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Global Forces and Monetary Policy Effectiveness

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8.1 Introduction

In many respects, the economic integration of the U.S. economy with the rest of the world has deepened in the last two decades. International trade has continued to expand more rapidly than economic activity in industrialized countries. For the United States, the amount of goods and services imported and exported that represented 18 percent of gross domestic product (GDP) in the mid-1980s represents more than 27 percent in 2005. But the globalization of finance has shown a much more dramatic development. During the same period, the ratio of foreign assets and liabilities to GDP has increased from approximately 80 percent to more than 300 percent in the twenty-three most industrialized economies, according to Lane and Milesi-Ferretti (2006). As global economic integration spreads, it is often argued that macroeconomic variables in one country—whether they pertain to measures of economic activity, inflation, or interest rates—should increasingly reflect events occurring in the rest of the world.[1]

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1. For example, the President of the Federal Reserve Bank of Dallas, Richard Fisher, and Michael Cox (2007) have argued that domestic inflation may be increasingly determined in the rest of the world. Advocating a "new inflation equation," they conclude that "globalization

Such developments naturally raise two sets of questions, which we attempt to address in this chapter. First, to what extent have international factors affected the determination of key macroeconomic variables in the U.S. economy? Is it the case that with the recent globalization, this economy has become more strongly affected by international factors? Second, has the very rapid globalization of finance weakened the ability of U.S. monetary policy to influence domestic financial market conditions, and through it, the rest of the economy? In other words, does a change in the Federal Funds rate have a smaller impact on the U.S. economy now than it used to?

Central bankers and economists in the financial press have pointed out the fact that while the U.S. central bank raised the Federal funds rate target by 425 basis points between June 2004 and July 2006, long-term rates remained at historically low levels, with the ten-year Treasury bond yield increasing by less than 40 basis points and the twenty-year yield actually falling by 20 basis points during that time. This phenomenon, which former Federal Reserve Chairman Alan Greenspan labeled "conundrum," highlights the fact that U.S. long-term interest rates may have become more dependent on international factors than had been observed historically. As then-governor Bernanke (2005) explained, a more extensive global financial integration and the increased amount of savings outside the U.S.—in particular in developing economies—may have resulted in a "global saving glut," which may have put downward pressures on long-term interest rates. A casual look at such recent historical episodes raises the possibility that the long-term yields may respond less to changes in Federal funds rates than in the past. Given that monetary policy does at least in part affect the economy through its effect on long-term rates, it is natural to wonder about the implications of the globalization of finance for the effectiveness of monetary policy. Certainly, the answers to such questions have key implications for a proper understanding of the determinants of economic fluctuations, and for policy.

To address these questions, we provide in this chapter an empirical assessment of the synchronization between international factors and key U.S. economic variables. We then investigate whether the importance of these global forces has changed for the U.S. economy over the last two decades, and how such a possible change has affected the transmission of monetary policy.

The general empirical framework that we consider is a factor-augmented vector autoregression model (FAVAR), as described in Bernanke, Boivin, and Eliasz (2005), but extended to explicitly include international or "global" factors. One of its key features is to provide estimates of macroeconomic factors that affect the data of interest by systematically exploiting all infor-

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has been changing how we consume as well as the way we do business. It's high time economic doctrine caught up." *The Economist* (2005), citing Stephen Roach, chief economist of Morgan Stanley, and the 2005 annual report of the Bank for International Settlements, suggests that global forces have become more important relative to domestic factors in determining inflation in individual countries.

mation from a large set of economic indicators. In our application, we estimate the empirical model based on the information from a large number of macroeconomic indicators and disaggregated data for the United States, as well as a large set of macroeconomic indicators for the fifteen major U.S. trade partners. By identifying U.S. monetary policy shocks, this framework allows us to uncover the transmission of such shocks to a large set of macroeconomic indicators. Our interest in studying the responses to monetary policy shocks does not reside in the fact that these shocks are important. In fact, it is well-known that they contribute only a little to U.S. output fluctuations. Rather, we find the responses to such shocks interesting as they allow us to trace out the effects of monetary policy on the economy.

Many studies have provided evidence that key macroeconomic variables display substantial comovements across countries. For instance, Kose, Otrok, and Whiteman (2003), analyzing output, consumption, and investment data from sixty countries over the 1960 to 1990 period, document that a large fraction of business cycles fluctuations of developed economies is accounted by a common world factor. The latter factor—a component of economic activity that is common to all countries considered—explains more than one-third of output fluctuations in the United States and in Europe.[2] Ciccarelli and Mojon (2005) argue that inflation in industrialized economies is also largely a global phenomenon: they find that on average, about 70 percent of inflation variance is attributable to a common global factor given by the component of inflation that is common across countries. Moreover, Ehrmann, Fratzscher, and Rigobon (2005) show that shocks to money, bond, and equity markets result in substantial spillovers between the United States and Europe.

Other researchers have recently examined whether the importance of such comovements across regions has changed over time. The evidence regarding the output synchronization is mixed. Kose, Prasad, and Terrones (2003)

2. Similar comovements in economic activity have been documented for more restricted sets of countries. Gerlach (1988) found that industrial production is positively correlated across several Organization for Economic Cooperation and Development (OECD) countries. Backus, Kehoe, and Kydland (1995) and Baxter (1995) found that business cycles share similarities in major industrial economies. Gregory, Head, and Raynauld (1997) in an early estimation of a factor model on economic activity data for the G7 countries, detected a significant common factor across countries. Bergman, Bordo, and Jonung (1998), analyzing more than one-hundred years of data, found that the synchronization in activity across thirteen industrialized countries remains strong regardless of the monetary regime. Forni et al. (2000), proposing a generalized dynamic factor model and applying it to data of ten European economies, find that a common European activity factor explains between 35 percent and 96 percent of the volatility in countries' GDP. Clark and Shin (2000) similarly find that a common factor accounts substantial variations in industrial production of European economies, and Lumsdaine and Prasad (2003), examining correlations between industrial output in seventeen OECD countries and a common component, find evidence of a world business cycle and of a European business cycle. Canova, Ciccarelli, and Ortega (2004), estimating a Bayesian panel VAR model on G7 data, find also a significant world business cycle, but find no evidence of a cycle specific to the euro area, in contrast to some of the other studies.

report evidence of stronger comovements of output in industrialized countries with a world factor (since the early 1980s) than in the preceding two decades. However, Doyle and Faust (2005), testing for changes in comovements among real activity measures for the G7 countries, find very few statistically significant changes over the 1960 to 2000 period. When looking at their point estimates, they even find some evidence of a fall in the correlation across countries since the early 1980s. Such a reduced synchronization is in fact consistent with findings of Helbling and Bayoumi (2003); Monfort, Renne, Ruffer, and Vitale (2003); Heathcote and Perri (2004); Stock and Watson (2005); and Kose, Otrok, and Whiteman (2005). According to Stock and Watson (2005), and Kose, Otrok, and Whiteman (2005), the fact that the output correlations across countries were particularly high in the 1970s may reflect unusually strong common shocks—such as large movements in oil prices—during that period. These authors thus argue that the reduction in the volatility of common international shocks since in the early 1980s, compared to the 1960s and 1970s, provides an important explanation for the reduced synchronization among G7 countries since the early 1980s, and that the correlation in output across countries would have been larger, had the international common shocks been as important in the 1980s and the 1990s, as they were in the 1960s and 1970s.

In addition, some authors have argued that the development of trade in goods and services, especially with low cost producing economies such as China and India, may have altered the relationship between some measure of the output gap and domestic inflation (see, e.g., Rogoff 2004, Borio and Filardo 2006, Ihrig et al. 2007).

While we also seek to characterize changes in U.S. macroeconomic dynamics due to global forces, our chapter distinguishes itself from the papers just mentioned in several respects.

First, in general, global comovements among macrovariables could arise from the presence of exogenous global—or worldwide—shocks, or from the international transmission of domestic shocks. Our central focus in this chapter is the implications for monetary policy of the changes in the role of global forces. It is thus important to stress that, while we allow for the presence of global shocks like in many of the papers just cited, our interest will be mainly on the characterization of the international transmission of regional shocks. In particular, we determine to what extent the transmission of U.S. monetary policy shocks—as measured by exogenous changes in the Federal funds rate—to key U.S. economic variables such as long-term interest rates, output, inflation, and so on, has been altered by global forces.

Second, in order to identify the monetary transmission mechanism, we jointly model multiple dimensions of the U.S. economy. Thus, rather than restricting ourselves to the comparison of a single type of measures across regions of the world—for example, only economic activity measures or only inflation measures—we adopt a more general and encompassing approach

that allows us to compare a set of factors summarizing the U.S. macroeconomic dynamics with those summarizing the rest of the world's macroeconomic dynamics. Another contribution is to consider a much broader set of macroeconomic indicators than has been used before in order to document the changes in the importance of global forces for the determination of U.S. measures of real activity, inflation, interest rates, and various other series.

Finally, we focus on the evolution since 1984. Our sample includes the period during which the globalization of financial flows accelerated significantly and allows us to sidestep an important issue: the considerable changes that occurred in the preceding decade. The period of large common shocks, in the 1970s and the early 1980s, during which the business cycles of many countries were strongly correlated, was followed in the United States by a rapid adjustment—called "great moderation"—to a regime characterized by lower output volatility.[3] Some studies have explained the reduction in volatility with a reduced volatility of shocks (e.g., Stock and Watson 2002a, Sims and Zha 2006, Smets and Wouters 2007, Justiniano and Primiceri 2008). In addition, as documented in Clarida, Galí, and Gertler (2000), Boivin (2006), Cogley and Sargent (2002, 2005), and Boivin and Giannoni (2002, 2006b), the systematic response of U.S. monetary policy to fluctuations in inflation and output changed significantly around 1980, revealing a greater tendency to stabilize inflation fluctuations. As Boivin and Giannoni (2006b) emphasize, such a change in policy can explain in large part why the responses of output and inflation to an unexpected change in the Federal funds rate of a given size have been much smaller since the early 1980s than they were in the 1960s and 1970s. By considering the period after 1984; that is, a period during which both the variance of the shocks may reasonably be assumed to have remained constant and the systematic monetary policy rule has not been found to have dramatically changed, we hope to better isolate the effect of international factors.

It is important to stress, however, that our sample is relatively short: it contains a bit more than twenty years of quarterly data. We expect a priori that this will make statistical relationships harder to detect and will constitute an important constraint on the richness of the models that we can contemplate in the empirical exercise following. This is an important sense in which we see our analysis as an exploration of how important global forces might have become for the U.S. economy. But as the results seem to suggest, there is still sufficient statistical information in the sample that allows us to learn something useful about changes in the economy in the recent past.

Our findings can be summarized as follows. First, we find that common

3. Many researchers have documented a sharp drop in the volatility of the U.S. real GDP in the early 1980s (see, e.g., McConnell and Perez-Quiros 2000; Blanchard and Simon 2001; Boivin and Giannoni 2002; Stock and Watson 2002a). Stock and Watson (2005) show that other G7 countries, with the exception of France, have similarly experienced lower output volatility since the mid-1980s, compared to the previous decades.

factors capture, on average, a sizable fraction of the fluctuations in U.S. macroeconomic indicators. This provides support for the use of our empirical model. Second, there is evidence that the role of international factors in explaining U.S. variables has been changing over the 1984 to 2005 period, but this evolution is not systematic across series, and it is difficult to see a pattern suggesting that they have become generally more important. Some variables such as the long-term interest rates, as well as import and export prices, however, do display a systematic increase of their correlation with global factors throughout our sample.

We do not find strong statistical evidence of a significant change in the transmission mechanism of monetary policy due to global forces. Taking our point estimates literally, global forces do not seem to have played an important role in the U.S. monetary transmission mechanism between 1984 and 1999. Also, since 2000, the initial response of the U.S. economy following a monetary policy shock—the first six to eight quarters—is essentially the same as the one that has been observed in the 1984 to 1999 period. However, point estimates suggest that the growing importance of global forces might have contributed to reducing some of the persistence in the responses, two or more years after the shocks.

Overall, we conclude that if global forces have had an effect on the monetary transmission mechanism, this is a recent phenomenon. This means, however, that we will need more data before we can get strong statistical conclusions on this question.

The rest of the chapter is organized as follows. In section 8.2, we describe the econometric framework adopted and the estimation approach. In section 8.3, we present empirical results on the comovements between international factors and U.S. data, and document changes in these relationships over the last two decades. In section 8.4, we document to what extent the role of global factors has changed the transmission mechanism of monetary policy. Section 8.5 concludes.

8.2 Econometric Framework: FAVAR

One key objective of this study is to evaluate the importance of the rest of the world in the transmission of U.S. monetary policy. That is, we seek to estimate to what extent the response of the rest of the world's economy enhances or mitigates the effect of U.S. monetary policy on the U.S. economy, and, importantly, whether this has changed over time. The FAVAR model described in Bernanke, Boivin, and Eliasz (2005) (henceforth, BBE) provides a natural framework to address these questions. In this section, we describe the empirical model and our estimation approach.

8.2.1 Description of FAVAR

The econometric framework that we consider is based on the FAVAR, extended to include international factors. We consider two regions: the U.S.

economy and the rest of the world, which we denote with *. We assume that in each region, the state of the economy, which is possibly unobserved, can be summarized by a $K \times 1$ vector C_t in the United States, and a $K^* \times 1$ vector C_t^* for the rest of the world. We measure the state of the economy in each region with large vectors of macroeconomic indicators, denoted by X_t for the United States, and X_t^* for the rest of the world. These vectors are of dimension $N \times 1$ and $N^* \times 1$, respectively. The indicators are assumed to relate to the state of the economy in each region according to the observation equations

$$X_t = \Lambda C_t + e_t \tag{1}$$

$$X_t^* = \Lambda^* C_t^* + e_t^*, \tag{2}$$

where Λ and Λ^* are matrices of factor loadings of appropriate dimensions, and the $N \times 1$ (respectively, $N^* \times 1$) vectors e_t and e_t^* contain (mean zero) series-specific components that are uncorrelated with the common components C_t (respectively, C_t^*), but are allowed to be serially correlated and weakly correlated across indicators. The number of common factors is assumed to be small relative to the number of indicators; that is, $N > K$ and $N^* > K^*$.

Under this structure, C_t and C_t^* constitute two sets of components that are common to all data series in the respective region and in general correlated across regions. Equations (1) and (2) reflect the fact that the common factors represent pervasive forces that drive the common dynamics of the data, and summarize at each date the state of the economy in each region. The variables in X_t are thus noisy measures of the underlying unobserved factors C_t. Note that it is in principle not restrictive to assume that X_t depends only on the current values of the factors, as C_t can always capture arbitrary lags of some fundamental factors.[4] The unobserved factors should reflect general region-specific economic conditions such as "economic activity," the "general level of prices," the level of "productivity," and key dimensions of the interest rate term structure, which may not easily be captured by a few time series, but rather by a wide range of economic variables.

