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Central Bank Design[†]

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Starting with a blank slate, how could one design the institutions of a central bank for the United States? This question is not as outlandish as it may seem. As soon as the Iraq war ended in 2003, "the first major issue that Coalition economists confronted: What should be done with the Iraqi dinar?" (Foote, Block, Crane, and Gray 2004, p. 60). The economists involved stated that adopting a new central bank law in March 2004 was one of their first and most important economic accomplishments, and a similar judgment would hold true when independent central banks were created in most transition countries as well. Even looking at high-income economies, in 1992, Europeans had to answer to this question after they signed the Maastricht Treaty (von Hagen 1997). The US Federal Reserve has not been an institution set in stone; slowly, and with turns in different directions, its structure has been molded over 100 years into what it is today.

My goal here is not to describe these historical developments; for those who would like a detailed history, Friedman and Schwartz (1963) is the classic account of the history of the Federal Reserve, and Meltzer (2003, 2009a, 2009b) offers a more recent alternative. Instead, this paper explores the question of how to design a central bank, drawing on the relevant economic literature and historical experiences while staying free from concerns about how the Fed got to be what it is today or the short-term political constraints it has faced at various times. The goal is to provide an opinionated overview that puts forward the trade-offs associated with different choices and identifies areas where there are clear messages about

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optimal central bank design. Romer and Romer (1997) and Blinder (2006) are important precursors.

Stripped to its core, a central bank is the sole institution in a country with the power to borrow from banks in the form of reserves while committing to exchange these reserves on par with banknotes that the central bank can freely issue. More broadly, the central bank can choose some policy instruments that it controls directly, as well as a set of announcements about its knowledge of the economy or future policy intentions. Designing the central bank then consists of specifying three elements: First is the *objective function*, which comes from somewhere or someone, and includes only a few macroeconomic variables, which serve as goals for the central bank, potentially at different horizons, matching the small set of instruments at its disposal. Second, the central bank faces a *resource constraint*, limiting both its ability to distribute dividends as well as the set of policies that it can pursue. Third, there is a set of *equilibrium constraints* mapping policy actions and announcements onto the simultaneous evolution of private agents' beliefs and macroeconomic outcomes, so that commitments by the central bank and transparency about its future intentions can have an effect right away. In the course of exploring these three broad categories, I will discuss twelve dimensions in central bank design.

The Central Bank's Goals

Choosing goals includes reflecting on who makes those choices, which macroeconomic variables are included and at what time horizon, and how to consider differing views.

Dimension 1: The Strictness of the Central Bank's Mandate

A central bank is an agent of the government that should serve society. Basic democratic principles suggest that society should give it a clear set of goals.

However, the mandate of central banks has traditionally been vague. In the United States, the Federal Reserve Reform Act of 1977 established certain goals for the central bank: "maximum employment, stable prices and moderate long-term interest rates." Before spending too much time at their job, most Fed governors give at least one official speech in which they state their interpretation of this mandate: after all, maximum employment does not mean that every able man or woman must have a job, stable prices do not mean average measured inflation is exactly zero, and the third goal—moderate long-term interest rates—is often a consequence of the first two. The mere fact that the governors feel compelled to make their goals clear shows that they have a great deal of discretion in setting the yardsticks by which their own performance is measured.

An active literature has studied the benefits of giving the central bank more precise mandates. Some of the suggestions are to set an objective function that puts a higher weight on inflation relative to other components of social welfare or that explicitly links the central banker's salary or chances of dismissal to

numerical measures of performance (Rogoff 1985; Walsh 1995; Svensson 1997). A well-established consensus argues for central banks to adopt a numerical nominal anchor, even if an active debate remains on how to pick that anchor and on the strictness and speed at which to reach the target (Bernanke and Mishkin 1997; Woodford 2012). These proposals require a mandate that makes society's goals clear and that offers some direction on how to weight each goal relative to the others.

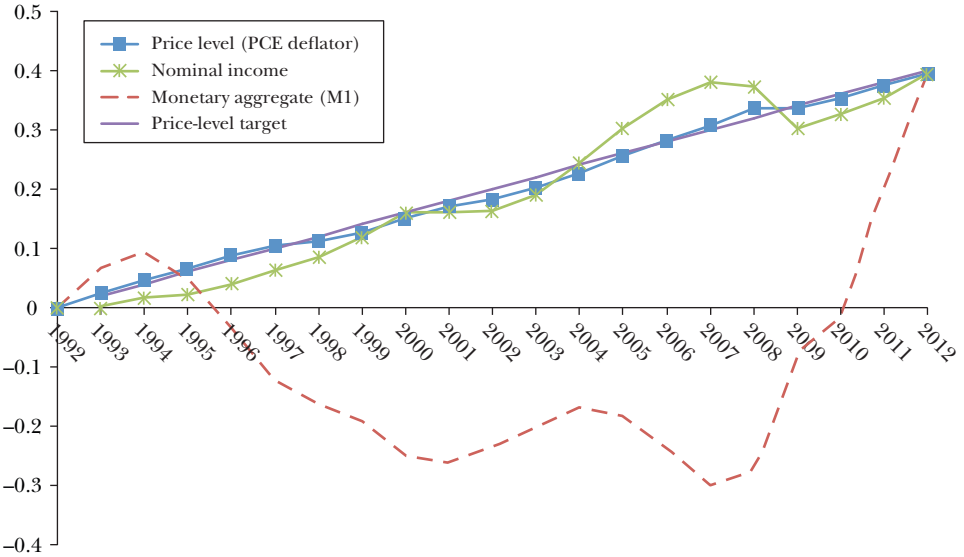
At the same time, questions about what the optimal inflation rate is, whether to target inflation or the price level, or how aggressively to adjust policy in response to unexpected changes in output, involve mostly technical considerations and to a lesser extent disputes on social value. Bureaucrats do not just implement policies, but also shape them. The central bank may be more effective in technical tasks where ability to incorporate quickly changing knowledge is more important than effort at meeting the goals in a strict mandate, and where redistribution is not an important consideration (Alesina and Tabellini 2007). If this is the case, some discretion may achieve an outcome that is closer to fulfilling the overall mandate, even if there is a thin line separating the principles handed to the central bank and the operational targets it sets for itself.

Dimension 2: The Choice of Long-Run Goals

Whether across time, or across countries, there is a strikingly high correlation between the change in the monetary base, the nominal interest rate, and the change in the price level over a period of 30 years (for example, Benati 2009). As Milton Friedman (1970) famously put it: "Inflation is always and everywhere a monetary phenomenon." Because long-run inflation imposes social costs and the central bank has almost perfect control over the quantity of banknotes in circulation and the amount of reserves that banks hold, and can also freely set the interest rate it pays on those reserves and the interest rate at which it lends to banks, it then follows that price stability is a natural long-run goal for a central bank. Indeed, this is true for all central banks of which I am aware, even though with remarkable frequency, actual policy gets focused on a succession of urgent short runs, and prices end up drifting away, as perhaps happened in the 1970s in the United States (Goodfriend 2007). Therefore, it is worth repeating that the central bank should be the agency responsible for establishing a stable nominal anchor.

