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Abstract

In an important sense the present survey reaches a conclusion similar to the one highlighted by Laidler and Parkin (1975) over forty years ago. Inflation, if fully anticipated, produces modest social costs. We are no closer to knowing what is 'optimal' inflation except that low and stable inflation come closest to reducing the loss of purchasing power of money. Because prices of goods and services incorporate elements that are difficult to measure precisely we cannot even be sure what the actual level of inflation really is. Hence, what is deemed low may well differ across countries and across time. Nevertheless, avoiding inflation is not only desirable because it represents a form of taxation without representation but, in theory at least, low and stable inflation ought to be more easily forecasted thereby reducing the likelihood of large and persistent forecast errors.

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THE ANATOMY OF INFLATION: AN ECONOMIC HISTORY PERSPECTIVE[*]

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1 Introduction

Over forty years ago Laidler and Parkin (1975) published a survey of inflation. Readers were reminded that inflation has social consequences including effects on the distribution of income, wealth effects, and the purchasing power of money. At the time economies around the world were beginning to grapple with the fallout from the first oil price shock. A second one would be inflicted on the world economy a few years later leading to a combination of high inflation and unsatisfactory economic growth that came to be called stagflation. Rather strikingly their survey concluded as follows: "Until we have a much more fully articulated analysis of the formation of expectations and of the interaction of expectations formation and the behaviour of economic agents it is hard to see how we are going to make any significant further progress in understanding inflation." Beyond understanding the formation of inflation expectations we continue to struggle to disentangle the demand and supply side influences of oil price shocks on inflation (e.g., Parkin 1980, Bordo and Orphanides 2013).

Fast forward over 30 years later as the gathering storm of what would eventually be called the Global Financial Crisis (GFC) was about to change the course of history, then Fed Chairman Ben Bernanke (2008) would utter the following words: "But there is much we do not understand about inflation expectations, their determination, and their implications." As this is written we no longer worry about the consequences of high inflation. Instead it is low inflation and low economic growth, that is, lowflation and secular stagnation, that preoccupies central banks. In any case, inflation and understanding its dynamics continues to remain at the centre of the work of macroeconomics.

In spite of considerable progress in both the theoretical and empirical realms there continues to be much that can be learned from how inflation has evolved. One area where both theory and empirics provide clear answers about the dynamics of inflation but has been neglected in recent years concerns the economics of hyperinflation. Other than the relatively recent experience of hyperinflation in Zimbabwe and Venezuela episodes of this kind have become a curiosity. Curiously, one does not have to wait very long once the GFC erupted for several prominent

observers to worry that the response of the monetary authorities, via massive injections of liquidity now referred to as Quantitative Easing (QE), would lead to a return to high inflation (e.g., Meltzer 2009), if not hyperinflation. Hence, a more up to date survey of inflation ought to include a reminder of what episodes of hyperinflation teach us about the dynamics of inflation.

The remainder of this survey is organized as follows. The next section provides a short list of some stylized facts about the evolution of inflation across countries and time. We next provide a brief summary of the behavior of inflation in some commodity money systems. This provides a contrast for the challenges facing a fiat money system where central banks are expected to control inflation and the connection with the policy strategy in place. We then turn to an overview of the extreme case of hyperinflation which illuminates some of the key insights in modern monetary and macroeconomics. The chapter concludes with a summary, and future questions that remain to be addressed.

2 Some Stylized Facts about Inflation

Almost half a century ago Milton Friedman (1970) made famous the following proposition: "Inflation is always and everywhere a monetary phenomenon in the sense that it can be produced only by a more rapid increase in the quantity of money than in output …". Figures 1 and 2 show the annual history of price and money supply movements in the U.K. and Norway. For prices the data go back to at least 1600 while for the two money supply indicators the data are shown only since the late 1800s.[1] While price level rises and money supply level changes do appear to parallel each other the relationship between the various time series also suggests that there may be other factors that contribute to changes in inflation over the time.[2]

Figure 1 and 2 about here

[1] It is actually possible to go back earlier than 1600 and provide more observations for the money supply. However, the consistency of the time series may not be quite the same for longer samples and the arguments made below would not, in any case, be affected. Data are from Bordo and Siklos (2018). The data are in log levels to highlight the relative movements in the time series shown.

[2] Indeed, a simple test (Engle-Granger variety) of cointegration between the (log) CPI and either of the two (log) money supply time series is soundly rejected for the full available sample (i.e., 1880-2015). A constant and a linear trend are used in the test specification.

One obvious element that explains the relationship between money and prices is the monetary policy strategy in place. Figures 1 and 2 also highlight the duration of four monetary policy regimes that have so far been established. Well after each central bank was created (also shown in the Figures) the gold standard was introduced. In both the U.K. and Norway this regime is identified not only by stable prices, at least relative to the regimes that follow, but also by its duration. This is especially visible in the U.K.'s case. Three other regimes mark monetary history over the past four centuries. They are Bretton Woods, where a form of exchange rate pegging was in place; monetary or exchange rate targeting introduced to stem the rise in inflation once the Bretton Woods era essentially ended and, together with the two oil price shocks of the 1970s, led to greater emphasis on inflation control; finally, inflation targeting has become the monetary regime of choice in a large number of countries (Siklos 2017) over the past two to three decades once it became clear that other alternatives had failed to produce low and stable inflation.

As economies gravitated towards inflation targeting there was also a movement away from reliance on monetary aggregates to determine the likely inflationary outcome of changes in the stance of monetary policy. Instead, the focus shifted to using an interest rate instrument that would be adjusted according to the degree of economic slack and whether inflation exceeded some mandated or implicit level deemed acceptable. This modus operandi was captured by the now eponymous Taylor rule (Taylor 1993). Until the GFC of 2007-2009 the policy recommendations based on such a rule dominated the conduct of monetary policy.

Together with questions stemming from the inability to achieve a consensus on how best to define 'money' in light of the technological changes that influenced developments in the financial sector, money as a determinant of inflation disappeared into the background. The theoretical work of Woodford and others also helped bury the role of money as a relic of past ideas (e.g., Woodford 2003). However, reports of money's demise are perhaps greatly exaggerated. Part of the reason for relegating money to the dustbin of history were the growing number of studies worldwide that suggested that the long-run relationship between a monetary aggregate, almost any that one cared to used, interest rates, and GDP, that is, the constituents of a stable money demand function, broke down (e.g., Friedman and Kuttner 1992, Siklos and Barton 2001).

However, Lucas and Nicolini (2015), and Benati et al. (2016) have produced evidence that revives the notion that a stable money demand exists in a large number of countries.

Figure 3 plots inflation in major parts of the globe. There are at least three notable features in the data. First, the record of inflation over the past 50 years or so indicates considerable diversity in inflation performance around the world.[3] Historically, inflation has tended to be lowest in advanced economies and highest in the emerging and developing world. Second, inflation rates are volatile and exhibit sharp movements over time. Clearly, the two oil price shocks and the GFC, both highlighted in the Figure, explain some of these movements. The Figure also hints at some possible global co-movement in inflation around the globe. Indeed, this recent phenomenon gave rise to continuing interest in estimating the extent to which movements in inflation are influenced by global factors (e.g., Ciccarelli and Mojon 2010) or the rise of China (e.g., Pang and Siklos 2016).

Figure 3 about here

Next, even if we take a liberal view of how low and stable inflation might be defined,[4] namely a range of 1 to 6%, achieving low and stable inflation is a fairly recent phenomenon (also see Bordo and Siklos 2016). Finally, a remarkable feature of the global inflation record is the apparent tendency for inflation to converge since the early 2000s. Not since the 1950s to early 1960s have inflation rates remained so low or stable. Indeed, as this is written, policy makers are asking whether the emphasis on inflation control has been too strict, and whether inflation worldwide is too low. Alternatively, the suggestion has also been made that the growth of e-commerce and the emerge of large firms with a global reach and market dominance (e.g., Amazon) may also partially explain the persistence of low inflation in spite of the economic recovery since the crisis of 2007-2008 and the introduction of QE. However, the evidence to date is limited and does not yet point to these forces as the principal explanation of the low inflation environment as this is written (e.g., Charbonneau et al. 2017, Gorodnichenko and Talavera 2017). All of the foregoing

[3] The data plotted in Figure 3 are annual since 1969.

