

NBER WORKING PAPER SERIES

CENTRAL BANK CREDIBILITY BEFORE AND AFTER THE CRISIS

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Working Paper 21710
<http://www.nber.org/papers/w21710>

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
November 2015

Part of the research for this paper was done while the second author was a National Fellow at the Hoover Institution and a Visiting Scholar at the University of Tasmania. An appendix to the paper is available on request. An earlier version of this paper was presented at the XVIII Annual Inflation Targeting seminar, Banco Central do Brasil, Rio de Janeiro (May 2016). Comments by José Renato Haas Ornelas are gratefully acknowledged. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

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Central bank Credibility Before and After the Crisis

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NBER Working Paper No. 21710

November 2015, Revised July 2016

JEL No. C31,E31,E58

ABSTRACT

A new measure of credibility is constructed as a function of the differential between observed inflation and some estimate of the inflation rate that the central bank targets. The target is assumed to be met flexibly. Credibility is calculated for a large group of both advanced and emerging countries from 1980 to 2014. Financial crises reduce central bank credibility and central banks with strong institutional features tend to do better when hit by a shock of the magnitude of the 2007-2008 financial crisis. The VIX, adopting an inflation target and central bank transparency, are the most reliable determinants of credibility. Similarly, real economic growth has a significant influence on central bank credibility even in inflation targeting economies.

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Q: How consequential is the difference between promising 2 percent and delivering 1 percent? (Appelbaum)

A: I think it's very consequential in terms of central bank credibility. If you say I'm going to hit a 2 percent inflation target and you're unable to do it, that's very consequential in terms of confidence in the central bank and your ability to meet your commitments. (Bullard)

Appelbaum (2016)

1. Introduction

In the past two decades the credibility of central banks has been high, at least until the global financial crisis (GFC) of 2007-2008. An important contributor to achieving credibility has been the introduction of inflation targeting by many countries.¹ In other words, institutional considerations play a potentially crucial role in defining credibility. However, as Blinder (2000) points out, the profession has a difficult time measuring it. His approach relies on a survey of central banks. Since then economic theory effectively amounts to stating that credibility is something of the nature 'we know it when we see it' (Cukierman 1986) but is crucially dependent on the relationship between observed and expected inflation that is also part and parcel of the Phillips curve and the Taylor rule approach to understanding monetary policy.

Many of the policies implemented in 2007 and 2008 moved central banks away from their traditional role of protecting deposit taking institutions and the payments mechanism (Bordo 2014). For example, the US Federal Reserve (Fed), Bank of England (BOE), and others began adopting credit policy that targets certain segments of the financial system. These responses are usually viewed as a form of fiscal policy (Goodfriend 2012).

In response to the crisis many central banks have also elevated the objective of financial stability to the same level of importance as macro stability. This is based on arguments that the

¹ Regressions in Bordo and Siklos (2016) show that key determinants of credibility include the policy regime followed (especially the gold standard), central bank independence from the fiscal authorities and financial crises. Since the 1980s credibility has been enhanced by adhering to inflation targeting (IT) which is associated with better communication and transparency.

credit cycle leads to significant imbalances involving credit and asset price booms, which can burst leading to serious recessions. Some have argued that central banks should also use their monetary policy tools to prevent credit and asset booms from getting out of control. This strategy creates problems for the use of the central bank's single instrument of monetary policy, the policy rate, in meeting multiple objectives.

The question of the much awaited exit strategy toward the restoration of normal monetary policy also has crucial implications for central bank credibility. Central banks with large balance sheets are exposed to credit risk when short-term rates rise and worry about the implications of conventional tightening (Cochrane 2014). Equally problematic is that a return to an interest rate as the principal policy instrument must be accompanied by an explanation of the role policy rate changes will play alongside macro-prudential tools. Indeed, some central banks backtracked on earlier policy rate increases, or delayed planned rate rises, triggered in part by inflating asset prices (viz., housing) because of the implications of raising interest rates when the real economy is weak (e.g., Swedish Riksbank, Reserve Bank of Australia (RBA)).

In this paper we construct a new measure of credibility. It is a function of the differential between observed inflation and some estimate of the inflation rate that the central bank targets. The target is assumed to be met flexibly in a manner to be described more fully below. For inflation targeting (IT) economies the implied target is either the numerical announced objective or is tied to it in view of the fact that such objectives are to be flexibly attained over some horizon or is subject to a pre-specified target range.

We then ask empirically what determines movements in credibility based on a set of economic, institutional and financial variables, as well as accounting for endogeneity. We investigate the drivers of credibility for a large group of both advanced and emerging countries over the period 1980 to 2014. The approach we take is different from, but complementary to, our earlier work where we constructed measures of credibility for a smaller panel of advanced countries over a 120 year time span. We also consider how the crisis of 2007-2008 as well as other economic and financial determinants affected credibility.

An unbalanced panel consisting of inflation expectations data for up to 86 countries from Consensus Economics is used.² The samples range from the late 1980s to the present for advanced economies and several emerging market economies while the data begin in the mid-2000s for the remaining set of emerging market economies examined. We examine the relationships of interest across a variety of country groups (e.g., G7, Inflation targeting economies, emerging market economies). The principal advantage of our strategy is that it brings a much larger set of economies to bear on the data to investigate what drives central bank credibility. Indeed, one of our objectives is to find cross-country common factors or determinants of credibility.

To ease the interpretation and implications of our results the sources of changes in credibility are organized into groups of variables that represent real (e.g., output growth), financial (e.g., the VIX or non-performing loans, incidence of financial crises), and institutional (e.g., inflation targets, central bank transparency) determinants for the proposed central bank credibility proxy. Real variables are included to ascertain whether central banks do respond to real economic conditions and not simply to inflation performance alone. The financial variables are included because central banks have devoted much more attention to this objective, especially since the global financial crisis of 2007-9, by possibly downgrading their inflation goals. Institutional variables are important because central bankers are fond of underscoring the importance of inflation objectives as well as the transparency required to sustain these.³

We find that financial crises reduce central bank credibility but not for all central banks. Central banks with strong institutional determinants tend to do better when hit by a financial crisis of the magnitude of 2007-2008. Asset prices are found to have a detrimental impact on credibility in the Asia-Pacific but not among G7 economies where financial asset price volatility as

² In Bordo and Siklos (2015), owing to the absence of market-based measures of inflationary expectations, our credibility indicator was derived from a reduced form expression based on a small structural model.

³ That said, an important limitation of these institutional variables, important as they are, is that they change very slowly and the requisite data are available either at the annual or even decadal sampling frequencies. Moreover, even at the annual frequency, data for all the economies in our dataset are not available. A case in point is an indicator of central bank transparency (CBI; e.g., see Eijffinger and Geraats (2006) Dincer and Eichengreen 2014). Furthermore, the sample for the bulk of the economies in this study where CBI might well have played an important role is short enough such that there is insufficient variation in existing CBI indicators to render them empirically useful.

measured by the VIX is a more important culprit. Differences across central banks in various parts of the world are what stand out in our empirical findings. Other than perhaps the VIX, the adoption of an inflation target, or the degree of central bank transparency, it is difficult to find widespread common determinants of credibility.

Section 2 discusses the data used. Section 3 discusses the empirical methodology. Section 4 presents the stylized facts and econometric results and section 5 presents our conclusions.

2. Data

Current year and one year ahead CPI inflation and real GDP growth from Consensus economics for up to 86 economies are used in the empirical analysis below. Since the usual time horizon for monetary policy is around two years the combination of inflation forecasts over such a time horizon approaches that which captures the response to these decisions. The number of economies sampled falls to 61 when observed real GDP growth are added in the empirical analysis.⁴

The availability of data for other potential covariates also affects the number of cross-sections that can be examined at one time (see below). Data for the various determinants of credibility considered are generally available since the early 1990s for advanced economies, notably the G7 economies, while forecasts for the remaining economies begin from the mid-1990s to 2005. Typically, the smallest samples are for emerging or developing economies relying on the International Monetary Fund's (IMF) definition. The sample ends in April 2014 when monthly Consensus data are used while for some explanatory variables (viz., institutional proxies) the data are available until the end of 2013 or the first quarter of 2014. The raw forecast data are monthly which are subsequently converted into quarterly data (via arithmetic averaging) in order to conduct an econometric analysis of the determinants of central bank credibility.⁵

⁴ In some cases the data were not available from the IMF's *International Financial Statistics*; in a few other cases the available samples were so short that it did not seem practical to collect the available data.

⁵ For several emerging or developing economies the data were initially published on a bi-monthly basis. Eventually, the data were published monthly. Bi-monthly data were converted into monthly data via interpolation using the Catmull-Rom spline algorithm.

A salient feature of the raw Consensus data is that they are published as *fixed horizon* forecasts. That is, published figures represent forecasts of inflation or real GDP growth in the current or following calendar year as opposed to the *fixed event* forecasts that economists generally have in mind when thinking about expectations (i.e., one year ahead forecast published at time t). Typically, the conversion of one type of forecast into another involves estimating a linear combination of current and next year fixed horizon forecasts to mimic the preferred fixed event forecasts.⁶ Hence, while these forecasts cover two calendar years for the purposes of their interpretation we refer to them as one year ahead forecasts.

Monthly forecasts for inflation and real GDP growth are combined with monthly data for observed changes in a Consumer Price Index (CPI). In contrast, observed real GDP growth data are generally available only at the quarterly frequency. Data were obtained from the IMF's International Financial Statistics (IFS; October 2014 CD_ROM version as well as the online version; <http://www.elibrary.imf.org/>).⁷ A few series, such as interest rates (long-term, short-term, and policy rates, where applicable), and exchange rates were also collected from the same source. Long-term interest rate data were collected for 33 economies, while short-term yields were obtained for 39 economies. The former are typically government bonds that mature in 10 years or more while the latter represent three-month government instruments (e.g., Treasury bills). These were used to generate a term spread, namely the difference between long-term and short-term yields.

For 50 economies the Bank for International Settlements (BIS; www.bis.org) provides real exchange rate and credit data. While exchange rates in advanced economies float against each other, emerging markets often actively manage their exchange rates (e.g., Reinhart and Rogoff

⁶ See Siklos (2013), and references therein, for discussion. If monthly inflation is denoted by π the transformation is as follows: $\pi_{m,t}^{FH} = [(13-m)/12]\pi_t^{FE} + [(m-1)/12]\pi_{m,t+1}^{FE}$ where $\pi_{m,t}^{FE}, \pi_{m,t}^{FH}$ are, respectively, fixed event (FE) and fixed horizon (FH) forecasts, at time t , in month m . The same transformation is used to create fixed horizon real GDP growth forecasts.

⁷ Observed inflation data are also generally available at the monthly frequency. Australia and New Zealand are two notable exceptions since they publish only quarterly data.

