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Liquidity: Meaning, Measurement, Management

Robert E. Lucas, Jr.

This article is based on the author's Homer Jones Memorial Lecture delivered at the Federal Reserve Bank of St. Louis, April 2, 2014. (JEL E31, E42, E52, E58)

Federal Reserve Bank of St. Louis *Review*, Third Quarter 2014, *96*(3), pp. 199-212.

"We are Canada's central bank. We work to preserve the value of money by keeping inflation low and stable."
http://bankofcanada.ca/

I like this brief mission statement from the Bank of Canada, both for what it includes and what it leaves out. I think Homer Jones would have liked it too. The maintenance of consistently low inflation rates is an important goal that central banks can actually achieve and, in fact, have been achieving quite well over the past 25 years. One objective of this article is to describe the underlying economic theory that tells us how Federal Reserve actions can attain this goal and the evidence that supports this theory.

Financial stability is another classic responsibility of the Fed. Financial panics are the results of sudden declines in liquidity, and we know that Fed actions can partially offset liquidity declines in an economy on short notice. Is there an underlying economic theory that tells us how this can be done, or better yet, how to arrange matters so that liquidity declines are less likely to occur in the first place? There has been a flood of economic theorizing on this question since 2008, much of it valuable and stimulating, but nothing like the solid evidence that guides the monetary control of inflation has yet been found. My second objective is to explain why short-run monetary stability is so much harder to control than long-run inflation rates.

THE FED AND THE PAYMENTS SYSTEM

The main—really, the *only*—tool the Fed has for influencing the inflation rate is its ability to add to or subtract from the amount of government-issued money—I'll call it cash—in the hands of the public. This is done, of course, by selling government bonds for cash, decreasing

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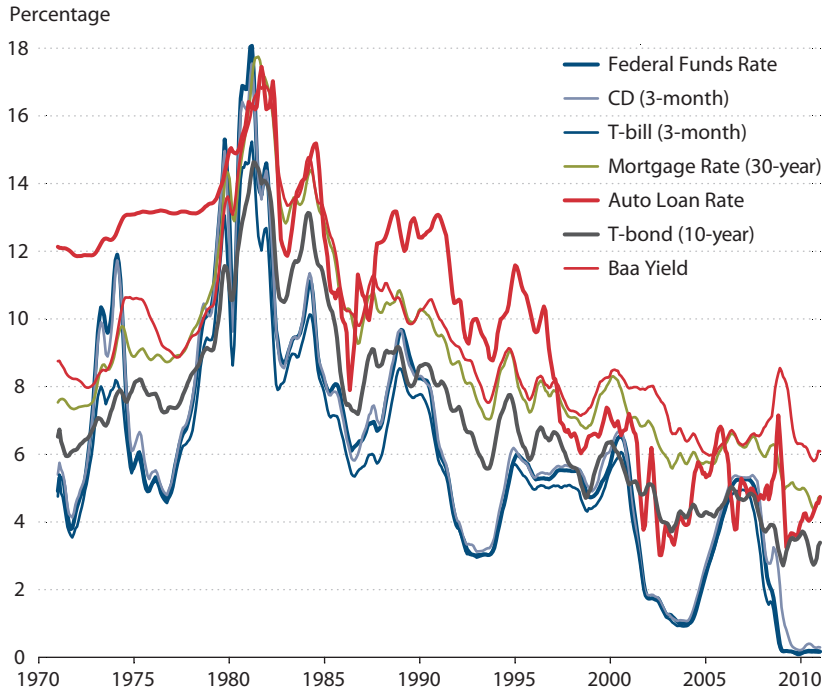
Figure 1

Various Monthly Yields: Low-Frequency Only



SOURCE: Updated from Kim, Hagen. "Common and Idiosyncratic Fluctuations of Interest Rates from Various Issuers: A Dynamic Factor Approach." Ph.D. dissertation, University of Chicago, 2003. Used with permission.

the cash held by the public, or buying bonds with cash, and so increasing the cash outstanding. Here I take a Monetarist view that (i) open market operations affect the quantity of liquidity in the system—the money supply, if you like—and (ii) changes in this magnitude are what determine inflation rates.

These operations affect interest rates, too—how could they not?—but the assets used in monetary policy are money market instruments with yields that are not closely related to interest rates in general. This is clear from Figure 1, which plots seven different interest rates over the period 1970-2012. The three blue curves on the figure are the federal funds rate and rates for T-bills and 3-month certificates of deposit (CDs). They are all alike. High-grade commercial paper would fit right in too. The other four series are rates for auto loans, home mortgages, long-term bonds, and the yield on Baa-rated securities. One can see from the figure that these four do not closely track the three money market yields. No one uses these money market instruments to finance an investment project, a new house, or a college education. These are specialized assets that are useful in cash management: interest-bearing securities that can be easily converted into non-interest-bearing cash as payments come due. In a cashless economy (if there were such a thing), they would not exist at all.

The only reason anyone ever holds cash is to be ready to make payments to someone. That's it. There is no other reason to hold this dominated asset—an asset that has no risk advantage over other assets that offer a higher return. This fact gives rise to a host of other assets that people believe can be traded for cash on short notice, on predictable terms, and without undue labor costs. These qualities define the terms *liquidity* and *liquid asset*. These terms have no meaning outside a payments system. What we mean by liquid assets, then, is a combination of government-issued cash together with various kinds of promissory notes—IOUs, really—that play a role in the payments system by economizing on cash. Like cash, all these money market instruments have lower yields than other assets with the same risk characteristics: They command a liquidity premium. (Again, look at Figure 1.)

It would be useful to have a theoretical understanding of the relationships of different money market instruments to one another. One might think of these assets as being ordered according to the size of their liquidity premiums: government-issued cash first, then bank demand deposits, then Treasury bills and other money market instruments, and so on. As we go down such a list, the effort involved in converting each asset to cash increases. The convenience of the most-liquid assets offsets their lower yields. Think of a "technology" where labor (ours and that of people we employ) and various liquid assets are combined to generate the highest return consistent with payment objectives without increasing risk.

INFLATION AND THE QUANTITY THEORY OF MONEY

We do not now have an established model of such a payments system (though there is a great deal of current research that seems headed in this direction). So I will do what theorists do and replace the complicated reality sketched above with a much simpler, fictional world that will serve as a useful surrogate for some purposes. The surrogate I describe yields some sharp predictions on observable variables. As I will illustrate shortly, these predictions conform extremely well to historical evidence.

Step back from the complexity of actual money markets, then, and imagine an economy in which every payment is made in cash: There is no choice among payment methods and no one will accept any sort of IOU. In this setting, money holdings are well defined and it is natural to assume that average money holdings of individuals and firms will be *proportional* to spending flows: For some constant K,

$$\$ \text{ Spending/year} = K \times (\text{Average } \$ \text{ money holdings}).$$

If my spending doubles, then I want to hold twice as much cash. If the money supply doubles, so will everyone's spending.

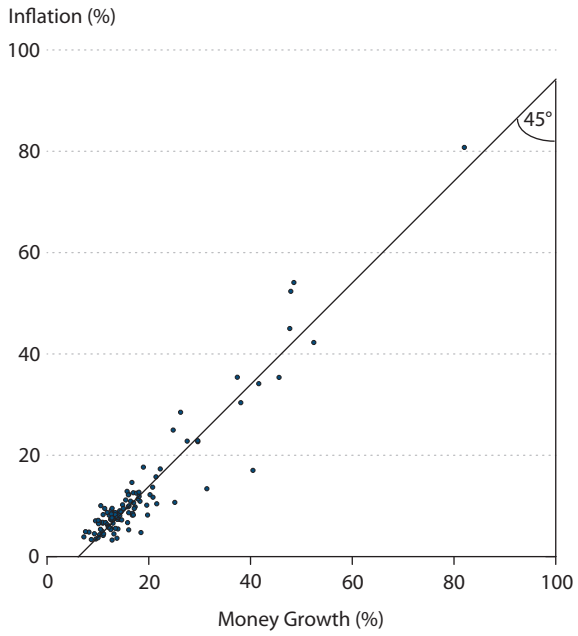
In terms of growth rates, the above formula implies that

$$\% \text{ Spending growth/year} = \% \text{ Money growth/year}.$$

Finally, we add the hypothesis that real growth is a constant 3 percent per year, unaffected by monetary policy. Then,

Figure 2

Money Growth and Inflation: A High, Positive Correlation



NOTE: The figure shows average annual rates of growth in M2 and in consumer prices during 1960-90 in 110 countries.

SOURCE: Data source IMF. Reproduced with permission from McCandless and Weber (1995, Chart 1, p. 5).

Table 1

Correlation Coefficients for Money Growth and Inflation

	Coefficient for each definition of money		
Sample	**M0**	**M1**	**M2**
All 110 countries	0.925	0.958	0.950
Subsamples			
21 OECD countries	0.894	0.940	0.958
14 Latin American countries	0.973	0.992	0.993

NOTE: Based on data from 1960-90. Inflation is defined as changes in a measure of consumer prices.

SOURCE: Data source IMF. Reproduced with permission from McCandless and Weber (1995, Table 1, p. 4).

$$\text{Inflation} = \%\ \text{Money growth/year} - 3\%.$$

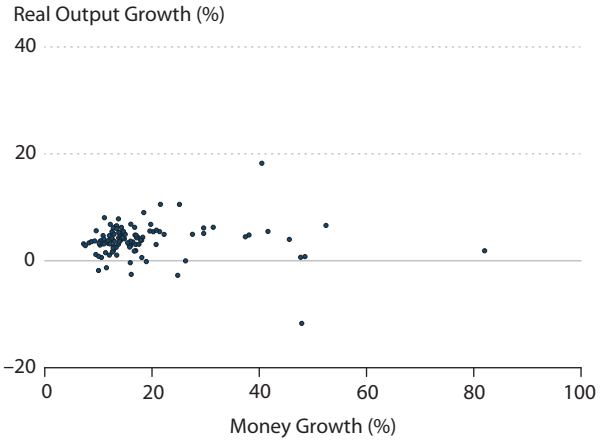
This formula is one expression of what we call the quantity theory of money.

Can these strong assumptions possibly express some useful facts? Let's look at some evidence. To do so, we first need to match objects in the model as best we can with objects we can measure. The National Economic Accounts provide measures of inflation, or we can use the very similar consumer price index (CPI). For the money supply, we have an embarrassment of riches because there is so little agreement on the meaning of the term "money supply" or even whether this idea is worth measuring. (Of course, the same problem arises with the term "liquidity.") Despite this, many measures of money have been proposed and usefully applied over the years.

The measures of money include M0 (actual government-supplied cash), M1 (publicly held currency plus demand deposits), M2 (M1 plus time deposits), and the even broader M3. All of these contain some information about the liquidity in an economy. If we use any but the first of these, we are treating a complicated mix of different liquid assets as though it were a homogeneous "money supply." Clearly there is no right way to do this, but there are useful ways.

Figure 3

Money and Real Output Growth: No Correlation in the Full Sample…

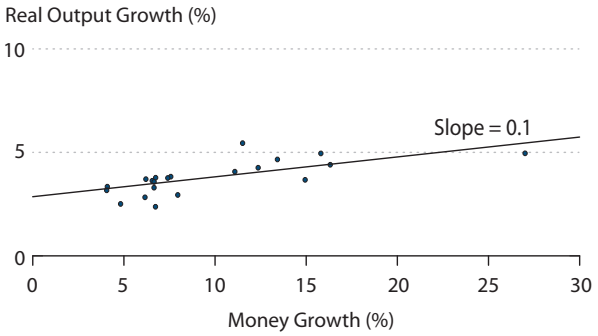


NOTE: The figure shows average annual rates of growth in M2 and in nominal GDP, deflated by consumer prices during 1960-90 in 110 countries.

SOURCE: Data source IMF. Reproduced with permission from McCandless and Weber (1995, Chart 2, p. 7).

Figure 4

…But a Positive Correlation in the OECD Subsample



NOTE: The figure shows average annual rates of growth in M0 and in nominal GDP, deflated by consumer prices during 1960-90 in 21 countries.

SOURCE: Data source IMF. Reproduced with permission from McCandless and Weber (1995, Chart 3, p. 8).

We look first at cross-country evidence from International Monetary Fund (IMF) data from 110 countries over the period 1960-90, as presented by George McCandless and Warren Weber (1995). Several different measures of money are used in the figures and tables that follow.

The results are a striking confirmation of the one-for-one effects of money growth on inflation. The money measure used in Figure 2 is M2, but Table 1 shows that M0 and M1 yield very similar results. Figure 3 plots average real gross domestic product (GDP) growth over the same period and the same countries. Using the entire sample, they appear unrelated. For the subsample of members of the Organisation for Economic Co-operation and Development (OECD), there is a slight positive correlation of money growth and real growth (Figure 4). Other studies of money growth and real variables have also been inconclusive. There is no systematic relation between real and nominal growth, but some kind of relation cannot be ruled out.

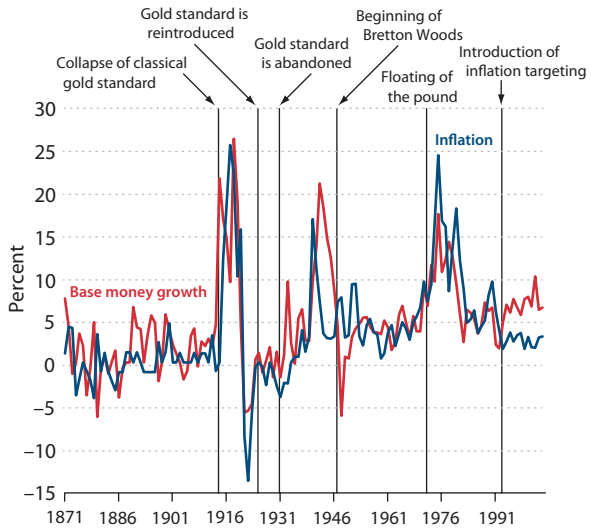
We have looked at 30-year average inflation rates across countries. Can we learn more from data over time within specific countries? This is a harder question, but worth pursuing. Here I rely on a series of papers by Luca Benati (2005, 2009). Figures 5 and 6 illustrate the methodology. Figures 7 through 9 provide more evidence from several countries and for different choices of monetary aggregates.

Figure 5 plots the monetary base (M0) and inflation rates for the United Kingdom over the period 1870-2005. The two series tend to move together, but the details are hard to read:

Figure 5

Inflation and Money Growth in the United Kingdom: Raw Data

Composite Index Price* and M0 (annual rates of changes)



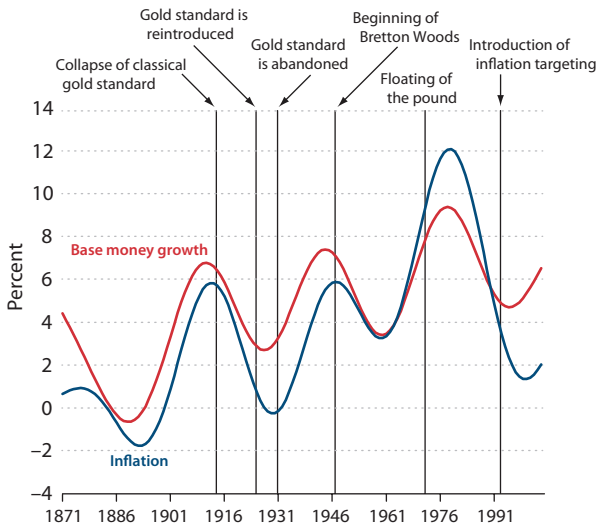
NOTE: *See O'Donoghue, Goulding, and Allen (2004).

SOURCE: Reproduced from Benati (2005, Chart 1a) with permission from the Bank of England.

Figure 6

Inflation and Money Growth in the United Kingdom: Components Beyond 30 Years

Composite Index Price and M0 (annual changes)



SOURCE: Reproduced from Benati (2005, Chart 2a) with permission from the Bank of England.

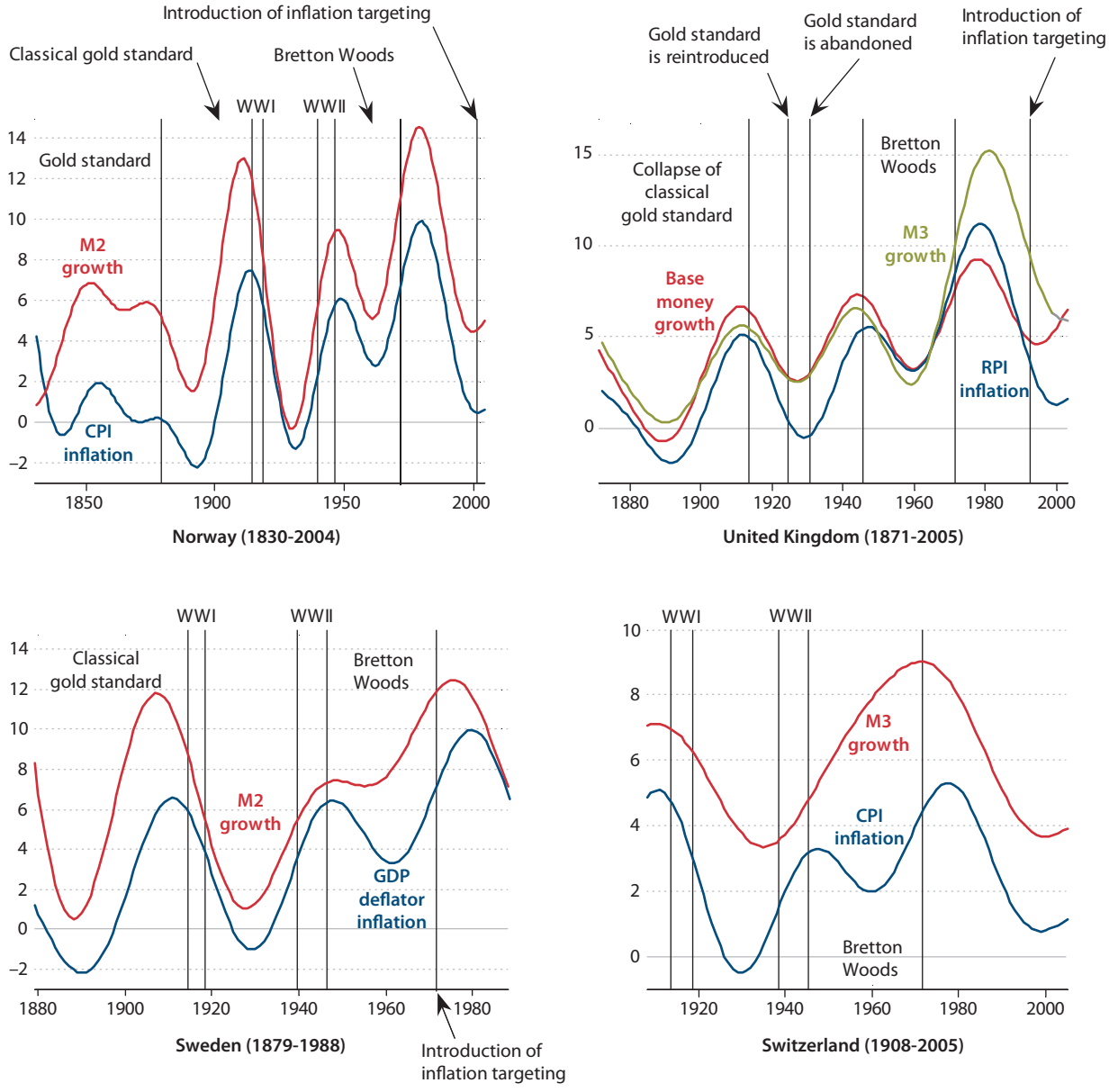
How similar are these series? Figure 6 offers one way to answer this question. It is based on the same data used in Figure 5 but with the high-frequency movements removed using a statistical filter. The filtering process loses a lot of information, but in return provides a crystal clear picture of the long-run relation between base money and inflation rates. These two filtered time series exhibit exactly the same one-for-one relation seen in the cross sections!

Figures 7 through 9 all apply the same filter used in Figure 6. They differ in the countries studied, the time periods, and the measures of the money supply used. There are interesting differences among these, to be sure, but it is easy to see the predominance of this one-for-one relation in all of them.

These data compare filtered versions of two completely different time series—inflation rates (determined by millions of individual prices) and money growth rates (based on a variety of liquidity measures), over which the Fed has decisive influence. People who do not do empirical work in economics (which includes many economists!) may not appreciate just how good these results are, but I would not recommend a scientific career to anyone who is not impressed by this evidence.

Figure 7

Low-Frequency Components of Inflation and Money Growth Since the Gold Standard Era: Norway, United Kingdom, Sweden, and Switzerland

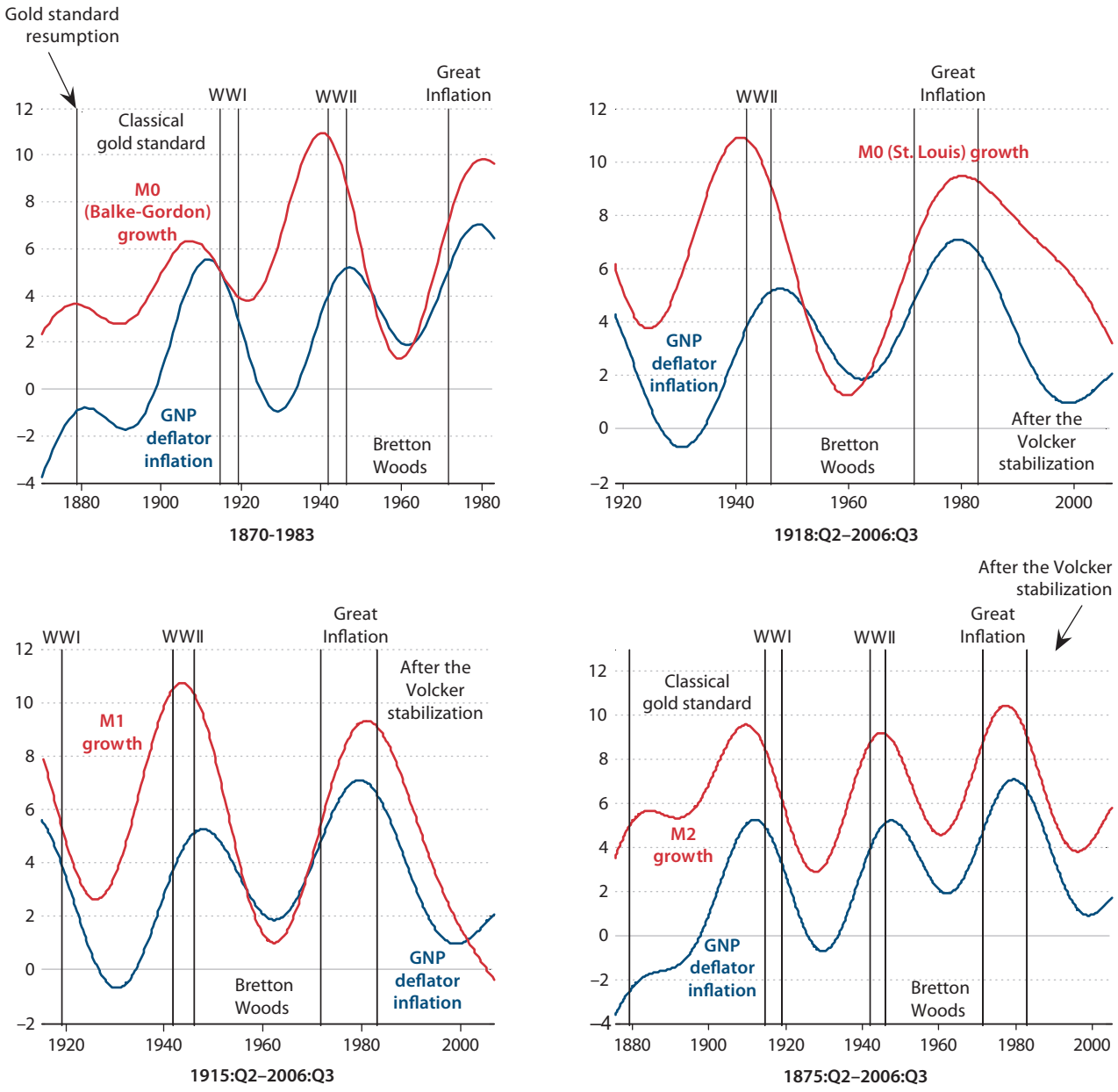


NOTE: RPI, retail price index.

SOURCE: Benati (2009). Used with permission.

Figure 8

Low-Frequency Components of Inflation and Money Growth Since the Gold Standard Era: United States

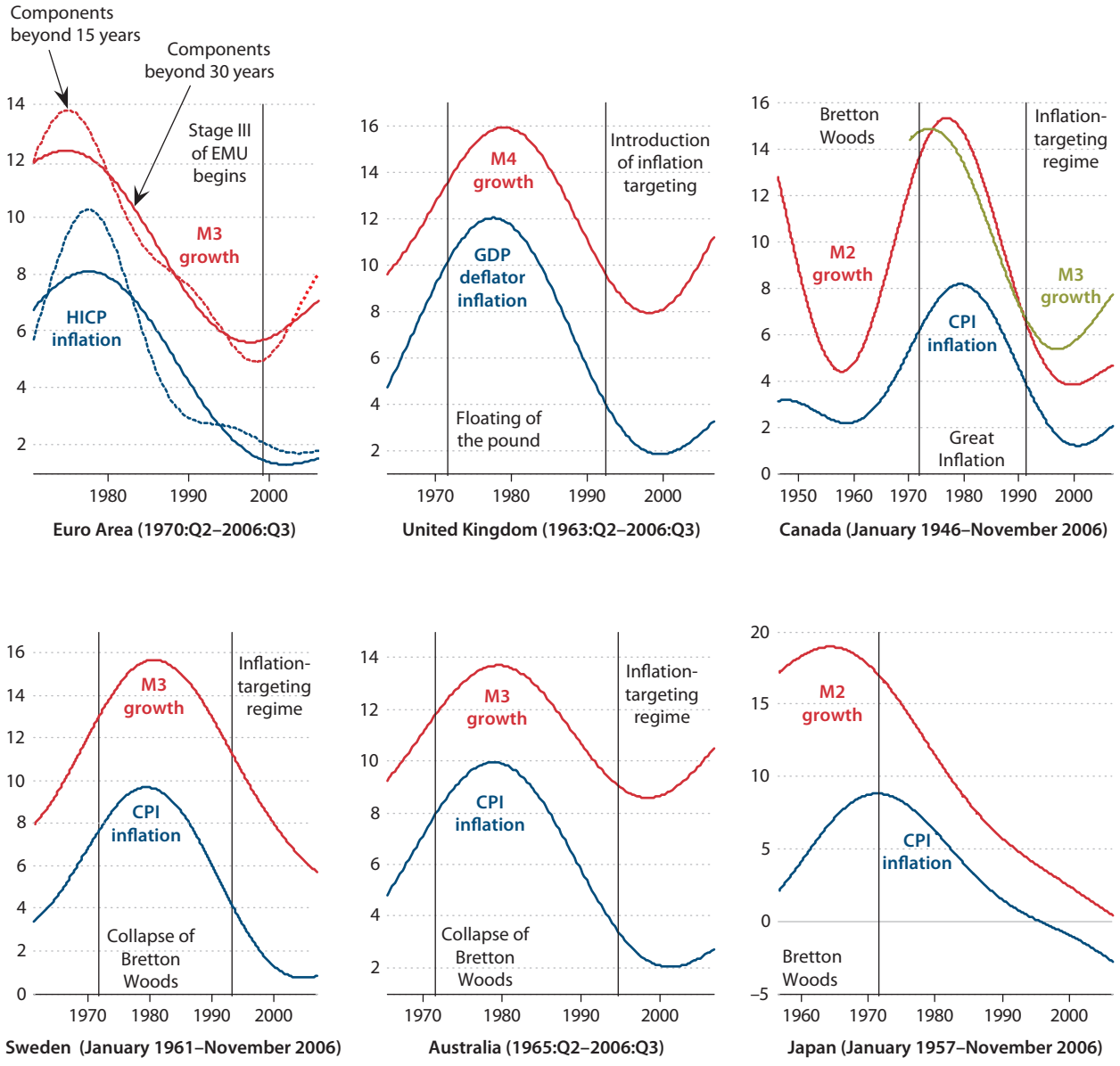


NOTE: GNP, gross national product.

SOURCE: Benati (2009). Used with permission.

Figure 9

Low-Frequency Components of Inflation and Money Growth Over the Post-WWII Era: Euro Area, United Kingdom, Canada, Sweden, Australia, and Japan



NOTE: EMU, European Economic and Monetary Union; HICP, Harmonised Index of Consumer Prices.

SOURCE: Benati (2009). Used with permission.

But are these results simply too good to be true? We know that payments systems in reality involve a mix of many different liquid assets. How can a theory that ignores these complexities, as the quantity theory does, do so well? It must be the case that, at least in the long run, all these different forms of liquidity grow at something like a common rate, maintaining fairly stable shares in money market portfolios over time. If this is so, it would not be surprising if measures such as M0, M1, and so on simply reflect different collections of liquid assets. This idea is disturbingly vague, I know. It would be a real step forward if it could be replaced by a more precisely stated hypothesis.

Accepting some form of the quantity theory of money, then, we have a theory of inflation. How do we apply this theory to control the inflation rate? One possibility would be to commit to a constant rate of money growth, chosen to imply the desired inflation rate. But what if the theory is not quite accurate or becomes obsolete because of changes in banking practices? A better, more flexible idea, developed in the 1970s, is inflation targeting. The central bank sets a goal, a target of (say) 2 percent—or perhaps a range such as 1 to 3 percent—and if actual inflation goes above the targeted range, the bank reduces the rate of money growth. If inflation continues above 3 percent, the bank reduces the money growth rate some more and keeps taking money out of the system until inflation is brought back within the targeted range. How do we know this will work? All the evidence I have just presented implies that it will. (It also implies that this may take some time.) Central banks all over the world that have used inflation targeting (stated or not) have had remarkable success in keeping inflation low and stable since the early 1980s, even during and after the crisis of 2008.

I have described inflation targeting as though it is implemented by adding to or reducing the money supply. As noted previously, today it is more customary to describe monetary policy as carried out by changes in short-term money market rates, not as changes in the money supply. In normal times, changes in the money supply are effected through trades in money markets; expanding the money supply and reducing the federal funds rate are just two ways of saying the same thing. There is not much reason to argue over the terminology. But since 2008 the funds rate has been so close to zero that reducing the rate is either impossible or meaningless. We talk about "unconventional policy" and "quantitative easing." From the Monetarist view that I am taking, of course, nothing could be more conventional than "quantitative easing." It is just another way to say "increasing the money supply." The Fed does this by buying something other than short-term government securities—long-term governments bonds, for example—but almost any asset would do.

THE NATURE OF FINANCIAL CRISES

I have spent most of my time on the easy parts of monetary policy: the actions that central banks know how to use to stabilize inflation. I have outlined some of the evidence on which these actions are largely based. I have noted the remarkable success of inflation targeting, persisting through the crisis of 2008-09 and the years since. Nevertheless, it must also be said that the financial crisis of 2008 was very costly in terms of lost production, and there is little

Table 2

U.S. Payments Flows (2013)

Cash transfers	Annual flow ($ billions)	Average transaction size ($ thousands)
Automated clearinghouse	24,400	2
Checks processed	8,000	1.3
Fedwire Funds Service	713,000	5,300
Fedwire Securities Service	295,000	15,500
National Settlement Service	17,000	

agreement even among leading economists on how it happened and how it might have been prevented. Some additional discussion of this event seems warranted.

