Central bank Credibility Before and After the Crisis

Michael D. Bordo and Pierre L. Siklos

1. Introduction

Central bank credibility is an important topic in modern central banking. Central banks have been in existence since the seventeenth century. Central bank credibility has waxed and waned throughout this period. In the past two decades the credibility of central banks has been high, at least until the financial crisis of 2007-2008. An important contributor to the achievement of credibility has been the advent and adoption of inflation targeting by many countries.

In our earlier work (Bordo and Siklos 2014 and 2015) we defined central bank credibility as the difference between measured inflation and the central bank's objective derived from a model that assumes that the central bank uses either an interest rate or an exchange rate instrument.

Our research, reported in Bordo and Siklos (2014), for a panel of advanced and emerging market countries from 1880 to the present using both empirics and historical narratives, shows that credibility has behaved much like a pendulum with credibility high under the classical gold standard before 1914, then credibility declined after 1914 and was not fully regained until the 1980s with the advent of the current fiat money regime with primacy for low inflation.

Regressions in Bordo and Siklos (2015) 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 (Bordo and Siklos 2014). These results provide additional support for the pendulum like swing in central bank credibility over time and across countries. Nevertheless, in large part for both historical and institutional reasons, the pendulum view of changes in central bank credibility does not appear to readily extend to the case of many emerging market economies.

During the crisis the Federal Reserve and other central banks (e.g., Bank of England, European Central Bank) undertook extraordinary lender of last resort measures to prevent a repeat of the events of the early 1930s, when a series of banking panics in the US led to the Great Contraction which spread to the rest of the world through the fixed exchange rate gold standard. 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, facilities like the TAF (term auction facility) and TSLF (term securities lending facility) in the US and government bond purchases by the Bank of England (BOE) led central banks to protect virtually the entire financial system. The Bank of Japan has similarly engaged in a large number of interventions in the financial sector including the purchase of equities. In addition, the Fed, BOE, and others began following credit policy, picking winners and losers, which is usually viewed as a form of fiscal policy (Goodfriend 2012). Also noteworthy is that many of the facilities developed during the crisis involved both the Fed and the Treasury. These actions may have compromised the Fed's credibility. This, in spite of the fact that both the Fed and the BOE have an understanding vis-à-vis their respective Treasuries indemnifying them from certain losses stemming from interventions in the financial system.

Once the zero lower bound was reached at the end of 2008 the Fed and other CBs adopted quantitative easing (QE), the purchases of long –term Treasury securities and mortgage backed securities. These were viewed as unconventional forms of monetary policy. In addition to the open market purchases of unconventional assets, the Fed (and the BOE, among other central banks) adopted forward guidance in an attempt to manage expectations. There is considerable debate over the effectiveness of QE. The current consensus view holds that it has had a significant but limited effect (Bernanke 2012). There is also a debate over the effectiveness of forward guidance and there have been a number of well-known events when central banks have created confusion by changing their statements in unpredictable ways (e.g., the Taper tantrum in May 2013, the BOE backing away from thresholds for the unemployment soon after they were introduced). Indeed, the Bank of Canada Governor has recently argued that forward guidance should be used sparingly, preferably only in times of crisis (Poloz 2014). The resort to

these unconventional tools also begs the question whether central bank credibility has been affected.

In reaction to the crisis many central banks have also decided to elevate the objective of financial stability to the same level of importance as macro stability. This is based on arguments that the credit cycle leads to significant imbalances involving credit booms 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 policy rate in meeting multiple objectives. At the same time, many central banks have begun using macro-prudential tools including capital ratios, leverage ratios, liquidity ratios, to name just a few examples, to head off credit and asset price booms. Finally, the question of the exit strategy to be used to restore normal monetary policy has crucial implications for central bank credibility. Central banks with large balance sheets with long maturities are exposed to credit risk when short–term rates rise. Some argue in favor of central banks raising interest on excess reserves while keeping the balance sheet constant to avoid the problems of conventional tightening (Cochrane 2014).

How the exit actually plays out may impinge on central bank credibility as has the fact that, for example, the Fed began to publicly discuss an exit strategy since 2009. Equally problematic is that since the major central banks have signaled a desire for a return to 'normality', that is, a return to reliance on an interest rate as the principal policy instrument, they have yet to clarify what role policy rate changes will play alongside macro-prudential tools. Indeed, we have seen some central banks backtracking on earlier policy rate increases or delaying 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). As a result, asset prices may be artificially inflated by the maintenance of ultra-low interest rates. This state of affairs makes it difficult to see how to square macro-prudential concerns with the maintenance of price stability. Needless to say, all of the above pressures pose serious challenges for monetary policy. Poloz (2014), in reflecting on the challenges facing

monetary policy makers today, suggests that financial stability and inflation risks are negatively related to each other. As a result, "…the remedy to the inflation front could worsen financial stability risks, …". However, to our knowledge, other than Siklos (2014) who examines a small group of countries, there is effectively no empirical support for this view.

In our previous papers, 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. In this paper we construct an unbalanced panel consisting of inflation expectations data for 86 countries available from Consensus Economics. 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. This allows us to construct a more direct indicator of credibility as well as permitting an examination of how the crisis of 2007-2008 affected central bank credibility.

Nevertheless, as mentioned previously all monetary policy regimes, including IT, face difficulties because of the expansion of central bank responsibilities in the maintenance of financial stability. Indeed, from an institutional perspective, one might argue that a conflict of interest exists between monetary policy's emphasis on interest rates to control inflation and maintain stable real economic outcomes and financial system stability which is threatened by a central bank unwilling to rely on its main monetary policy instrument when it is required because it is willing to risk being 'irresponsible' (Woodford 2012) about financial stability in order to deliver the necessary monetary policy stimulus.

Econometrically, the paper takes on board some of the warnings from Geraats (2014), about panel estimates that mix IT and non-IT economies. She criticizes the methodology and questioned the results by Ball and Sheridan (2005) who argued that the inflation targeting (IT) policy strategy has little to offer in delivering a desirable inflation performance. Of course, neither Ball and Sheridan (2005) nor Geraats (2014) evince any concern about financial system stability as part of a central bank's policy strategy. We estimate an unbalanced panel consisting of 53 emerging market economies, 32 advanced economies, including 24 countries that have announced a formal inflation target. The raw data are monthly, quarterly, and annual. In the

estimation phase we convert all series to the quarterly frequency. After estimating the evolution and empirical properties of credibility, as defined in Bordo and Siklos (2014, 2014a) we estimate an ordered probit model, which asks: what are the factors, both economic and institutional, which statistically influence credibility. The factors are global and domestic in nature (e.g., domestic output developments, oil and commodity prices, changes in the stance of monetary policy), and institutional (e.g., whether the country targets inflation, the transparency of the central bank, the exchange rate regime in place, degree of capital mobility, general governance environment a central bank operates under).

To this we add proxies for financial stability. There is as yet no consensus on how to best measure financial stability risks. Consequently, we construct updated and improved measures of financial stability as discussed in Siklos (2014). We extend these measures to the much larger data set that is examined in this study. For example, asset price gaps, defined as the mean of HP filtered housing prices and deviations from broken trends in the log level of housing prices for over 50 countries, represent one such indicator. Others include the first principal component of selected financial indicators from a World Bank dataset on the composition and state of the financial sector (e.g., percent of non-performing loans, domestic credit to GDP, risk premium on lending) for the 86 economies in the sample. The volatility of equity returns, in real exchange rates, as well conditional volatility of inflation forecast errors are other potential candidates for inclusion. Finally, of course, we can use principal components analysis to reduce the dimensionality of the disparate determinants of financial stability.

Section 2 discusses the data used. Section 3 discusses the empirical methodologies followed. 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 85 economies are used in the empirical analysis below. The number of economies sampled falls to 61 when observed real GDP growth is used simultaneously in the analysis.[1] The availability of data for other potential covariates also has a significant impact on the number of cross-sections that can be examined at one time (see below). Data for the various determinants of credibility considered are available since the late 1980s or 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 definition. The period examined below ends in April 2014 for the monthly Consensus data while for many of the explanatory variables the data are available until the end of 2013 or the first quarter of 2014. An Appendix provides the list of economies considered. The raw data are monthly.[2]

A salient feature of the raw Consensus data is that they are published as *fixed horizon* forecasts. That is, published figures represent the forecaster's view of inflation or real GDP growth in the current or next calendar year as opposed to the *fixed event* that economist generally have in mind when thinking about expectations. Put differently, most estimated econometric models rely on expectations of future economic activity a year ahead or longer as opposed to the calendar year horizon, which remains fixed until the year, ends. 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.[3]

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[1] 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. Other data limitations are discussed below.

[2] 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.

[3] See Siklos (2013), and references therein, for a discussion. If 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 and fixed horizon forecasts, at time *t*, in month *m*. The same transformation is used to create fixed horizon real GDP growth 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. Relevant data were obtained from the International Monetary Fund's International Financial Statistics (IFS; October 2014 CD_ROM version as well as the online version; http://www.elibrary.imf.org/).[4] A few series, such as interest rates (long-term, short-term, and policy rates, where available), and exchange rates were also collected from the same source. Long-term interest rate data were found for 33 economies, while short-term yields for 39 economies were collected. The former are typically for 10 years or longer government bonds 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 of the economies in the sample the Bank for International Settlements (BIS; www.bis.org) makes available real exchange rate data, housing and credit data.

For ease of exposition most of the stylized facts below are presented in the form of regional groupings. We follow the definitions found in the IMF's World Economic Outlook (http://www.imf.org/external/ns/cs.aspx?id=29) database. However, we also created a few country groupings of our own partly to examine the robustness of the results. In addition to the G7, EU, Eurozone, and group of Advanced economies, we also examined the G4 (U.S., Eurozone, Japan, U.K.), inflation targeting (IT) economies, economies of the Asia-Pacific region, and a group of "other" economies that did not fit any of the other classifications just discussed. IT economies are further sub-divided according to whether their members are advanced economies or emerging market economies. A list of IT economies is also available in the Appendix where the target values or ranges since their inception until 2014, as well as the dates when the policy regime was introduced, is also provided. The Asia-Pacific region potentially includes the following 12 economies. They are: Australia, Bangladesh, China, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, New Zealand, Philippines, Singapore, and Thailand. With the

[4] Observed inflation data are also generally available at the monthly frequency. Australia and New Zealand are two notable exceptions since they publish only quarterly figures. As explained in n. 2 the monthly data were created via interpolation.

exception of the G4 and G7 economies data limitations imply that some of the economies cannot be included when some of the panels are estimated.