2004). Clearly, real exchange rates, via parity type conditions, impact both observed and expected inflation performance and are likely to be a determinant of central bank credibility.⁸

To conserve space we group economies. Recent events, for example, have highlighted the divide between inflation and non-inflation targeting economies on the one hand and emerging markets economies versus advanced economies on the other. We follow the definitions used in the IMF's World Economic Outlook (<http://www.imf.org/external/ns/cs.aspx?id=29>) database. Nevertheless, we also created additional country groupings partly to evaluate the robustness of our results. In addition to the G7, EU, Eurozone, and Advanced economies, we also consider the G4 (U.S., Eurozone, Japan, U.K.), inflation targeting (IT) economies, economies in the Asia-Pacific region, and a group of "other" economies that did not fit any of the other classifications listed. IT economies are further sub-divided according to whether the countries in question belong to the Advanced or emerging market classifications.

We also include the BIS's credit indicators. Credit and housing prices have been assigned pride of place by the BIS and others as culprits in the GFC of 2007-2008. Indeed, Borio et.al. (2015) find that asset price deflations as opposed to goods price deflations, are economically more damaging. Similarly, the BIS has argued that asset price bubbles are more likely when monetary policy is too loose (e.g., see BIS 2015). Therefore, asset price movements have the potential to influence central bank credibility. Data are available for 40 economies at the quarterly frequency. The data represent nominal and real credit measures for private non-financial sector, household, and non-financial corporations (<https://www.bis.org/statistics/credtopriv.htm?m=6%7C326>). We also consider the rate of changes in equity prices where the latter are aggregated in index form. Monthly data were obtained from the IMF and the St. Louis Federal Reserve data base (<http://research.stlouis.org/fred2/>; FRED).

Proxies for the potential impact of financial stability are obtained from the World Bank's *Development Indicators* (<http://data.worldbank.org/data-catalog/world-development-indicators>). We posit that financial system stability can be summarized by the percent of non-

⁸ A positive change in the real exchange rate is defined as a real appreciation.

performing loans to GDP, the capital-asset ratio⁹, domestic credit to GDP, and an estimate of the risk premium on lending. All of these variables have been mentioned in the recent literature on the determinants of financial stability or have been emphasized by policy makers (e.g., central banks) as early warning type signals of financial stability (e.g., see Borio 2014, Vredin 2015, and references therein).¹⁰ Another proxy for financial stability, available at a much higher sampling frequency, is the VIX index. This represents the implied volatility in the S&P500 and is often seen as a portent of financial stability since it represents the markets' near term expectation of future stock market volatility. As Adrian et. al. (2014) point out "...a dramatic decline in capital ratios in the years leading up to the financial crisis as perceived risk – often measured by the VIX or credit spreads – fell to low levels." They go on to emphasize the importance of the VIX as an indicator of the procyclicality of the financial cycle. The data are from FRED. Another source of institutional change is the World Bank's *Worldwide Governance Indicators*.¹¹ Indicators of the rule of law, voice and accountability and political stability indicators were also considered as potential institutional determinants of central bank credibility.¹²

⁹ It was pointed out to us that not all central banks supervise the financial system. Hence, it is unclear why the capital-asset ratio should be considered a determinant of central bank credibility. This variable is a proxy for financial stability and even if the central bank does not directly supervise the banking system almost all central banks are expected (whether explicitly or not) to ensure financial system stability.

¹⁰ Only a small number of central banks relative to the size of our data set have created indexes of financial stress or stability by combining a large number of related factors.

¹¹ <http://info.worldbank.org/governance/wgi/index.aspx#home>. Voice and accountability is defined as "capturing perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media." Rule of law represents "...perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence." Political stability captures "perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism." See Kaufmann, Kraay, and Mastuzzi (2010. pg. 4).

¹² We also considered *Heritage Foundation's* index of economic freedom or fiscal freedom (<http://www.heritage.org/>). Economic freedom is based on a grouping of 10 quantitative and qualitative factors that include the rule of law, property rights, regulatory efficiency and trade openness. A more complete definition is available at <http://www.heritage.org/index/about>. Fiscal freedom is an aggregation of three indicators, namely the top marginal tax rate on individual income, the top marginal tax rate on corporate income, and the total tax burden as a percent of GDP. More details are available at <http://www.heritage.org/index/fiscal-freedom>. The conclusions discussed below were largely unaffected when data from this source was included. Hence, their use is not discussed further.

As explained below our methodology includes, where feasible, ‘gaps’ in both inflation and real GDP. This acknowledges that the starting point for our estimates is the traditional quadratic loss function with inflation and output as its determinants.¹³ Essentially, two different strategies were adopted in the estimation. First, we computed 2-year and 5-year moving averages of observed and forecasted inflation or real GDP growth. Alternatively, one-sided HP filters for the series were fitted. We return to this issue below when discussing our methodology in more detail.

Because real GDP and price level data were not available for a sufficiently long span of data much beyond the advanced economies the filters were applied to the rate of change data. This is somewhat non-standard. As a result, a very high smoothing parameter (100,000) was applied to ensure that sensible estimates of the gap are generated. Alternatively, in the case of real GDP, we also used the change in real GDP growth. The latter can be likened to a ‘speed limit’ indicator of monetary policy.¹⁴

Finally, we consider the impact of the adoption of inflation targeting and changing central bank transparency. An annual index of central bank transparency since 1998, originally developed by Dincer and Eichengreen (2007, 2014), and updated by Siklos (2011, 2016), is used.¹⁵ Not surprisingly, the rise of central bank transparency parallels the adoption of inflation targets.¹⁶

¹³ It was pointed out to us that exchange rate management is also likely part of the several central bank loss functions. Clarida (2001), and Collins and Siklos (2004), for example, demonstrate empirically and via simulation exercises that the traditional loss function is not significantly improved by the explicit addition of a real exchange rate objective. Nevertheless, as noted above, the real exchange rate is included as a separate determinant of credibility.

¹⁴ Our conclusions were unaffected when we compare our gap estimates with ones, where available, generated from growth rate data. The one-sided filters were estimated twice holding either the first or last observation end-points fixed. In the case of estimates of the output gap we also examined the mean of the two one-sided estimates. The concern here is over the well-known end-point problem with traditional estimates that rely on an HP filter.

¹⁵ Central bank transparency data (up to 2011; data up to 2013 will be released shortly) are available from the Central Bank Communication Network <http://www.central-bank-communication.net>. The index aggregates 15 attributes which are then sub-divided into five broad categories. They are: *political transparency*, which measures how open the central bank is about its policy objectives; *economic transparency*, an indicator of the type of information used in the conduct of monetary policy; *procedural transparency*, which provides information about how monetary policy decisions are made; *policy transparency*, a measure of the content and how promptly decisions are made public by the central bank; and, finally, *operational transparency*, which summarizes how the

Potential determinants of central bank credibility are expressed as a percent of GDP, as indexes or dummy variables (e.g., adoption of inflation targeting, central bank transparency, governance), or in rate of change form (credit variables, real exchange rates, asset prices).¹⁷

3. Methodology

Our analysis proceeds in two steps. First, we compute two separate estimates of credibility. As noted in the introduction most central banks have a responsibility to control inflation. Accountability, at least in legislative terms, may be stricter for some than for others (e.g., in IT central banks versus others). Hence, it is natural to think of central bank credibility, broadly speaking, as a function of the differential between observed inflation and some estimate of the inflation rate that the central bank targets. Even when a numerical objective is available it is often expressed in the form of a range and there is usually sufficient flexibility in the mandate of the central bank to miss the target range over some horizon that is at least two years, or longer. It is the essence of flexible inflation targeting which suggests that a useful indicator of credibility should not penalize a central bank the same way for missing the stated (or implicitly stated) target each and every period as opposed to exceeding or undershooting its target range. While it is more difficult to make the same case for non-IT central banks there is also likely to be some tolerance for missing an estimate of some implicit inflation objective.

Next, we must decide on the penalty a central bank incurs to its credibility when the inflation objective is missed. A straightforward assumption, in common with the literature on central bank objective functions, is to assume that the loss of credibility rises non-linearly the further away observed inflation is from target. A definition that meets this criterion is provided below.

central bank evaluates its own performance. Note also that central bank transparency and independence are not unrelated as Dincer and Eichengreen (2014) have pointed out.

¹⁶ The rise in transparency is not, however, solely associated with the formal adoption of numerical targets since the U.S., Federal Reserve, the European Central Bank (ECB), and the Swiss National Bank (SNB) are not, ordinarily, included among the group of inflation targeting economies even though they are considered to be central banks where inflation control is part of their remit.

¹⁷ In some of the estimated specifications we also include dummies for the GFC and the Asian Financial Crisis (AFC). The former is dated 2007Q1-2009Q4; the latter is set at one for the period 1997Q1-1998Q4.

Note that the foregoing considerations do not relegate output (or the exchange rate) to irrelevance. As pointed out above, both the extant empirical and theoretical literatures recognize that flexibility around any inflation objective matters precisely because central banks also care about other indicators of economic performance. Moreover, any departure from an inflation goal need not automatically translate into an immediate loss of credibility.

Ideally, as in Bordo and Siklos (2015), we would estimate the central bank's inflation objective based on a model where the central bank is aware that the neutral or equilibrium real interest rate can change over time, as well as the other variables that define the state of the economy, as summarized by a monetary policy rule such as the oft-used Taylor rule.¹⁸ In a large cross-section data set of the kind used here such an approach is impractical because of data limitations. Instead, we assume that a central bank's implicit inflation target is influenced by its forecasts over a two year horizon. Since we are unable to rely on central bank forecasts instead we use Consensus forecasts as a proxy.¹⁹

It is also conceivable, of course, that the central bank's inflation target has a backward-looking component.²⁰ In this case the monetary authority's inflation objective is also influenced by current and past inflation performance.²¹ In this case a moving average, or some other method that smooths past inflation (e.g., an H-P filter applied to inflation), such that it is in line with the target that the central bank has in mind acts as a proxy for an inflation target. This view is also consistent with the notion that inflation expectations display history dependence (e.g., Woodford 2003).

¹⁸ In Bordo and Siklos (2016) the rule can be a Taylor rule, a money growth rule, or an exchange rate rule. The choice of rules depends on the policy regime actually in place. Otherwise, they are counterfactuals. In an appendix we present purely for illustrative purposes, central bank inflation targets estimated in Bordo and Siklos (2016) for 10 advanced economies since the early 1990s. Note that the model generated inflation objectives that the authors generated are based on annual, not monthly, data and over a much longer sample than the one examined below.

¹⁹ Several advanced economies only began to publish their own (or their staff's) forecasts for inflation and real GDP growth in the early to mid-2000s. Indeed, many still report Consensus style forecasts when discussing the inflation outlook.

²⁰ In most IT economies the target is often unchanged possibly after a gradual reduction of the target in the early years of such a regime. Hence, even in IT economies, there can be a backward-looking element to the target.