The quantity theory that I have described is consistent with the idea that a sudden reduction in the money supply leads to deflation and reduction in spending. This happens because a sudden loss of liquidity leads people to reduce spending to rebuild a desired ratio of cash to spending flows. But central banks do not just suddenly reduce the money supply. They did not do so in the 1929 crash or in 2008-09. The source of a financial crisis or panic generally lies in a loss of confidence in privately issued promises of cash, not in reductions in government-supplied money. If so, the quantity theory of money as I have applied it here—treating all liquid assets as though they were cash—will not be helpful in the analysis of such crises.

In the 1930s, it was runs on uninsured bank deposits that suffered a loss of confidence. In 2008, it was the "run on repo" (using the terminology Gary Gorton made familiar in his book *Slapped by the Invisible Hand: The Panic of 2007*). In both cases, these runs were in no sense induced by the Fed, but they both demanded a quick response. In the 1930s, the Fed failed to inject liquidity and, as described in Friedman and Schwartz's (1963) monograph, the results were very bad. In 2008, the Fed responded boldly and quickly, but even so this did not completely forestall large reductions in production in the two successive quarters that followed.

To make progress in understanding these events, we need to get into the details of the payments technology, of the mix of liquid assets—part cash but mostly promises of cash—that are used to pay the bills. We begin with some data on U.S. cash flows tabulated by the Fed.

The total annual payments—cash transfers over the year—recorded in Table 2 add up to $1,057,400 billion: roughly $1 quadrillion. Compare this figure with the dollar value of U.S. GDP in 2013, about $17,000 billion: $17 trillion. This means that $62 was transferred from someone to someone else for every dollar of final goods and services produced. Perhaps there are as much as $8 to $10 used in payments flows per dollar of GDP: Payments to factors of production need to be added and so do payments for intermediate goods. But this does not get us close to $62. It is clear that the payments system must cover much more than purchases of goods and services. The rest—most of it—must be settlements of asset exchanges. We can see this in the table.

Look at the differences in transaction sizes. Automated clearinghouse payments and checks processed total about $32 trillion. The average transaction sizes are around $2,000. These

involve payments by households and nonfinancial firms. In contrast, the average transaction size for Fedwire services, which total about $1,000 trillion per year, is about $15 million: Transactions of this size will be made mostly by financial firms, the only firms that routinely trade assets at anything like this volume.

Imagine trying to carry out trading at this volume using government-provided cash, paying no interest or nearly so, to settle accounts. The opportunity cost would be staggering. Financial firms have much larger incentives to economize on cash than do households and nonfinancial firms exactly because their payment rates are orders of magnitude larger. To deal with this problem, they adopt methods to clear among themselves using suitably designed derivative securities. "Suitably designed"? A useful instrument will have both a low trading cost (i.e., labor costs: financial and legal experts) and a solid backup plan if it falls in value—good collateral. There is nothing new about the financial sector's need to economize on cash or on the methods it uses to do so. Promises to pay have substituted for payments in cash since records were kept on cuneiform tablets.

There is nothing necessarily dishonest or fraudulent in this manner of trading, this economizing on cash. We all do it to some degree, and people managing cash flows that differ from ours by many orders of magnitude do it much, much better. They do this today by constructing short-term liquid assets from pieces of illiquid securities. Some of these securities were derived from mortgages. Many other securities could have been and, indeed, have been used.[1] As with any IOU, creditors accept it only when they think they can pass it on. What we mean by a "financial crisis" is an occasion when this confidence vanishes—for whatever reason. The effect of this situation is just like an old-fashioned bank run: Financial firms that were working with minimal amounts of cash are now cash hungry. But there is only so much cash out there, so this can only mean that cash available to households and nonfinancial firms has to shrink.

In quantity-theoretic terms, the money supply available for purchases of goods and services shrinks drastically, implying deflation or losses of production or both. In the 1930s, both of these occurred. In 2008-09, the dramatic, timely injection of new reserves led to a much better outcome. But we can hardly view this as a solution to the problem. In the two quarters following the failure of Lehman Brothers, production flows in the United States fell by something like 6 percent below trend. None of this has been recouped.

CONCLUDING REMARKS

The crisis of 2008-09 revealed weak points in some of our favorite models. Was this a failure of economics? Relative to what we would like to have known, of course. But we can also see enormous progress that would have pleased Homer Jones. The inflation of the 1970s—the largest peacetime inflation in U.S. history—was treated at the time with wage and price controls as the Fed watched inflation climb to 14 percent. The new idea of inflation targeting, focused exclusively on inflation control, has avoided attempts to affect prices by dictating to corporations and labor unions. It has provided us with a feasible monetary policy that has worked well right up to now in the United States and elsewhere.

On the other hand, crisis prevention—the elimination of runs—is still largely an unsolved problem. Any solution must involve a governmental guarantee of deposits, insurance of some kind, and this in turn necessitates regulations on the assets deposit-takers can hold. The 1933 Glass-Steagall Act, based on a mixture of deposit insurance and the regulation of designated commercial banks, was followed by 75 crisis-free years. The act was repealed in 1999, but by then the financial sector and large businesses had moved deposits out of commercial banks.

The Dodd-Frank Act acknowledged this reality and incorporated investment banks under regulation by the Fed. This response completely misses the point. The main reason commercial banks lost deposits in the 1970s and 1980s was the combination of Regulation Q, which prevented interest on deposits, and the onset of inflation. Look again at Figure 1. Why did anyone hold zero-interest deposits in 1980? What if Glass-Steagall had remained in force but with Regulation Q removed? When banks are regulated, there will always be incentives to create liquid assets outside the banking system, however broadly banks are defined. The long, successful history of Glass-Steagall shows that these incentives need not be fatal to regulation, as long as the costs remain reasonable. ■

NOTE

[1] See the long list of examples of securitized asset classes in Gorton (2010).

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Making Sense of Dissents: A History of FOMC Dissents

Daniel L. Thornton and David C. Wheelock

This article presents a record of dissents on Federal Open Market Committee (FOMC) monetary policy votes from the Committee's inception in its modern form in 1936 through 2013. Dissents were rare during the Committee's first 20 years but began to increase in the late 1950s. The number of dissents increased sharply during the late 1970s and early 1980s, when both inflation and unemployment were unusually high. However, at other times, the number of dissents was not correlated with either inflation or the unemployment rate. A review of FOMC records and published statements indicates that dissents often reflect fundamental disagreement about (i) how to achieve the Committee's macroeconomic objectives and (ii) the current stance of policy. The number of dissents also appears to have been influenced by the language used by the FOMC to communicate instructions to the manager of the System Open Market Account. (JEL E61, E65, N12)

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The Federal Open Market Committee (FOMC) is the principal monetary policymaking arm of the Federal Reserve System. The Committee consists of the seven Federal Reserve governors and five Federal Reserve Bank presidents.[1] The FOMC ordinarily meets eight times per year and at each meeting votes on a directive that governs the conduct of monetary policy during the period between meetings. The policy directives are usually supported by a strong majority of the Committee's members. Since 1936, when the FOMC first met in its current form, 94 percent of all votes by FOMC members were cast in favor of the policy directive adopted by the Committee. Dissenting votes are not unusual, but the frequency of dissents has varied considerably over the FOMC's history. There were almost no dissents during the Committee's first 20 years and relatively few during the past 20 years. However, since 2008, a few members have dissented at nearly every meeting during their annual terms as voting members of the Committee. And three members dissented against the directives adopted at the August 9 and September 21, 2011, FOMC meetings, which was the largest number of dissents at a meeting since November 17, 1992. The recent uptick in dissents has sparked renewed interest in the frequency of and reasons for dissents.[2]

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This article examines dissents on FOMC monetary policy votes since 1936 with two main objectives. The first is to provide a complete and accessible history of FOMC dissents. The second is to explore patterns that might explain variations in the number of dissents over time. Our study suggests two main reasons for such variations: (i) differences in macroeconomic conditions and (ii) the level of disagreement among the Committee members about how to judge the stance of policy and how best to achieve the Committee's ultimate objectives. The next section presents data on the number of dissents by year and member type (i.e., Federal Reserve governor or president), the number of dissents by every member who ever cast a dissenting policy vote, and the number and frequency of dissents during the terms of each Federal Reserve Chairman. Subsequent sections examine (i) the relationship between the annual number of dissents per meeting and current inflation and unemployment rates, (ii) the reasons for dissents provided in official Committee records, and (iii) the differences between Federal Reserve governors and Reserve Bank presidents in the direction of policy dissents—that is, the tendency to dissent in favor of "tighter" or "easier" policies than those adopted by the majority.

ANNUAL DATA ON DISSENTS

Official records of FOMC policy decisions identify all members' votes, including those who voted with the majority and those, if any, who dissented.[3] The records also provide information about the reasons for the Committee's decision and usually a summary of any dissenting views. The dataset that accompanies this article online provides a summary of FOMC policy votes from 1936 through 2013. It includes the number of votes for and against each policy directive, the names of any dissenters, and a classification of all dissents as favoring tighter or easier policy or reasons for dissenting other than the stance of policy. (In some cases, no reason is provided in the official records or statements.) Most policy votes occur at scheduled FOMC meetings. However, the Committee occasionally holds extraordinary meetings in unusual circumstances and policy votes are sometimes taken at those meetings. The data reported in the online dataset include all votes on the policy directive, not just those taken at scheduled meetings. However, we exclude votes on matters other than the Committee's current monetary policy directive.[4]

There were only a handful of dissents during FOMC policy votes between 1936 and 1956, all of which occurred between 1938 and 1940.[5] During World War II, the Federal Reserve pledged to cooperate fully with the Treasury Department to finance the war effort. The Fed used open market operations to peg the rate on 91-day Treasury bills at 0.375 percent and to enforce a ceiling on longer-term Treasury yields. No member of the FOMC dissented from this policy. The Fed's rate-pegging policy ended in July 1947. However, at the request of the Treasury Department, the Fed continued to use open market operations primarily to support the government securities market and, in particular, to enforce a ceiling yield of 2.5 percent on long-term Treasury bonds. The Board of Governors adjusted reserve requirements and credit controls to manage the growth of private credit in an effort to limit inflation (Carlson and Wheelock, 2014).

Federal spending and budget deficits increased when the Korean War began in 1950. Inflation began to rise and the Fed found it increasingly difficult to prevent interest rates from rising. With the support of key members of Congress, the Fed successfully negotiated an agreement with the Treasury Department, known as the Fed-Treasury Accord, in March 1951. The Accord enabled the Fed to redirect open market policy toward macroeconomic goals, such as low inflation and maximum employment.

Differences among FOMC members soon arose over how to implement monetary policy to achieve the Committee's macroeconomic objectives. However, until 1957, no member ever dissented on a policy vote. The absence of dissents in the early post-Accord years may have reflected, at least in part, how the Committee was organized and the nature of the policy directives issued by the Committee. The Banking Act of 1935 required the FOMC to meet at least four times per year. At that time, directives issued by the full Committee were vaguely worded statements that members may have found little to disagree with. An executive committee consisting of the Chairman and Vice Chairman and three other members met biweekly to issue operating instructions to the manager of the Open Market Desk at the New York Fed. Presumably, those instructions were in line with the desires of the full Committee.[6]

FOMC procedures changed in 1955. In that year, the FOMC voted to abolish the executive committee and to meet more frequently—every three to four weeks, instead of just once per quarter. Beginning in 1956, at each meeting the full Committee voted on the operating directive to the manager of the Open Market Account, resulting in about 18 policy votes per year instead of the usual four votes in preceding years. The FOMC maintained this schedule until the early 1980s, when the number of scheduled meetings was reduced to eight per year.

The increased frequency of FOMC meetings after 1955 meant more opportunities for members to dissent, and over time dissents did become more frequent. The first post-Accord dissent was at the November 12, 1957, meeting. Figure 1 shows the total number of dissents each year from 1957 to 2013. Of 7,094 votes cast for FOMC policy directives during these years, 6,645 (94 percent) supported the majority and 449 (6 percent) were dissents. The frequency of dissents varied considerably over time. Dissents were particularly high during the 1962-65 and 1978-80 periods. The annual number of dissents was less than 15 in all other years and 10 or fewer in most years. There were especially few dissents during 1994-2007.

Figure 2 shows separately the number of dissents by Federal Reserve governors and Reserve Bank presidents in each year from 1957 to 2013. Over the entire period, the number of dissents by presidents (241) exceeded the number of dissents by governors (208).[7] However, in many years, the number of dissents by governors exceeded those by presidents. For example, during 1962-65, the number of dissents by governors (56) was more than twice that of presidents (26). However, Reserve Bank presidents accounted for 72 of 76 dissents between 1994 and 2013 and all of the dissents during 2006-13.

Table 1 reports the number of dissenting votes by every member who dissented at least once between 1936 and 2013. Chairman Marriner Eccles cast three dissenting votes in 1938-39. Since then, no FOMC Chairman has ever cast a dissenting vote, though Paul Volcker dissented four times when he was president of the Federal Reserve Bank of New York. Philip Coldwell, who served as both a president (Dallas Fed) and a governor, dissented three times as a president

Figure 1

Numbers of Dissents by Year (1957-2013)

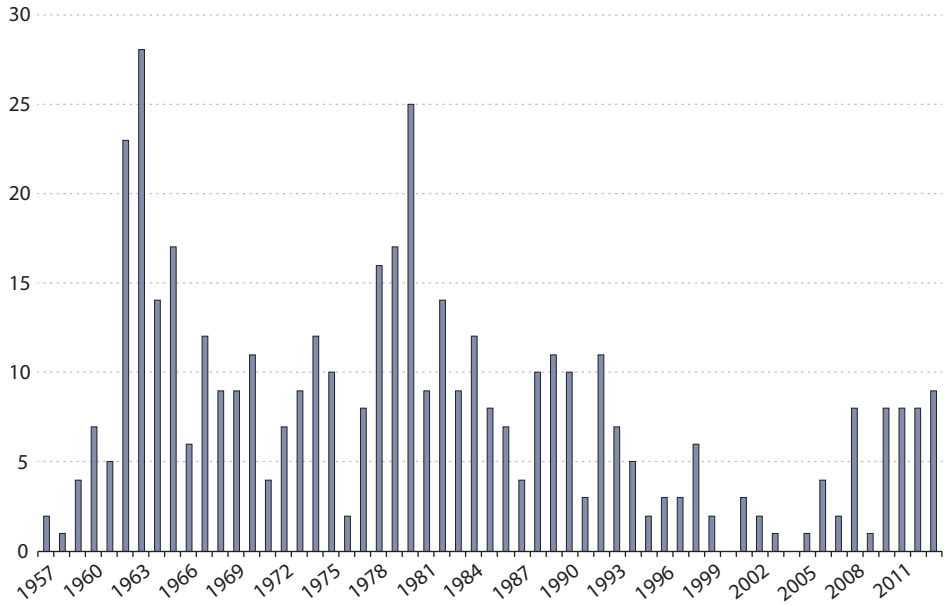


Figure 2

Dissents by Year and Member Type (1957-2013)

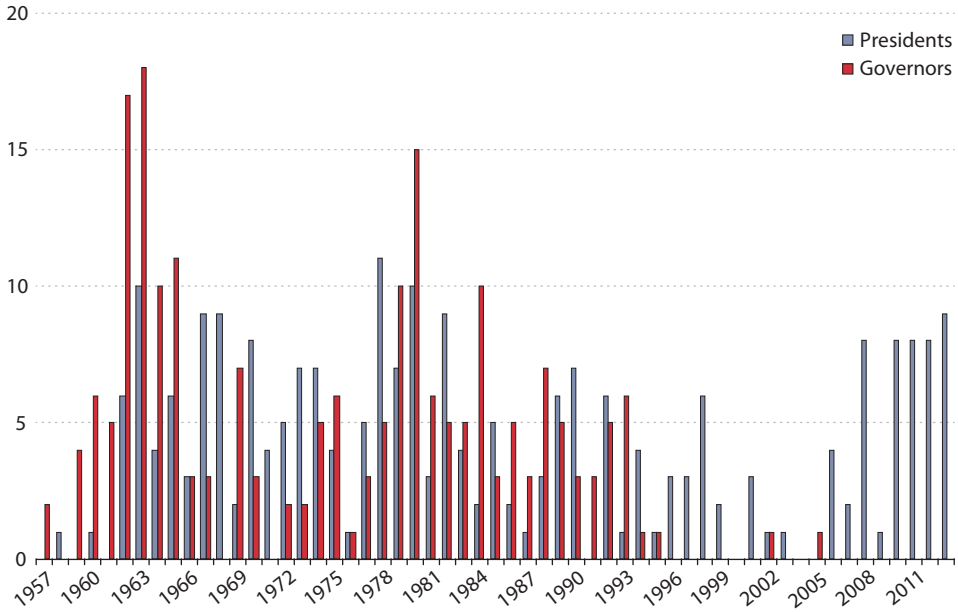


Table 1

Number of Dissents by FOMC Members (1936-2013)

Presidents	Reserve Bank	Dissents
Alfred Hayes	New York	26
Darryl R. Francis	St. Louis	14
Jeffrey M. Lacker	Richmond	13
Robert P. Black	Richmond	12
Thomas H. Hoenig	Kansas City	12
Thomas C. Melzer	St. Louis	9
Frank E. Morris	Boston	9
Jerry L. Jordan	Cleveland	8
Richard W. Fisher	Dallas	7
Esther George	Kansas City	7
W. Lee Hoskins	Cleveland	7
Mark H. Willes	Minneapolis	7
J. Alfred Broaddus Jr.	Richmond	6
Lawrence K. Roos	St. Louis	6
Robert H. Boykin	Dallas	5
William F. Ford	Atlanta	5
J. Roger Guffey	Kansas City	5
M. Monroe Kimbrel	Atlanta	5
Willis J. Winn	Cleveland	5
John J. Balles	San Francisco	4
George H. Clay	Kansas City	4
W. Braddock Hickman	Cleveland	4
Charles I. Plosser	Philadelphia	4
Charles J. Scanlon	Chicago	4
Anthony M. Solomon	New York	4
Paul A. Volcker	New York	4
Karl R. Bopp	Philadelphia	3
Philip E. Coldwell	Dallas	3
David Eastburn	Philadelphia	3
George H. Ellis	Boston	3
Robert D. McTeer Jr.	Dallas	3
Robert T. Parry	San Francisco	3
William Poole	St. Louis	3
Gary H. Stern	Minneapolis	3
William Treiber*	New York	3
Charles E. Evans	Chicago	2
Waltrous H. Irons	Dallas	2
Narayana Kocherlakota	Minneapolis	2
Eric Rosengren	Boston	2
Carl E. Allen	Chicago	1
Ernest T. Baughman	Dallas	1
Edward G. Boehne	Philadelphia	1
Malcolm Bryan	Atlanta	1
James Bullard	St. Louis	1
Frederick L. Deming	Minneapolis	1
Karen N. Horn	Cleveland	1
Bruce K. MacLaury	Minneapolis	1
Eliot J. Swan	San Francisco	1
Edward A. Wayne	Richmond	1

Governors	Dissents
Henry Wallich	27
A.L. Mills Jr.	25
George W. Mitchell	20
Martha Seger	18
J.L. Robertson	17
Nancy Teeters	12
Philip Coldwell	8
Wayne Angell	8
Sherman Maisel	8
Ernest Draper	7
Charles Shepardson	7
John LaWare	6
C. Canby Balderston	5
Preston Martin	5
J. Charles Partee	5
Jeffrey Bucher	5
Lawrence Lindsey	4
Emmett Rice	4
Andrew Brimmer	3
J. Dewey Daane	3
Marriner Eccles	3
Lyle Gramley	3
G.H. King Jr.	3
Ronald Ransom	3
John Sheehan	3
Edward W. Kelley Jr.	2
Edward Gramlich	1
Robert Holland	1
Philip C. Jackson Jr.	1
Manuel Johnson	1
David Lilly	1
Mark Olson	1
M.S. Szymczak	1

NOTE: *William Treiber was first vice president of the New York Fed and voted as an alternate.

Table 2

Number and Frequency of Dissents Under FOMC Chairmen (1936-2013)

Chairman	Tenure	Total dissents	Dissents per meeting
Marriner Eccles	Nov. 15, 1934–Apr. 15, 1948	13	0.23
Thomas McCabe	Apr. 15, 1948–Mar. 31, 1951	0	0.00
William McChesney Martin Jr.	Apr. 2, 1951–Jan. 31, 1970	137	0.51
Arthur Burns	Feb. 1, 1970–Mar. 7, 1978	63	0.62
G. William Miller	Mar. 8, 1978–Aug. 6, 1979	27	1.42
Paul Volcker	Aug. 6, 1979–Aug. 11, 1987	92	1.23
Alan Greenspan	Aug. 11, 1987–Jan. 31, 2006	82	0.54
Ben Bernanke*	Feb. 1, 2006–Jan. 31, 2014	48	0.74

NOTE: *Chairman Bernanke presided over one meeting not included in the sample: January 28-29, 2014.

and eight times as a governor. By contrast, Janet Yellen, who became Chair of the Federal Reserve Board and FOMC in 2014, cast no dissenting votes during her tenures as a member of the Board of Governors and as the president of the Federal Reserve Bank of San Francisco. Henry Wallich, who served as a governor from 1974 to 1986, had the most dissents (27) from 1936 to 2013, closely followed by Alfred Hayes, who cast 26 dissenting votes as president of the Federal Reserve Bank of New York from 1956 to 1975. Of course, members who served fewer years would have had fewer opportunities to dissent. Still, some members dissented at a much higher rate than others.

Table 2 reports the total number of dissents and the average number of dissents per meeting during the tenures of each FOMC Chairman through 2013. The total number of dissents under Chairman William McChesney Martin Jr. (137) exceeded that of all other Chairmen, though Martin also presided over more meetings during his tenure than any other Chairman. Under Martin, the average number of dissents per meeting (0.51) was similar to the averages under Arthur Burns (0.62), Alan Greenspan (0.54), and Ben Bernanke (0.74) and less than half the averages under G. William Miller (1.42) and Paul Volcker (1.23).[8]

Although many FOMC members cast at least one dissenting vote during their tenures, one or two voters often accounted for many, and occasionally all, dissents within a given year. This was especially true during 2006-13. For example, President Jeffrey Lacker (Richmond Fed) cast all four of the Committee's dissenting votes in 2006 and all eight dissenting votes in 2012. Similarly, President Thomas Hoenig (Kansas City Fed) cast all eight dissenting votes in 2010. There were only three years between 2006 and 2013 when more than one voter dissented on a policy vote, and just one year (2011) when more than two members cast dissenting votes. In that year, Presidents Charles Evans (Chicago Fed), Richard Fisher (Dallas Fed), Narayana Kocherlakota (Minneapolis Fed), and Charles Plosser (Philadelphia Fed) all dissented at least once.

INFLATION, UNEMPLOYMENT, AND DISSENTS

The terms of Chairmen Miller (March 8, 1978–August 6, 1979) and Volcker (August 6, 1979–August 11, 1987) coincided with the highest sustained levels of both the inflation rate and the unemployment rate (during 1957-2013). The relatively high rates of dissent during their tenures suggest that dissents were related to economic conditions at the time. Federal Reserve records and statements indicate that many dissents reflected differences of opinion about economic conditions and whether the stance of policy was appropriately calibrated to achieve the Committee's macroeconomic objectives. The Federal Reserve Reform Act of 1977 requires the Fed to "promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates." Even before Congress formally imposed the so-called dual mandate on the Fed, monetary policymakers generally sought policies that would control inflation and promote full employment.[9] Thus, a positive relationship might be expected between the rate of dissents and inflation or unemployment rates.

Figure 3 plots the dissent rate (vertical axis) against the monthly annualized CPI inflation rate (horizontal axis) over the period 1957-2013. The chart includes a line derived from a simple linear regression of the dissent rate on inflation (the regression results are summarized in the figure note). The relationship between inflation and dissents is positive and statistically significant, indicating that the average number of dissents rose with the inflation rate. However, the relationship is relatively weak and the slope of the regression line is strongly influenced by a few years when inflation was unusually high, specifically the period 1974-82 (identified in the figure by red symbols). If those years are omitted, the relationship between inflation and the dissent rate is weaker still and not statistically significant. Of course, the absence of a strong relationship between inflation *at the time* and the dissent rate does not imply that policymakers were unconcerned about inflation. Indeed, concerns about *prospective* inflation were often given as a reason for members' dissents. Usually, these dissenters argued that the Committee's policies would cause inflation to rise; however, during 2011-13, four members cited concerns about inflation being below the FOMC's announced target in explaining their dissents.

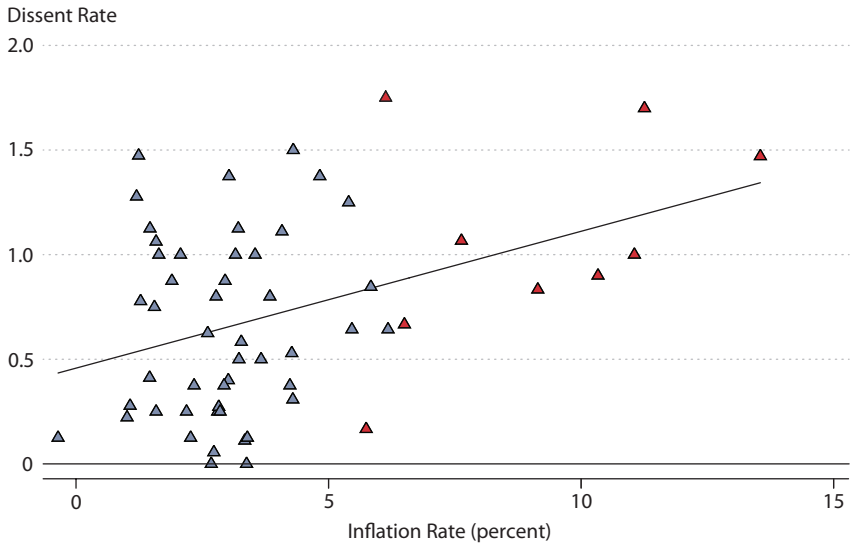
Figure 4 shows the dissent rate and the unemployment rate from 1957 to 2013. The regression line shows that the dissent rate and unemployment rate are positively correlated. However, as with inflation, the relationship is weak and essentially nonexistent during the 42 years when the unemployment rate was less than 7 percent.[10]

REASONS FOR DISSENTS

Although the average number of dissents per FOMC meeting is only weakly associated with observed inflation or unemployment, FOMC records and statements indicate that many—perhaps most—dissents were motivated at least somewhat by concern that the monetary policy approved by the Committee would have an undesired effect on economic conditions. Many dissents reflected fundamental disagreements about the role of monetary policy in the economy or disagreements about operating procedures and targets. For example, during the 1960s and 1970s, FOMC members often disagreed about the causes and costs of inflation, the valid-

Figure 3

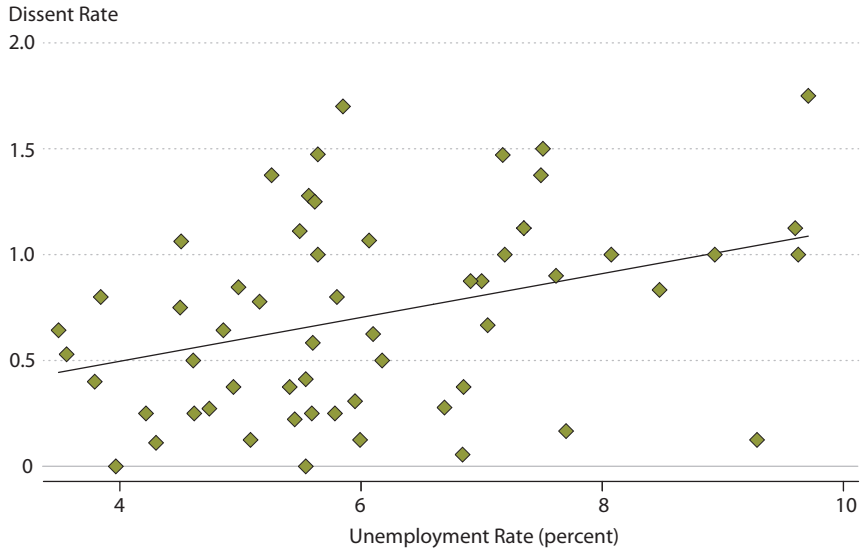
Dissent Rate and Inflation (1957-2013)



NOTE: The dissent rate is the average annual number of dissents per meeting. Years of unusually high inflation (1974-82) are red. Regression equation; *t*-statistics are shown in parentheses: $DR_t = 0.458 + 0.065IR_t$; $\bar{R}^2 = 0.153$.
(4.63) (3.15)

Figure 4

Dissent Rate and Unemployment Rate (1956-2013)



NOTE: The dissent rate is the average annual numbers of dissents per meeting. Regression equation; *t*-statistics are shown in parentheses: $DR_t = 0.082 + 0.104UR_t$; $\bar{R}^2 = 0.123$.
(0.35) (2.78)

ity of an apparent trade-off between inflation and unemployment, the appropriate targets for monetary policy, and how to judge the stance of policy.[11] Notably, in the 1970s, Fed Chairman Arthur Burns and many other Fed officials frequently blamed inflation on "excessive" increases in wage rates, rising energy prices, and government budget deficits. By contrast, so-called Monetarists blamed inflation on the Fed for permitting excessive growth of the money supply. Burns championed direct controls on wages and prices, rather than tighter monetary policy, to contain inflation. Darryl Francis, president of the Federal Reserve Bank of St. Louis from 1966 to 1976, was among those who argued that inflation could be contained only by slowing the growth rate of the money supply.[12]

A related and long-standing debate among FOMC members concerned the appropriate operating target for policy. Traditionally, Fed officials judged the stance of monetary policy by the level of short-term interest rates (or, more broadly, "money market conditions"), and policy directives would specify the Committee's intent in terms of money market conditions or the degree of "pressure" on bank reserve positions. By the 1960s, however, some members had begun to press for setting policy in terms of the growth of monetary aggregates, and those voices grew louder over time as inflation rose and the Fed faced mounting criticism.

Many dissents—especially in the 1970s, but also more recently—reflected disagreement about (i) how monetary policy affects the economy and (ii) operating tactics and the stance of policy. Discerning the reasons for many dissents is complicated by the fact that the Committee's policy directives were often vaguely worded statements that could be interpreted only in light of the underlying policy discussion. For example, in the 1970s, the operational part of the directive remained a vaguely worded statement about money market conditions even as Committee deliberations focused on interest rates and the growth rate of various monetary aggregates. A typical policy directive calling for no change in policy might read as follows: "System open market operations…shall be conducted with a view to maintaining the prevailing firm conditions in the money market…" A desired move toward an easier policy stance would express "a view to achieving slightly less firm conditions…" Comparable adjustments to the directive's language about money market conditions would be made if the Committee desired a tighter policy. St. Louis Fed President Darryl Francis was among those who objected to focusing on money market conditions in the implementation of policy. He dissented at several FOMC meetings because he felt that the stance of policy was inappropriate for achieving the Committee's policy goals. However, on one occasion (July 17, 1973), he dissented not because he disagreed with the intended stance of policy, but because he believed that the objective would not be achieved because of the constraint on money market conditions.

In 1977, the FOMC began to set annual targets for the growth rates of various money stock measures. Although the Committee's operating directives continued to express policy in terms of money market conditions, they also specified the Committee's long-run objectives and near-term expectations for growth of the monetary aggregates and an "operational objective" for the federal funds rate, which was usually a range of either 50 or 75 basis points. Directives also typically ended with a statement that, if the operating constraints imposed by the directive were "significantly inconsistent," the manager would promptly notify the Chairman, who would then decide if the Committee should issue supplementary instructions. The explanation given

for dissenting votes in FOMC records indicates that dissenters sometimes disagreed with the Committee's chosen growth rate targets for monetary aggregates, the tolerance range for money market conditions or the funds rate, or some other element of the broader directive.