This mandate leaves open the choice of the appropriate nominal anchor: for example, it can be based in some way on prices, on the quantity of the money supply, or on a measure of national income. My reading of the current literature is that price-level targets bring about less volatile long-run inflation without necessarily higher short-run volatility of output, when compared with measures of either money or nominal income. Monetary aggregates suffer from the important pitfall that financial innovation invariably leads to large fluctuations in the relationship between most broad measures of money and the price level. Moreover, while there are strong arguments for why price instability lowers welfare—for instance, because of the opportunity cost it imposes on holders of currency, or because of inefficient variability in relative prices if prices are set infrequently—research has struggled to

Figure 1
Comparing Long-run Nominal Anchors for the United States, 1992–2012



Source: Author using data from FRED database of the Federal Reserve Bank of Saint Louis.
Notes: Figure 1 uses US data for the last 20 years to plot the price level (the deflator on personal consumption expenditures), a monetary aggregate (M1), and nominal GDP, subtracting a trend from each of these last two series so that their value in 2012 is exactly the same as that for the price level. It also plots a hypothetical price-level target of 2 percent per year.

come up with arguments that are both persuasive and quantitatively large for why instability in monetary aggregates is costly per se, independent of price stability (Williamson and Wright 2010; Woodford 2010). As for nominal income, especially outside the United States over the past century, there was considerable uncertainty on the long-run rate of economic growth in many countries. A central bank can do little about this long-run rate of economic growth, but if it sought to achieve a pre-set nominal income target, this would lead to an unstable price level.[1]

Figure 1 illustrates this point using US data for the last 20 years. It plots the price level, a monetary aggregate (M1), and nominal GDP, subtracting a trend from each of these last two series so that their beginning value in 1992 and their ending value in 2012 is exactly the same as that for the price level. This detrending exercise generously assumes that, in designing policies that target monetary aggregates or nominal income, the central bank would know the long-run trends in velocity and real output. Nevertheless, as the figure shows, while the Federal Reserve policy of focusing on prices has led to a reasonably steady rate of increase in price level, it has

[1] This distinction should not be overstretched; in the short run, a flexible price-level target that responds to the output gap with a coefficient α is equivalent to a nominal income rule with a coefficient $1 - \alpha$ on the output gap.

produced large fluctuations in money and, to a lesser degree, in nominal income. If the Fed had instead pursued these alternative long-run goals, price levels would have likely been more volatile.

If the central bank is focused on a nominal anchor rooted in price data, choices still remain: should it consider the rate of inflation, or should it consider a target for the price level? A price level target might aim to have the price level rise at 2 percent a year, for example. This is not equivalent to a policy targeting inflation at 2 percent. Under an inflation target, bygones are bygones: if inflation exceeds the target in one period, the price level stays higher forever. With price-level targets, higher-than-planned inflation in one period must be followed by commensurately lower inflation in a later period to get back on the target.[2] The literature has identified at least six distinct theoretical arguments for why price-level targets dominate inflation targets at reducing macroeconomic volatility.

First, if a main cost of price variability is that it disrupts people's plans, which they only infrequently or imperfectly update, then it is undesirable to propagate a one-time mistake in inflation forever by making it a part of a permanently higher price level. If the price level is to provide a standard of measurement, much like the meter or the foot, but policymakers cannot prevent deviations in the real counterpart of these units, then they can at least strive to make these deviations short-lived (Hall 1984; Ball, Mankiw, and Reis 2005).

Second, if firms' plans involve sticky prices, then a price-level target has the virtue that forward-looking price setters will moderate how much they increase their prices following a positive inflationary shock today. After a positive inflationary shock, a price-level target translates into a commitment to bring prices back down in the future. Since price setters anticipate they may not be able to change their prices again for a while, they raise their prices by less in response to the shock, so the deviation of inflation from target is lower to start with (Woodford 2003).

Third, a price-level target provides a stronger commitment against the temptation that a central bank continually faces to surprise private agents with inflation. A central bank is tempted to surprise private agents with inflation because a surge of unexpected inflation can increase output and employment in the short run as well as reduce the real cost of government debt. Price-level targeting reduces the incentives for this classic inflation bias as it commits the central bank to undo any positive deviations of inflation from the announced target (Svensson 1999; Clarida, Galí, and Gertner 1999).

Fourth, with a price-level target, there is a smaller benefit of indexing contracts to past inflation than with an inflation target. With a price-level target, workers and firms know that the price level will revert back to its original path after any deviation,

[2] Here is a numerical example: Imagine you have a 0 percent inflation target, but this year some shock hits such that inflation ends up being 1 percent. Then the price level goes from 100 to 101. The next year, the policy says aim for 0 percent inflation again, so prices stay at 101 the following year, so the price level is 101 forever after. If instead your policy is to have the price-level target rise 0 percent, after the price goes to 101, your policy would have you get back to 100 resulting in –1 percent inflation the next year. You would get back to 100 right away and forever.

while with an inflation target, they realize that it requires indexation to have wages and prices keep up with past inflation. Therefore, because fewer firms and workers choose to index their prices and wages, a price-level target frees these prices to become more flexible to react to other shocks (Amano, Ambler, and Ireland 2007).

Fifth, price-level targeting results in a lower cost of capital for the economy relative to inflation targeting. With inflation targeting, the price level follows a random walk: since surprises are never reversed, as one looks further into the future, prices can drift further from the starting point and the variance becomes unbounded. The real payment on nominal assets becomes riskier, which raises their risk premium and therefore the cost of capital in the economy (Fischer 1981).

Sixth, and particularly relevant today, a price-level target is an effective way to guarantee that if a shock pushes the economy into low inflation and zero nominal interest rates, then the central bank automatically commits to higher future inflation escaping from the liquidity trap (Eggertsson and Woodford 2003).

In spite of all of these theoretical virtues, price-level targets have only very rarely been adopted by actual central banks. While each theoretical mechanism above has some evidence to back it, the policy of adopting a price-level target has not been tested. One common objection is that the central bank would have trouble communicating the ever-changing goal for the inflation rate that comes with a price-level target (where positive inflation surprises must come with negative inflation adjustment), to a public that is accustomed nowadays to focusing on 2 percent inflation every year. Yet, over the past few decades, the Federal Reserve has shifted from using targets for monetary aggregates, to targets for the federal funds rate, to targets for inflation. People adapted. In the last few years, the Federal Reserve has offered more frequent speeches, policy announcements about the "quantitative easing" bond purchases, and forward guidance about commitments to a future path for the federal funds interest rates. Again, people adapted. Price-level targets do not seem like such a radical change, in comparison. Another objection is that if agents form expectations of future inflation adaptively as a function of past inflation, price-level targeting will increase instability (Ball 1999). But this begs the question of why agents, even backward-looking ones, would use past inflation instead of the past price level to form their expectations in an economy with a price-level target.