²¹ Since the calculations include contemporaneous inflation, a small forward-looking element remains in the estimates of the monetary authority's inflation objective. There is usually a lag in the publication of current month or quarter inflation rates.

Our first, and preferred, definition of central bank credibility is written as follows:

$$\begin{aligned} \text{CRED}_t &= (\pi_{t+1}^f - \pi_t^*), \text{ if } \pi_t^* - 1 \leq \pi_{t+1}^e \leq \pi_t^* + 1 \\ \text{CRED}_t &= (\pi_{t+1}^f - \pi_t^*)^2, \text{ if } \pi_t^* - 1 > \pi_{t+1}^e > \pi_t^* + 1 \end{aligned} \quad (1)$$

where π_{t+1}^e is expected inflation for the year ahead which is proxied by π_{t+1}^f , namely the one year ahead fixed horizon inflation forecast, as previously defined, and π_t^* is the proxy for the time-varying inflation objective or target.²² Equation (1) defines credibility (CRED) in terms of a forward-looking measure and makes clear that the penalty for missing the target is greater when expectations are outside the $\pm 1\%$ interval than when forecasts miss the target inside the target range. A smaller penalty is assessed when the gap between the inflation target and expectations allows small deviations from an IT to have an inconsequential impact on credibility. After all, inflation cannot be controlled perfectly. Hence, a typical inflation control regime will make allowances for missing a target by specifying a target range for inflation. For completeness we also consider the case when the loss of credibility is zero so long as $|\pi_{t+1}^e - \pi_t^*| \leq 1$ but our conclusions are unchanged. These results are not discussed further.

As noted above most, though not all, inflation targeting regimes with an explicit numerical objective specify a $\pm 1\%$ range of indifference.²³ We assume, even if the central bank is not required to adhere to a numerically agreed to and publicly announced inflation target, that the monetary authority has a mandate to control inflation. Squaring deviations from an inflation target is natural under the circumstances and follows from assuming a quadratic form for losses in central bank objective functions. Indeed, depending on the persistence properties of inflation

²² Note that π_t^* is not the mean inflation rate but an inflation objective as defined above. Hence, the second part of equation (1) is not the variance or a measure of inflation volatility.

²³ For example, examining economies that adopted inflation targeting finds that only South Africa and Thailand specify target ranges that are slightly larger than the $\pm 1\%$ presumed in our calculations.

forecasts inside the range the central bank's credibility may not be negatively impacted at all. However, persistent deviations within the range would result in a loss of credibility.²⁴

Alternatively, we also generate a version of equation (1) by replacing the one year ahead inflation forecast, π_{t+1}^f with a smoothed inflation rates based on observed data. In this case expected inflation is extrapolated from past inflation performance. This implies a backward-looking credibility indicator written as follows:

$$\begin{aligned} \text{CRED}_t' &= (\pi_t - \pi_t^*), \text{ if } \pi_t^* - 1 \leq \bar{\pi}_t \leq \pi_t^* + 1 \\ \text{CRED}_t' &= (\pi_t - \pi_t^*)^2, \text{ if } \pi_t^* - 1 > \bar{\pi}_t > \pi_t^* + 1 \end{aligned} \quad (2)$$

where $\bar{\pi}_t$ is a moving average (2 to 5 years) of past inflation.

Equation (2) says that credibility is determined by how far inflation outturns are from what the central bank, in principle, believes is the medium-term inflation objective. The backward-looking nature of the credibility indicator is somewhat less desirable especially since most central banks have been at pains to underscore the importance of the forward-looking nature of monetary policy. Nevertheless, our conclusions are largely unaffected whether π_{t+1}^f or $\bar{\pi}_t$ are used. Hence, virtually all results discussed in the next section are shown assuming that a central bank's inflation objective is based on Consensus forecasts i.e., equation (1)). We also normalize estimates of (1) and (2) to facilitate cross-economy comparisons.

A few additional remarks about our measure of credibility are in order. First, in IT economies the inflation target is announced ahead of time. Hence, credibility can be assessed in relation to a publicly announced value for π_t^* . In non-IT economies it is likely that there are more informal expressions for the likely inflation target.²⁵ Yet, financial markets (i.e., bond and currency markets) as well as households will form a view of the central bank's objective.

²⁴ The relevance of this point is highlighted in recent discussions, mainly in some advanced economies, that inflation rates have been persistently below (or some years ago, persistently above) some inflation objective.

²⁵ An example is when a central bank provides some information about the outlook or discusses the outlook as seen by other stakeholders (e.g., financial markets, professional forecasters).

Having defined an indicator of central bank credibility we then ask what are its determinants over time. Letting i refer to a group of economies, we consider three potential sets of economic determinants. They are: economic, financial, and institutional. Therefore, we write

$$CRED_{it} = f(ECON_{it}, FIN_{it}, INST_{it}) + \varepsilon_{it} \quad (3)$$

where CRED is the indicator of central bank credibility for country i at time t , defined in equation (1),²⁶ ECON is a vector of macroeconomic factors, FIN represents financial stability determinants of credibility, and INST is a vector institutional determinants. ECON includes real GDP growth (or the output gap), and the real exchange rate.²⁷ For FIN several candidates were considered, as previously explained. Variables include the term spread, the rate of change in housing prices, the growth of private sector credit, equity returns, and indicators of non-performing loans, credit risk, capital adequacy, and risk premium on loans. We use the World Bank indicators when other FIN data were unavailable. We also include the VIX which, as argued above, is considered to be an important indicator of financial system stability.²⁸ Finally, INST is captured by indicators of the rule of law, voice and accountability, and political stability from the World Bank's governance indicators. We also separately control, where appropriate, for whether the economies in question adopted formal inflation targets and the level of central bank transparency.

In estimating the regression implied by equation (3) we also consider the possibility that some of the right hand side variables are endogenous. Given the variety of sampling frequencies in the raw data, equation (3) is estimated via two stage least squares with fixed effects where relevant.²⁹ Potentially, there is considerable heterogeneity across the many central banks in our data set. It may be misleading then to focus solely on the mean responses to the various

²⁶ Or (2) but the results discussed below focus almost exclusively on the version of CRED defined in (1).

²⁷ We also considered oil prices (i.e., rate of change in either the Texas or Brent crude oil prices) but this variable was usually statistically insignificant. Hence, it is not discussed further.

²⁸ It is true that the VIX includes an unobservable risk premium. An alternative, such as the volatility in some domestic financial asset price indicator (e.g., a stock market index) is equally plausible. However, resort to the VIX is ubiquitous in the literature. Hence, we retain this variable as a proxy for financial stability.

²⁹ That is, we test whether the fixed effects are redundant or not. Owing to the limitations of the data a single lag of the right hand side variables serve as instruments. A panel version of the Stock-Yogo (2005) suggests that the chosen strategy is satisfactory.

determinants of central bank credibility considered. Therefore, we supplement estimates with quantile regressions (e.g., see Koenker 2005, Canay 2011) in a panel setting. Specifically, we provide estimates for the median central bank together with estimates for the two tails of the distribution of central bank credibility, that is, the least and most credible central banks (i.e., the tails of the distribution of central bank credibility estimates defined as the top and bottom 10% of the distribution). In this case equation (3) is rewritten as follows:

$$\text{CRED}_{it}(\tau) = f(\text{ECON}_{it}(\tau), \text{FIN}_{it}(\tau), \text{INST}_{it}(\tau)) + F_{\varepsilon}^{-1}(\tau) \quad (4)$$

where F_{ε}^{-1} denotes the common distribution function of the errors, τ are the quantiles, and all other terms have previously been defined.

To conserve space we focus attention on the search for common determinants of central bank credibility by grouping economies as previously discussed. It is not always immediately clear what the signs of the right hand side variables in (3) and (4) ought to be. However, in view of the received evidence about the role of inflation targeting, INST ought to play an especially important role. In particular, stronger institutions ought to improve credibility. Next, given the widespread acceptance of the role of inflation and economic activity in influencing the stance of monetary policy one also expects ECON to be significant since a central bank can generate credibility by using the instrument(s) at its disposal to guide inflation and its expectation toward the stated objective. Central banks that are seen as responding to real economic conditions appropriately should also be more credible. Whether a concern for financial stability raises or reduces credibility is an empirical question since extant theory is divided on the question and the emerging literature on the role and uses of macroprudential policies is far away from reaching a consensus.

4. Stylized Facts and Econometric Results

(a) Stylized Facts

We begin with some stylized facts. Figure 1 plots observed and (median) inflation forecasts for inflation targeting regimes, depending on whether the economies in question are members of

the group of advanced economies, the Eurozone,³⁰ or the remaining economies in the dataset. The data shown are monthly. Differences in the samples shown reflect data limitations.

Examining the record of advanced IT economies and the Eurozone we observe that inflation forecasts tend to be less volatile than movements in the observed inflation rates. In addition, periods when Consensus forecasts deviate from observed inflation can and do persist for long periods of time. This is also the case for all economies shown. It is interesting that, during the 2008-2009 financial crisis, Consensus forecasts temporarily underestimate by a sizeable margin observed inflation in both advanced IT economies as well as in the Eurozone. The sharp downturn in inflation in advanced IT economies post-GFC presumably reflects the anticipated impact of the Great Recession. The effect is equally noticeable in the Eurozone. Between 2009 and early 2014, forecasts of inflation were, more often than not, overly pessimistic (i.e., the median forecast exceeds inflation outturns) in advanced IT economies while the opposite seems to be true much of the time in the Eurozone. Clearly, these features of the data also help explain why central banks continued to loosen policies. Equally important, observations such as these suggest some possible interdependence between inflation and output growth forecasts though it is likely time-varying.³¹

Turning to the other economies considered that also target inflation, median inflation has fallen steadily over time with the exception of a temporary spike during the GFC. Moreover, by the early 2000s, the gap between observed and forecasts of inflation begins to resemble that seen in advanced economies. In contrast, economies that neither target inflation nor are part of any of the other country groupings considered, experience not only more volatile inflation but median inflation rates do not appear to have changed as much as they have elsewhere in the world.³²

³⁰ Eurozone data is only used since the European Central Bank came into existence in 1998. All inflation forecasts and determinants of ECB credibility are also examined based on variables whose coverage only consists of the Eurozone (membership varies over time). See www.ecb.europa.eu/ecb/euro/intro/html/map.en.html.

³¹ In an earlier draft we also discussed real GDP growth (observed and forecasted) performance in the various country groupings examined. It is worth noting that forecasts in the Advanced economies are persistently downgraded relative to forecasts in the last years of the Great Moderation.

