternative scenarios that are both plausible and consistent with the current data that could underwrite a campaign for why the expected path of the policy rate should be Above (**Case A**) or Below (**Case B**) what is currently priced in financial markets. In the framework, financial market forecasts for key macroeconomic variables serve as the baseline and delineate between Case A versus Case B-type of scenarios. The staff should augment the two scenarios with an exhaustive list of risks with a qualitative assessment of their implications for policy. Whether the staff can quantify these risks into official macroeconomic scenarios will depend on the resources available. The framework is constructed so that the central bank first tries to understand what is priced in financial markets to then position themselves to nudge markets in a particular direction while discussing the costs and benefits associated with different types of A or B scenarios. The Case A, B and market reference framing attempts to provide some structure to the cacophony of voices commenting on monetary policy.

Figure 2 shows a snippet of the Central Bank of Armenia's 2024Q2 Monetary Policy Report that illustrates the conditional Case A and B paths for the policy rate. Each case gets their day in court and should roughly approximate the types of uncertainty and magnitudes that the staff are most concerned about during the projection round. The presentation of the two cases illustrates the policy reaction function and provides a contingency plan depending on which future materializes.

Figure 2: Illustrative Case A, Case B and Market Reference Scenarios

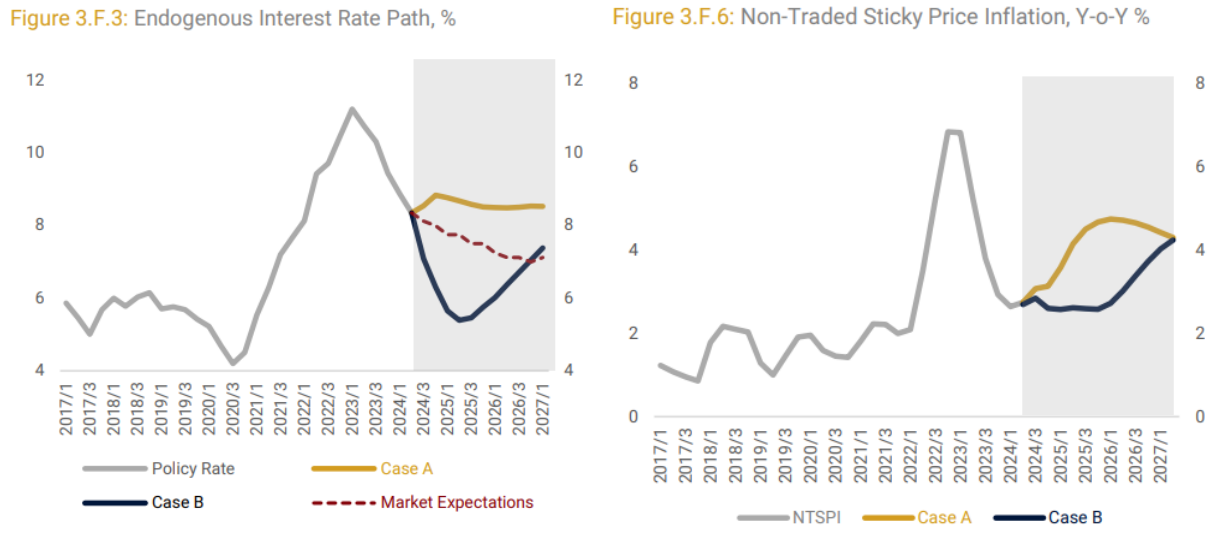


Figure 3.F.4: Real GDP Growth, Y-o-Y %

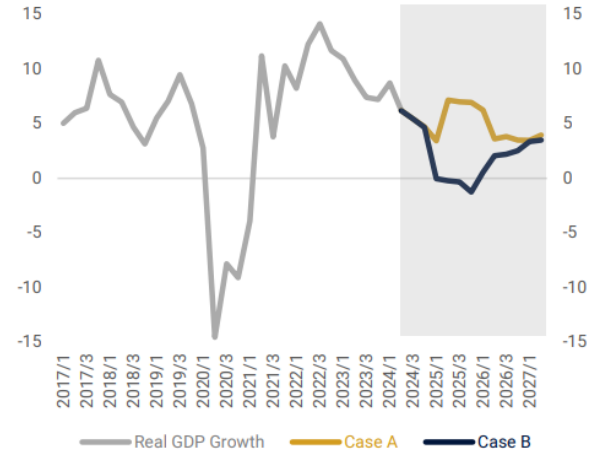
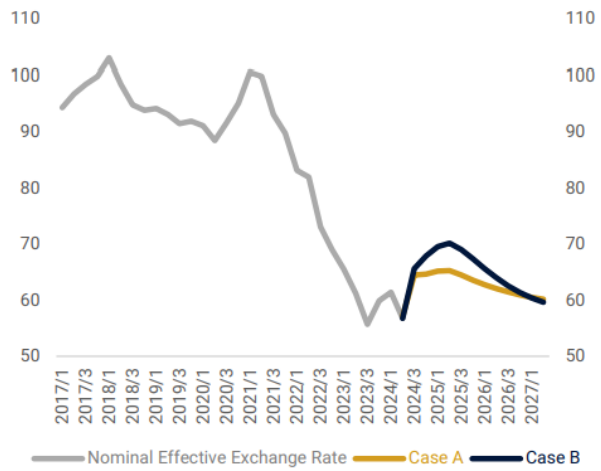


Figure 3.F.10: Nominal Effective Exchange Rate, Index



Source: Central Bank of Armenia, Monetary Policy Report, 2024Q2

> "given our inevitably incomplete knowledge about key structural aspects of our ever-changing economy and the sometimes asymmetric costs or benefits of particular outcomes, a central bank seeking to maximize its probability of achieving its goals is driven…to a risk-management approach to policy. By this I mean that ***policymakers need to consider not only the most likely future path for the economy but also the distribution of possible outcomes about that path***. They then need to reach a judgment about the probabilities, costs, and benefits of the various possible outcomes under alternative choices for policy." (Greenspan 2003)

(ii) Stress policies of least regret when relevant as the prominent risk-manager of the economy

Fed Chairmans tend to write insightful retrospectives after their time. These reflections are often helpful for understanding how monetary policy is conducted at the Fed and periodically contain regrets. Among the most famous retrospectives is Arthur Burns and his speech on the Anguish of Central Banking (1987) which highlights the analytical mistakes made during his tenure. These were a lack of investigation into potential movements in the NAIRU and an underappreciation of an inflation premium getting embedded in the economy after a period of high inflation.

Under FPAS Mark II, the staff are expected to regularly question the underlying forces in the economy such as the NAIRU and inflation expectations. The end goal being that at a bare minimum, policymakers are acutely aware of these underlying issues and can regularly communicate such uncertainty to financial markets. Of course, mistakes will be made as the future is uncertain and therefore a policymaker will undoubtedly always have regrets when their term is over. However, there is a difference between regret formed from ignorance versus misjudging the circumstances. Analytical mistakes will always be made, however, in the latter example, there at least exists an ex-ante contingency plan for shifting policy while the former presents a potential existential threat to a central bank's objective.