The dynamics of the common factors are modeled as a structural Vector Autoregression (VAR)

$$\Phi_0 \begin{bmatrix} C_t^* \\ C_t \end{bmatrix} = \Phi(L) \begin{bmatrix} C_{t-1}^* \\ C_{t-1} \end{bmatrix} + \begin{bmatrix} v_t^* \\ v_t \end{bmatrix}, \tag{3}$$

where Φ_0 is a matrix of appropriate size on which we will later impose some restrictions, $\Phi(L)$ is a conformable lag polynomial of finite order, and the "structural" shocks v_t and v_t^* are assumed to be i.i.d. with mean zero and diagonal covariance matrix Q and Q^*, respectively. While these shocks are

4. This is why Stock and Watson (1999) refer to (1) as a dynamic factor model.

uncorrelated, anyone of these shocks may affect common factors of the other region immediately or over time, through the off-diagonal elements of Φ_0 and $\Phi(L)$. This structural VAR has a reduced-form representation obtained by premultiplying on both sides of (3) by Φ_0^{-1}:

$$\begin{bmatrix} C_t^* \\ C_t \end{bmatrix} = \begin{bmatrix} \Psi_{11}(L) & \Psi_{12}(L) \\ \Psi_{21}(L) & \Psi_{22}(L) \end{bmatrix} \begin{bmatrix} C_{t-1}^* \\ C_{t-1} \end{bmatrix} + \begin{bmatrix} u_t^* \\ u_t \end{bmatrix}, \tag{4}$$

where the reduced-form innovations u_t and u_t^* are cross-correlated.

Because we will ultimately be interested in characterizing the effects of monetary policy on the economy, we include in the vector of U.S. common components an observable measure of the monetary policy stance. As in most related VAR applications, we assume that the Federal funds rate, R_t, is the policy instrument. The latter will be allowed to have pervasive effect throughout the economy and will thus be considered as a common component of all U.S. data series. We thus write

$$C_t = \begin{bmatrix} F_t \\ R_t \end{bmatrix},$$

where F_t is a vector of latent macroeconomic factors summarizing the behavior of the U.S. economy.

8.2.2 Interpreting the FAVAR Structure in an International Context

The empirical model we just laid out is a dynamic factor model that links a large set of observable indicators to a small set of common components through the observation equations (1) and (2). The evolution of these common components is specified by the transition equation (3) or its reduced-form representation (4). It is useful to spell out more clearly the economic interpretation of this empirical model and, in particular, the relationship with possible underlying structural models.

As in Bernanke, Boivin, and Eliasz (2005) and in Boivin and Giannoni (2006a), we interpret the unobserved factors, C_t and C_t^*, as corresponding to theoretical concepts or variables that would enter a structural macroeconomic model. For instance, open economy dynamic general equilibrium models such as those of Benigno and Benigno (2001), Clarida, Galí, and Gertler (2002), Lubik and Schorfheide (2006), and those of many papers collected in this volume fully characterize the equilibrium evolution of inflation, output, interest rates, net exports, and other variables in two regions. In terms of the notation in our empirical framework, all of these variables would be in C_t and C_t^*. The dynamic evolution of these variables implied by such open economy models can be approximated by an unrestricted VAR of the form (4).[5] If all of these macroeconomic concepts were perfectly

5. For a formal description of the link between the solution of a dynamic stochastic general equilibrium (DSGE) model in state-space form and a VAR (see, e.g., Fernández-Villaverde et al. [2007] and references therein).

observed, the system (4) would boil down to a standard multicountry VAR and could be estimated directly, as in, for example, Eichenbaum and Evans (1995), Grilli and Roubini (1995, 1996), Cushman and Zha (1997), Kim and Roubini (2000), and Scholl and Uhlig (2006). In such a case, there would be no need to use the large set of indicators X_t.

However, there are reasons to believe that not all relevant concepts are perfectly observed. First, some macroeconomic concepts are simply measured with error.[6] Second, some of the macroeconomic variables that are key for the model's dynamics may be fundamentally latent. For instance, the concept of "potential output," often critical in monetary models, cannot be measured directly. By using a large data set, one is able to extract empirically the components that are most important in explaining fluctuations in the entire data set. While each common component does not need to represent any single economic concept, the common components C_t and C_t^* should constitute a linear combination of all of the relevant latent variables driving the set of noisy indicators X_t and X_t^*, to the extent that we extract the correct number of common components from the data set.

An advantage of this empirical framework is that it provides, both for the U.S. and the international data sets, summary measures of the state of these economies at each date, in the form of factors that may summarize many features of the economy. We thus do not restrict ourselves simply to measures of inflation or output. Another advantage of our approach, as BBE argue, is that this framework should lead to a better identification of the monetary policy shock than standard VARs, because it explicitly recognizes the large information set that the Federal Reserve and financial market participants exploit in practice, and also because, as just argued, it does not require to take a stand on the appropriate measures of prices and real activity that can simply be treated as latent common components. Moreover, for a set of identifying assumptions, a natural by-product of the estimation is to provide impulse response functions for any variable included in the data set. This is particularly useful in our case, since we want to understand the effect of globalization on the transmission of monetary policy to a wide range of economic variables.

The empirical model (1) and (2) and (4) provides a convenient decomposition of all data series into components driven by the U.S. factors C_t (i.e., the Federal funds rate and other U.S. latent factors F_t), non-U.S. latent factors C_t^*, and by series-specific components unrelated to the general state of the economies, e_t or e_t^*. For instance, (1) specifies that indicators of measures of U.S. economic activity or inflation are driven by the Federal funds rate R_t, U.S. latent factors F_t, and a component that is specific to each individual series (representing, e.g., measurement error or other idiosyncrasies of each series). The dynamics of the U.S. common components are in turn specified by (4).

6. Boivin and Giannoni (2006a) argue, for example, that inflation is imperfectly measured by any single indicator, and that it is important to use multiple indicators of it for proper inference.

Note that the factors C_t and C_t^* summarizing macroeconomic conditions in the U.S. respectively, in the rest of the world, may be affected both by their own region-specific shocks and by worldwide or "global" shocks. In fact, since reduced-form innovations u_t and u_t^* may be cross-correlated, they could be expressed as the sum of a component that is common both the U.S. and the rest of the world, possibly due to "global" shocks and a component that is exclusively region-specific. The reduced-form VAR may thus be rewritten as

$$C_t^* = \Psi_{11}(L)C_{t-1}^* + \Psi_{12}(L)C_{t-1} + \Gamma_1 g_t + \varepsilon_t^* \tag{5}$$

$$C_t = \Psi_{21}(L)C_{t-1}^* + \Psi_{22}(L)C_{t-1} + \Gamma_2 g_t + \varepsilon_t, \tag{6}$$

where g_t is a vector of "global" exogenous shocks, and ε_t^*, ε_t are disturbances that are specific to each region and uncorrelated across regions.[7]

8.2.3 Estimation

As in Stock and Watson (2002b) and BBE, we estimate our empirical model using a variant of a two-step principal component approach that we briefly outline here. We refer to these papers for a more detailed description.

The first step consists of extracting principal components from X_t and X_t^* to obtain consistent estimates of the common factors under the structure laid out. In the second step, the Federal funds rate is added to the estimated factors and the VAR in equation (4) is estimated. Note that in the first step, BBE do not impose the constraint that the Federal funds rate is one of the common components. So if this interest rate is really a common component, it should be captured by the principal components. To remove the Federal funds rate from the space covered by the principal components, in the second step BBE perform a transformation of the principal components exploiting the different behavior of what they call "slow moving" and "fast moving" variables. Our implementation is slightly different, however. We adopt a more direct approach, which consists of imposing the constraint that Federal funds rate is one of the factors in the first-step estimation. This guarantees that the estimated latent factors recover dimensions of the common dynamics not captured by the Federal funds rate.[8] To do so, we adopt the following procedure in the first step of the estimation. Starting from an initial estimate of F_t, denoted by $F_t^{(0)}$ and obtained as the first $K-1$ principal components of X_t, we iterate through the following steps:

1. Regress X_t on $F_t^{(0)}$ and R_t, to obtain $\hat{\lambda}_R^{(0)}$.

7. In this respect, C_t and C_t^* have a different interpretation than the world factors estimated by, for example, Gregory, Head, and Reynauld (1997), Forni et al. (2000), Kose, Otrok, and Whiteman (2003), and Ciccarelli and Mojon (2005). While these authors estimate a world factor and orthogonal region-(or country)-specific factors, our estimated C_t and C_t^* contain both fluctuations in regional and world factors.

8. We thank Olivier Blanchard for pointing us in that direction.

2. Compute $\tilde{X}_t^{(0)} = X_t - \hat{\lambda}_R^{(0)} R_t$.
3. Estimate $F_t^{(1)}$ as the first $K-1$ principal components of $\tilde{X}_t^{(0)}$.
4. Back to 1.

Having estimated the factors C_t and C_t^* and the factor loadings Λ, Λ^*, we can estimate the VAR (4). As we will argue in section 8.4, the matrix polynomial $\Psi_{21}(L)$ will be of particular interest to us, as it captures the effects of international factors on domestic variables. For now, note that the VAR coefficients $\Psi_{ij}(L)$ are identified provided that the variance-covariance matrix of the innovations $[u_t^{*\prime}, u_t']'$ is nonsingular. A sufficient condition for this is that the variance-covariance matrices of ε_t^* and ε_t are both full-ranked in the VAR representations (5) and (6).[9] In that case, C_t^* Granger causes C_t, and the domestic factors C_t do not constitute sufficient statistics to uncover the dynamics of the domestic economy. In other words, the domestic economy is not a statistical "island." Alternatively, if the rest of the world had no region-specific shocks, so that $E(\varepsilon_t^*\varepsilon_t^{*\prime}) = 0$, then $\Psi_{21}(L)$ would not be identified, as international factors would bring no additional information. The estimate of the VAR coefficients $\Psi_{21}(L)$ will thus rely on the presence of independent variations originating in the rest of the world, and the Granger-causality tests that we report following will guarantee that there is indeed sufficient such variation.

8.2.4 Data

The data we use for the estimation of the FAVAR are a balanced panel of 720 quarterly series for the period running from 1984:1 to 2005:2. The data series are listed in the appendix. They comprise 671 U.S. series. Among these, there are 129 macroeconomic indicators that measure economic activity, employment, prices, interest rates, exchange rates, and other key financial variables. In addition, we include the 542 series of disaggregate consumption, and consumer and producer price series used in Boivin, Giannoni, and Mihov (2009). As discussed in that paper, disaggregate price data provide useful information for the appropriate estimation of the monetary policy shocks, and are found to mitigate the price puzzle obtained in conventional VARs or factor models that omit that information. For the rest of the world, we consider a panel of forty-nine quarterly data series for the fifteen main U.S. trade partners. This data set includes—for each country—measures of economic activity, prices, and short- and long-term interest rates (if available). All data series have been transformed to induce stationarity, and the transformations applied are indicated in the appendix.

8.2.5 Preferred Specification of the FAVAR

For the model selection, there are two important observations to keep in

9. In terms of instrumental variables (IV) intuition, to estimate $\Psi_{12}(L)$, we need some independent variation in C_t^* in order to be able to use it as an instrument for itself in equation (6). For a formal treatment of this argument, see Hausman and Taylor (1983).

mind. First, the sample size severely constrains the class of specifications we can consider, especially the number of lags in (4), as the number of factors gets large. Second, in trying to identify the monetary policy transmission mechanism, we are more worried about bias than efficiency. Available information criteria for selecting the number of factors are thus not clearly adequate in that respect. Our general approach for selecting our preferred specification has thus been to try with up to twenty domestic factors and up to ten foreign factors.

It turns out that irrespective of the number of factors that we include, the Bayesian information criterion selects 1 lag in (4) over the post-1984 sample. We found that including more than ten domestic factors and four global factors did not change substantially the dynamic response of the economy to monetary policy, although, obviously, the uncertainty around the estimates increases with more factors. In fact, very similar results are obtained with as few as six domestic factors and three foreign factors, although point estimates suggest some price puzzle for some of the price series.

Our preferred specification thus includes ten domestic latent factors and four global factors, and the transition equation (4) has 1 lag.

8.3 International Factors and U.S. Economic Dynamics

Several studies have recently attempted to determine the degree of comovement of a few macroeconomic series across countries. For instance, Kose, Otrok, and Whiteman (2003, 2005) and Stock and Watson (2005) study the comovement of economic activity measures, and Ciccarelli and Mojon (2005) focus on inflation. In this chapter, rather than restricting ourself to the comparison of a single type of measure across regions of the world, we use our FAVAR framework to compare how the factors summarizing the U.S. macroeconomic dynamics relate to the rest of the world's factors.[10] If global forces are important to describe the dynamics of the U.S. economy, they should be captured by the latent factor space of the FAVAR. We use the common factors extracted from our large data set and determine the fraction of fluctuations in U.S. indicators of real activity, inflation, and interest rates that can be explained by U.S. and global factors, respectively. After showing to what extent key U.S. economic variables comove with U.S. and international factors, we determine whether these relationships have changed since the mid-1980s. We then attempt to measure whether foreign factors do "cause" (in a Granger sense) fluctuations in U.S. factors. In the next section, we report how monetary policy shocks affect a large number of variables, how the transmission mechanism has changed over time, and to what extent the change is due to international factors.

10. Justiniano (2004) similarly studies the comovement of multiple macroeconomic series between Canada, Australia, and the rest of the world.

8.3.1 Comovements between U.S. and International Factors

We first start by determining to what extent U.S. variables are correlated with U.S. and foreign factors. Table 8.1 reports the fraction of the volatility in the series listed in the first column that is explained by the eleven U.S. factors C_t (i.e., ten latent factors and the Federal funds rate), the four foreign factors C_t^*, and all factors taken together. This corresponds to the R^2 statistics obtained by the regressions of these variables on the appropriate set of factors for the entire 1984:1 to 2005:2 sample. Note that since the U.S. and international factors are allowed to be correlated, the fraction of the variance in any given variable explained by the U.S. factors (first column) plus that explained by the international factors (second column) do not correspond to the fraction of the variance explained jointly by both sets of factors (third column). However, by comparing the numbers in the third column to the sum of the other two columns, we may have a rough sense of how the determinants of the variable of interest may be correlated across countries.

Looking at table 8.1, several observations are worth mentioning. First,

Table 8.1 **R2 for regressions of selected U.S. series on various sets of factors (sample 1984:1–2005:2)**

	U.S. factors	Intl. factors	All factors
All U.S. data X_t (average over all U.S. data)	0.39	0.13	0.45
Selected U.S. indicators			
Interest rate (Federal funds)	1.00	0.65	1.00
GDP	0.30	0.18	0.37
Consumption	0.28	0.14	0.33
Investment	0.50	0.08	0.51
Exports	0.38	0.31	0.57
Imports	0.45	0.18	0.55
GDP deflator	0.54	0.33	0.69
Consumption deflator (PCE)	0.66	0.37	0.70
Investment deflator	0.53	0.11	0.58
Export deflator	0.58	0.08	0.65
Import deflator	0.42	0.06	0.49
Consumer price index (CPI)	0.50	0.23	0.56
Producer price index (PPI)	0.78	0.03	0.81
Industrial production	0.79	0.12	0.84
Employment (total nonfarm)	0.84	0.34	0.85
Real personal expenditures: durable goods	0.29	0.01	0.29
Real personal expenditures: nondurable goods	0.77	0.09	0.80
Price of personal expenditures: durable goods	0.58	0.43	0.68
Price of personal expenditures: nondurable goods	0.85	0.03	0.87
Price of personal expenditures: services	0.67	0.46	0.74
Long-term interest rate (10 years)	0.91	0.86	0.93
U.S. dollar (trade-weighted nominal exchange rate)	0.74	0.27	0.78

the entire U.S. data set X_t is on average quite strongly correlated with the common factors. On average, all factors explain 45 percent of the variance of U.S. series. Most of the common fluctuations in U.S. series is, however, provided by U.S. factors, as the R^2 for these factors amounts to 0.39. However, foreign factors do also appear to be correlated with U.S. data series, with an R^2 of 0.13. Note that, at this point, we do not attempt to determine the origin of the fluctuations in the factors and the direction of causality between U.S. and international factors. We realize that, in general, U.S. variables may be affected by global economic shocks that impact simultaneously U.S. and international factors. Instead, we attempt to assess to what extent international factors can explain fluctuations in various U.S. macroeconomic variables with information that is not contained in U.S. factors.