Because the FOMC set targets for both the federal funds rate and the growth of monetary aggregates, the Committee was sometimes forced to change its directive between scheduled meetings when the targets for interest rates and money growth proved incompatible. The Committee would sometimes attempt to avoid such conflicts by establishing wide tolerance ranges for monetary growth or interest rates or by communicating a willingness to allow deviations from one target to preserve the other. FOMC members did not always agree about whether the funds rate or monetary growth target should take precedence, however, and this led to some dissents. For example, Paul Volcker, then-president of the New York Fed, dissented at an FOMC meeting in July 1976 because he opposed a directive that would allow the federal funds rate to deviate by more than 50 basis points in either direction from the midpoint of the range specified by the Committee merely to prevent money stock growth outside its target range.[13]

In 1983, the FOMC began to include information in the directive about the likely direction of future changes in policy. Subsequently, some dissents were against the signaling statement rather than the current policy stance. For example, the explanation for a dissent by President Edward Boehne (Philadelphia) on an FOMC directive issued on May 18, 1993, stated that "Mr. Boehne supported a steady policy course, but he dissented because he objected to a directive that was biased toward tightening." Although the explanations for some dissents cite disagreement with statements about the likely direction of future policy, such language may have helped build consensus among Committee members and thereby limited the number of dissenting votes (Thornton and Wheelock, 2000).

The frequency of dissents has at times been associated with the use of unconventional policy measures. For example, in the early 1960s, the FOMC abandoned its long-standing policy of conducting open market operations solely in Treasury bills. Some members opposed the move, as well as explicit efforts to simultaneously lower long-term interest rates while raising short-term rates—a policy sometimes referred to as "Operation Twist."[14] More recently, after the FOMC lowered its target for the federal funds rate to the zero lower bound in 2008, some members expressed skepticism about the use of certain unconventional policy measures, including "credit easing," "forward guidance," and "maturity extension programs" to ease monetary conditions further. For example, President Jeffrey Lacker (Richmond Fed) cast a dissenting vote at an FOMC meeting on January 28, 2009, "because he preferred to expand the monetary base by purchasing U.S. Treasury securities rather than through targeted credit programs. Mr. Lacker was fully supportive of the significant expansion of the Federal Reserve's balance sheet and the intention to maintain the size of the balance sheet at a high level. However…he saw no evidence of market failures that made targeted credit programs…necessary."

The Direction of Policy Dissents

We used the explanations provided in official FOMC records to classify most dissents as favoring either tighter or easier policy than specified in the policy directive approved by the majority. Of 462 dissents between 1936 and 2013, we classify 249 as favoring a tighter policy

Table 3

Dissents By Member Type (1936-2013)

Dissent direction	President	Governor	Total
Easier	35	125	160
Tighter	180	69	249
Total:	215	194	409

and 160 favoring an easier policy. For the remaining 53 dissents, official records either provide no reason for the dissent or indicate that the dissent was cast because of disagreement with language in the FOMC directive or statement concerning possible future policy actions, rather than with the stance of policy adopted for the forthcoming intermeeting period.

Sometimes Reserve Bank presidents are considered to have a stronger preference for low inflation than members of the Board of Governors, perhaps reflecting differences in how presidents and governors are appointed. District Bank presidents are appointed by their local boards of directors (with approval by the Board of Governors), and Federal Reserve governors are appointed by the president of the United States and confirmed by the Senate. Some researchers argue that governors are thus more responsive to the desires of politicians (who must consider reelection) and thus favor lower interest rates and unemployment rates in the short run even at the cost of higher inflation (and perhaps higher interest rates and unemployment) over the longer run. Reserve Bank presidents, by contrast, may have stronger preferences for low inflation, and thus generally tighter monetary policy, than governors. Several studies have noted that Reserve Bank presidents have historically cast a majority of dissents favoring tighter policies, whereas governors have cast more dissents favoring easier policies. However, researchers have not reached a consensus about whether these differences indicate that presidents generally care more about controlling inflation and governors care more about unemployment.[15]

Table 3 reports the number of dissents for easier and for tighter policy by Reserve Bank presidents and members of the Board of Governors for the entire period from 1936 to 2013. Of 215 dissents by presidents, 35 were for easier policy and 180 were for tighter policy. Presidents accounted for 22 percent of all dissents for easier policy and 72 percent of all dissents for tighter policy. By contrast, of 194 dissents by governors, 125 were for easier policy and 69 were for tighter policy. Governors accounted for 78 percent of dissents for easier policy, but 28 percent of dissents for tighter policy. A statistical test of the hypothesis that the direction of dissents (i.e., for tighter or easier policy) is independent of FOMC member type (governor or president) is easily rejected at conventional levels of significance.[16]

As noted previously, we were unable to classify 53 dissents as favoring either tighter or easier policy because official records indicate that these dissents were based on considerations other than the current stance of policy or provide no explanation at all. However, the records are not always clear and some dissents are more difficult to classify than others. Further, we do not classify dissents as favoring either tighter or easier policy if the explanation indicates that the voter agreed with the Committee's decision about the current stance of policy but

dissented because he or she disagreed with language in the Committee's statement about possible future changes in policy. For example, as noted previously, we do not classify President Boehne's dissent on May 18, 1993, as a dissent for easier policy because records indicate that Boehne dissented over the inclusion of a statement about the likely future direction of policy.

In a similar vein, we do not classify the dissents of presidents Fisher (Dallas), Kocherlakota (Minneapolis), and Plosser (Philadelphia) at the August 9, 2011, FOMC meeting as favoring either easier or tighter policy because the records do not indicate disagreement with the stance of policy for the forthcoming intermeeting period. Instead, the records indicate that the dissenters "preferred to continue to describe economic conditions as likely to warrant exceptionally low levels for the federal funds rate for an extended period," rather than express the Committee's expectations about policy in terms of a specific calendar date. Similarly, we do not classify President Lacker's dissents at the first three FOMC meetings in 2012 because the explanations given for these dissents indicate that Lacker opposed the Committee's "forward guidance" statements, rather than the stance of policy adopted for the current intermeeting period. For example, the explanation for his dissent on January 25, 2012, indicates only that "he preferred to omit the description of the time period over which economic conditions were likely to warrant exceptionally low levels of the federal funds rate."

Some researchers might disagree with our treatment of dissents over forward guidance in FOMC statements as favoring neither tighter nor easier policy. However, even if we were to treat these dissents otherwise, we would still reject the hypothesis that the direction of dissents was independent of member type. Indeed, even if all unclassified dissents by presidents are treated as dissents for *easier* policy and all unclassified dissents by governors are treated as dissents for *tighter* policy, we would still reject the hypothesis. Of course, additional research is required to determine why presidents historically have tended to dissent more often for tighter policies and governors for easier policies and whether those tendencies were broad based or the result of voting by just a few members.

CONCLUSION

After several years with few dissenting votes on FOMC policy decisions, the number of dissents rose to an average of nearly one per meeting between 2008 and 2013. Although the increase in dissents attracted attention, the frequency of dissents during the period 2008-13 was not unusual in the modern history of the FOMC. Since 1957, the number of dissents per year has ranged from zero (in 2000 and 2004) to as many as 28 (in 1963). Between 1957 and 2013, the number of dissents per meeting was somewhat higher during years with unusually high inflation or unemployment rates, but the relationship between economic conditions at the time and dissents was not strong. Outside the 1974-82 period, the relationship between current inflation and unemployment rates and dissent rates is not statistically significant. Explanations for dissenting votes in official FOMC records indicate that dissents often reflected fundamental disagreements among members about the impact of monetary policy on the economy and how to implement policy, as well as whether the current stance of policy was appropriate for meeting the Committee's economic objectives.

The number of dissents between 2008 and 2013 was not unusual, but the fact that Reserve Bank presidents accounted for all of the dissents in those years was unusual. Between 1936 and 1995, the number of dissents by Fed governors (219) exceeded those by Reserve Bank presidents (174). However, after 1995, there were just two dissents by governors compared with 67 by presidents. Like other researchers, we find that over the FOMC's history, Federal Reserve Bank presidents more often dissented in favor of tighter policy than easier policy, whereas a majority of dissents by Federal Reserve governors were in favor of easier policy. We leave it to future research, however, to explore why the direction of dissents has tended to vary systematically between presidents and governors.

Similarly, further research is required to answer questions such as why the frequency of dissents varied under different Federal Reserve Chairmen, whether dissent rates were affected by changes in the language of FOMC policy directives and statements, and whether dissent rates were influenced by changes in the forms and extent of FOMC communication with the public. The compilation of a comprehensive database on FOMC policy votes since 1936 is a first step toward addressing these sorts of questions. ■

NOTES

[1] The Banking Act of 1933 created the FOMC, but the Committee's current structure (the seven governors and five District presidents) was established by the Banking Act of 1935. The Chairman of the Board of Governors is the FOMC Chairman. The president of the Federal Reserve Bank of New York is a permanent voting member of the FOMC and serves as the Committee's Vice Chairman. The remaining 11 Reserve Bank presidents (or their representatives) also attend every FOMC meeting and participate in Committee deliberations. However, only five presidents (including the New York Fed president) serve as voting members of the Committee at any one time. The rotation of presidents to one-year terms is specified in the Federal Reserve Act.

[2] For example, see Zumbrun (2013).

[3] Official records of all FOMC policy actions since 1936 are available from the Board of Governors of the Federal Reserve System (see Transcripts and Other Historical Materials; http://www.federalreserve.gov/monetarypolicy/fomc_historical.htm).

[4] For example, we exclude votes on authorizations to purchase intermediate- and long-term Treasury securities that were not part of the operating directive for the intermeeting period (common in the early 1960s) and on objectives for longer-run growth of monetary aggregates (common during the 1970s and 1980s), as well as on authorizations for reciprocal currency agreements (i.e., swap lines) and various routine matters (e.g., the appointments of Committee chairs and staff).

[5] The Committee's *Record of Policy Actions* provides no reasons for the dissents in 1938-39, although it does provide reasons for two dissents in 1940. However, a majority voted for a directive that called for permitting the System's holdings of Treasury bills to decline if they could not be replaced without paying a premium. Interestingly, Chairman Marriner Eccles was among those dissenting at three meetings in 1938-39. See Meltzer (2003, pp. 533-34) for a discussion of this topic.

[6] This article and the related dataset on FOMC dissents focus exclusively on monetary policy votes of the full FOMC. We have not compiled a record of executive committee votes.

[7] All 13 dissents before 1957 were by governors. Hence, for 1936-2013 as a whole, there were 241 dissents by presidents and 221 by governors.

[8] Excluding the years 1951-56, when there were no dissents, the rate of dissents per meeting under Martin during 1957-70 was 0.62.

[9] See Thornton (2012) for a discussion of the FOMC's use of the dual mandate.

[10] Our results are similar to those of Krause (1994), which show that, for 1967-90 as a whole, inflation and unemployment rates had a positive but weak effect on the number of dissents.

[11] By comparison, Meade and Thornton (2012) find almost no references to the so-called Phillips curve trade-off during 1979-94, but a sharp increase in references to the Phillips curve during 1994-2000, mostly by academic economists (Alan Blinder, Janet Yellen, and Laurence Meyer) who were governors during the period.

[12] See Poole, Rasche, and Wheelock (2013) for a comparison of the views of Burns and Monetarists about the causes of inflation and the role of monetary policy. Hetzel (2008), Meltzer (2010), Bordo and Orphanides (2013), and the papers referenced therein examine the causes of the Great Inflation and policy deliberations within the Fed at the time.

[13] The explanation for Volcker's dissent is provided in the *Record of Policy Actions* for July 19-20, 1976 (see Transcripts and Other Historical Material, 1976; http://www.federalreserve.gov/monetarypolicy/fomchistorical1976.htm).

[14] See Meltzer (2010, pp. 315-24).

[15] In a study of dissents from 1970 to 1987, Belden (1991) finds that presidents were significantly more likely than governors to dissent in favor of tighter policy. The study also finds that presidents were more likely to dissent in favor of tighter policy than easier policy, whereas governors were about equally likely to dissent for tighter and easier policy. Further evidence that governors prefer easier policy than presidents is reported in Chappell, Havrilesky, and McGregor (1993), but evidence to the contrary is reported in Tootell (1991), which finds no difference in the tendency of presidents and governors to dissent in a particular direction after controlling for forecasts of economic conditions. See Woolley (1984) for more discussion of the importance of political forces on Federal Reserve policymaking.

[16] The null hypothesis of independence of attributes has a chi-square distribution with one degree of freedom. The value of the test statistic equals 99.29, which easily exceeds the critical value of 6.64 at the 1 percent significance level.

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The Effects of Terrorism on Trade: A Factor Supply Approach

Subhayu Bandyopadhyay and Todd Sandler

The conventional view of terrorism is that it raises risks and, as a result, reduces trade. The authors use a factor supply approach to show that this hypothesis is not necessarily correct. They use a two-good, two-factor, small open economy model to show that terrorism can either reduce or raise trade depending on critical factors, such as the impact of terrorism on the intensive factor of the export or the import sector. They then extend the analysis to models with several goods and factors and identify conditions under which trade may rise or fall with a greater incidence of terrorism. Finally, they provide an analysis of the effects of terrorism on trade in the presence of an optimal counterterrorism policy. The authors find that a nation's adjustment of its counterterrorism level in response to a greater terrorist threat may moderate the impact of terrorism on trade. (JEL F11, F52, H56)

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This article reconsiders the effects of terrorism on trade. The conventional wisdom is that trade with a nation affected by terrorism involves higher risks. The consequent rise in the transaction costs is akin to a rise in transportation costs, which tend to reduce trade. Based on such an argument, Nitsch and Schumacher (2004) and Blomberg and Hess (2006) find evidence that terrorism indeed tends to depress a nation's trade. However, terrorism not only affects transaction costs for a trading nation, but also can deplete a nation's supply of scarce productive factors. This depletion may result from terrorist groups drawing the nation's radicalized elements into terrorism activities or terrorist groups directing attacks on the nation's people or productive capital.

Negative impacts on the economy may also stem from foreign investors being dissuaded from investing because of potential terrorist activities. The literature in this area has already documented these effects,[1] but there has been no analysis of how these factor supply effects may influence the pattern of trade. This is an important gap because once factor supply effects are considered, the predictions of how terrorism may affect trade may be reversed.[2] When terrorism affects a nation's factor supplies, its production possibility frontier will shift and

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may twist. In a multifactor, multigood world, as in the standard Heckscher-Ohlin model, depletion of some factors may shift the production possibility frontier in the direction of increasing the exportable commodity. In this case, trade tends to rise with an increased level of terrorism, moderating and opposing the trade-reducing effects of the increased terrorism-related transaction costs noted in the literature. In contrasting situations, the factor supply effects may reduce the supply of the exportable good. In such cases, trade is reduced and the factor supply effects compound the trade-reducing effects of increased transaction costs.[3] Thus, a priori, it is not possible to predict whether terrorism will raise or reduce trade. The objective of this article is to identify conditions under which a greater incidence of terrorism is likely to raise or reduce a nation's trade.[4]

Although we find that terrorism may raise trade, the loss of a nation's productive resources is necessarily welfare reducing for a small open economy. Therefore, regardless of the effect on trade, the terrorists do impose costs (and achieve their goals) by inflicting damage on their target nation. This conclusion, however, does not extend to a large open economy. The trade literature has established that while a rise in a factor endowment must benefit a small open economy, it may hurt a large nation because of terms-of-trade effects. Similarly, if terrorism improves a nation's terms of trade by reducing the supply of the exportable good, the negative welfare consequences of terrorism may be mitigated and, in extreme cases, reversed. Our analysis helps to shed light on these issues, and further analysis with endogenous terms of trade will help to provide a more complete picture. This avenue of research will show under which circumstances terrorists are able to hurt an economy through the trade channel. Many terrorist groups state that one of their explicit goals is to hurt the economies of target countries (Enders and Sandler, 2012).

In this article, we present a small, open economy model of trade in which terrorism affects factor supplies. We establish necessary and/or sufficient conditions for terrorism to raise/reduce trade and evaluate these conditions within the context of standard neoclassical trade models. The following section presents the analysis for a two-good, two-factor small open economy. We then extend the analysis to the case of several goods and several factors. A separate section presents the analysis in the presence of an optimal counterterrorism policy.

A 2 × 2 SMALL OPEN ECONOMY MODEL

Consider a small open economy that suffers from terrorism. Competitive firms in this nation produce two goods, goods 1 and 2, with two factors of production, labor and capital. Factor endowments are subject to depletion caused by the terrorism and are given by[5]

$$L(T),\ L'(T) \leq 0;\ \text{and}\ K(T),\ K'(T) \leq 0; \tag{1}$$

where T is an index of terrorism and L and K are the endowments of labor and capital, respectively, available for production. Terrorism depletes these factors by pulling them into the terrorism sector or by inflicting damage by means of attack. Terrorism-associated risk can also reduce investment and, hence, capital formation (Blomberg, Hess, and Orphanides, 2004,

Gaibulloev and Sandler, 2008, 2011). Terrorism risks can also increase the cost of conducting business, thereby affecting labor and capital. Given that the nation is a small open economy, the prices of goods 1 and 2 (p_1 and p_2, respectively) are exogenously given.

Following Dixit and Norman (1980), we consider a representative consumer who derives utility, u, from consumption. The trade balance for this economy requires the representative consumer's expenditure on consumption to be equal to the nation's revenues from the production of the two goods. The consumer's expenditure is represented by a standard expenditure function, $e(p_1, p_2, u)$, and the nation's revenues are denoted by a standard revenue function, $R(p_1, p_2, L, K)$.[6] Choosing good 2 as the numeraire, we set its price, p_2, at unity. Using equation (1), we can write the trade balance relationship as

$$e\left(p_1, 1, u\right) = R\left[p_1, 1, L\left(T\right), K\left(T\right)\right], \tag{2}$$

where the country's expenditure matches its revenue. By the implicit function theorem, equation (2) yields

$$u = u\left(p_1, T\right), \text{ where } \frac{\partial u}{\partial T} = u_T(\bullet) = \frac{R_L L'(T) + R_K K'(T)}{e_u}. \tag{3}$$

The term $u_T(\bullet)$ measures the loss in utility for the representative consumer from a marginal rise in terrorism. The last expression in equation (3) may be explained as follows: The terms $R_L L'(T)$ and $R_K K'(T)$ reflect the revenue losses from the damaging effect of terrorism on the labor and capital endowments, respectively. The Mathematical Appendix shows that the inverse of e_u measures the marginal utility of income. Thus, the last term in equation (3) is the utility equivalent of revenue losses from a greater incidence of terrorism.

The partial derivative of the expenditure function with respect to the price of good i yields the domestic demand function for the good. Moreover, the domestic production of good i is given by the corresponding partial derivative of the revenue function (see note 6). Net export of good i, say, EX^i, is the difference between the nation's domestic production and its domestic demand. Using equations (1) through (3), we have

$$EX^i = R_i\left[p_1, 1, L\left(T\right), K\left(T\right)\right] - e_i\left[p_1, 1, u\left(p_1, T\right)\right] = EX^i\left(T\right), \tag{4}$$

where the last term on the right-hand side of equation (4) suppresses prices from the functional form. Equation (4) can be used to find the comparative static effect of terrorism on trade. In a two-good world with given prices, the volume of trade is proportional to the volume of net export of either good.[7] Therefore, we can focus only on good 1. Differentiating equation (4) yields

$$\frac{\partial EX^1}{\partial T} = R_{1L} L'(T) + R_{1K} K'(T) - e_{1u} u_T. \tag{5}$$

Note that $R_{1v}\left(=\frac{\partial R_1}{\partial v}=\frac{\partial X^1}{\partial v}\right)$ represents the increase (or decrease) in production of good 1 (say, X^1) in response to an increase in factor endowment v. Therefore, the first two terms on the right-hand side of equation (5) reflect the changes in production of good 1 from terrorism-induced destruction of labor and capital endowments, respectively. The last term indicates the fall in demand for good 1 caused by the terrorism-related utility loss of the representative consumer. The net effect of these supply and demand changes on the export of good 1 is reflected in equation (5).

Now, we use equation (3) to substitute for u_T in equation (5). In addition, in view of note 6, we can substitute w (wage rate for labor) and r (rental rate for capital) for R_L and R_K, respectively. These substitutions and some rearrangement of terms yield[8]

$$\frac{\partial EX^1}{\partial T}=\left(R_{1L}-w\times mpc^1\right)L'(T)+\left(R_{1K}-r\times mpc^1\right)K'(T). \tag{6}$$

Without loss of generality, consider good 1 to be the export good (i.e., $EX^1>0$). Using equation (6) and note 7, we conclude that trade will rise with terrorism (i.e., $\frac{\partial EX^1}{\partial T}>0$) if and only if

$$R_{1L}-w\times mpc^1<-z(T)\left(R_{1K}-r\times mpc^1\right),\ z(T)\equiv\frac{K'(T)}{L'(T)}>0, \tag{7}$$

where z represents the relative rate of terrorism-induced destruction of capital and labor. The intuition behind equation (7) is best understood by using the special cases below.

For simplicity, we first consider a case where only labor is depleted by terrorism, but the capital stock is unaffected.[9] In this case, $K'(T)=0\Rightarrow z(T)=0$, and hence equation (7) can be reduced to

$$\frac{\partial EX^1}{\partial T}>0 \text{ if and only if } R_{1L}<w\times mpc^1. \tag{8}$$

Now let us consider the special case of the Heckscher-Ohlin model: Here, in addition to perfect competition, we invoke constant returns to scale in production. If good 1 is capital intensive, the output of good 1 is necessarily negatively related to the abundance of labor (i.e., $R_{1L}<0$) from the Rybczynski theorem. In this case, normality in the consumption of good 1 (i.e., $mpc^1>0$) is sufficient to ensure that equation (8) is satisfied, so that terrorism must raise trade. The following intuition applies. Terrorism reduces labor endowment, leading to an increase in the production of good 1. Also, the reduction of the labor endowment leads to a loss in labor income for the representative consumer, which translates to a fall in demand for good 1, assuming normality. Thus, the export of good 1 must increase because of a rise in its production and a fall in its domestic demand. This finding contrasts with the trade effects of terrorism identified in the literature by Nitsch and Schumacher (2004) and Blomberg and Hess (2006). The difference stems from the fact that our representation highlights the effect of terrorism on

factor supplies rather than transaction costs. It is important to note, however, that even though terrorism expands trade in the example above, trade may shrink in other scenarios. The analysis below identifies and discusses these alternative possibilities.

A MULTIGOOD, MULTIFACTOR *n* × *m* MODEL

The analysis is now extended to a small open economy that trades n goods and uses m factors of production. The price vector for the n goods is given by $p = (p_1, p_2, \ldots, p_n)$, while the endowment vector of the m factors is denoted by $v = (v^1, v^2, \ldots, v^m)$. As in the earlier section, factor endowments are again subject to terrorism-induced depletion, such that

$$v(T) = \left[v^1(T), v^2(T), \ldots v^m(T)\right], \ \frac{\partial v^j(T)}{\partial T} = v_T^j \leq 0. \tag{9}$$

Again, terrorism destroys resources, attracts some resources into the terrorism sector, raises risks, and increases the cost of conducting business. The trade balance for this multigood, multifactor open economy requires expenditure to match revenue:

$$e(p,u) = R\left[p, v(T)\right]. \tag{10}$$

Based on the implicit function theorem, equation (10) yields

$$u = u(p,T), \frac{\partial u}{\partial T} = u_T(\bullet) = \frac{\sum_{j=1}^{m} R_{v^j} v^{j\prime}(T)}{e_u} = \frac{\sum_{j=1}^{m} \omega^j v^{j\prime}(T)}{e_u}, \tag{11}$$

where $\omega^j = R_{v^j}$ is the price of factor j. Using equation (11) and suppressing the output price vector in the last term on the right-hand side of the following equation yields

$$EX^i = R_i\left[p, v(T)\right] - e_i\left[p, u\left(p,T\right)\right] = EX^i(T), \ i = 1,2,\ldots,n, \tag{12}$$

where good i is exportable (importable) if EX^i is positive (negative). Differentiating equation (12) with respect to terrorism and substituting equation (11) into the resulting expression, we can express the terrorism-induced change in the net export of good i as

$$\frac{\partial EX^i}{\partial T} = \sum_{j=1}^{m} \left(R_{iv^j} - mpc^i \times \omega^j\right) v^{j\prime}(T), \ i = 1,2,\ldots,n. \tag{13}$$

Equation (13) may be understood using the following logic. For any factor j, $v^{j\prime}(T)$ represents depletion of its endowment as a result of terrorism. The term R_{iv^j} is the change in production of good i for a marginal change in the endowment of factor j. On the other hand, along the lines of the income effect discussed following equation (8), the term $mpc^i \times \omega^j$ reflects the fall in demand for good i resulting from the depletion of factor income from destruction of factor j. Therefore, the net effect on export of good i from damage to a particular factor j is captured by the term $(R_{iv^j} - mpc^i \times \omega^j)v^{j\prime}(T)$. Given that terrorism can potentially damage all

m factors, the total effect on the export of good i must be reflected by the sum of these terms over all the factors.

Now, consider one of the exportable goods such that $EX^i > 0$. Given that $v^{j'}(T)$ is nonpositive for all factors, a necessary condition for $\frac{\partial EX^i}{\partial T} > 0$ is that for (at least) one factor j^*, it must be that

$$(14) \qquad \left(R_{iv^{j^*}} - mpc^i \times \omega^{j^*}\right) v^{j^{*\prime}}(T) > 0 \Rightarrow v^{j^{*\prime}}(T) < 0, \text{ and also } R_{iv^{j^*}} - mpc^i \times \omega^{j^*} < 0.$$

Equation (8) in the previous section is a special case of equation (14). Although equation (8) is both a necessary and a sufficient condition for trade to rise with terrorism, in the general model considered here, it is simply a necessary condition for the export of a particular good (not necessarily the summed value of all exports) to rise with terrorism. Below, we provide some textbook cases of trade nested within the current $n \times m$ model and evaluate equations (13) and (14), where appropriate, within the contexts of these special cases.

Case 1: A 2 × 1 Ricardian Model

Consider a Ricardian model where there are two goods ($n = 2$) and only one factor of production, denoted by labor (i.e., $m = 1$). Under standard assumptions, this model yields complete specialization in the production of the exportable good (say, good 1). If good 2 is the numeraire, then balance of trade requires that

$$(15) \qquad p_1 EX^1 = IM^2,\ EX^1 = X^1 - c^1, \text{ and } IM^2 = c^2,$$

where X^1 is the production of good 1 and c^i is the domestic consumption of good i ($i = 1,2$). As terrorism reduces the labor endowment (since $L'(T) < 0$), the output of good 1 must fall. Consumption of good 1 also falls because of the income effect discussed previously. A rise in exports may appear possible; however, the loss of income will also reduce the consumption of good 2, which denotes imports in this representation. When we use this fact in equation (15), terrorism *must* reduce trade.

Case 2: A 2 × 3 Specific Factors Model

Here, we consider a standard specific factors model and show that, as in the Heckscher-Ohlin model, terrorism may raise or reduce trade. We offer two contrasting examples within the context of this model. In the first, terrorism must raise trade; in the second, terrorism must reduce trade. In a specific factors model, this establishes that, unless the pattern of the effects of terrorism on the different factor endowments is known, the effects on trade cannot be predicted.

Assume that two goods ($n = 2$) are produced by three factors: labor, land, and capital ($m = 3$). Think of one of the goods as being food and the other as being manufacturing. Further assume that labor is used to produce both goods, while land and capital are specific factors for food and manufacturing, respectively. Let manufacturing (good 1) be the export good and food (good 2) be the import good. Using equation (13), we have

$$\frac{\partial EX^1}{\partial T} = \left(R_{1L} - mpc^1 \times w\right) L'(T) + \left(R_{1K} - mpc^1 \times r\right) K'(T) + \left(R_{1\lambda} - mpc^1 \times \rho\right) \lambda'(T), \tag{16}$$

where ρ and $\lambda(T)$ are the land rental and land endowment, respectively.

Consider the possibility that terrorism reduces land availability for food production but does not affect other factors of production. This may be the case where a guerrilla group that deploys terrorist attacks controls land in the countryside, as in the case of the Revolutionary Armed Forces of Colombia (FARC) or the Shining Path in the 1980s in Peru. In this case, $L'(T) = K'(T) = 0$ and $\lambda'(T) < 0$, such that equation (16) degenerates to

$$\frac{\partial EX^1}{\partial T} = \left(R_{1\lambda} - mpc^1 \times \rho\right) \lambda'(T). \tag{17}$$

Equation (17) corresponds to equation (14). In this specific factors model, a standard result is that the rise in the land endowment must reduce the output of the manufacturing good, denoted by X^1 (i.e., $R_{1\lambda} = \frac{\partial X^1}{\partial \lambda} < 0$). Given $R_{1\lambda} < 0$, equation (17) implies that the normality of good 1 is sufficient for terrorism to augment trade. This follows because, as terrorism destroys land that can be used for cultivation, output of food falls and so some labor is reallocated to manufacturing, where output increases. However, the loss in national income resulting from the decline in productive land must reduce domestic consumption of the manufactured good (under normality). The resulting expansion of the gap between the nation's domestic supply of manufacturing and its domestic demand is absorbed through an expansion of manufacturing export. Thus, in this example, terrorism results in enhanced trade.

Now, we put forward an example where terrorism must reduce trade. Consider a scenario where terrorism destroys capital but does not affect land or labor resources. This would be true of terrorist groups that target infrastructure and foreign direct investment, such as Euskadi ta Askatasuna (ETA) in Spain (Enders and Sandler, 1996). In this case, $L'(T) = \lambda'(T) = 0$ and $K'(T) < 0$. When applied to good 2, equation (13) gives

$$\frac{\partial EX^2}{\partial T} = \left(R_{2K} - mpc^2 \times r\right) K'(T) > 0 \tag{18}$$

if and only if $R_{2K} - mpc^2 \times r < 0$.

In this model, a rise in capital must reduce the output of food, denoted by X^2 (i.e., $R_{2K} = \frac{\partial X^2}{\partial K} < 0$). Given $R_{2K} < 0$ and the import nature of good 2 (i.e., $IM^2 = -EX^2 > 0$), equation (18) gives

$$\frac{\partial EX^2}{\partial T} = \left(R_{2K} - mpc^2 \times r\right) K'(T) > 0 \Rightarrow \frac{\partial IM^2}{\partial T} = \frac{\partial\left(-EX^2\right)}{\partial T} < 0. \tag{19}$$

In this alternative scenario, terrorism reduces the volume of imports for two reasons. First, the terrorism-induced destruction of productive capital shrinks manufacturing and

some manufacturing labor is reallocated to agriculture, so that food production rises. Second, the loss of national income caused by the terrorism-induced capital depletion reduces the domestic demand for food. These two factors shrink the gap between domestic demand and domestic supply of food, thereby reducing the import of food. Since, in this example, capital is the only factor that is reduced by terrorism, trade must decline.