[4] In advanced economies low and stable inflation is a range that encompasses 1 to 3% in CPI inflation with a mean target of usually 2%. The same range tends to be more variable, wider and associated with a higher mean inflation target in less advanced economies.

developments mark the most serious threat to the inflation targeting regime in particular since this type of monetary policy strategy came on the scene in the late 1980s and early 1990s, pioneered by New Zealand and Canada. Nevertheless, low inflation has become a global phenomenon and all monetary policy regimes are being called into question.

So far we have assumed that there is a widely accepted consensus about the precision with which inflation is measured. Nothing is further from the truth. In particular, it is easy to confuse a general increase in the price level, the most general definition of inflation, with a change in relative prices. The former is what monetary policy is tasked to control, while the latter reflects the forces of aggregate demand and supply. Even if the foregoing distinction is clearly understood there is then the problem of choosing the right price level against which policy decisions are evaluated.

To illustrate, consider the case of Canada. Figure 4 plots seven different indicators of inflation in Canada since 2000.[5] Two of the seven are highlighted, namely inflation in the CPI, also often referred to as headline inflation, and CPI that excludes food, energy prices, and indirect taxes (CPI XFET), also known as core inflation. The former is the one that the public has come to expect is the focus of monetary policy performance; the latter is considerably less volatile and by excluding price variations likely due to mainly changes in aggregate supply conditions, provides clearer signals to the central bank about whether a correction in the stance of monetary policy is needed. Nevertheless, there are other ways of 'smoothing' out volatile components in headline CPI. Hence, CPI common, CPI median, and CPI trim represent three different methodologies used to filter out the 'unwanted' variation in aggregate price changes. Methodological details are outside the scope of this chapter but the point is that there are many ways of defining inflation.

Figure 4 about here

Although a consumer price index, or CPI, is a term used around the globe to express changes in the purchasing power of money over time, there are subtle but important differences depending, for example, on how housing and interest rates costs are factored in, among other differences

[5] The data were obtained from http://www.bankofcanada.ca/rates/price-indexes/bcpi/.

that impact the measurement of prices. It would take us far afield to devote any more space to these issues. Instead, the point is that since the CPI captures a representative basket of goods and services the monetary authorities must make allowances for some of the components of CPI that are likely to be highly volatile, such as food and energy prices. Of course, food and energy prices need not be the only component one may wish to focus on. Instead, policy makers, and others interested in the evolution of price movements, may also be interested in particular types of prices, such as changes in transportation, computing, and oil prices, to give three examples, because some of these may be harbingers of broader changes in future CPI movements if changes in these prices feed into aggregate prices.

Why should we care? The degree to which changes in individual prices of goods and services feed into aggregate prices translates into inflation. Perhaps more importantly, changes in inflation may well lead to changes in inflation expectations. Economic theory and the tenets of modern central banking give pride of place to the role of inflation expectations. Indeed, the behavior of both observed and expected inflation has taken on an even more critical role since inflation rates, especially in the advanced economies, have undershot announced objectives for several consecutive years (e.g., Ehrmann 2015).

Persistently low inflation is potentially as much of a worry as persistently high inflation because it raises the possibility that current inflation will be strongly influenced by its past history. In slightly more technical terms this means that inflation can be well modelled as a first order autoregressive process, that is:

$$\pi_t = \beta_0 + \beta_1 \pi_{t-1} + \varepsilon_t \,. \tag{1}$$

If the parameter β_1 is high this implies a high degree of persistence. Now write equation (1) as follows:

$$\pi_t = \beta_0 + \beta_1 \pi_{t-1} + \beta_2 I_t + \varepsilon_t \,. \tag{2}$$

If observed inflation is below the inflation target then β_2 has the effect in equation (2) of actually raising the degree of inflation persistence. Just as the introduction of inflation targeting reduced

inflation persistence (e.g., Siklos 1999, Benati 2008) there is the possibility that the GFC reversed the direction of persistence.

To illustrate we use the data for inflation in advanced economies referred to above. For the sample of annual data from 1969-2005 the estimate of β_1 in equation (1) is 0.80. The same coefficient drops to 0.46 for the period after 1995 when most advanced economies, including ones that adopted an explicit numerical target for inflation, placed inflation control as the heart of their monetary policy strategy. Finally, for the period from 2007 to 2016 the persistence parameter falls still further to 0.07 and is statistically insignificant, an indication of the disappearance of persistence in inflation in the conventional sense since the GFC. When emerging and developing economies are considered, persistence falls dramatically from 0.77 (1970-2016 period) to 0.11 (2001-2016). The year 2001 is chosen as this is approximately when several emerging markets began to adopt inflation targeting (e.g., Siklos 2017).

Estimates of equation (2) confirm the significant drop in persistence (not shown). Assuming that the GFC is defined as a period that begins in 2007 and ends in 2009 we observe a rise in inflation persistence although the coefficient is only marginally statistically significant at conventional levels (i.e., 10% level). A similar results for both $\beta_2 I_t$ and the GFC is obtained for the data from emerging market economies. Clearly, the experience of individual economies within each group will differ significantly.

What helps anchor inflation expectations? If inflation is high and the public does not believe the promises made by the central bank to reduce inflation, then their expectations will not adjust until it is convinced that inflation is under control and remains consistently lower than before.

We next take a step back from differences in how inflation is measured or the quality of such measurements and, in what follows, assume that the focus of our analysis is some indicator of headline inflation.

3 Inflation in the Commodity Currency Era

Throughout history there have been several commodity based currencies. These include regimes based on commodities ranging from playing cards to the bimetallic systems used in parts of

Europe and the U.S. However, the most important commodity money system has undoubtedly been the gold standard (e.g., Velde and Weber 2008, Bordo 1999).

It is important to remind readers that there is more than one type of gold standard regime depending on the extent to which the monetary system is tethered to the price of gold. In theory, the price of gold dictated the quantity of money in circulation. While gold coins could circulate it quickly became apparent that it was more efficient, and safer, to print notes that were fully backed by the available gold reserves. Therefore, unless there were gold discoveries that allowed growth in the available quantity of money, the price of gold would have to change to accommodate a rise in the demand for currency in response to economic growth. Strictly speaking then, the gold standard constrains price level movements by fixing the quantity of money. This explains a good portion of the changes in prices in the U.K. and Norway in the 19th century.[6]

In practical terms all countries that adopt such a gold standard also ought to lead to common price level movements. The reason is that, with unfettered capital flows, the gold standard induces an automatic balance of payments adjustment. For example, a positive economic shock in one country would, since the quantity of money is more or less constant in the short-run, produce a fall in prices. This makes exports more attractive thereby producing, other things equal, a balance of payments surplus which also translates into an inflow of gold. The latter creates forces that offset the initial fall in prices. Inflation does exist under a gold standard but the price-specie-flow mechanism returns inflation to zero once the shocks end. Note that if inflation is possible, deflation is also certain under the classical gold standard. As shown in Figure 5 for six economies movements in prices broadly parallel each other.[7]

Figure 5 about here

Indeed, in the absence of some of the uncontrollable factors, and assuming that governments and their central banks adhere to the 'rules of the game', inflation should behave like a stationary

[6] England was effectively on a gold standard beginning in 1717 and formally adopted the regime in 1819.
[7] Indeed, continuing with the implications of this result for the statistical properties of the time series in question one would expect that the (log) of prices are cointegrated. A test confirms this to be the case (results not shown).

process, that is, a time series with a roughly zero mean and a constant variance. Consider the period referred to as the 'classical' gold standard, that is, when most countries that adopted the regime followed its precepts yielding little inflation. The mean inflation rate, for example, in the U.K. between 1880 and 1914 was -0.19% with a standard deviation of 4.07%; the same figures for Norway are, respectively, 0.23% and 3.55%.[8] As others have noted (e.g., Eichengreen 1992, Bordo 1981, Bordo and Schwartz 1984) this was also a period of strong economic growth. Unfortunately, the regime could not survive the onset of World War I when it broke down. Instead, an era of inflation emerged as is apparent from Figure 6 which highlights inflation performance in the U.K. and Norway during and after the classical gold standard era.