The main reason why the Fed has not discussed adopting a price-level instead of an inflation target is probably empirical. Figure 1 plots what a 2 percent annual rise in the price-level would look like, and it is very close to the actual evolution of the price level. The distinction between inflation targeting and price-level targeting may therefore seem empty of empirical substance. This conclusion would be incorrect. In modern macroeconomics, policy targets and rules affect the expectations and choices of private rational agents, so that even if by chance the path of the price level under policies of price-level and inflation targeting is the same, the six channels described above will lead to higher welfare and more stable real activity under a price-level target. Moreover, modern econometrics teaches us that it would take a great deal more data than 20 years to distinguish

between stable inflation at 2 percent and a stable price level growing at 2 percent a year. A more intriguing possibility revealed by Figure 1 is that the Fed's actions may already be close to a price-level target even as it describes its actions as following an inflation target.

Whether a central bank chooses the inflation rate or the price level, it still faces a question of how to measure the price level. Most measures of inflation are strongly correlated at low frequencies, like a decade or more, but they can differ from each other substantially over shorter periods of several years. Having to wait more than a decade for feedback would obviously make it difficult to assess the central bank's performance. Another difficulty is that even if a broad measure of changes in the cost of living captures social welfare, its variation is dominated by relative-price changes associated with structural changes to potential GDP. If the central bank accepts that monetary policy does not affect potential GDP, then these long-run changes in relative prices are beyond its control. This last argument suggests two ways to construct an appropriate yearly measure of long-run target inflation: look at the change in prices that are by construction uncorrelated with output at low frequencies such as a decade or more (Quah and Vahey 1995), or find a measure of "pure inflation" that filters out all relative-price movements and captures only the changes in the unit of account that the central bank can affect (Reis and Watson 2010).

Finally, since real outcomes are what matter to people, it is tempting to suggest that the central bank should also have a real long-run target. However, there is almost a consensus around the Friedman–Phelps claim that the long-run Phillips curve is vertical, meaning there is no permanent trade-off between inflation and real activity.[3] This implies that the central bank cannot use its power over the price level to affect output or employment in the long run, so there is no point in asking it to focus on a long-run real target. Moreover, even if the central bank had such a target, if we do not understand reasonably well the specifics of the long-run tradeoff between prices and output, setting monetary policy in a way that seeks to achieve a real long-run target could have the undesired consequences of inflation or deflation. These two arguments have convinced most central banks not to have a real long-run target, and the large bulk of the literature supports this choice.

However, it is worth remembering that the empirical evidence that there is zero association between the rate of inflation and the rate of economic growth and employment is quite weak. If inflation goes well into the two-digits, the data seem to suggest that there is a negative association with growth and employment. For inflation rates below 10 percent, the failure to reject the null hypothesis of no association involves confidence intervals wide enough that this failure should not be confused for positive evidence that the long-run Phillips curve is truly vertical.[4]

[3] For recent theoretical arguments for why the long-run Phillips curve may instead be upward or downward sloping, see Berentsen, Menzio, and Wright (2011) and Akerlof, Dickens, and Perry (2000), respectively.
[4] See Bruno and Easterly (1998) for the long-run evidence, and Svensson (2013) for a recent empirical argument for a non-vertical Phillips curve in Sweden.

Dimension 3: The Potential Role of Additional Short-Term Goals

In the short run, should a central bank focus solely on a nominal measure, or should it have a dual mandate and also consider some measure of real activity? There is compelling evidence, using multiple methods, time periods, and datasets, that monetary policy has a large and prolonged effect on real activity (among many others, see Christiano, Eichenbaum, and Evans 1999; Romer and Romer 2004b). Steering the economy using nominal interest rates is neither easy nor mechanical, and the debates over the strength and stability of the monetary transmission mechanism may at times seem endless (Boivin, Kiley, and Mishkin 2010). Yet, the history of the Federal Reserve suggests that whenever the central bank neglected the effect of its actions on output and employment, the economy suffered (Romer and Romer 2013). Because social welfare likely depends at least as much on people having a job and food on the table as it does on inflation, there is a strong argument for including some measure of real activity, like output or employment, in the objective function of the central bank (Friedman 2008).

However, including real activity as a goal is only relevant if 1) there is a short-run trade-off between unemployment and inflation—a downward-sloping Phillips curve—that the central bank can exploit, even if only imperfectly, and 2) stabilizing inflation per se does not guarantee by "divine coincidence" that real activity will also perform at its best possible level (Blanchard and Galí 2007). These issues are hotly debated today, but the current state of knowledge leans towards there being a Phillips curve that is downward-sloping in the short run, as well as a trade-off between price stability and real stability such that giving up some price stability can increase the real stability of an economy. As a starting point to exploring this literature, Mankiw and Reis (2010) offer a modern treatment of the theory behind the Phillips curve and Woodford (2010) of optimal stabilization policy. Therefore, this research suggests the case for a dual mandate that looks at both nominal and real outcomes, like the one for the Federal Reserve.

How to weight the nominal or price-based targets and the real-output or employment-based targets when they are in conflict remains open for discussion. At one extreme, the central bank could be quite patient at reversing increases in inflation, with the hope that gradualism will minimize the potential resulting recession, so that the long-term goal of price stability is reached with a lag of several years. At the other extreme, price stability can receive primacy over economic growth and employment, as in the case of the legislation guiding the European Central Bank. Different societies may choose different extents to which the price level is allowed to deviate from target if there is an output gap; this decision will be based on different social weights on the two goals, different opinions on the slope of the Phillips curve, and different estimates of how quickly inflation expectations adjust to news. Whatever the choice, the central bank can adjust to advances in knowledge in these parameters by changing the degree of gradualism in policy while remaining within what is known as flexible price-level targeting (Woodford 2007; Svensson 2010).

A more contentious debate is whether to have a tripartite mandate that also includes financial stability. After all, the two largest US recessions in the last

century—the Great Depression of the 1930s and the Great Recession that started in 2007—were associated with financial crises. Similar to the question of real targets discussed above, if financial stability is to be included as a separate goal for the central bank, it must pass certain tests: 1) there must be a measurable definition of financial stability, 2) there has to be a convincing case that monetary policy can achieve the target of bringing about a more stable financial system, and 3) financial stability must pose a trade-off with the other two goals, creating situations where prices and activity are stable but financial instability justifies a change in policy that potentially leads to a recession or causes inflation to exceed its target.