THE 2 × 2 SMALL OPEN ECONOMY MODEL UNDER AN OPTIMAL COUNTERTERRORISM POLICY

Next, we extend the investigation to analyze the effect of terrorism on trade in the 2 × 2 model in the presence of an optimal counterterrorism policy. Such policies take two essential forms: defensive measures intended to deter future terrorist acts through the hardening of potential targets or longer prison sentences for convicted terrorists (Landes, 1978) and proactive measures to limit the terrorists' capabilities by capturing or killing their operatives or leaders (Sandler and Siqueira, 2006).[10] Drone attacks on al-Qaida's leadership or the infiltration of terrorist groups also denote proactive counterterrorism measures. Suppose that terrorism can be reduced by either form of counterterrorism measures, denoted by μ. These measures are reflected in the terrorism index, T, used previously, which now takes the form

$$T = T(\alpha, \mu),\ T_\alpha > 0,\ \text{and}\ \ T_\mu < 0,^{11} \tag{20}$$

where α is a shift parameter capturing exogenous factors that augment terrorism for any given level of μ. As in equation (1), labor and capital endowments may be reduced by terrorism. Additionally, we assume that (i) counterterrorism effort is paid for in units of good 2 (i.e., the numeraire) and (ii) counterterrorism's marginal cost is constant at unity. Therefore, the trade balance condition must reflect the equality between consumption expenditure and production revenues, net of the counterterrorism expense. Based on equations (1) and (20) and the modified trade balance, this relationship may be represented as

$$e(p_1, 1, u) = R\left\{p_1, 1, L\left[T(\alpha, \mu)\right], K\left[T(\alpha, \mu)\right]\right\} - \mu. \tag{21}$$

Suppressing p_1 from the functional form and using the implicit function theorem, we can reexpress equation (21) as

$$u = u(\alpha, \mu),\ \frac{\partial u}{\partial \alpha} = u_\alpha(\bullet) = \frac{\left[R_L L'(T) + R_K K'(T)\right] T_\alpha}{e_u}\ \text{and} \tag{22}$$

$$\frac{\partial u}{\partial \mu} = u_\mu(\bullet) = \frac{\left[R_L L'(T) + R_K K'(T)\right] T_\mu - 1}{e_u}.$$

Now, counterterrorism policy is a choice variable for the government, which seeks to maximize the utility of the representative consumer. While greater counterterrorism effort helps to contain the terrorism threat, and thereby saves resources, it also costs the nation units of potential consumption of good 2 (or potential consumption of good 1, because good 2 can be

traded for good 1 at constant terms of trade). The balance of these marginal gains and losses determines the optimal level of counterterrorism policy. The first-order condition reflecting this choice is obtained by setting $u_\mu(\bullet)$ equal to zero[12]:

$$\{R_L(\bullet)L'[T(\bullet)]+R_K(\bullet)K'[T(\bullet)]\}T_\mu(\bullet)=1. \tag{23}$$

At the margin, as counterterrorism reduces terrorism, labor endowment rises, which in turn allows for additional production revenues of $R_L L'(T)T_\mu$. Similarly, $R_K K'(T)T_\mu$ measures the additional revenues arising from the capital-augmenting effect of counterterrorism effort. The left-hand side of equation (23) measures the sum of these two effects, which denotes the marginal national gain from counterterrorism effort. The right-hand side measures the marginal cost of counterterrorism for the nation, normalized at a value of 1. Hence, equation (23) implicitly defines the optimal counterterrorism policy as

$$\mu=\mu(\alpha). \tag{24}$$

Using equations (20) through (24), we can represent the net export of good 1 as

$$EX^1=R_1\left[p_1,1,L\{T[\alpha,\mu(\alpha)]\},K\{T[\alpha,\mu(\alpha)]\}\right]-e_1\{p_1,1,u[\alpha,\mu(\alpha)]\}. \tag{25}$$

Suppressing price from the functional form and noting that $u_\mu(\bullet) = 0$, we differentiate equation (25) and use equation (22) to derive

$$\frac{\partial EX^1}{\partial\alpha}=\left[R_{1L}L'(T)+R_{1K}K'(T)\right]\times\left[T_\alpha+T_\mu\mu'(\alpha)\right]-mpc^1\times\left[R_L L'(T)+R_K K'(T)\right]T_\alpha. \tag{26}$$

The first term on the right-hand side of equation (26) measures changes in the supply of good 1 resulting from labor and capital losses stemming from a change in terrorism due to both an exogenous rise in α and the endogenous response of μ. Moreover, the last term of equation (26) measures the change in the demand for good 1 resulting from the terrorism-induced loss in utility. Because $u_\mu(\bullet) = 0$, the effect on demand related to the change in μ disappears and only the effect of the exogenous change in terrorism (represented by T_α) remains.

Assuming that good 1 is the export good (see the section titled "A 2 × 2 Small Open Economy Model"), we consider the case where $K'(T) = 0$ and $L'(T) < 0$, such that terrorism affects labor but not capital. Given that $R_L = w$, equation (26) yields

$$\frac{\partial EX^1}{\partial\alpha}=L'(T)\left[\left(R_{1L}-w\times mpc^1\right)T_\alpha+R_{1L}T_\mu\mu'(\alpha)\right]>0, \tag{27}$$
$$\text{if and only if } \left(R_{1L}-w\times mpc^1\right)T_\alpha+R_{1L}T_\mu\mu'(\alpha)<0.$$

In the model analyzed previously, we showed that strict negativity of the term $(R_{1L} - w \times mpc^1)$ is both a necessary and a sufficient condition for trade to rise with an exogenous increase in terrorism in an analogous case. As is evident from equation (27), this is no longer true under the optimal counterterrorism policy because $R_{1L}T_\mu\mu'(\alpha)$ may be positive.

This difference may be clarified by the following example. Assume that $R_{1L} < 0$ such that a fall in the labor endowment raises the supply of the exportable good. Given that $T_{\mu} < 0$, if counterterrorism effort rises with the terrorism-inducing α (i.e., $\mu' > 0$),[13] it must follow that $R_{1L}T_{\mu}\mu'(\alpha) > 0$. In this case, as a rise in α increases terrorism, the optimal counterterrorism effort must also increase. This counterterrorism response partially mitigates the exogenous rise in terrorism, thereby moderating the increase in the production of the exportable good. Consequently, the rise in export volume is also moderated compared with the case previously analyzed. As a consequence, the impact of terrorism on trade depends not only on how terrorism affects factor supplies in the export sector, but also on how counterterrorism measures may mitigate this impact. The myriad possibilities that surface go beyond the established literature that paints terrorism as necessarily having an adverse influence on trade. Our more complete analysis recognizes Samuelson's and Rybczynski's classic contributions that taught us to account for the general equilibrium nature of trade and, in particular, how factor supply affects export and import industries differently owing to factor intensity considerations.

CONCLUSION

We present three variants of a model to analyze how terrorism may affect trade through its effects on factor supplies. First, we present a two-good, two-factor model (2×2 model) and derive a necessary and sufficient condition for terrorism to raise trade. Next, we extend this model to the case of arbitrary numbers of goods and factors and derive a necessary (but not sufficient) condition for terrorism to raise trade. This general model nests the Ricardian, Heckscher-Ohlin, and the specific factors models as special cases. We show that while terrorism cannot increase trade in the single-factor Ricardian model, in the other two multifactor models it is possible for trade to rise with terrorism depending on the production structure of an economy. Finally, we present an augmented 2×2 model where counterterrorism policy is optimally chosen. The findings indicate that changes in counterterrorism policy in response to a greater terrorist threat may moderate the effect of terrorism on trade.

Our analysis should serve to dispel the notion that terrorism necessarily reduces trade for a nation affected by terrorism. The novelty of our article lies in the presentation of a competitive general equilibrium analysis of the effects of terrorism on trade flows, where factor supply effects are a central consideration. In addition, the conditions identified in this article should help in determining when terrorism should be expected to raise or reduce trade. As a general tendency, if terrorism reduces the intensive factor in the import industry, then exports and, thus, trade are generally favored. The result typically carries over to the specific factors representation when terrorism negatively affects the import industry's specific factor of production, thereby shifting resources to and increasing output of the exportable good. By reducing terrorism, counterterrorism ameliorates the impact on factor supplies—say, in the import sector—thereby reducing the increase in the export industry. Empirical measurements of exports, imports, their intensive factor supplies, and terrorism should permit a subsequent analysis of the influence of terrorism on trade. There are many possibilities, and simple rules of thumb that characterize the literature are not necessarily valid. Although some forms of

terrorism may augment trade, this is obviously not a desirable route to enhance trade. However, knowledge of the true effect of terrorism on trade under alternative scenarios will allow for more intelligent aid and stabilization policies. ■

MATHEMATICAL APPENDIX

Consider the identity between Marshallian and Hicksian demand functions $D^i(\bullet)$ and $e_i(\bullet)$, respectively, at a given budget m, denoted as

$$e_i\left[p_1,1,u\left(p_1,1,m\right)\right]\equiv D^i\left(p_1,1,m\right)\Rightarrow mpc^i=\frac{\partial D^i}{\partial m}=e_{iu}u_m. \tag{A.1}$$

Next, consider the identity between the expenditure function and the budget m:

$$e\left[p_1,1,u\left(p_1,1,m\right)\right]\equiv m\Rightarrow e_u u_m=1\Rightarrow u_m=\frac{1}{e_u}. \tag{A.2}$$

Using equation (A.2) in (A.1), we have

$$mpc^i=\frac{e_{iu}}{e_u}. \tag{A.3}$$

NOTES

[1] Abadie and Gardeazabal (2008); Bandyopadhyay, Sandler, and Younas (2014); Enders, Sachsida, and Sandler (2006); and Enders and Sandler (1996) provide models of terrorism and foreign direct investment that show that greater incidence of terrorism tends to reduce foreign direct investment in developing and developed nations. Bandyopadhyay and Sandler (2014), among others, indicate that terrorism may reduce productive resources available for a nation that hosts a transnational terrorist group. For more on the economic impact of terrorism, see Abadie and Gardeazabal (2003); Blomberg, Hess, and Weerapana (2004); Enders and Sandler (2012); and Keefer and Loayza (2008).

[2] An interesting case is that of narco-terrorism pursued by groups such as FARC (Revolutionary Armed Forces of Colombia). Drugs are traded by such organizations to fund terrorist activities, including imports of arms for terrorists (e.g., see Library of Congress, 2002). In this scenario, terrorism directly leads to trade, albeit illegal. The mechanisms we identify in our article do not directly relate to this case; however, our model can be used as a benchmark to consider resource allocation issues relevant for such scenarios.

[3] Since the effects of higher terrorism-related transaction costs have already been explored in the literature and given that their negative effect on trade is uncontroversial, we choose to focus only on the factor supply effects.

[4] In a recent paper, Egger and Gassebner (2014) use a structural gravity model to investigate the effects of terrorism on trade. Their findings suggest that terrorism does not have quantitatively important effects on trade. This is not inconsistent with our findings, which suggest that both factor supply effects on production and income-induced changes in demand determine the ultimate effect of terrorism on trade. If, for example, terrorism reduces the production of the exportable commodity through the factor supply channel, while at the same time reducing its domestic demand through the income channel, then exports will be largely unaffected. We should note that, while Egger and Gassebner do account for a general equilibrium channel through which income may affect trade, their channel is only indirectly related to the factor supply approach highlighted here.

[5] The representation below offers reduced-form models that analyze the effects of terrorism on factor supplies.

[6] In a competitive economy, the partial derivative of a revenue function with respect to the price of good *i* yields the general equilibrium supply function of good *i*. On the other hand, the partial derivative of the revenue function with respect to the endowment of factor *j* yields the price of factor *j*. For details, see Dixit and Norman (1980).

[7] Notice that the trade balance requires the value of exports to equal the value of imports at world prices. In our model, this is equivalent to $p_1 EX^1 = IM^2$, where IM^2 is the volume of import of good 2 and is the negative of net export of good 2 (i.e., $IM^2 = -EX^2 = e_2 - R_2$).

[8] In this derivation, we also use the fact that the expression $\left(\frac{e_{1u}}{e_u}\right)$ denotes the marginal propensity to consume good 1, say mpc^1. This is established in the Mathematical Appendix.

[9] Consider the reasoning behind the assumption that the capital stock remains unaffected. First, it may be that terrorism does not affect investment, although it may affect labor or land endowments. Second, in a static analysis, we can focus only on the existing stock of capital and abstract from issues of capital accumulation.

[10] Hardening of potential targets involves making a potential terrorist target more difficult to hit. For example, raising the security level/quality of screening at an airport considered a potential target would make it harder for terrorists to hijack planes departing from that airport. In contrast, a "soft target" is one that is undefended and easily hit by terrorists interested in doing so.

[11] It may seem reasonable that counterterrorism policies may not necessarily reduce terrorism, especially if there is a backlash effect (e.g., see Rosendorff and Sandler, 2010). However, in the current context, if $T_\mu > 0$, there are no benefits from counterterrorism effort. Therefore, $T_\mu < 0$ is a necessary condition for an interior equilibrium involving optimal counterterrorism policy.

[12] We assume that $T_{\mu\mu} > 0$. Because $T_\mu < 0$, the sign of $T_{\mu\mu}$ implies diminishing returns to counterterrorism effort. In addition, we assume that these diminishing returns are sufficiently strong to ensure that the second-order condition is satisfied for this optimization problem.

[13] Equations (23) and (24) can be used to analyze the comparative static effect of terrorism-inducer, α, on counterterrorism, μ. Among other things, a rise in α will tend to raise μ if $L''(T) < 0$. Because $L'(T) < 0$, strict negativity of

$L''(T)$ implies increasing marginal damages resulting from terrorism. In this case, when α increases, it raises the level of terrorism, magnifying the marginal damage. In turn, this increases the marginal benefit of containing terrorism, thereby inducing a higher optimal level of counterterrorism effort.

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When and How To Exit Quantitative Easing?

Yi Wen

The essence of quantitative easing (QE) is reducing the cost of private borrowing through large-scale purchases of privately issued debt instead of public debt (Bernanke, 2009). Considering the economy has drastically recovered, it is time to consider how exiting from these private asset purchases will affect the economy. In a standard economic model, if monetary injections can increase aggregate output and employment, then the reverse action may undo such effects. But does this imply that the U.S. economy will dive into another recession once the Fed starts its large-scale asset sales (under the assumption that QE has successfully pulled the economy out of the Great Recession)? This article studies the likely impact of QE and its exit strategy on the economy. In particular, it shows that three aspects of the Federal Reserve's exit strategy are important in achieving (or maintaining) maximum gains (if any) in aggregate output and employment under QE: (i) the timing of the exit, (ii) the pace of the exit, and (iii) the private sector's expectations of when and how the Fed will exit. (JEL E50, E52)

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Since the onset of the financial crisis in late 2007, the Federal Reserve has injected an astronomical amount of money into the economy through its large-scale asset purchase (LSAP) programs. According to former Fed Chairman Ben Bernanke (2009, p. 5), the essence of LSAP is "credit easing" (CE)—that is, reducing the cost of private borrowing by direct purchases of privately issued debt instead of government debt. However, given that the government has no intention to hold private debt on its balance sheet forever, at some point the Fed must sell it.

The goal of this article is to answer the following questions about the likely effects of the Fed's exit strategies:

- Will the Fed's exit from quantitative easing (QE) undo the gains of LSAPs (if any)?
- Do the timing and pace of the exit matter?

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- Should the exit be state dependent, and how would the economy respond to a fully anticipated exit compared with an unanticipated exit?

In this article, I use a calibrated general equilibrium model to shed light on these questions. The model's framework features explicit asset purchases by the government that mimic the real-world scenario. In this article, QE, CE, and LSAPs are considered synonymous. To highlight the general equilibrium effects of QE and facilitate the study of exit strategies, I use a real model in which long-run inflation is fully anchored, consistent with the fact that the U.S. inflation rate has remained stable and below the 2 percent target since the implementation of QE in 2008. In the real model, all transactions and payments are conducted by the exchange/transfer of goods, so there is no need to distinguish monetary authority from fiscal authority. More specifically, I assume there is a consolidated government that can purchase private assets using revenues raised by lump-sum taxes or sales of public debt.[1]

My basic findings can be summarized as follows. Assuming that inflation is fully anchored, the longer and more massively the Fed can hold private debt on its balance sheet before the adverse financial shocks dissipate, the more likely QE will be able to stimulate aggregate investment and employment. In other words, QE is unlikely to have any significant effect on the economy if its scope is too small and too transitory. However, when the aggregate shocks are not permanent, QE may lower the steady-state output if the Fed never exits QE. Consequently, not only does an optimal timing of the Fed's exit exist (depending on the persistence of the financial shocks), but the pace of the exit and whether the exit is anticipated or unanticipated also matter. In particular, it is optimal for the exit to be completely unanticipated by the public to preserve the maximum gains on aggregate output and employment achieved under QE. However, once the exit starts, it is better for it to be quick rather than gradual. Accordingly, it would be a mistake for the Fed to pre-announce or discuss in advance the timing of an exit from QE soon after it was implemented; this sort of announcement would shorten the effective duration of QE anticipated by the public. On the other hand, if the exit is too gradual, the long-run adverse effects of QE would arise and thus offset the benefits from QE gained in the earlier periods.

My model is a fairly standard, off-the-shelf model based on the recent macro-finance literature.[2] A key feature of this class of models is that an endogenously determined distribution of heterogeneous creditors/debtors (instead of households' time preferences per se) pins down the real interest rate and asset prices in the asset market through the demand and supply of privately issued debt. QE influences the real economy by affecting the allocation (distributions) of credit/debt in asset markets. Two key assumptions in the model dictate my results:

(i) Debtors are relatively more productive than creditors—in other words, more productive agents opt to issue debt and less productive agents opt to lend.

(ii) Financial markets are incomplete—that is, agents face uninsurable idiosyncratic shocks and are borrowing constrained.

Under these fairly standard assumptions, the following properties emerge naturally from the model. First, the demand for liquid assets increases despite their low returns relative to

capital investment. Second, when the cost of borrowing is reduced, marginal creditors self-select to become debtors, which can raise the quantity of aggregate debt but also unambiguously lower the average quality (efficiency) of loans.

Given these core properties, it is clear that QE's main effect on aggregate output is changing the distribution of credit/debt in the financial market—that is, QE pushes more creditors to become debtors, which in turn increases the total quantity of loans but at the same time decreases the average efficiency of loans. When economic activities depend not only on the extent and scope of credit but also on the quality of loans, such a trade-off between quantity and quality implies two things: (i) Aggregate output and employment are *insensitive* to small-scale temporary asset purchases even with relatively large changes in the real interest rate and asset prices (Wen, 2013). And (ii) QE's positive *quantitative* effect on aggregate investment may dominate its adverse *qualitative* effect in the short run to mitigate negative financial shocks if asset purchases are sufficiently large and persistent relative to the magnitudes of financial shocks. This property renders QE much less effective if its exit is fully anticipated. On the other hand, since permanent QE may reduce the steady-state output when financial shocks are not permanent, it is desirable to exit not only at a certain point in time, but also as quickly as possible once the exit starts.

THE MODEL

The key actors in the model are firms, which make production and investment decisions in an uncertain world. There is a credit market where firms can lend/borrow from each other by issuing/purchasing private debt. Firms face idiosyncratic uncertainty in the rate of return to their investment projects, modeled specifically as an idiosyncratic shock to the marginal efficiency of firm-level investment (as specified below). In any period, some firms opt to lend and some opt to borrow, depending on their draws of the idiosyncratic shock to the return on investment projects. The real interest rate will then be determined endogenously by the supply and demand of private debt.

Government

The consolidated government uses lump-sum taxes on household income to finance purchases of private debt. Total private debt purchased by the government in period t is denoted by B_{t+1} and the market price of private debt by $\frac{1}{1+r_t}$, where r_t is the real interest rate on private debt. Total money supply at the end of period t is denoted by M_{t+1}, the aggregate price level by P_t, and the inflation rate by $1+\pi_t = \frac{P_t}{P_{t-1}}$. The government budget constraint in each period is given by

$$G_t + \frac{1}{1+r_t} B_{t+1} = B_t + \frac{(M_{t+1} - M_t)}{P_t} + T_t, \tag{1}$$

where the left-hand side is total government expenditures and the right-hand side is total government revenues. Government outlays include government spending G_t and new purchases of private debt B_{t+1} at price $\frac{1}{1+r_t}$. Total government revenues include debt repayment B_t from the private sector, real seigniorage income $\frac{(M_{t+1}-M_t)}{P_t}$, and lump-sum taxes T_t.

Firms' Problem

There is a continuum of firms indexed by i ∈ [0,1]. A firm *i*'s objective is to maximize the present value of its discounted future dividends,

$$V_t(i) = \max E_t \sum_{\tau=0}^{\infty} \beta^{\tau} \frac{\Lambda_{t+\tau}}{\Lambda_t} d_{t+\tau}(i), \tag{2}$$

where $d_t(i)$ is firm *i*'s dividend in period *t* and Λ_t is the representative household's marginal utility, which firms take as given. The production technology is given by the constant returns to scale function

$$y_t(i) = A_t k_t(i)^{\alpha} n_t(i)^{1-\alpha}, \tag{3}$$

where A_t represents the aggregate technology level and $n_t(i)$ and $k_t(i)$ are firm-level employment and capital, respectively. Firms accumulate their own capital stock through the law of motion,

$$k_{t+1}(i) = (1-\delta) k_t(i) + \varepsilon_t(i) x_t(i), \tag{4}$$

where investment $x_t(i)$ denotes investment and is irreversible,

$$x_t(i) \geq 0; \tag{5}$$

and $\varepsilon_t(i)$ is an i.i.d. idiosyncratic shock to the marginal efficiency of investment. In each period *t*, a firm needs to pay wages $W_t n_t(i)$, decide whether to invest in fixed capital, and distribute dividends $d_t(i)$ to households. Firms' investment is financed by internal cash flow and external funds. Firms raise external funds by issuing one-period debt (bonds), $b_{t+1}(i)$, which pay the competitive market interest rate r_t. Note that $b_{t+1}(i) < 0$ when a firm holds bonds issued by other firms (i.e., $b_{t+1}(i)$ can be either positive or negative).

A firm's dividend in period *t* is then given by

$$d_t(i) = y_t(i) + \frac{b_{t+1}(i)}{1+r_t} - i_t(i) - w_t n_t(i) - (1-\mathbf{P}_t) b_t(i), \tag{6}$$

where the probability of default or the aggregate default risk of private debt is denoted by $\mathbf{P}_t$. For ease of exposition, we temporarily set $\mathbf{P}_t = 0$ and defer further discussion to the section entitled "State-Contingent QE." Firms cannot pay negative dividends,

(7) $$d_t(i) \geq 0,$$

which is the same as saying that fixed investment is financed entirely by internal cash flow ($y_t(i) - W_t n_t(i)$) and external funds net of loan repayment ($\frac{b_{t+1}(i)}{1+r_t} - b_t(i)$). The idiosyncratic shock to investment efficiency has the cumulative distribution function $F(\varepsilon)$.

Loans are subject to collateral constraints. That is, firm i is allowed to pledge a fraction $\theta \in [0,1]$ of its fixed capital stock $k_t(i)$ at the beginning of period t as collateral. In general, the parameter θ represents the extent of financial market imperfections or the tightness of the financial market. At the end of period t, the pledged collateral is priced by the market value of newly installed capital, so the market value of collateral is simply Tobin's q, denoted by q_t, which is equivalent to the expected value of a firm that owns collateralizable capital stock $\theta k_t(i)$. The borrowing constraint is thus given by

(8) $$b_{t+1}(i) \leq \theta q_t k_t(i),$$

which specifies that any new debt issued cannot exceed the collateral value (q_t) of a firm with the pledged capital stock $\theta k_t(i)$. When $\theta = 0$ for all t, the model is identical to one that prohibits external financing.

Firms affect both the supply and demand of private debt, and they may also affect the demand for money when the real rate of return on money dominates that on private debt. To simplify the analysis, I start with the equilibrium condition that $\frac{1}{1+\pi} < 1+r$, so that firms hold only private debt and no money. When this condition is violated (i.e., when $\frac{1}{1+\pi} = 1+r$), the two assets become perfect substitutes. In this case, firms are indifferent between holding money and private debt, and their portfolios are determined in equilibrium by the aggregate supply of each asset. This situation is called a "liquidity trap."[3]

The Household's Problem

There is a representative household, and it is assumed that the household is subject to the cash-in-advance (CIA) constraint for consumption purchases, $C_t \leq \frac{M_t}{P_t}$. Since firms may also hold money as an alternative store of value, the CIA constraint implies that the household is always the residual claimant of the aggregate money stock whenever the CIA constraint binds. Because there is a liquidity premium on the privately issued bonds and households do not face idiosyncratic risk and incomplete financial markets, the rate of return to private bonds is dominated by that of equity. Hence, the household does not hold private bonds in equilibrium. The representative household chooses nominal money demand M_{t+1}, consumption plan C_t, labor supply N_t, and share holdings $s_{t+1}(i)$ of each firm i to solve

$$\max \sum_{t=0}^{\infty} \beta^t \left\{ \log C_t - \frac{N_t^{1+\gamma}}{1+\gamma} \right\} \tag{9}$$

subject to the constraints,

$$C_t \leq \frac{M_t}{P_t} \tag{10}$$

$$C_t + \frac{M_{t+1}}{P_t} + \int_{i=0}^{1} s_{t+1}(i)\left[V_t(i) - d_t(i)\right] di \leq \frac{M_t}{P_t} + W_t N_t + \int_{i=0}^{1} s_t(i) V_t(i)\, di - T_t, \tag{11}$$

where T_t denotes lump-sum income taxes, $s_t(i) \in [0,1]$ denotes firm i's equity shares, and $V_t(i)$ denotes the value of the firm (stock price). Let Λ_t be the Lagrangian multiplier of budget constraint (11); the first-order condition for $s_{t+1}(i)$ is given by

$$V_t(i) = d_t(i) + E_t \beta \frac{\Lambda_{t+1}}{\Lambda_t} V_{t+1}(i). \tag{12}$$

Equation (12) implies that the stock price $V_t(i)$ of firm i is determined by the present value of the firm's discounted future dividends, as in equation (2).

COMPETITIVE EQUILIBRIUM

Given (i) the initial money balance of the household M_0, (ii) the initial level of government holdings of private debt B_0, and (iii) the initial distributions of private debt $b_0(i)$ and capital stocks $k_0(i)$ across firms, a competitive equilibrium consists of the sequences and distributions of quantities $\{C_t, N_t, M_t\}_{t=0}^{\infty}$, $\{x_t(i), n_t(i), y_t(i), k_{t+1}(i), b_{t+1}(i)\}_{t\geq 0}$ for $i \in [0,1]$ and the sequences of prices $\{P_t, W_t, V_t(i), r_t\}_{t=0}^{\infty}$ such that

(i) Given prices $\{W_t, r_t\}_{t\geq 0}$, the sequences $\{x_t(i), n_t(i), y_t(i), k_{t+1}(i), b_{t+1}(i)\}_{t\geq 0}$ solve problem (2) for all firms subject to constraints (3) through (8).

(ii) Given prices $\{P_t, W_t, V_t(i)\}_{t\geq 0}$, the sequences $\{C_t, N_t, M_t, s_{t+1}(i)\}_{t\geq 0}$ maximize the household's lifetime utility (9) subject to its budget constraint (11) and the CIA constraint (10).

(iii) All markets clear:

$$\int b_{t+1}(i)\, di = B_{t+1} \tag{13}$$

$$s_{t+1}(i) = 1 \text{ for all } i \in [0,1] \tag{14}$$

$$N_t = \int n_t(i)\, di \tag{15}$$

$$C_t + \int x_t(i)\, di + G_t = \int y_t(i)\, di \tag{16}$$

$$M_t = \bar{M}, \tag{17}$$

where equation (13) states that the net supply of private bonds issued by all firms equals the total purchases of private bonds by the government. Note that if $B_{t+1} = 0$, then the government holds zero private debt and all bonds issued by firms are circulated only among themselves with zero net supply/demand.

Firms' Decision Rules

Under constant returns to scale technology, a firm's labor demand is proportional to its capital stock. Hence, a firm's net cash flow (revenue minus wage costs) is also a linear function of its capital stock,

$$y_t(i) - W_t n_t(i) = \alpha A_t \left(\frac{(1-\alpha) A_t}{w_t} \right)^{\frac{1-\alpha}{\alpha}} k_t(i) \equiv R(W_t, A_t) k_t(i), \tag{18}$$

where R_t depends only on the aggregate state. With this notation of R_t, we have the following two propositions:

Proposition 1 *The decision rule for investment is characterized by an optimal cutoff ε_t^* such that a firm undertakes capital investment if and only if $\varepsilon_t(i) \geq \varepsilon_t^*$:*

$$x_t(i) = \begin{cases} \left[R_t + \dfrac{\theta_t q_t}{1+r_t} \right] k_t(i) - b_t(i) & \text{if } \varepsilon_t(i) \geq \varepsilon_t^* \\ 0 & \text{if } \varepsilon_t(i) < \varepsilon_t^* \end{cases}, \tag{19}$$

where the cutoff ε_t^* is a function of the aggregate state space only, is independent of the individual firm's history, and is a sufficient statistic for characterizing the distribution of the firm's actions.

Proof. See Appendix A.

Proposition 2 *The equilibrium interest rate of private debt satisfies the following relation:*

$$\frac{1}{1+r_t} = \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t} Q\left(\varepsilon_{t+1}^*\right), \tag{20}$$

where

$$Q\left(\varepsilon_t^*\right) \equiv \int_{\varepsilon(i) < \varepsilon_t^*} dF(\varepsilon) + \int_{\varepsilon(i) \geq \varepsilon_t^*} \frac{\varepsilon_t(i)}{\varepsilon_t^*} dF(\varepsilon).$$

Proof. See Appendix B.

Aggregation

Proposition 3 *Define aggregate capital stock as* $K_t = \int k_t(i)\,di$, *aggregate employment as* $N_t = \int n_t(i)\,di$, *aggregate output as* $Y_t = \int y_t(i)\,di$, *and aggregate investment expenditure as* $I_t = \int x_t(i)\,di$. *Since the cutoff* ε_t^* *is a sufficient statistic for characterizing the distribution of firms, the model's equilibrium can be fully characterized as the sequences of aggregate variables* $\{C_t, K_{t+1}, I_t, Y_t, N_t, R_t, \varepsilon_t^*, r_t, W_t, P_t\}_{t=0}^{\infty}$, *which can be solved by the following system of nonlinear equations (given the path of any aggregate shocks, money supply* $\{\bar{M}_t\}_{t=0}^{\infty}$, *the distribution function* $F(\varepsilon)$, *and the initial distributions of private debts* $b_0(i)$ *and capital stocks* $k_0(i)$*)*:

(21) $$C_t = \frac{M_t}{P_t}$$

(22) $$\Lambda_t W_t = N_t^{\gamma}$$

(23) $$\frac{1}{C_t} = \Lambda_t + \Theta_t$$

(24) $$\Lambda_t = \frac{\beta}{1+\pi} E_t\left(\Lambda_{t+1} + \Theta_{t+1}\right)$$

(25) $$C_t + I_t + G_t = Y_t$$

(26) $$\frac{1}{\varepsilon_t^*} = \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t}\left\{R_{t+1} Q\left(\varepsilon_{t+1}^*\right) + \frac{\theta_{t+1}}{\varepsilon_{t+1}^*}\frac{\left[Q\left(\varepsilon_{t+1}^*\right) - 1\right]}{1+r_{t+1}} + \frac{(1-\delta)}{\varepsilon_{t+1}^*}\right\}$$

(27) $$\frac{1}{1+r_t} = \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t} Q\left(\varepsilon_{t+1}^*\right)$$

(28) $$I_t = \left\{\left(R_t + \frac{\theta_t}{(1+r_t)\varepsilon_t^*}\right)K_t - B_t\right\}\left[1 - F\left(\varepsilon_t^*\right)\right]$$

(29) $$K_{t+1} = (1-\delta)K_t + Z\left(\varepsilon_t^*\right) I_t$$

(30) $$R_t = \alpha \frac{Y_t}{K_t}$$

(31) $$W_t = (1-\alpha)\frac{Y_t}{N_t}$$

$$Y_t = A_t K_t^{\alpha} N_t^{1-\alpha}, \tag{32}$$

where $Q(\varepsilon_t^*) \equiv \int \max\left\{\frac{\varepsilon}{\varepsilon_t^*}, 1\right\} dF(\varepsilon)$ and $Z(\varepsilon_t^*) \equiv \left[\int_{\varepsilon \geq \varepsilon_t^*} \varepsilon f(\varepsilon) d\varepsilon\right]\left[1 - F(\varepsilon_t^*)\right]^{-1}$.