Figure 6 about here

The end of that conflict brought about a nostalgia for the return to rules to guide the conduct of in monetary policy. However, for reasons alluded to above, the price at which gold is fixed is critical and by the early 1930s it was massive outflows of gold, following an inappropriate fixing of the price of gold that forced the U.K. to abandon the standard. The U.S. also hastened the demise of the gold exchange standard, as it was now called, when President Franklin Roosevelt suspended the regime. By this time policy makers were no longer as keen to adhere to the version of the gold standard that prevailed during the classical period so that the 'Golden Fetters' no longer bound the quantity of money to the price of gold to the same degree. Many decades later, after several bouts of high inflation (see below), the attraction to gold among some observers remains. Nevertheless, to avoid inflation running out of control, as well as for practical reasons, policy makers prefer today to tie their hands by following other kinds of rules (e.g., by following a Taylor type rule previously mentioned) rather than return to what Keynes (1924) once called "a barbarous relic".

[8] For Norway the classical period is thought to be from 1875 to 1914.

4 Central Banks and Inflation

4.1 The Road to Inflation Targeting

The end of World War II may have ended the appeal of the gold standard but it did not end preference for stable exchange rates since to do so otherwise would allow the potential for beggar thy neighbour policies that contributed to the turmoil in international economic relations during the 1920s. Hence, the Bretton Woods system ushered in an era of stable exchange rates around a narrow fluctuation band. Exchange rates could be adjusted but only if sanctioned by a newly formed international organization, the International Monetary Fund, and conditional of reforms undertaken to mitigate the likelihood of a future devaluation. In the immediate post-war era the focus was on the performance of the current account balance. It would take almost two decades after the end of the 1939-1945 conflict for movements in financial flows to begin and eventually to take centre stage in international policy-making.

Despite best laid plans the agreement at Bretton Woods put the U.S., the dominant post-1945 global economic power, at the heart of an asymmetric system that perpetuated an imbalance exacerbated by two oil price shocks during the 1970s as well as the rising costs of the Vietnam war. Since the global currency of trade was in U.S. dollars a U.S. current account deficit would be required to finance a surplus elsewhere. Accordingly, any additional shocks to the U.S. economy that would produce continued rises in trade deficits would simply create the conditions that would become unsustainable. The problem was, of course, well known, in the form of the Triffin paradox, even before the eventual collapse of the Bretton Woods system.

Eventually, the pressure on large surplus economies with a desire for low and stable inflation, such as Germany, produced a divergence in inflationary pressure that could no longer be contained. Hence, the exchange rate anchor that was supposed to hold inflation differentials within some limits was no longer sustainable. Increasingly, advanced economies began to adopt floating exchange rates which, in principle, permitted inflation to be determined entirely based on domestic considerations by acting as a shock absorber against external shocks.

The only exceptions were several countries in the European continent which began preparations for what would eventually become the single currency area, namely the Eurozone. Potential

member economies experimented with several variants of exchange rate regimes with constraints on exchange rate variability again as a means of limiting inflation differentials. Success was, at best, also limited. In spite of setbacks, including the 1992 exchange rate crisis which was an almost existential one, politics trumped economics and the Eurozone came into being in 1999 with the new single currency circulating by 2001.[9]

Once the anchor implicit in the Bretton Woods system could no longer be sustained the search began for a new anchor that would both placate those worried that some countries might take advantage over others via exchange rates, thereby impacting inflation, as well as generate a domestic inflation rate that was economically and politically acceptable. The next candidate, a reflection of the ascendancy of monetarism, was to target some indicator of money growth. Unfortunately, the proposed system was more suitable in theory than in practice. In a world where the central bank can control the amount of currency in circulation and bank reserves, and has good knowledge of the multipliers linking the monetary base, namely the sum of currency and reserves, combined with Friedman's dictum cited at the beginning of the chapter, there is a theoretical and empirical link between money growth and inflation. There are other factors as well such as the velocity of circulation and the interest sensitivity of money demand. If the money demand function is relatively stable then monetary targeting does offer the possibility of inflation control. However, when the money demand function becomes unstable then the money growth-inflation link cannot be severed.

Beyond the potential instability of money demand a central bank that implicitly announces an inflation objective based on a projected level of money growth, usually with a tolerance range to account for uncontrollable factors and permit some flexibility, must revise the money growth objective from the point at which a new money growth target must be announced. As a result, because bygones are bygones, the money growth targeting regime had a built-in base drift problem. Moreover, because it can take some time for any tightening of loosening of policy via

[9] From the standpoint of the history of inflation the Eurozone is an interesting example for the Treaty that established the phases leading to the introduction of the single currency explicitly required prospective, and future, members to meet an inflation convergence requirement. Indeed, a reading of the history of the creation of the European Monetary System (e.g., James 2016), highlights that the focus of concern on the part of the originators of the idea of a single currency was attention to inflation in the prospective member states.

changes in money growth to eventually influence inflation, this posed additional challenges for central banks attempting to tame inflation.

After only a few years of trying the monetary targeting regime collapsed. As former Governor of the Bank of Canada, Gerald Bouey, famously said: “We did not abandon M1, M1 abandoned us.” The unhappy history of monetary targeting in six advanced economies is detailed in Bernanke and Mishkin (1992). Several emerging market economies also claimed to target money growth but, as with the experience of advanced economies, there was little success in adopting this strategy to control inflation (e.g., Mahadeva and Sterne 2000). Indeed, as the monetary targeting experiment showed signs of failure the number of aggregates that central banks monitored began to mushroom. This did not mean that monetary aggregates could not be useful for potentially controlling inflation (e.g., Friedman and Kuttner 1992, Siklos and Barton 2001) but the link became too unreliable for the monetary authorities to retain the strategy.

With exchange rates and money growth falling out favour as anchors the search for a new anchor continued. Meanwhile, central banks were increasingly operating in a world where reserve requirements were no longer the primary instrument used to control the stance of monetary policy. Instead, an interest rate, typically on overnight or short-term funds, was the instrument of choice to influence liquidity in the financial system. The resulting policy rate also had the advantage of being far more transparent than any monetary aggregate. Increases in a policy rate, ceteris paribus, implied a tightening of monetary policy while a loosening would be signalled via a fall in the policy rate. The policy rate became so ubiquitous as the monetary policy instrument par excellence that it served to launch one of the most successful tools to assess the stance of policy and the performance of central banks, namely the so-called Taylor rule (Taylor 1993).

Once a link between an interest rate and monetary policy was established the theoretical device of the Fisher equation provided the necessary link between expected inflation and interest rates. All that was then required was a strategy that guided the public’s expectations concerning monetary policy. In essence this is how inflation targeting was born. By becoming accountable for meeting an inflation objective in the medium-term the central bank communicated via interest rate changes its determination to meet this objective. Moreover, if the mandate to

achieve a stable inflation rate, possibly with a tolerance band, was agreed to or determined by political officials then not only was there some added transparency but, perhaps more importantly, there was the additional requirement of accountability for public officials that would be met. Inflation targeting spread quickly as some of the early adopters (e.g., New Zealand and Canada) experience successes aided no doubt by the benign environment that characterized the Great Moderation (e.g., Bernanke 2004, Blanchard and Simon 2001, Siklos 2017).

The literature on inflation targeting is vast. It is worth noting that no central bank or government has recanted its desire to aim for low and stable inflation. Moreover, in spite of the fact that a sizeable portion of the world economy has adopted the inflation targeting policy strategy, the GFC did mark a shift in emphasis away from a concern over inflation being too high to inflation becoming too low, a point noted earlier. As a result, new adoptions of the inflation targeting regime fell to a trickle after the GFC as central banks and governments became focused on financial system stability. If we date the adoption of inflation targeting to the early 1990s in advanced economies, and the early 2000s among emerging markets, the inflation targeting strategy has become one of the most durable, if not successful, monetary policy strategies ever implemented. The fact that the original idea for controlling inflation via direct emphasis on the performance of the price level goes back to at least the 1930s (e.g., Berg and Jonung 1999) demonstrates that some old ideas prove their mettle at the right time and not necessarily when they are first proposed.