Looking at selected U.S. indicators, we find that quarterly growth rates of measures of real economic activity, such as quarterly averages of industrial production and employment, display very high correlations with the U.S. factors (R^2 statistics of 0.79 and 0.84, respectively). It may be surprising that other activity measures such as real GDP or consumption from the national income accounts do not appear as strongly correlated with the U.S. factors, especially when compared with existing evidence based on similar factor models. However, this is purely an artifact of our use of quarterly growth for GDP components mixed with quarterly averages of monthly data. In fact, the quarterly growth rates of the GDP components display more high-frequency variability than those of (the quarterly averages of) employment and industrial production. Because that variability is not well captured by U.S. factors, a large fraction of these series volatility is explained by the idiosyncratic terms. Were we to consider year-over-year growth rates of the variables, GDP and consumption would display much larger contributions of U.S. factors. The important point, however, is that most of the fluctuations in industrial production, consumption, investment, or employment indicators are determined by domestic factors. While these indicators display some correlation with the international factors, the additional explanatory power of the latter factors is relatively low. In fact, the R^2 obtained for these variables by them regressing on all factors are not much higher than those found by regressing only on the U.S. factors.

Quite naturally, the picture is different for U.S. real exports and imports, as they appear to be much more strongly related to international factors. Adding the international factors to the U.S. factors increases the fraction of the variance of exports explained from 0.38 to 0.57, and raises the R^2 of imports from 0.45 to 0.55. These global factors thus contain substantial information not already contained in U.S. factors, and that is correlated with real exports and imports. Real GDP then reflects the descriptions of its underlying components: while domestic factors are certainly key, adding the international factors increases the R^2 by 7 percentage points.

For U.S. quarterly inflation rates, the importance of international factors

varies sensibly depending on the price index used. Inflation of the producer price index (PPI), for instance, is well described by U.S. factors and displays very little correlation with international factors. However, growth rates of the U.S. GDP deflator and of consumer prices, whether based on the consumer price index (CPI) or the personal personal consumption expenditure (PCE) deflator, are more correlated with international factors. The latter factors explain 37 percent of fluctuations in inflation of the PCE deflator. Nonetheless, the international factors do not seem to explain much more of consumer price inflation than what is explained by U.S. domestic factors. This suggests that the U.S. and international factors that explain well inflation are strongly correlated. This is consistent with Ciccarelli and Mojon (2005), who find that an important component of consumer price inflation is shared globally. For the GDP deflator, however, global factors contain information not included in U.S. factors. In fact, regressing this indicator on all factors raises the R^2 to 0.69, compared to 0.54, when we consider only U.S. factors. One possible explanation is that export prices depend sensibly on international factors in a way that is not captured by U.S. factors. The inflation rate of the exports' deflator does not however, appear to be strongly correlated with international factors over our entire sample. As we will see following, this low correlation with international factors is deceptive, as it appears to be due to considerable instability over the sample.

The nominal exchange rate is strongly correlated with domestic factors, and the R^2 with international factors is 0.27, but these global factors seem to contain surprisingly little information not already contained in the domestic factors, and the R^2 with all factors is only a little higher than the one with only U.S. factors.

Finally, for nominal interest rates, the Federal funds rate is by assumption a U.S. factor, but it is also strongly correlated with international factors. Similarly, the long-term U.S. interest rate is very strongly correlated with U.S. and international factors. This suggests that all of the countries considered in our data set are affected by a common factor resembling U.S. interest rates.

8.3.2 Have U.S. and International Forces Become More Strongly Correlated?

Overall, the evidence reported in table 8.1 indicates that most selected key U.S. variables are strongly correlated with U.S. factors and, to a lesser extent, with international factors. Such results have been obtained for the sample that runs from 1984:1 to 2005:2. As mentioned in the introduction, though, the U.S. economy's trade in goods and services with the rest of the world has expanded considerably, and the financial globalization, as measured by the sum of external assets and liabilities, has developed at an unprecedented pace during this period.

Such dramatic developments are likely to have affected the relationship

between U.S. variables and international factors. To date, however, the evidence about change in the synchronization of the U.S. economy with the rest of the world is mixed. While Kose, Prasad, and Terrones (2003) find stronger comovements of output in industrialized countries with a world factor (since the early 1980s) than in the preceding two decades, Doyle and Faust (2005) find little evidence of statistically significant changes, and Helbling and Bayoumi (2003), Monfort et al. (2003), Heathcote and Perri (2004), Stock and Watson (2005), and Kose, Otrok, and Whiteman (2005) find reductions in the synchronization of output fluctuations across countries. In addition, these studies typically consider the period subsequent to the mid-1980s as a whole, and do not allow for changes during that period.

Several observers have nonetheless suggested that key macroeconomic variables might have become more dependent on the state of the economy in the rest of the world in the last few years. Chairman Bernanke (2007) pointed out that long-term interest rates in the United States have become sensibly more correlated with those of Germany and other industrialized economies. Some have argued that U.S. inflation may have become more strongly affected by international developments, such as the rise of China as a source of goods and services sold in the United States (see, e.g., Rogoff 2003; Kamin, Marazzi, and Schindler 2006; Borio and Filardo 2006; Ihrig et al. 2007). While some U.S. variables may well have become more strongly correlated with international factors, our framework allows us to assess whether a large number of macroeconomic variables in the United States have become systematically more synchronized with the factors of its major trade partners.

It is important to keep in mind that a formal empirical analysis of the recent changes due to the greater globalization is difficult, and faces limits, as the data samples are still very short. Nevertheless, our framework provides a rich account of these changes since 1984, which can show to what extent the global components have revealed changes in the correlations with U.S. variables. Figure 8.1, panels A and B, document the comovement of U.S. variables with global forces over time. They show the fraction of the variability in U.S. variables explained by the global factors, where the estimation is done using a ten-year rolling window. The dates correspond to the midpoint of that window.

These figures reveal several interesting results. First, they show that international factors have *not* become more strongly correlated with a *broad* set of U.S. variables since 1984. The regressions of the U.S. common components on all international components result in R^2 statistics that have not increased on average. Second, despite a fairly constant correlation between international and U.S. factors, when taken as a whole, the importance of global forces on some individual U.S. variables has varied considerably over the sample. Part of that variation certainly reflects the short samples, and may exaggerate the nature of the true changes. Nonetheless, the R^2 of the

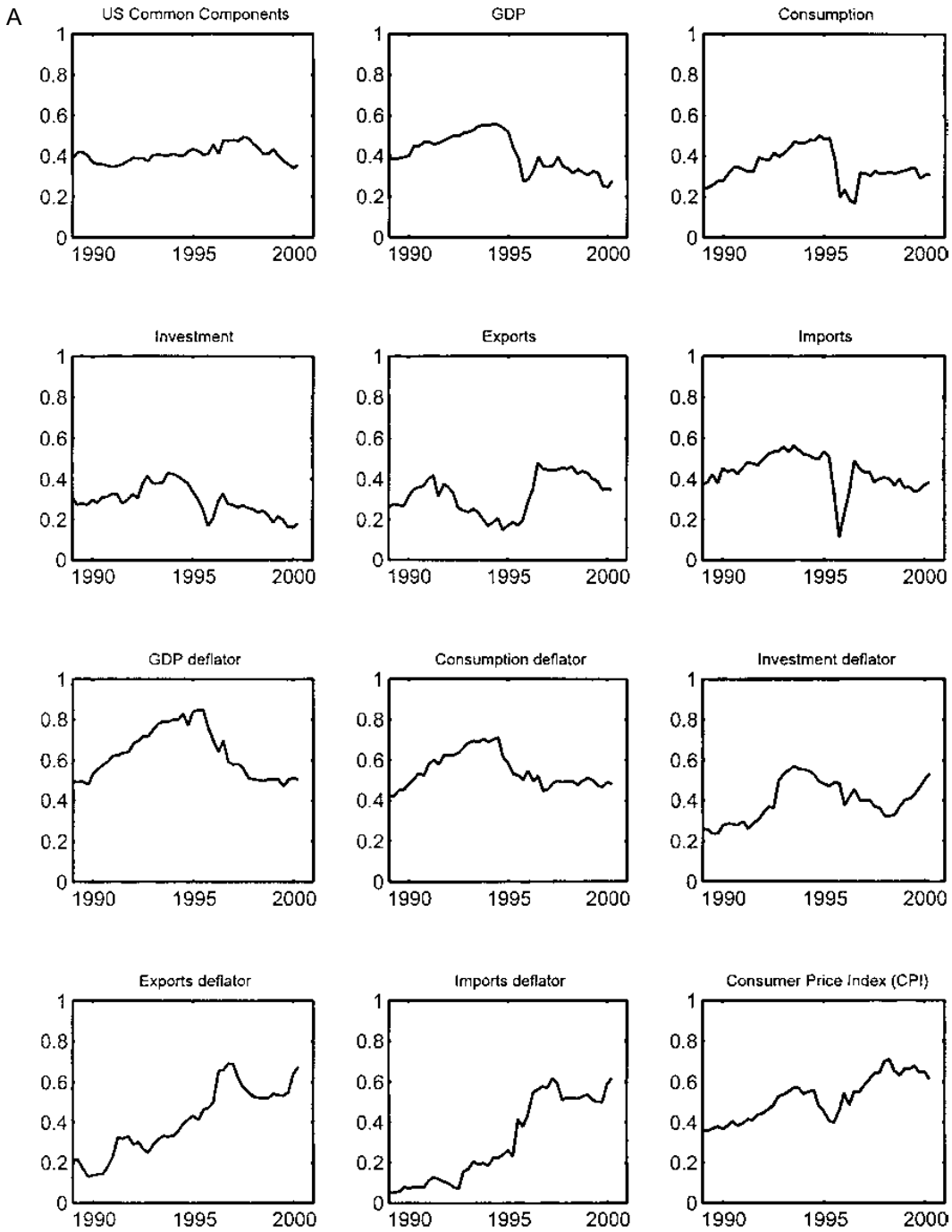

Fig. 8.1 Fraction of the variance of individual series explained by global factors, in regressions with 10-year rolling windows

regression of real GDP growth on international factors fell from 1995 (corresponding to the period that spans 1990 to 2000) to 2000 (i.e., the period that spans 1995 to 2005). A similar evolution can be found for consumption, investment, and imports, though the R^2 found at the end of the sample are not very different from those obtained at the beginning of the sample. The

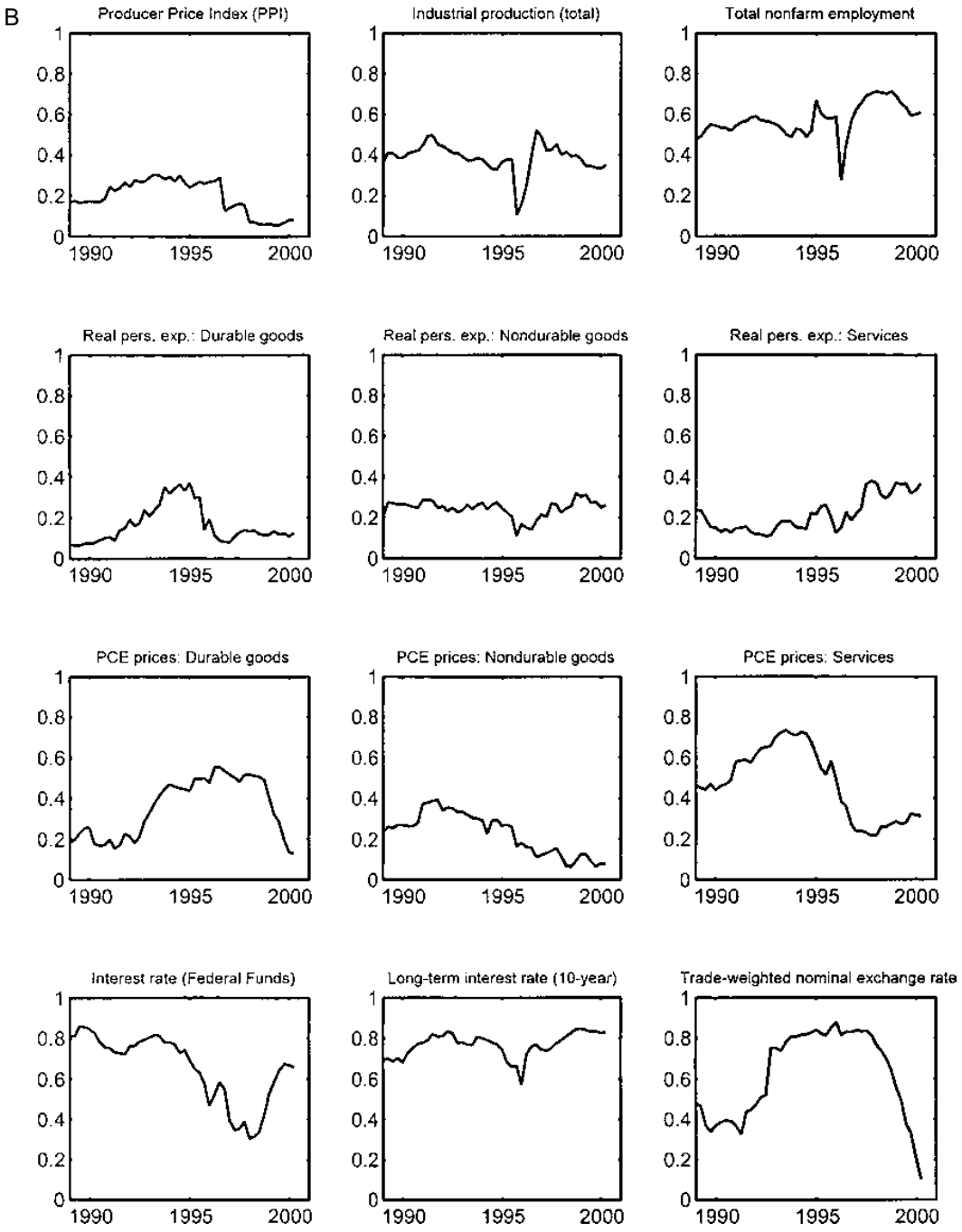

Fig. 8.1 (cont.)

U.S. exports, however, do seem to be more strongly correlated with international factors after the mid-1990s, with R^2 doubling from approximately 0.20 to 0.40.