The adversarial collaborative process is geared towards supporting the communication of a *policy of least regrets*. Coined by the RBNZ to describe their policy strategy during the initial phases of the COVID-19 pandemic to explain the mix of ultra-easy monetary and expansionary fiscal policies (Hawkesby 2021). Such policies, if successful, were known at the time to have inflationary consequences but the ex-ante risk was considered acceptable given the uncertainty around the collapse in demand from the lockdowns. This mirrors the strategic mindset expressed by Greenspan and the ex-ante cost-benefit analysis that is encouraged by the FPAS Mark II Case A and B scenarios:

> "At times, policy practitioners operating under a risk-management paradigm may be led to undertake actions intended to provide some insurance against the emergence of especially adverse outcomes." (Greenspan 2003)

(iii) **Doing judgment-heavy policy analysis**

While the FPAS Mark I or II framework has some basic incontrovertible concepts embedded in it such as how the transmission mechanism of monetary policy works, the framework is still meant to be flexible to incorporate a very wide range of possible views and interpretations for the future. This flexible structure addresses Greenspan's acknowledgement of the inextricable role of judgment in monetary policy:

> "In implementing a risk-management approach to policy, we must confront the fact that only a limited number of risks can be quantified with any confidence. And even these risks are generally quantifiable only if we accept the assumption that the future will replicate the past. ***Other risks are essentially unquantifiable--representing Knightian uncertainty***... As a result, ***risk management often involves significant judgment on the part of policymakers***, as we evaluate the risks of different events and the probability that our actions will alter those risks… For such judgment ***rather than relying solely on the specific linkages expressed in our formal models, have tended to draw from broader, though less mathematically precise, hypotheses of how the world works***… ***Some critics have argued that such an approach to policy is too undisciplined--judgmental, seemingly discretionary, and difficult to explain***." (Greenspan 2003)

The critique that monetary policy is judgment-heavy and can be highly discretionary is true but as Greenspan concludes, that view simply does not recognize the realities that the economy is complex and always changing. Models will always be slow to recognize whether we are in a linear vs non-linear world and rules-based systems are likely to always be lacking to capture such complexity. Judgment is a necessary evil. The best antidote is a structured and transparent analytical framework such as the FPAS to provide an outlet for accountability when judgment is applied. That said, Orphanides (2024) has proposed a framework that incorporates many different monetary policy rules into the decision-making fabric as a benchmark that can help delineate when judgment is being applied relative to a rule. Instead of undermining the judgment, the rules act as a benchmark for comparison and good judgment should be able to easily articulate as to why they are deviating from the rule-of-thumb (Qvigstad 2005).

V. Evaluating the Potential Use Value of Models

> …the straight line leads to the downfall of mankind. The straight line has become an absolute tyranny. The straight line is something cowardly drawn with a rule, without thought or feeling; it is the line which does not exist in nature. And that line is the rotten foundation of our doomed civilization. Even if there are places where it is recognized that this line is rapidly leading to perdition, its course continues to be plotted. (Hundertwasser, as quoted in Kennedy (1992), p. 102)

The straight line is at the core of our macro modeling critique. If the economy is indeed a linearized version that we approximate in most macro models, then the world is probably simple enough that we do not need their insights in the first place. Policymakers can probably make that determination on their own. The time and place when we need models to provide structure for policymakers is when there is a concern that we are in a non-linear state. However, the predominant linear modeling paradigm tends to break down when needed most.

In any case, let's put the religious wars behind us as Vines and Willis (2018) ended their summary of the rebuilding project and focus on promoting good versus bad economics where we agree the answer lies in pluralism. Of course, what is considered good or bad is subjective and so the battles will likely continue. However, we can try to offer some examples that we believe are good and bad use cases for the different modeling methods but conclude that the core model paradigm among central banks should be a semi-structural QPM that is flexible enough to incorporate non-linearities that are relevant for policymakers to navigate a non-linear policy space. Continuing the religious analogy, macro models should not be considered as something sacred that we pray to hoping we will get the answers from. They should by and large act as organizational devices for an economist to make sense of the world. Models can inspire, but divine intervention is largely on the part of the economist. Following our brief assessment of macro modeling, we will demonstrate the flexibility of semi-structural models to incorporate endogenous policy credibility, a non-linear Phillips curve and a quadratic monetary policy loss function as a satellite model to support an FPAS Mark II framework.

(i) Microfounded (M-DSGE) models

We will not go into detail of the issues we have with the New Keynesian DSGE benchmark model. OxREP 2018 did a lot of heavy lifting and identified many areas that can make M-DSGE models more desirable to central bank practitioners: softening the expectational channel, using Bayesian techniques for estimation, enhancing tractability, producing more sensible output gap estimates, adding endogenous money creation, and exploring non-linearities. Our main issue with M-DSGE models is that they simply are not ready for prime time at this stage. Within the FPAS, this means replacing the semi-structural QPM with a M-DSGE model as the core model for organizing resources. Maybe one day this would make sense, but we are not there yet, and it is not clear that we need M-DSGE models for this function in any case. Again, turning to Greenspan:

> "Every model, no matter how detailed or how well designed conceptually and empirically, is a vastly simplified representation of the world that we experience with all its intricacies on a day-to-day basis. Consequently, even with large advances in

> computational capabilities and greater comprehension of economic linkages, our knowledge base is barely able to keep pace with the ever-increasing complexity of our global economy." (2003)

The problem is not an individual model but the complexity and variability of the economy that continues to change. Therefore, we need to focus more on the suite of models that will help us sift through the issues of the day and sources of uncertainty versus investing heavily in any one model. In our experience, M-DSGE modeling tends to have a pernicious effect on the analytical culture of an institution which we were glad to see this sentiment shared by other authors in OxREP 2018 that are perhaps more invested in the M-DSGE world than us and the push for more pluralism as a countermeasure. Th one model must rule culture, is the path towards analytical blindness and simply incompatible with the need for imagination to explore sources of uncertainty that threatens the central bank's objectives. However, a lot of investment has gone into M-DSGE modeling so the urge to make them the focal point is tempting but should be resisted.

M-DSGE models require a highly trained and specialized individual (not necessarily a great economist) to build, operate and change. When you recognize that models should be treated more as an organizational device for an economist to think through different issues then an important practical feature for models is to have a low barrier of entry to make changes and experiment. This feature will greatly affect the practical usage of models within central banks. Often something new has happened in the world and how quickly can we code up a model in response to study the issue? 1 day, 1 week, 1 month, 1 year? These are questions that need to be answered when it comes to the reality of central banking.

Lastly, to reiterate Blanchard's point (OxREP 2018) because we view it more important than his other critiques is that M-DSGE models are poor normative and communication devices. The use value of models really hinges on being able to provide normative advice to policymakers and in turn policymakers able to make convincing arguments to financial markets regarding the policy strategy. Effective communication with financial markets and the public is the bedrock of good monetary policy and the models used at a central bank should reinforce the communication strategy. Financial markets should be able to draw a direct line from how the policymakers communicate monetary policy and the outlook provided by the staff.

> "QPM is much more than the sum of its individual equations; the model was built "from the top down" so as to bring aggregate macro behavior to the forefront of the analysis. In keeping with this, our approach is to present the key ideas that lie behind the model's dynamic structure and to document the results through extensive discussion of its properties, rather than through the details of individual equations" (Coletti et al, 1996)

That said, there is a lot of good within M-DSGE economics such as studying nominal versus real rigidities. Some M-DSGE models now have a financial sector which includes endogenous money creation and can provide insight into how financial crises can propagate and accelerate (Benes et al 2014, Harding and Wouters 2022). However, when a central bank goes down the path to make a M-DSGE model the focal point it runs the risk of missing important analytical concepts such as how to measure the output gap. Of course, there has been an effort to incorporate a flexible-price output gap within the M-DSGE models, however, a cursory look at

the results from these estimates show how they are rife with measurement errors and extreme assumptions nested within the overall M-DSGE framework. The COVID-19 pandemic provided the perfect backdrop for the type of situation where understanding the concept of potential output would have been critical for an economist to provide the necessary real-time judgment to adjust estimates of potential (forthcoming working paper Jaloyan 2024).