³² One possibility is that pass-through effects from commodity prices are relatively lower in emerging market economies that target inflation than in the other economies group shown in Figure 1 (e.g., see Mihaljek and Klau

Figure 2 illustrates a potentially important feature of the data that helps us better understand the relationship between inflation forecasts and observed inflation performance across countries and regions of the world. The top portion of the Figure shows, for the group of advanced economies in the sample, the range of inflation rates and forecasts from the highest forecasted inflation rates to lowest inflation rate forecasts. When inflation rates are relatively low they are not only relatively less volatile but considerably easier to forecast. Notice however, that the worst performing economies in the advanced world exhibit not only highly variable inflation rates but forecasts are generally too optimistic compared to outcomes. The bottom plot in Figure 2, however, considers the inflationary experience in the Asia-Pacific region. Clearly, this part of the world is not immune to volatility or to the presence of persistent and, occasionally large, deviations of forecasts from observed inflation, at least until after the financial crisis of 2007-9 when forecast errors begin to diminish or evaporate.

Next, we turn to some estimates of central bank credibility. To facilitate comparability across countries or regions the credibility indicators are given by equation (1). Essentially, credibility may be interpreted as percent deviations from the central bank's presumed inflation objective. Figure 3 is sub-divided into two separate samples, 1995 to 2004 and 2005-2014. Note that a credibility *loss* implies that the indicator derived from equation (1) *rises* and vice-versa. Therefore, credibility is lower the higher is the value shown on the vertical axis.

Central banks in Advanced economies are generally always more credible than monetary authorities in other parts of the world as seen by the scaling of the vertical axis. Notice also that emerging markets that eventually adopt inflation targets (IT EME) beginning in the early 2000s, display large gains in credibility. Indeed, by the mid-2000s (bottom portion of Figure 3), credibility levels in emerging market economies that target inflation are not visibly different from those seen in more advanced economies or for that matter the Eurozone. The BRICS economies, as well as economies not otherwise classified (Other), frequently experience credibility losses. During financial crises, as shown by the shaded areas, most central banks outside the Advanced group of economies suffer credibility losses whether or not they were

2008, Bussière and Peltonen 2008). In addition, the share of volatile prices (i.e., food and energy) in the CPI of the other economies is likely considerably higher than in the remaining economies considered in this study.

directly implicated in the crisis. In contrast, during the GFC, temporary credibility losses were experienced on a global scale but recovered quickly.

In Figure 4a, the credibility record of advanced and Eurozone economies is shown in a different light. Here we illustrate the range of the credibility indicator from the highest to the lowest performers for a variety of country groups. The plots reveal credibility losses, as captured by the widening gap between best and worst performers, around both the AFC and GFC in Advanced economies while other economies are hardly affected. The data also suggest that there were indications of sizeable credibility losses during the second half of 2007 when there were early signs that a financial crisis on a global scale was imminent.³³ The figures also make clear that once lost, central bank credibility takes time to recover. Finally, and equally importantly, there exists a wide range in credibility losses across central banks even among the advanced group of economies. In the case of the Eurozone our indicator reveals a loss of credibility soon after the European Central Bank is created in 1998 and an even larger loss as the sovereign debt crisis of 2009 erupts.

Figure 4b reveals stark differences in credibility between emerging market economies that adopted inflation targeting relative to the remaining economies in the sample (Other). Among the IT EMEs, there is a remarkable convergence in credibility between the best and worst performers across the region beginning in the mid-2000s. After hard won improvements in credibility emerging market economies generally not directly implicated in the global crisis do not subsequently experience any noticeable credibility losses. In contrast, central banks in the other economies category suffer large credibility losses during the financial crisis and again in 2012 and 2013, possibly because of the knock on effects of the appreciation of the U.S. dollar. It is conceivable that the adoption of inflation targeting is able to explain the differences shown.

Although the stylized facts give a general idea of the evolution of central bank credibility around the world it may be useful to consider a few country-specific examples since the sample of countries considered in this paper is very large. Therefore, Figure 5 plots the evolution of

³³ Recall that there were sharp increases in commodity prices beginning in 2007 and into 2008 which clearly spilled over into credibility losses.

credibility in four selected economies. Both credibility indicators (i.e., equations (1) and (2)) defined above are shown.

The Fed's credibility (top left) temporarily suffers a large drop during the financial crisis of 2007-2009 before recovering once the worst of the GFC has passed. However, the loss is somewhat more persistent when observed (i.e., based on equation (2)) as opposed to a forecast-based measure of inflation (equation (1)) are used. Interestingly, there is another sudden and fairly large loss of credibility in early 2013 that is quickly reversed especially when the forward-looking credibility measure is used. This takes place in the aftermath of even more quantitative easing in the last quarter of 2012, soon followed by the introduction of forward guidance linked to underlying economic conditions. These developments appear to have boosted Fed credibility.

The Swiss experience (top right) shows quite clearly large and persistent credibility losses during the second half of the 1990s but relatively more so when the measure based on observed inflation is used. The situation is only reversed once the Swiss National Bank adopts inflation control measures and targets a forecast of inflation beginning in 2000. The adoption of an inflation control objective seems to have led to a noticeable improvement in credibility and both credibility proxies essentially give the same result. The financial crisis, followed by the Eurozone sovereign debt crisis, also leads to a steady loss of credibility. Credibility only improves when the SNB puts a ceiling on the Swiss franc exchange rate in 2011 (since abandoned in January 2015; not shown in the Figure). Nevertheless, the SNB is still not seen as credible as it was during the early days of inflation forecast targeting.

The Hong Kong Monetary Authority's experience (bottom left) is dominated by large negative credibility shocks during the Asian Financial Crisis of 1997-1998.³⁴ However, credibility losses are generally larger when observed inflation is used to construct the indicator. In relative terms, the impact of the latest financial crisis is barely noticeable. It is also interesting to note that

³⁴ The HKMA, of course, operates a pegged exchange rate regime. Therefore, it largely imparts US inflation throughout the sample. Nevertheless, the credibility of such a regime also rests on the inflationary consequences of the regime choice. After all, pass-through effects and other factors still create scope for an inflation differential vis-à-vis the US.

persistent divergences prevail between observed and expectations-based credibility of the HKMA throughout the 2000s. Recall that this is the period when the Fed was gradually tightening monetary policy. Given the Hong Kong dollar peg this was deflationary for Hong Kong as seen from the observed inflation-based credibility measure. However, expectations of inflation remain sticky so that the forward-looking credibility indicator shows a rise during this period.

Finally, Argentina's record (bottom right) is a good illustration of the sensitivity, especially of the forward-looking credibility indicator, to a change in perceptions about the monetary regime in place. It is clear that the central bank begins to lose credibility in 2013 when it became increasingly clear that published inflation data were deemed untrustworthy. Similarly, abandoning the currency board arrangement in 2002, produces a sharp and persistent credibility loss that last several years.

(b) Econometric Results

Results are presented in Tables 1 and 2. They are based on the standardized version of the credibility proxy (i.e., equation (1)) defined above. Hence, the estimated coefficients have an elasticity-type interpretation. We began by examining the time series properties of the CRED proxy. All tests, in a panel setting, soundly reject the null hypothesis of a unit root in the data.³⁵ Hence, the dependent variable in equations (3) and (4) is specified in levels. The panels are unbalanced and the number of available cross-sections can change when we separately estimate pre and post crisis samples.³⁶ We experimented with several variants of equation (3) to determine whether or not our conclusions would be affected since the number of available determinants of credibility varies across groups of countries and over time. Not surprisingly, the availability of data problem is a more serious problem for emerging markets and the remaining

³⁵ Based on the Im, Pesaran and Shin (2003) panel unit root test, as well as the panel versions of the conventional ADF, and Phillips-Perron (PP) unit root tests.

³⁶ As a robustness check we also estimated the relationships shown below for the full sample allowing for an "exogenous" break due to the GFC and the AFC. Again the main conclusions discussed below are unaffected. An alternative we did not implement is to rely on idiosyncratic dating for the global financial crisis (e.g., see Hashimoto, Ito and Dominguez 2012) as opposed to assuming that the GFC's duration is the same for every country.

economies (i.e., other economies) in the data set. We believe, however, that the estimates presented below are representative and reasonably robust.

The results in Table 1 are estimated over two distinct samples. The “pre-crisis” sample consists of available data until 2006Q4. The crisis and post-crisis sample, labeled ‘post-crisis’, begins in 2007Q1 and ends in 2013Q4 or 2014Q1, again depending on data availability.³⁷ All estimates rely on quarterly data. In Table 2, estimates for the median, maximum and minimum credibility cases are for equation (4) for the full sample only with dummy variables for the GFC and AFC. This is done to conserve space but also to provide separate evidence of the potential statistical impact of these two major financial crises on central bank credibility.

Our discussion begins with Table 1. We find there is considerable variety in the drivers of central bank credibility in the five regions shown. Generally, higher real GDP growth is seen as improving central bank credibility, particularly in the post-crisis sample. Other than perhaps the VIX (see below) real GDP growth post-crisis comes closest to being a common factor affecting central bank credibility across the globe. Interestingly, credibility improvements are relatively smaller in the G7, Advanced, and IT EME economies in the post-crisis sample. The difference, however, is only statistically significant for the G7 group. Conceivably, the economies most directly impacted by the financial crisis might well have generated even larger credibility gains had they been seen as more responsive to output conditions. We return to this question below. In the Asia-Pacific, the response of credibility to real GDP growth is significantly higher after 2006 than in the earlier sample.

Changes in the real exchange rate produce a variety of credibility responses across the various regions examined. In the G7, Advanced and Asia-Pacific economies post-crisis, a real appreciation signals increased credibility likely because this is consistent with lower expected inflation. It is interesting to note that, pre-crisis, real exchange rate *depreciations* raise central bank credibility in the Asia-Pacific region. This is likely to be a reflection of the lingering effects of the Asian Financial Crisis of 1997-1998. Similarly, a real depreciation raises credibility post

³⁷ We also generated estimates for the 2007Q1-2010Q4 sample (i.e., a ‘pure’ crisis sample) but these paralleled the results for the crisis/post-crisis sample shown in Table 1.

2006 in emerging market economies with numerical inflation targets. Real depreciations were perhaps seen as a device to counter exchange rate pressure from the extraordinary loosening of monetary policy among the G7 economies.³⁸

The VIX consistently explains mean variations in credibility with the exception of advanced economies and IT EME economies. An increase in the VIX reduces credibility in the pre-crisis sample while the opposite is true after 2006. It is possible that pre-crisis stock market volatility was also associated with inflation volatility as has been extensively documented (e.g., Schwert 1989, Engle and Rangel 2008). However, the crisis and its aftermath raised the profile of financial stability in central banks. This led to a concerted reduction in policy rates, and interest rates more generally, especially throughout much of the advanced world and was associated with lower inflation rates (e.g., see Figure 1). This could explain why the sign on the VIX variable is reversed.