Proof. See Appendix C.

Equations (21) through (24) are the household's first-order conditions; equation (25) is the aggregate resource identity derived from the household's budget constraint; equations (26) through (28) are derived from the firm's decision rules based on the law of large numbers; equation (29) is the law of motion for the aggregate capital stock, where $Z(\varepsilon^*)$ denotes aggregate investment efficiency; equations (30) and (31) relate the firm's marginal products to factor prices; and equation (32) is the aggregate production function.

MACROECONOMIC EFFECTS OF QE

In the model, QE affects aggregate output indirectly through its direct impact on the distribution of credit/debt. In particular, QE affects aggregate output by influencing the aggregate capital stock (in the absence of a productivity change, employment demand is determined entirely by the capital stock, which determines the marginal product of labor). However, equation (29) shows that the level of aggregate capital stock depends on two margins: the volume of aggregate investment I and the average efficiency of firm-level investment Z. The product ZI can be called the efficient level of aggregate investment.

QE affects both the volume and the efficiency level of investment in the economy by changing the distribution of credit/debt in the private asset market. On the one hand, QE can lower the interest rate r and raise the market value of the firm q, thus boosting firm-level investment along the intensive margin (see equation (19)). In addition, because of a lower borrowing cost and a lower rate of return to saving (due to a lower interest rate), more creditors self-select to become debtors, thus boosting aggregate investment along the extensive margin (i.e., the cutoff, ε^*, decreases). On the other hand, as more creditors self-select to become debtors, since these new investors (debtors) are less productive, the average rate of return to investment (as measured by the aggregate efficiency Z) declines, thus offsetting the positive impact of investment volume on the formation of aggregate capital (see equation (29)).

In other words, QE works by pushing more creditors to become debtors, which in turn increases the total demand for loans but decreases the average efficiency of loans. In addition, since the number of voluntary lenders is reduced, the increased aggregate demand for loans can be met only by the government's supply of credit through QE (or a lump-sum tax on the consumers). When the economy depends not only on the extent and scope of credit/debt but also on the *quality* of loans, such a trade-off between quantity and quality implies the following: (i) Aggregate output and employment may be *insensitive* to small-scale asset purchases even with relatively large changes in the real interest rate and asset prices. And (ii) the positive *quantitative* effect of QE on aggregate investment volume may or may not dominate the adverse

Table 1

Parameter Values

Parameter	β	δ	γ	α	$\bar{\theta}$	π	$\varepsilon_{\max}$	$\bar{\varepsilon}$	$\bar{b}$	ρ_θ	ρ_A	$\rho_{\mathbf{p}}$
Calibration	0.99	0.025	0.5	0.36	0.5	0.03	2.0	1.0	0.4	0.9	0.95	0.9

qualitative effect on aggregate investment efficiency in the steady state. Thus, aggregate output may either increase or decrease under QE, depending on the time horizon and parameter values of the model.

Calibration

Let the time period be one quarter, the time discount rate $\beta = 0.99$, the rate of capital depreciation $\delta = 0.025$, the capital income share $\alpha = 0.36$, and the inverse labor supply elasticity $\gamma = 0.5$. In the United States, the total private debt-to-GDP (gross domestic product) ratio of nonfinancial firms doubled from 23 percent to 48 percent over the past half century. The model-implied private debt-to-output ratio is about 25 percent when $\theta = 0.1$ and about 50 percent when $\theta = 0.5$. Assume that the idiosyncratic shock ε follows the power distribution $F(\varepsilon) = \left(\frac{\varepsilon}{\varepsilon_{\max}}\right)^{\eta}$ with $\varepsilon \in [0, \varepsilon_{\max}]$ and $\eta > 0$. The shape parameter is set to $\eta = \frac{\bar{\varepsilon}}{\varepsilon_{\max} - \bar{\varepsilon}}$ to easily control the mean ($\bar{\varepsilon}$) and conduct mean-preserving experiments on the variance of idiosyncratic shocks by changing the upper bound $\varepsilon_{\max}$. The distribution becomes uniform when the mean $\bar{\varepsilon} = \frac{1}{2}\varepsilon_{\max}$. I choose the steady-state ratio of private asset purchases to GDP $\bar{b} = 0.4$ as the benchmark value. This large value is chosen to make the effects of QE large enough for the qualitative analysis. With this parameterization, the positive mitigating effect of QE on output is significant in the short run. However, although QE can mitigate the negative impact of financial shocks on GDP in the short run, it can also permanently lower the level of GDP in the steady state if QE never ends. In this case, it is easy to see the differential effects of anticipated exits compared with unanticipated exits on output and the optimal timing of exit. Table 1 summarizes the calibrated parameter values.

State-Contingent QE

Three aggregate shocks are introduced into the benchmark model to evaluate the effects of the central bank's unconventional monetary policy for combating a simulated financial crisis. For this purpose, it is assumed that (i) the debt limit θ is a stochastic process with the law of motion,

$$\log\theta_t = (1-\rho_\theta)\log\bar{\theta} + \rho_\theta \log\theta_{t-1} + \varepsilon_{\theta t}; \tag{33}$$

(ii) total factor productivity (TFP) is a stochastic process with the law of motion,

$$\log A_t = (1-\rho_A)\log \overline{A} + \rho_A \log A_{t-1} + \varepsilon_{At}; \tag{34}$$

and (iii) the default risk **P** is a stochastic process with the law of motion,

$$\log \mathbf{P}_t = (1-\rho_{\mathbf{p}})\log \overline{\mathbf{P}} + \rho_{\mathbf{p}} \log \mathbf{P}_{t-1} + \varepsilon_{\mathbf{p}t}. \tag{35}$$

We introduce the default risk shock as follows. A firm *i* solves

$$V_t(i) = \max E_t \sum_{\tau=0}^{\infty} \beta^{\tau} \frac{\Lambda_{t+\tau}}{\Lambda_t} d_{t+\tau}(i) \tag{36}$$

subject to

$$d_t(i) \equiv R_t k_t(i) - x_t(i) + \frac{b_{t+1}(i)}{1+r_t} - (1-\mathbf{P}_t) b_t(i) \geq 0, \tag{37}$$

$$k_{t+1}(i) = (1-\delta) k_t(i) + \varepsilon_t(i) i_t(i), \tag{38}$$

$$b_{t+1}(i) \leq \theta_t (1-\mathbf{P}_t) q_t k_t(i), \text{ and} \tag{39}$$

$$x_t(i) \geq 0, \tag{40}$$

where $\mathbf{P}_t$ denotes the systemic default risk of private debt. When $\mathbf{P}_t$ increases, each firm's existing debt level is reduced from $b_t(i)$ to $(1 - \mathbf{P}_t)b_t(i)$, which also reduces the firm's ability to pledge collateral by a factor of $(1 - \mathbf{P}_t)$. Thus, firms' ability to issue debt is severely hindered when the aggregate default risk rises. In the extreme case of a 100 percent default probability, firms are no longer able to issue debt, so the asset market shuts down and the real interest rate shoots up to infinity.

All three shocks—negative shocks to both θ_t and A_t and a positive shock to $\mathbf{P}_t$—can generate financial-crisis-like effects on output, consumption, investment, and employment: They all decline sharply. The real interest rate, however, decreases under a negative shock to either the credit limit θ_t or TFP (as in the United States) but increases under a positive shock to default risk (as in Europe during the recent debt crisis). The asset price (q_t) increases under θ_t and $\mathbf{P}_t$ shocks but decreases under a TFP shock.

A state-contingent QE policy is specified as

$$\hat{B}_{t+1} = \rho_B \hat{B}_t + \sigma_x \hat{\mathbf{X}}_t, \tag{41}$$

where $\rho_B \in [0,1]$ measures the persistence of QE, $\sigma_x = [\sigma_\theta \quad \sigma_A \quad \sigma_P]$ is a 1×3 row vector, and $\hat{\mathbf{X}} = [\hat{\theta}_t \quad \hat{A}_t \quad \hat{\mathbf{P}}_t]'$ is a 3×1 column vector. Notice that $\rho_B = 1$ implies that QE never ends.

Exit Strategies

Consider the following types of exit strategies:

- A one-time exit:

$$\hat{B}_{t+1} = \hat{B}_t + \sigma_x \hat{\mathbf{X}}_t \text{ for } t = 0,1,...T-1; \tag{42}$$

$$\hat{B}_{t+1} = 0 \text{ for } t \geq T; \tag{43}$$

where T is the number of periods of QE.

- A gradual exit:

$$\hat{B}_{t+1} = \hat{B}_t + \sigma_x \hat{\mathbf{X}}_t, \text{ for } t = 0,1,...,T-1; \tag{44}$$

$$\hat{B}_{t+1+j} = \frac{N-j}{N}\hat{B}_t, \text{ for } t = T \text{ and } j = 1,...,N; \tag{45}$$

$$\hat{B}_{T+N+1+h} = 0 \text{ for } h \geq 0; \tag{46}$$

where T is the number of QE periods and $N \geq 1$ is the number of periods over which the exit will occur.

In both exit scenarios, I consider anticipated and unanticipated exits.

Figure 1 shows the impulse response functions of output, total asset prices, the real interest rate, and total asset purchases by the government to a persistent credit crunch shock (θ_t). Three different scenarios are compared for each variable: (i) no government intervention (no QE, shown by dark-blue dashed lines on the figure), (ii) no exit (light-blue dotted lines), and (iii) a fully anticipated one-time exit after 20 periods of QE intervention (red dash-dotted lines). Therefore, each panel shows three impulse responses.

Figure 1A shows clearly that the sharp drop in output under a credit crunch can be significantly mitigated by QE with or without an exit. However, the short-run mitigation effect is much stronger if there is no exit. On the other hand, there would be permanent output losses in the long run if there is never an exit from QE. This sharp contrast between the short- and long-run effects of QE on output is the consequence of the trade-off between the positive quantity effect of QE on aggregate investment volume and the negative quality effect of QE on average investment efficiency. Because the capital stock is relatively fixed in the short run, the quantity effect dominates in the short run because a higher total investment volume has a strong demand-side effect on the economy. In the long run, however, despite a larger volume of total investment, the average efficiency of investment is lowered by QE, leading to a lower (instead of a higher) effective capital stock. A lower capital stock in turn leads to lower labor demand and, hence, lower aggregate output. This interesting trade-off between the quantity and the quality of investment generates a dynamic trade-off between the short-run and long-

run mitigating effects of QE on the economy, leading to interesting and surprising implications for the optimal timing and manner of the exit strategies under different shocks with state-contingent QE policies.

Figure 2 shows the impulse responses of the same variables as in Figure 1 (output, total asset prices, the real interest rate, and total asset purchases by the government) to a persistent TFP shock. The pattern of the output responses to the TFP shock is similar to that under a credit crunch with respect to the mitigating effects of QE policies. Note that, as before, exiting QE in the 20th period has no visible impact on output, although such an impact is obvious in the other three variables. This result is also due to the trade-off between the quantity effect and the quality effect of QE on aggregate investment.

Figure 3 shows the impulse response functions of output, asset prices, the real interest rate, and total asset purchases by the government to a persistent default-risk shock. As before, I compare three different scenarios. Again, the broad pattern of the output responses to a default risk shock is similar to those under a credit crunch with respect to the mitigating effects of QE policies.

Figure 4 shows the differential effects of an unanticipated one-time exit and an anticipated gradual exit under a credit crunch, in addition to the other cases considered earlier. The dashed blue lines in each panel in Figure 4 are impulse responses of the different variables to the θ_t shock with no QE. This case serves as the benchmark. Note that in this case, total asset purchases remain in the steady state (Figure 4B) and output decreases sharply by 2 percent on impact and then gradually returns to the steady state.

The red dotted lines in Figure 4 show the scenario for permanent QE with no exit. In this case, total asset purchases increase permanently from 0 percent to 500 percent above the steady-state level under QE (see Figure 4B). The output level drops by 0.6 percent on impact (see Figure 4A), showing a significant mitigating effect of QE. However, in the long run, output remains more than 0.1 percent below the steady state, suggesting that QE has an adverse long-run effect on output.

Two of the exit scenarios consider a one-time complete exit of QE in period 20 after QE is implemented. In one case, the exit is completely unanticipated (dash-dotted orange lines in Figure 4). In the other case, the exit is fully anticipated in period 0 (dashed green lines) as in Figure 1. In both cases, total asset purchases suddenly drop back to the steady-state level after 20 periods (see Figure 4B). However, output (see Figure 4A) behaves quite differently under the two scenarios: With an unanticipated exit, the negative impact of a credit crunch on output is significantly mitigated in the first 20 periods (as in the case with permanent QE with no exit), because in this case agents treat QE as a permanent policy with no exit before the unanticipated exit in period 20. With an anticipated exit, the mitigating effect of QE is much weaker in the first 20 periods (albeit still stronger than the case with no QE). Because of the sudden unanticipated one-time exit of QE, output drops sharply in period 20, unlike the case with an anticipated one-time exit.

Finally, consider the scenario with an anticipated but gradual exit of QE starting in period 20, with the total exit time equal to 40 periods. The diagonal dashed line in Figure 4B shows that total asset purchases start to decline in period 20 and gradually reach the steady state in

Figure 1

Impulse Response to θ With and Without an Exit Strategy

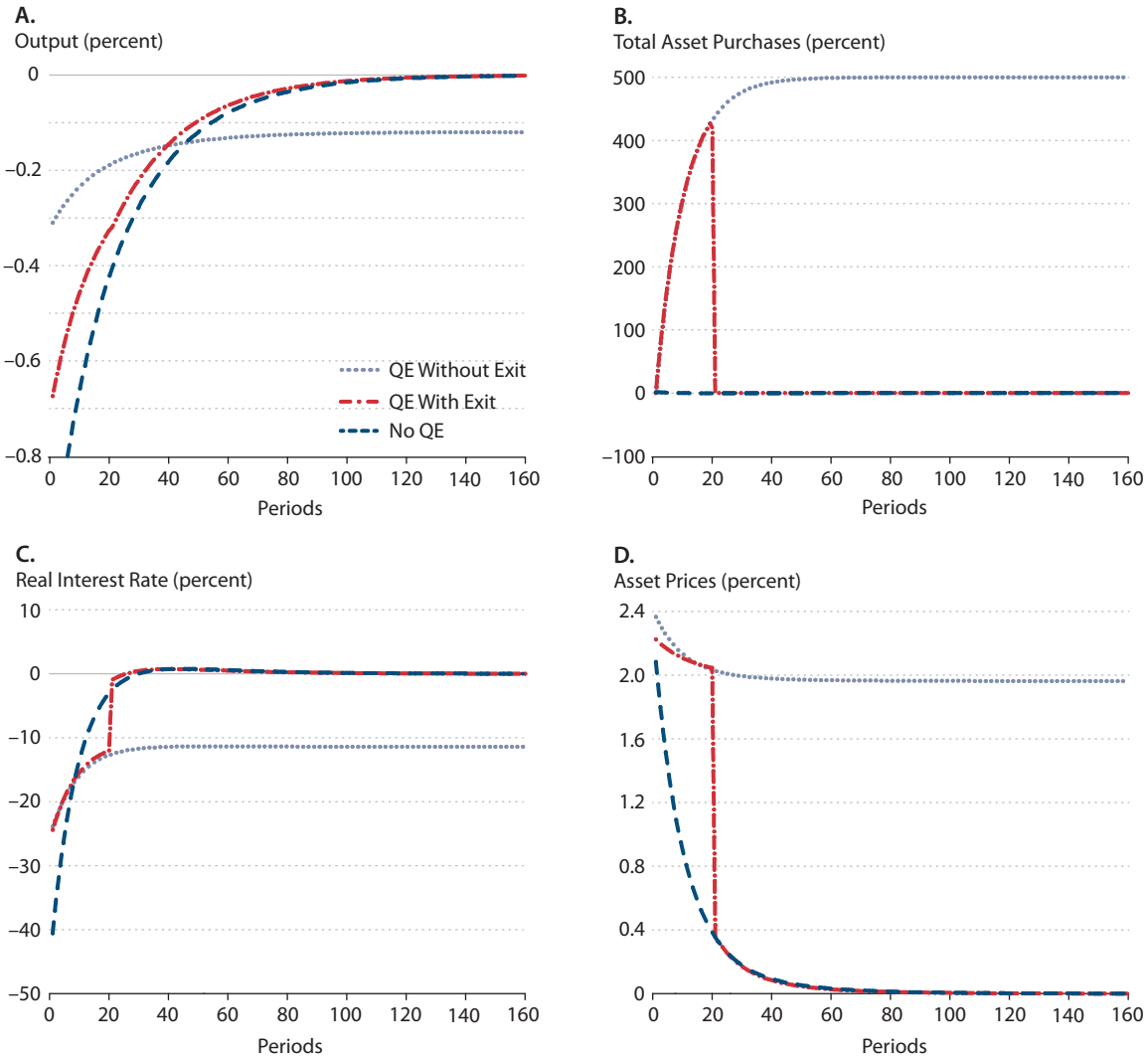


Figure 2

Impulse Response to A_t With and Without an Exit Strategy

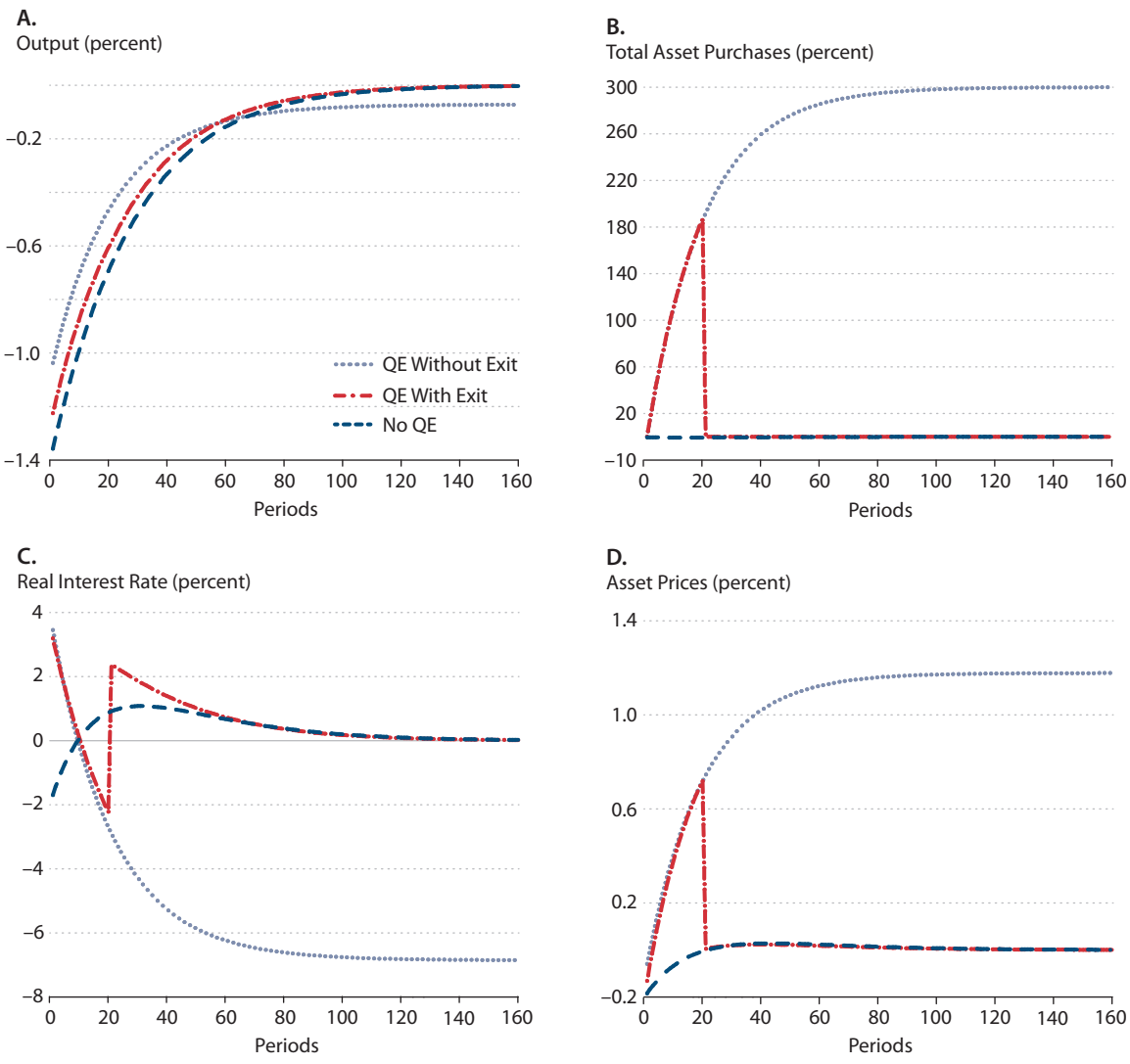


Figure 3

Impulse Response to P_t With and Without an Exit Strategy

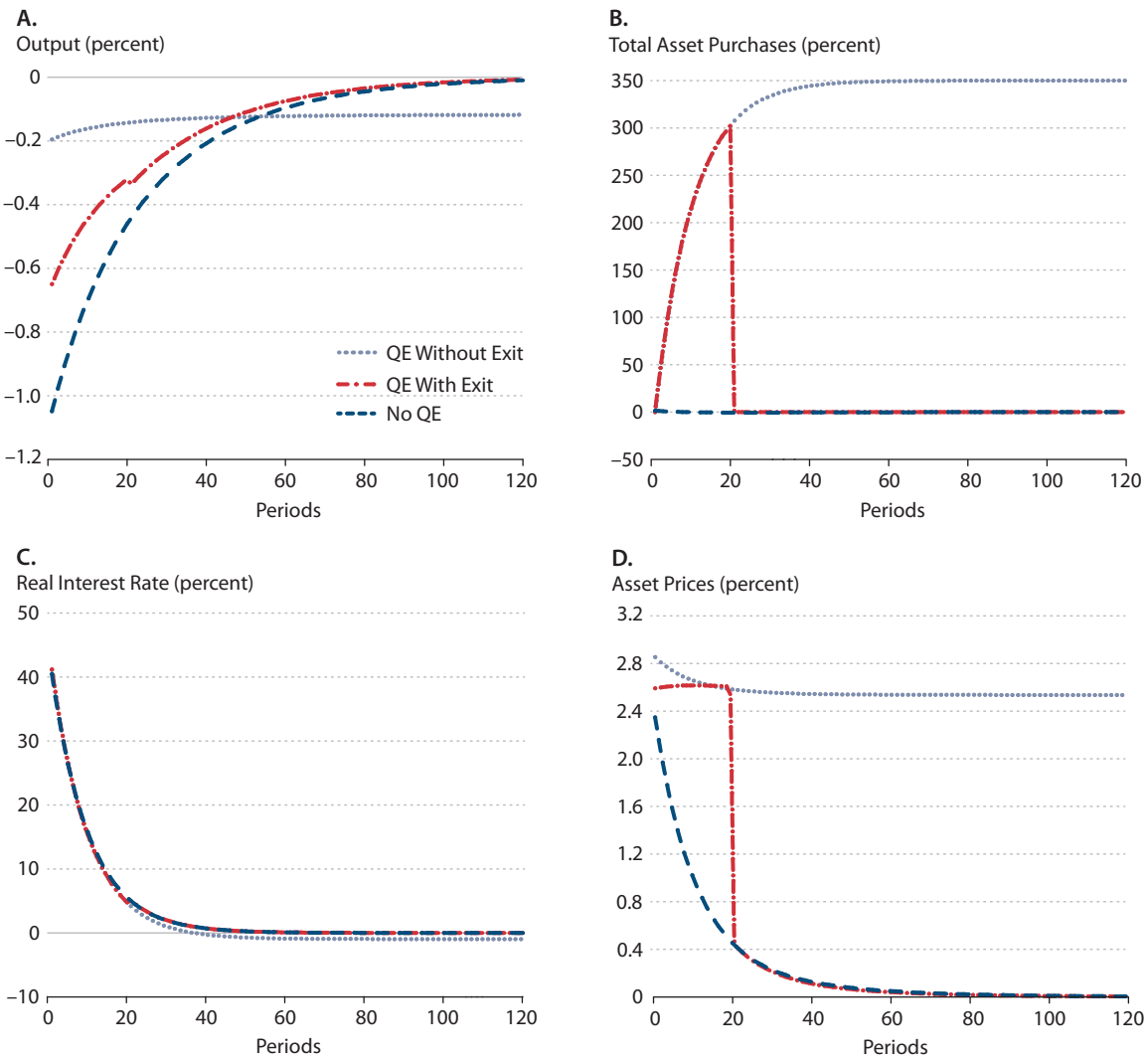
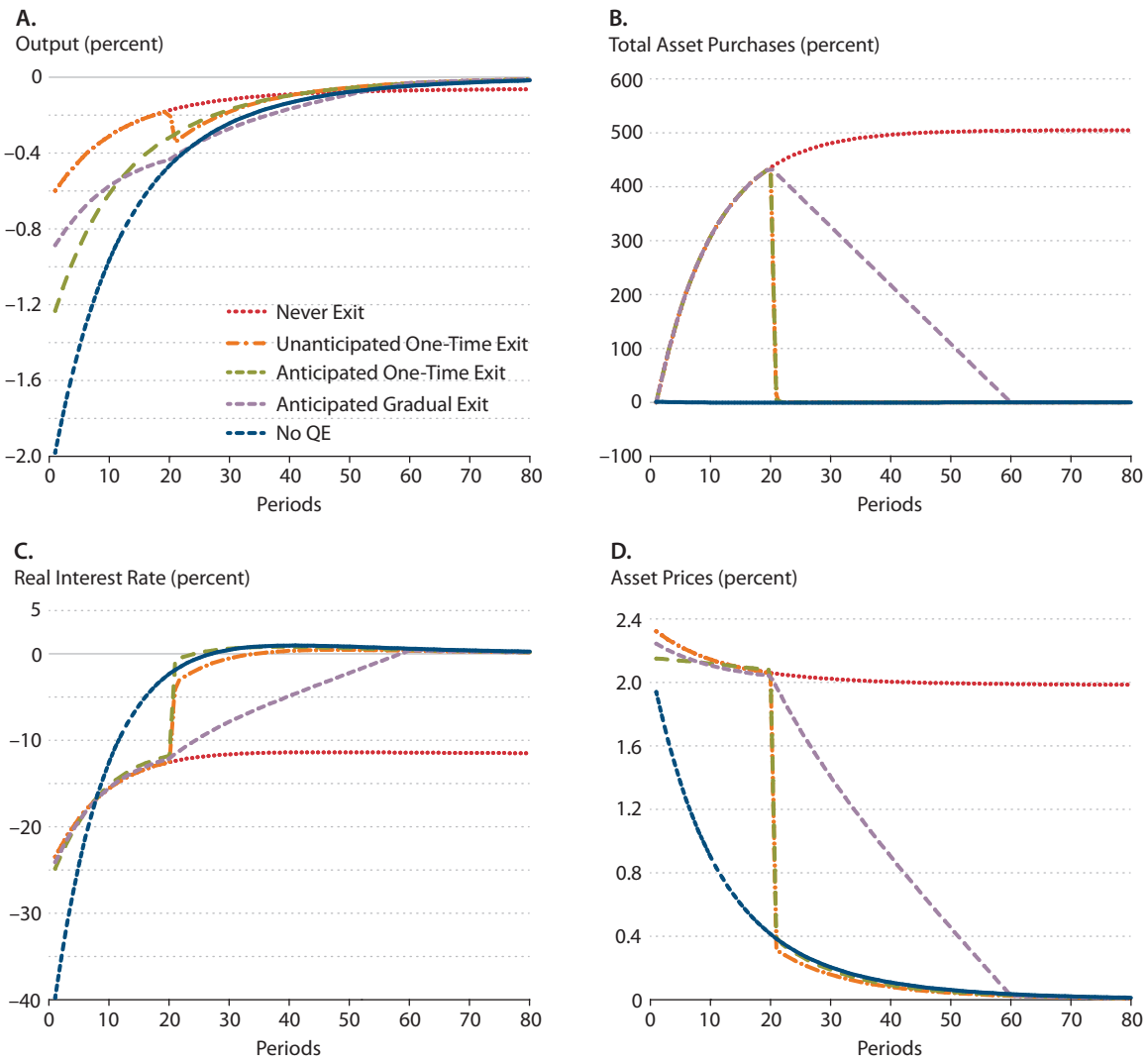


Figure 4

Effects of Different Exit Strategies



period 60. Because the exit of QE is gradual, QE generates a larger mitigating effect on output than an anticipated one-time exit in the initial 10 periods (see Figure 4A). However, output performs worse than in the case of a one-time anticipated exit afterward because the long-run adverse effect of QE begins even before the exit of QE takes place. Clearly, since the exit is nonetheless finished in finite time periods, output does not suffer from permanent losses as in the case of permanent QE.

To summarize, these scenarios suggest that (i) QE can mitigate the negative impact of financial shocks on output in the short run if it is aggressive enough; (ii) there is an optimal timing to exit with respect to maximizing the mitigating effect of QE, which is around 35 to 40 periods under the current parameter configuration; (iii) an unanticipated exit works better than an anticipated exit, everything else equal; and (iv) a one-time exit is likely to work better than a gradual exit provided the timing of the exit is not too early compared with the optimal timing.[4]

CONCLUSION

Despite the popularity of QE among central banks since the financial crisis, few studies exist to explicitly model and study the macroeconomic effects of QE and its various exit strategies. This article fills this void by constructing a general equilibrium model featuring explicitly large-scale private asset purchases. I show that both the timing and the manner in which central banks unwind and reverse their asset purchase programs matter greatly for the economy. An anticipated exit that is too early can render QE ineffective in mitigating the financial crisis. On the other hand, an exit that is too late may also damage the economy because highly persistent (or permanent) QE promotes risk-taking behavior that is too intense (i.e., it encourages too many less-productive firms to undertake investment) and generates long-run inefficiency. ■

APPENDIXES

Appendix A: Proof of Proposition 1

Applying the definition in equation (18), the firm's problem can be rewritten as

$$\max_{\{i_t(i),b_{t+1}(i),k_{t+1}(i)\}} E_0\sum_{t=0}^{\infty}\beta^t\frac{\Lambda_t}{\Lambda_0}\left(R_t k_t(i)-i_t(i)+\frac{b_{t+1}(i)}{1+r_t^c}-b_t(i)\right) \tag{A.1}$$

subject to

$$k_{t+1}(i)=(1-\delta)k_t(i)+\varepsilon_t(i)i_t(i) \tag{A.2}$$

$$i_t(i)\geq 0 \tag{A.3}$$

$$i_t(i)\leq R_t k_t(i)+\frac{b_{t+1}(i)}{1+r_t}-b_t(i) \tag{A.4}$$

$$b_{t+1}(i)\leq\theta_t q_t k_t(i). \tag{A.5}$$

Notice that if $r_t>\frac{1}{1+\pi_t}-1$, firms do not hold money. On the other hand, if $r_t=\frac{1}{1+\pi_t}-1$, firms are indifferent between holding private debt and money. Which case prevails depends on the steady-state supply of debt and the inflation rate (Wen, 2013). I proceed by assuming $\frac{1}{1+\pi}<1+r<\frac{1}{\beta}$ in equilibrium and refer readers to Wen (2013) for the other cases.