Finally, Blanchard's five kinds of equilibrium models illustrate how M-DSGE models are just one class of models within a larger ecosystem of models that would form a comprehensive analytical framework. They deserve a place within the overall suite of models approach but that is the extent of their use value where they can be used to explore specific ideas and offer useful insights from time to time. Although there is a path forward for M-DSGE models to continue to make incremental progress, the question is about how many resources should be devoted to them given their current and expected use value.

(ii) A return of reduced-form econometric models?

This holy war is hopefully behind us. Central banks have by-and-large put reduced-form econometrics in the closet as they proved to be impotent to provide a relevant solution to the inflationary episodes of the 1970's. However, Hendry and Muellbauer 2018 propose that central banks should return to this old-style econometric tradition. While this method could be appropriate for studying certain issues such as consumption functions, these models do not incorporate the first principle of monetary policy. Hendry and Muellbauer refer to a 1996 Bank of Canada (BoC) paper documenting their new semi-structural Quarterly Projection Model (QPM). That paper stated 5 general lessons learned by the BoC including the first principle which Hendry and Muellbauer omit:

> "Many of the research issues that arise in policy analysis require Bank staff to consider the long-run equilibration processes in the economy and to provide the fundamental explanation of results that can only come from explicit economic structure. ***Moreover, part of this explicit structure must be a representation of the role and functioning of macro policy***" Coletti et al 1996

When a central bank asks the simple question: What do we need to do with our policy instruments to achieve our objectives? It becomes clear that reduced-form econometrics are not fit-for-purpose as the role of monetary policy is absent. We have numerous examples of central banks explaining the change in methodology when they first documented their own QPM's which needed to address the previous old-style econometric methodology. For example, when the Norges Bank introduced its new analytical framework, it too recognized the importance of the staff be able to answer real-world policy questions for the policymaker:

> "***The key question in the new regime is: What should interest rates be today and in the future in order to best achieve our objectives?*** To provide a good basis for answering this question, analytical tools with a number of prerequisites are needed. First and foremost, monetary policy must have a clearly defined role in a model designed to support inflation targeting. The model framework must be such that it is possible and necessary for monetary policy to act to bring inflation back to target following economic disturbances. For the model to be of practical use in the policy process, it should reflect

> the policymakers view about the workings of the economy. In particular, the role of expectations has to be taken seriously." (Brubakk et al., 2006)

The CNB perhaps described its econometric predecessors best in its inaugural FPAS paper:

> "The original approach to macroeconomic modeling in policy institutions, in the 1960s, 1970s and early 1980s was to construct large econometric models, with equations specified and estimated independently, or in small subsets. It was thought that the goal of modeling was to provide as good a job as possible in tracking historical dynamic properties of the data, and that, somehow, everything would work out at the higher level. ***This approach requires a lot of resources, not just in the original model construction, but also in maintenance.*** Moreover, it was found that re-estimation often changed model simulation properties dramatically. ***Researchers usually spent more time patching up the models to provide acceptable answers to specific questions, or to cater to the idiosyncrasies of the forecasting issues of the day, than in carrying out contemplative research on policy issues.*** Many of these models could not simulate very far into the future, because insufficient attention had been paid to the consistency requirements of a general equilibrium system." (Coats et al, 2003)

These are just a few of the reasons why macroeconometric models were abandoned by central banks some time ago, however, the critique of both M-DSGE and reduced-form econometric models is perhaps as simple as what Greg Mankiw said when reflecting on macro models during his career:

> …I remember being skeptical (of the large macroeconometric models of the 1970's). And if you go back to the rise of Lucas…it was about stagflation and the events of the 70's. But part of it was that people were getting a little tired of these big models because they were large, non-intuitive, …very black boxy…and they started losing credibility. I think that a lot of (M-)DSGE models are suffering from the same fate now. They are getting large and complicated with lots of equations and you don't know exactly what's driving what result. At some point people will get tired of them for that reason." (2024)

That said, reduced-form econometric and M-DSGE models have their place within a comprehensive analytical framework, but we must be vigilant not to utilize them beyond their capacity. The critiques presented here or in OxREP 2018 do not suggest we discard these approaches. However, central banks should be wary not to make either of them the dominant analytical culture. Again, Mankiw is like-minded:

> "If you're an actual practical central banker, you listen to your staff present the results, but you don't take it as Gods truth. Any good central banker takes a healthy dose of skepticism. When I was in Washington, I watched Alan Greenspan up close…he had a healthy skepticism of the macroeconometric models. I should note…my own research I tend to focus not on big models that purport to be realistic but rather ***smaller models that are more illustrating points than trying to say this is a real replication of the whole economy. I never really want to go back to those huge models***." (2024)

(iii) Semi-structural (S-DSGE) models

It was Olivier Blanchard during his time as Chief Economist of the IMF, when conversating over the semi-structural QPM's developed under the FPAS project where he made the observation that these models are Dynamic, Stochastic and have General Equilibrium implications so why don't we call them DSGE models? Here we make the distinction between microfounded (M-DSGE) models and semi-structural (S-DSGE) models. M-DSGE models are for doing the more foundational types of macro modeling with optimizing behavior and heterogenous agents etc. while S-DSGE models are designed to flesh out the economics within M-DSGE models and bring them to the reality of the policymaking world. Therefore, a symbiotic relationship between M-DSGE models and semi-structural models exists where the M-DSGE modelers can help the semi-structural modelers to map out the structure while the semi-structural modelers can help the M-DSGE modelers with parameterization and dynamics. Together if we understand the limitations of each method, we can produce different stories for policymakers to use when they engage financial markets about the risks to the outlook.

In keeping with Mankiw's preferred type of models and Blanchard's toy models analogy referring to those models created by Dornbush or Mundell, we tend to view the best models as toys for an economist to play with and illustrate a point or narrative. However, some models also provide a better sandbox than others that allow for many economists to participate by bringing in their own toy models to tell different toy model stories. The types of models that exemplify the sandbox best are semi-structural policy models versus their M-DSGE counterpart which are more rigid, unrealistic and have a higher barrier of entry. We will provide an example of a semi-structural model where we use the insights from Rudi Dornbusch's overshooting sticky price toy model (1976) to motivate a view of the underlying forces in the economy that would generate a very different policy path than what is currently priced in financial markets.

As for semi-structural models, a strong feature is the explicit representation of forward-looking expectations. This point is discussed in detail by Brayton et al 1997 as they describe the role of expectations in FRB/US, and we will not be able to do that analysis justice here. Suffice it to say, these types of semi-structural models are relatively flexible for policy analysis because they have an explicit representation of the interaction between policy choices and forward-looking expectations. Policymakers can imagine a broad array of policy scenarios, and the rest of the model can be assumed to be invariant to the choice, within reason. For example, most characterizations of monetary policy that provide a nominal anchor for expectations could be simulated without compromising the dynamic structure in the rest of the model. The essence of the Lucas critique is that private decision rules will depend on the policy regime chosen.

Furthermore, the explicit representation of forward-looking expectations positions an analyst to explore the implications of various assumptions regarding the information available to agents when making decisions. For instance, policymakers dedicate significant effort to communicating the Bank's policy objectives to the public, aiming to influence agents in the economy to align their economic choices with the inflation target. If the target is well understood and the system remains anchored, then it is reasonable to expect the negative side effects from a series of shocks such as those present during the COVID-19 era should be smaller than would otherwise be the case. Furthermore, this structure provides an opportunity to quantify the costs and benefits of (imperfect) credibility depending on the strength of the evidence for how anchored the system is at the time of the projection round.