Housing price inflation and credit growth are now variables often associated with financial stability concerns (e.g., BIS 2015). Housing prices do not affect central bank credibility in the G7 economies. In the Asia-Pacific region rising housing prices appear to raise credibility pre-crisis but the sign is reversed post-crisis. The post-crisis response in the Asia-Pacific region (this includes Australia and New Zealand) likely reflects a potential link between goods price and asset price inflation. Recall that credibility is measured in terms of goods price inflation. Housing price inflation is also seen as improving credibility in the Advanced economies.³⁹ It is unclear why rising housing prices might raise credibility outside the G7 pre-crisis unless this was seen as reflecting a shift away from demand for goods and services and, therefore, less inflation pressure. Unfortunately, the data do not permit the precise identification of the channels through which these types of effects take place. Nevertheless, the results underscore a link between credibility and asset price inflation.

Turning to credit growth, there is an interesting contrast between the G7 and the Asia-Pacific economies after 2006. In the Post-crisis period, rising credit growth in the Asia-Pacific reduces

³⁸ There was insufficient data to include a real exchange rate variable in the group of other economies considered.

³⁹ Part of our findings might be due to the fact that we do not weight the economies by size or some other weighting scheme. Estimates using cross-section weights, however, did not change the conclusions.

central bank credibility while the opposite holds for the G7. We should keep in mind, as pointed out above, that G7 economies faced inflation rates that were below target and these were also the economies most directly affected by the GFC. Economies in the Asia-Pacific did not face the same challenge not even in the aftermath of the AFC. If credit growth in the G7 is interpreted as a reflection of policy makers' attempt to reflate their economies then the result shown is to be expected.

In the G7, a rise in long-term rates relative to short rates (i.e., a rise in the term spread), often a signal of higher future real growth, raises central bank credibility.⁴⁰ It is also worth noting that the parameter estimate is several times smaller in the pre-crisis period (and the difference is statistically significant). If the prospect of higher future inflation occurs, particularly when current inflation is well below target levels, a credibility boost from a steeper yield curve is to be expected. Next, the data indicate that central bank credibility is negatively related to stock market performance. We do know, however, that stock market returns and monetary policy inflation are related to each other, at least in advanced economies (e.g., see Bohl, Siklos, and Werner 2007, and Bohl, Siklos and Sondermann 2008, and references therein). There is only one exception to the above result, namely the post-crisis sample for the G7 economies. Since it was pointed out earlier that inflation fell to very low levels it is plausible that spillovers from equity to goods market inflation were severed.

As is clear from Table 1 we have fewer covariates available for the full set of emerging market economies or economies not otherwise classified (Other). Nevertheless, there is some evidence that rising non-performing (bank) loans reduce credibility pre-crisis in the group of Other economies. Instead, it is plausible that rising capital adequacy requirements, another financial stability indicator and a focus of regulators after the GFC, takes the place of the NPL variable. Hence, higher bank capital-asset ratios contribute to enhancing central bank credibility. Since we have insufficient data on central bank transparency for this group of economies voice and accountability acts as a substitute. Pre-crisis greater voice is seen as improving credibility but the effect disappears post-crisis.

⁴⁰ There were too few observations to include a comparable series in the other cross-sections considered.

The most prominent institutional variable considered is the adoption of inflation targets and the concomitant rise in central bank transparency.⁴¹ Inflation targets have no impact on central bank credibility in the G7 but generate significant improvements in credibility in the Asia-Pacific region. It is likely that by the time the sample begins in 1995, inflation targeting had matured in Canada and in the UK, the only two G7 economies where numerical inflation targets were already in place for a few years. Turning to central bank transparency this is seen as improving credibility in Advanced economies in both samples. Indeed, the improvements in credibility are significantly larger in the post-2006 sample. Elsewhere, such as in emerging market economies that adopted inflation targeting there is no separate effect from greater central bank transparency.

In Table 2 we turn to estimates at the median and tails of the distribution of our forward-looking indicator of credibility (standardized, as previously defined). In this fashion we are able to examine how the median, best (i.e., min value of CRED), and least credible central banks respond to various determinants of central bank credibility. To conserve space we only report results for G7 and Asia-Pacific economies where we have a full complement of asset price data.⁴² Also, only full sample estimates are shown although we add dummies for the GFC and AFC.

The results are striking for they highlight the potential pitfalls of focusing solely on the mean responses of central banks shown in Table 1 as well as the differences in the determinants of central bank credibility between the relatively homogeneous G7 and the more diverse Asia-Pacific economies. Overall, the median central banks in the region respond quite differently to the various determinants considered at least when compared to central banks that are at the most or least credible range of the credibility distribution. It is interesting that the median and most credible central banks in the G7 lose credibility when financial markets are more volatile

⁴¹ As mentioned previously, the adoption of inflation targeting (and its duration) seems roughly inversely proportional to the rise in central bank transparency. Indeed, when we replace an inflation targeting dummy with the overall indicator of central bank transparency we obtain comparable results. We do not pursue the possibility that the adoption of inflation targets and the rise of central bank transparency may interact with each other (or with some of the other right hand side variables, for that matter).

⁴² In the previous version of this paper results for the Advanced group of economies were shown but the G7 has the advantage of being a more homogeneous group.

(i.e., the VIX rises) while obtaining a credibility boost from greater transparency. Median G7 central banks also experience a credibility gain from a higher term spread. Otherwise, median central banks in this group respond to the VIX (a lower value gives a credibility boost) and transparency (more transparency provides a credibility boost). The GFC does not appear to have affected the credibility of any of the three types of central banks examined other than for the median Asia-Pacific central banks perhaps because inflation did not experience a surge in spite of the quantitative easing and looser fiscal policy. A real appreciation and rising housing prices provide a credibility boost to the most credible G7 central banks in the distribution. In contrast, rising equity prices and faster credit growth diminishes central bank credibility among the best performing G7 central banks. Instead, the effect of credit growth on credibility easily dwarfs the offsetting impact from exchange rate and housing price developments.⁴³

Median and least credible central banks in the Asia-Pacific region share the same response to the VIX as their counterparts in the advanced economies. Otherwise, what is salient are the differences in what the central bank types in each group respond to. For example, only the VIX is able to explain a small portion of variation in central bank credibility among the least credible monetary authorities in the region. In contrast, a mix of real, financial and institutional factors explains credibility among the median and most credible central banks in the Asia-Pacific. Interestingly, while the most credible Asia-Pacific central banks gain credibility because they respond to output, only the least credible G7 central banks enjoy a similar credibility improvement. It should be kept in mind, as previously pointed out, that differences between most and least credible central banks in the G7 are relatively narrower than is found for the Asia-Pacific economies.⁴⁴ Unlike the G7, rising housing prices are detrimental to the credibility of the best performing Asia-Pacific central banks while higher credit growth reduces credibility for the median central banks in this group. Also worth highlighting is the finding that greater central bank transparency improves credibility significantly more among the least credible central banks in the G7 than in either their median or most credible counterparts. Overall, most

⁴³ These conclusions are based on Wald tests (not shown).

⁴⁴ A separate list of the most and least credible central banks on an annual basis is relegated to an appendix (not shown).

striking are the differences across central bank types.⁴⁵ Other than perhaps the VIX, inflation targeting, and central bank transparency, there is no single common determinant of credibility across country groups or over time. It is also interesting that the AFC did not result in credibility losses. Of course, this does not mean that individual central banks in the region were unaffected. It is quite possible that the diversity of the economies in this region contributes to this finding.

5. Conclusions

This paper has generated credibility indicators for up to 80 economies since the early 1990s. Our indicators are instructive for several reasons. First, they indicate that financial crises can lead to a credibility loss but not for all central banks or at all times. When central banks perform well in terms of credibility they respond to economic, financial and institutional determinants differently from the median and least credible central banks. It is apparent that central banks do respond to asset prices and financial stability indicators more generally. Financial stability, partly captured by the VIX, generally reduces central bank credibility when it is larger, that is, when equity returns are more volatile. The bottom line, however, is that when it comes to the relationship between financial stability and central bank credibility the data suggest that caution is in order for those who would argue that monetary authorities should take on broader responsibilities for the financial performance of economies. After all, as the opening quote makes clear, credibility is indelibly associated with inflation performance.

Institutional factors, such as the adoption of inflation targeting or greater central bank transparency, are significant determinants of central bank credibility. In a similar vein, real economic growth has a significant influence on central bank credibility even in inflation targeting economies. This puts paid the notion that responding to real economic factors is necessarily detrimental to central bank credibility.

To be sure the results so far can only be characterized as tentative. Beyond a fairly small group of advanced economies the range of quantifiable candidate determinants of central bank

⁴⁵ Indeed, regressions suggest that the relative homogeneity of the G7 translates into more explanatory power. See Table 2.

credibility is small. Indeed, the challenges of constructing a comprehensive dataset, allowing us to answer the question about how central banks ought to respond to financial conditions, are substantial. Moreover, we have not examined more complex (i.e., non-linear) ways of asking how credibility and its economic and financial determinants are related or whether the link between asset price movements and credibility is asymmetric. For example, asset price declines may be more likely to impact credibility than asset price inflation especially if the public is more attentive to one than the other. Also, as we have seen, the GFC led to temporary credibility losses that were quickly reversed. Indeed, the various regressions clearly suggest that the handling of the GFC did not lead to a permanent credibility loss. Therefore, regressions of the kind shown here should be supplemented with narratives from individual economies or groups of economies that are closely related to each other. Finally, there may well be other forms of standardization of our indicators of central bank credibility that might provide different insights into its most robust determinants.

Several other issues also need addressing. In particular, even if there is consensus that credibility should be measured according to some inflation metric, incorporating more explicitly a real component, may yield additional insights about what drives credibility. Nevertheless, because of differences across regions, over time, and according to the performance of central banks, there remains what could be characterized as anomalies in how economic and financial factors influence credibility. This is likely a further reflection of the difficulty of marshaling clear evidence for diverse sets of economies. On the other hand, the results also suggest that central banks are ultimately far more diverse than the myth of the monetary authority driven only by inflation performance relative to a singular inflation objective. If credibility is what central banks and the public care about then we clearly have a lot more to learn on a global scale about some of its common features.