This is not to deny that there are serious criticisms of the inflation targeting regime. Some have complained that the risks of deflation are magnified by a preference for low inflation, whether or not there is a tolerance factor. Others point to what they perceive as central banks becoming obsessed with inflation to the exclusion of a concern for real economic factors. As Mervyn King, former Governor of the Bank of England, once stated (King 1997) there is little evidence that central banks with an inflation targeting mandate are “inflation nutters”. Instead, and in line with the Taylor rule formulation, inflation targeting central banks practice a flexible form of inflation targeting (Svensson 2009).

While the GFC has brought the question of low inflation to the forefront there is another momentous development that may also have contributed to the low inflation environment over the past decade or so, namely the rise of China. Beginning in the 1980s and accelerating during the 1990s China has become the second largest economy in the world. The inflationary experience of China has ranged from high inflation to low inflation with a bout of deflation in between (e.g., Burdekin 2008). Some saw deflation in China which took place during the 1998-2003 period, in contrast with the protracted one in Japan, as supply side driven, or of the "good variety" (e.g., Bernanke 2002) while others have argued that demand factors were also at play (e.g., Burdekin and Siklos 2004, Siklos and Zhang 2010, Borio et al. 2015).

In any event, the combination of a fixed exchange rate and low or falling prices, together with massive increases in output led the argument that low inflation was being exported to the rest of the world (e.g., Côté and De Resende 2008, Kamin et al. 2004). Even if there is some truth to the argument its empirical validity must be assessed against a few of other developments especially in advanced economies. First, real commodity prices fell rapidly during the 1980s and then remained fairly stable until the early 2000s. Second, monetary policy, was becoming tighter in most advanced economies from the mid-1990s again until the early 2000s, that is, until some economies, notably the U.S., were experiencing their first bout of low inflation that threatened to become a deflation no doubt exacerbated by the brief recession of 2001 following the bursting of the tech bubble. Finally, the era in question also coincided with the spread of globalization which also put downward pressure on the growth in consumer prices. We may never know how much of the low inflation was due to the growth of China alone but the fact that inflation continues to be low, many years after China relaxed its fixed exchange rate regime and saw inflation rise, suggests that its role was at best a passing phase in the history of inflation.

4.2 It's a Question of Credibility

In the highly unlikely event that the world returns to a commodity money standard the current fiat money standard will persist and, with it, the risk of potentially significant movements in inflation. While institutional efforts to limit the range of inflation rates experienced in any given economy have spread around the world ultimately it is the market and the public's trust in central banks and governments to deliver low and stable inflation rates that remains essential. Put differently, a successful monetary policy strategy must ensure that the monetary authority remains credible.

Unfortunately, there is no universal agreement on what constitutes credibility. Matters are made more difficult because even if the central bank can control inflation in the medium term there are other sources of shocks that can also influence price developments, including fiscal policy and external shocks, to name just two. Nevertheless, at the core of any definition of credibility there must be the belief that the central bank's views about future inflationary developments are reasonably accurate. Put differently, forecast errors about future inflation ideally should be small and not persist over time. This is the easiest way for market and the public to anchor their expectations and the added constraint of an inflation objective for which the central bank is held to account also helps.[10]

With one exception (i.e., the U.S. Federal Reserve), it is only fairly recently that central banks have published forecasts of members of their policy committee or their staff. Previously, one had to rely on several competing inflation forecasts and surveys of the public's views about future inflation (e.g., Siklos 2018). In any case, one might have expected that, with the arrival of lower and more stable inflation, forecast errors would at least have decreased over time. Sadly, this is not necessarily the case. Figure 7 plots the forecast errors for the G7 economies since the late 1980s.[11] The forecasts are the ones published by *The Economist* on a monthly basis and they are representative of private sector forecasts (e.g., Survey of Professional Forecasters, Consensus Economics forecasts). Large forecast errors persist and can be large and not only because of the

[10] Bordo and Siklos (2016) review the issues surrounding the measurement of credibility and provide long-run historical evidence.
[11] Earlier data are difficult to obtain or are unavailable.

shock of the GFC. Even the introduction of forecasts by central banks, a development of the 2000s, with the exception of the U.S., has not contributed to a reduction in the size of forecast errors. If the errors shown give an indication of the scope for unexpected inflation then there is still, as 2017 comes to an end, considerable room for improvement. After all, most of the negative effects from inflation originate from the portion that is unexpected. It is also notable that, across the G7, forecasters have been routinely over-estimated inflation in the years since the GFC.

Figure 7 about here

4.3 The Link between Inflation and Relative Price Variability

The recent literature on the welfare cost of inflation emphasizes the impact of inflation on the variability of relative prices. Expected and unexpected inflation have both been proposed to increase relative price variability and to distort the information content of prices. Theories explaining the welfare cost of inflation through its impact on relative price variability are typically based on menu cost (Sheshinski and Weiss 1977, Rotemberg 1983) and signal extraction models (Lucas 1973, Barro 1976, Hercowitz 1981). Both approaches predict that inflation increases relative price variability and, thus, decreases the informativeness of prices resulting in a decrease of welfare due to the misallocation of resources. While menu cost models emphasize the effects of expected inflation, the focus of signal extraction models is on the cost of unexpected inflation.

In line with the theoretical predictions, several studies have provided evidence in favor of a positive impact of inflation on relative price variability for various countries (Debelle and Lamont 1997, Aarstol 1999, Jaramillo 1999, Konieczny and Skrzypacz 2005). Nevertheless, following Lastrapes (2006), the relationship between U.S. inflation and relative price variability breaks down in the mid-eighties. Fielding and Mizen (2000) and Silver and Ioannidis (2001) find evidence of a negative relationship between relative price variability and inflation for several European countries. A possible explanation for the mixed empirical evidence is that the investigations rely on the linearity of the relative price variability relationship and that the relationship between inflation and relative price variability is more complex than the linear one (among others, Baglan et al. 2016, Nautz and Scharff 2012).

5 Extraordinary Spells of Inflation: Hyperinflations

While the discussion above dealt with low and moderate inflation rates, we now jump to the extraordinary case of hyperinflation episodes. According to the definition in Cagan's (1956) seminal study hyperinflations start whenever the monthly inflation rate exceeds fifty percent and end in the month the inflation rate drops below that amount and remains below for at least one year. The definition of hyperinflation periods is arbitrary in nature but widely accepted in the literature. Applying this definition, the updated version of Hanke-Krus' World Hyperinflation Table contains 57 hyperinflation episodes as of December 2016 (Hanke and Krus 2012, Hanke and Bushnell 2016). Modern examples of hyperinflations include Zimbabwe and, since November 2016, Venezuela.

Hyperinflations are destructive events for societies. Hence, an important reason for economists to study hyperinflations is to learn how to prevent their outbreak and their damaging effects. Moreover, Cagan (1956) argues that hyperinflation periods provide the unique opportunity to investigate monetary phenomena largely in isolation from changes in real macroeconomic variables because the dynamics of real factors are small compared to the enormous changes in monetary measures. Hyperinflations can be viewed as the laboratory experiments in the field of macroeconomics. Like earth quakes and hurricanes hyperinflationary episodes provide to researchers an unusual type of data. These data can be exploited to learn important policy lessons which cannot be drawn relying on data produced under normal economic circumstances.

As a considerable literature exists about hyperinflations this chapter concentrates on outlining the principal arguments, while the empirical findings are discussed to a lesser extent. The survey starts with the reasons for the origin of hyperinflations in 5.1. Issues on the money demand function and the discussion on self-generating inflation processes can be found in 5.2. Chapter 5.3 is devoted to the termination of hyperinflation episodes.

5.1 Origins

The most obvious reason for the origin of hyperinflations is the excessive growth in the supply of money. The increases in the supply of money necessary to produce such high inflation rates can only occur in systems with fiat money ruling out hyperinflation periods under metallic currency systems or a gold standard. To address the deeper question why central banks excessively print money the government budget constraint needs to be considered. Governments being unable to finance their expenditures on goods and services through regular means of borrowing and taxation resort to monetary financing as the remaining source. The central bank's money printing produces seignorage revenues for the government and increases the supply of money which is, if maintained, ultimately responsible for the hyperinflation. While these arguments are fairly straightforward, it is more difficult to answer the question under what circumstances huge budgetary imbalances are possible to trigger hyperinflations.