QPMs have utilized a top-down modelling strategy which has allowed the modelers to maintain clarity on what is required to support policymakers by addressing a wide range of policy questions.

> "Notwithstanding the importance of the goals in this regard, it would not be satisfactory for the model to give plausible answers to policy questions for implausible reasons." Coletti et al 1996

At the end of the day the semi-structural QPM serves as a vessel to organize and marshal resources on both an individual and institutional level that straddles the need to have a theoretical structure to ensure macroeconomic consistency while also being flexible enough to consider alternative judgment or assumptions that can be found in the insights provided by a DSGE, econometric, forecasting, toy, or foundational model. It should be noted that recent attempts by the ECB to publish a formal analytical framework that also views semi-structural models as forming the core of the framework while M-DSGE models play a supporting role is a welcomed sight (Ciccarelli et al. 2024). As Jesper Linde noted as a discussant of the paper, "the paper suggests key staffing challenges lie ahead" for the ECB since the more practical semi-structural policy modeling skills are different from the more theoretical M-DSGE type of modeling. This perspective also appeared to be echoed by Bernanke in his review of the Bank of England given the numerous references to semi-structural models although a specific model recommendation was outside the scope of the review it does appear as though the tides within the Big 4 are shifting towards the semi-structural, scenarios-based approach to monetary policy.

The choices within the core S-DSGE model are meant to represent uncontroversial views about how the economy responds to a standard set of shocks. However, a bare-bones model means the staff should actively search for alternative analysis outside the model or ways to turn the model into a satellite model by exploring specific issues of concern such as policy credibility, a non-linear Phillips curve or a monetary policy loss function.

VI. Endogenous Policy Credibility Model (ENDOCRED)

> "We need models in which the credibility of a central bank is endogenous to its actions." — Mervyn King, *The Quest for Nominal Stability: Lessons from Three Decades with Inflation Targeting*, Sveriges Riksbank, 23–24 May 2024

A class of models that we believe central banks could use to augment their analytical frameworks are models such as ENDOCRED that include:

- *An endogenous policy credibility process*—starting from a situation in which inflation is expected to remain high, policymakers may build credibility over time, such that public expectations of inflation only converge gradually to the target, or lose credibility as the public begins to doubt their commitment to achieving inflation target;
- *A few nonlinearities*—most importantly in the specification of convexity in Phillips curve and in the specification of the process by which credibility changes; and

- *A loss function for monetary policy*—recognizes the costs of deviations of inflation from target and output from potential as well as fluctuations in interest rates, in place of a conventional reaction function for the policy interest rate.

ENDOCRED illustrates the adaptability of semi-structural models to include a host of different properties that are relevant to policymakers. In this example and consistent with the FPAS Mark II objective of avoiding dark corners, the insights of ENDOCRED are about providing a central bank strategy for dealing with potential scenarios where inflation expectations were not assumed to be well anchored (imperfect policy credibility) and restoring credibility as well as a strategy for dealing with the effective lower bound (monetary policy loss function).

Central bank credibility has been around since the origins of Inflation Targeting in Laxton, Ricketts, and Rose (1993) and developed over the years in (Isard and Laxton, 1998), (Laxton and N'Diaye ,2002), (Argov et al, 2007) (Alichi et al, 2009). The notion of credibility just seemed like a necessary precondition for a central bank that communicates a target, would only work when financial markets believe the commitment. The word "credibility" is frequently mentioned in discussions on monetary policy; however, few central banks have adopted a strategy that explicitly incorporates credibility into their regular risk analysis and communication. Central bank credibility in this framework means a credible macroeconomic framework where:

- Long-term inflation expectations are anchored in bond markets
- Long-term inflation expectations are anchored by wage and price setters
- The monetary policy transmission mechanism is operating by design i.e. the long-term real interest rate and the exchange rate work as shock absorbers not emitters. If a central bank gets mired in a low inflation trap with policy rates at the ELB, then the monetary policy transmission mechanism will tend to break down and requires immediate action to try and rectify the situation.

This is especially pertinent in the current day where after several years of above target inflation, credibility is under threat. It can also help explain the issues that have plagued central banks such as the ECB and BoJ where the exchange rate periodically works against their objectives. The following is largely an adapted version from Kostanyan et al 2022 to describe the process for constructing credibility with an historical example applied to the US. A forthcoming working paper by Magzhanov et al 2024 will provide the full two-country setup for the US and Eurozone with non-traded sticky price inflation and historical credibility constructed for the ECB.

To construct a credibility index, we first need to describe a model of inflation to understand how credibility influences inflation dynamics through expectational mechanisms. Specifically, we are interested in modeling inflation expectations ($\pi 4_t^e$) in the standard-inflation expectations-augmented Phillips curve.

$$\pi_t = \lambda_1 \pi 4_t^e + (1-\lambda_1)\pi 4_{t-1} + \lambda_2 \left(\frac{\hat{y}_{t-1}}{\hat{y}_{max} - \hat{y}_{t-1}} \hat{y}_{max}\right) + \varepsilon_t^{\pi} \quad (1)$$

where, $\pi 4_t^e$ and $\pi 4_{t-1}$, respectively, are the forward-looking and backward-looking components of our inflation measure π_t; $\hat{y}_{t-1}$ is the output gap in period *t*–1; and $\hat{y}_{max}$ is the maximum possible

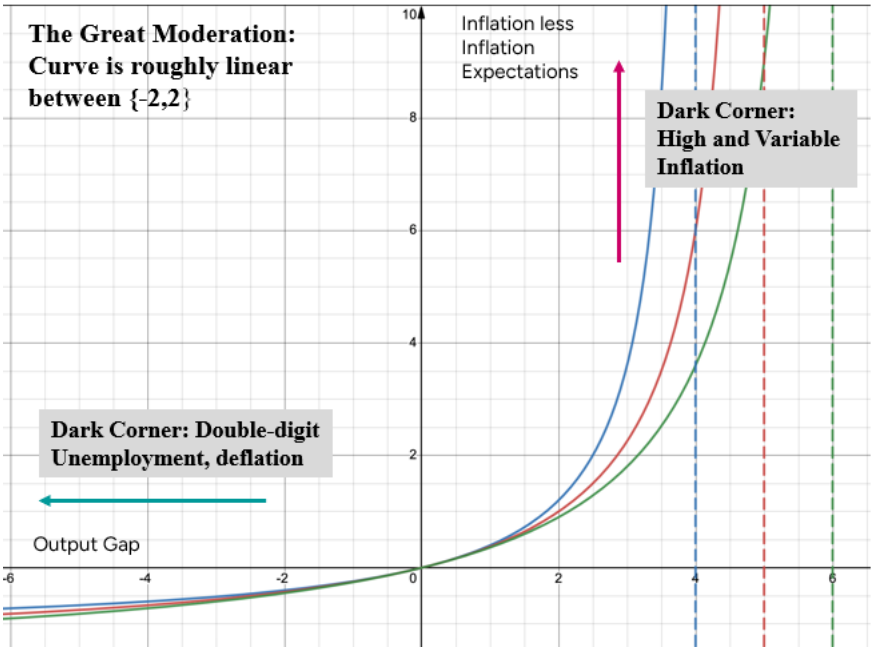
excess demand pressures. The term ε_t^{π} represents the critical role for cost-push supply shocks that directly impact inflation and create the short-run tradeoff between the output gap and inflation.