Older approaches to this question did not fulfill these three criteria, and thus did not justify treating financial stability as a separate criterion for monetary policy. Before the Fed was founded, seasonal and random changes in the demand for currency and reserves led to wide fluctuations in interest rates and to occasional bank failures and panics. The Fed was in part founded to supply an "elastic currency"—that is, to adjust the supply of money to accommodate these demand shocks. Yet the volatility of interest rates in these cases almost always comes with volatile inflation and real activity, so financial stability was aligned with the other goals, and in that sense did not seem to merit separate consideration. Moreover, deposit insurance and financial regulation conducted outside of the central bank already address many of the stability concerns related to shifts in the demand for liquidity. Another approach to defining financial stability was in terms of large asset price movements. Yet, at most dates, there seems to be someone crying "bubble" at one financial market or another, and the central bank does not seem particularly well equipped to either spot the fires in specific asset markets, nor to steer equity prices (Blinder and Reis 2005; Blinder 2006).

A more promising modern approach begins with thinking about how to define financial stability: for example, in terms of the build-up of leverage, or the spread between certain key borrowing and lending rates, or the fragility of the funding of financial intermediaries (for example, Gertler and Kiyotaki 2010; Cúrdia and Woodford 2010; Adrian and Shin 2010; Brunnermeier and Sannikov, forthcoming; among many others). This literature has also started gathering evidence that when the central bank changes interest rates, reserves, or the assets it buys, it can have a significant effect on the composition of the balance sheets of financial intermediaries as well as on the risks that they choose to take (Kashyap, Berner, and Goodhart 2011; Jimenez, Ongena, Peydro, and Saurina 2012). As a result, even for fixed output and prices, changes in the funding structure of banks, in their net worth, or in their perception of tail risk, can create a misallocation of resources that significantly lowers social welfare. While it is not quite there yet, this modern approach to financial stability promises to be able to deliver a concrete recommendation for a third mandate for monetary policy that can be quantified and implemented.

Dimension 4: The Choice of Central Banker(s)

Society can give a central bank a clear mandate with long and short-run goals, but eventually it must appoint individuals to execute that mandate, and they will

always have some discretion. Choosing the central banker is a complementary way to pick an objective function for the central bank. For example, Romer and Romer (2004a) argue in this journal that different chairmen of the Federal Reserve chose very different policies, in spite of an essentially unchanged legal mandate, mostly due to different views on the role and effects of monetary policy.

Most countries do not pick a single person to have absolute power over the central bank, but prefer a committee of several people. A committee has several advantages including the ability to pool information, the gains from having a diversity of views that must be argued for and against, the checks it provides against autocratic power, and the experimental evidence that committees make less volatile decisions (Blinder 2004). For these potential virtues to be realized requires that the committee members have different perspectives, supported by independent staffs, while sharing a common framework to communicate effectively and to come to agreements (Charness and Sutter 2012).

When a committee makes decisions, there needs to be a rule to aggregate the separate preferences of individuals. There is a long literature on voting rules that have some desirable properties, and there is little about the Federal Open Market Committee that requires special treatment (Vandenbussche 2006). A more interesting question is who should have a vote in the committee if the goal is to elicit talent and bring together different information. For example, is it useful to draw at least some of the membership of the committee from different regions of the country? On the twelve-member Federal Open Market Committee, the seven Washington-based members of the Board of Governors are joined by five heads of the existing twelve regional Federal Reserve banks. These regional Federal Reserve banks are not just local offices of the central bank, spread around the country to interact with and provide services to local communities, but actually have some autonomy and a say in monetary policy. The locations of the regional banks, and even the fact that there are twelve districts, resulted from delicate political equilibriums that only partly reflected economic considerations (Hammes 2001). The Federal Reserve Act leaves vague how the twelve regional banks should interact and work together (Eichengreen 1992).

In considering how regional interests are represented at the Fed, one should note there is evidence that US states share most of their risks (Asdrubali, Sorensen, and Yosha 1996). So even if regional governors had only the consumption of people in their region in mind, this fact would justify a focus on eliminating aggregate risk and ignoring idiosyncratic regional shocks. Might regional governors bring additional information that originates from or pertains to their region? Looking at the forecast performance for key macroeconomic variables, the members of the Fed Open Market Committee seem to add little value to the forecast produced by the staff at the Board of Governors (Romer and Romer 2008). Therefore, the case for having regional governors relies more strongly on promoting different perspectives and stimulating original thinking. Geographical distance and separate staffs and budgets may help to cultivate competition in the market for ideas in interpreting the data and arriving at policy proposals (Goodfriend 1999).

Monetary policy not only responds to economic shocks, but it can also be a source of aggregate risk that agents cannot insure against and that induces redistributions of wealth.[5] In a representative democracy, different age cohorts or business sectors may legitimately ask to be represented when these decisions are made. There are two counterarguments to such a request. First, the literature has so far not been able to determine the systematic direction in which monetary policy redistributes wealth across industries or stable groups in the population. While some people may be hurt in each decision to raise or lower the interest rate, if there is no persistent conflict, then it is hard to defend that some groups should permanently have a say when monetary policy decisions are made. Instead, policymakers can, and perhaps should, take into account the redistributions of wealth that their policies induce without having some members of the Federal Open Market Committee designated to stand for the interests of one group. Second, fiscal policy is a more targeted tool when it comes to distributing resources. Even if redistribution is a side effect of monetary policy, fiscal policies may be a preferable tool to undo its effects on the distribution of income, wealth, or consumption.

The Central Bank's Resources and Policy Tools

Like any other economic agent, central banks have limited real resources that constrain their policies (Reis 2013b). The tools of central banks include interest-rate policies that try to control one or more interest rates, quantitative policies choosing the size of the Fed's liabilities and its dividends, and credit policies determining the composition of the assets of the central banks. Designing the central bank requires making sure that these policies all respect the resource constraint of the central bank, and this suggests four more dimensions of central bank design.

Dimension 5: The Role of the Central Bank as a Dependable Source Of Revenue

It is an old adage in monetary policy that the central bank should not monetize fiscal deficits. History teaches that the surest way to produce inflation is to finance government budgets by printing money. Yet these statements are not quite correct. Almost all central banks issue reserves to buy government debt as part of their open-market operations. Printing money that pays for budget deficits is not a taboo, but rather the day-to-day workings of monetary policy. Moreover, when the interest paid on bank reserves is the same as the short-term return on government bonds, as it is today, then when a central bank uses reserves to buy these bonds it is just exchanging one government liability for another, making it hard to argue that this will have any dramatic impact on anything of relevance.

[5] See Bullard and Waller (2004) for some theory applied to central bank design, and Doepke and Schneider (2006), Berriel (2013), and Coibion, Gorodnichenko, Kueng, and Silvia (2012) for evidence on redistribution.