Among others, Hamilton (1977) connects wars and hyperinflations. Increases of military expenditures lead to high public deficits which are eventually financed by printing paper currency. However, Capie (1986) argues that it is not war itself that leads to hyperinflation because a war between countries raises patriotism and, hence, enables the government to borrow and collect taxes from the public. Rather civil wars, revolutions or social unrest of different groups within a country trigger hyperinflations. In these internal unstable conditions the collection of taxes and borrowing from the public becomes difficult which ultimately leads to monetary financing.

Weak or inexperienced governments are another potential source triggering hyperinflation episodes. In this case, monetary financing results due to the government's inability to collect taxes and their temptation to provide financial transfers and subsidies to different groups of the society in order to strengthen the political base. Lastly, reparation demands and occupation payments from the allied powers is a potential trigger of hyperinflation (Bresciani-Turroni 1937, Kindleberger 1987).

In general, a necessary condition for the emergence of hyperinflation is the lack of independence of the central bank from the government. If the dependence is strong enough, the government

has an access to the printing press to finance a huge budget. The drastic increase in money supply is the common feature of all hyperinflations.

5.2 Development

Cagan's (1956) money demand function is a special case of Friedman's (1956) demand for money function relating real money balances solely to the expected inflation rate:

$$(m_t - p_t) = \alpha \pi^e_{t+1} + \varepsilon_t \,. \tag{3}$$

The parameter α is expected to be negative, because a rise in inflation expectations π^e_{t+1} is hypothesized to produce a reduction in the demand for real balances $(m_t - p_t)$. Under the circumstances of hyperinflation relative changes in real income and interest rates are small compared to changes in nominal money and aggregate prices so that other principal determinants of money demand can be excluded in (3). One objective of Cagan's study was to demonstrate the existence of a stable money demand function even under severe monetary stress of hyperinflationary periods.

The estimation of the money demand function (3) requires data on the money stock and the price level which are sourced from the countries' official statistics. While data real money stock are directly observable, the expected inflation rate is per se an unobservable variable. The empirical literature solved this data issue in different ways. Cagan (1956) relied on the adaptive model of expectations formation in which the expected inflation rate is a function of both past inflation and inflation expectation. Solving recursively, the real money stock is a function of a distributed lag of past actual inflation rates.

The conceptual difficulties and the literature on rational expectations has led to an examination of the conditions under which the adaptive expectations process is rational (Muth 1961, Sargent and Wallace 1973, Sargent 1977). Alternatively, Frenkel (1977) propose a direct measure of inflation expectations that is based on observed data from the forward market for foreign exchange. The premium (discount) on a forward contract for foreign exchange measures the anticipated depreciation (appreciation) of the domestic currency in terms of foreign exchange.

Hence, the specification of the demand for money includes the anticipated change in the exchange rate as measured by the forward premium (or discount).

While Frenkel's approach is appealing, the role the forward premium plays in the demand function is not straightforward. In Frenkel's approach the forward premium serves as a measure of inflation expectations which is the true argument in the money demand function. An alternative interpretation emphasizes the substitution possibilities between domestic and foreign currencies. Under condition of hyperinflation, agents have strong incentive to substitute foreign for domestic currency. With this interpretation the expected rate of currency depreciation is the true variable in the money demand function. Moreover, both domestic goods and services as well as foreign currencies may be alternatives to holding domestic money. With this interpretation expected inflation and expected depreciation are both arguments in the money demand function (Abel et al. 1979).

Cagan's framework suffers not only from using the adaptive expectations approach due to its well-known conceptual difficulties and econometric drawbacks, but in addition, – understandable given the econometric knowledge of the time – from reliance on non-stationary time series. Both aspects are taken into account simultaneously by Taylor (1991). Relying on the cointegration technique (Engle and Granger 1987, Johansen 1988) Taylor puts forward a test of the Cagan model which is subject only to very weak assumptions concerning the inflation expectations, i.e., agents' inflation forecasting errors are stationary. Consequently, the actual inflation rate rather than a measure of the expected inflation rate appears in (3). If the time series of real money balances and the inflation rate are integrated of order one and are cointegrated, estimates of the parameter of interest are then super consistent and robust to simultaneity and omitted variables. Moreover, Cagan's conjectures concerning the relative magnitude of real and financial variables during hyperinflation are supported subject to the very weak assumption on agents' expectations that forecasting errors are stationary. The application of cointegration techniques to estimate Cagan's money demand function has the additional advantage that a valid cointegrating relation between real money balances and inflation rate implies the stability of the money demand function.

Relying on Taylor's argument the actual inflation rate instead a measure of the expected inflation rate is used in (3). As hyperinflations arise under extreme conditions, like wars, revolutions, political mismanagement, barriers to the recording and publication of reliable official inflation statistics exist. The lack of reliable price index data can be overcome relying on the principle of purchasing power parity. In its relative form the inflation rate differential between two countries is equal to the change of the exchange rate. In case a free market for currencies exist and market data are available, changes in the exchange rate are reliable estimates of the country's inflation rate (Frenkel 1976, Hanke and Kwok 2009).

With a few exceptions only the empirical findings show a negative estimate of the money demand parameter α. Moreover, the findings mostly indicate a cointegrating relation between real money balances and the inflation rate. The empirical evidence varies to some extent depending on the individual country, the sample period, the data set, treatment of extreme values and the econometric specification. Hence, Cagan's original findings concerning the parameter of interest and the stability of the money demand function are largely confirmed by the application of up to date econometric techniques.

Cagan's work was not only the origin of research on the demand for money during hyperinflation, it was also the beginning of studies on the possibility of self-generating hyperinflations. Following Cagan's argumentation, in a self-generating inflation a small rise in money supply causes a disproportional increase in the price level. More current treatments utilize the argumentation of a rational bubble in prices. Speculative hyperinflations exhibit explosive price paths both related to monetary growth and speculative bubbles. Rational bubbles reflect price level dynamics which are driven by self-fulfilling expectation independently of fundamental determinants. The appropriate policy to deal with hyperinflations is different depending on the nature of the underlying inflation generating process. If bubbles are not present, the cause of hyperinflation is solely fundamental. A necessary and sufficient condition to stop hyperinflation is to take firm control of the market fundamentals. If, however, hyperinflation is driven by rational bubbles, restrictive policy actions will not necessarily bring an end to the hyperinflation. Rather, inflation stabilization program has to consist of actions needed to prick the bubble process.

Flood and Garber (1980) propose direct tests for price bubbles. However, as direct tests places strong restrictions both on the relation between inflation and market fundamentals and on the nature of bubbles, the correct specification of the tests is doubtful. As a consequence non-structural test approaches are used. Hamilton and Whiteman (1985) suggest a test of the order of integration in the time series of interest: If the price level time series exhibits a higher order of non-stationarity than any of the underlying fundamentals evidence in favor of speculative bubbles in the inflation process is found. The same order of integrability indicates the absence of bubbles in the hyperinflation process.

Hamilton and Whiteman's approach has the deficit that even if the time series of the price level and the fundamental variables are integrated of the same order, a rational speculative bubble cannot be ruled out. Following Diba and Grossman (1988a) the existence of a cointegrating relationship between prices and fundamentals indicates the absence of bubbles in the price process, while in case of no cointegration bubbles may exist. In essence, if prices are not more explosive than money supply, then it can be concluded that rational bubbles are not present, since they would generate an explosive component to prices. Diba and Grossman (1988b) provide a theoretical foundation for the application of conventional cointegration tests as these rely only on the expansion phase and ignore the burst of a bubble process. Diba and Grossman show that if bubbles crash they cannot start again which makes continuously growing and bursting bubbles impossible. Nevertheless, allowing for a more general class of periodically collapsing bubbles or temporary bubbles the application of conventional cointegration tests may lead to a rejection of the existence of rational bubbles even if periodically collapsing or temporary bubbles are present (Evans 1991). In this vein, Funke, Hall and Sola (1994) put forward a variant of Hamilton's (1990) Markov Switching technique to analyze rational bubbles during hyperinflationary periods.

Glancing through the literature the existence of speculative bubble components in hyperinflation processes can be ruled out empirically. Hence, the empirical studies find mostly evidence against self-generating hyperinflations. This finding has policy implications for the ending of hyperinflationary periods.