Other candidate determinants of central bank credibility are sometimes available only at the annual frequency. This is the case either because, in a panel of the kind considered here, quarterly data are simply not available or, as in the case of potential institutional determinants of central bank credibility, these change slowly over time. As a result, many proxies of institutional change are only available at the annual sampling frequency. Proxies for the potential impact of financial stability, we rely on data from the World Bank's *Development Indicators* (http://data.worldbank.org/data-catalog/world-development-indicators). In particular, we posit that financial system stability can be summarized by the percent of non-performing loans to GDP, the capital-asset ratio, 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 they have been emphasized by policy makers (e.g., central banks) as early warning type signals of financial stability. A popular proxy for financial stability (e.g., see Adrian et.al. 2014), 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. The data are available from the St. Louis Federal Reserve's database (i.e., FRED; http://research.stlouisfed.org/fred2/).

Alternatively, we also rely on some of the BIS's credit indicators to assess the maintenance of financial system stability. In particular, credit and housing prices have been assigned pride of place as culprits in the global financial crisis of 2007-2008. 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). Finally, we also consider the rate of changes in equity prices where the latter are indices. Monthly data were obtained from the IMF and FRED.

Another source of institutional change is the World Bank's *Worldwide Governance Indicators* (http://info.worldbank.org/governance/wgi/index.aspx#home). [5] Indicators of the rule of law, voice and accountability and political stability indicators were also considered to be potential institutional determinants of central bank credibility. [6]

Finally, arguably the most important developments in central banking since the early 1990s was the adoption of inflation targeting, and the simultaneous rise in the importance of 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.[7] Perhaps unsurprisingly, the rise of central bank transparency parallels the adoption of inflation targets.[8]

Given the variety of sources, sampling frequencies, and compilation methods, the resulting panel of data is unbalanced. In addition, it seems most practical to estimate the econometric relationships of interest at the quarterly sampling frequency.

[5] 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 "g 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).

[6] We also considered *Heritage House*'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. Hence, their use is not discussed further.

[7] Central bank transparency data 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 central bank evaluates its own performance.

[8] 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.

As explained below our methodology considers, where feasible, the inclusion of 'gaps' for both inflation and real GDP. Essentially, two different strategies were adopted in the estimation. First, we computed either a 2-year or a 5-year moving average of observed and forecasted inflation or real GDP growth. Alternatively, one-sided HP filters for the series were fitted. 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. Hence, 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.[9] More generally, candidates selected as potential determinants of central bank credibility are expressed as a percent of GDP, in index form (e.g., adoption of inflation targeting, central bank transparency, governance), or in rate of change form (credit variables, real exchange rates, asset prices).

3. Methodologies

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. For some accountability, at least in legislative terms, may be stricter than for others (e.g., in inflation targeting central banks versus others). Hence, it is natural to think of central bank credibility, broadly speaking, as a function of the differential between forecasted or observed inflation and some estimate of the inflation rate that the central bank targets. As central banks have become more forward-looking over time they have placed a premium on the outlook for inflation (and real economic activity more generally) rather than simply relying on past performance. 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, at least temporarily. Hence, the mid-point of a target range, often used as a proxy for the monetary authority's inflation objective, seems too stringent an assumption to make about the near term

[9] Our conclusions were unaffected when we compare our gap estimates with ones, where available, generated from levels 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 resort to an HP filter.

inflation objective of some central banks. Next, we must decide on the penalty a central bank suffers 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. An operational definition that meets this criterion is provided below.

Estimates which assume that any departure from some estimate of the inflation objective represents a departure from perfect credibility are, by construction, unconditional. In other words, although departures from the central bank's inflation objective is a good proxy for its credibility such a measure is not informative about what are its driving forces. Hence, it is of considerable interest to investigate the extent to which economic, financial, or institutional factors that can explain variations in credibility over time.

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.[10] Unfortunately, in a large cross-section data set of the kind used here such an approach is impractical because there are insufficient data of the kind we require to generate time-varying inflation objectives beyond a relatively small number of advanced economies. Instead, we assume that a central bank's inflation target is linked to variations in the Consensus forecast over the medium-term.[11] These are smoothed (see below) near-term forecasts that reflect the likelihood that a medium-term inflation objective will not vary as much as short-term inflation forecasts that are published at the monthly frequency. Moreover, the medium-term forecast in this manner can deviate, even persistently so, from some numerically announced target due to the flexible application of inflation targeting, where relevant.[12]

[10] In Bordo and Siklos (2015) 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.

[11] Most advanced economies only began to publish their own (or their staff's) forecasts for inflation and real GDP growth in the mid-2000s. Indeed, many would report Consensus forecasts when discussing the inflation outlook.

[12] In an appendix we present purely for illustrative purposes, central bank inflation targets estimated in Bordo and Siklos (2015) for 10 advanced economies since the early 1990s. Note that the model generated inflation objectives

It is also conceivable, of course, that the central bank's inflation target is more backward-looking. In this case the monetary authority's inflation objective is driven by past inflation performance. The backward-looking version is also smoothed in the manner described above for the Consensus forecasts based inflation objectives.[13] In any event, since the two proxies for a central bank's inflation objective range from being either purely forward-looking to being backward-looking, we are effectively providing a range of credibility estimates. Most (e.g., Woodford 2003) would argue that inflation expectations combine forward and backward-looking elements.

The foregoing discussion suggests the following two definitions of central bank credibility. They are:

$$\begin{aligned} &(\pi^{f}_{t+1} - \overline{\pi}_t)^2, \quad \text{if } \left|\pi^{f}_{t+1} - \overline{\pi}_t\right| > 1 \\ &(\pi^{f}_{t+1} - \overline{\pi}_t), \quad \text{if } \left|\pi^{f}_{t+1} - \overline{\pi}_t\right| \leq 1 \end{aligned} \tag{0.1}$$

where π^{f}_{t+1} is the fixed horizon one year ahead (i.e., *t*+1) inflation forecast published in month *t*, and $\overline{\pi}_t$ is the proxy for the time-varying inflation objective. Most, though not all, inflation control regimes specify a $\pm$ 1% range of indifference.[14] We implicitly assume that even if the central bank is not required to adhere to a numerically agreed inflation target it is, at least in principle, interested in adopting a similar range to maintain its credibility. Hence, it seems plausible to assume that a central bank's credibility is penalized relatively more heavily when the monthly forecast is outside the range than when it is inside the range.[15] Squaring the deviations is a natural definition that follows from the standard approach of assuming a quadratic form for losses in central bank objective functions. Clearly, other assumptions are

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the authors generated are based on annual, not monthly, data and over a much longer sample that the one examined below.

[13] 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.

[14] A look at the economies that adopted inflation targeting (see the Appendix A) finds that only South Africa and Thailand specify target ranges that are slightly larger than the $\pm$ 1% presumed in our calculations.

[15] Our definition of credibility can also be modified so that no penalty is attached when inflation fluctuates inside the ±1% range. In any event, the conclusions reached below appear unchanged when this change is made.

possible.[16] Indeed, depending on the persistence properties of inflation forecasts inside the range the central bank's credibility may not be negatively impacted at all. However, persistent deviations within the range may result in a loss of credibility.[17]

Recall that $\overline{\pi}_t$ is either forward-looking, as when it is based on one year ahead Consensus forecasts, or backward-looking, as when it is based on moving averages or H-P filtered observed inflation rates. We first proxy the time-varying inflation goal, $\overline{\pi}_t$, either with a two or five year moving average of inflation forecasts or a forecast derived by applying an HP filter to inflation forecasts in the manner also discussed above. In the absence of the required information to formally derive a central bank's own forecast we implicitly assume, at least over the medium-term, that forecasts by the monetary authorities and the central bank will coincide. Alternatively, we also generate a version of equation (1.1) by replacing the one year ahead inflation forecast, π_{t+1}^{f} with observed smoothed inflation rates. This implies a measure of credibility defined as follows:

$$\begin{aligned} &(\pi_t - \overline{\pi}_t)^2, \quad \text{if } \left|\pi_t - \overline{\pi}_t\right| > 1 \\ &(\pi_t - \overline{\pi}_t), \quad \text{if } \left|\pi_t - \overline{\pi}_t\right| \leq 1 \end{aligned} \tag{0.2}$$

This approach says that credibility is dictated by how far inflation outturns are from what the central bank, in principle, believes is the medium-term inflation objective. The same smoothing filters are applied to observed inflation rates as was the case for the Consensus forecasts. Since our conclusions are essentially the same across the various smoothing alternatives considered all results discussed in the next section are based on the assumption that a central bank's inflation objective is a five year moving average of monthly Consensus forecasts or monthly observed inflation rates.

If equations (1.1) and (1.2) each represent indicators of central bank credibility, denoted CRED, we next ask what determines credibility over time. Letting *i* refer to the regional groupings

[16] The issue is discussed in greater detail in Bordo and Siklos (2015).

[17] The relevance of this point is highlighted in recent discussions, mainly in some advanced economies, that inflation rates are persistently below (or some years ago, persistently) some target range of inflation.

considered, we consider three potential sources of influence on credibility over time. They are: economic, financial, and institutional. We can, therefore, write

$$CRED_{it} = f(ECON_{it}, FIN_{it}, INS_{it}) + \varepsilon_{it} \quad (0.3)$$

Where CRED is the indicator of central bank credibility defined in equations (1.1) or (1.2), ECON is a vector of macroeconomic factors, FIN represents determinants of credibility related to financial stability considerations, and INS is a vector institutional indicators. ECON includes real GDP growth (or the real GDP gap), and the real exchange rate.[18] For FIN several candidates were considered, namely 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, risk premium on loans, all from the World Bank's development indicators. We opted to include the World Bank indicators when other FIN data were unavailable. We also add the VIX as a variable that links central bank credibility to financial stability. Finally, INS is proxied by indicators of the rule of law, voice and accountability, and political stability from the World Bank's governance indicators. Again, we tended to consider these variables for regions outside the Advanced and Asia-Pacific economies in part to offset the shortage of other data available at higher sampling frequencies. In addition, we add indicators of whether the economies in question adopted formal inflation targets or central bank transparency.