The terms in the equation represent:

- forward- and backward-looking components to the expectations process [$\lambda_1 \pi 4_t^e$ + (1-λ_1)$\pi 4_{t-1}$] where $\pi 4_{t-1} = \frac{1}{4}\sum_{j=1}^{4} \pi_{t-j}$. Conceptually, $\pi 4_t^e$, should represent what inflation is expected to be over the next year.
- non-linear output gap effect (λ_2 * [$\frac{\hat{y}_{t-1}}{\hat{y}_{max} - \hat{y}_{t-1}} \hat{y}_{max}$]).

The first parameter, λ_1, determines the weight on inflation expectations versus lagged inflation. A value for λ_1 = 0.70, implies a weight of 0.30 on past inflation. This would suggest that even in a world where inflation expectations are perfectly anchored to a 2% target there would still exist a small amount of inflation persistence in the inflation process. Here an economist should be trained to understand the implications of different parameter values and their uncertainty without the need to formally estimate these types of equations. The world is a big place, this type of skill becomes useful when applying macro modeling techniques to emerging market countries that lack the data richness to estimate these types of parameters with any reliability.

Figure 3: Convex Phillips Curve According to Different Values of y_{max} between 4 and 6



Source: Author's Illustrative Phillips Curve, Kostanyan et al 2022

The second parameter, λ_2 = 0:30, is the slope of the Phillips Curve when the output gap is zero, or near zero. The y_{max} parameter is the maximum possible excess demand pressures. As the output gap gets closer and closer to this maximum value, the slope of the Phillips curve gets steeper and steeper (see Figure 3). The y_{max} parameter follows the logic of the relationship between output gap and

unemployment gap set forth by Okun's Law, in that a very high output gap would result in an unsustainably low unemployment gap.

(i) Expectations Process and Credibility

Standard linear models presume perfect levels of central bank credibility, but as periods of high or persistent inflation demonstrate, central bank credibility is often, if not always, imperfect. If inflation is allowed to deviate persistently from the target, this will eventually result in a loss of credibility, where long-term inflation expectations ratchet upwards and the expectational process that governs wage- and price-setting behavior begins to price in an inflation premium. It can be dangerous to assume that inflation expectations are always forward-looking, as the empirical evidence suggests that they are clearly backward-looking. In general, inflation expectations are better thought of as having a combination of both forward- and backward-looking components. To make an imperfect analogy, the process by which inflation expectations are formed is not dissimilar to the process of firms fixing prices for a period of time (e.g. one year). Just as firms would look out one year and back one year to understand where to set prices, a similar *ex post* and *ex ante* logic follows for how inflation expectations are formed. The following equation contains a mechanism that allows the formation of expectations to become more backward-looking than in standard DSGE models that assume a weight of one on model-consistent expectations.

$$\pi 4_t^e = \gamma_t * \pi 4_{t+4} + (1-\gamma_t) * \pi 4_{t-1} + \kappa * (1-\gamma_t) + \varepsilon_t^{\pi^e} \quad (2)$$

The first two terms in the equation for expected inflation comprise a weighted average of a model-consistent forecast of the 4-quarter ahead year-on-year inflation rate (forward-looking component) and the year-on-year inflation rate observed last quarter (backward-looking component). The weight on the forward-looking component, γ_t, is a measure of the stock of credibility, and ranges between 0 (no credibility) and 1 (full credibility). When credibility is less than one, two important processes emerge: first, any level of existing inflation tends to become more persistent; and second, inflation expectations tend to ratchet upwards. To model how inflation expectations can ratchet upwards when credibility declines, we include an additional term, κ, to capture this bias in the transition from imperfect to perfect credibility. We assume κ is equal to 0.1, which represents a conservative estimate, even for advanced economies such as the US.

Credibility, γ_t, is equivalent to the reputation that the central bank has developed by first specifying a numerical objective for long-term inflation, and second by whether it has been able to achieve that target on average over time. The term "on average" is simply meant to represent that many measures of inflation contain significant noise in the data, and even if a central bank was behaving perfectly, inflation will not be equal to the target on a period-by-period basis. However, the public will obviously be skeptical if the performance of the central bank has allowed periods of high and variable inflation. We therefore think of credibility as a stock, in the sense that it depends on the accumulated performance of the central bank over time.

To construct the credibility index, we first think about two regimes: one, where inflation is always expected to converge quickly back to the target; and second, where inflation is expected to be high and variable. These two regimes capture the type of counterfactual analysis that Mervyn King suggested in his Riksbank speech. In the first regime, people expect that the central bank is going to be successful in achieving their 2% inflation target ($\pi^* = 2$) over a horizon of 1-2 years. This would be consistent with believing in a rule-of-thumb forecasting equation that produces a forecast for inflation that gradually adjusts toward 2% over a horizon of 1-2 years:

$$\pi 4_t^{\pi^*=2} = \Upsilon^{\pi^*=2} * \pi 4_{t-1} + \left(1 - \Upsilon^{\pi^*=2}\right) * \pi^* \quad (3)$$

($\Upsilon^{\pi^*=2}$ = 0.5, π^* = 2.0)

The error term is represented by the following equation, representing the difference between actual and forecasted inflation:

$$\varepsilon_t^{\pi 4^{\pi*=2}} = \pi 4_t - \pi 4_t^{\pi^*=2} \quad (4)$$

In general, we would assume that agents might not know the value of the error term ($\varepsilon_t^{\pi 4^{\pi*=2}}$) when forming expectations of inflation in period *t*. In such cases, the error term would represent the forecasting error that they would make by basing their forecast on such an equation ($\pi 4_t^{\pi^*=2} = \Upsilon^{\pi^*=2} * \pi 4_{t-1} + \left(1 - \Upsilon^{\pi^*=2}\right) * \pi^*$), which represents the deviation between using a forecasting equation and the actual outcome for inflation.

The second regime corresponds to a 'High Inflation' scenario, where there is a suspicion that monetary policy might become like the 1970s, where inflation is much higher than the announced target. The idea of the high and variable inflation regime is that people think inflation is persistent and tends to drift up toward double digits, which we approximate with a value of 10%. In practical terms, people would believe in such a regime versus the stationary inflation-targeting regime (where inflation always converges to the target) if they observe that inflation was highly persistent and gradually rose over time. In the context of a standard monetary policy model, one can think of this 10% as where people think inflation will converge to in the long run, which in these standard models, is the perceived inflation target. Under the 'H' scenario, inflation would converge at a much slower rate, gradually approaching 10%:

$$\pi 4_t^H = \Upsilon^H * \pi 4_{t-1} + (1 - \Upsilon^H) * \pi^H \quad (5)$$

(Υ^H = 0.9, $\pi^H = 10$)