5.3 Ending

Accepting the empirical finding of the absence of self-generating components as drivers of hyperinflation, hyperinflationary periods can be stopped by a combination of economic policies affecting fundamentals, like the exchange rate, the public deficit, the money supply and measures for wages and prices. A critical element for the success of stabilization programs is the government's credibility and their capability to convince the public to follow stable policies in the future. All hyperinflation end abruptly, although several attempts to stabilize inflation have failed.

Given the approximate validity of the purchasing power parity the exchange rate is the crucial link between foreign and domestic prices for goods and service. During hyperinflation the exchange rate depreciates at approximately the same rate as the domestic price level increases. Hence, stabilizing the exchange rate may stabilize domestic prices as well. After a devaluation of the official exchange rate stabilization programs require to fix the exchange rate at a level which can be defended by the central bank. A stable exchange rate, in turn, requires a tight fiscal policy (Dornbusch and Fischer 1986).

The most fundamental step in ending hyperinflation is to eliminate the budgetary problems leading to the hyperinflation (Sargent 1982). Successful stabilization programs require a reorganization of government finances and an ending to the reliance of the government to finance its expenditures through the issue of money. Solving budget problems is a precondition to gain control over monetary growth so that hyperinflationary periods can be stopped by ending monetary accommodation. The step consists of an increase in political independence of the central bank to refuse money creation. Moreover, improvement of the budget situation requires fiscal austerity and a rise of tax revenues. This involves a comprehensive tax reform and the elimination of government subsidies (Morales and Sachs 1989).

The above considerations concentrate on an orthodox mix of fiscal and monetary policies. The combination of orthodox policies with measures aimed at wages and prices is called heterodox stabilization policies to ending hyperinflations (Bruno et al. 1988). The heterodox approach argues that tight fiscal and monetary policy are not sufficient to stop hyperinflation. Heterodox stabilization programs justify the direct interventions into wage and price settings with the

argument of a large component of inflation inertia emanating mainly from long-term labor contracts and wage indexation based on past inflation. Wage and price controls at the beginning of the reform interrupt inflation inertia and bring down the public inflation expectations. In addition, peoples' confidence in the stabilization program is promoted.

6 Conclusions

In an important sense the present survey reaches a conclusion similar to the one highlighted by Laidler and Parkin (1975) over forty years ago. Inflation, if fully anticipated, produces modest social costs. We are no closer to knowing what is 'optimal' inflation except that low and stable inflation come closest to reducing the loss of purchasing power of money. Because prices of goods and services incorporate elements that are difficult to measure precisely we cannot even be sure what the actual level of inflation really is. Hence, what is deemed low may well differ across countries and across time. Nevertheless, avoiding inflation is not only desirable because it represents a form of taxation without representation but, in theory at least, low and stable inflation ought to be more easily forecasted thereby reducing the likelihood of large and persistent forecast errors.

The common feature of all hyperinflations is a drastic increase in the money supply which results from the need to finance huge budget deficits. Hyperinflations emerge only in regimes of fiat money. Lack of independence of the central bank which can be forced to finance the government budget deficit via money printing is another precondition. Moreover, hyperinflations emerge during or in the aftermaths of war, civil war, revolution or social unrest. Even under the enormous monetary stress money demand functions are stable. During hyperinflationary periods speculative bubbles can be ruled out. Stopping hyperinflations requires a combination of policies concerning the exchange rate, public budget, money supply and, in some cases, direct measures aimed at wages and prices as well as public confidence in the package of measures.

In terms of monetary policy, generally inflation performance represents a critical determinant of central bank credibility. Once lost, credibility is difficult to re-establish. Unfortunately, low and stable inflation need not imply that it is easier to forecast. In spite of great advances in theory and empirical evidence, the economics profession remains far away from providing a conclusive

account of the dynamics of inflation. It is hoped that, by the time the next survey of inflation is written, we will have successfully addressed this issue.

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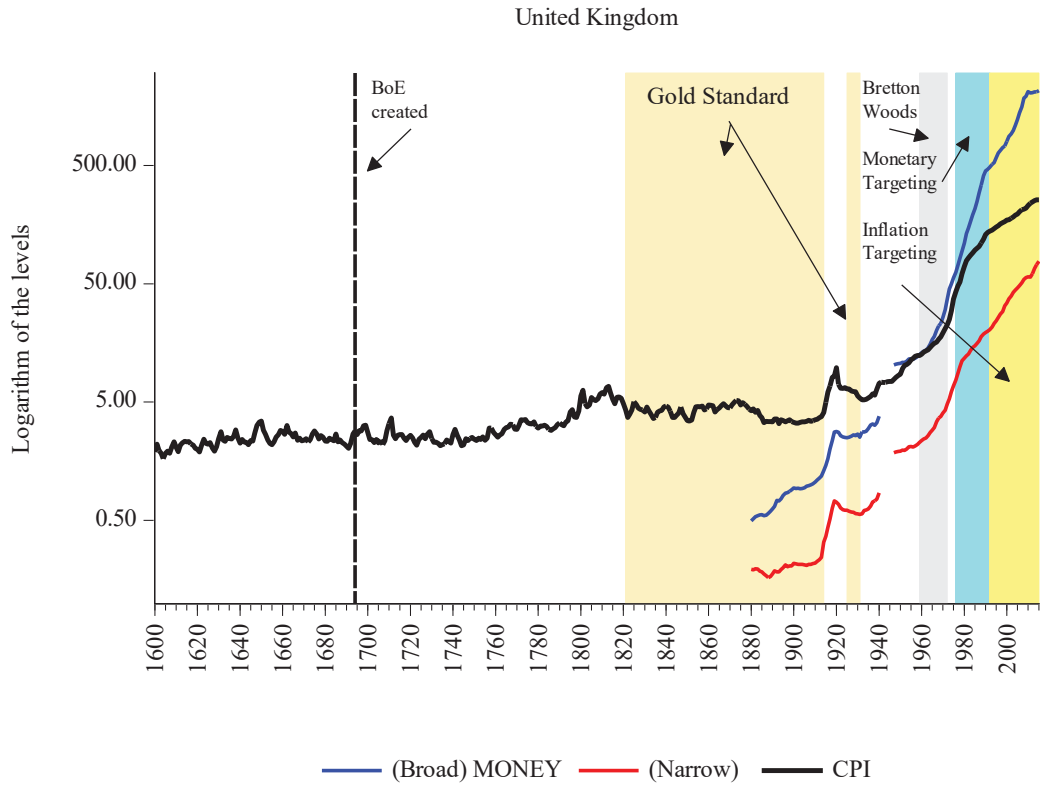
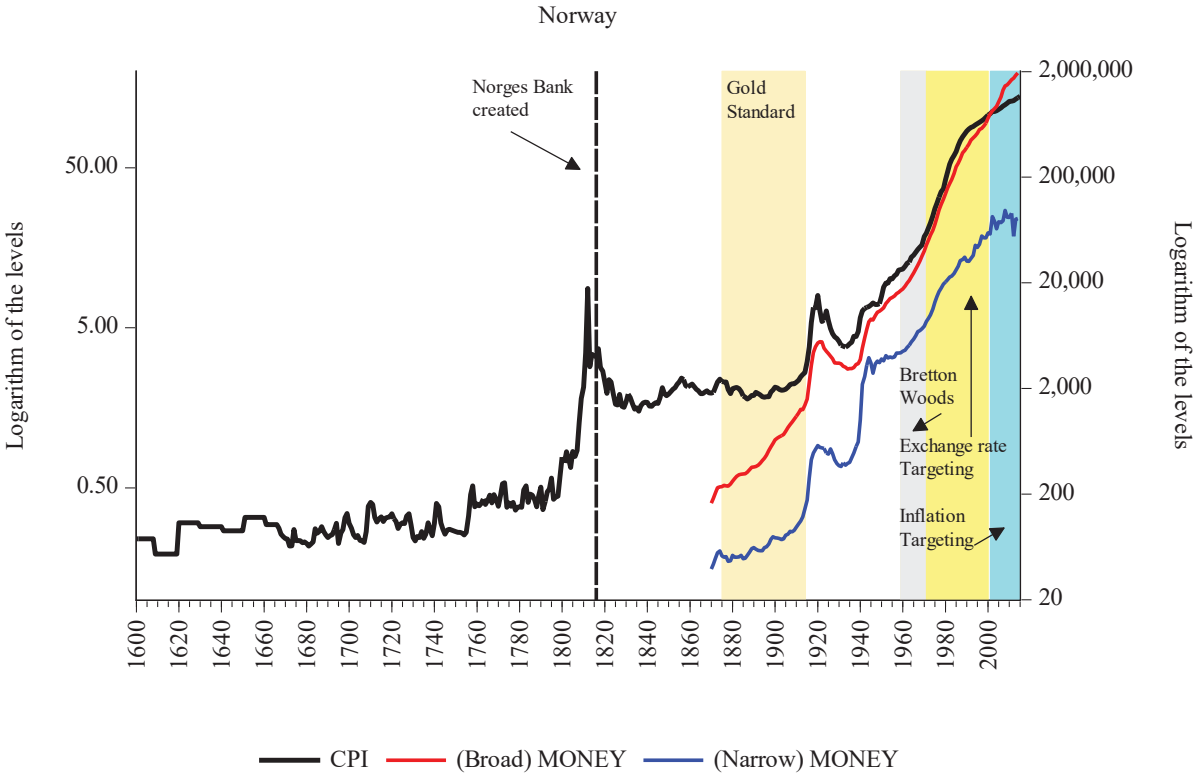
Figure 1: Consumer Prices and the Money Supply in the U.K. Since 1600