In terms of prices, inflation in export prices is increasingly more correlated with the international factors throughout the sample. While international

factors explain only about 20 percent of the variance of the export prices' inflation rate around 1990, they explain close to 70 percent of this variance a decade later. Import prices similarly see their correlation with international factors steadily increase over time. This is consistent with the idea that import prices have been rising more slowly than other consumer prices, due in part to an increase in imports from low-cost emerging economies. In fact, Kamin, Marazzi, and Schindler (2006) find that trade with China has reduced inflation in import prices by about 1 percentage point. This ends up being reflected in a greater correlation of the international factors with U.S. inflation as measured by the CPI, but surprisingly, there is no such effect on the inflation rate of PCE prices. In addition, there is no evidence that the GDP deflator has become more strongly correlated with international factors since the mid-1990s. If anything, the R^2 statistic has decreased since 1995 for the inflation based on the GDP deflator and on the PCE deflator. These findings contrast sharply with the claims often made that U.S. inflation may have become increasingly determined in the rest of the world (e.g., Borio and Filardo 2006), but are consistent with the results of Ihrig et al. (2007).

Regarding interest rates, the Federal funds rate appears very strongly correlated with international factors until mid-1995, and again by the year 2000. But in the second half of the 1990s, the Federal funds rate appears to disconnect from the international factors for several years. For ten-year rates, the correlation with international factors seems to increase by the late 1990s, a fact consistent with the finding by Bernanke (2007) that long-term yields in industrialized countries have become more strongly correlated in the last few years. While we do not attempt to determine why that correlation has increased, we note that it does not necessarily imply that U.S. rates are determined to a greater extent on foreign capital market. In fact, such a finding is also consistent with the idea that U.S. monetary policy may now have larger effects on international bond markets at the same time as it affects U.S. financial markets (see Ehrmann, Fratzscher, and Rigobon 2005; Faust et al. 2007).

Finally, while the value of the U.S. dollar seems to have been strongly correlated with international factors for a large part of the 1990s, the recent decline in the value of the dollar appears to have had little relation with global factors. Instead, it has been much more determined by U.S. domestic factors.

While table 8.1 and figure 8.1 have provided an interesting account of the relationship between various U.S. macroeconomic variables and international factors, the numbers reported are, however, merely correlations, and do not imply that fluctuations in U.S. variables such as the Federal funds rate are caused by changes in international conditions. It may well be that changes in U.S. conditions may be sufficiently important to cause changes in foreign factors.

Table 8.2 **Granger-causality tests for international factors affecting U.S. factors**

	Full sample	84:1–94:4	95:1–05:2
Factors			
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.18
4	0.04	0.06	0.01
5	0.07	0.24	0.35
6	0.00	0.00	0.00
7	0.01	0.10	0.00
8	0.03	0.29	0.04
9	0.05	0.38	0.00
10	0.00	0.00	0.03
Fed. funds rate	0.00	0.00	0.00

Note: Table reports *p*-values.

8.3.3 Testing the Relevance of Global Forces for U.S. Fluctuations

Granger Causality Tests

To check formally whether global forces do matter for U.S. fluctuations, we now turn to Granger causality tests. Results are presented in table 8.2. We test whether the lags of all international factors, C^*_{t-1}, jointly have predictive power for the current values of U.S. factors C_t listed in the first column, over and beyond lags of domestic factors, C_{t-1}. Under the null hypothesis, foreign factors have no predictive power. The table suggests that all but one U.S. common factors, including the Fed funds rate, are Granger-caused by international factors at the 5 percent level over the entire sample considered. The evidence is somewhat weaker when we perform the test over the 1984:1 to 1994:4 period. At this stage, this might only be reflecting lower power of the test over the smaller subsamples. Interestingly, however, combined with the evidence that we report in section 8.4, it seems that global factors were not very important to explain U.S. economic dynamics before the late 1990s. This evidence implies that the feedback from the rest of the world to the U.S. economy as measured by $\Psi_{21}(L)$, and to which we return in section 8.4, are identified.

Has the Influence of International Factors on U.S. Factors Increased over the Last Two Decades?

As the comparison of the Granger causality tests between the two subsamples crudely suggests, the relationship of the global factors with the U.S. economy might have changed over time. In fact, if there is any content to the claims that the greater economic integration between the U.S. and the rest of the world has affected the dynamics of U.S. economic variables, the Granger causality relationship must have changed over time.

Table 8.3 **Stability tests for Granger-causality coefficients of international factors affecting future U.S. factors**

	Joint-Global
Factors	
1	41.59**
2	85.17**
3	47.53**
4	38.14**
5	102.15**
6	34.92**
7	30.90**
8	20.78**
9	17.44*
10	62.20**
Fed. funds rate	15.94

Note: Table reports QLR statistics and confidence level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

One way to get formal evidence on this question is to test for the stability of the Granger causality relationships. We do so using the Quandt likelihood ratio test (QLR), the asymptotic distribution of which has been derived by Andrews (1993).[11] We apply the test jointly to all global factors.

The results are reported in table 8.3. As is clear from the table, we reject stability at the 5 percent level in most cases. Based on this, one important observation is that even though we have a fairly short sample, the latter contains sufficient information to allow us to detect statistically significant changes. It remains to be investigated whether these changes have been sufficiently important, economically speaking, to affect the transmission mechanism of monetary policy. Interestingly, the Federal funds rate is the only variable for which the stability is not rejected. The data thus suggests that while the setting of the Federal funds rate has been affected by global factors, the role of the latter factors does not seem to have changed significantly in our sample.

8.4 Implications for the Monetary Transmission Mechanism

In the last section, we determined that some of U.S. factors have become more synchronized with international factors over the last two decades. A

11. In doing so, we ignore the uncertainty in the factor estimates. When the cross section of macro indicators is large, the uncertainty in the factor estimates should be negligible asymptotically (see Bai and Ng 2006).

natural question that arises, then, is to what extent has U.S. monetary policy become more constrained by the expansion of international trade, and to a larger extent by the much greater globalization of finance. Do global forces mitigate the effects of U.S. monetary policy more than they used to?

There is little doubt that, despite this globalization, the Federal Reserve has retained its capacity to align the Federal funds rate with its target rate by managing the supply of funds in the interbank market. It is thus still reasonable to think of the Federal funds rate as being the instrument of monetary policy. As other short-term rates, such as yields on three-month or six-month U.S. Treasury securities, remain very strongly correlated with actual Federal funds rate (the correlation between the Federal funds rate and three-month securities is above 0.99 for the period 1984 to 2007 and has remained as high since 2000) they can still be viewed as primarily affected by monetary policy.

Clearly, longer-term interest rates reflect, at least in part, expectations of future short-term rates, and depend on announcements provided by central bankers. Longer-term rates have, however, become more strongly correlated with international factors in recent years, as mentioned before. Part of this change may reflect a greater influence of international capital markets on U.S. long-term rates.[12] Alternatively, U.S. factors may have more impact on international capital markets (see Ehrmann, Fratzscher, and Rigobon 2005; Faust et al. 2007). At the same time, since monetary policy's effect on other variables such as economic activity and inflation is believed to depend partly on long-term rates, it is possible that these other variables might have become less affected by Federal funds rate movements. In addition, the increase in international trade in goods and services may explain why U.S. import and export prices have become more correlated with international factors. A natural question, then, is what are the implications of these changes for the transmission of U.S. monetary policy?

8.4.1 Empirical Strategy

In the context of our FAVAR framework, we can characterize the transmission mechanism of monetary policy by computing the response of selected macroeconomic series to an identified monetary policy shock. In the spirit of VAR analyses, we impose only the minimum number of restrictions needed to identify the policy shock. This allows us to document some facts about the evolution of the monetary transmission mechanism that should not be otherwise contaminated by auxiliary assumptions.

Recall that the structural representation of our VAR transition equation takes the form (3), where again $C_t = [F_t', R_t]'$. To identify monetary policy shocks (i.e., the surprise changes in the Federal funds rate) we assume that

12. See, for example, Bernanke (2005) for an argument that increased saving in emerging economies and in oil-producing countries has contributed to maintaining low long-term U.S. interest rates.

the latent factors F_t and C_t^* cannot respond to innovations in R_t in the period of the shock. The Fed funds rate, however, is allowed to respond to contemporaneous fluctuations in such factors. We thus impose the restriction that the matrix Φ_0 in (3) has ones on the main diagonal, and zeroes in the last column, except for the lower right element, which is one. This has the implication that the monetary policy shock enters only in the last element of the innovations vector $\boldsymbol{u_t}$ in the reduced-form VAR (4), which we repeat here for convenience:

$$\begin{bmatrix} C_t^* \\ C_t \end{bmatrix} = \begin{bmatrix} \Psi_{11}(L) & \Psi_{12}(L) \\ \Psi_{21}(L) & \Psi_{22}(L) \end{bmatrix} \begin{bmatrix} C_{t-1}^* \\ C_{t-1} \end{bmatrix} + \begin{bmatrix} u_t^* \\ u_t \end{bmatrix}.$$

As mentioned previously, the matrix polynomials $\Psi_{12}(L)$ and $\Psi_{21}(L)$ determine the magnitude of the spillovers between the U.S. and the rest of the world's economic variables. When $\Psi_{21}(L) = 0$, the rest of the world has no spillovers on the U.S. economy, meaning that fluctuations in foreign economic variables do not cause (in the sense of Granger) any fluctuations in U.S. variables. Following a U.S. monetary policy shock, $\Psi_{21}(L)$ measures the extent to which the rest of the world contributes to the transmission of the U.S. monetary policy domestically.

Our strategy involves computing impulse response functions to a monetary policy shock in the aforementioned system, and comparing them to those obtained with different values of $\Psi_{21}(L)$. The difference between these impulse responses provides a measure of the importance of the endogenous response of the rest of the world in the U.S. transmission of monetary policy. (Note that in both cases, C_t^* is allowed to move only in response to the monetary shock.) In addition, to the extent that the greater integration of the world economies has changed the role played by the rest of the world in the transmission of U.S. monetary policy, this should imply a change in $\Psi_{21}(L)$. Consequently, by documenting the changes over time in $\Psi_{21}(L)$ and its implications on the impulse response functions, it is possible to evaluate whether globalization has reduced the ability of U.S. monetary policy to affect domestic variables.

To illustrate more directly the exercise we perform, let us consider a simplified version of this model in which the macroeconomic factors are actually observed. To fix ideas more concretely, think of the set of relevant domestic factors C_t as being given by the domestic (or world) interest rate R_t, and domestic real activity Y_t, and the foreign factors C_t^* as corresponding foreign real activity Y_t^*. Let us assume that the structural model relating these variables is as follows:

$$\begin{aligned} Y_t^* &= \psi_{11} Y_{t-1}^* + \psi_{12} Y_{t-1} + \psi_{13} R_{t-1} + g_t + \varepsilon_t^* \\ Y_t &= \psi_{21} Y_{t-1}^* + \psi_{22} Y_{t-1} + \psi_{23} R_{t-1} + g_t + \varepsilon_t \\ R_t &= \phi Y_{t-1} + \eta_t, \end{aligned}$$

where ε_t^* and ε_t are region-specific output shocks and g_t is a worldwide shock. The first two equations are reduced-form equations determining output in both regions, while the third equation can be interpreted as an interest rate rule, so that η_t can be viewed as a monetary policy shock.

In this context, our approach consists of comparing the impulse response functions of Y_t and R_t implied by this unrestricted system, with those obtained for different values of ψ_{21}. For instance, setting $\psi_{21} = 0$ is equivalent to assuming that domestic variables are not affected by international developments. Comparing the two sets of impulse response functions thus provides a way to assess the importance of the "feedback" or "spillover" from the rest of the world in explaining the transmission mechanism of monetary policy.

Whether or not our strategy identifies the effect of international factors (i.e., the effect of Y_t^*) in the transmission mechanism of monetary policy depends solely on whether the parameter ψ_{21} is identified. As mentioned in section 8.2, ψ_{21} is identified provided that the variances of ε_t and ε_t^* are nonzero. If $var(\varepsilon_t^*)$ were equal to zero, the system would be reduced-ranked and it would not be possible to identify separately all the parameters ψ_{ij}, as Y_t^* and Y_t would be perfectly collinear. Notice that the condition that $var(\varepsilon_t) > 0$ and $var(\varepsilon_t^*) > 0$ is equivalent to saying that Y_t^* Granger causes Y_t (conditional on past values of Y_t).

It is important to note that our analysis does not identify directly "worldwide shocks," which would affect simultaneously domestic and international factors (such as the shock g_t) in the previous example, in the absence of further restrictions. It is, however, not necessary to identify such global shocks in order to quantify the effects of international factors of the transmission of U.S. monetary policy shocks.

For illustration purposes, in this simple example, we assumed that the factors C_t and C_t^* were perfectly observed. In our application, however, these factors are unobserved and relate to a large set of informative variables according to (1) and (2). This does not change any of the arguments just made in the context of the simple example. Once we have estimates of C_t and C_t^*, we are back in the world described in the previous example. The matrix polynomial $\psi_{21}(L)$ is similarly identified when the matrix $var(\varepsilon_t^*)$ is full rank or, alternatively, provided that C_t^* Granger causes C_t.

8.4.2 Implementation

In estimating the FAVAR over the sample 1984:1 to 2005:2, we allow for the possibility that the international factors may affect U.S. variables differently after the year 2000. More specifically, we expand the VAR system of our FAVAR with a dummy variable interacted with all the lags of the foreign factors. More precisely, we estimate the following system

$$\begin{bmatrix} C_t^* \\ C_t \end{bmatrix} = \begin{bmatrix} \Psi_{11}(L) & \Psi_{12}(L) \\ \Psi_{21}(L) & \Psi_{22}(L) \end{bmatrix} \begin{bmatrix} C_{t-1}^* \\ C_{t-1} \end{bmatrix} + \begin{bmatrix} \Psi_{11}^d(L) \\ \Psi_{21}^d(L) \end{bmatrix} d_t C_{t-1}^* + \begin{bmatrix} u_t^* \\ u_t \end{bmatrix},$$

where d_t takes the value 0 for the period 1984:1 to 1999:4 and 1 after. This means that the coefficients on the lag international factors in the equations for C_t are equal to $\psi_{21}(L)$ for 1984:1 to 1999:4, and to $\psi_{21}(L) + \psi_{21}^{d}(L)$ thereafter. Given that our preferred specification has only one lag, notice that allowing for this form of instability requires estimating four additional parameters per equation, so it is not too costly in terms of degrees of freedom.

8.4.3 The Effects of Monetary Policy Shocks

Figure 8.2, panels A and B, show the estimated impulse responses of a set of macroeconomic indicators to a tightening of monetary policy; that is, an innovation in the Federal funds rate corresponding to an unexpected increase of 25 basis points. The solid lines represent the responses computed using the relationship between the U.S. factors and the international factors as estimated during the 1984:1 to 1999:4 period, along with the 70 percent confidence intervals.[13] The dashed lines, instead, display the responses using the same FAVAR, but assuming that the U.S. and international factors relate as estimated after 2000. A comparison of these two sets of impulse responses allows us to gauge the effects on the monetary transmission mechanism of the changes in the relationship between international factors and U.S. variables. In fact, between the two sets of responses, the only relationships that are allowed to change are those that describe how foreign factors end up affecting U.S. data. Note that by doing so, we maximize the length of our sample in the estimation, yet we allow for a change in the role of international factors.