There is a clearer way to state this important wisdom. As part of its activities, the central bank will generate resources, which have three properties: First, these resources, in present value, come exclusively from the seignorage arising from money creation: that is, the resources arise because the central bank pays less-than-market interest on some of its liabilities in exchange for the service that they provide and at the same time earns market interest rates on the assets backed by these liabilities (Reis 2013b). Second, seignorage depends primarily on the level of inflation, since higher inflation taxes the holders of currency by lowering the value of this government liability relative to the goods it can buy; but the generation of substantial revenue requires very high inflation (Hilscher, Raviv, and Reis, in progress). Third, if the central bank pays out its net income every period, then its budget constraint will be respected regardless of the monetary policy that is chosen (Hall and Reis 2013). Governments will always, under fiscal stress, be tempted to demand that the central bank generate more resources and transfer them to the Treasury. Combining the three properties above, we know that 1) the resources come from seignorage, 2) which requires higher inflation, and 3) the central bank can feasibly make the transfers desired by the Treasury. This suggests that to keep prices stable in the long run, central bank design should allow the bank to resist fiscal demands.

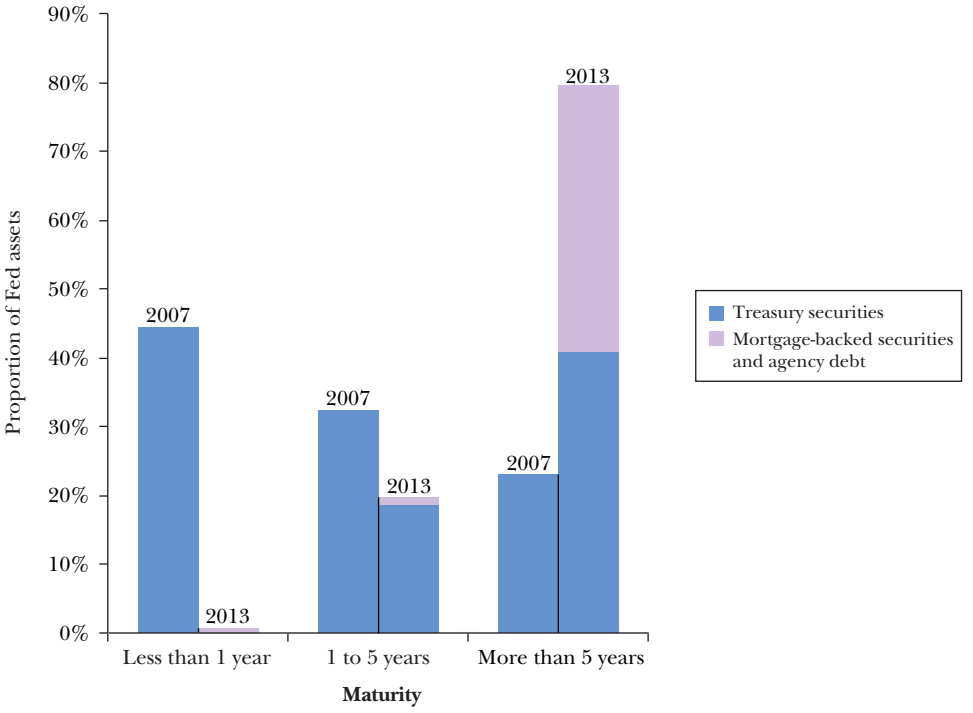
This lesson does not preclude considering the interaction between monetary and fiscal policy in determining inflation (for example, Sims 2013). It also does not deny that it may be optimal in some states of the world to generate fiscal revenues via inflation (Sims 2001; Chari, Christiano, and Kehoe 1991). It simply distinguishes between seignorage revenues, which are small and require high expected inflation, from the fiscal benefits from unexpected inflation that arise, for instance, by lowering the real value of public debt outstanding.

Dimension 6: The Importance of Fiscal Backing for the Central Bank

In conventional times, the Federal Reserve mostly holds government bonds of short maturities and implements monetary policy by buying and selling them from banks in exchange for reserves (Friedman and Kuttner 2010). Under this "old-style" central banking, using open market operations, the assets and liabilities of the Fed are close to riskless and they are matched in their maturity, so net income will almost always be positive (Hall and Reis 2013).

However, if the central bank pays interest on reserves and, especially, if it holds other assets that create a risk–maturity mismatch with its liabilities, sometimes the net income of the central bank will be negative. This is true of the Federal Reserve today as it has embraced a "new-style" central banking where long-term securities that are either issued by the Treasury or implicitly guaranteed by it (agency debt and mortgage-backed securities) now dominate its assets, as shown in Figure 2. The figure shows that in 2007, almost all Federal Reserve assets were in the form of Treasury securities, mainly of short maturities. By 2013, a large share of Federal Reserve assets were in the form of mortgage-backed securities and agency debt, and the Fed primarily held long-term securities.

Figure 2
The Assets of the Federal Reserve by Maturity and Type: Old-Style (December 31, 2007) versus New Style (September 26, 2013)



Source: Author using data from the Federal Reserve statistical release, table H.41.

Most central banks have a rule, more or less explicit, of handing over their positive net income to the Treasury, and the Fed has done so in every year of its existence. However, if there is no transfer in the other direction when income is negative, then the budget constraint of the central bank will not hold (Hall and Reis 2013). Something must give. One plausible consequence is that inflation rises above target so that seignorage is higher and net income does not become negative. Even if this event is rare, expectations of higher inflation can set in even while net income is positive.

Preventing this outcome requires giving fiscal backing to the central bank. One design principle that achieves this backing is to commit the Treasury to transfer resources to the central bank if net income is negative. An alternative is to allow the central bank to build a deferred account against the Treasury when net income is negative, which is then offset against future positive income. Such steps require strict audits of the Fed's accounts, limits to the risks it can take, and an upper bound on this backing, none of which are easy to specify.

A bolder measure that is simpler to implement would be to sever completely the resource link between the central bank and the Treasury. In that case, instead of sending its net income to the fiscal authority, the central bank would directly fund a public good or a public trust fund. As long as the use of funds does not require a stable stream of income, such that periods of negative net income and held-back dividends are not too disruptive, and if its direct recipients do not have the political power to try to extract more from the central bank, the problems raised above would be reduced. (Funding basic research in the social sciences is a provocative candidate!) Under this structure, the central bank would not need the Treasury to provide fiscal backing. The present value of seignorage would become the relevant constraint to cover possible losses and to restrain the risks the central bank takes.

Dimension 7: The Set of Assets Held by the Central Bank

Usually, the Federal Reserve only intervenes directly in the small federal funds market for overnight funds, where not even most banks can trade. Yet the central bank ultimately wants to affect the spending, pricing, and investment decisions of many or most economic agents in order to reach its macroeconomic goals. It must therefore rely on investors, working individually, to move resources across financial markets given the new federal funds rate, ultimately resulting in financial returns moving in all financial markets, both across types of risk and across maturities. Profit seeking will transmit monetary policy choices to the relevant interest rates for the agents' marginal decisions as long as financial markets function reasonably well, meaning that the relationships across securities with different risk and liquidity premia are fairly constant and predictable so that altering one interest rate will create a series of arbitrage opportunities that will end with all interest rates being affected. As long as these conditions hold, even if the central bank could buy other assets, this would make no difference in the effects of policy (Wallace 1981).