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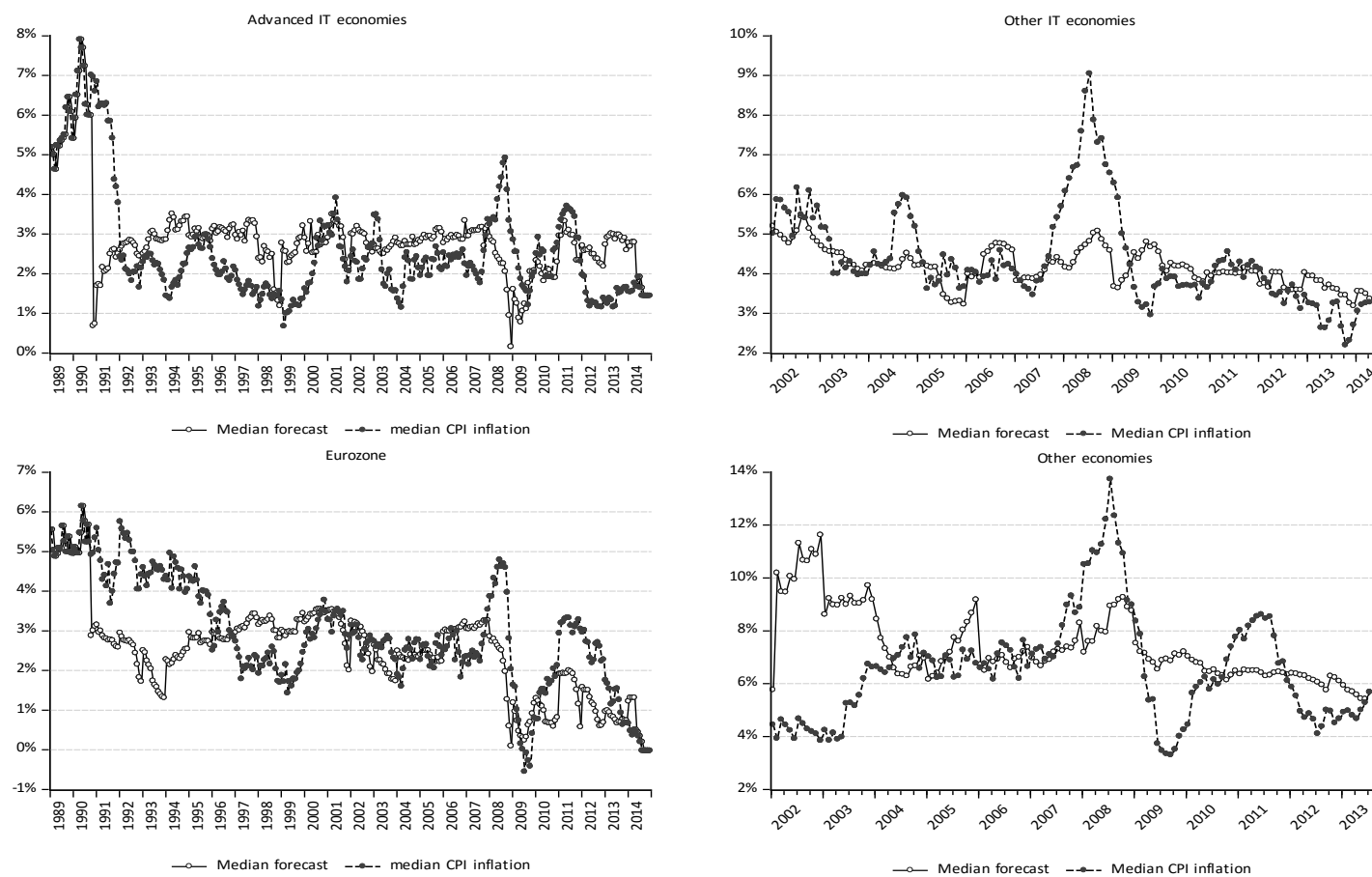
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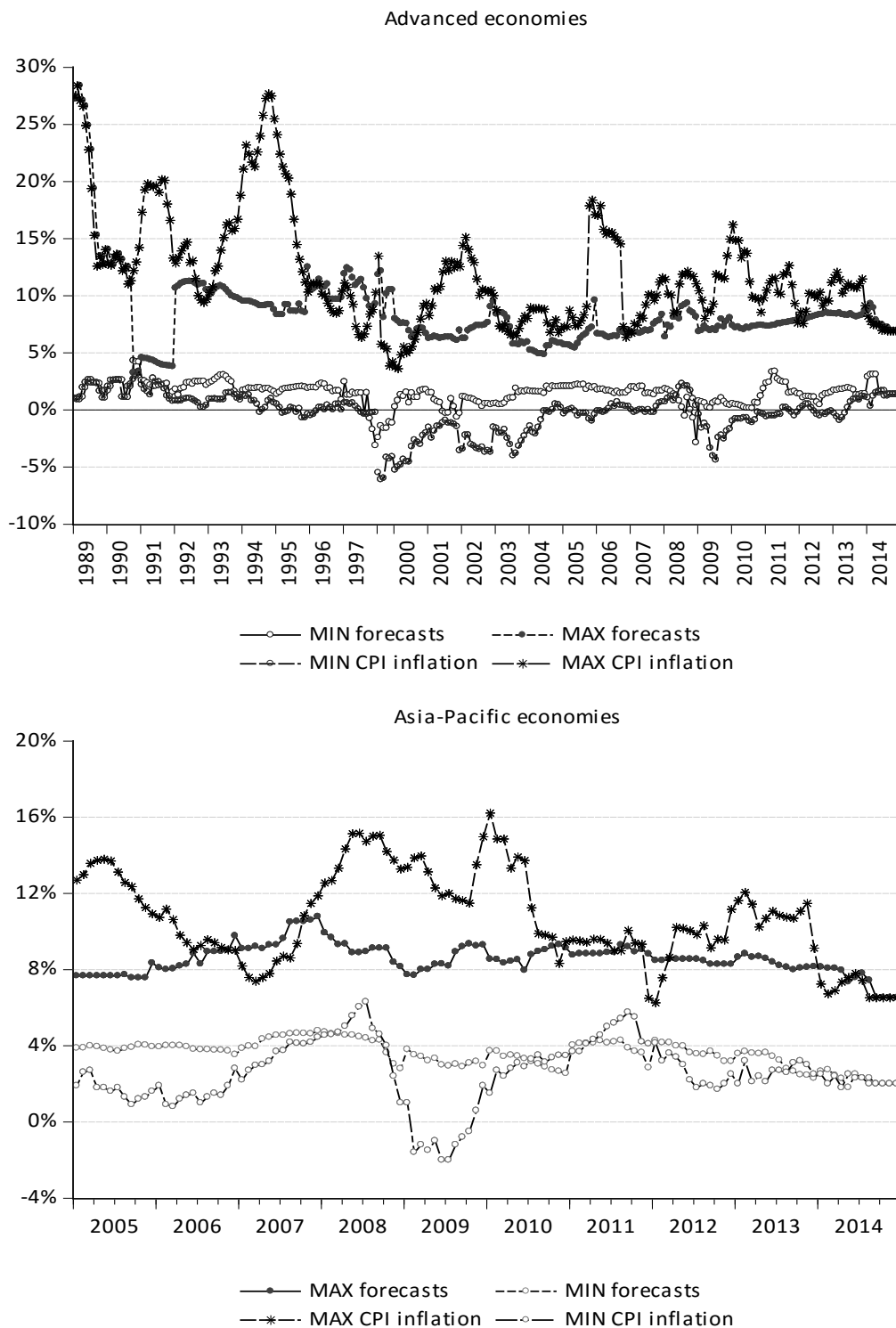
Woodford, M. (2003), *Interest and Prices: Foundations of a Theory of Monetary Policy* (Princeton, N.J.: Princeton University Press).

Figure 1 Fixed Horizon CPI Inflation Forecasts Across Various Regions of the World



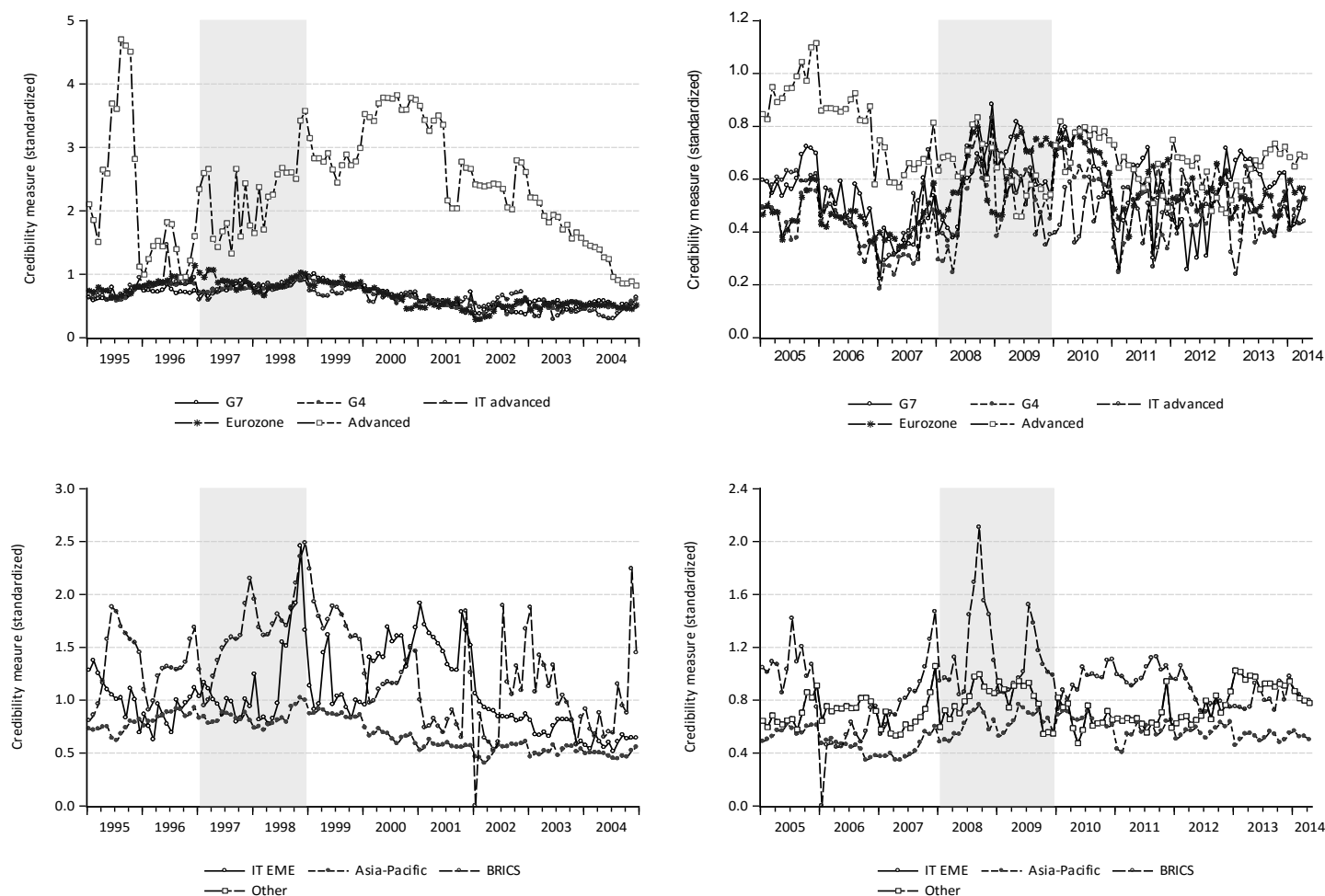
Note: See the text for the definition and sources. An Appendix lists the economies included in each regional grouping. Data are monthly.