In estimating the regression implied by equation (1.3) we also account for the possibility that some of the right hand side variables are endogenous. Given the variety of sampling frequencies in the raw data we estimate (1.3) via two stage least squares with fixed effects where relevant.[19] As will become apparent in the next section there is considerable heterogeneity across the many central banks examined. It may be misleading then to focus solely on the man responses to the various determinants of central bank credibility considered. Therefore, we supplement our estimates with quantile regressions also in a panel setting.

[18] 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.

[19] 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 adopted strategy is satisfactory.

Specifically, we present 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 over time in a particular group of economies. In this case equation (1.3) is rewritten as follows:

$$CRED_{it}(\tau) = f(ECON_{it}, FIN_{it}, INS_{it}) + F_{\varepsilon}^{-1}(\tau) \qquad (0.4)$$

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

4. Stylized Facts and Econometric Results

(a) Stylized Facts

We begin with a general description of the data and some stylized facts. These are presented according to the region of type of policy regime in place. 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, or the remaining economies (i.e., not otherwise classified) in the dataset. The data shown are monthly. Differences in the samples shown reflect differences in data availability.

Examining the record of advanced IT economies and the Eurozone we observe that inflation forecasts tend to be more stable than movements in the realized inflation rates. In addition, periods when Consensus forecasts deviate from observed inflation can and do persist over long periods of time. Nevertheless, it is interesting that, during the 2008-2009 financial crisis, Consensus forecasts greatly underestimate observed inflation in both advanced IT economies as well as in the Eurozone. In contrast, between 2009 and early 2014, forecasts of inflation were overly pessimistic in IT economies while the exact opposite occurs in the Eurozone where median forecasts are persistently over-optimistic, at least until well into 2013. As we shall see below, these developments may partly be explained by observed economic growth performance. Turning to the other economies considered we find that for those economies, in the main referred to as emerging market economies, median inflation has fallen quite

noticeably over time and the gap between observed and forecasts begins to resemble that seen in advanced economies. In contrast, economies that neither target inflation nor are part of any of the other country or regional groupings considered, experience not only more volatile inflation but median inflation rates do not appear to have fallen as far as they have elsewhere in the world.

Figure 2 illustrates a potentially important feature of the data that not only influences our credibility indicators but also helps us better understand the relationship between inflation forecasts and observed inflation performance across countries and regions of the world. Figure 2a shows, for the group of advanced economies in the sample, the range of inflation rates and forecasts from the worst (i.e., highest inflation rates) to the best performers (i.e., lowest inflation rates). When inflation rates are relatively low that are not only relatively less volatile but considerably easier to forecast. Presumably, this kind of outcome ought to boost a central bank's credibility. Notice, however, that the worst performing economies in the advanced world generate not only highly variable inflation rates but forecasts are generally far too optimistic compared to outcomes. Presumably, this should imply a loss of central bank credibility over time.

Figure 2b, however, illustrates that the foregoing result need not always apply. Inflation performance, even when it is the best in the region, here in the Asia-Pacific, is not immune to volatility nor to the presence of persistent and, occasionally large, deviations from observed inflation, at least until after the financial crisis when forecast errors largely disappear. Clearly, other factors, such as the policy regime or institutional factors, are also likely to play a role in explaining central bank credibility.

Next, we turn to some estimates of central bank credibility. Figures 3 present some regional estimates of our indicator of central bank credibility. Figure 3 plots estimates of equation (1.1) using the smoothed Consensus estimates of inflation as the proxy for central banks inflation objective since the mid-1990s based on monthly data. The plots are sub-divided into two separate samples, namely from 1995 to 2004 in the top part of the Figure and for the period 2005-2014 in the bottom portion of the same Figures, in order that differences in credibility can

be shown more clearly. Given our definition of credibility a *loss* of credibility takes place when the indicator *rises* and vice-versa. In other words, central bank credibility is *inversely* related to the credibility indicator in equation (1.1).[20]

Clearly, central bank in more advanced economies are generally always more credible than monetary authorities in other parts of the world. Notice also that emerging markets that eventually adopt inflation targets, typically in the early 2000s, display large increases in credibility. However, once the targets are in place, credibility levels are not visibly different from those seen in more advanced economies, whether they formally target inflation or not, or the Eurozone. The BRICS economies as well as economies not otherwise classified, frequently experience credibility losses (i.e., the CRED indicator rises). It is also the case, during financial crises, such as the Asian financial crisis of 1997-1998 and again in 2008-2009, that central banks most directly implicated suffer credibility losses. It is interesting to note, however, that whereas the global financial crisis leads to credibility losses on a global scale the same is not true for the Asian financial crisis. These are early indications that there is a link between central bank credibility and financial crises.

Figure 4a repeats the exercise carried out in Figure 3 for different types of economies. Here only the case of advanced and Eurozone economies are highlighted. The Figures show even more clearly the credibility losses around the financial crisis but also suggests that there were indications of substantial credibility losses during the second half of 2007 when there were early indications that a global financial crisis was imminent. The figures also make clear that, once lost, central bank credibility can take time to recover (also see Bordo and Siklos 2015). 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 economies, which adopted inflation targeting but are not among the advanced economies relative to other economies not in any of the other country classifications considered. After hard won improvements in credibility the IT

[20] This is similar to the definition used in Bordo and Siklos (2015).

economies not directly implicated in the crisis do not experience any noticeable losses since the mid-2000s. In contrast, comparable economies in the other 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. Whether the adoption of inflation targeting is able to explain the differences shown remains to be seen.

The fact that, in certain periods, many central banks in different parts of the world and which have adopted different policy regimes appear to experience rises or falls in credibility together also suggests the possibility that there exists a global component to credibility gains or losses.[21] Indeed, the various regional measures of credibility appear at times highly correlated while, in other periods, they are either uncorrelated or even negatively correlated (results not shown). Hence, to the extent that a global component to central bank credibility exists, it is not constant though it is an empirical question whether financial crises or institutional factors contribute to this result.

Although the figures so far give a general idea of the evolution of central bank credibility around the world it may be useful to consider a few specific examples. The sample of countries considered in this paper is too large to discuss the experience of each economy. Hence, by way of illustration, Figure 5 plots the evolution of credibility in four economies. In addition, both indictors of credibility are shown (i.e., equations (1.1) (1.2)). Although the two proxies parallel each other there are clearly differences. The Fed's credibility (top left) suffers a large drop during the financial crisis of 2007-2009. However, the loss is more persistent when observed as opposed to forecasts of inflation are used. Indeed, the proxy generated on the basis of equation (1.2) tends to be relatively more persistent. The Swiss experience (top right) shows quite clearly large and persistent credibility losses during the second half of the 1990s. The situation is only reversed once the Swiss National Bank adopts inflation control measures and targets a forecast of inflation. The financial crisis, followed by the Eurozone sovereign debt crisis, also leads to credibility losses. Credibility only improves when the SNB puts a ceiling on

[21] We do not explore this possibility empirically as space limitations prevent us from exploring the issues in greater detail except in so far as the global financial crisis is a rough proxy for a common shock to central bank credibility (see, however, Table 2).

the Swiss franc exchange rate in 2011 (since abandoned in January 2015). The Hong Kong Monetary Authority's experience (bottom left) is dominated by large negative credibility shocks during the Asian Financial Crisis of 1997-1998. The impact of the latest financial crisis is hardly noticeable. Finally, Argentina's record (bottom right) is a good illustration of our preference for the forward-looking credibility indicator. It is clear that the central bank begins to lose credibility in 2012 when it became increasingly clear that published inflation data were deemed untrustworthy. In contrast, the indicator that relies on realized inflation rates rises more modestly.

The final stylized fact concerns observed and forecasted real GDP growth. The top portion of Figure 6 plots realized real GDP growth rates for the major country groupings considered in this study while the bottom part displays real GDP growth forecasts for the same groups of economies. The observed data are at the quarterly frequency while forecasts shown are monthly. Two facts are worth highlighting. First, all economies experience large reductions in real GDP growth during the global financial crisis. This is not the case for the Asian financial crisis of 1997-1998. Nevertheless, in both cases, forecasters were too optimistic about real GDP growth in both crises but especially the 2008-2009 financial crisis. Second, by 2013, a global convergence of sorts in economic growth rates begins to emerge but this is not accompanied by a similar convergence in growth forecasts. Only among the G4 and Eurozone economies are growth forecasts more in line with observed growth rates and lower than at any other time since the early 1990s. Forecasters elsewhere, including ones in advanced economies with IT but also in the BRICS group of economies appear to be persistently too optimistic about economic growth prospects.

(b) *Econometric Results*

Tables 1 and 2 present the main results. The results are based on the credibility proxy defined in equation (1.1). As noted previously the forward-looking definition seems the most natural one under the circumstances. However, most of the results carry forward to the case where equation (1.2) serves as the proxy. Nevertheless, some differences do emerge as is perhaps apparent from the discussion surrounding Figure 5. 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.[22] Hence, estimates of equation (1.3) and (1.4) are in the levels.

Readers are also reminded that the panels are unbalanced and there is the added challenge that the number of available cross-sections changes when we contrast pre and post crisis samples.[23] We experimented with several variants of equation (1.3) to determine how our conclusions would be affected but this need not always result in an improvement. For example, to ensure that the number of cross-sections in the sub-samples considered this meant dropping some variables that well prove to be statistically significant in a longer sample. Nevertheless, when all is said and done, we believe that the estimates presented, especially in Table 1, are fairly representative of the results obtained across the large number of variants of equation (1.3) estimated. We return to this issue in the concluding section.

The results in Table 1 are sub-divided into two samples. The "pre-crisis" sample consists of available data until 2006Q4. The "crisis and post-crisis" samples begin in 2007Q1 and end in 2013Q4 or 2014Q1, again depending on data availability.[24] For simplicity, we refer to the second sub-sample as the "post-crisis" sample. All estimates rely on the quarterly sampling frequency. In Table 2, in part to economize on space, estimates for the median, maximum and minimum credibility cases are estimates of equation (1.4) for the full sample with the addition of a dummy variable for the global financial crisis (see n. 23 for the definition).