Between 2007 and 2009, the Federal Reserve more than doubled its liabilities, from less than $900 billion to slightly more than $2 trillion, acquiring a myriad of other assets that had different risks, maturities, and counterparties. The Fed started making loans to banks, primary dealers, and money market funds; it accepted as collateral commercial bonds as well as auto, student, and small business loans; and it participated in the government bailouts of Bear Sterns and AIG (Reis 2009; Bernanke 2012). Most of these assets were quickly sold as the financial crisis subsided and none of them are left on the balance sheet today. While setting interest rates, and choosing or adjusting the size of its assets are necessarily part of monetary policy, credit policies that change the composition of the assets that a central bank holds are more controversial (Goodfriend 1994). However, in a financial crisis, the central bank has a need, a means, and an ambition to do more than usual and engage in these credit policies. The need arises if cuts in the interest rate in the federal funds market do not lower rates in other financial markets. Perhaps because investors are constrained in their ability to borrow, arbitrage across financial markets will not function well. In this case, the usual mechanism for transmitting monetary policy across interest rates is broken, and purchasing other assets is a

way to bypass it. The means comes because, if markets are quite illiquid, then even the relatively small-scale purchases by central banks can significantly raise security prices and lower their yields (Krishnamurthy and Vissing-Jorgensen 2011). Finally, the ambition is that, if a combination of illiquidity and limits to arbitrage leads relative prices of financial assets to be distorted, then there will be a misallocation of resources that the central bank may be able to correct.

On the other side, there are several objections to a central bank engaging in credit policies. The central bank may realize significant losses, a risk which is greatly magnified with credit policies. Furthermore, if the markets are illiquid enough for the central bank's purchases to make a difference when buying, they are also potentially likewise illiquid enough for it to have trouble selling when it wants to—at least without incurring large losses. Moreover, even when the central bank lends against strong collateral to failed banks, if this keeps nonviable entities operating with growing losses and deposits, it increases the potential losses that deposit insurance will eventually have to bear (Goodfriend 2011). It is also tempting for the central bank to become overconfident about its ability to detect and correct financial market mispricings and to jeopardize the focus on its macroeconomic objectives. Moreover, correcting market distortions is typically the domain of tax and regulatory policy, not central banking.

A final objection is that aggressive credit policy exposes the central bank to legitimate political questions of why some firms, markets, or securities were chosen for support and not others. While conventional buying and selling of government bonds does not clearly benefit one firm or sector, credit policies have clear redistributive effects. At the same time, they also expose the central bank to lobbying pressure from financial market participants. Both will likely get in the way of the central bank's goals (Reis 2013a). A different type of pressure and temptation may come from within the central bank. Without a clear policy rule forbidding the bailing out of systemically important financial institutions, it will always be optimal to do so to avoid a larger crisis; however, the expectation of a bailout may create incentives for banks to become larger, take on more risk, and correlate their exposure so that they become systemically important and thus prime candidates for bailouts (Goodfriend 1994; Stern and Feldman 2004; Farhi and Tirole 2012; Chari and Kehoe 2013).

Given so many virtues as well as objections to credit policy, thoughtful design of a central bank likely puts some restrictions on the assets that the central bank can buy. At one extreme, the policy could be the one that the Federal Reserve faced in 2007, of having to justify unconventional policies to Congress as being due to "unusual and exigent circumstances," which is a fairly vague standard and thus not difficult to meet. At the other extreme, if we judge that there is too much of a temptation for the central bank to find a way to get around the rules, then a strict "buy only Treasuries" rule may be the answer (Goodfriend 2011). Even in this case, the central bank would still be able to shift between short-term and long-term government bonds. These "quantitative easing" policies expose the central bank to maturity risk—when policy becomes contractionary and markets start expecting an upward-sloping path for short-term interest rates, long-term bond prices will fall,

inducing capital losses on the Fed's portfolio—but most empirical estimates of this risk come up with relatively small losses in worst-case scenarios that could easily be written off against a few future years of positive earnings (Hall and Reis 2013; Carpenter, Ihrig, Klee, Quinn, and Boote 2013; Greenlaw, Hamilton, Hooper, and Mishkin 2013).

Between these two extremes, many alternatives are plausible. One concrete restriction would be to prevent the central bank from taking part in ad hoc interventions targeted at specific institutions: that is, the central bank would have to stick to a general policy that is applied uniformly at arms-length across the entire financial sector. This would prevent the Federal Reserve from being able to resolve a particular financial institution, as happened in the bailouts of Bear Stearns in March 2008 and AIG in September 2008. A tighter restriction would require the central bank to purchase only securities for which there is a market price, with enough market participants that compete for the central bank's funds. A stronger version of this rule would prevent the Federal Reserve from intervening in any over-the-counter financial markets. A weaker version could draw from the experience in industrial organization and require the central bank to run a reverse auction, with even a small set of institutions, designed to ensure that its purchases are allocated efficiently.

Dimension 8: The Payment of Interest on Reserves

When a central bank pays interest on the reserves deposited by banks, it can use quantitative policy to satisfy the liquidity needs of the economy. By choosing both the interest on reserves and the federal funds rate, the central bank can at the same time set the short-term interest rate that will determine inflation, as well as affect the amount of liquidity held in the banking sector (Kashyap and Stein 2012). Separately from its interest-rate policy, the Fed can have a large balance sheet, like it does at present, if society wants to keep a larger share of wealth in money-like investments, or the balance sheet can quickly shrink to the pre-crisis levels, all without consequences or dangers for the rate of inflation. Most central banks around the world have the authority to pay interest on reserves, and the Fed joined them in October 2008.

The central bank could go one step further along these lines (Hall 1986). A general principle of economic efficiency is that the marginal cost of producing a good should equal its marginal benefit to society. In monetary economics, this principle leads to the "Friedman rule" which has been reaffirmed repeatedly in a wide variety of models of the demand for money (Lucas 2000; Chari and Kehoe 1999; Lagos and Wright 2005). Applied to reserves, note that it costs nothing to add an extra unit to a bank's reserves balances at the Fed, and that the benefit, or opportunity cost, of holding reserves is the overnight federal funds rate at which banks could lend these funds to other banks. Therefore, the Friedman rule dictates that the central bank should pay an interest rate on overnight reserves equal to the overnight federal funds rate, thus satiating the market with as many reserves as it wants. This "floor policy" would make the interest rate on reserves the primary

instrument of monetary policy and, unlike the federal funds rate, it is perfectly set and controlled by the central bank (Goodfriend 2002; Woodford 2003). There is a strong case for requiring the central bank to not just pay interest on reserves, but also to always follow the Friedman rule via a floor policy.