Denoting $\{\lambda_t(i),\pi_t(i),\mu_t(i),\varphi_t(i)\}$ as the Lagrangian multipliers of constraints (A.2) through (A.5), respectively, the firm's first-order conditions for $\{i_t(i),k_{t+1}(i),b_{t+1}(i)\}$ are given, respectively, by

$$1+\mu_t(i)=\varepsilon_t(i)\lambda_t(i)+\pi_t(i), \tag{A.6}$$

$$\lambda_t(i)=\beta E_t\frac{\Lambda_{t+1}}{\Lambda_t}\left\{\left[1+\mu_{t+1}(i)\right]R_{t+1}+(1-\delta)\lambda_{t+1}(i)+\theta_{t+1}q_{t+1}\varphi_{t+1}(i)\right\}, \tag{A.7}$$

$$\frac{1+\mu_t(i)}{1+r_t^c}=\beta E_t\left\{\frac{\Lambda_{t+1}}{\Lambda_t}\left[1+\mu_{t+1}(i)\right]\right\}+\varphi_t(i). \tag{A.8}$$

The complementary slackness conditions are $\pi_t(i)i_t(i)=0$, $[R_t k_t(i)-i_t(i)+b_{t+1}(i)/(1+r_t^c)-b_t(i)]\mu_t(i)=0$, and $\varphi_t(i)[\theta q_t k_t(i)-b_{t+1}(i)]=0$.

Proof. Consider two possible cases for the efficiency shock $\varepsilon_t(i)$.

Case A: $\varepsilon_t(i) \geq \varepsilon_t^*$. In this case, firm i receives a favorable shock. Suppose this shock induces the firm to invest, resulting in $i_t(i) > 0$ and $\pi_t(i) = 0$. By the law of iterated expectations, equations (A.6) and (A.7) then become

$$\frac{1+\mu_t(i)}{\varepsilon_t(i)} = \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t}\left\{\left[1+\overline{\mu}_{t+1}\right]R_{t+1} + (1-\delta)\overline{\lambda}_{t+1} + \theta_{t+1} q_{t+1} \overline{\varphi}_{t+1}\right\}. \tag{A.9}$$

Since the multiplier $\mu_t(i) \geq 0$, this equation implies

$$\varepsilon_t(i) \geq \left[\beta E_t \frac{\Lambda_{t+1}}{\Lambda_t}\left\{\left[1+\overline{\mu}_{t+1}\right]R_{t+1} + (1-\delta)\overline{\lambda}_{t+1} + \theta_{t+1} q_{t+1} \overline{\varphi}_{t+1}\right\}\right]^{-1} \equiv \varepsilon_t^*. \tag{A.10}$$

Thus, equation (A.7) implies $\lambda_t(i) = \frac{1}{\varepsilon_t^*}$. Since $\pi(i) = 0$, equation (A.6) then becomes

$$\frac{1+\mu_t(i)}{\varepsilon_t(i)} = \frac{1}{\varepsilon_t^*}. \tag{A.11}$$

Hence, $\mu_t(i) > 0$ if and only if $\varepsilon_t(i) > \varepsilon_t^*$. It follows that under Case A firm i opts to invest at full capacity,

$$i_t(i) = R_t k_t(i) + \frac{b_{t+1}(i)}{1+r_t^c} - b_t(i), \tag{A.12}$$

and pays no dividend. Also, since $\mu_t(i) \geq 0$, equation (A.8) implies

$$\varphi_t(i) \geq \frac{1}{1+r_t^c} - \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t}\left\{\left[1+\overline{\mu}_{t+1}\right]\right\} \equiv \varphi_t^*, \tag{A.13}$$

where the right-hand side defines the cutoff φ_t^*, which is independent of i. Note that $\varphi_t^* \geq 0$ because it is the value of the Lagrangian multiplier when $\mu_t(i) = 0$. Hence, equation (A.8) can also be written as

$$\varphi_t(i) = \frac{\varepsilon_t(i) - \varepsilon_t^*}{\varepsilon_t^*}\frac{1}{1+r_t^c} + \varphi_t^*. \tag{A.14}$$

Because $\varphi_t^* \geq 0$, $\varphi_t(i) > 0$ when $\varepsilon_t(i) > \varepsilon_t^*$, which means that under Case A firms are willing to borrow up to the borrowing limit $b_{t+1}(i) = \theta q_t k_t(i)$ to finance investment. Therefore, the optimal investment equation (A.12) can be rewritten as

$$i_t(i) = \left[R_t + \frac{\theta q_t}{1+r_t^c}\right]k_t(i) - b_t(i). \tag{A.15}$$

Case B: $\varepsilon_t(i) < \varepsilon_t^*$. In this case, firm i receives an unfavorable shock, so the firm opts to underinvest, $i_t(i) < R_t k_t(i) + \frac{b_{t+1}}{1+r_t^c} - b_t$; then the multiplier $\mu_t(i) = 0$. Equation (A.6) implies that $\pi_t(i) = \frac{1}{\varepsilon_t(i)} - \frac{1}{\varepsilon_t^*} > 0$. Thus, the firm opts not to invest at all, $i_t(i) = 0$. Since $\int_0^1 b_{t+1}(i)\,di = 0$ and $b_{t+1}(i) = \theta q_t k_t(i) > 0$ when $\varepsilon_t(i) > \varepsilon_t^*(i)$, there must exist firms indexed by j such that $b_{t+1}(j) < 0$ if $\varepsilon_t(j) < \varepsilon_t^*$. It then follows that $\varphi_t(j) = \varphi_t^* = 0$ under Case B. That is, firms that receive unfavorable shocks will not invest in fixed capital but instead will opt to invest in financial assets in the bond market by lending a portion of their cash flows to other (more productive) firms.

A firm's optimal investment policy is thus given by the decision rules in Proposition 1, and the Lagrangian multipliers must satisfy

(A.16)
$$\pi_t(i) = \begin{cases} 0 & \text{if } \varepsilon_t(i) \geq \varepsilon_t^* \\ \frac{1}{\varepsilon_t(i)} - \frac{1}{\varepsilon_t^*} & \text{if } \varepsilon_t(i) < \varepsilon_t^* \end{cases},$$

(A.17)
$$\mu_t(i) = \begin{cases} \frac{\varepsilon_t(i) - \varepsilon_t^*}{\varepsilon_t^*} & \text{if } \varepsilon_t(i) \geq \varepsilon_t^* \\ 0 & \text{if } \varepsilon_t(i) < \varepsilon_t^* \end{cases},$$

(A.18)
$$\varphi_t(i) = \begin{cases} \frac{\varepsilon_t(i) - \varepsilon_t^*}{\varepsilon_t^*} \frac{1}{1+r_t^c} & \text{if } \varepsilon_t(i) \geq \varepsilon_t^* \\ 0 & \text{if } \varepsilon_t(i) < \varepsilon_t^* \end{cases} = \frac{\mu_t(i)}{1+r_t^c}.$$

Using equations (A.16) to (A.18) and equations $\lambda_t(i) = \frac{1}{\varepsilon_t^*}$ and (A.7), the cutoff ε_t^* can be expressed as a recursive equation:

(A.19)
$$\frac{1}{\varepsilon_t^*} = \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t} \left\{ R_{t+1}^L Q\left(\varepsilon_{t+1}^*\right) + \frac{\theta_{t+1}}{\varepsilon_{t+1}^*} \frac{\left[Q\left(\varepsilon_{t+1}^*\right) - 1\right]}{1+r_{t+1}^c} + \frac{(1-\delta)}{\varepsilon_{t+1}^*} \right\},$$

which determines the cutoff as a function of aggregate states only. Finally, equations (A.16) to (A.18) also imply that all the Lagrangian multipliers $\{\lambda_t(i), \pi_t(i), \mu_t(i), \varphi_t(i)\}$ depend only on aggregate states and the current idiosyncratic shock $\varepsilon_t(i)$. Hence, their expected values $\{\bar{\lambda}_t, \bar{\pi}_t, \bar{\mu}_t, \bar{\varphi}_t\}$ are independent of individual history and i.

Appendix B. Proof of Proposition 2

Proof. Using equation (A.17), equation (A.8) can be rewritten as

$$\frac{[1+\mu_t(i)]}{r_t^c} = \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t} Q\left(\varepsilon_{t+1}^*\right) + \varphi_t(i). \tag{B.1}$$

Evaluating this equation for firms with $\varepsilon_t(i) < \varepsilon_t^*$ yields equation (20).

Appendix C. Proof of Proposition 3

Proof. By definition, the aggregate investment is $I_t \equiv \int i_t(j)dj$. Integrating equation (19) gives equation (28). The aggregate capital stock evolves according to

$$K_{t+1} = (1-\delta)K_t + \int_{\varepsilon_t(j)\geq\varepsilon_t^*} i_t(j)\varepsilon_t(j)dj, \tag{C.1}$$

which by the firm's investment decision rule implies

$$\begin{aligned} K_{t+1} &= (1-\delta)K_t + \left(R_t K_t + B_t^g\right)\int_{\xi_t(j)\geq\xi_t^*}\xi_t(j)dj \\ &= (1-\delta)K_t + I_t\left[1-\mathbf{F}\left(\varepsilon_t^*\right)\right]^{-1}\int_{\varepsilon_t(j)\geq\varepsilon_t^*}\varepsilon_t(j)dj. \end{aligned} \tag{C.2}$$

Defining $Z\left(\varepsilon_t^*\right) \equiv \left[\int_{\varepsilon\geq\varepsilon_t^*}\varepsilon d\mathbf{F}(\varepsilon)\right]\left[1-\mathbf{F}\left(\varepsilon_t^*\right)\right]^{-1}$ as the measure of aggregate (or average) investment efficiency gives (29). Equation (18) implies $(1-\alpha)\left[\frac{Y_t}{N_t}\right]^{1-\sigma} A_t^{\sigma} = w_t$. Since the capital-to-labor ratio is identical across firms, it must be true that $\frac{k(i)}{n(i)} = \frac{K}{N}$. It follows that the aggregate production function is given by $Y_t = A_t K_t^{\alpha} N_t^{1-\alpha}$. By the property of constant returns to scale, the defined function $R(w_t, A_t)$ in equation (18) is then the capital share, $R_t = \alpha\left(\frac{Y_t}{K_t}\right)^{1-\sigma}$, which equals the marginal product of aggregate capital. Because $\int_0^1 b_t(i)\,di = B_t$ and the equity share $s_{t+1}(i) = 1$ in equilibrium, the aggregate dividend and profit income are given by $D_t + \Pi_t = [Y_t - I_t - w_t N_t] + \left[\frac{B_{t+1}}{1+r_t^c} - B_t\right]$. Hence, given the government budget constraint, the household resource constraint becomes $C_t + I_t + G_t = Y_t$, as in equation (25).

NOTES

[1] To simplify the analysis, public debt is not modeled here. Interested readers are referred to Wen (2013) for the case when LSAPs involve both public and private debt.

[2] See, for example, Wang and Wen (2009, 2012, 2013) and Wen (2013).

[3] However, the liquidity trap is not addressed in this article; interested readers are referred to Wen (2013). Ignoring the liquidity trap has no effect on the conclusions here because exiting QE tends to increase the interest rate and, thus, relax the constraint of the zero lower bound on the economy.

[4] An obvious future project is to mathematically design an optimal state-contingent exit strategy that can maximize the mitigating effects of QE, which is beyond the scope of this article.

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An International Perspective on the Recent Behavior of Inflation

Silvio Contessi, Pierangelo De Pace, and Li Li

Several commentators have been concerned about the possibility that the euro area may be experiencing disinflation with the risk of deflation. However, the euro area is not the only economy navigating the risky waters of low inflation. Several other advanced economies have recently experienced below-target inflation as well as outright deflation. In this article, the authors collect data for nine advanced economies and document several facts about the behavior of inflation during the 2002-14 period. First, they show that the relationship between inflation rates and short-term rates displays similar changes across advanced economies—with and without central bank programs designed to increase the size of their balance sheets (e.g., large-scale asset purchases). Second, they describe recent indications that headline and core inflation are below target for individual countries. They then discuss various explanations for this trend (global factors, output gaps, and changes in inflation expectations), showing that there is some important heterogeneity across countries. Finally, they show that while output has become even more synchronized across countries since 2008, the cross-country correlation of inflation is no longer higher than the cross-country correlation of output. (JEL E31, E43, F42, F44)

Federal Reserve Bank of St. Louis *Review*, Third Quarter 2014, *96*(3), pp. 267-94.

The 2007-09 financial crisis was accompanied by the first global recession in decades (Imbs, 2010). During that global recession and subsequent recovery, the behavior of inflation has attracted the interest of policymakers and researchers. In particular, several commentators have voiced concerns about low inflation in the euro area—or "lowflation," as the International Monetary Fund (IMF) recently described this environment (see Moghadam, Teja, and Berkmen, 2014). Several other advanced economies have experienced either below-target inflation or outright, if mild, deflation.

In this article, we collect inflation data for nine advanced economies: three large advanced economies (the euro area, Japan, and the United States) and three small open economies (Sweden, Switzerland, and the United Kingdom)—all of which have implemented or are still implementing some form of program designed to increase the size of the central bank's balance sheet (such as large-scale asset purchases [LSAPs])—plus three small open economies without

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LSAP programs (Canada, Denmark, and Norway). We then document several facts about the behavior of inflation during the 2002:01–2014:04 period.[1] First, we show informally that the relationship between inflation rates and short-term interest rates displays similar changes across advanced economies with and without large LSAP programs. Second, we document that headline and core inflation have recently been below inflation targets in all nine countries. However, observing inflation and price levels from a medium-term perspective reveals some important heterogeneity; very few countries are far from their medium-run objective. We discuss various explanations for this phenomenon: global shocks, economic slack, and changing inflation expectations. Among the large economies, the recent behavior of inflation suggests different trends and explanations. Finally, we show that the cross-country correlation of inflation is no longer higher than the cross-country correlation of output.

THE MONETARY POLICY FRAMEWORK OF NINE ADVANCED ECONOMIES

A large body of research has examined recent changes in monetary policy in advanced economies (see, for example, Bullard, 2010; Fawley and Neely, 2014; and Thornton, 2014). Here we provide a synthetic description of the monetary policy framework and stance in the nine economies studied. In most figures, the top panel represents the three large economies (the euro area, Japan, and the United States), all of which have implemented (or are still implementing) some form of LSAP program, as measured by a large expansion of the central bank's balance sheet. The middle panel represents the three small open economies (Sweden, Switzerland, and the United Kingdom) that have implemented or had implemented some form of LSAP program. The bottom panel represents the three small open economies (Canada, Denmark, and Norway) without LSAP programs.

Table 1 summarizes the historical and current inflation targets and the monetary policy instrument. Figure 1 plots the monetary policy rates of the nine economies and the asset sizes of their respective central bank balance sheets divided by nominal gross domestic product (GDP); this provides a sense of the magnitude of the unconventional monetary policy. Generally speaking, at the time this article was written, policy rates for most countries were at or close to the zero lower bound and had been there for a few years. In six of the economies, different LSAPs have been used in combination with extremely accommodative policy rates. Seven of these countries use forward guidance, as discussed below.

Inflation Targeting

Inflation targets are implemented in about 30 countries in various formats. Hammond (2012) provides an excellent review of the main modalities and country experiences. Hatcher and Minford (2013) survey recent strands of the literature to compare inflation targeting and price-level targeting as macroeconomic stabilization policies. As Hammond (2012, p. 5) explains,

> Inflation targeting is a framework rather than a rigid set of rules for monetary policy. Nonetheless there are a number of essential elements of an inflation-targeting regime:

Table 1

Inflation Targets

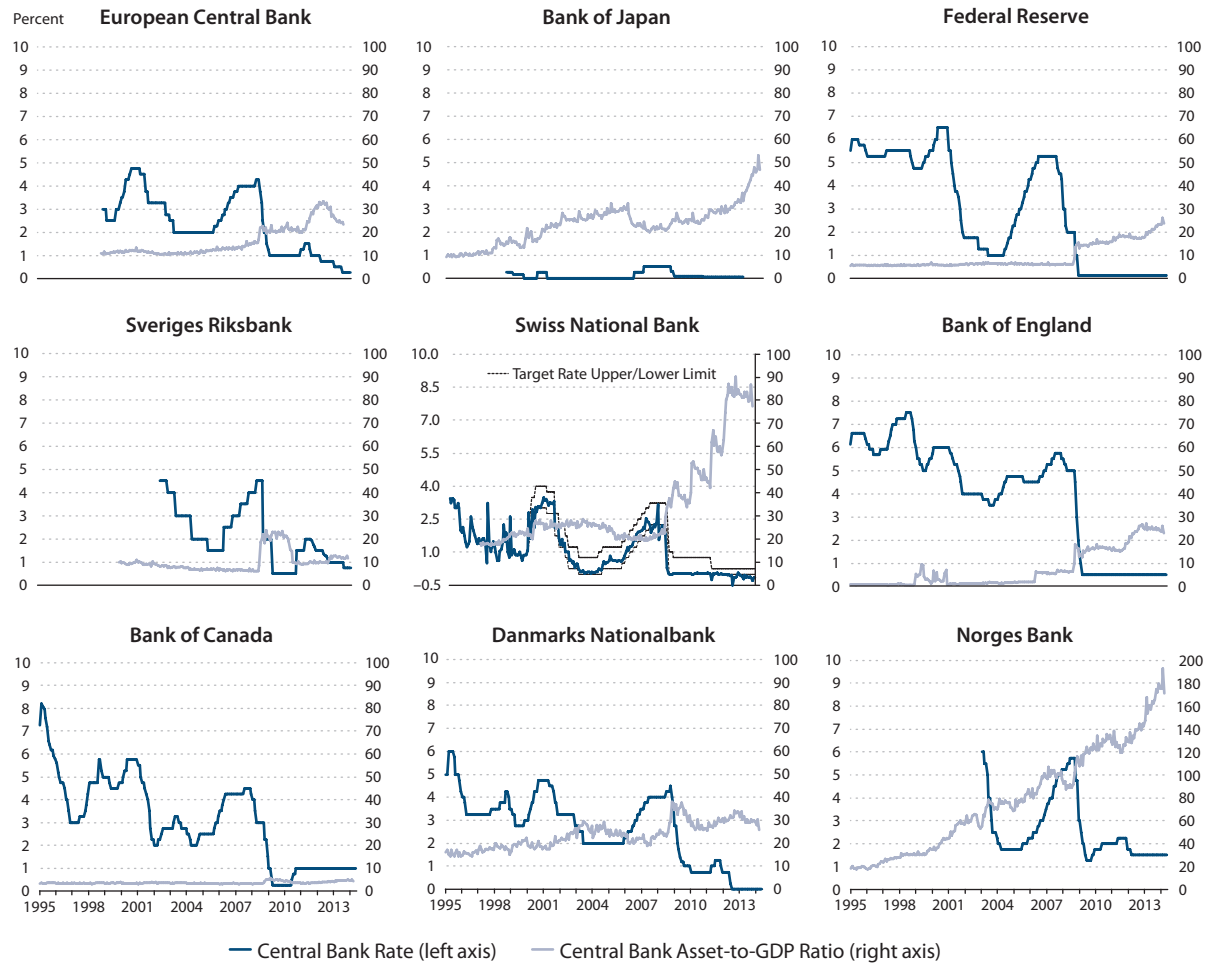
Country	Target	Start	Target[2]	Short-term rate in OECD data	Policy rate (May 2014)
Euro Area 18	0-2% yr/yr HICP	January 1999	"Price stability is defined as a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2%." The Governing Council has also clarified that, in the pursuit of price stability, it aims to maintain inflation rates below, but close to, 2% over the medium term.	3-month European Interbank Offered Rate	0.25%
Japan	2% yr/yr CPI (1% until January 2013)	January 2013	"The Bank set the 'price stability target' at 2% in terms of the year-on-year rate of change in the consumer price index (CPI) in January 2013, and has made a commitment to achieving this target at the earliest possible time."	Rates and yields on 3-month or 90-day certificates of deposit	0.5% (April 2013)
United States	2% yr/yr PCE	January 2012	"The Federal Open Market Committee judges that inflation at the rate of 2 percent (as measured by the annual change in the price index for personal consumption expenditures [PCE]) is most consistent over the longer run with the Federal Reserve's mandate for price stability and maximum employment."	Rates on 3-month or 90-day certificates of deposit	0.125
Sweden	2% yr/yr CPI (±1%) in 1993	January 1993	"The inflation target has since been defined as keeping the annual rise in the CPI at 2%. The main reasons for defining the target in terms of the CPI are that this is the best-known and most frequently used measure of inflation, it comprises a very large proportion of household consumption, and it is published monthly." The Riksbank specifies that the objective of monetary policy is to limit the annual increase in the CPI in 1995 and onward to 2%, with a degree of tolerance of ±1% (January 1995).	3-month or 90-day yields on Treasury securities	1%
Switzerland	0-2% yr/yr CPI	January 2000	"The SNB equates price stability with a rise in the national CPI of less than 2% per annum. In so doing, it takes into consideration the fact that not every price increase is necessarily inflationary and that inflation cannot be measured accurately."	3-month or 90-day interbank rates	–0.15%
United Kingdom	2% RPIX 2% CPI	October 1992 December 2003	"The inflation target of 2% is expressed in terms of an annual rate of inflation based on the CPI. The remit is not to achieve the lowest possible inflation rate. Inflation below the target of 2% is judged to be just as bad as inflation above the target. The inflation target is therefore symmetrical."	3-month or 90-day interbank rates	0.5%
Canada	(1-3%) yr/yr (2% midpoint) CPI	February 1991	"The Bank of Canada aims to keep inflation at the 2% midpoint of an inflation-control target range of 1% to 3%. The inflation target is expressed as the year-over-year increase in the total CPI."	3-month or 90-day yields on commercial/ corporate paper	1%
Denmark	No inflation target, but exchange rate target		"Denmark conducts a fixed-exchange-rate policy vis-à-vis the euro." This means that the aim of monetary and foreign-exchange policy is to keep the krone stable vis-à-vis the euro. The main objective in the monetary policy in the euro area is to maintain price stability (i.e., to avoid inflation). "By keeping the krone stable against the euro, a basis for low inflation is also created in Denmark over the slightly longer term."	3-month or 90-day interbank rates	0%
Norway	2.5% yr/yr CPI (±1%)	March 2001	"The operational target of monetary policy shall be annual consumer price inflation of close to 2.5% over time."	3-month NIBOR	1.5%

NOTE: NIBOR, Norwegian Interbank Offered Rate; RPIX, Retail Price Index, excluding mortgage interest payments; yr/yr, year-over-year.

SOURCE: Authors, OECD, Hammond (2012), and references cited in Note 2.

Figure 1

Asset-to-GDP Ratio and Policy Rates by Country (1995:01–2014:05)



NOTE: The last observation for the central bank rate is May 2014; the last observation for the central bank asset-to-GDP ratio is March 2014.
SOURCE: National central banks and authors' calculations.

(i) Price stability is explicitly recognised as the main goal of monetary policy.
(ii) There is a public announcement of a quantitative target for inflation.
(iii) Monetary policy is based on a wide set of information, including an inflation forecast.
(iv) Transparency.
(v) Accountability mechanisms.

In most of the countries on which we focus, the inflation target is currently typically set at 2 percent of the year-over-year increase in the consumer price index (CPI), with some exceptions and qualifications as follows:

- The European Central Bank (ECB) aims at inflation rates of below, but close to, 2 percent over the medium term clarified by the Governing Council of the ECB.
- In the United States, the target is 2 percent of the year-over-year increase in the personal expenditure chain-type price index, with an emphasis on core inflation.
- In Japan, the inflation target was moved from 1 percent to 2 percent in January 2013.[3]
- In Switzerland, the target is 2 percent CPI inflation or below.
- In Norway, the target is 2.5 percent CPI inflation.
- Denmark targets the exchange rate stability with respect to the euro.
- Canada targets a 1 to 3 percent band centered on a 2 percent CPI inflation rate.

Figure 2 shows the deviation from the target of headline and core inflation rates for the nine advanced economies in June 2013, December 2013, and June 2014. We set the target at 2 percent except for Norway (2.5 percent) and attribute to Denmark the same target as the euro area because this country targets exchange rate stability with respect to the euro. Essentially all countries have recently been below their targets for both core and headline inflation. Sweden and Switzerland are experiencing moderate deflation.

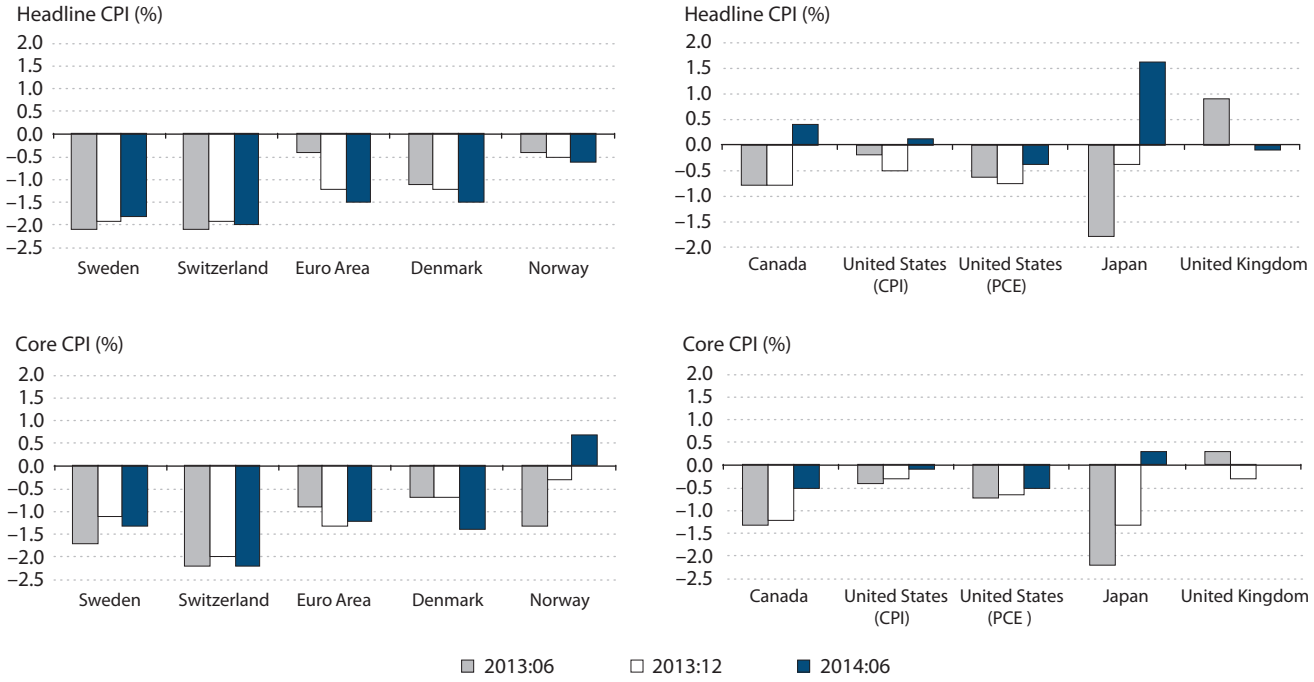
Figure 3 shows the path of the price level since June 2009 with a focus on the months since January 2012 in the top-left inset boxes. We plot lines and bands for the price level consistent with target inflation rates from June 2009 forward in each of the panels; the exceptions apply to the United States, which started its inflation target in January 2012, and Japan, which started its 2 percent inflation target in January 2013. June 2009 represents the end of the U.S. recession according to the dating by the National Bureau of Economic Research. The U.S. panel also clearly shows the lower inflation rates associated with a slower-growing price level in 2013 and early 2014. The panel shows that the price-level path (solid black line) is quite heterogeneous across countries: Most economies are relatively close to the price level consistent with their inflation targets *over the medium and long term* (red dotted lines or dotted bands, depending on how the inflation target is specified), even if they have experienced relatively low inflation (solid blue line) in the very recent past (the past 18 months or so). For example, examining inflation and the price level for the euro area over these past five years does not prompt the same worries as examining them over the past two years. Clearly, if one projects lower inflation for the upcoming months or year, then the euro area may appear to be at risk of deflationary pressures. Japan is an important exception because it shows an upward movement beginning in December 2012.

Forward Guidance

The central banks of several of these countries have adopted forward guidance—that is, they communicate to the public the stance of monetary policy expected to prevail in the future (see Contessi and Li, 2013a,b, for a discussion of the main elements of forward guidance in advanced economies; also see Board of Governors of the Federal Reserve System, 2014, for the United States). It is widely understood that expectations play an important role in the economy and affect a variety of decisions, such as consumption, saving, and investment. Managing expectations is an important channel a central bank can use to achieve its policy

Figure 2

Differences Between the Target Inflation Rate and Actual Headline and Core Inflation Rates in June 2013, December 2013, and June 2014 for Nine Advanced Economies



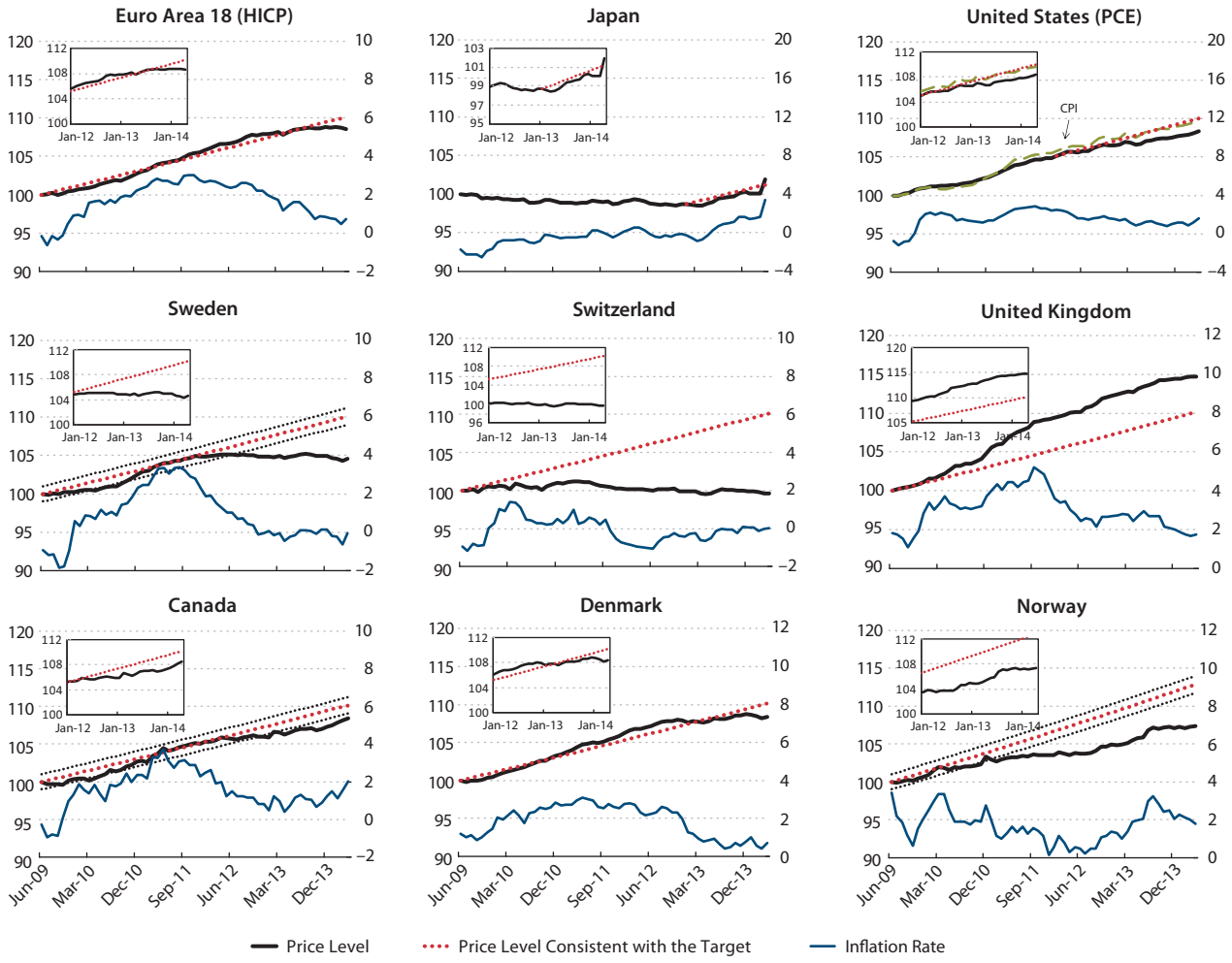
NOTE: Sweden, Switzerland, Japan, Canada, and the United Kingdom set the inflation target at 2 percent in terms of the year-over-year rate of change in the headline CPI. The euro area set the inflation target at 2 percent in terms of the year-over-year rate of change in the headline HICP. The United States set the inflation target at 2 percent in terms of the year-over-year rate of change in the headline personal consumption expenditures (PCE). Norway set the inflation target at 2.5 percent in terms of the year-over-year target of change in the headline CPI. Denmark does not have an explicit inflation target but targets the nominal exchange rate with the euro.