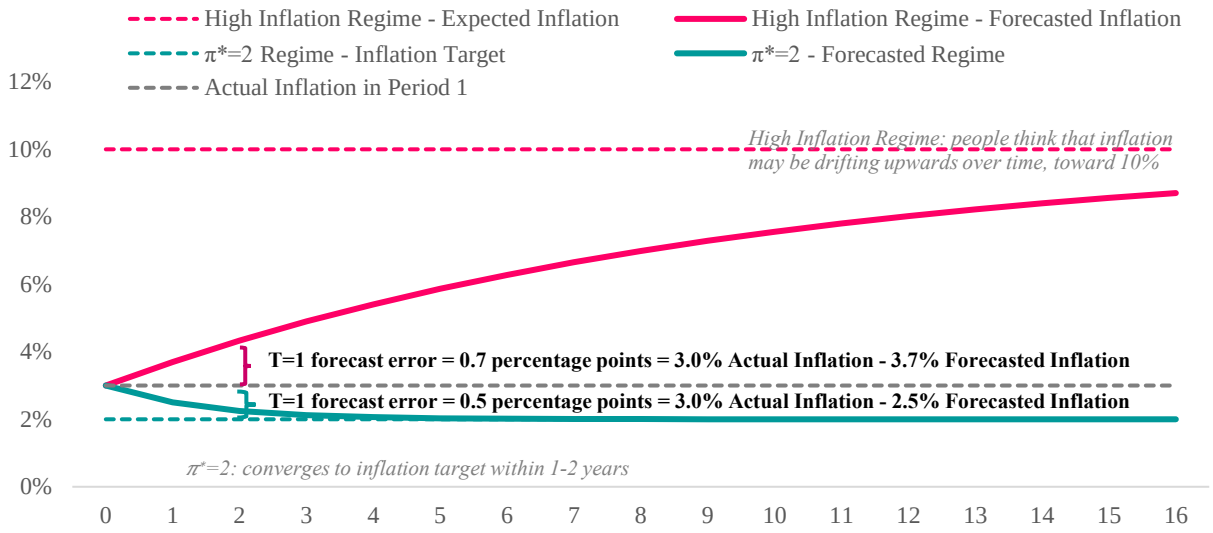
The error term for the high-inflation regime would be constructed similarly as above:

$$\varepsilon_t^{\pi 4^H} = \pi 4_t - \pi 4_t^H \quad (6)$$

An important distinguishing characteristic is the low inflation regime is expected to converge quickly to the target, while in the second regime, inflation tends to drift upward toward double-digit inflation, albeit at a more gradual pace. This characteristic of the model allows it to explain key

stylized facts, including that higher inflation is typically associated with higher inflation uncertainty, as inflation becomes more persistent (Figure 4).

Figure 4: Forecast Errors in "$\pi^* = 2$" and "High Inflation" Regimes



Source: Author calculations

In the "$\pi^* = 2$" regime, if actual inflation in period one is assumed to be 3.0% (represented by a constant line in the chart), the period zero forecasted inflation of 2.5% would represent a forecasting error of 0.5 percentage points. In the "H" regime, assuming the same actual inflation of 3.0% in period one, the forecasted inflation of 3.7% represents a forecasting error of 0.7 percentage points, higher than in the "$\pi^* = 2$" scenario. These forecasting errors provide important inputs to the model where the costs of inflation deviations from forecasts and targets are considered signals that enter the process that governs credibility.

We use these two hypothetical inflation regimes to define a central bank sticky-price inflation indicator (CBSPII), η_t

$$\eta_t = \frac{\left(\varepsilon_t^{\pi 4^H}\right)^2}{\left(\varepsilon_t^{\pi 4^H}\right)^2 + \left(\varepsilon_t^{\pi 4^{\pi^*=2}}\right)^2} \qquad (7)$$

The flow variable η_t provides a rough measure of the extent to which inflation outcomes are seen as consistent with the '$\pi^* = 2$' inflation scenario. In the '$\pi^* = 2$' case, inflation converges gradually to the inflation target as implied by equation (3). η_t equals 1 since the term ($\varepsilon_t^{\pi 4^{\pi^*=2}}$) in the denominator of equation (7) equals 0. If inflation is at the level postulated in the 'H' case, the numerator ($\varepsilon_t^{\pi 4^H}$) equals 0, and thus η_t equals 0, implying a lack of credibility.

The central bank credibility stock index (CBCI), γ_t, then evolves according to a standard stock accumulation process, where credibility depends partly on its lag and partly on the signal of recent central bank performance:

$$\gamma_t = \rho * \gamma_{t-1} + (1-\rho) * \eta_{t-1} + \varepsilon_t^{\gamma} \quad (8)$$

An increase in η_t results in a rise in the weight on the forward-looking component of expectations, $\gamma_t * \pi 4_{t+4}$, as in equation (2), presented again below for the reader's convenience.

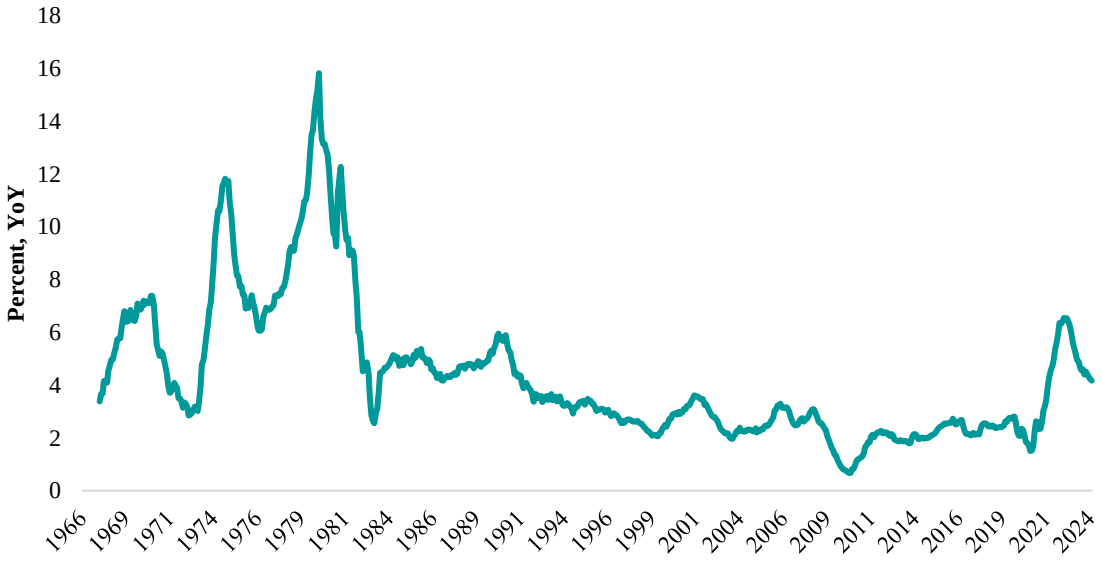
$$\pi 4_t^e = \gamma_t * \pi 4_{t+4} + (1-\gamma_t) * \pi 4_{t-1} + \kappa * (1-\gamma_t) + \varepsilon_t^{\pi^e} \quad (2')$$

This reduces inflation persistence and ties inflation more tightly to the target, such that the central bank must do less in response to shocks, and convergence to the target rate is faster. The disturbance term, ε_t^{γ} represents a shock to central bank credibility, which may be positive or negative. The basic intuition is that a loss of credibility is costly, because if the public loses trust in policymakers' ability to achieve their policy objectives, then the central bank must adjust its policy rate more aggressively implying larger cumulative output and unemployment costs to reduce inflation once it becomes embedded. This logic introduces a key underlying principle that delaying policy actions in response to different types of shocks (such as overheating, or upward shifts in the equilibrium real interest rate) are costly.