There are several features to note in the results. First, there is considerable variety in the drivers of central bank credibility in the five regions shown. Unfortunately, we are unable establish the extent to which this is driven by the data limitation previously noted. Second, the VIX consistently explains mean variations in credibility with the exception of inflation targeting

[22] Namely, 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. Results are not shown.

[23] As a robustness check we also estimated the relationships shown below for the full sample allowing for an "exogenous" break due to the Global Financial Crisis of 2007-2008 or the Asian Financial Crisis of 1997-1998. Again the main conclusions discussed below are unaffected though, not surprisingly, the size of some of the coefficients is affected by the resort to full sample estimation. 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 crisis (starting date: 2007Q1 and ending 2010Q4) duration is the same for every country in the sample.

[24] We also generated estimates for the 2007Q1-2010Q4 sample but these paralleled the results for the crisis/post-crisis sample shown in Table 1.

emerging market economies. Generally, increases in the VIX are seen in both samples as reducing central bank credibility. This is the case in the five country groupings shown which cover the vast majority of the planet. Only in the post-crisis phase in the Asia-Pacific and the otherwise unclassified economies (i.e., OTHER) is a rise in the VIZ associated with a rise in credibility. Since the VIX is based on the performance of the U.S. S&P 500 index this could reflect a spillover effect wherein higher volatility in U.S. options is seen as improving domestic credibility though the data are silent on the mechanism through which this takes place.

Evidence for the G7 suggests that financial stability related determinants are indeed important in both samples while the economic determinants considered (i.e., real exchange rates and real GDP growth) typically affect credibility post-crisis. A rise in economic growth post-crisis raises central bank credibility an indication perhaps that central banks in the G7 placed relatively greater weight on the real side of the economy relative to pre-crisis times. Elsewhere in the advanced world rising economic growth is also seen as improving central bank credibility often both before and after the appearance of the global financial crisis. Other than the VIX real economic outcomes post-crisis comes closest to being a common factor across the globe. However, it should be noted that the coefficient on real GDP growth post-crisis is considerably and statistically significantly smaller in all regions examined other than for the G7.

In the G7, advanced economies post-crisis, and Asia-Pacific economies throughout the period considered, a real appreciation signals greater 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.

Returning to the financial stability-central bank credibility links we observe that housing prices and credit growth, impact the G7 and other advanced economies differently.[25] Rising housing prices improve credibility in the G7 pre-crisis but, in the advanced economies, which, of course,

[25] There was insufficient data to estimate the impact of these variables

include the G7, this result carries over into the post-crisis period as well.[26] Similarly, higher credit growth improves central bank credibility post-crisis. Turing to the Asia-Pacific economies, the only other grouping for which we had sufficient housing and credit growth data, the situation is reversed post-crisis. Higher growth rates in both variables reduce central bank credibility in the region. As was noted above, the impact of the global financial crisis was felt mainly the advanced economies. Unfortunately, we could only reliably estimate the impact of the spread for the G7 where this is seen as a financial variable that improves credibility.[27] Put differently, a rise in long-term rates relative to short rates, often a signal of higher future real growth, raises central bank credibility. In particular, it is also worth noting that the parameter estimate is over twice as large relative to the pre-crisis period (and the difference is statistically significant). Finally, where available, the data indicate that central bank credibility is positively related to stock market performance. Whether this is an indication of higher future economic growth and/or stable future inflation is unclear. We do know, however, that stock market returns and monetary policy are linked to each other in advanced economies (e.g., see Bohl, Siklos, and Werner, and Bohl, Siklos and Sondermann).

As is clear from Table 1 we have far fewer of the covariates available for the full set of emerging market economies or other economies not otherwise classified. Nevertheless, there is some evidence that rising non-performing (bank) loans reduce credibility in the group of 'other' economies. Because we have insufficient data on central bank transparency for this group of economies voice and accountability acts as a substitute. Pre-crisis this is seen as improving credibility but the effect disappears post-crisis.

The most prominent institutional variable considered is the adoption of inflation targets and the concomitant rise in central bank transparency.[28] These are seen to improve credibility pre-

[26] 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 did not change the conclusions.

[27] Too many cross-sections are lost even when we attempt to include the term spread in the panel of advanced economies.

[28] 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 the inflation targeting dummy with the overall indicator of central bank transparency we obtain comparable results. We do not pursue the possibility

crisis only in the G7, and throughout the entire sample in the Asia-Pacific. Elsewhere, that is, in the advanced economies as well in emerging market economies that adopted inflation targeting, greater central bank transparency is the vehicle through which credibility improvements take place although the effect is no longer statistically significant post-crisis in the emerging market group considered.

In Table 2 we turn to estimates at the median and tails of the distribution of credibility. in this fashion we are able to examine how the best, worst, and middle of the distribution of central banks respond to the available determinants of central bank credibility. To conserve space we report results for Advanced and Asia-Pacific economies. Combined these economies represent the overwhelming fraction of the world's GDP.

The results are striking for they highlight the disadvantages of focusing solely in the mean responses of central banks, as in Table 1. Hence, the median central bank responds quite differently to the various determinants considered compared to central banks that are at the most or least credible range of the credibility distribution. It is interesting that the most credible central banks in the advanced economies generally do not respond to any of the financial stability indicators with the exception of the term spread, a traditional variable that central banks have long used to gauge expected economic conditions. Median central banks in that region earn a credibility boost when equity returns and credit conditions ease via a rise in the growth of credit. In contrast, median and the most credible central banks in the Asia-Pacific region are seen to lose credibility when asset prices rise. These results indicate the potential risks for central banks to become too heavily or directly responsive to asset prices.

It is also notable that central bank transparency benefits the median and most credible central banks in the advanced economies and only the most credible central banks in the Asia-Pacific region. Indeed, the least credible central banks in that region actually lose credibility in response to more transparency. In other words, transparency for its own sake is not sufficient. To derive any benefits it should be combined with other determinants of central bank

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that the adoption of inflation targets and the rise of central bank transparency may interact with each (or with some of the other right hand side variables, for that matter).

credibility. Finally, it is worth remarking that median central banks in advanced economies lost credibility during the global financial crisis while the least credible central banks paid a credibility price during the Asian Financial Crisis. Interestingly, Asia-Pacific central banks gained credibility during the 2007-2009 crisis, likely a reflection that these economies, take together, acquitted themselves relatively well during this period.

5. Conclusions

This paper has generated credibility indicators for over 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. When central banks perform well in terms of credibility they respond to economic, financial and institutional determinants differently from the median or least credible central banks.

It is apparent that central banks do respond to asset prices and financial indicators more generally. Nevertheless, asset price inflation can boost credibility as well as reduce it. Increases in equity returns can raise credibility and the same result is found for housing prices. The picture is more mixed when assessing the response to credit growth. Nevertheless, when we examine the central banks that perform best on the credibility scale they either do not respond to asset prices, other than to the term spread, or can suffer credibility losses when asset prices inflate.

Finally, 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. The same is true for the best performing central banks. This put paid the notion that good central banking requires the monetary authority to ignore the real economy.

The bottom line 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 ever broader responsibilities for the financial performance of economies.

To be sure the results so far can only be characterized as tentative. Beyond a fairly small group of advanced economies the range of candidate determinants of central bank credibility is thin. Indeed, the challenges in constructing a comprehensive dataset, allowing us to answer the question about how central banks ought to respond to financial conditions, are substantial. However, this should reinforce caution in requiring central banks to take on too many responsibilities.

References

Adrian, T., D. Covitz, and N. Liang (2014), "Financial Stability Monitoring", Federal Reserve Bank of New York Staff Report 601, June.

Ball, L. and N. Sheridan (2005) "Does Inflation Targeting Matter?" in Ben

Bernanke, Michael Woodford (eds) The Inflation Targeting Debate, NBER Studies in Income and Wealth. Chicago: University of Chicago Press.

Michael D Bordo (2014) " Rules for a Lender of Last Resort" in *Journal of Economic Dynamics and Control. Special Issue : Frameworks for Central Banking in the Next Century: A Special Issue on the Occasion of the Centennial of the Founding of the Federal Reserve* (guest editors)Michael D. Bordo, William Dupour and John B. Taylor, pp 126-125

Bordo, M.D. and P.L. Siklos (2015) "Central Bank Credibility and Reputation: An Historical Exploration", NBER Working Paper 20824, January

Bordo, M.D., and P.L. Siklos (2014), "Central Bank Credibility, Reputation and Inflation Targeting in Historical Perspective", NBER working paper 20693, November.

John Cochrane (2014) " Monetary Policy with Interest on Reserves" in *Journal of Economic Dynamics and Control. Special Issue: Frameworks for Central Banking in the Next Century: A Special Issue on the Occasion of the Centennial of the Founding of the Federal Reserve.* (Guest editors) Michael D. Bordo, William Dupour and John B. Taylor.

Dincer, N., and B. Eichengreen (2014), "Central Bank Transparency and Independence: Updates and New Measures", *International Journal of Central Banking* (March): 189-253.

Dincer, N., and B. Eichengreen (2007), "Central Bank Transparency: Where, Why, and with What Effects?, NBER working paper 13003, March.

Eijfinger, S., and P. Geraats (2006), "How Transparent Are Central Bank?", *European Journal of Political Economy* 22 (March): 1-21.

Geraats. P. (2014), "Monetary Policy Transparency", in J. Foessbaeck and L. Oxelheim (Eds), Oxford Handbook of Institutional and Economic Transparency (Oxford: Oxford University Press), pp. 68-97.

Marvin Goodfriend (2012) " The Elusive Promise of Central Banking" *Monetary and Economic Studies* vol. 30, pp 39-54.

Hashimoto, Y., T. Ito, and K. Dominguez (2012), "International Reserves and the Global Financial Crisis," with, *Journal of International Economics* 88 (2): 388-406.

Im, K.S., M.H. Pesaran, and Y. Shin (2003), "Testing for unit roots in heterogeneous panels", *Journal of Econometrics* 115: 53–74.

Kaufmann, D., A. Kraay, and M. Mastruzzi (2010), "The Worldwide Governance Indicators: Methodology and Analytical Issues", Policy Research working paper 5430, September.