SOURCE: Eurostat, Bureau of Economic Analysis, Statistics Bureau of Japan, Office for National Statistics, Statistics Canada, and authors' calculations.

objectives. In normal times, when the policy rate is not near zero, monetary policy authorities set policy instruments in response to economic fluctuations. Several models support the notion that a clear, easily understood policy rule can help successfully guide private sector expectations and ultimately may influence the economy consistent with the central bank's objectives. While the full-blown adoption of forward guidance in the United States was concurrent with the financial crisis and the zero lower bound, when further stimulus in the form of lower long-term yields was sought, the Federal Reserve and other central banks also experimented with forward guidance or practiced it to some extent when the policy rate was well above its zero lower bound. These two different environments (policy rates not near zero and policy rates near zero) tend to correspond to two different approaches to managing expectations. In the first case, the central bank simply forecasts and communicates to the public the economic outlook and the expected monetary policy action consistent with this outlook but does not commit to a specific policy action. The monetary policy stance could change in response to

Figure 3

Price Level by Country (2009:06–2014:04)



NOTE: The inset charts are from January 2012 to February 2014; the *y*-axis scale is the same as the main chart.
SOURCE: Haver Analytics.

events that deviate from the forecast, but the change would still be consistent with the policy rule. In the second case, the central bank may want to guide private sector expectations with a commitment to monetary policy action in case of future deviations from the underlying policy rule, essentially tying its own hands. In particular, the goal of forward guidance at the zero lower bound has been to make agents expect the interest rate to stay at zero (or at least remain low) as the economy recovers. If people believe this expectation and real rates rise in a recovery, then, according to the Fisher equation, there should be downward pressure on inflation as it adjusts to clear the bond market (Gallmeyer et al., 2007).

"THE PERIL" STRIKES BACK

With this succinct description of policy frameworks in mind, we now focus on the relationship between short-term rates and inflation rates. Figure 3 indicates that inflation has recently been low not only for the euro area and the United States, but also for all advanced economies; some commentators describe this environment as "lowflation," or creeping disinflation (see Moghadam, Teja, and Berkmen, 2014). Figures 4 and 5 are constructed similar to those in Bullard (2010), who pointed out the dangers of falling into a Japanese-style deflationary environment and advocated boosting quantitative easing (QE) to avoid this scenario.

The vertical axes on Figures 4 and 5 represent short-term rates as reported by the Organisation for Economic Co-operation and Development (OECD), and the horizontal axes represent inflation as described in the labels. The most recent short-term rates (as of June 2014) are listed in Table 1. In Figure 4, we use the individual-country inflation measure of headline inflation (for most countries, the monthly year-over-year CPI). In Figure 5, we use the year-over-year core inflation using the OECD measure of core inflation. The thicker vertical bar identifies the inflation target at 2 percent for all countries (except Norway, which is 2.5 percent), acknowledging that this is an approximation because of the exceptions discussed above.

We arbitrarily identify four periods: (i) 2002:01–2008:09 (the initial data point in Bullard, 2010, corresponding to the beginning of the recovery from the 2001 recession through Lehman Brothers' collapse in September 2008); (ii) 2008:10–2009:06 (the period between the collapse of Lehman Brothers/beginning of the U.S. zero lower bound and the end of the U.S. recession); (iii) 2009:07–2012:11 (the recovery through the beginning of "Abenomics"—the set of new policies of Japanese Prime Minister Shinzo Abe); (iv) 2012:12–end of series (Abenomics).

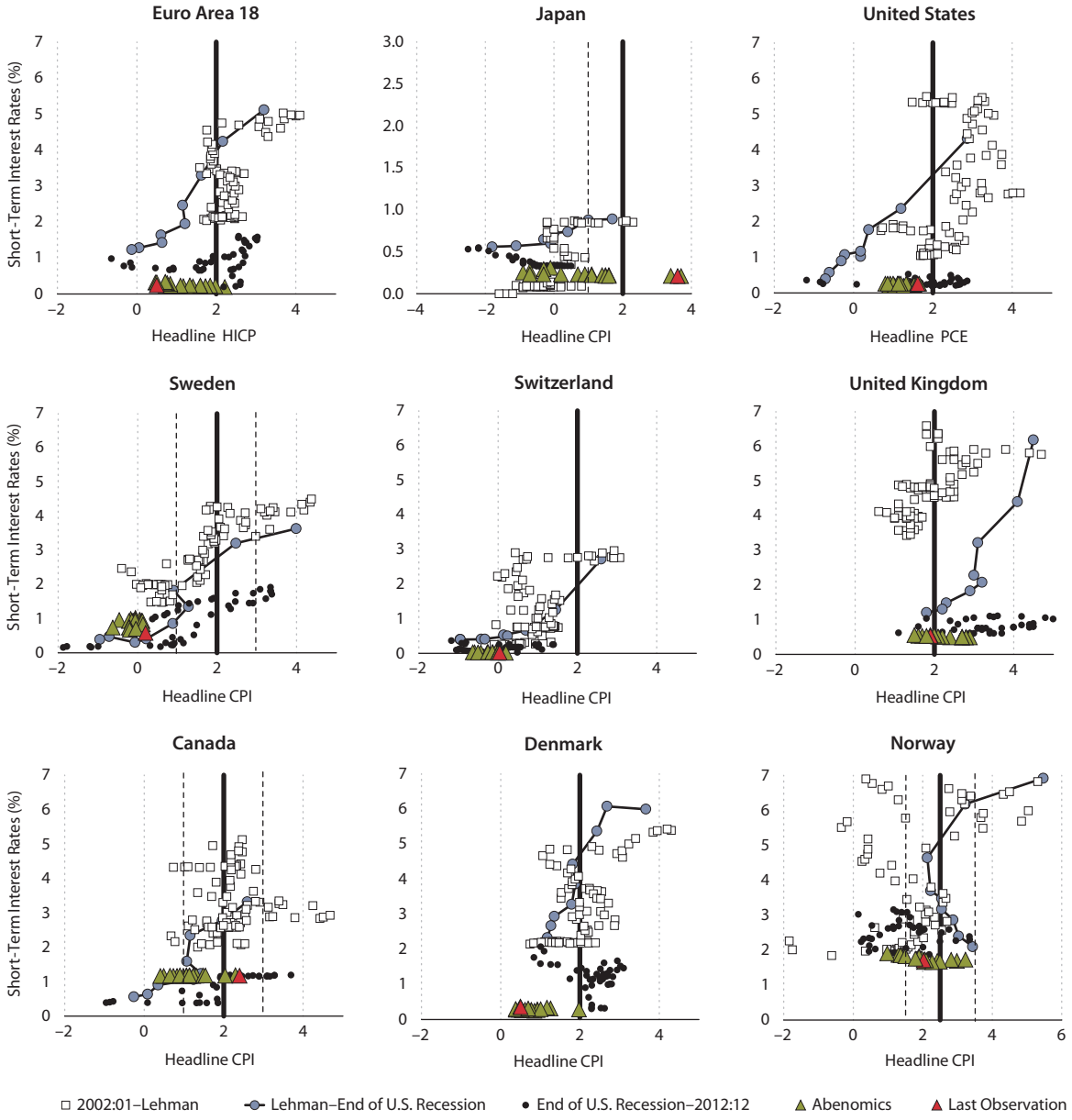
Considering the nine countries in the same panel shows the following:

- In the period between the end of the 2001 U.S. recession and the collapse of Lehman Brothers that marks the beginning of the zero-lower-bound period in the United States, all countries were essentially circling around target. This is particularly evident considering the core measure of inflation.
- In the post-Lehman Brothers period through the end of the U.S. 2007-09 recession, all countries experienced falling inflation (sometimes with brief deflation) and quickly falling short-term rates.
- The period corresponding to the U.S. recovery witnessed a return to positive inflation circling around 2 percent for all countries but Switzerland (close to zero) and the United Kingdom (close to 3 percent).
- The months since the beginning of Abenomics were characterized by almost-zero lower bound rates and falling inflation. In some countries, rates were still positive but in others they were already negative (Sweden and Switzerland). In all countries but Japan, headline inflation had trended downward, but most recent data (second quarter of 2014) show an upward movement.

A comparison between Figures 4 and 5 shows a similar pattern emerging when only core inflation (the OECD measure, comparable across countries) is considered. While this could

Figure 4

International Comparison of the Relationship between Short-Term Rates and Inflation Rate (2002:01–2014:06)

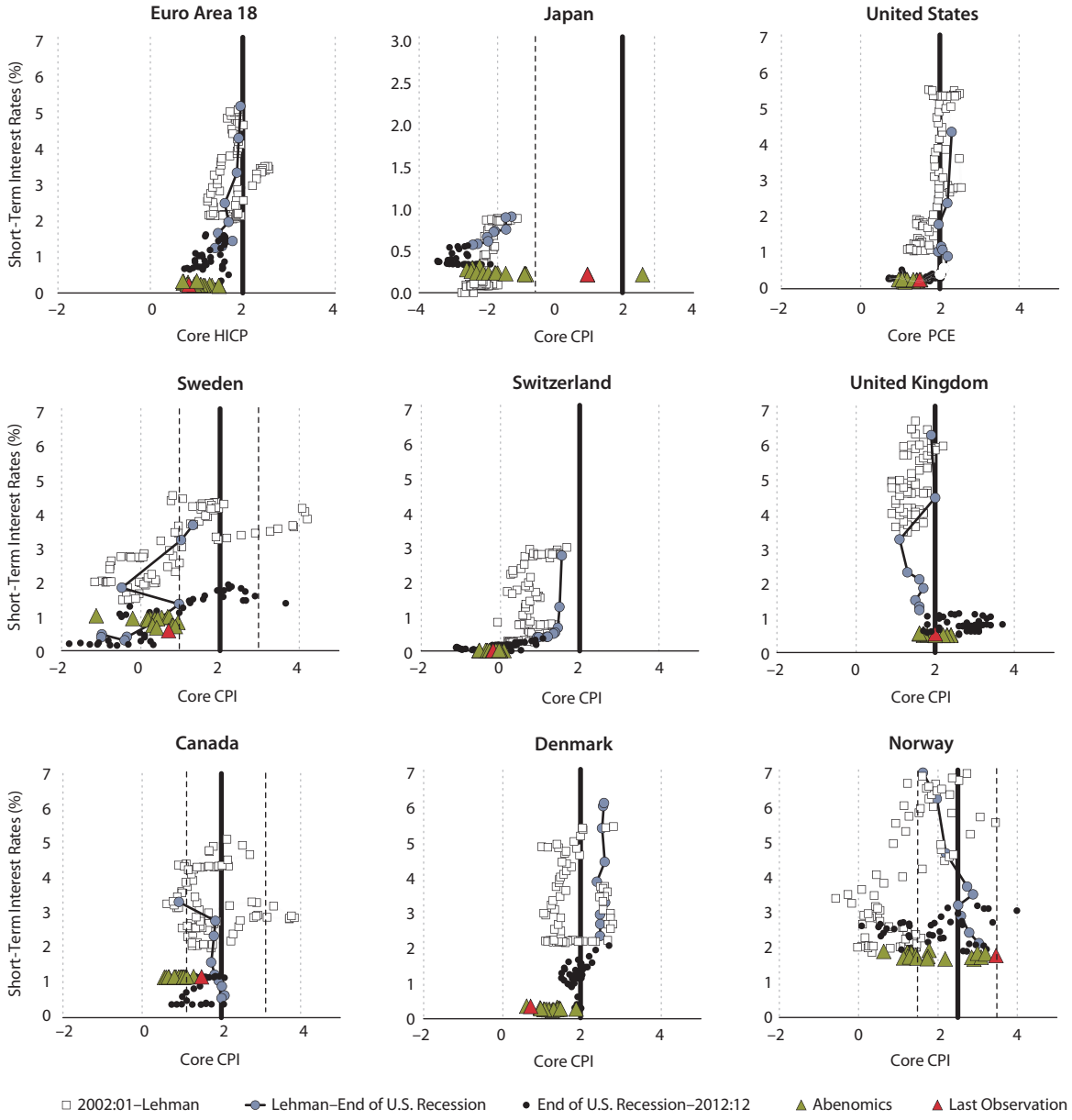


NOTE: Short-term rates are defined by the OECD and vary across countries. The thick vertical bars indicate the inflation target; in some cases it is the upper bound and in some cases the dashed bars indicate the target ranges. Japan targeted inflation at 1 percent until January 2013, but the bar in Japan's chart indicates the new 2 percent inflation target. The dates on which countries started adopting inflation targets are February 1991 (Canada), January 1993 (Sweden), January 1999 (euro area), January 2000 (Switzerland), March 2001 (Norway), December 2003 (United Kingdom), January 2012 (United States), and January 2013 (Japan). Denmark targets the exchange rate with the euro area.

SOURCE: Authors' calculations based on OECD statistics.

Figure 5

International Comparison of the Relationship between Short-Term Rates and the OECD Measure of Core Inflation (2002:01–2014:06)



NOTE: Short-term rates are defined by the OECD and vary across countries. The thick vertical bars indicate the inflation target; in some cases it is the upper bound and in some cases the dashed bars indicate the target ranges. Japan targeted inflation at 1 percent until January 2013, but the bar in Japan's chart indicates the new 2 percent inflation target. The dates on which countries started adopting inflation targets are February 1991 (Canada), January 1993 (Sweden), January 1999 (euro area), January 2000 (Switzerland), March 2001 (Norway), December 2003 (United Kingdom), January 2012 (United States), and January 2013 (Japan). Denmark targets the exchange rate with the euro area.

SOURCE: Authors' calculations based on OECD statistics.

be considered soft evidence that the downward trend in headline inflation is not driven solely by food and oil shocks, there is no hard evidence countering this claim.

If all countries were entered into an "advanced economies" group, the plot would show a picture very similar to that of advanced economies today, as Bullard (2010) has shown for the United States up to 2010. Bullard's analysis was an application of the model developed by Benhabib, Schmitt-Grohé, and Uribe (2001). Based on the Fisher relation and a nonlinear Taylor rule, Benhabib, Schmitt-Grohé, and Uribe identify two steady states in the economy: the "targeted" steady state (with positive interest rates and inflation) and the "unintended" steady state (with interest rates close to zero and deflation). When an active Taylor-type rule combines with the zero-lower-bound nominal interest rates, the economy may get locked into the unintended steady state, similar to Japanese-style deflation. Bullard (2010) then emphasizes that (i) the "extended period" language introduced by the Federal Open Market Committee (FOMC) and some of the post-crisis forward guidance language guidance may be increasing the probability of a Japanese-style outcome for the United States but, at the same time, (ii) the QE program offers the best tool to avoid such an outcome. More recently, formal and structured models have been developed to study the so-called creeping disinflation, particularly in Piazza (2014) and Armenter (2014).

WHY SUCH LOW INFLATION IN SO MANY COUNTRIES?

Various combinations of three arguments could explain the low inflation recently observed: (i) global shocks and composition effects, (ii) economic slack, and (iii) changing inflation expectations. In this section, we informally examine these explanations and examine them within the larger literature on inflation.

Global Shocks

An established literature estimates the role of global elements in determining domestic inflation.[4] The basic argument is that global factors pass through domestic inflation rates, perhaps at different degrees across countries, so that inflation rates can be decomposed into global components, a regional component, and a domestic component. This argument is typically made using factor models that show the growing relevance of global factors in explaining domestic inflation rates over the years. Regarding the recent low inflation rates, some commentators have argued they may be due to the effect of a commodity glut, particularly oil, destined to continue because of structural changes in the world market, particularly growing capacity in the oil industry.

As noted in January 2014 by ECB President Mario Draghi (2014a), it is important to consider the comovement of different components of inflation rates (at both the geographic and industry levels) when attempting to evaluate the likelihood of a deflation scenario:

> When we define deflation as a broad-based, self-fulfilling, self-feeding fall in prices, we do not see that in the euro area. Even when we look at individual countries we may actually see negative inflation rates in one or two countries, but then we should also ask how much of this is due to

> the necessary rebalancing of an economy that had lost competitiveness and had gone into a financial and budgetary crisis? And how much of it is due to actual true deflation? So, by and large, we do not see deflation in the Japanese sense of the 1990s.

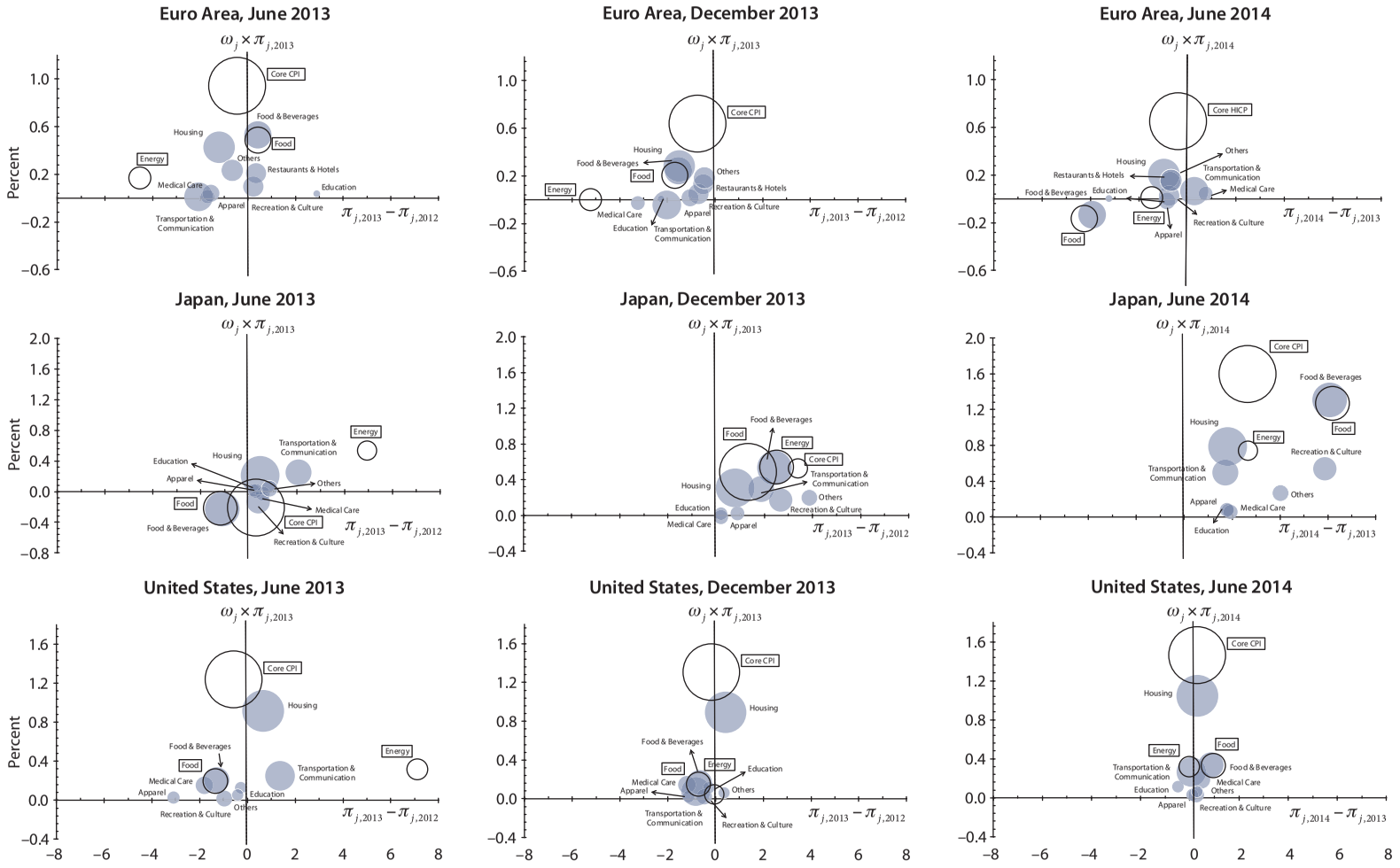
Therefore, the role of global and domestic shocks can be intuitively observed by considering the dynamics of the noncore component of the inflation rate (food and energy) as well as in individual sectors. Limiting the discussion to the United States, Martin (2013) shows that falling prices in 2013 originated mostly in services (i.e., health care and housing), which are heavily influenced by policy intervention. A similar point was recently made by Sandra Pianalto (2014), then-President of the Federal Reserve Bank of Cleveland, who said that "a bout of sustained low inflation" is due to "two main sources: slow economic growth, which has put very little upward pressure on prices and wages; and special, temporary forces that have held back some prices, such as the deceleration of medical care costs." While this observation does not explain the downward trend of inflation in several advanced economies, it raises the possibility that different country-specific factors may be playing an important role in explaining low inflation in each, at the same time that global prices have been dormant.

To investigate the role of various types of goods and services in inflation, in Figure 6 we describe the dynamic behavior of inflation between 2012 and 2014 for three countries. The figure shows the contributions of inflation components to headline CPI inflation rates in the United States, the euro area, and Japan in June and December 2013 and January 2014. We choose these three months to focus on short-run movements. The size of each circle in the figure indicates the weight or relative importance of each component to the inflation rates. For example, food and beverages account for about 15 percent of the items in the goods and services basket for the United States, while housing accounts for about 41 percent (the weight in the personal chain-type expenditure price index inflation rate is about half of that). The center of a circle represents the respective (x,y) point of a certain category. The y-axis represents the inflation contributions of each component to total CPI or the Harmonised Index of Consumer Prices (HICP) inflation rates. For example, in the United States, the inflation component for housing contributed about half of the total 2.08 percent CPI inflation rate in June 2014. The x-axis represents the percentage-point change of inflation rates from the previous year, $\pi_{i,t} - \pi_{i,t-1}$,where i is the component of inflation index and t = June 2013, December 2013, and June 2014. For example, for the circle representing food and beverages, the value on the x-axis is the year-over-year inflation rate only for these goods in June 2014 minus the year-over-year inflation rates for them in June 2013; if the inflation rate of food and beverages is falling between June 2013 and June 2014, then the circles will be in one of the left quadrants.

The United States experienced low inflation in 2013 and the beginning of 2014 but once it reached 1 to 1.5 percent, it stopped falling and began to move closer to 2 percent after April 2014. As shown in Figure 6, all components except housing are clustered in the top-left corner around zero in December 2013, indicating a slight decrease in each component's inflation rate from a year earlier, and thus the CPI inflation rate decreased as well to 1.5 percent. Recent U.S. CPI inflation rates are slowly moving up: The June 2014 CPI inflation rate reached 2.07 percent. Figure 6 shows that the circles are moving toward the top-right corner but are still

Figure 6

Contributions to One-Year Change in Headline CPI in the United States and Japan and in Headline HICP in the Euro Area (June and December 2013 and June 2014)



NOTE: In this figure, headline inflation is broken down according to two classifications of goods and services. The open circles represent the breakdown in core (excluding food and energy), food, and energy CPI/HICP inflation. The solid circles represent a finer breakdown of the same index. In addition, to improve comparability across countries, some categories are regrouped as follows: In the euro area, housing includes (i) housing, water, electricity, gas and other fuels, and (ii) furnishings, household equipment, and routine household maintenance. In Japan, housing includes housing, furniture, and household utensils. In the United States and the euro area, the transportation and communication circle is obtained by combining the transportation and communication categories, which are already one group in Japan. The food and beverages category includes nonalcoholic and alcoholic beverages. All inflation rates are the year-over-year percent changes calculated using nonseasonally adjusted price levels.

SOURCE: Eurostat, Bureau of Economic Analysis, Statistics Bureau of Japan.

very close to the vertical line, which indicates that the upward trend is moderate. In the euro area, however, the majority of the circles move downward and toward the left, indicating a downward trend in the HICP inflation rate between June 2013 and June 2014.

Japan shows a completely different picture with most circles in the top-right quadrant (see Figure 6). In December 2013 there was a small upward trend in each component, which resulted in a 1.61 percent CPI inflation rate. The movement became much larger in June 2014, resulting in a 3.41 percent CPI inflation rate. If we plotted the same panel for early 2013, most of the circles for Japan would be in the bottom-left quadrant instead. Because most of the circles are in the right quadrants in the panel, there is a very visible shift associated with Abenomics—namely, that prices are growing across the categories of goods and services.

What do we make of these breakdowns? The first message is that while these economies have experienced somewhat persistent inflation below or close to 2 percent, the underlying trends appear quite different and low inflation rates in the three areas may have different explanations or the timing of creeping disinflation may be different. The euro area is facing the most serious threat of creeping disinflation, while the United States and Japan are experiencing either stable or mildly increasing prices across a wide spectrum of goods and services. This interpretation is reinforced by the most recent figures on U.S. inflation showing a noticeable increase in June 2014, relative to the previous months. Second, several studies have shown a growing global component to domestic inflation derived from food and energy prices (non-core items). However, this global component is contributing to domestic inflation in the three areas in different ways. Imagine there was a large global shock (due to, say, military tension) that caused a large increase in oil prices. Then the circle corresponding to energy would likely be in the upper-right quadrant for all three areas because energy inflation would be growing and its impact on total inflation would be increasing. However, energy and food prices have not behaved in the same way in the three areas: Energy prices are increasing in Japan but decreasing in the euro area (see "Energy" in Figure 6). Also, food prices are rising rapidly in Japan, are mildly crescent in the United States, but are decreasing in the euro area (see "Food" in Figure 6). These different directions suggest that the current inflation behavior, particularly in the United States, the euro area, and Japan, may be responding more to domestic conditions because global shocks have been dormant.[5] Clearly, a more structured analysis is needed to study the effect of global shocks.[6]

Here, to gauge the importance of global factors, we rely on an approach used in Ciccarelli and Mojon (2010). They estimate a dynamic factor model for 20 OECD countries and show that a simple average of headline inflation across countries proxies the first factor reasonably well. Similar factor models are estimated in Macklem (2014) and the Bank for International Settlements (2014, Chap. 3).

In practice, we decompose domestic inflation rates for the nine countries ($\pi_{1t},\ldots,\pi_{9t}$) as follows:

$$\begin{bmatrix} \pi_{1t} \\ \cdots \\ \pi_{9t} \end{bmatrix} = \begin{bmatrix} \Lambda_1 \\ \cdots \\ \Lambda_9 \end{bmatrix} f_t + \begin{bmatrix} \varepsilon_{1t} \\ \cdots \\ \varepsilon_{9t} \end{bmatrix}.$$

The vector Λ captures the effect of a common factor f_t to which each country n responds differently through a factor loading Λ_n, with $n = 1,2,\ldots,9$. The last term, ε_{nt}, refers to the idiosyncratic shocks whose effects remain local. We assume orthogonality between the factor and the idiosyncratic component, as well as normality of the idiosyncratic term.[7]

We estimate a one-factor model for the monthly data on the sample beginning in 2002. The share of variance explained by the first factor is 50.85 percent.[8]

In Figure 7, the time series of the first factor is then plotted along with the individual country inflation rate and the simple unweighted average of inflation rates across the nine countries. It is clear that there is a high correlation between the nine countries' simple average and the first factor extracted from our monthly data. More interestingly, there is a generally high correlation between the global factor and the domestic inflation rates (see Figure 7). In addition, in Figure 8, we show that the global factor comoves quite clearly with food and energy price indexes from the IMF. Particularly noteworthy is the very visible deviation of the Japanese inflation rate from global factors in the past 18 months.

The past few months are also interesting in light of the fact that commodity prices lead the global factor, and this leads domestic inflation over the entire sample. If the stable commodity prices have inhibited inflation, then inflationary pressures may mount if and when commodity prices increase.

While this analysis is significant to understanding headline inflation drivers and makes the global shock argument appear to be an important ingredient of any lowflation narrative, it is difficult to explain the observed low core inflation unless we assume a high degree of pass-through from noncore prices to core inflation. Therefore, we now examine two other explanations, the first of which can be tied to global factors.

Economic Slack and Output Gaps

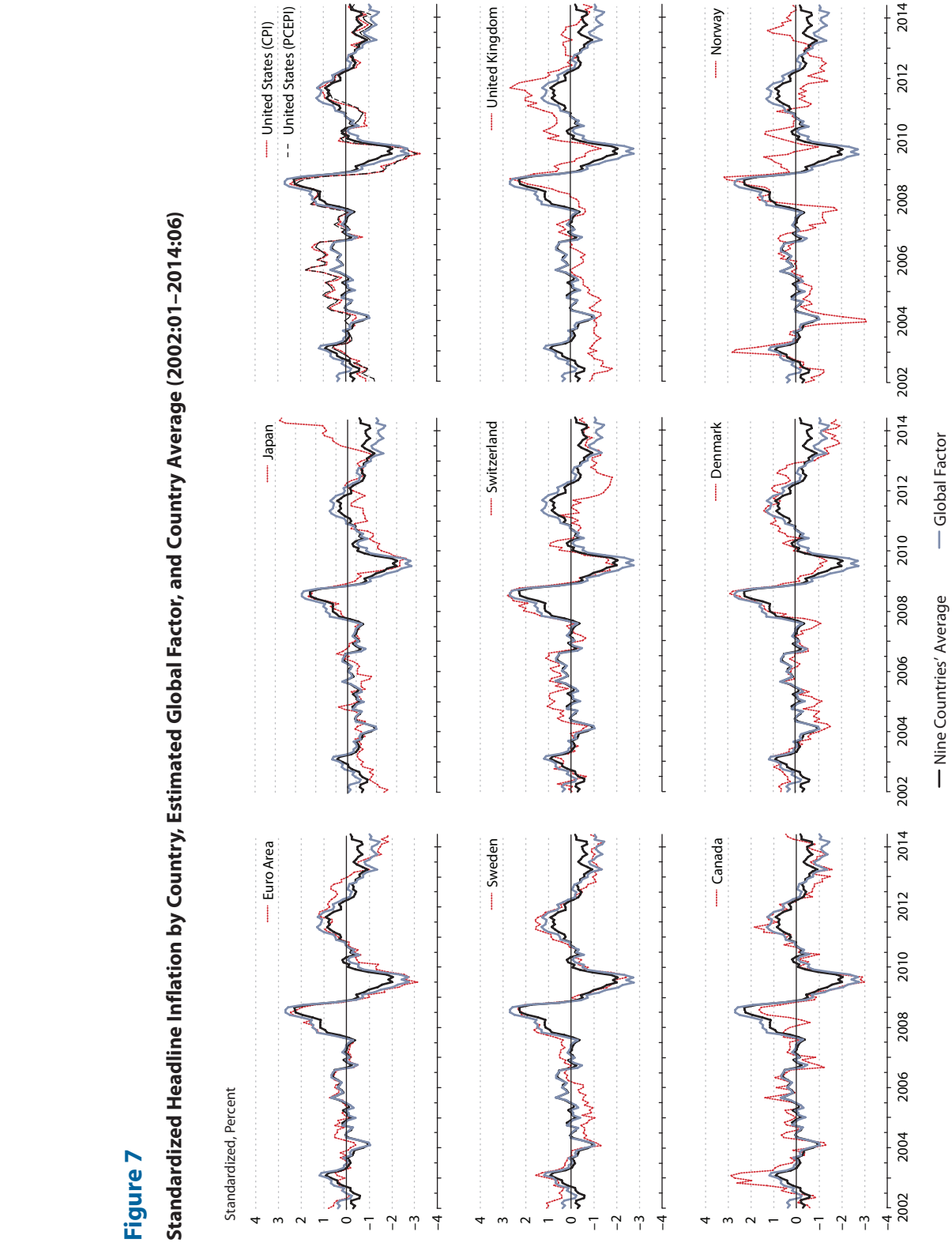
The second explanation we consider is the role of economic slack and large output gaps (a measure—albeit problematic—of economic slack) following the Great Recession (see Ball, 2014).[9] These arguments are related to the so-called mystery of "missing disinflation" studied in more detail in Ball and Mazumder (2011), Coibion and Gorodnichenko (2013), Gordon (2013), and others. The "missing deflation puzzle" was clearly explained by Williams (2010, p. 8) as follows:

> The surprise [about inflation] is that it's fallen so little, given the depth and duration of the recent downturn. Based on the experience of past severe recessions, I would have expected inflation to fall by twice as much as it has.