Figure 2 Range of Fixed Event CPI Inflation Forecasts in Select Regions of the World



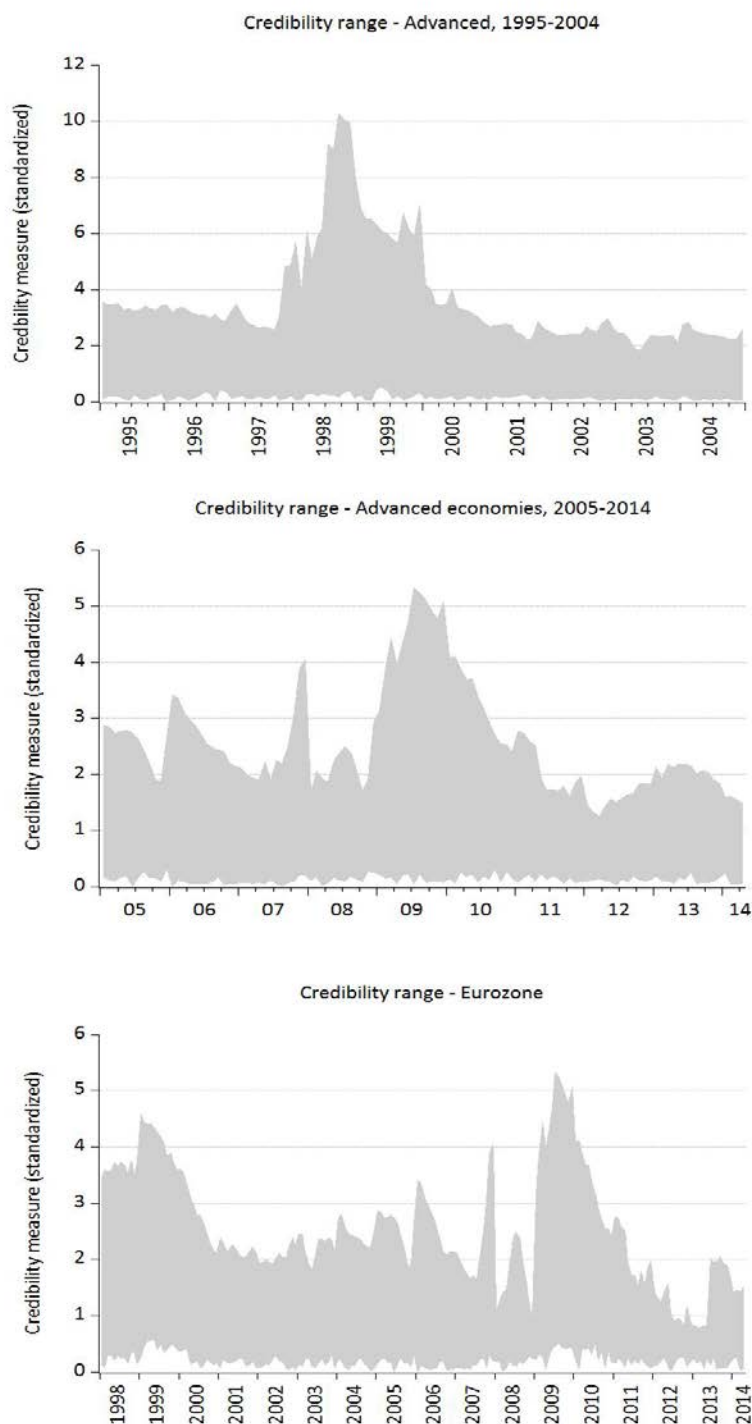
Note: MAX refers to the most pessimistic (highest) inflation forecast or outturn; MIN the most optimistic (lowest) forecast or outturn. See text for sources and definitions. Data are monthly.

Figure 3 Estimates of Credibility Based on Forward-Looking Indicator, 1995-2004 & 2005-2014



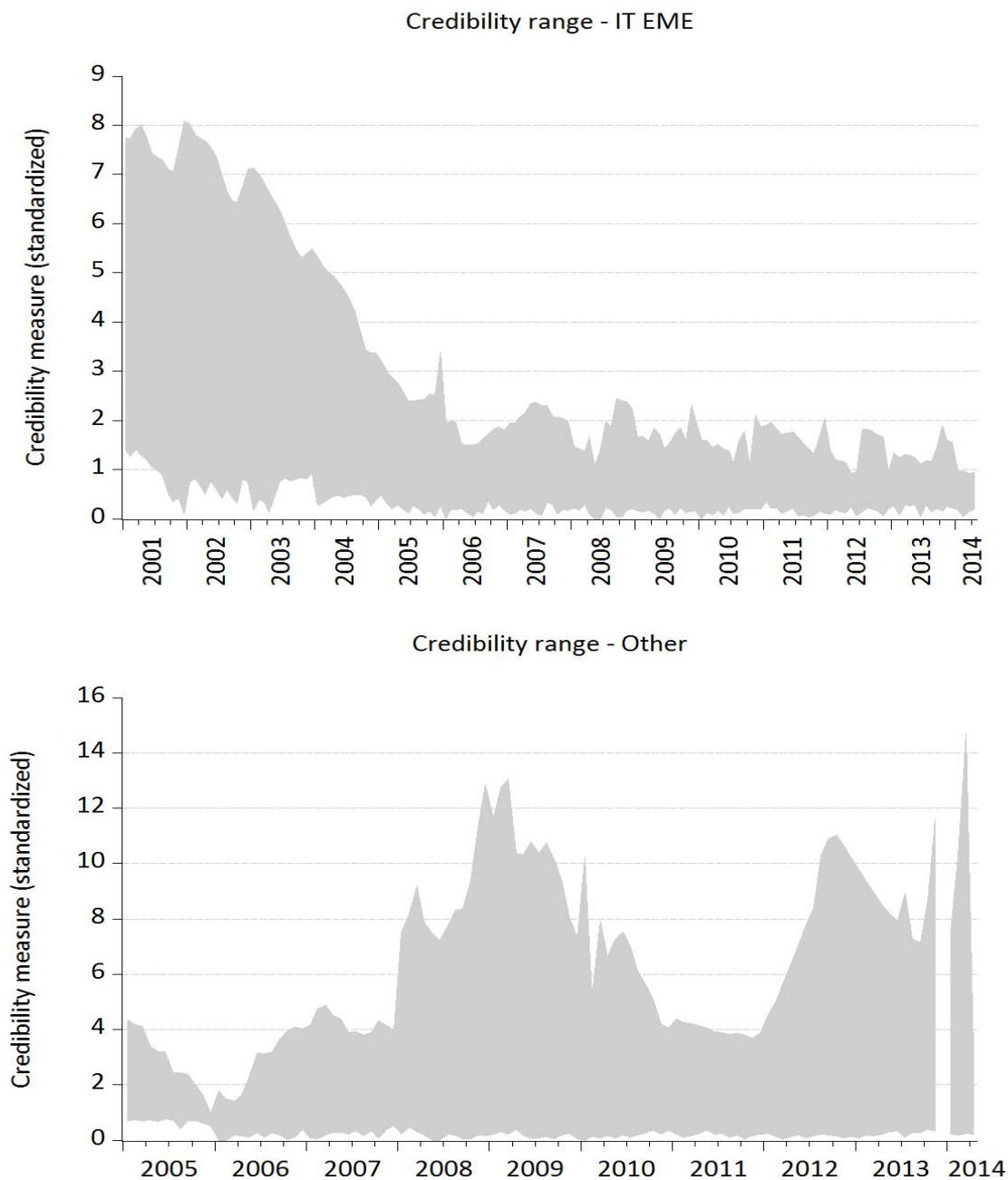
Note: Based on equation (1). For the economies included in each regional grouping, see the Appendix. Data are monthly. The shaded areas (1997-1998 and 2008-2009) represent the Asian and global financial crises.

Figure 4a Range of Credibility Estimates in Select Regions



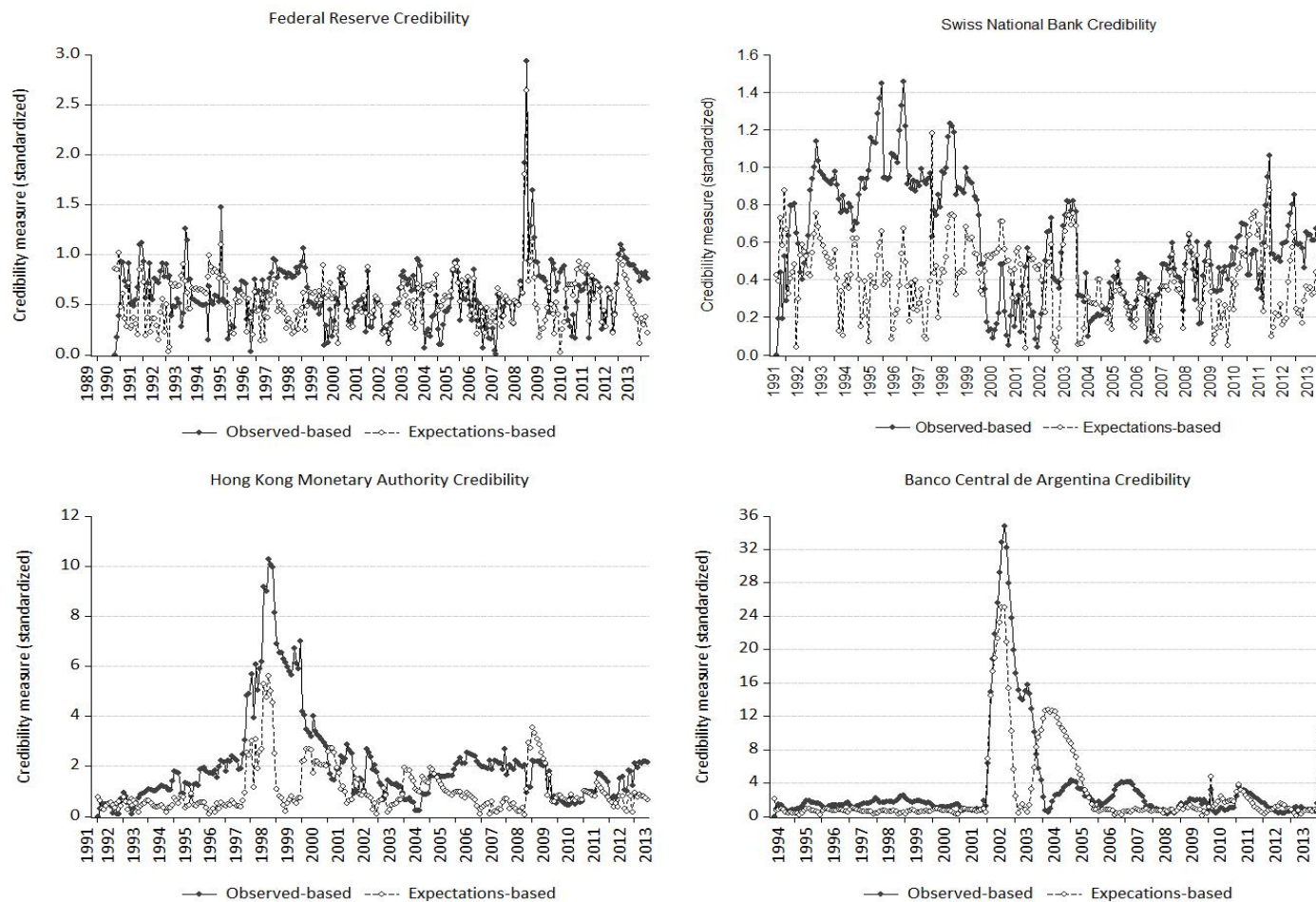
Note: Credibility estimates are based on the forward-looking indicator of credibility (equation(1)).