Poloz, S. (2014), "The Legacy of the Financial Crisis: What We Know, and What We Don't Know", speech to the Canadian Council of Public and Private Partnerships, http://www.bankofcanada.ca/2014/11/legacy-financial-crisis/.

Siklos, P.L. (2016), *Central Banks Into the Breach* (New York: Oxford University Press, forthcoming).

Siklos, P.L. (2014), "Communications Challenges for Multi-Tasking Central Banks: Evidence and Implications", *International Finance* 17 (Spring): 77-98.

Siklos, P.L. (2014a), "Has Monetary Policy Changed? How the Crisis Has Shifted the Ground Under Central Banks", unpublished working paper, Wilfrid Laurier University.

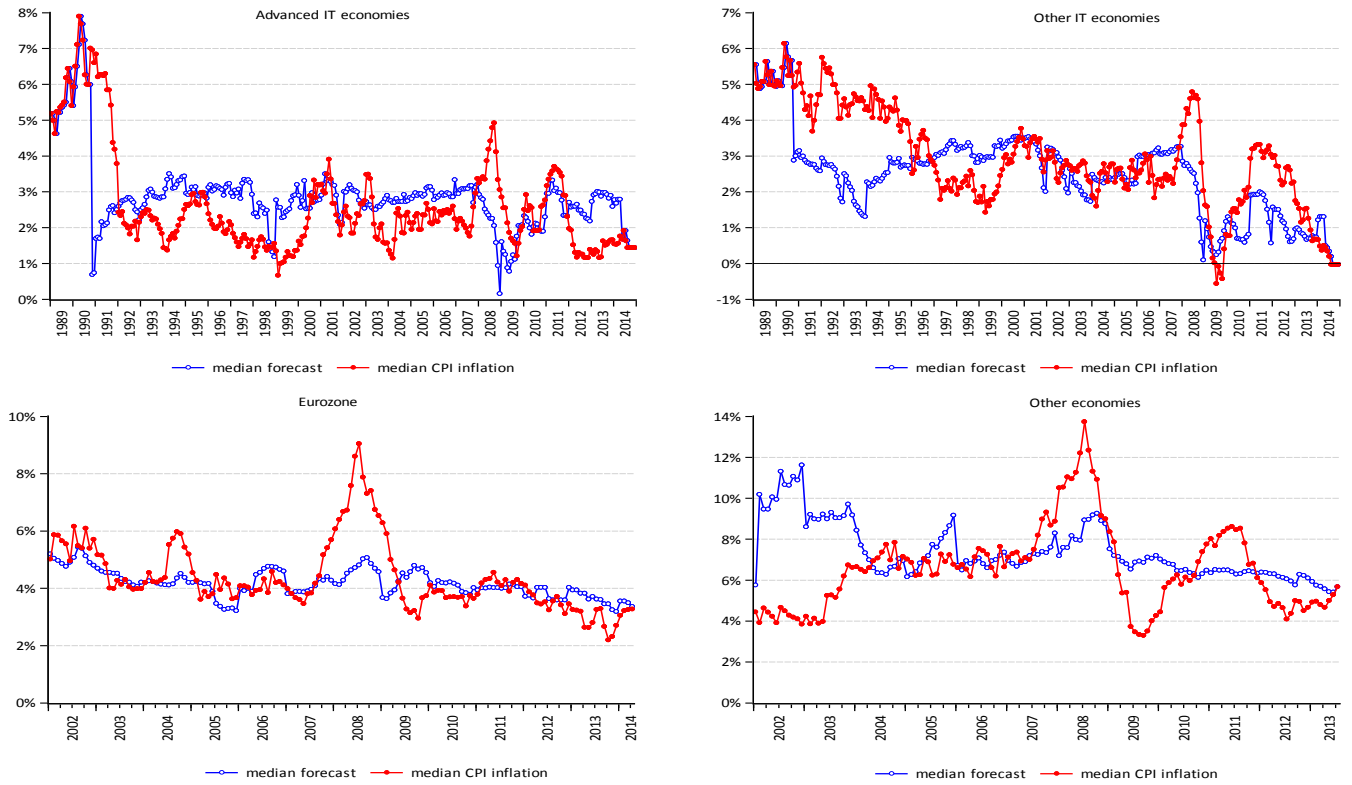
Siklos, P. (2013), "Sources of Disagreement in Inflation Forecasts: An International Empirical Investigation", *Journal of International Economics* 90 (May): 218-231.

Siklos, P. (2011), "Central Bank Transparency: Another Look", *Applied Economics Letters* 18 (10): 929-33.

Stock, J., and M. Yogo (2005), "Testing for Weak Instruments in Linear IV Regression", In: Andrews DWK Identification and Inference for Econometric Models. New York: Cambridge University Press; 2005. pp. 80-108.

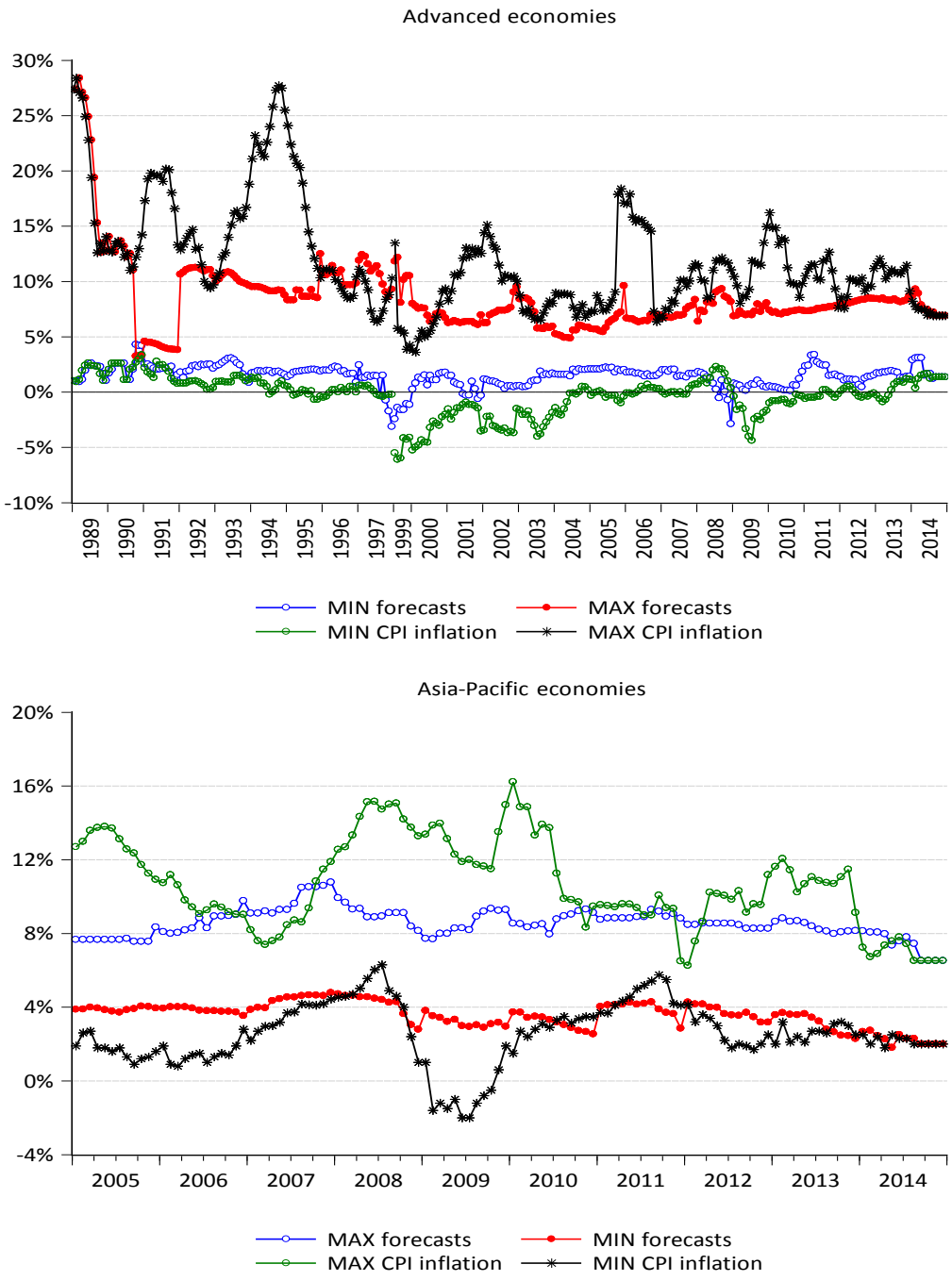
Woodford, M. (2003), *Interest and Prices: Foundations of a Theory of Monetary Policy* (Princeton, N.J.: Princeton University Press).