(ii) Applying the methodology to the US

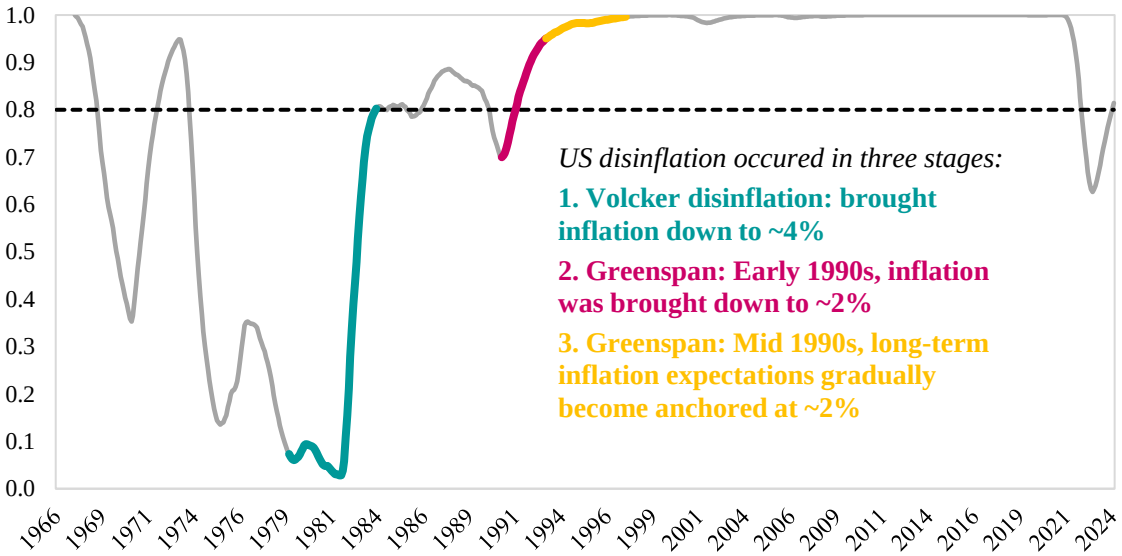
For the US, we take the sticky price index from the Atlanta Fed as our preferred measure for tracking central bank performance. Sticky prices are prices that are adjusted infrequently and may contain information on the underlying price-setting behavior in the economy. A commonly used example is haircuts. In most cases, a haircut would be a non-traded service that requires domestic labor to produce. Haircut prices are usually stable in countries that have anchored long-term inflation expectations. Haircut prices would be adjusted periodically to keep up with underlying inflation, but it would also depend importantly on the demand and supply for haircuts.

Figure 5: Core Sticky-Price YoY Inflation for the US



Source: Atlanta Fed, Author Calculations

Figure 6: Central Bank Credibility Stock Index for United States



Source: Atlanta Fed, Author Calculations

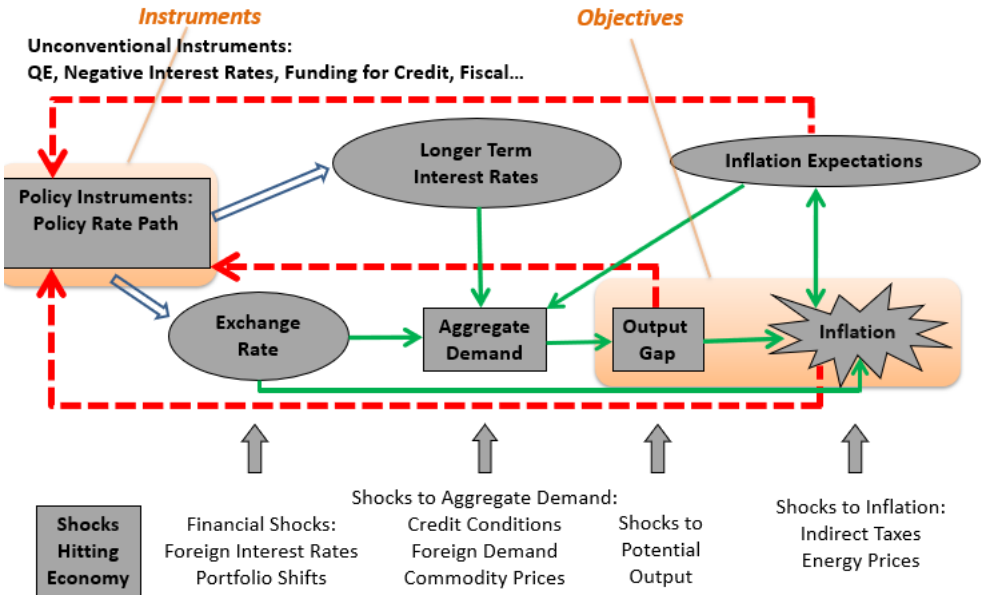
The two indices show a plausible story behind how credibility of the Fed has evolved over time, beginning with the period of high credibility in the 1960s, which was ultimately lost under Burns' Fed in the 1970's by allowing inflation and inflation expectations to significantly ratchet up and become entrenched. Then the Volcker era was tasked with restoring price stability under a low credibility regime, which required a more severe response from monetary policy. This leads to an insight from the model: when credibility is lost, the magnitude of monetary tightening necessary to bring inflation down to the target increases (i.e., the sacrifice ratio increases). In the decades which followed, whether due to good policy or sheer luck, inflation never exceeded a high threshold, allowing the Fed to accumulate credibility. That lasted until the latest Covid-era inflation spell, which has brought the notion of credibility back to the forefront.

To study economies such as Japan or the Euro area, we have an extended version of the model that penalizes credibility where the perceived target is below the target of the BoJ or ECB. This allows us to model situations where long-term inflation expectations can ratchet downwards, and the economy can become vulnerable to further contractionary shocks when the economy is at the effective lower bound.

VII. The ECB: A Cautionary Tale from a Lack of Credibility

We extend the model to two countries for the US and Eurozone with a risk-adjusted uncovered interest parity equation to study the implications of credibility, or lack thereof, can have on the monetary transmission mechanism, namely the exchange rate (Figure 7). If the transmission mechanism is not working properly then serious and immediate action is required to fix it otherwise the central bank is courting a macroeconomic meltdown.

Figure 7: Monetary Policy Transmission Mechanism



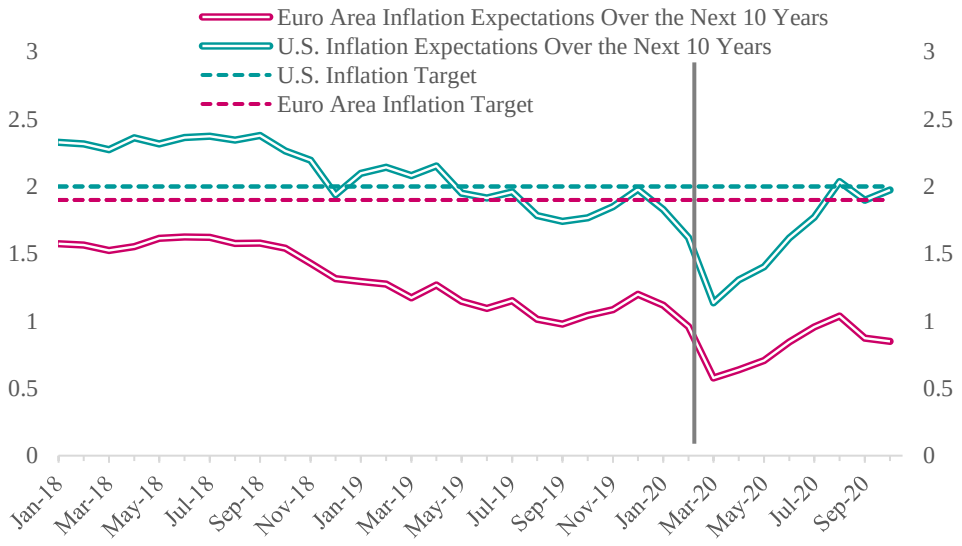
First, we want to highlight the monetary policy loss function that penalizes squared deviations of output from its potential, y_{t+j}^2, and inflation from the target, $(\pi 4_{t+j} - \pi^*)^2$. Guided by this type of policy perspective likely would have suggested interest rates be taken to the ELB in the immediate aftermath of the GFC and could have lowered the risk of the Eurozone getting stuck in a low inflation trap and being better prepared by the challenges presented by the COVID-19 pandemic.

$$Loss_t = \sum_{j=0}^{\infty} \rho^j [\, \omega_1 (\pi 4_{t+j} - \pi^*)^2 + \omega_2 y_{t+j}^2 + \omega_3 (i_{t+j} - i_{t+j-1})^2] \quad (9)$$

The term ρ represents the discount rate. The weights (ω_i) embody the costs that policymakers attach to each of these items. Monetary policy minimizes this loss function, subject to the constraints imposed by the structure of the model. Monetary policy has choices with respect to the speed at which inflation returns to the target. This may be faster if the cost of missing the inflation target is high relative to the costs of output gaps and interest rate instability. Or, it may be slower, if the cost of inflation-targeting errors is relatively low, such as when long-term inflation expectations are well-anchored and there is a high degree of confidence in the inflation-targeting regime.