Figure 4b Range of Credibility Estimates in Select Regions



Note: The area represents the distance between the smallest and the largest values for the credibility indicator as defined in equation (1). A smaller value indicates higher credibility; a larger value means less central bank credibility. An Appendix provides the country group definitions. Note that a large value in 2013Q4 is excluded because it would distort the Figure. (Venezuela's credibility indicator is 80.15). Estimates of credibility are based on the square root of equation (1). Also, see notes to Figure 4a.

Figure 5 Select Estimates of Central Bank Credibility



Note: Estimates of central bank credibility based on the square root of estimates of equations (1) and (2). Data are monthly.

Table 1 Determinants of Central Bank Credibility: Panel Estimates, Quarterly Data

Dependent Variable: Credibility (equation (1))										
	G7 Economies		Advanced Economies		Asia-Pacific Economies		IT EME		OTHER Economies	
	Pre-crisis 1995Q1- 2006Q4	Post-Crisis 2007Q1- 2013Q4	Pre-crisis 1999Q1- 2006Q4	Post-Crisis 2007Q1- 2013Q4	Pre-crisis 1995Q2- 2006Q4	Post-Crisis 2007Q1- 2013Q4	Pre-crisis 2001Q1- 2006Q4	Post-Crisis 2007Q1- 2013Q4	Pre-crisis 2003Q1- 2006Q4	Post-Crisis 2007Q1- 2013Q4
Variable	Coefficient t-statistic (p-value)	Coefficient t-statistic (p-value)	Coefficient t-statistic (p-value)	Coefficient t-statistic (p-value)	Coefficient t-statistic (p-value)	Coefficient t-statistic (p-value)	Coefficient t-statistic (p-value)	Coefficient t-statistic (p-value)	Coefficient t-statistic (p-value)	Coefficient t-statistic (p-value)
Constant	0.284 2.821 (0.005)	0.872 9.535 (0.000)	1.915 4.168 (0.000)	2.935 6.846 (0.000)	0.153 04520 (0.674)	2.200 6.879 (0.000)	4.975 3.082 (0.002)	1.798 2.764 (0.006)	-23.36 -4.20 (0.004)	3.543 5.775 (0.000)
Real GDP Growth	-0.061 -2.271 (0.024)	-0.033 -2.918 (0.004)	-0.063 -2.037 (0.214)	-0.054 -6.831 (0.000)	-0.043 -1.327 (0.186)	-0.226 -4.415 (0.000)	-0.436 -2.785 (0.006)	-0.008 -0.843 (0.400)	-0.068 -0.229 (0.821)	-0.064 -3.548 (0.001)
Real Exchange Rate ($\Delta \ln$)	-0.007 -1.812 (0.071)	-0.018 -2.071 (0.035)	-0.002 -0.260 (0.795)	-0.014 -4.961 (0.000)	0.033 2.998 (0.003)	-0.054 -4.270 (0.000)	0.001 0.106 (0.916)	0.008 2.022 (0.044)		
VIX	0.026 5.124 (0.000)	-0.005 -1.742 (0.083)	0.010 1.461 (0.145)	0.003 1.011 (0.312)	0.068 4.354 (0.000)	-0.032 -2.448 (0.015)	0.007 0.133 (0.894)	0.005 1.352 (0.177)	0.405 3.615 (0.002)	-0.062 -3.454 (0.001)
Housing Price Growth	-0.006 -1.609 (0.109)	0.001 0.090 (0.929)	-0.024 -3.396 (0.001)	-0.011 -2.468 (0.014)	-0.043 -4.306 (0.000)	0.039 3.006 (0.003)				
Term spread	-0.039 -1.692 (0.091)	-0.080 -4.244 (0.000)								
Private Credit Growth	-0.007 -1.010 0.314	-0.038 -5.573 (0.000)			*	0.048 3.210 (0.002)				

Equity Price Growth	0.009 4.808 (0.000)	0.002 1.274 (0.204)	0.009 2.375 (0.018)	0.006 6.477 (0.000)	0.008 1.614 (0.108)	0.015 2.426 (0.016)				
Inflation Targeting	-0.018 -0.708 (0.480)	-0.053 -0.976 (0.330)			-0.504 -3.097 (0.002)	-0.708 -3.873 (0.000)				
Central Bank Transparency			-0.127 -3.771 (0.000)	-0.217 -5.542 (0.000)			-0.049 -1.588 (0.577)	-0.028 -0.528 (0.598)		
Capital Adequacy							-0.104 -1.425 (0.156)	-0.095 -2.539 (0.012)		
Non-performing loans									0.786 8.681 (0.000)	0.014 0.649 (0.517)
Voice & Accountability									-23.072 -2.534 (0.019)	-0.075 -0.046 (0.963)
Summary Statistics										
Adj. R ²	0.23	0.22	0.55	0.56	0.21	0.06	0.62	0.24	0.85	0.12
Cross-sections	7	7	23	29	8	12	13	14	8	8
F (p-value)	19.27(0.00)	10.57(0.00)	27.41 (0.00)	32.46(0.00)	14.08(0.00)	11.83(0.00)	31.70(0.00)	7.54(0.00)	27.10(0.00)	8.04(0.00)

Note: Estimates are based on two-stage least squares with White cross-section standard errors. Instruments include one lag of each independent variable and the constant. Blanks indicate either that the data were unavailable, or there were too few available observations to include the variable. It was necessary to exclude some economies because of insufficient data. No exclusions for the G7 economies or Advanced economies (post-crisis). Pre-crisis Advanced economies excluded are: CZ, SL, V, DK, GR, PT. No exclusions for the Asia-Pacific region post-crisis. Pre-crisis CN, ID, IN, and PH are excluded. In the IT-EME group GT and RS omitted in both samples. In the OTHER group AR, BO, BY, CR, EC, EG, PY, and UA are included in the pre-crisis panel; CR, GE, HR, and MK are added in the post-crisis sample. Other economies (see appendix) are omitted as there was usually insufficient or no data beyond the governance variables. The appendix provides the country names. All post-crisis samples are: 2007Q1-2013Q4. Pre-crisis samples are: 1995Q2-2006Q4 (G7); 1999Q1-2006Q4 (Advanced); 1995Q2-2006Q4 (Asia-Pacific); 2001Q1-2006Q4 (IT-EME); 2003Q1-2006Q4 (Other economies). * Too many cross-sections were lost when this variable is added.

Table 2 Determinants of Central Bank Credibility: Panel Quantile Estimates, Quarterly Data

Dependent Variable: Credibility (equation (1))						
	G7: 1990Q1-2013Q4			Asia-Pacific Economies: 1990Q4-2013Q4		
	Median	Min	Max	Median	Min	Max
Variable	Coefficient t-statistic (p-value)	Coefficient t-statistic (p-value)	Coefficient t-statistic (p-value)	Coefficient t-statistic (p-value)	Coefficient t-statistic (p-value)	Coefficient t-statistic (p-value)
Constant	0.799 8.271 (0.000)	0.342 7.133 (0.000)	1.468 4.895 (0.000)	0.797 4.919 (0.000)	0.476 2.782 (0.007)	0.201 4.680 (0.000)
Real GDP Growth	-0.013 -0.921 (0.360)	-0.011 -1.316 (0.192)	-0.057 -3.621 (0.000)	-0.020 -0.946 (0.347)	-0.053 -2.755 (0.007)	0.001 0.285 (0.776)
Real Exchange Rate ($\Delta \ln$)	-0.008 -1.076 (0.285)	-0.004 -1.797 (0.076)	0.021 2.767 (0.007)	-0.005 -0.387 (0.700)	0.004 1.149 (0.253)	-0.005 -0.543 (0.589)
VIX	0.005 2.049 (0.044)	0.004 2.278 (0.025)	0.002 0.382 (0.703)	0.017 3.746 (0.000)	0.008 1.093 (0.277)	0.003 1.659 (0.101)
Housing Price Growth	-0.001 -0.159 (0.874)	-0.004 -1.975 (0.052)	-0.007 -1.845 (0.068)	-0.006 -0.606 (0.546)	0.032 3.250 (0.002)	-0.000 -0.142 (0.867)

Term Spread	0.044 1.889 (0.062)	-0.019 -1.547 (0.126)	0.026 0.608 (0.545)			
Private Credit Growth	0.001 0.061 (0.951)	0.031 4.124 (0.000)	0.024 1.350 (0.181)	-0.056 -2.155 (0.034)	0.002 0.252 (0.802)	-0.004 -1.490 (0.140)
Equity Price Growth	0.002 1.537 (0.128)	0.002 2.260 (0.026)	0.007 3.549 (0.001)			
Central Bank Transparency	-0.040 -7.103 (0.005)	-0.035 -8.296 (0.000)	-0.059 -3.580 (0.01)	-0.005 0.480 (0.632)	-0.066 -2.192 (0.031)	-0.007 -0.896 (0.373)
Global Financial Crisis	-0.071 -1.776 (0.243)	0.006 0.124 (0.902)	-0.146 -1.095 (0.277)	-0.283 -2.610 (0.011)	-0.118 -0.673 (0.503)	-0.038 -0.901 (0.370)
Asian Financial Crisis				0.046 0.348 (0.729)	-0.250 -1.051 (0.296)	0.076 1.303 (0.196)
Adj. R ²	0.48	0.51	0.33	0.18	0.31	0.16
F (p-value)	10.56 (0.00)	11.51(0.00)	6.091(0.00)	3.62(0.00)	6.07(0.00)	3.17(0.00)

Note: See notes to Table 1. Median refers to the median central bank in the particular regional grouping listed above; Min refers to the most credible central banks (top 10% of the distribution); Max to the least credible central banks (bottom 10% of the distribution). Credibility is based on equation (1).