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



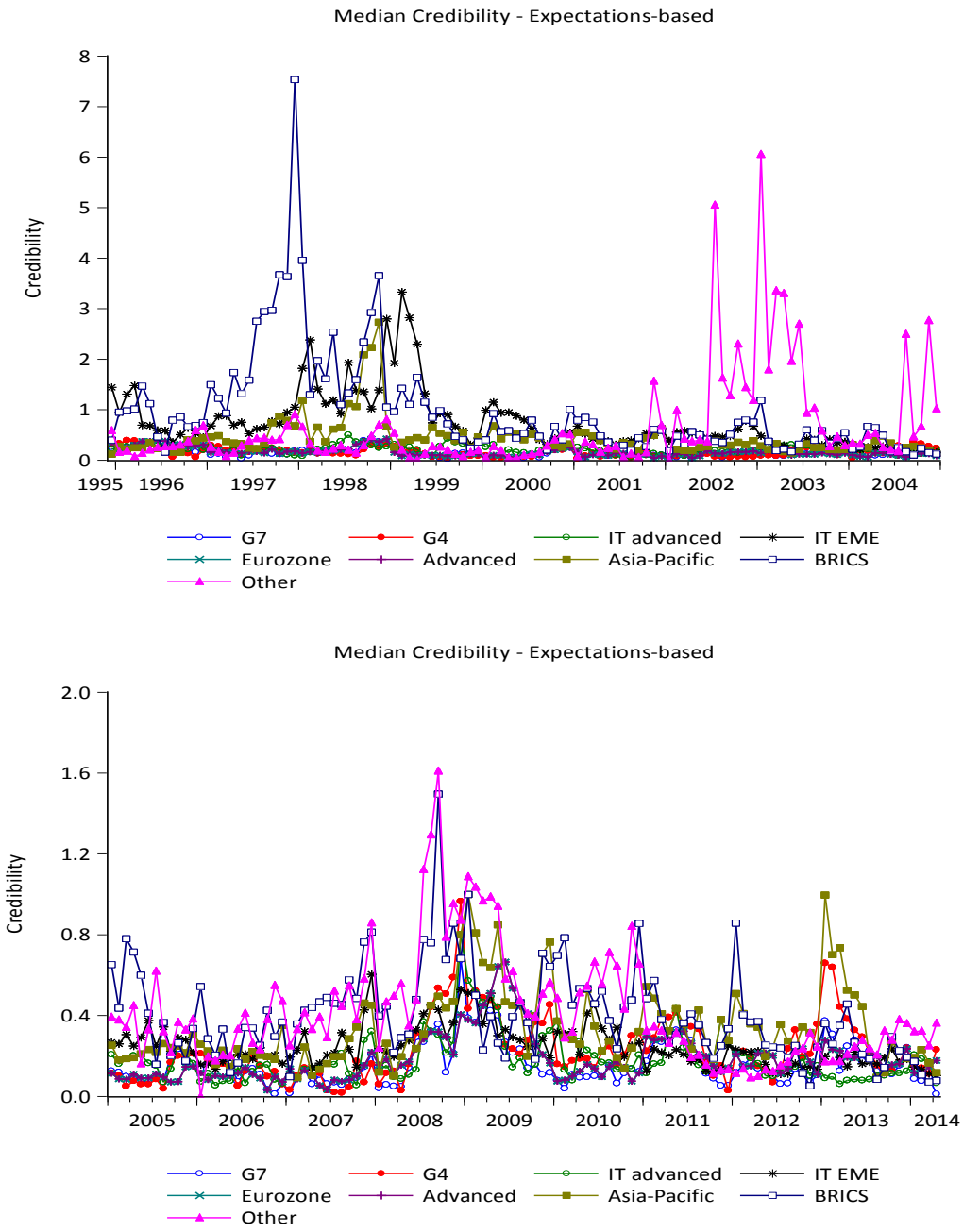
Note: See the text for the definition and sources. The Appendix lists the economies included in each regional grouping. Data are monthly.

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



Note: Based on equation (1.1). For the economies included in each regional grouping, see the Appendix. Data are monthly.

Figure 4A Range of Credibility Estimates in Select Regions

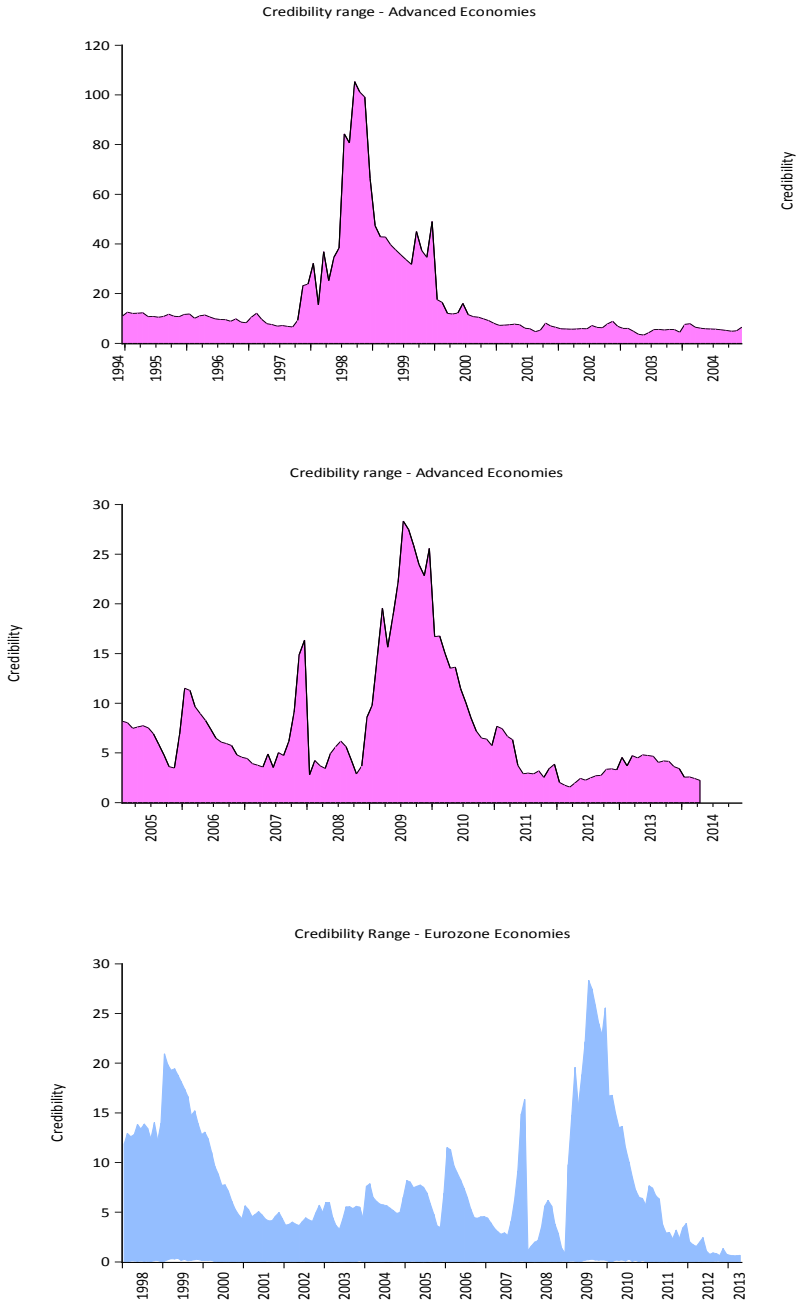
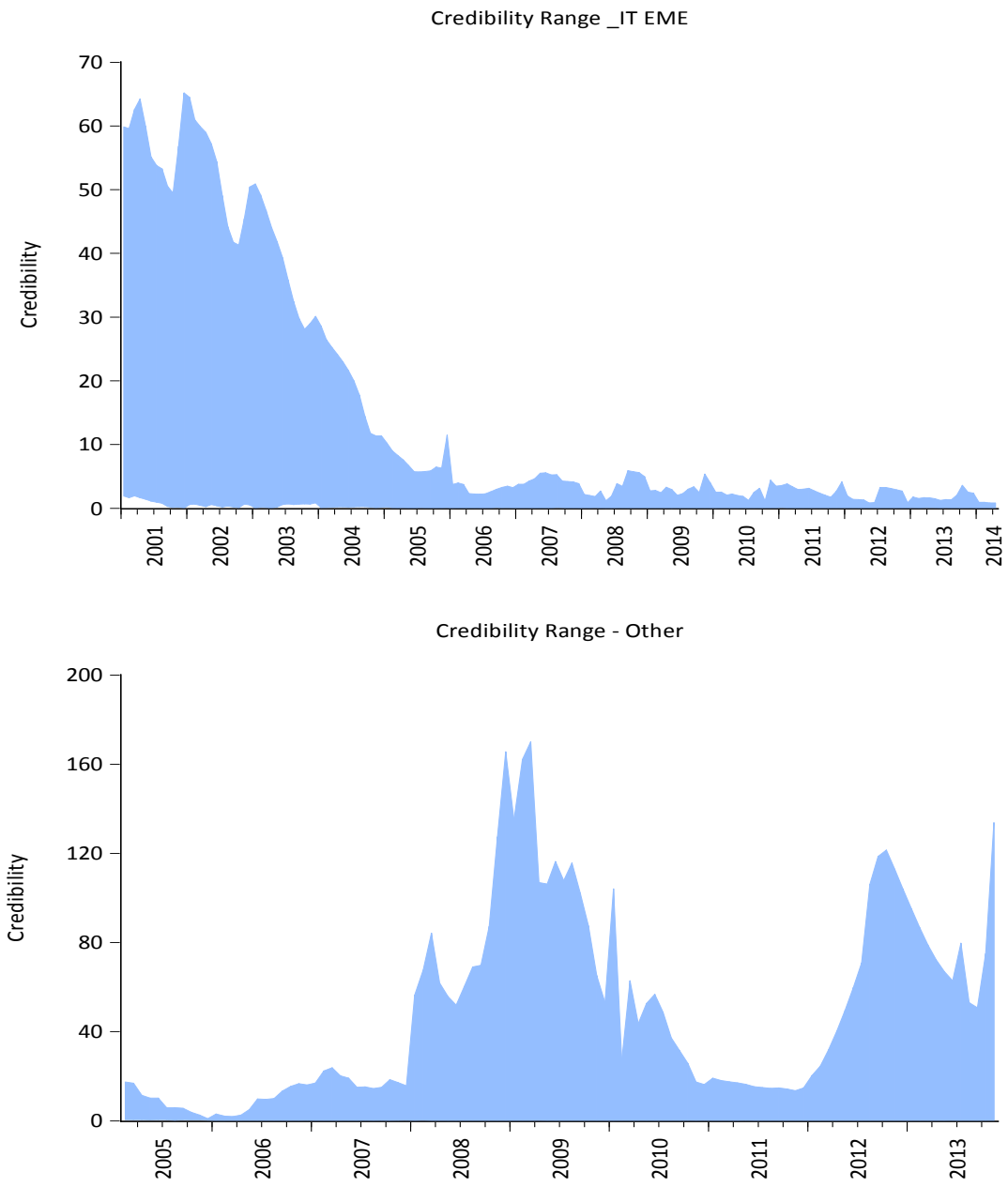
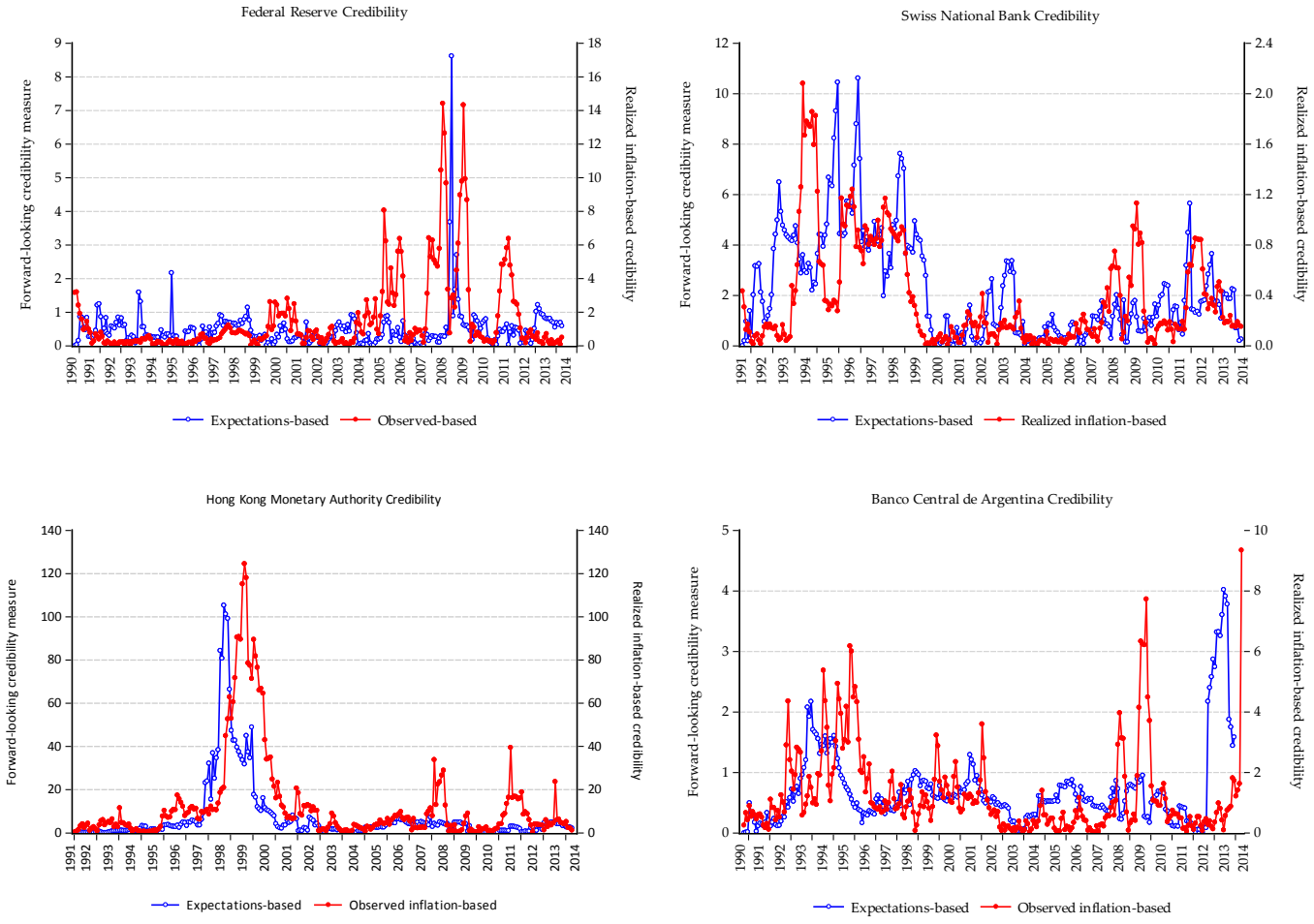