The quadratic loss function implies symmetric aversion to overshoots and undershoots with respect to the inflation target. One might argue that policymakers' preferences would not be symmetric under a program of inflation reduction. They might regard an undershoot of inflation as a benign, albeit unexpectedly rapid, approach to the low-inflation objective, but an overshoot as a serious threat to the program. In any case, the Eurozone found itself mired in a low inflation trap with inflation expectations markedly below its target going into the COVID-19 pandemic while inflation expectations in the US were well-anchored.

Figure 8: Inflation Expectations Over the Next 10 Years in the U.S. and Euro Area



Source: Bloomberg

Once the pandemic hit, inflation expectations ratcheted downwards in both countries from the uncertainty presented by the lockdown policies which not only hit the supply side of the economy but also demand, reducing inflation in the short run. Normally under these circumstances, an Inflation Forecast Targeting central bank would be expected to reduce the policy rate and the exchange rate would depreciate and act as a shock absorber to help eliminate the output gap and steer inflation back to the target.

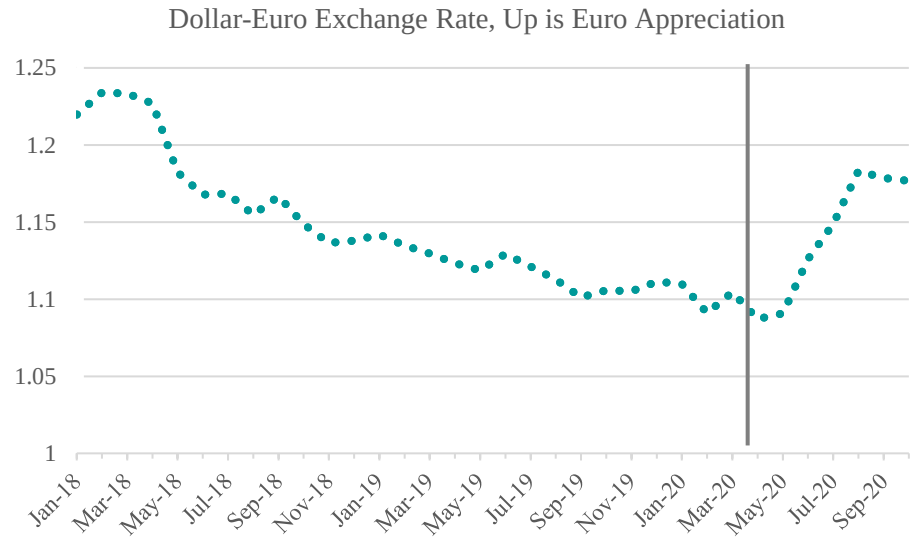
$$\sum_{j=0}^{k} i_{t+j} \downarrow = [s_{t+k+1} - s_t] \uparrow + \sum_{j=0}^{k} [i^f_{t+j} + u_{t+j}]$$

However, in the immediate onset of the pandemic where central banks were cutting interest rates to stimulate their economies, the ECB was handicapped with rates still at the ELB. Consequently, as inflation expectations ratcheted down, real interest rates rose and applied further appreciation pressure on the exchange rate (Figure 9) at a time when the ECB was seeking the opposite and reinforcing its low inflation trap.

$$\sum_{j=0}^{k} i_{t+j} = [s_{t+k+1} - s_t] \downarrow + \sum_{j=0}^{k} [i^f_{t+j} + u_{t+j}]$$

$$r_t = i_t + E_t \pi_{t+1}$$

Figure 9: The Exchange Rate Illustrates a Breakdown in the ECB Transmission Mechanism due to the ELB



Source: Bloomberg

Next in the sequence of events was the tightening cycle and enters another non-linearity for policymakers to confront: debt * interest. When debt levels are high and sustainability is a concern, a central bank might be reticent about raising interest rates too rapidly for fear of causing a fiscal crisis from explosive debt dynamics. The ECB was relatively slow to respond, and an interest rate differential emerged, and the exchange rate depreciated during a time when the Eurozone was also responding to an inflation shock, so again, not ideal when the exchange rate is acting against the central banks interests.

Looking forward, although the macroeconomic situation has moderated with no explosive inflation or debt dynamics, we still express concern that the path forward for both the US and Eurozone economies remains precarious. There remains important non-linearities that exist on either end of the plausible risk spectrum. A candidate Case A scenario for both countries would be a scenario where non-traded sticky price inflation is not merely a statistical artifact that will normalize but, in fact, could reflect a more insidious price setting behavior in the economy responsible for underlying inflation and inflation expectations being higher than expected. If true, then credibility is imperfect, and it may be worth it to nudge financial markets towards higher interest rates to restore credibility faster. Another supply shock, say from oil prices, could happen at any moment. Under imperfect credibility, experiencing another supply shock would likely require a non-linear response from monetary policy where the shock gets transmitted more quickly into longer-term inflation expectations.

On the other hand, a narrow corridor exists for achieving macroeconomic and financial stability when public debt is at elevated levels. On top of that there is a risk of a large asset price bubble in both equities and houses in the US where if interest rates were to rise too much could have severe negative, deflationary ramifications. Policymakers must be cognizant of this as well, but it seems imperative for central banks to establish a credible monetary policy framework if they have not done so and restore credibility to be better prepared for another inflationary development. So, while central banks are focused on a benign baseline forecast where there are

no shocks and therefore makes perfect sense to ease up on monetary policy to optimize the short-run output inflation trade-off, the risk of bubbles, higher underlying inflation, higher equilibrium real interest rate, higher NAIRU or geopolitics, suggests the more prudent risk management approach is a cautious one that takes advantage of a relatively calm global economy.

VIII. Conclusion

The recent reflection from the macroeconomic uncertainty spurred by the COVID-19 pandemic made it clear that central banks need to formally adopt a risk management approach to monetary policy. The FPAS Mark II is a proposal of an analytical framework that addresses the institutional requirements for creating a risk management approach to monetary policy. The Big 4 central banks would be wise to establish a more credible analytical framework to minimize the risk of an inflation scare and ensure that the monetary policy transmission mechanism is working properly.

When thinking about the future of macroeconomic models, it is important to understand the analytical frameworks in which they will be used. While academia focuses on theory and empirics, semi-structural policy models provide a nice balance, and something useful to learn in university. Furthermore, exploration into the non-linear spaces of macroeconomics is what will prove most helpful for policymakers when models can provide important structure.

We recommend central banks pursue models with endogenous credibility, a concept they should want to maintain since the corridor for achieving their objectives has narrowed due to potential financial market distortions and public debt constraints.

> "In summary then, monetary policy based on risk management appears to be the most useful regime by which to conduct policy. The increasingly intricate economic and financial linkages in our global economy, in my judgment, compel such a conclusion." (Greenspan 2003)

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