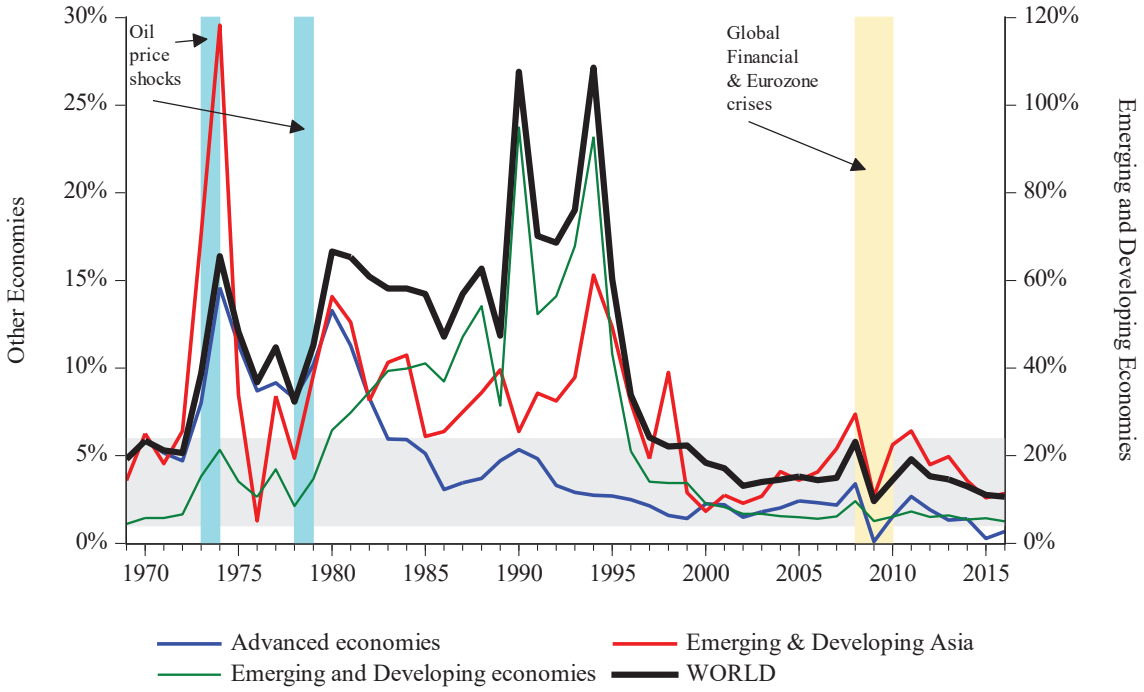
Note: Data and sources are from Bordo and Siklos (2016, 2018). Narrow money is essentially currency and bank reserves; broad money includes deposits. Definitions of reserves and deposits change over time. CPI is a measure of consumer prices. Precise dating of policy regimes is given in Bordo and Siklos (2018).

Figure 2: Consumer Prices and the Money Supply in Norway Since 1600



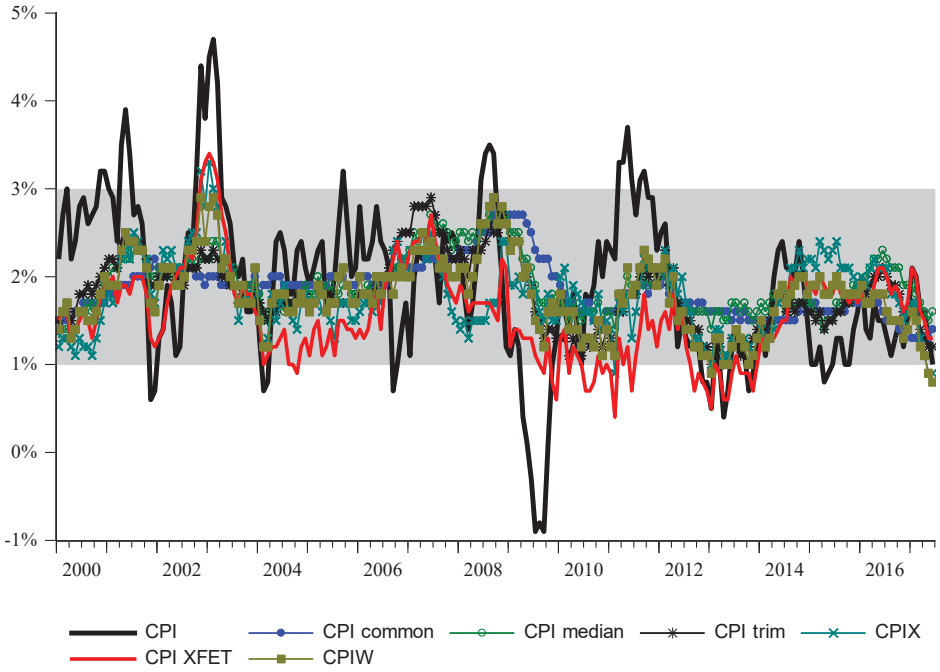
Note: See note to Figure 1.

Figure 3: Inflation Rates in Various Parts of the Globe Since 1969



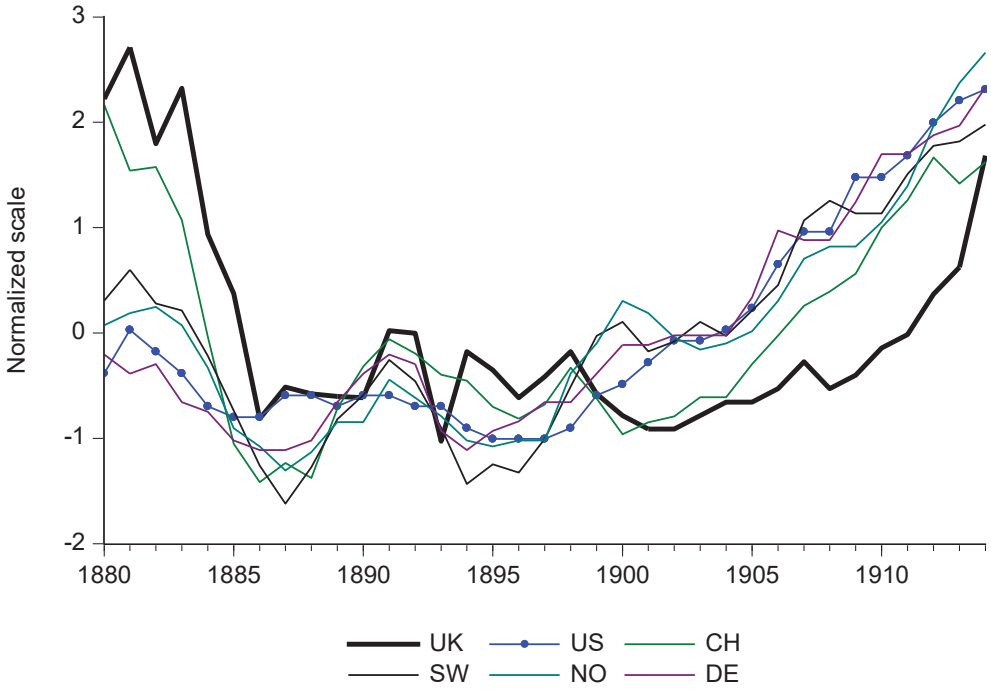
Note: Inflation is the percent change in the CPI. Country groupings are as defined by the International Monetary Fund. Data are annual from International Financial Statistics (Washington, D.C.: International Monetary Fund), July 2017 CD-ROM. Oil shocks are 1973-1974, and 1979-1980. Global financial crisis is 2008-2009.