As the impulse responses based on the effects of international factors estimated for the 1984:1 to 1999:4 sample reveal in figure 8.2, an unexpected tightening in monetary policy results in a gradual decline in real GDP, which tends to revert back to the original level after about three years. Other measures of activity, such as industrial production and employment, both respond in a similar way. Consumption also shows a similar although smaller response, while investment falls much more. Together with the fall in domestic demand, imports fall in response to the interest rate increase. The reduction in imports appears to be reinforced by a significant appreciation in the value of the U.S. dollar, lasting about two years following the shock. Exports to the rest of the world also fall significantly following the monetary tightening. This is consistent with the fact that the U.S. dollar appreciates, and that output in foreign trade partners falls (not reported).

All price indexes (reported in levels) show little response on impact, but also tend to fall progressively, and in a persistent way, following the monetary tightening. However, while the import and export price deflators seem to respond rapidly to the shock, it takes about three quarters for the GDP deflator and the CPI to show any movement. While the import price response may reflect a slowing domestic economy, the response of export prices may

13. The confidence intervals were obtained using Kilian's (1998) bootstrap procedure.

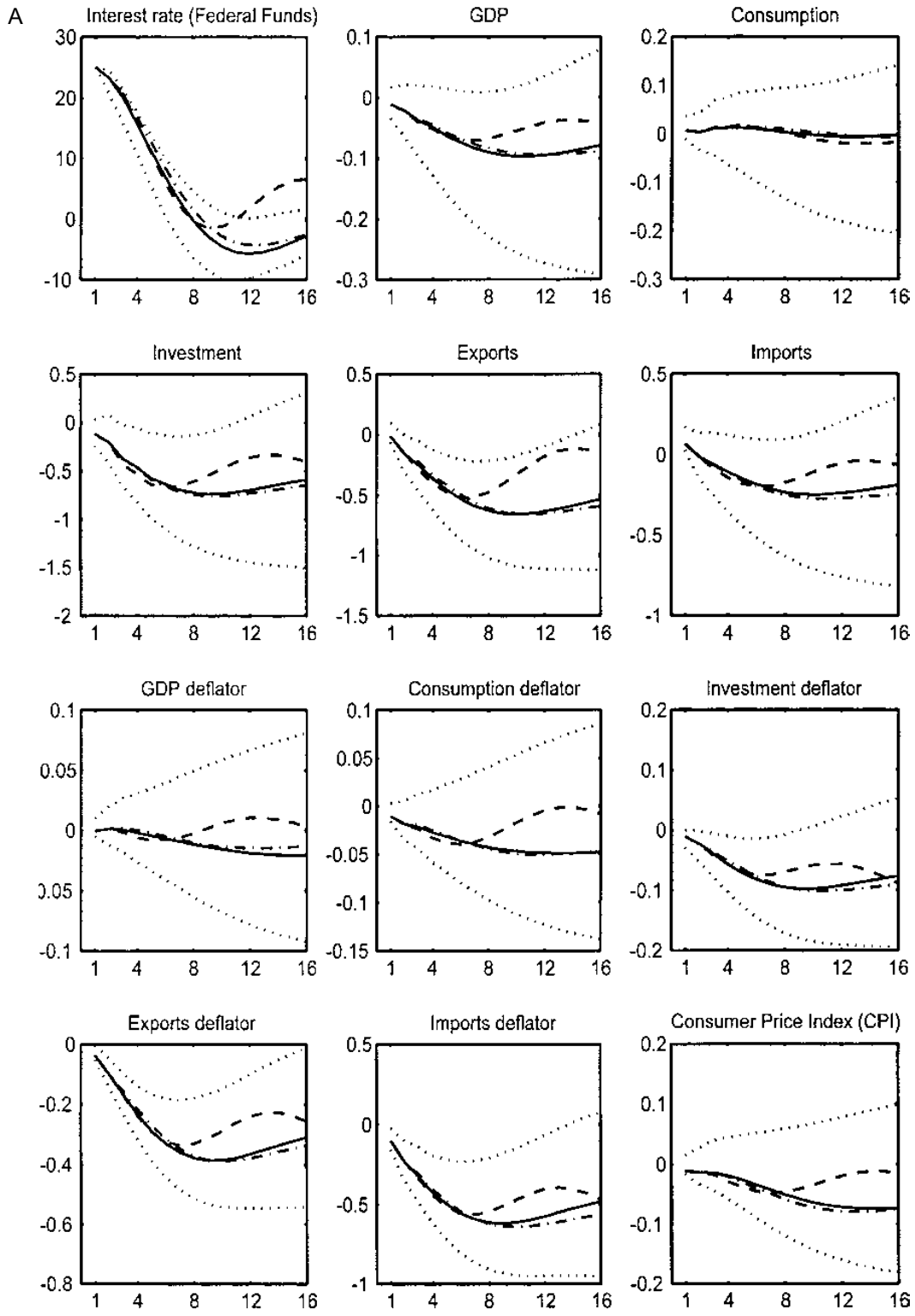

Fig. 8.2 Impulse responses to an identified monetary policy shock

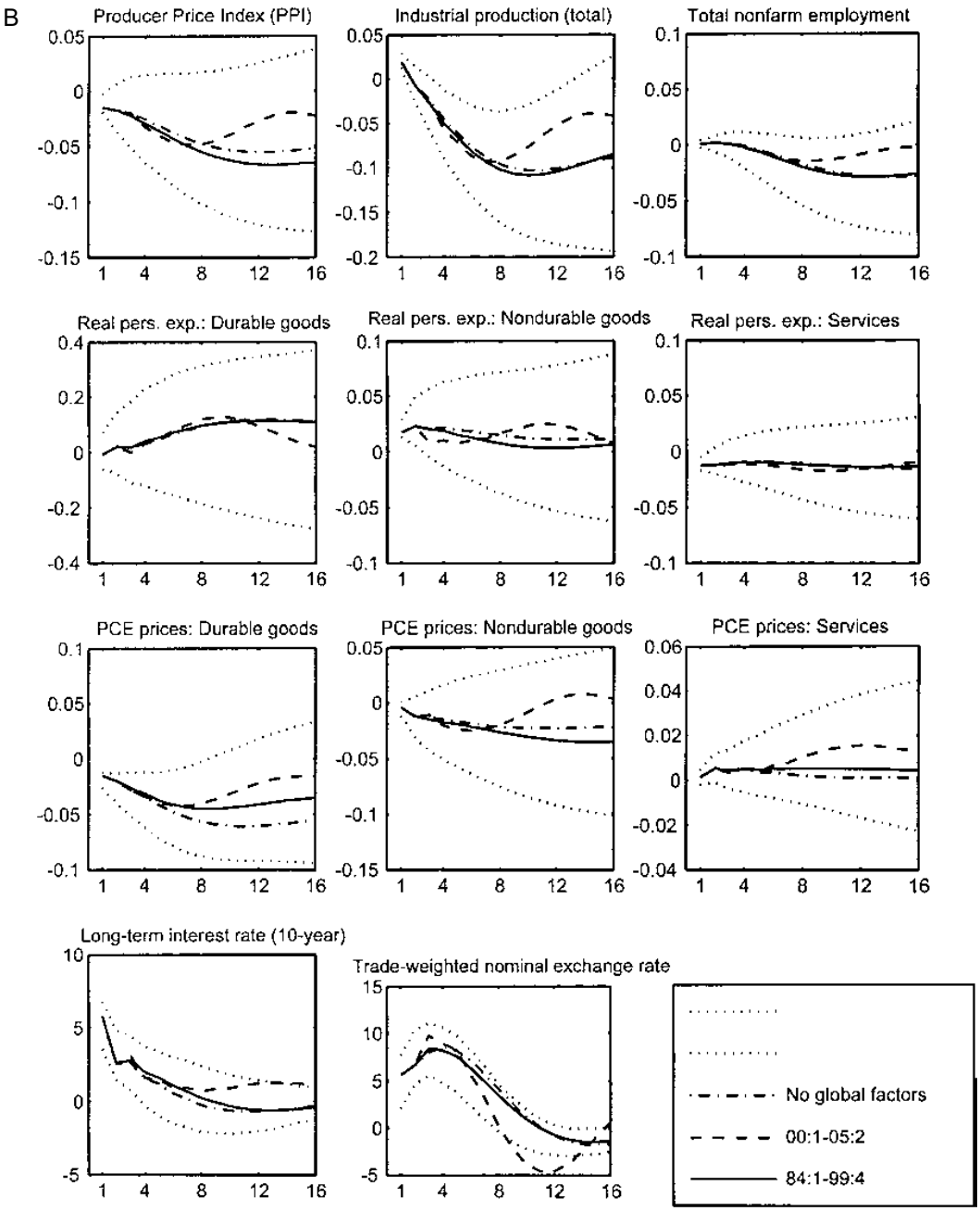

Fig. 8.2 (cont.)

be explained by a drop in foreign demand for U.S. goods, due both to an appreciating U.S. dollar and to a slowing foreign economy.

8.4.4 Has the Role of Global Forces on the U.S. Monetary Transmission Changed?

We find little overall evidence that global forces have had an important effect on the U.S. monetary transmission mechanism, and find little evi-

dence of change over the last several years. To determine to what extent the response of macroeconomic variables to a monetary tightening has changed recently, we compare the impulse responses based on the FAVAR involving the link between domestic and international factors as estimated since 2000 (dashed lines) to those based on international factors in the 1984 to 1999 period (solid lines). One interesting conclusion that emerges from this exercise is that the variables display in both cases almost identical responses in the first six to seven quarters following the shock. After that, the responses based on the most recent international factors reveal a slightly more rapid return to the initial level. The output and various measures of prices, for instance, show less persistent responses to the monetary tightening. But most changes are not statistically significant. Only for the Federal funds rate, the long-term interest rate, and the exchange rate do we have sharper evidence that the impulse responses have changed after three or four years, when using the more recent factors. And the expectation of a higher Federal funds rate three or more years following the shock is reflected in a slightly higher value of the ten-year yield.

The changes in the impulse responses just documented were obtained by allowing a different relationship between the U.S. and international factors starting in year 2000. For robustness, we checked with alternative break dates, and found that in all cases, the changes were similar or smaller than those reported in the figures. This suggests that if there has been a change in the response to monetary policy shock, this phenomenon is very recent.

In brief, we found no evidence that the responses of a large number of key U.S. variables to monetary policy shocks have changed in the first six to seven quarters following the shock. However, we found some evidence that the relationship between U.S. and international factors has changed in such a way as to imply a lower persistence in the response to monetary policy shocks eight or more quarters after the shock.

How important are global forces for the monetary transmission? When the Federal Reserve changes the course of monetary policy, it affects both U.S. and international factors. The response of the latter may in turn constrain the response of the U.S. economy. A crude way of assessing the role of global forces in the transmission of U.S. monetary policy is to report the responses of U.S. macroeconomic variables to a monetary policy shock, but assume that the U.S. factors do not respond to global factors. Specifically, we compute the responses of the monetary shock by setting to zero the submatrices ψ_{21} and ψ_{21}^{d}, referring to the international factors C_t^*. These impulse responses that abstract from international factors are shown with dashed-dotted lines in figure 8.2, panels A and B.

A striking conclusion is that these responses almost perfectly replicate those estimated with the international factors in the 1984 to 1999 period (solid lines). It follows that the global factors in that period do not seem to have more than a marginal impact on the response of the U.S. economy to

monetary shocks. Of course, we are *not* saying that global factors do not have an impact on the economy, and that the Federal Reserve does not need to give any consideration to the international economic situation. In fact, as we reported in the previous section, several key variables *are* strongly correlated with international factors. Our results suggest, however, that *conditional on changing the Federal funds rate* in a particular way, the response of the main U.S. macroeconomic variables have been little affected by the response of international factors.

It is important, however, to keep in mind that in the counterfactual experiment just described, as well as in our assessment of the change over time in the effect of foreign factors, we assume that the coefficients measuring the response of U.S. variables to U.S. factors as well as those characterizing the dynamics of the U.S. factors do not change. While we would in principle want to allow for possible changes over time in the latter coefficients, such exercises are unfortunately unlikely to provide reliable results in our empirical model, given the number of extra parameters that we would need to estimate, and given our relatively short sample. Such an assumption may well not be satisfied. For instance, several authors have argued that the slope of the Phillips curve relating U.S. inflation to domestic measures of marginal costs or of activity may have changed following the greater economic integration of the United States with the rest of the world. However, Sbordone (chapter 10, this volume) and Woodford (chapter 1, this volume) argue, in simple calibrated models, that such changes are unlikely to be large. Another possibility is that the processes determining expectations about future domestic variables be altered by the greater openness of the domestic economy. By not letting the relationships among domestic variables change in our empirical model with the increased globalization, we are technically subject to the Lucas critique. One would thus need a fully-specified forward-looking structural model to account for this issue.

8.5 Conclusion

It has been widely documented that international trade has continued to advance, and that the globalization of finance has seen an extraordinary expansion since the mid-1980s. In this context, several observers have argued that global factors may now have a greater influence than in the past on the determination of key U.S. macroeconomic variables, and that conditions in international capital markets may impose more constraints on the transmission of monetary policy.

In this chapter, we have attempted to quantify the changes in the relationship between international forces and the U.S. economy over the 1984 to 2005 period. To do so, we have used an empirical model that allows us to summarize the macroeconomic conditions of the U.S. economy and of the rest of the world with a small number of factors. This framework allows us to quantify

the extent of comovement between many key U.S. macroeconomic variables and international factors. It allows us to characterize empirically the transmission of monetary policy shocks to a large set of macroeconomic indicators.

Our findings can be summarized as follows. First, we find that common factors capture, on average, a sizable fraction of the fluctuations in U.S. macroeconomic indicators. This provides support to the use of our empirical model. Second, there is evidence that the role of international factors in explaining U.S. variables has been changing over the 1984 to 2005 period, but this evolution is not systematic across series, and it is difficult to see a pattern suggesting that international factors have become generally more important. Some variables such as the long-term interest rates, as well as import and export prices, however, do display a systematic increase of their correlation with global factors throughout our sample.

We do not find strong statistical evidence of a significant change in the transmission mechanism of monetary policy due to global forces. Taking our point estimates literally, global forces do not seem to have played an important role in the U.S. monetary transmission mechanism between 1984 and 1999. This does not mean that global factors do not have an impact on the economy, as other shocks, such as international shocks, may have an important effect on U.S. economic variables. However, our results suggest that *conditional on a monetary policy shock* in the United States, the response of the main U.S. macroeconomic variables have been little affected by the response of international factors.

In addition, since the year 2000, the initial response of the U.S. economy following a monetary policy shock—the first six to eight quarters—is essentially the same as the one that has been observed in the 1984 to 1999 period. However, point estimates suggest that the growing importance of global forces might have contributed to reducing some of the persistence in the responses, two or more years after the shocks.

Overall, we conclude that if global forces have had an effect on the monetary transmission mechanism, this is a recent phenomenon. This means, however, that we will need more data before we can get strong statistical conclusions on this question.