The role of large output gaps can be discussed within the framework of the so-called New Keynesian Phillips curve. In such a framework, current inflation, π_t, is positively related to inflation expectations, $E(\pi_t)$, and negatively related to the current output gap, as measured by the level of cyclical unemployment, $(\tilde{u}_t)$, $\pi_t = E(\pi_t) - \kappa\tilde{u}_t$, where κ is a parameter referred to as the slope of the Phillips curve. This stylized representation is a simplification of the "true" process driving inflation rates and a useful tool to help assess the role of the potential drivers of inflation over time.

Figure 7

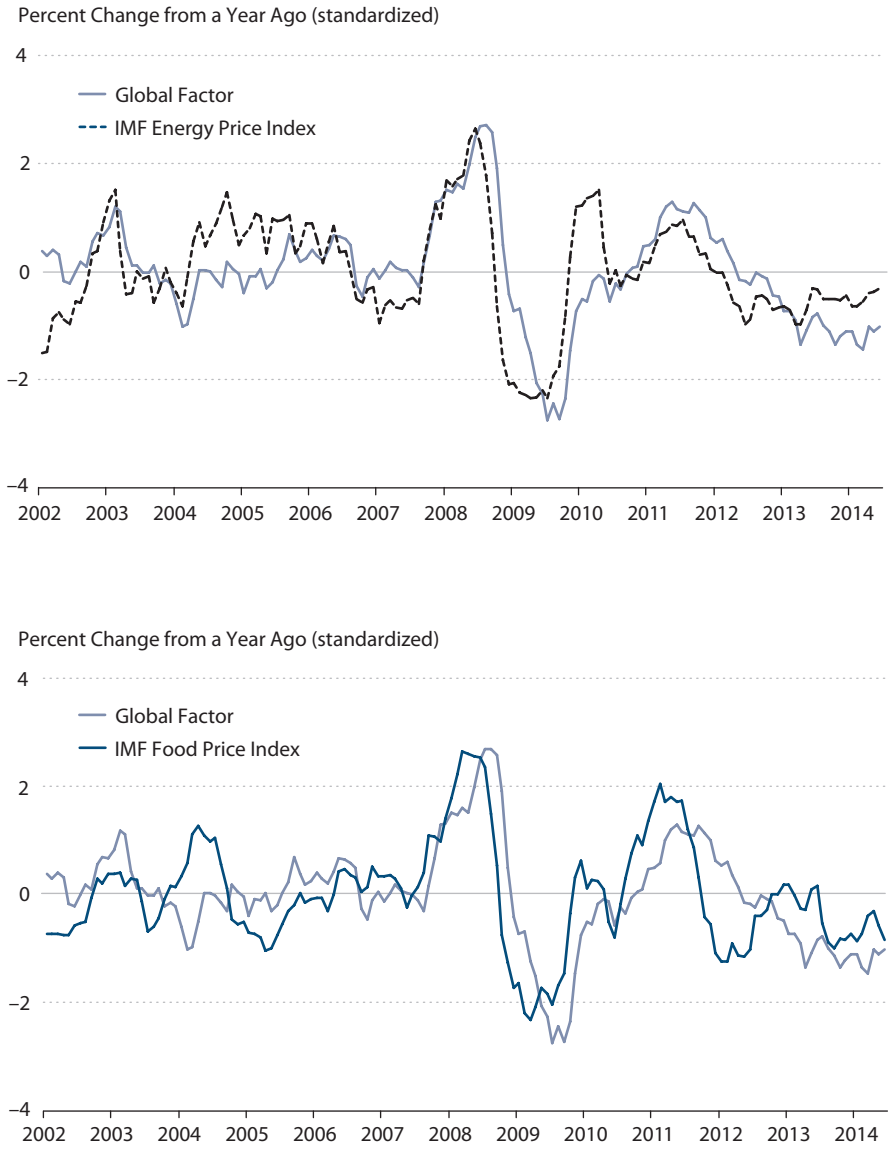
Standardized Headline Inflation by Country, Estimated Global Factor, and Country Average (2002:01–2014:06)



SOURCE: National inflation rates and IMF.

Figure 8

Global Factor Versus Global Energy and Food Price Inflation (Demeaned and Normalized by Standard Deviation; 2002:01–2014:06)



NOTE: The price indexes series are standardized as $(\pi - \mu)/\sigma$. π is the sample mean, and σ is the sample standard deviation.

SOURCE: IMF and authors' calculations.

In the above context, the fall in inflation during the Great Recession could have been limited for three possible reasons: (i) Increased unemployment might have been structural and thus there might have been only a small change in cyclical unemployment. (ii) More-credible central banks might have made inflation expectations more stable (see the next section). (iii) The Phillips curve might have become flatter than in the past (κ might have decreased over the years), and thus the sensitivity of inflation to changes in cyclical unemployment (i.e., the responsiveness of inflation to economic slack) might now be less significant.

Some international evidence regarding the relationship between output and inflation is available in Simon, Matheson, and Sandri (2013, Chap. 3). They find that (i) a considerable share of the increase in unemployment during the Great Recession was cyclical, not structural; (ii) inflation expectations have become more anchored around targets during the past two decades; and (iii) the relationship between economic slack and changes in inflation has gone from positive (falling inflation with more negative output gaps) to essentially null between the late 1970s/early 1980s and the period after 1995.

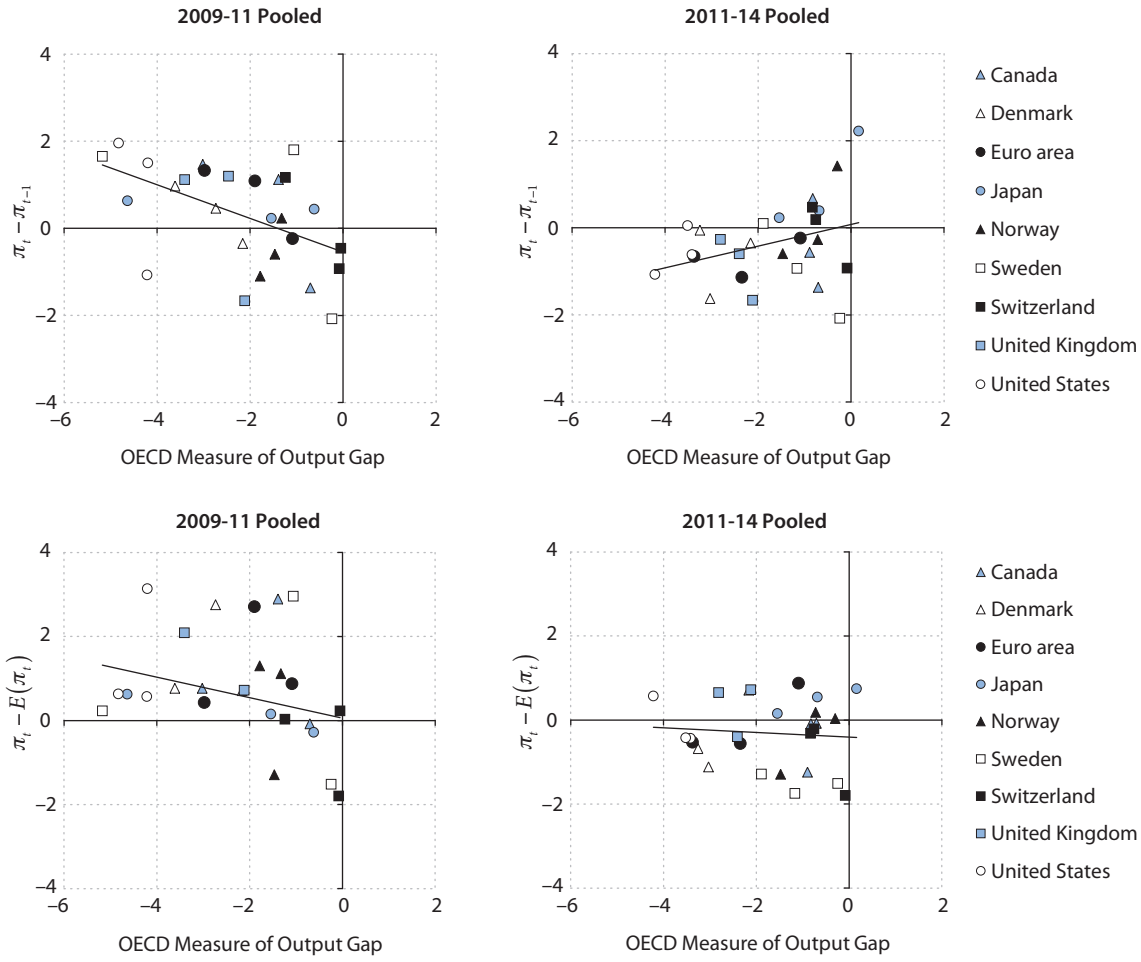
While empirically evaluating the changed relationship between measures of economic slack and inflation is beyond the scope of this article, we look informally at this relationship over the past few years. In Figure 9, on the horizontal axes we plot output gap measures provided by the OECD and constructed using a methodology that is consistent across countries. The figure shows plots for the 2009-11 and the 2012-14 periods (data for 2014 are projections). According to these measures, in the nine countries considered, the simple average output gap fell from 3.58 percent in 2007 to –3.36 percent in 2009 and then bounced back to –1.84 percent in 2013. By 2002-13 standards, these output gaps are not small (the average output gap for the 2002-13 is –0.14). On the vertical axes we plot the change in inflation between any two years using both actual inflation in two subsequent periods (top panel) and inflation minus inflation expectations (bottom panel). We measured inflation expectations for each year using the CPI/HICP from the OECD *Economic Outlook*—Annual Projections for OECD countries dataset for June of the previous year. We pool all nine countries together. For inflation expectations, the relationship between output gaps and changes in inflation is negative (larger output gaps are associated with growing inflation) during both the 2009-11 and 2012-14 periods. Generally, a clear relationship with changes in inflation similar to historical evidence does not emerge when simply eyeballing the panel, consistent with more formal analysis reported in Simon, Matheson, and Sandri (2013, Chap. 3).

Recent research by Borio and Filardo (2007), as well as the Bank for International Settlements (2014, Chap. 3), has pointed out that Phillips curve analyses incorporating measures of global economic slack can resurrect the trade-off between economic slack and inflation at the domestic level. Measures of global economic slack can be added to commodity prices as external factors affecting domestic inflation rates, which could be positively correlated with latent factors such as the one estimated in the previous subsection.

Nevertheless, in addition to the weakening of the relationship between inflation and output gaps, it should be noted that a narrative relating these two variables during the recent recovery would need to account for the facts that (i) inflation was higher a few years ago when output gaps were larger (by any estimate) and (ii) it fell below target in many countries as output gaps likely shrank with the progress of the recovery.

Figure 9

Annual Output Gaps and Changes in Inflation in the Nine Countries (2009-11 and 2011-14)



NOTE: The inflation rates are all the year-over-year rate of change in headline CPI, expect the euro area uses the headline HICP (top panel). In the bottom panel, we replace lagged inflation with the expectation of inflation for the following year as published in the *Economic Outlook*—Annual Projections for OECD countries.

SOURCE: OECD; 2014 figures are projections.

Changes in Inflation Expectations

Finally, we consider another potentially important driver of low inflation that is also connected to Phillips curve analyses: inflation expectations. Several central banks have successfully anchored inflation expectations close to their targets since late 1980. Large deviations in inflation expectations from target levels would signal that agents may readjust their expectations, in this case downward, and then build-in the lower expected inflation in price and wage contracts.

Figures 10 and 11 show the recent behavior of two possible measures of inflation expectation—monthly vintages of the inflation forecast by the FocusEconomics Consensus Forecast and market-based inflation expectations inferred from breakeven rates—for the countries for which this measure can be reconstructed. It should be recognized that there is consensus that advanced economies have kept short- and medium-run inflation expectations anchored to their targets and that short-run fluctuations away from the target are not unusual.

Figure 10 shows quite clearly that expected inflation for 2014 has progressively fallen for the euro area, Sweden, Switzerland, and Denmark; mildly decreased for the United States, United Kingdom, and Canada; and remained stable for Norway. A similar pattern is evident in the breakeven-rate-based measure of expectations for the countries for which rates are available. Quite impressively, inflation expectations are trending upward for all measures available for Japan.[10]

A potentially more inflammatory explanation is that inflation expectations have changed and/or LSAP/QE is deflationary (see Williamson's *New Monetarist* blog on November 27, 2013; Andolfatto's *MacroMania* blog on December 1, 2013; and the counterargument made in Krugman's *Conscience of a Liberal* blog on November 29, 2013). The *Economist*'s version of this hypothesis is that "prolonged" LSAP/QE is effectively a signal that the central bank is unwilling to commit to higher inflation and, therefore, QE reinforces expectations that economic activity will run below potential and demand shocks will not be completely offset (see London, 2013). Such conjecture would not explain why countries with no history of LSAP/QE are also experiencing low inflation (for example, Canada and Norway), unless the possibility of large cross-country spillovers of inflation is also considered, as examined in the next section.

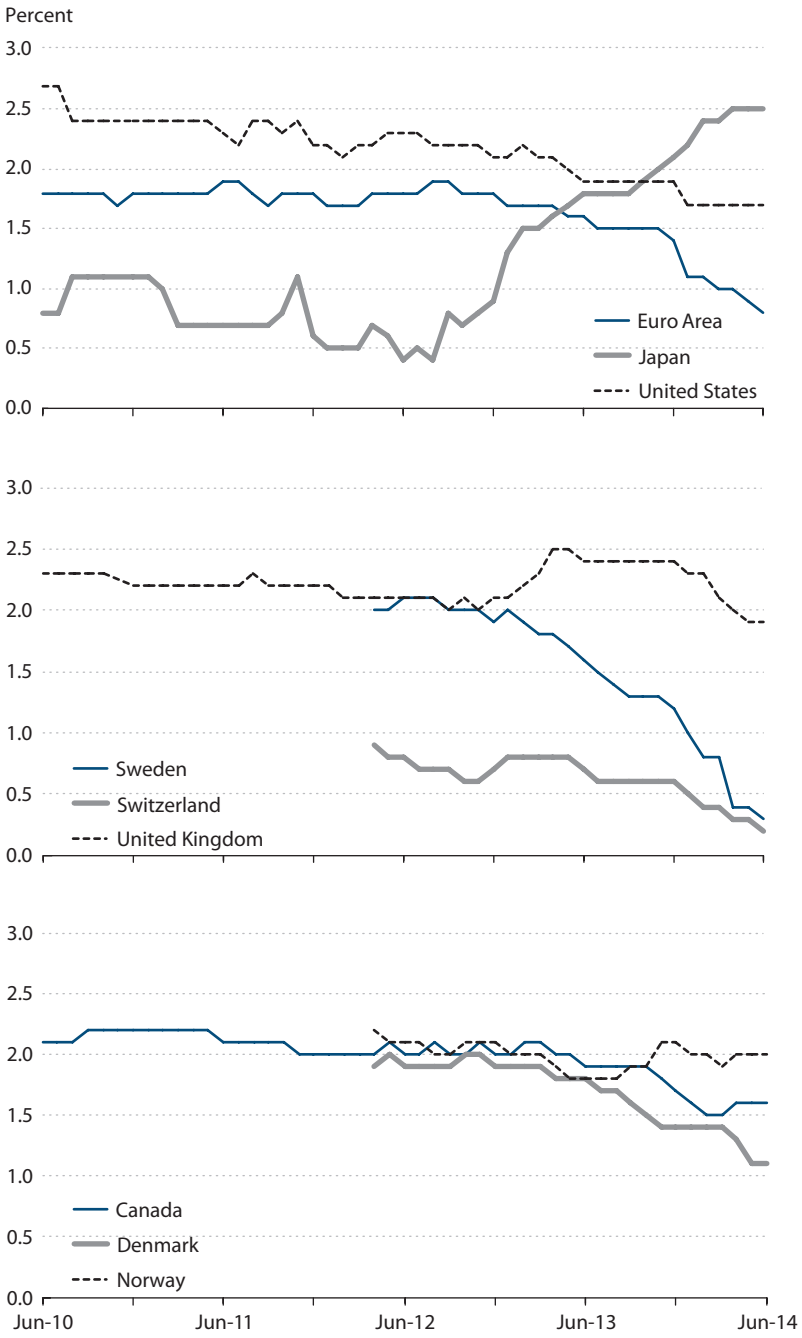
THE CROSS-COUNTRY CORRELATION OF INFLATION

The last step of our analysis is to consider the cross-sectional correlation of inflation. Thanks to Wang and Wen (2007), we know that inflation has been more correlated across countries than real output growth at business cycle frequencies. How did this correlation change after the financial crisis? Their article considers quarterly data from 18 economies for the January 1977 to April 1998 period. We reconsider the issue using a shorter but updated period; we use the months and quarters since the beginning of 2002 and the same group of countries. Several combinations of measures of inflation could be considered. We chose monthly headline CPI inflation and industrial production (IP) growth; in an unreported analysis we obtain similar correlations using the cyclical component of the IP index and the price level after using a Christiano-Fitzgerald band-pass filter. Figure 12 shows a scattergram of correlations between pairs of countries for IP growth (horizontal axis) and CPI inflation (vertical axis) for the 2002:01–2008:8 period on the left side and the 2008:09–2014:04 period on the right side.

The first observation, also highlighted by Imbs (2010), is that cross-country correlations of IP growth have grown since the beginning of the financial crisis, which is clear from the rightward movement of the correlations on the horizontal axis: Output growth measured by the IP index growth rate has increased visibly. For inflation, the correlation of the inflation

Figure 10

Inflation Expectations for 2014 by Country and Vintage (2010:06–2014:06)

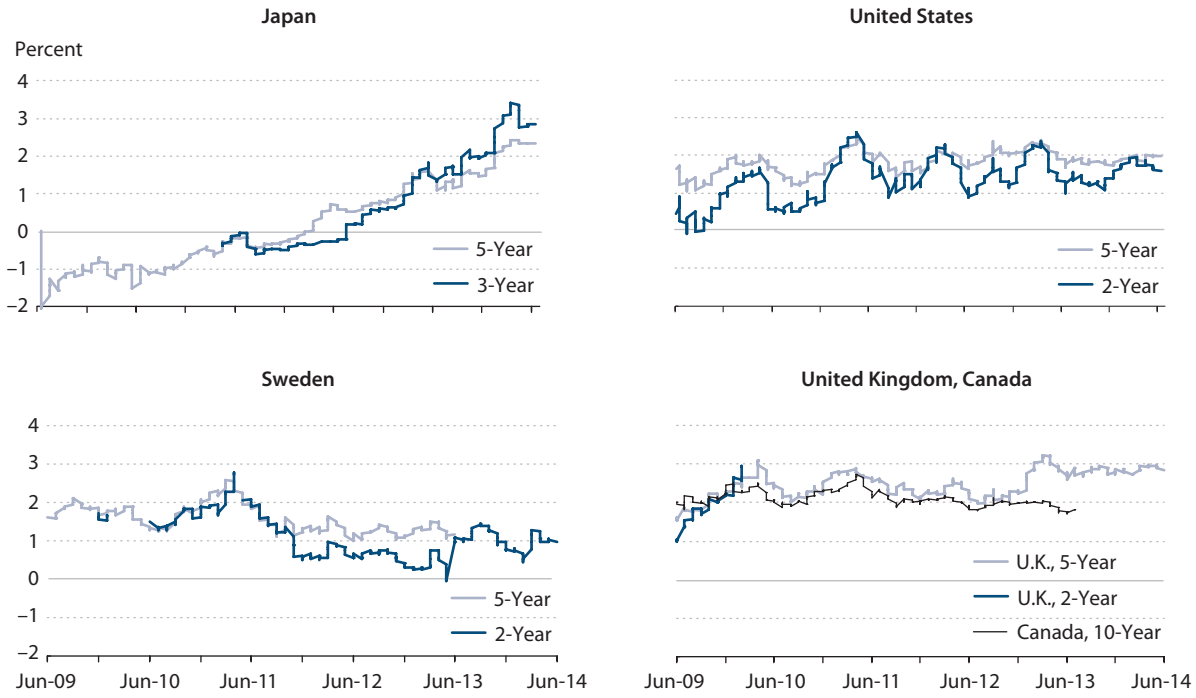


NOTE: Each data point represents the inflation forecast for 2014 that is made at that point in time.

SOURCE: FocusEconomics Consensus Forecast.

Figure 11

Short-Term Inflation Expectations by Country: Breakeven Rates (2009:06–2014:06)



SOURCE: Data from Bloomberg.

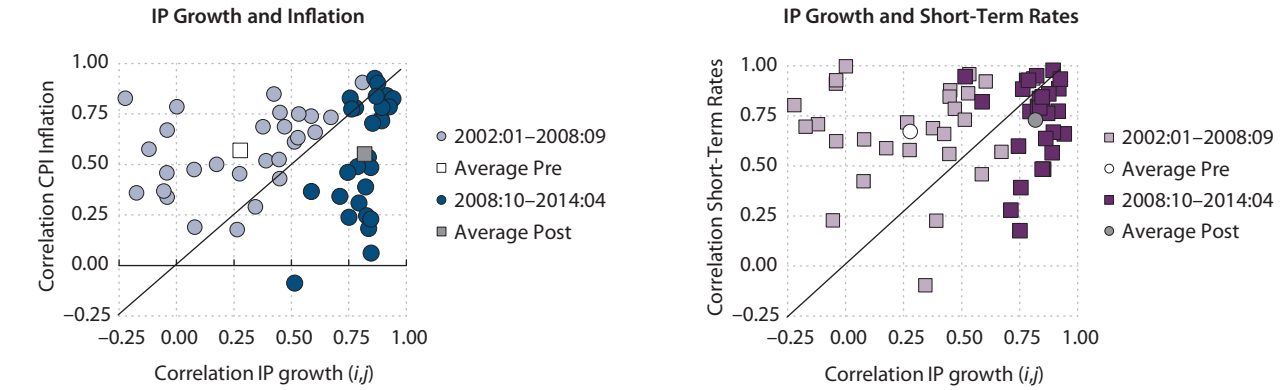
rate has not changed much compared with the increase in the correlation of the IP index growth: The cross-country average correlation of IP growth rates has moved from 0.28 to 0.82 (+0.54) while inflation correlation has increased from 0.67 to 0.73 on average (+0.06). This shows that inflation is no longer more correlated across countries than output. It is also noteworthy that the average standard deviation of inflation has increased from 0.20 to 0.28.

Figure 12 also allows comparison of similar correlations with respect to nominal short-term rates: Short-term rate correlations increased visibly. The cross-country averages increased from 0.67 to 0.73, and they are now less correlated than output, unlike in the pre-crisis years.

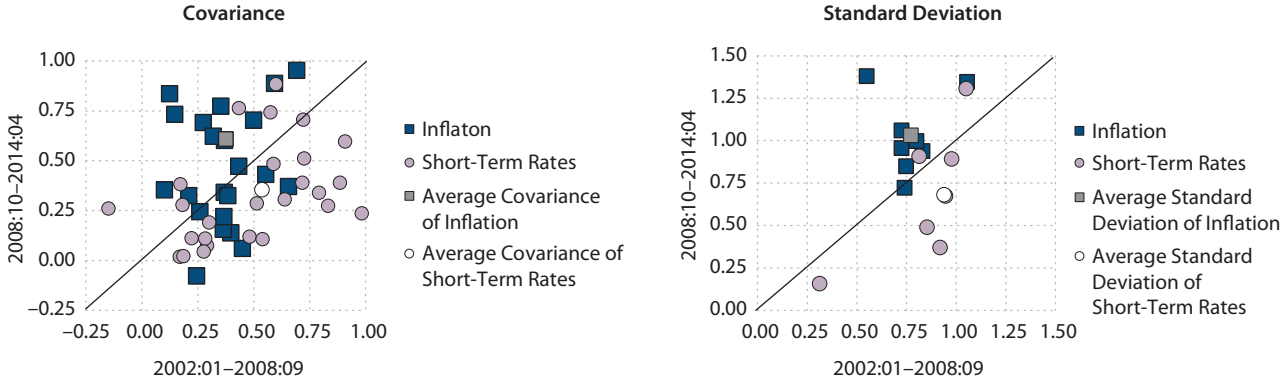
What do these changes indicate? With small cross-country spillovers of shocks, Taylor rules, and domestic no-arbitrage conditions, Henriksen, Kydland, and Ŝustek (2013) generate a ranking of correlations similar to the pre-crisis scattergram. They argue that small international spillovers and similar policy reaction functions in various countries can persistently generate highly correlated inflation rates. One possibility is that low inflation produced in large economies for domestic reasons may be spilling over to neighboring small open economies through a similar mechanism. Thus low inflation may be observed in large economies because of domestic reasons[11] as explained above, but falling inflation in small open economies may be due to monetary policy reaction functions that include a component connecting them to

Figure 12

Cross-Country Correlation of IP Growth, Headline CPI Inflation, and Short-Term Rates (2002:01–2014:04)



Cross-Country Covariance and Standard Deviation of Headline CPI Inflation and Short-Term Interest Rates in Two Periods



SOURCE: OECD and authors' calculations.

their larger partners and neighbors. This is clearly evident for Canada with respect to the United States and even more so for Denmark with respect to the European Union, as Denmark specifically targets the exchange rate with the euro, making this link even more explicit. For the crisis period, it appears that the real spillovers captured by the cross-country correlations of IP growth rates have been much more significant than any monetary spillover measured by cross-country inflation rates and short-term interest rates correlations. This would suggest that global factors for real measures of output might have become more relevant in the post-crisis period.

The bottom panels in Figure 12 also point to the source of these changes in correlations: While inflation rates correlations have changed little, the panels show that this is the outcome of an increase in both the covariances and the standard deviations of inflation rates, which

net out to produce a mild increase in correlations. As for short-term rates, both covariances and standard deviations have fallen on average, with the net effect of a mild increase in correlations, as the former fell less than the latter.

This analysis of bilateral relationships warrants further research on the role of global spillovers in the analysis of global inflation after the Great Financial Crisis.

CONCLUSION

In this article, we collect data for nine advanced economies and document the following facts about the behavior of inflation during the 2002-14 period. First, we show that the relationship between inflation rates and short-term rates displays similar changes across advanced economies that have or have not implemented forms of central bank programs designed to increase the size of their balance sheets (such as LSAPs/QE). Second, recent data indicate that headline and core inflation are below the inflation targets of individual countries. We discuss various explanations for this trend in the post-financial crisis world—global factors and composition effects, economic slack and output gaps, changing inflation expectations—showing there is some heterogeneity across countries, particularly large economies. Finally, we show that while output has become even more synchronized across countries since 2008, the cross-country correlation of inflation is no longer higher than the cross-country correlation of output.

Our main conclusion is that there are striking similarities across advanced economies regarding the behavior of inflation after the Great Financial Crisis, perhaps mirroring the global nature of the recent crisis and recovery, as well as broadly similar monetary policy responses. Under the surface, however, there are also important international differences that warrant further research. While the evidence provided here is informal and simply suggestive, very recent low inflation rates across countries are likely the combination of economic slack in the global economy (particularly in the euro area) and the stability of commodity prices. ■

NOTES

[1] The object of analysis is the period of the Great Financial Crisis and the subsequent recovery. We use the pre-crisis years as a term of comparison. We acknowledge this is a limited time period. In more technical ongoing research, we use a longer period and a larger number of countries. Preliminary results from this larger dataset suggest that our results concerning the factor model and comovement are robust to the extension.

[2] See the following references for the "Target" descriptions: Euro Area 18 (ECB, undated); Japan (Bank of Japan, 2013a); United States (FOMC, 2013); Sweden (Sveriges Riksbank, undated); Switzerland (Swiss National Bank, 2011); United Kingdom (Bank of England, undated); Canada (Bank of Canada, undated); Denmark (Rasmussen, 2013); Norway (Norges Bank, 2003).

[3] The Bank of Japan (2013b) set the "price stability goal in the medium to long term" in a positive range of 2 percent or lower in terms of the year-over-year rate of change in the CPI and set a goal at 1 percent. On January 22, 2013, the Bank of Japan replaced a "goal" with a "target" and set that target at 2 percent in terms of the year-over-year rate of change in the CPI.

[4] Examples of this research include work by Ciccarelli and Mojon (2010), Mumtaz and Surico (2012), Neely and Rapach (2011), and Monacelli and Sala (2009).

[5] See Macklem (2014) for a more formal analysis of global factors in domestic inflation.

[6] One such analysis is contained in a speech by the former senior deputy governor of the Bank of Canada, Tiff Macklem (2014). In this speech, Macklem refers to a staff factor model analysis of Canadian inflation and reaches conclusions similar to our informal analysis here—that is, global factors play a role in explaining low inflation in Canada, but other factors are also at play.

[7] As in Ciccarelli and Mojon (2010), the factors are estimated using static principal component methods described in Stock and Watson (2003), with standardized data.

[8] This share is lower than Ciccarelli and Mojon's (2010) results, based on quarterly data beginning in 1960.

[9] Simon, Matheson, and Sandri's (2013) Chap. 3 in the 2013 *World Economic Outlook* provides one of the most recent analyses of the relationship between output gap and inflation rates in the United States and OECD countries. We rely in part on this analysis for this section.

[10] Coibion and Gorodnichenko (2013) make the interesting point that inflation expectations by consumers are more volatile and responsive to energy and other global prices than inflation expectations of professional forecasters. Because the evidence from countries with both consumer and firm-level inflation expectations surveys shows that these are closer than consumer and professional forecasters' expectations, consumer-survey-based expectations should be used in Phillips curve analyses. Once this is done for the United States, the Phillips curve can be "resurrected."

[11] For example, slow-growing health care costs in the United States as suggested by Pianalto (2014), more intense competition in the distribution sectors in Canada as suggested by Macklem (2014), or large recessions in the euro area countries as suggested by Draghi (2014b).

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