Figure 4: Varieties of Inflation Rates: The Case of Canada, 2000-2017



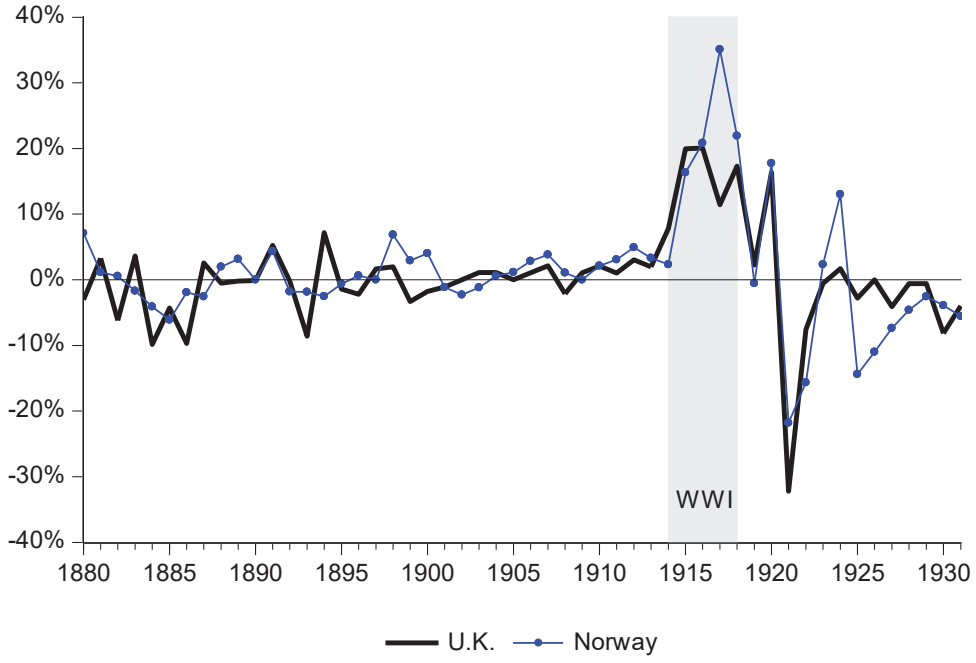
Note: Data source is given in the text. The data source also provides detailed definitions for each measure of inflation. The shaded area represents the 1-3% inflation target range the Bank of Canada is expected to meet. Inflation is 100 times the first log difference of consumer prices. Data are monthly.

Figure 5: Price Levels During the Gold Standard, 1880-1914



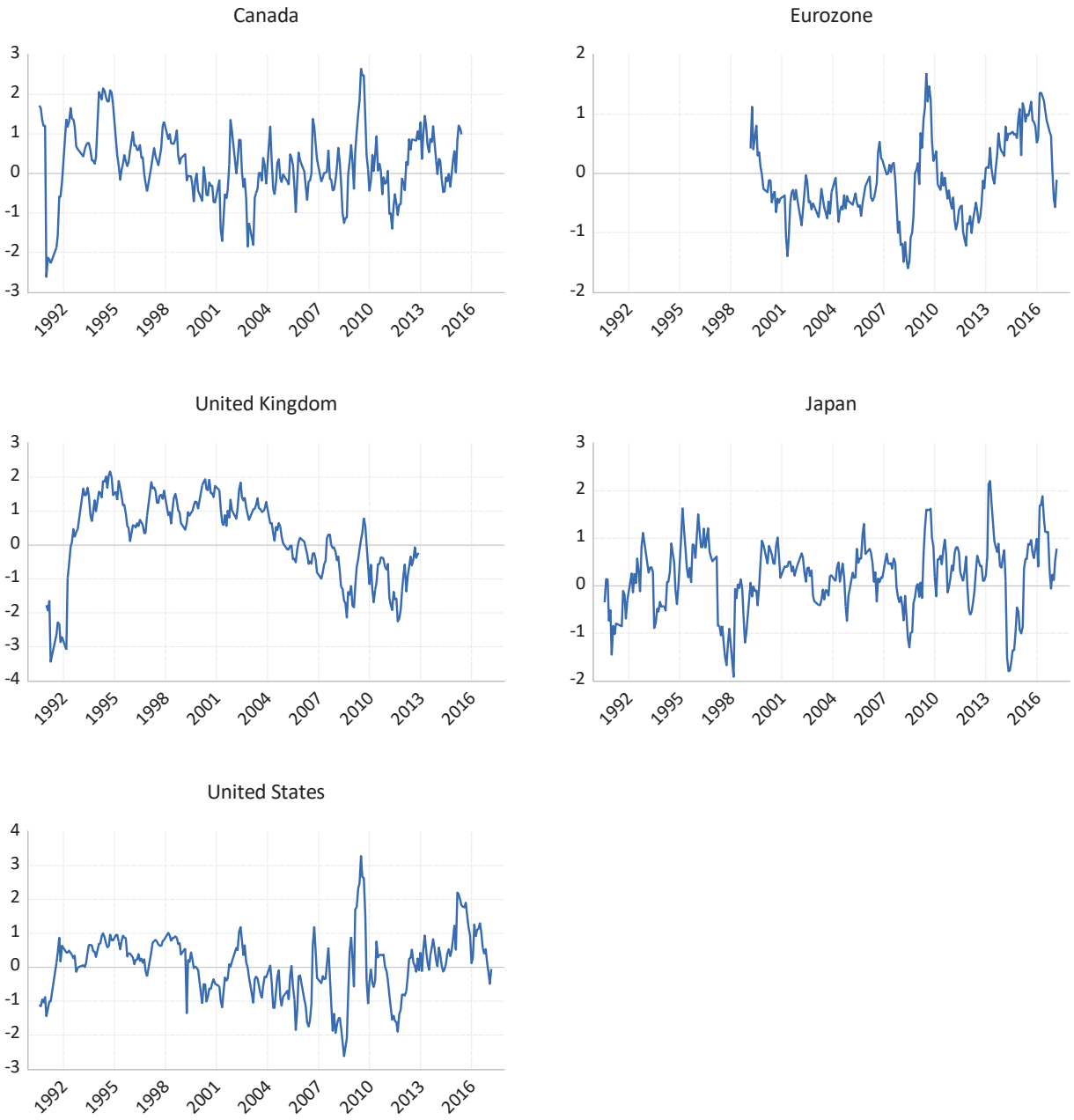
Note: The price levels (different base years) are normalized (i.e., divided by their respective standard deviations) to ensure comparability. UK is United Kingdom, US is United States, CH is Switzerland, SW is Sweden, NO is Norway, and DE is Germany. Data are annual from Bordo and Siklos (2018).

Figure 6: Inflation in the UK and Norway During the Gold Standard, 1880-1931



Note: Source is the same as for Figure 5. Inflation is 100 times the log first difference of the price level.

Figure 7: Inflation Forecast Errors, G7



Note: Inflation in CPI from June 2017 International Financial Statistics CD-ROM (Washington, D.C.: International Monetary Fund). Current year forecasts converted to fixed horizon (i.e., one year ahead) forecasts using the formula in Siklos (2013). Data are monthly from *The Economist*. Shown is the difference between the forecasted and observed inflation rates. A positive number signifies a pessimistic forecast relative to outturns and vice-versa for an optimistic forecast.