Transparency, Commitments, and Accountability

Designing the central bank also involves choosing the rules of the game that it will play with private agents. These include what the central bank will reveal, what it will commit to do, and how it will be held accountable to its promises and goals. For example, central bank announcements can be valuable to economic agents because of the information about the economy that they provide, and because they can justify current policy and reveal likely future policies. In some circumstances, like in the "liquidity trap" setting when interest rates have been pushed to zero, forward guidance about keeping short-term interest rates low for a prolonged period of time in order to reduce long-term interest rates right away is one of the few effective tools left for the central bank to stimulate aggregate demand (Eggertsson and Woodford 2003).

Dimension 9: The Importance of Announcements and Commitments

Even when policymakers are benevolent in their intentions, the history of government includes many mistakes and blunders because of incompetence, shortsightedness, hubris, false models, or bad ideas. Milton Friedman (1968) strongly argued that rules for monetary policy are an effective way to prevent mismanagement. The difficulty with most strict instrument rules, such as Friedman's proposal for a constant growth rate of the money supply, is that our understanding of economics is far from complete. Knowledge is still evolving quickly, our data is imperfect, and our theories have uncovered few relationships that are invariant to the policies adopted. Therefore, situations typically arise rather quickly in which any rule becomes not slightly, but grossly, sub-optimal. By the time that Friedman's proposal for a constant growth rate of the money supply became popular in the early 1980s, this policy floundered as the velocity of money started fluctuating wildly. Even with a rule, there is still a significant role for what, for lack of a better word, may be called judgment.

Yet a remarkable result in economics shows that even if policymakers have the same goals and information as private agents, and even if they exercise their judgment to do what seems best, we may end up with clearly inferior outcomes (Kydland and Prescott 1977). The reason is that, even if the policymaker has no initial desire to mislead private agents, after they have made their choices, the incentives of the policymaker change, and it may then decide to implement a different policy from the one that was announced. If agents anticipate this behavior, society may end up worse off. Designing the central bank to tie the hands of policymakers along some dimensions may then improve welfare.

There is a long literature investigating different forms for implementing this commitment (for example, Stokey 2003; Alesina and Stella 2010). One design principle is that if there is a temptation—for instance to generate excess inflation in an attempt to maintain positive output gaps forever—then removing the temptation in the first place (if possible) eliminates the source of the time inconsistency (Blinder 1998). One design that has been adopted all over the world with some success gives central bank governors a long but nonrenewable term of office, which then limits the ability of politicians to remove them or exert pressure to temporarily lower unemployment to win elections (Crowe and Meade 2007).

This does not make the deeper problem disappear: after all, sometimes it will be socially optimal for inflation at a later time to be above what agents had been led to expect. Moreover, if this generates a temptation for the central bank to renege on previous commitments to private agents, it likewise generates a temptation for the government to dismiss a central banker who wished to follow the pre-existing understanding or to alter the terms of the contract it had offered the banker. The literature has suggested that if the central bank makes a public commitment and cares about its reputation in keeping to this commitment, it may be able to bring about a favorable equilibrium (Barro and Gordon 1983; Backus and Driffill 1985). Several countries have done so by adopting rules requiring that the central bank target inflation, and no country has so far abandoned such a rule. The key point here is not to make a case for inflation targeting in particular, but rather to argue for the importance of a commitment by the central bank to announce its projections for the variables in its objective function as transparently as possible.[6] Publishing periodic inflation reports, like the Bank of England or Norway's Norges Bank do, is a way for the central bank to justify its actions and commit to forecasts of its targets. Based on such reports, economic agents can infer whether the policymaker is sticking to its objectives or trying to mislead them. They can compare outcomes with previous announcements and adjust their future actions and expectations to punish policymakers that are perceived to be reneging on their commitment.

Dimension 10: Choosing the Extent of Transparency

While the US Federal Reserve does not publish an inflation report, the Federal Open Market Committee releases a statement and holds a press conference right after it makes decisions and, with varying but increasingly short delays, it makes available the votes, forecasts, and arguments made by each governor, releasing all transcripts after five years. How far can transparency go? Once information has been internally produced, revealing information has a cost that is close to zero on one side of the scale, and positive benefits on the other side of the scale arising from commitment, from improving public information about the economy, and

[6] Chari and Kehoe (2006) associate the adoption of clear rules with addressing the time-inconsistency problem, Svensson (2003) explains targeting rules, Giannoni and Woodford (2010) provide a very general theoretical treatment, and Bernanke and Mishkin (1997) early on defined inflation targeting as a broad framework where communication and transparency are central.

from providing forward guidance about future monetary policy (Woodford 2005; Blinder, Ehrmann, Fratzscher, De Haan, and Jansen 2008). Moreover, there is a prima facie argument for public institutions to be open in order to be democratically legitimate. The question should therefore be put backwards: is there any strong argument for the central bank *not* to reveal everything it knows?

It is arguably appropriate for the central bank to keep to itself the private information it receives from banks it regulates. It may also lead to a more productive internal discussion if the central bank does not reveal every step of its deliberative process too soon after monetary policy decisions. But both of these points are minor exceptions to the general rule of openness, and there is as much risk of these exceptions being violated as there is of them being overstretched.

Of greater concern is whether central bank announcements foster confusion rather than better understanding. A small literature uses models where agents have cognitive or informational limitations that can lead them to misinterpret public information. If the central bank reveals signals about the state variables that agents use to make decisions but it does so in a manner that buries the information in statistical noise, or if it announces the information too soon before it becomes relevant, or if it focuses on variables that are too far from the policy targets, then it is possible to lower the precision of private actions and achieve worse outcomes (Reis 2011; Eusepi and Preston 2010; Gaballo 2013). Moreover, public signals may lead agents to collect less private information, making the price system less efficient and inducing an overreaction of expectations to noisy public signals (Morris and Shin 2002, 2005; Amador and Weill 2010). But while the literature has developed theoretical arguments for why less information *might* raise welfare in a model, it has not convincingly shown that these effects are likely to be present (Roca 2010), quantitatively important (Svensson 2006), or empirically significant (Crowe 2010) in reality. Moreover, in these models, what is usually better than revealing less information is to optimize the form and timing of announcements. The work of national statistical agencies is subject to the same caveats, and they respond by working harder at being informative and clear, not by embracing obscurantism.