Appendix

Data Sets

1—U.S. Macroeconomic Series

Format contains series number; series mnemonic; data span (in quarters); transformation code; and series description as appears in the database. The transformation codes are: 1—no transformation; 2—first difference; 4—log-

arithm; 5—first difference of logarithm. Second differencing of logarithms was not used. Our main data set contains seventeen quarterly series and 112 monthly series with no missing observations. Quarterly averages of monthly series were taken. The series were taken from DRI/McGraw Hill's Basic Economics database, and Data Insight's U.S. Central database.

National Income and Products Accounts (NIPA)

1	GDPR.Q	1983:4–2005:2	5	Real Gross Domestic Product Billions of Chained (2000) Dollars, SAAR
2	CR.Q	1983:4–2005:2	5	Real Personal Consumption Expenditures Billions of Chained (2000) Dollars, SAAR
3	IR.Q	1983:4–2005:2	5	Real Gross Private Domestic Investment Billions of Chained (2000) Dollars, SAAR
4	XR.Q	1983:4–2005:2	5	Real Exports Billions of Chained (2000) Dollars, SAAR
5	MR.Q	1983:4–2005:2	5	Real Imports Billions of Chained (2000) Dollars, SAAR
6	GR.Q	1983:4–2005:2	5	Real Government Consumption Exp. & Gross Invest., Bil. of Chained (2000) Dollars, SAAR
7	X.Q	1983:4–2005:2	5	Exports of Goods and Services Billions of Dollars, SAAR
8	XFY.Q	1983:4–2005:2	5	Income Receipts from the Rest of the World Billions of Dollars, SAAR
9	M.Q	1983:4–2005:2	5	Imports of Goods and Services Billions of Dollars, SAAR
10	MFY.Q	1983:4–2005:2	5	Income payments to the Rest of the World Billions of Dollars, SAAR
11	MTAXATRF.Q	1983:4–2005:2	5	Current Taxes And Transfer Payments to Rest of the World (net) Bil. of Dollars, SAAR
12	JPGDP.Q	1983:4–2005:2	5	Gross Domestic Product Price Index (2000 = 100), SA
13	JPC.Q	1983:4–2005:2	5	Personal Consumption Expenditures Price Index (2000 = 100), SA
14	JPI.Q	1983:4–2005:2	5	Gross Private Domestic Investment Price Index (2000 = 100), SAAR
15	JPX.Q	1983:4–2005:2	5	Exports Price Index (2000 = 100), SA
16	JPM.Q	1983:4–2005:2	5	Imports Price Index (2000 = 100), SA
17	JPG.Q	1983:4–2005:2	5	Government Consumption Expenditures & Gross Investment Price Index (2000 = 100), SA

OUT—Real Output and Income

18	IPS11	1983:4–2005:2	5	Industrial Production Index–Products, Total
19	IPS299	1983:4–2005:2	5	Industrial Production Index–Final Products
20	IPS12	1983:4–2005:2	5	Industrial Production Index–Consumer Goods

21	IPS13	1983:4–2005:2	5	Industrial Production Index–Durable Consumer Goods
22	IPS18	1983:4–2005:2	5	Industrial Production Index–Nondurable Consumer Goods
23	IPS25	1983:4–2005:2	5	Industrial Production Index–Business Equipment
24	IPS32	1983:4–2005:2	5	Industrial Production Index–Materials
25	IPS34	1983:4–2005:2	5	Industrial Production Index–Durable Goods Materials
26	IPS38	1983:4–2005:2	5	Industrial Production Index–Nondurable Goods Materials
27	IPS43	1983:4–2005:2	5	Industrial Production Index–Manufacturing (SIC)
28	IPS67e	1983:4–2005:2	5	Industrial Production Index–Mining NAICS = 21
29	IPS68e	1983:4–2005:2	5	Industrial Production Index–Electric and Gas Utilities
30	IPS10	1983:4–2005:2	5	Industrial Production Index–Total Index
31	PMI	1983:4–2005:2	5	Purchasing Managers' Index (SA)
32	PMP	1983:4–2005:2	5	NAPM Production Index (Percent)
33	PYQ	1983:4–2005:2	5	Personal Income (Chained) (Bil 2000$, SAAR)
34	MYXPQ	1983:4–2005:2	5	Personal Income Less Transfer Payments (Chained) (Bil 2000$, SAAR)
35	IPS307	1983:4–2005:2	5	Industrial Production Index–Residential Utilities
36	IPS316	1983:4–2005:2	5	Industrial Production Index–Basic Metals

EMP—Employment and Hours

37	LHEL	1983:4–2005:2	5	Index of Help-Wanted Advertising in Newspapers (1967 = 100; SA)
38	LHELX	1983:4–2005:2	4	Employment: Ratio; Help-Wanted Ads: No. Unemployed Clf
39	LHEM	1983:4–2005:2	5	Civilian Labor Force: Employed, Total (Thous., SA)
40	LHNAG	1983:4–2005:2	5	Civilian Labor Force: Employed, Nonagric. Industries (Thous., SA)
41	LHUR	1983:4–2005:2	1	Unemployment Rate: All Workers, 16 Years & Over (%, SA)
42	LHU680	1983:4–2005:2	1	Unemploy. by Duration: Average (Mean) Duration in Weeks (SA)
43	LHU5	1983:4–2005:2	1	Unemploy. by Duration: Persons Unempl. Less Than 5 Wks (Thous., SA)
44	LHU14	1983:4–2005:2	1	Unemploy. by Duration: Persons Unempl. 5 To 14 Wks (Thous., SA)
45	LHU15	1983:4–2005:2	1	Unemploy. by Duration: Persons Unempl. 15 Wks + (Thous., SA)
46	LHU26	1983:4–2005:2	1	Unemploy. by Duration: Persons Unempl. 15 To 26 Wks (Thous., SA)
47	BLS_LPNAG	1983:4–2005:2	5	Total Nonfarm Employment (SA)–CES0000000001

48	BLS_LP	1983:4–2005:2	5	Total Private Employment (SA)–CES0500000001
49	BLS_LPGD	1983:4–2005:2	5	Goods-Producing Employment (SA)–CES0600000001
50	BLS_LPMI	1983:4–2005:2	5	Natural Resources and Mining Employment (SA)–CES1000000001
51	BLS_LPCC	1983:4–2005:2	5	Construction Employment (SA)–CES2000000001
52	BLS_LPEM	1983:4–2005:2	5	Manufacturing Employment (SA)–CES3000000001
53	BLS_LPED	1983:4–2005:2	5	Durable Goods Manufacturing Employment (SA)–CES3100000001
54	BLS_LPEN	1983:4–2005:2	5	Nondurable Goods Manufacturing Employment (SA)–CES3200000001
55	BLS_Ser.-EMP	1983:4–2005:2	5	Service-Providing Employment (SA)–CES0700000001
56	BLS_Tra.EMP	1983:4–2005:2	5	Trade, Transportation, and Utilities Employment (SA)–CES4000000001
57	BLS_Ret.-EMP	1983:4–2005:2	5	Retail Trade Employment (SA)–CES4200000001
58	BLS_Whol. EMP	1983:4–2005:2	5	Wholesale Trade Employment (SA)–CES4142000001
59	BLS_Fin.-EMP	1983:4–2005:2	5	Financial Activities Employment (SA)–CES5500000001
60	BLS_P-Ser.EMP	1983:4–2005:2	5	Private Service-Providing Employment (SA)–CES0800000001
61	BLS_LPGOV	1983:4–2005:2	5	Government Employment (SA)–CES9000000001
62	BLS_LPHRM	1983:4–2005:2	1	Manufacturing Average Weekly Hours of Production Workers (SA)–CES3000000005
63	BLS_LPMOSA	1983:4–2005:2	1	Manufacturing Average Weekly Overtime of Production Workers (SA)–CES3000000007
64	PMEMP	1983:4–2005:2		NAPM Employment Index (Percent)

HSS—Housing Starts and Sales

65	HSFR	1983:4–2005:2	4	Housing Starts: Nonfarm (1947–1958); Total Farm & Nonfarm (1959–); (Thous. U., SA)
66	HSNE	1983:4–2005:2	4	Housing Starts: Northeast (Thous. U., SA)
67	HSMW	1983:4–2005:2	4	Housing Starts: Midwest (Thous. U., SA)
68	HSSOU	1983:4–2005:2	4	Housing Starts: South (Thous. U., SA)
69	HSWST	1983:4–2005:2	4	Housing Starts: West (Thous. U., SA)
70	HSBR	1983:4–2005:2	4	Housing Authorized: Total New Private Housing Units (Thous., SAAR)
71	HMOB	1983:4–2005:2	4	Mobile Homes: Manufacturers' Shipments (Thous. U., SAAR)

INV—Real Inventories and Inventory-Sales Ratios

72	PMNV	1983:4–2005:2	1	NAPM Inventories Index (Percent)

ORD—Orders and Unfilled Orders

73	PMNO	1983:4–2005:2	1	NAPM New Orders Index (Percent)
74	PMDEL	1983:4–2005:2	1	NAPM Vendor Deliveries Index (Percent)
75	MOCMQ	1983:4–2005:2	5	New Orders (Net)–Consumer Goods & Materials, 1996 Dollars (BCI)
76	MSONDQ	1983:4–2005:2	5	New Orders, Nondefense Capital Goods, In 1996 Dollars (BCI)

SPR—Stock Prices

77	FSPCOM	1983:4–2005:2	5	S&P's Common Stock Price Index: Composite (1941–1943 = 10)
78	FSPIN	1983:4–2005:2	5	S&P's Common Stock Price Index: Industrials (1941–1943 = 10)
79	FSDXP	1983:4–2005:2	1	S&P's Composite Common Stock: Dividend Yield (% Per Annum)
80	FSPXE	1983:4–2005:2	1	S&P's Composite Common Stock: Price-Earnings Ratio (%, NSA)
81	FSDJ	1983:4–2005:2		Common Stock Prices: Dow Jones Industrial Average

EXR—Exchange Rates

82	JRXTWCNS@06.M	1983:4–2005:2	1	Trade-weighted value of the U.S. Dollar (Nominal, 1995 = 100)
83	EXRSW	1983:4–2005:2	5	Foreign Exchange Rate: Switzerland (Swiss Franc Per U.S.$)
84	EXRJAN	1983:4–2005:2	5	Foreign Exchange Rate: Japan (Yen Per U.S.$)
85	EXRUK	1983:4–2005:2	5	Foreign Exchange Rate: United Kingdom (Cents Per Pound)
86	EXRCAN	1983:4–2005:2	5	Foreign Exchange Rate: Canada (Canadian $ Per U.S.$)

INT—Interest Rates

87	FYFF	1983:4–2005:2	1	Interest Rate: Federal Funds (Effective) (% Per Annum, NSA)
88	FYGM3	1983:4–2005:2	1	Interest Rate: U.S. Treasury Bills, Sec Mkt, 3–Mo. (% Per Ann., NSA)
89	FYGM6	1983:4–2005:2	1	Interest Rate: U.S. Treasury Bills, Sec Mkt, 6–Mo. (% Per Ann., NSA)
90	FYGT1	1983:4–2005:2	1	Interest Rate: U.S. Treasury Const Maturities, 1–Yr. (% Per Ann., NSA)
91	FYGT5	1983:4–2005:2	1	Interest Rate: U.S. Treasury Const Maturities, 5–Yr. (% Per Ann., NSA)
92	FYGT10	1983:4–2005:2	1	Interest Rate: U.S. Treasury Const Maturities, 10–Yr. (% Per Ann., NSA)
93	FYAAAC	1983:4–2005:2	1	Bond Yield: Moody's AAA Corporate (% Per Annum)
94	FYBAAC	1983:4–2005:2	1	Bond Yield: Moody's BAA Corporate (% Per Annum)
95	SFYGM3	1983:4–2005:2	1	Spread FYGM3–FYFF

96	SFYGM6	1983:4–2005:2	1	Spread FYGM6–FYFF
97	SFYGT1	1983:4–2005:2	1	Spread FYGT1–FYFF
98	SFYGT5	1983:4–2005:2	1	Spread FYGT5–FYFF
99	SFYGT10	1983:4–2005:2	1	Spread FYGT10–FYFF
100	SFYAAAC	1983:4–2005:2	1	Spread FYAAAC–FYFF
101	SFYBAAC	1983:4–2005:2	1	Spread FYBAAC–FYFF

MON—Money and Credit Quantity Aggregates

102	FM1	1983:4–2005:2	5	Money Stock: M1(Curr, Trav.Cks, Dem Dep, Other Ck'able Dep) (Bil$, SA)
103	FM2	1983:4–2005:2	5	Money Stock: M2(M1 + O'nite Rps, Euro$, G/P&B/D Mmmfs&SAv&Sm Time Dep (Bil$, SA)
104	FM3	1983:4–2005:2	5	Money Stock: M3(M2 + Lg Time Dep, Term Rp's&Inst nnly Mmmfs) (Bil$, SA)
105	FM2DQ	1983:4–2005:2	5	Money Supply–M2 in 1996 Dollars (BCI)
106	FMFBA	1983:4–2005:2	5	Monetary Base, Adj for Reserve Requirement Changes (Mil$, SA)
107	FMRRA	1983:4–2005:2	5	Depository Inst Reserves: Total, Adj For Reserve Req Chgs (Mil$, SA)
108	FMRNBA	1983:4–2005:2	5	Depository Inst Reserves: Nonborrowed, Adj Res Req Chgs (Mil$, SA)
109	FCLBMC	1983:4–2005:2	1	Wkly Rp Lg Com'l Banks: Net Change Com'l & Indus Loans (Bil$, SAAR)
110	CCINRV	1983:4–2005:2	5	Consumer Credit Outstanding–Nonrevolving (G19)
111	IMFCLNQ	1983:4–2005:2		Commercial & Industrial Loans Outstanding in 1996 Dollars

PRI—Price Indexes

112	PMCP	1983:4–2005:2	1	NAPM Commodity Prices Index (Percent)
113	PWFSA	1983:4–2005:2	5	Producer Price Index: Finished Goods (82 = 100, SA)
114	PWFCSA	1983:4–2005:2	5	Producer Price Index: Finished Consumer Goods (82 = 100, SA)
115	PWIMSA	1983:4–2005:2	5	Producer Price Index: Intermed Mat. Supplies & Components (82 = 100, SA)
116	PWCMSA	1983:4–2005:2	5	Producer Price Index: Crude Materials (82 = 100, SA)
117	PUNEW	1983:4–2005:2	5	CPI-U: All Items (82–84 = 100, SA)
118	PU83	1983:4–2005:2	5	CPI-U: Apparel & Upkeep (82–84 = 100, SA)
119	PU84	1983:4–2005:2	5	CPI-U: Transportation (82–84 = 100, SA)
120	PU85	1983:4–2005:2	5	CPI-U: Medical Care (82–84 = 100, SA)
121	PUC	1983:4–2005:2	5	CPI-U: Commodities (82–84 = 100, SA)
122	PUCD	1983:4–2005:2	5	CPI-U: Durables (82–84 = 100, SA)
123	PUXF	1983:4–2005:2	5	CPI-U: All Items Less Food (82–84 = 100, SA)
124	PUXHS	1983:4–2005:2	5	CPI-U: All Items Less Shelter (82–84 = 100, SA)

125	PUXM	1983:4–2005:2	5	CPI-U: All Items Less Medical Care (82–84 = 100, SA)
126	PSCCOM	1983:4–2005:2	5	Spot Market Price Index: BLS & CRB: All Commodities (1967 = 100)

AHE—Average Hourly Earnings

127	BLS_LEHCC	1983:4–2005:2	5	Construction Average Hourly Earnings of Production Workers (SA)–CES2000000006
128	BLS_LEHM	1983:4–2005:2	5	Manufacturing Average Hourly Earnings of Production Workers (SA)–CES3000000006

OTH—Miscellaneous

129	HHSNTN	1983:4–2005:2	1	U. of Michigan Index of Consumer Expectations (Bcd-83)

2—U.S. Personal Consumption Expenditures (Price Indexes and Nominal Expenditure)

Format is as previously: series number; series; data span (in quarters); transformation code; and series description as appears in the database. The transformation for all data was first difference of logarithms, which is coded as 5. This data set contains 194 monthly price series on Personal Consumption Expenditures with no missing observations, and 194 monthly real consumption series on Personal Consumption Expenditures. Quarterly averages were taken of all series. We describe here the 194 price series. The 194 corresponding real consumption series were ordered and transformed in a similar fashion. Series were downloaded from the underlying tables of the Bureau of Economic Analysis.