Figure 4B Range of Credibility Estimates in Select Regions



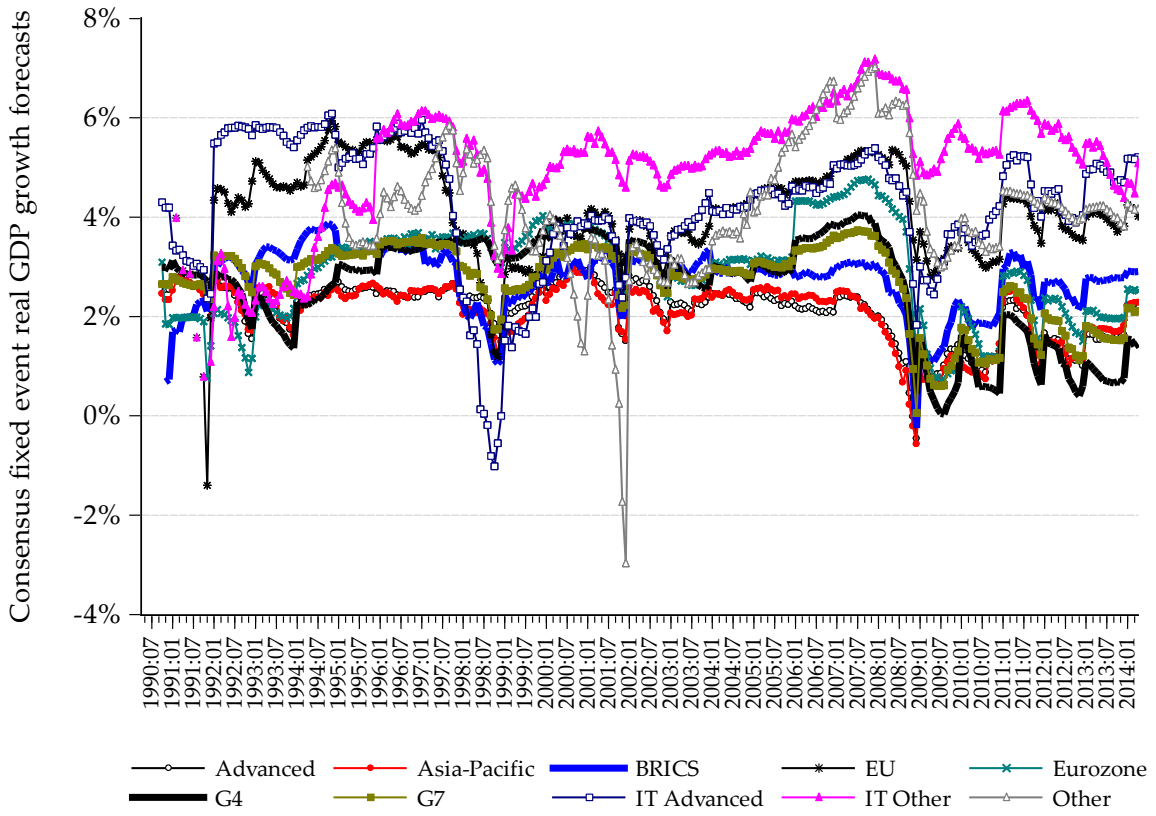
Note: The area represents the distance between the smallest and the largest values for the credibility indicator as defined in equation (1.1). A smaller value indicates higher credibility; a larger value means less central bank credibility. Also, see the Appendix for regional grouping definitions.

Figure 5 Select Estimates of Central Bank Credibility



Note: Estimates of central bank credibility based on estimates of equations (1.1) and (1.2). Data are monthly.

Figure 6 Fixed Event Real GDP Growth Forecasts in Various Regions of the World



Note: real GDP growth Consensus Forecasts. Economies included in each region are listed in the Appendix. Data are monthly.

Table 1 Determinants of Central Bank Credibility: Panel Estimates

Dependent Variable: Credibility (equation (1.1))										
	G7 Economies		Advanced Economies		Asia-Pacific Economies		IT EME		OTHER Economies	
	Pre-crisis	Post-Crisis	Pre-crisis	Post-Crisis	Pre-crisis	Post-Crisis	Pre-crisis	Post-Crisis	Pre-crisis	Post-Crisis
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	0.215 1.491 (0.137)	0.959 7.176 (0.000)	6.167 2.012 (0.045)	6.795 4.888 (0.000)	1.076 0.381 (0.703)	2.200 6.879 (0.000)	20.420 1.824 (0.070)	2.620 1.899 (0.058)	-334.664 -2.878 (0.009)	16.313 5.663 (0.000)
Real GDP Growth	-0.120 -3.049 (0.003)	-0.103 -4.755 (0.000)	-0.828 -2.037 (0.042)	-0.252 -8.617 (0.000)	-0.739 -2.948 (0.003)	-0.226 -4.415 (0.000)	-2.378 -1.895 (0.060)	-0.025 -1.125 (0.261)	-6.424 -1.093 (0.287)	-0.410 -3.272 (0.001)
Real Exchange Rate (Δln)	-0.008 -1.119 (0.264)	-0.031 -2.121 (0.035)	-0.050 -0.938 (0.349)	-0.033 -3.344 (0.001)	0.230 2.691 (0.008)	-0.054 -4.270 (0.000)	0.075 1.025 (0.307)	0.014 1.552 (0.122)		
VIX	0.028 5.079 (0.000)	-0.004 -1.816 (0.071)	0.070 1.518 (0.130)	0.029 2.219 (0.027)	0.270 2.228 (0.027)	-0.032 -2.448 (0.015)	0.151 0.414 (0.679)	0.010 1.059 (0.290)	5.297 2.337 (0.029)	-0.457 -3.873 (0.000)
Housing Price Growth	-0.011 -1.886 (0.060)	-0.005 -0.288 (0.774)	-0.080 -1.746 (0.081)	-0.048 -2.533 (0.012)	-0.352 -4.602 (0.000)	0.039 3.006 (0.003)				
Term spread	-0.076 -2.111 (0.036)	-0.186 -4.524 (0.000)								
Private Credit Growth	0.003 0.256 0.798	-0.057 -5.087 (0.000)				0.048 3.210 (0.002)				

Equity Price Growth	0.017 4.521 (0.000)	0.011 4.435 (0.000)	0.077 2.754 (0.006)	0.028 7.173 (0.000)	0.087 2.410 (0.017)	0.015 2.426 (0.016)				
Inflation Targeting	-0.071 -2.176 (0.031)	-0.083 -1.074 (0.284)			-2.378 -1.889 (0.060)	-0.708 -3.873 (0.000)				
Central Bank Transparency			-0.445 -2.278 (0.023)	-0.612 -4.843 (0.000)			-0.943 -1.779 (0.077)	-0.030 -0.276 (0.783)		
Capital Adequacy							0.275 0.431 (0.667)	-0.187 -2.656 (0.008)		
Non-performing loans									12.710 7.814 (0.000)	0.133 0.928 (0.354)
Voice & Accountability									-374.926 -2.162 (0.042)	4.610 0.471 (0.638)
Summary Statistics										
Adj. R^2	0.26	0.13	0.28	0.53	0.21	0.06	0.61	0.15	0.80	0.16
Cross-sections	7	7	23	29	8	12	14	14	8	12
F (p-value)	16.24(0.00)	10.37(0.00)	13.06 (0.00)	29.32(0.00)	12.45(0.00)	11.83(0.00)	26.33(0.00)	4.93(0.00)	14.47(0.00)	8.18(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).