Dimension 11: Picking the Channel(s) of Communication

The Federal Reserve has a particular decentralized structure with seven members of the Board of Governors in the center and twelve Federal Reserve Bank presidents as independent poles. Having this many actors in monetary policy poses challenges for making public announcements. First, a decentralized structure makes it difficult to have model-based monetary policy. There is an economic model in Washington, DC, that is used to make staff forecasts, but the district presidents have no input into it. In turn, each of the district presidents has his or her own model and set of predictions. It is hard to explain monetary policy decisions, and especially to announce and commit to future policy and targets, when so many decision makers are partially revealing their views and plans (Ehrmann and Fratzscher 2007). Second, many voices raise the danger of confusing disagreement with uncertainty, in spite of the two being conceptually distinct and empirically only weakly

related (Mankiw, Reis, and Wolfers 2004; Zarnowitz and Lambros 1987). Third, the decentralized structure makes it harder for agents to coordinate on the public signals provided by policy. Some research has suggested that to aid coordination, the central bank could have fewer speeches, which would be more precise and targeted at different groups in the population (Chahrour 2013; Morris and Shin 2007; Myatt and Wallace, forthcoming).

While none of these problems can be completely solved, all of them are ameliorated with more information, including requiring each member of the Federal Open Market Committee to justify his or her views and to report the numerical forecast distributions that support these views. The literature offers few objections to giving the central bank a general mandate to be as transparent as possible while leaving policymakers some discretion on how to implement this mandate.

Dimension 12: The Accountability of the Central Bank

Transparency is a, or perhaps *the*, way of achieving accountability. If the central bank is open about its objectives, its procedure, and its views of the future, that will go almost all the way towards being accountable in its missions to society as a whole (Blinder 2004).

Political oversight goes hand in hand with accountability. The seven members of the Board of Governors of the Federal Reserve are appointed by the President, confirmed by Senate, and periodically answer to Congress. In that sense, both the executive and legislative powers, and the public that elected them, are represented. The overlapping terms for the governors ensure that different waves of those holding political power have an influence, which research has suggested reduces the likelihood of the central bank becoming captured by partisan governors (Waller 1989, 2000).

The regional structure of the Federal Reserve makes power more diffuse, so it is in principle harder for the central bank's actions to be taken over by one particular interest group (Friedman and Schwartz 1963). The 12 presidents of the regional Federal Reserve banks each answer to a board of nine members: three appointed by the Board of Governors, three from the local community, and three from the banks in their district. After the passage of the Dodd–Frank Act of 2010, banks no longer have a vote appointing the president. An interesting open question is whether banks from that district should be singled out, either positively in terms of having three reserved seats in the board, or negatively in terms of having no vote.

Conclusion

This paper has discussed 12 dimensions of central bank design. Table 1 summarizes the recommendations, together with the questions it left unanswered, and an assessment of the Federal Reserve System at present. Three broad issues have been pervasive throughout.

The first issue is central bank independence. While many have defended the virtues of central bank independence in general for preventing the tendency of

Table 1
Dimensions of Central Bank Design

Dimensions	*Suggestions*	*Open questions*	*Federal Reserve*
The strictness of the central bank's mandate	Clear on main goals, otherwise give discretion	Adopt numerical or qualitative targets?	Vague
The choice of long-run goals	Price-level target as nominal anchor	What measure of inflation to use? Include real target?	To provide a nominal anchor
The potential role of additional short-term goals	Dual mandate with clear weights	Tripartite mandate including financial stability?	Dual mandate, price and real stability
The choice of central banker(s)	Committee that shares goals but competes on ideas	Should it consider distributional effects of policy?	Peculiar regional structure
The role of the central bank as a dependable source of revenue	Central bank should not yield to Treasury's demands	How should monetary and fiscal policy interact?	The Fed is independent from the Treasury
The importance of fiscal backing for the central bank	Central bank with a deferred account on the Treasury	Sever the resource link between bank and the Treasury?	Untested until it has negative income
The set of assets held by the central bank	Treasuries at all maturities, other assets in crises but with some limits	Forbid ad hoc interventions that are not arms-length?	Wide in the past, narrower in the future
The payment of interest on reserves	Yes, definitely	Should it always equal the short-term market rate?	Friedman rule at present, future to be seen
The importance of announcements and commitments	Policymakers with long-term mandate and publish inflation reports	How to keep a reputation?	Increasing role through forward guidance
Choosing the extent of transparency	Be as transparent as possible	What is the best timing and form of communication	Rapidly improving, revealing more and sooner?
Picking the channel(s) of communication	All committee members should report their views	How to have model-based policy and diversity?	Rapidly improving, frequent and clear speeches
The accountability of the central bank	Be transparent, have overlapping terms of office	Should banks be singled out as stakeholders?	Strong political oversight, peculiar role of banks

democratic politicians towards ever-higher inflation, looking at more specific questions led to a more mixed message. Even if there is a case for central banks to independently conduct the operations of monetary policy, democratic principles would imply that society would still choose the goals of monetary policy. Committing to a stable long-run nominal anchor may reduce the costs of price uncertainty, but that is not the same as having a fanatic central banker committed to 2 percent

inflation at all times, and research shows that a flexible price-level target may be able to lower the variance of inflation and real activity. In turn, releasing the central bank from the duty to raise seignorage to make transfers to fiscal authorities does not imply that the central bank can assume large risks through unchecked credit policies. Moreover, even if central bankers are appointed to long terms that are independent from political pressure, so that they will not be tempted by the siren lure of unexpected easy money, the goal of avoiding monetary policies that are inconsistent over time also requires that the policymakers are politically accountable and transparent.

The second broad topic was the level of decentralization of the central bank, and in particular of the Federal Reserve. There are reasons to be skeptical of the ability of the Fed's regional structure to reconcile different business interests or to produce new information, and having so many voices raises difficulties for effective communication. At the same time, a decentralized structure makes different actors accountable and fosters the competition of ideas and perspectives. It is harder to argue persuasively that this decentralization should be tied to geography and very hard to justify the current structure of the Federal Reserve System as optimal if one were starting from scratch. The best structure to maximize advantages and minimize disadvantages remains an open question.

The final broad topic was the use of unconventional policy. During a financial crisis, possibly including being stuck in a liquidity trap, the economics literature has put forward arguments that support price-level targets, forward guidance in setting interest rates, paying interest on reserves, allowing the Fed's balance sheet to grow, or changing the maturity of the Fed's holdings of government securities. Yet there are strong objections to letting the Fed hold any type of assets, especially as the risks that comes with them exposes the central bank to potentially large losses of resources, as well as to pressure and scrutiny by those who benefit or lose from those purchases. Moreover, because controlling inflation requires fiscal backing from the Treasury, there must also be limits on the risks to the central bank's net income. More generally, institutional design rules that do not cover exceptional times are incomplete, and the analysis above suggested principles that apply during crises and normal times.

There are many other design issues that were not addressed, especially concerning financial regulation (as discussed by Gorton and Metrick, this issue; Blinder 2010). The broader message of this paper is that designing a central bank need no longer involve a resort to hunches, old aphorisms, or vague platitudes. Diverse tools and models, drawn from different branches of economics, can come together in informing this particular application of mechanism design.

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