1	P1NDCG3	1983:4–2005:2	5	New domestic autos
2	P1NFCG3	1983:4–2005:2	5	New foreign autos
3	P1NETG3	1983:4–2005:2	5	Net transactions in used autos
4	P1MARG3	1983:4–2005:2	5	Net purchases of used autos: Used auto margin
5	P1REEG3	1983:4–2005:2	5	Net purchases of used autos: Employee reimbursement
6	P1TRUG3	1983:4–2005:2	5	Trucks, new and net used
7	P1REVG3	1983:4–2005:2	5	Recreational vehicles
8	P1TATG3	1983:4–2005:2	5	Tires and tubes
9	P1PAAG3	1983:4–2005:2	5	Accessories and parts
10	P1FNRG3	1983:4–2005:2	5	Furniture, including mattresses and bedsprings
11	P1MHAG3	1983:4–2005:2	5	Major household appliances
12	P1SEAG3	1983:4–2005:2	5	Small electric appliances
13	P1CHNG3	1983:4–2005:2	5	China, glassware, tableware, and utensils
14	P1RADG3	1983:4–2005:2	5	Video and audio goods, including musical instruments, and computer goods
15	P1FLRG3	1983:4–2005:2	5	Floor coverings

16	P1CLFG3	1983:4–2005:2	5	Clocks, lamps, and furnishings
17	P1TEXG3	1983:4–2005:2	5	Blinds, rods, and other
18	P1WTRG3	1983:4–2005:2	5	Writing equipment
19	P1HDWG3	1983:4–2005:2	5	Tools, hardware, and supplies
20	P1LWNG3	1983:4–2005:2	5	Outdoor equipment and supplies
21	P1OPTG3	1983:4–2005:2	5	Ophthalmic products and orthopedic appliances
22	P1GUNG3	1983:4–2005:2	5	Guns
23	P1SPTG3	1983:4–2005:2	5	Sporting equipment
24	P1CAMG3	1983:4–2005:2	5	Photographic equipment
25	P1BCYG3	1983:4–2005:2	5	Bicycles
26	P1MCYG3	1983:4–2005:2	5	Motorcycles
27	P1BOAG3	1983:4–2005:2	5	Pleasure boats
28	P1AIRG3	1983:4–2005:2	5	Pleasure aircraft
29	P1JRYG3	1983:4–2005:2	5	Jewelry and watches
30	P1BKSG3	1983:4–2005:2	5	Books and maps
31	P1GRAG3	1983:4–2005:2	5	Cereals
32	P1BAKG3	1983:4–2005:2	5	Bakery products
33	P1BEEG3	1983:4–2005:2	5	Beef and veal
34	P1PORG3	1983:4–2005:2	5	Pork
35	P1MEAG3	1983:4–2005:2	5	Other meats
36	P1POUG3	1983:4–2005:2	5	Poultry
37	P1FISG3	1983:4–2005:2	5	Fish and seafood
38	P1GGSG3	1983:4–2005:2	5	Eggs
39	P1MILG3	1983:4–2005:2	5	Fresh milk and cream
40	P1DAIG3	1983:4–2005:2	5	Processed dairy products
41	P1FRUG3	1983:4–2005:2	5	Fresh fruits
42	P1VEGG3	1983:4–2005:2	5	Fresh vegetables
43	P1PFVG3	1983:4–2005:2	5	Processed fruits and vegetables
44	P1JNBG3	1983:4–2005:2	5	Juices and nonalcoholic drinks
45	P1CTMG3	1983:4–2005:2	5	Coffee, tea, and beverage materials
46	P1FATG3	1983:4–2005:2	5	Fats and oils
47	P1SWEG3	1983:4–2005:2	5	Sugar and sweets
48	P1OFDG3	1983:4–2005:2	5	Other foods
49	P1PEFG3	1983:4–2005:2	5	Pet food
50	P1MLTG3	1983:4–2005:2	5	Beer and ale, at home
51	P1WING3	1983:4–2005:2	5	Wine and brandy, at home
52	P1LIQG3	1983:4–2005:2	5	Distilled spirits, at home
53	P1ESLG3	1983:4–2005:2	5	Elementary and secondary school lunch
54	P1HSLG3	1983:4–2005:2	5	Higher education school lunch
55	P1OPMG3	1983:4–2005:2	5	Other purchased meals
56	P1APMG3	1983:4–2005:2	5	Alcohol in purchased meals
57	P1CFDG3	1983:4–2005:2	5	Food supplied to employees: civilians
58	P1MFDG3	1983:4–2005:2	5	Food supplied to employees: military
59	P1FFDG3	1983:4–2005:2	5	Food produced and consumed on farms
60	P1SHUG3	1983:4–2005:2	5	Shoes
61	P1WGCG3	1983:4–2005:2	5	Clothing for females
62	P1WICG3	1983:4–2005:2	5	Clothing for infants
63	P1WSGG3	1983:4–2005:2	5	Sewing goods for females
64	P1WUGG3	1983:4–2005:2	5	Luggage for females
65	P1MBCG3	1983:4–2005:2	5	Clothing for males
66	P1MSGG3	1983:4–2005:2	5	Sewing goods for males

67	P1MUGG3	1983:4–2005:2	5	Luggage for males
68	P1MICG3	1983:4–2005:2	5	Standard clothing issued to military personnel (n.d.)
69	P1GASG3	1983:4–2005:2	5	Gasoline and other motor fuel
70	P1LUBG3	1983:4–2005:2	5	Lubricants
71	P1OILG3	1983:4–2005:2	5	Fuel oil
72	P1LPGG3	1983:4–2005:2	5	Liquefied petroleum gas and other fuel
73	P1TOBG3	1983:4–2005:2	5	Tobacco products
74	P1SOAG3	1983:4–2005:2	5	Soap
75	P1CSMG3	1983:4–2005:2	5	Cosmetics and perfumes
76	P1OPHG3	1983:4–2005:2	5	Other personal hygiene goods
77	P1SDHG3	1983:4–2005:2	5	Semidurable house furnishings
78	P1CLEG3	1983:4–2005:2	5	Cleaning preparations
79	P1LIGG3	1983:4–2005:2	5	Lighting supplies
80	P1PAPG3	1983:4–2005:2	5	Paper products
81	P1RXDG3	1983:4–2005:2	5	Prescription drugs
82	P1NRXG3	1983:4–2005:2	5	Nonprescription drugs
83	P1MDSG3	1983:4–2005:2	5	Medical supplies
84	P1GYNG3	1983:4–2005:2	5	Gynecological goods
85	P1DOLG3	1983:4–2005:2	5	Toys, dolls, and games
86	P1AMMG3	1983:4–2005:2	5	Sport supplies, including ammunition
87	P1FLMG3	1983:4–2005:2	5	Film and photo supplies
88	P1STSG3	1983:4–2005:2	5	Stationery and school supplies
89	P1GREG3	1983:4–2005:2	5	Greeting cards
90	P1ARTG3	1983:4–2005:2	5	Expenditures abroad by U.S. residents: Government expenditures abroad
91	P1ARSG3	1983:4–2005:2	5	Expenditures abroad by U.S. residents: Other private services
92	P1REMG3	1983:4–2005:2	5	Less: Personal remittances in kind to nonresidents
93	P1MGZG3	1983:4–2005:2	5	Magazines and sheet music
94	P1NWPG3	1983:4–2005:2	5	Newspapers
95	P1FLOG3	1983:4–2005:2	5	Flowers, seeds, and potted plants
96	P1OMHG3	1983:4–2005:2	5	Owner-occupied mobile homes
97	P1OSTG3	1983:4–2005:2	5	Owner-occupied stationary homes
98	P1TMHG3	1983:4–2005:2	5	Tenant-occupied mobile homes
99	P1TSPG3	1983:4–2005:2	5	Tenant-occupied stationary homes
100	P1TLDG3	1983:4–2005:2	5	Tenant landlord durables
101	P1FARG3	1983:4–2005:2	5	Rental value of farm dwellings
102	P1HOTG3	1983:4–2005:2	5	Hotels and motels
103	P1HFRG3	1983:4–2005:2	5	Clubs and fraternity housing
104	P1HHEG3	1983:4–2005:2	5	Higher education housing
105	P1HESG3	1983:4–2005:2	5	Elem. and second. education housing
106	P1TGRG3	1983:4–2005:2	5	Tenant group room and board
107	P1TGLG3	1983:4–2005:2	5	Tenant group employee lodging
108	P1ELCG3	1983:4–2005:2	5	Electricity
109	P1NGSG3	1983:4–2005:2	5	Gas
110	P1WSMG3	1983:4–2005:2	5	Water and sewerage maintenance
111	P1REFG3	1983:4–2005:2	5	Refuse collection
112	P1LOCG3	1983:4–2005:2	5	Local and cellular telephone
113	P1INCG3	1983:4–2005:2	5	Intrastate toll calls
114	P1ITCG3	1983:4–2005:2	5	Interstate toll calls

115	P1DMCG3	1983:4–2005:2	5	Domestic service, cash
116	P1DMIG3	1983:4–2005:2	5	Domestic service, in kind
117	P1MSEG3	1983:4–2005:2	5	Moving and storage
118	P1FIPG3	1983:4–2005:2	5	Household insurance premiums
119	P1FIBG3	1983:4–2005:2	5	Less: Household insurance benefits paid
120	P1RCLG3	1983:4–2005:2	5	Rug and furniture cleaning
121	P1EREG3	1983:4–2005:2	5	Electrical repair
122	P1FREG3	1983:4–2005:2	5	Reupholstery and furniture repair
123	P1PSTG3	1983:4–2005:2	5	Postage
124	P1MHOG3	1983:4–2005:2	5	Household operation services, n.e.c.
125	P1ARPG3	1983:4–2005:2	5	Motor vehicle repair
126	P1RLOG3	1983:4–2005:2	5	Motor vehicle rental, leasing, and other
127	P1TOLG3	1983:4–2005:2	5	Bridge, tunnel, ferry, and road tolls
128	P1AING3	1983:4–2005:2	5	Insurance premiums for user-operated transportation
129	P1IMTG3	1983:4–2005:2	5	Local transportation: Mass transit systems
130	P1TAXG3	1983:4–2005:2	5	Taxicab
131	P1IRRG3	1983:4–2005:2	5	Railway
132	P1IBUG3	1983:4–2005:2	5	Bus
133	P1IAIG3	1983:4–2005:2	5	Airline
134	P1TROG3	1983:4–2005:2	5	Other
135	P1PHYG3	1983:4–2005:2	5	Physicians
136	P1DENG3	1983:4–2005:2	5	Dentists
137	P1OPSG3	1983:4–2005:2	5	Other professional services
138	P1NPHG3	1983:4–2005:2	5	Hospitals: Nonprofit
139	P1FPHG3	1983:4–2005:2	5	Hospitals: Proprietary
140	P1GVHG3	1983:4–2005:2	5	Hospitals: Government
141	P1NRSG3	1983:4–2005:2	5	Nursing homes
142	P1MING3	1983:4–2005:2	5	Health insurance: Medical care and hospitalization
143	P1IING3	1983:4–2005:2	5	Health insurance: Income loss
144	P1PWCG3	1983:4–2005:2	5	Health insurance: Workers' compensation
145	P1MOVG3	1983:4–2005:2	5	Admissions to motion picture theaters
146	P1LEGG3	1983:4–2005:2	5	Admissions to theaters and opera, and entertainments of nonprofit instit. (except athletics)
147	P1SPEG3	1983:4–2005:2	5	Admissions to spectator sports
148	P1RTVG3	1983:4–2005:2	5	Radio and television repair
149	P1CLUG3	1983:4–2005:2	5	Clubs and fraternal organizations
150	P1SIGG3	1983:4–2005:2	5	Sightseeing
151	P1FLYG3	1983:4–2005:2	5	Private flying
152	P1BILG3	1983:4–2005:2	5	Bowling and billiards
153	P1CASG3	1983:4–2005:2	5	Casino gambling
154	P1OPAG3	1983:4–2005:2	5	Other commercial participant amusements
155	P1PARG3	1983:4–2005:2	5	Pari-mutuel net receipts
156	P1REOG3	1983:4–2005:2	5	Other recreation
157	P1SCLG3	1983:4–2005:2	5	Shoe repair
158	P1DRYG3	1983:4–2005:2	5	Drycleaning
159	P1LGRG3	1983:4–2005:2	5	Laundry and garment repair
160	P1BEAG3	1983:4–2005:2	5	Beauty shops, including combination
161	P1BARG3	1983:4–2005:2	5	Barber shops
162	P1WCRG3	1983:4–2005:2	5	Watch, clock, and jewelry repair

163	P1CRPG3	1983:4–2005:2	5	Miscellaneous personal services
164	P1BROG3	1983:4–2005:2	5	Brokerage charges and investment counseling
165	P1BNKG3	1983:4–2005:2	5	Bank service charges, trust services, and safe deposit box rental
166	P1IMCG3	1983:4–2005:2	5	Commercial banks
167	P1IMNG3	1983:4–2005:2	5	Other financial institutions
168	P1LIFG3	1983:4–2005:2	5	Expense of handling life insurance and pension plans
169	P1GALG3	1983:4–2005:2	5	Legal services
170	P1FUNG3	1983:4–2005:2	5	Funeral and burial expenses
171	P1UNSG3	1983:4–2005:2	5	Labor union expenses
172	P1ASSG3	1983:4–2005:2	5	Profession association expenses
173	P1GENG3	1983:4–2005:2	5	Employment agency fees
174	P1AMOG3	1983:4–2005:2	5	Money orders
175	P1CLAG3	1983:4–2005:2	5	Classified ads
176	P1ACCG3	1983:4–2005:2	5	Tax return preparation services
177	P1THEG3	1983:4–2005:2	5	Personal business services, n.e.c.
178	P1PEDG3	1983:4–2005:2	5	Private higher education
179	P1GEDG3	1983:4–2005:2	5	Public higher education
180	P1ESCG3	1983:4–2005:2	5	Elementary and secondary schools
181	P1NSCG3	1983:4–2005:2	5	Nursery schools
182	P1VEDG3	1983:4–2005:2	5	Commercial and vocational schools
183	P1REDG3	1983:4–2005:2	5	Foundations and nonprofit research
184	P1POLG3	1983:4–2005:2	5	Political organizations
185	P1MUSG3	1983:4–2005:2	5	Museums and libraries
186	P1FOUG3	1983:4–2005:2	5	Foundations to religion and welfare
187	P1WELG3	1983:4–2005:2	5	Social welfare
188	P1RELG3	1983:4–2005:2	5	Religion
189	P1FTRG3	1983:4–2005:2	5	Foreign travel by U.S. residents (110)
190	P1EXFG3	1983:4–2005:2	5	Less: Expenditures in the United States by nonresidents (112)
191	P1TDGG3	1983:4–2005:2	5	Durable goods
192	P1TNDG3	1983:4–2005:2	5	Nondurable goods
193	P1TSSG3	1983:4–2005:2	5	Services
194	PPCE	1983:4–2005:2	5	Personal Consumption Expenditures (all items)

3—U.S. Producer Price Indexes

Format is as previously: series number; series mnemonic (NAICS code); data span (in quarters); transformation code; and series description as appears in the database. Quarterly averages were taken of all series. The transformation for all data was first difference of logarithms, which is coded as 5. This data set contains 154 monthly series with no missing observations. All series are downloaded from the website of BLS.