Table 2 Determinants of Central Bank Credibility: Panel Quantile Estimates

Dependent Variable: Credibility (equation (1.1))						
	Advanced Economies			Asia-Pacific Economies		
	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	1.268 5.594 (0.000)	0.472 1.794 (0.076)	3.096 0.409 (0.683)	1.194 1.752 (0.083)	0.476 2.782 (0.007)	-0.914 -0.154 (0.878)
Real GDP Growth	0.066 1.334 (0.186)	-0.035 -3.120 (0.002)	0.807 2.512 (0.014)	-0.247 -2.926 (0.004)	-0.053 -2.755 (0.007)	0.403 0.873 (0.385)
Real Exchange Rate (Δln)	-0.011 -1.618 (0.109)	0.025 3.547 (0.001)	-0.181 -2.083 (0.040)	-0.022 -0.423 (0.673)	0.004 1.149 (0.253)	0.501 3.844 (0.000)
VIX	0.016 2.283 (0.025)	0.012 1.129 (0.262)	0.106 0.469 (0.641)	0.058 3.100 (0.003)	0.008 1.093 (0.277)	0.270 1.609 (0.111)
Housing Price Growth	0.067 2.957 (0.004)	0.012 0.960 (0.340)	-0.354 -2.036 (0.045)	0.107 2.562 (0.012)	0.032 3.250 (0.002)	-0.673 -5.117 (0.000)

Term Spread	-0.029 -0.572 (0.569)	0.126 3.173 (0.002)	-0.203 -0.621 (0.536)			
Private Credit Growth	-0.146 -6.826 (0.000)	0.017 -0.750 (0.455)	0.209 0.771 (0.443)	0.048 0.454 (0.651)	0.002 0.252 (0.802)	-0.493 -1.932 (0.056)
Equity Price Growth	-0.007 -2.065 (0.042)	-0.000 -0.070 (0.944)	0.081 1.192 (0.236)			
Central Bank Transparency	-0.056 -4.493 0.000	-0.084 -3.696 (0.000)	-0.110 -0.377 (0.707)	0.000 0.006 (0.995)	-0.066 -2.192 (0.031)	0.574 2.389 (0.019)
Global Financial Crisis	0.324 1.730 0.087	0.262 0.945 (0.347)	4.947 0.893 (0.374)	-1.596 -3.579 (0.001)	-0.118 -0.673 (0.503)	-7.653 -2.049 (0.043)
Asian Financial Crisis				-0.119 -0.215 (0.830)	-0.250 -1.051 (0.296)	43.874 8.686 (0.000)
Adj. R^2	0.41	0.27	0.13	0.18	0.14	0.60
F (p-value)	8.44 (0.00)	5.10(0.00)	2.61(0.01)	3.62(0.00)	2.91(0.01)	19.28(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; Max to the least credible central banks in the distribution of credibility. Credibility is based on equation (1.1).

Appendix A – Inflation Target Ranges

Country	Adoption date	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14
Industrial																										
Australia	93.2				2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3
Canada	91.1		2-4	2-4	1.5-3.5	1.5-3.5	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3
Korea	98.2									8-10	2-4	1.5-3.5	2-4	2-4	2-4	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5
New Zealand	90.1	3-5	2.5-4.5	1.5-3.5	0-2	0-3	0-3	0-3	0-3	0-3	0-3	0-3	0-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3
Norway	01.1												2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Sweden	93.1					2	2	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3
United Kingdom	92.4			1-4	1-4	1-4	1-4	1-4	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1-3	1-3	2	2	2	2	2	2	2	2	2
Emerging																										
Brazil	99.2										6-10	4-8	2-6	1.5-6.5	1.5-6.5	3-8	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5
Chile	90.3				10-11	9-10	7-8	6-7	5-6	4.5	4.5	3.5	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4
Colombia	99.3										15	10	8	6	5-6	5.5	4.5-5.5	3-5	3.5-4.5	3.5-4.5	4.5-5.5	2-4	2-4	2-4	2-4	2-4
Mexico	99.1										≤13	≤10	≤6.5	≤4.5	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4
Peru	02.1													1-4	1-4	1.5-3.5	1.5-3.5	1.5-3.5	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3
South Africa	00.1											3-6	3.5-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6
Czech R.	98.1									5.5-6.5	4-5	3.5-5.5	2-4	3-5	3-5	3-5	2-4	2-4	2-4	2-4	2-4	1-3	1-3	1-3	1-3	1-3
Hungary	01.1											6-8	3.5-5.5	3.5-5.5	2.5-4.5	3-5	2.5-4.5	3	3	3	3	3	3	3	3	3
Poland	98.4									≤9.5	8-8.5	5.4-6.8	6-8	4-6	2-4	1.5-3.5	1.5-3.5	1.5-3.5	1.5 – 3.5	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5
Israel	92.1					8	8-11	8-10	7.5-10	7-10	4	3-4	2.5-3.5	2-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3
Philippines	02.1													5-6	4-5	5-6	4-5	4-5	3-5	3-5	2.5-4.5	3.5-5.5	3-5	3-5	3-5	3-5
Thailand	00.2											0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5
Indonesia	00.1											3-5	4-6	9-10	4.5-6.5	4.5-6.5	5-7	7-9	5-7	4-6	3.5-5.5	4-6	4-6	3.5-5.5	3.5-5.5	3.5-5.5

Guatemala	05.4																	4-7	4-6	4-7	4.5-6.5	4-6	4-6	4-6	4-6	4-6
Romania	05.1																6.5-8.5	4-6	3-5	2.5-4.5	2.5-4.5	2.5-4.5	2-4	2-4	1.5-3.5	1.5-3.5
Serbia	08.4																				8-12	6-10	4-8	3-6	2.5-5.5	2.5-5.5
Turkey*	06													35	20	12	8	5	4	4	7.5	6.5	5.5	5	5	5
Armenia	06.2																	2.5-4.5	2.5-4.5	2.5-4.5	2.5-4.5	2.5-4.5	2.5-4.5	2.5-4.5	2.5-4.5	2.5-4.5
Albania	09																				2-4	2-4	2-4	2-4	2-4	2-4

Note: Data were collected from individual central bank web sites through the BIS's central bank hub (www.bis.org/central_bank_hub_overview.htm). Individual studies reviewing the experience to date with inflation targeting and published by several of the central banks were also consulted. Occasionally, some inconsistencies were found in the reporting of target ranges partly because the target range was changed mid-year from time to time (e.g., Brazil) or for reasons that are not clear. The shaded area highlights changes to the inflation target after the first three years of an inflation target. The adoption dates are based on the quarterly frequency used in the econometric analysis.

Appendix B – List of Countries

Code	Country	Code	Country
AL	Albania	IT	Italy
AM	Armenia	JP	Japan
AR	Argentina	KR	Korea
AT	Austria	KZ	Kazakhstan
AU	Australia	LT	Lithuania
AZ	Azerbaijan	LV	Latvia
BA	Bosnia & Herzegovina	MD	Moldova
BD	Bangladesh	MK	Macedonia
BE	Belgium	MX	Mexico
BG	Bulgaria	MY	Malaysia
BO	Bolivia	NG	Nigeria
BR	Brazil	NI	Nicaragua
BY	Belarus	NL	Netherlands
CA	Canada	NO	Norway
CH	Switzerland	NZ	New Zealand
CL	Chile	PA	Panama
CN	China	PE	Peru
CO	Colombia	PH	Philippines
CR	Costa Rica	PK	Pakistan
CY	Cyprus	PL	Poland
CZ	Czech Republic	PT	Portugal
DE	Germany	PY	Paraguay
DK	Denmark	RO	Romania
DO	Dominican Republic	RR	Serbia
EC	Ecuador	RU	Russia
EE	Estonia	SA	Saudi Arabia
EG	Egypt	SE	Sweden
ES	Spain	SI	Slovenia
FI	Finland	SK	Slovakia
FR	France	SG	Singapore
GB	United Kingdom	SV	El Salvador
GE	Georgia	TH	Thailand
GR	Greece	TM	Turkmenistan
GT	Guatemala	TR	Turkey
HK	Hong Kong	TW	Taiwan
HN	Honduras	UA	Ukraine
HR	Croatia	US	United States
HU	Hungary	UY	Uruguay
ID	Indonesia	UZ	Uzbekistan
IE	Ireland	VE	Venezuela
IN	India	ZA	South Africa
IS	Israel		

Appendix C – Country Groupings

Country Groupings									
	G7	G4	IT	EZ	EU	Advanced	Asia-Pacific	BRICS	Other
Economies	CA	US	AL	AT	EZ	AT	AU	CN	AL
	GB	JP	AM	BE	+	AU	BD	BR	AM
	IT	GB	AU*	CY	BG	BE	CN	IN	AR
	FR	EU	BR	DE	GB	CA	HK	RU	AZ
	DE		CA*	EE	HT	CH	ID	ZA	BA
	US		CL	ES	HU	CY	IN		BD
	JP		C0	FI	LT	CZ	JP		BG
			CZ	FR	PL	DE	KR		BO
			GT	GR	RO	DK	MY		BY
			HU	IE	SE	EE	NZ		CR
			ID	IT		ES	PH		DO
			IS	LV		FI	SG		EC
			MX	NL		FR	TH		EG
			NZ*	PT		GB	TW		GE
			NO*	SL		GR			HN
			PE	SK		HK			HR
			PH			IE			KZ
			PL			IT			MD
			RO			JP			MK
			RR			KR			NG
			ZA			LV			NI
			KR*			NL			PA
			SE*			NO			PK
			TH			NZ			PY
			TR			PT			SA
			GB*			SE			SV
						SL			TM
						SK			UA
						SG			UY
						TW			UZ
						US			VE

NOTES: See Appendix B for country names