1	311119	1983:4–2005:2	5	Other animal food manufacturing
2	311119p	1983:4–2005:2	5	Other animal food manufacturing (primary products)
3	311211	1983:4–2005:2	5	Flour milling

4	311212	1983:4–2005:2	5	Rice milling
5	311213	1983:4–2005:2	5	Malt mfg.
6	311223a	1983:4–2005:2	5	Other oilseed processing (cottonseed cake and meal and other byproducts)
7	311225p	1983:4–2005:2	5	Fats and oils refining and blending (primary products)
8	311311	1983:4–2005:2	5	Sugarcane mills
9	311313	1983:4–2005:2	5	Beet sugar manufacturing
10	311412	1983:4–2005:2	5	Frozen specialty food manufacturing
11	311520	1983:4–2005:2	5	Ice cream and frozen dessert mfg.
12	311920	1983:4–2005:2	5	Coffee and tea manufacturing
13	312140	1983:4–2005:2	5	Distilleries
14	32211–	1983:4–2005:2	5	Pulp mills
15	32213–	1983:4–2005:2	5	Paperboard mills
16	325620p	1983:4–2005:2	5	Toilet preparation mfg. (primary products)
17	325920	1983:4–2005:2	5	Explosives manufacturing
18	32731–	1983:4–2005:2	5	Cement mfg.
19	327320	1983:4–2005:2	5	Ready mixed concrete mfg. and dist.
20	327410	1983:4–2005:2	5	Lime
21	327420	1983:4–2005:2	5	Gypsum building products manufacturing
22	327910	1983:4–2005:2	5	Abrasive product manufacturing
23	331210	1983:4–2005:2	5	Iron steel pipe & tube mfg. from purch. steel
24	333210	1983:4–2005:2	5	Sawmill & woodworking machinery mfg.
25	334310	1983:4–2005:2	5	Audio & video equipment mfg.
26	335110	1983:4–2005:2	5	Electric lamp bulb & part mfg.
27	336370	1983:4–2005:2	5	Motor vehicle metal stamping
28	337910	1983:4–2005:2	5	Mattress mfg.
29	311421	1983:4–2005:2	5	Fruit and vegetable canning
30	311423	1983:4–2005:2	5	Dried and dehydrated food manufacturing
31	311513	1983:4–2005:2	5	Cheese manufacturing
32	311611	1983:4–2005:2	5	Animal except poultry slaughtering
33	311612	1983:4–2005:2	5	Meat processed from carcasses
34	311613	1983:4–2005:2	5	Rendering and meat byproduct processing
35	311711	1983:4–2005:2	5	Seafood canning
36	311712	1983:4–2005:2	5	Fresh & frozen seafood processing
37	311813p	1983:4–2005:2	5	Frozen cakes, pies, & other pastries mfg. (primary products)
38	3118233	1983:4–2005:2	5	Dry pasta manufacturing (macaroni, spaghetti, vermicelli, and noodles)
39	312111p	1983:4–2005:2	5	Soft drinks manufacturing (primary products)
40	312221	1983:4–2005:2	5	Cigarettes
41	3122291	1983:4–2005:2	5	Other tobacco product mfg. (cigars)
42	313111	1983:4–2005:2	5	Yarn spinning mills
43	3133111	1983:4–2005:2	5	Broadwoven fabric finishing mills (finished cotton broadwoven fabrics not finished in weaving mills)
44	315111	1983:4–2005:2	5	Sheer hosiery mills
45	315191	1983:4–2005:2	5	Outerwear knitting mills
46	315223	1983:4–2005:2	5	Men's boy's cut & sew shirt excl. work mfg.

47	315224	1983:4–2005:2	5	Men's boy's cut & sew trouser, slack, jean mfg.
48	315993	1983:4–2005:2	5	Men's and boys' neckwear mfg.
49	316211	1983:4–2005:2	5	Rubber and plastic footwear manufacturing
50	316213	1983:4–2005:2	5	Men's footwear excl. athletic mfg.
51	316214	1983:4–2005:2	5	Women's footwear excl. athletic mfg.
52	316992	1983:4–2005:2	5	Women's handbag & purse mfg.
53	321212	1983:4–2005:2	5	Softwood veneer or plywood mfg.
54	3212191	1983:4–2005:2	5	Reconstituted wood product mfg. (particleboard produced at this location)
55	3219181	1983:4–2005:2	5	Other millwork including flooring (wood moldings except prefinished moldings made from purchased moldings)
56	321991	1983:4–2005:2	5	Manufactured homes mobile homes mfg.
57	3221211	1983:4–2005:2	5	Paper except newsprint mills (clay coated printing and converting paper)
58	322214	1983:4–2005:2	5	Fiber can, tube, drum, & other products mfg.
59	324121	1983:4–2005:2	5	Asphalt paving mixture & block mfg.
60	324122	1983:4–2005:2	5	Asphalt shingle & coating materials mfg.
61	324191p	1983:4–2005:2	5	Petroleum lubricating oils and greases (primary products)
62	325181	1983:4–2005:2	5	Alkalies and chlorine
63	3251881	1983:4–2005:2	5	All other basic inorganic chemical manufacturing (sulfuric acid gross new and fortified)
64	3251921	1983:4–2005:2	5	Cyclic crude and intermediate manufacturing (cyclic coal tar intermediates)
65	325212	1983:4–2005:2	5	Synthetic rubber manufacturing
66	325222	1983:4–2005:2	5	Manufactured noncellulosic fibers
67	325314	1983:4–2005:2	5	Fertilizer mixing only manufacturing
68	3254111	1983:4–2005:2	5	Medicinal & botanical mfg. (synthetic organic medicinal chemicals in bulk)
69	3261131	1983:4–2005:2	5	Unsupported plastics film sheet excluding packaging manufacturing
70	326192	1983:4–2005:2	5	Resilient floor covering manufacturing
71	326211	1983:4–2005:2	5	Tire manufacturing except retreading
72	327111	1983:4–2005:2	5	Vitreous plumbing fixtures access ftg. mfg.
73	327121	1983:4–2005:2	5	Brick and structural clay tile
74	327122	1983:4–2005:2	5	Ceramic wall and floor tile
75	327124	1983:4–2005:2	5	Clay refractories
76	327125	1983:4–2005:2	5	Nonclay refractory manufacturing
77	327211	1983:4–2005:2	5	Flat glass manufacturing
78	327213	1983:4–2005:2	5	Glass container manufacturing
79	327331	1983:4–2005:2	5	Concrete block and brick manufacturing
80	3279931	1983:4–2005:2	5	Mineral wool manufacturing
81	331111	1983:4–2005:2	5	Iron and steel mills
82	331112	1983:4–2005:2	5	Electrometallurgical ferroalloy product mfg.
83	331221	1983:4–2005:2	5	Rolled steel shape manufacturing
84	331312	1983:4–2005:2	5	Primary aluminum production

85	331315	1983:4–2005:2	5	Aluminum sheet, plate, & foil mfg.
86	331316	1983:4–2005:2	5	Aluminum extruded products
87	331421	1983:4–2005:2	5	Copper rolling, drawing, & extruding
88	3314913	1983:4–2005:2	5	Other nonferrous metal roll draw extruding (titanium and titanium base alloy mill shapes excluding wire)
89	3314923	1983:4–2005:2	5	Other nonferrous secondary smelt refine alloying (secondary lead)
90	331511	1983:4–2005:2	5	Iron foundries
91	3322121	1983:4–2005:2	5	Hand and edge tools except machine tools and handsaws (mechanics' hand service tools)
92	332213	1983:4–2005:2	5	Saw blade & handsaw mfg.
93	3323111	1983:4–2005:2	5	Prefabricated metal building and component manufacturing (prefabricated metal building systems excluding farm service bldgs. & residential buildings)
94	332321	1983:4–2005:2	5	Metal window and door manufacturing
95	332431	1983:4–2005:2	5	Metal can mfg.
96	324393	1983:4–2005:2	5	Other metal container manufacturing (steel shipping barrels & drums excl. beer barrels more than 12 gallon capacity)
97	332611	1983:4–2005:2	5	Spring heavy gauge mfg.
98	3326122	1983:4–2005:2	5	Spring light gauge mfg. (precision mechanical springs)
99	3327224	1983:4–2005:2	5	Bolt, nut, screw, rivet, & washer mfg. (externally threaded metal fasteners except aircraft)
100	332913	1983:4–2005:2	5	Plumbing fixture fitting & trim mfg.
101	332991	1983:4–2005:2	5	Ball and roller bearings
102	332992	1983:4–2005:2	5	Small arms ammunition mfg.
103	332996	1983:4–2005:2	5	Fabricated pipe & pipe fitting mfg.
104	332998	1983:4–2005:2	5	Enameled iron & metal sanitary ware mfg.
105	333111	1983:4–2005:2	5	Farm machinery & equipment mfg.
106	333131	1983:4–2005:2	5	Mining machinery & equipment mfg.
107	333132	1983:4–2005:2	5	Oil and gas field machinery and equipment mfg.
108	333292	1983:4–2005:2	5	Textile machinery
109	333293	1983:4–2005:2	5	Printing machinery & equipment mfg.
110	3332941	1983:4–2005:2	5	Food products machinery mfg. (dairy and milk products plant machinery)
111	3332981	1983:4–2005:2	5	All other industrial machinery mfg. (chemical manufacturing machinery equip. and parts)
112	3333111	1983:4–2005:2	5	Automatic vending machine mfg. (automatic merchandising machines coin operated excluding parts)
113	333512	1983:4–2005:2	5	Machine tool metal cutting types mfg.
114	333513	1983:4–2005:2	5	Machine tool metal forming types mfg.
115	3335151	1983:4–2005:2	5	Cutting tool & machine tool accessory mfg. (small cutting tools for machine tools and metalworking machinery)

116	333612	1983:4–2005:2	5	Speed changer industrial high speed drive & gear mfg.
117	333618	1983:4–2005:2	5	Other engine equipment mfg.
118	3339111	1983:4–2005:2	5	Pump & pumping equipment mfg. (indus. pumps except hydraulic fluid power pumps)
119	333922	1983:4–2005:2	5	Conveyor & conveying equipment mfg.
120	3339233	1983:4–2005:2	5	Overhead crane hoist & monorail system mfg. (overhead traveling cranes and monorail systems)
121	3339241	1983:4–2005:2	5	Industrial truck, tractor, trailer, stacker, machinery mfg. (industrial trucks and tractors motorized and hand powered)
122	333992	1983:4–2005:2	5	Welding & soldering equipment mfg. (welding & soldering equipment mfg.)
123	333997	1983:4–2005:2	5	Scale & balance except laboratory mfg.
124	334411	1983:4–2005:2	5	Electron tube mfg.
125	334414	1983:4–2005:2	5	Electronic capacitor mfg.
126	334415	1983:4–2005:2	5	Electronic resistor mfg.
127	334417	1983:4–2005:2	5	Electronic connector mfg.
128	3345153	1983:4–2005:2	5	Electricity measuring testing instrument mfg. (test equipment for testing electrical radio & communication circuits & motors)
129	334517p	1983:4–2005:2	5	Irradiation apparatus manufacturing (primary products)
130	3351211	1983:4–2005:2	5	Residential electric lighting fixture mfg. (residential electric lighting fixtures except portable & parts)
131	335122	1983:4–2005:2	5	Commercial electric lighting fixture mfg.
132	335129	1983:4–2005:2	5	Other lighting equipment mfg.
133	335212	1983:4–2005:2	5	Household vacuum cleaner mfg.
134	335221	1983:4–2005:2	5	Household cooking appliance mfg.
135	335311	1983:4–2005:2	5	Power distribution specialty transformer mfg.
136	335312	1983:4–2005:2	5	Motor & generator mfg.
137	335314p	1983:4–2005:2	5	Relay & industrial control mfg. (primary products)
138	335911	1983:4–2005:2	5	Storage battery mfg.
139	3359291	1983:4–2005:2	5	Other communication and energy wire mfg. (power wire and cable made in plants that draw wire)
140	335932	1983:4–2005:2	5	Noncurrent carrying wiring device mfg.
141	335991p	1983:4–2005:2	5	Carbon & graphite product mfg. (primary products)
142	336321p	1983:4–2005:2	5	Vehicular lighting equipment mfg. (primary products)
143	337121	1983:4–2005:2	5	Upholstered household furniture mfg.
144	337122	1983:4–2005:2	5	Wood household furniture except upholstered
145	337124	1983:4–2005:2	5	Metal household furniture
146	337211	1983:4–2005:2	5	Wood office furniture mfg.
147	3372141	1983:4–2005:2	5	Nonwood office furniture (office seating including upholstered nonwood)

148	3399111	1983:4–2005:2	5	Jewelry except costume mfg. (jewelry made of solid platinum metals and solid karat gold)
149	3399123	1983:4–2005:2	5	Silverware & hollowware mfg. (flatware and carving sets made wholly of metal)
150	339931	1983:4–2005:2	5	Doll & stuffed toy mfg.
151	339932	1983:4–2005:2	5	Game toy & children's vehicle mfg.
152	339944	1983:4–2005:2	5	Carbon paper & inked ribbon mfg.
153	3399931	1983:4–2005:2	5	Fastener, button, needle, & pin mfg. (Buttons and parts except for precious or semiprecious metals and stones)
154	3399945	1983:4–2005:2	5	Broom, brush, & mop mfg. (other brushes)

4—International Data

Format is as previously: contains series number; series mnemonic; data span (in quarters); transformation code; and series description as appears in the database. The transformation codes are: 1—no transformation; 2—first difference; 4—logarithm; 5—first difference of logarithm. Our international data set contains fifty quarterly series. The series were taken mainly from Data Insight's International Monetary Fund (IMF) (International Financial Statistics [IFS]), OECD (Main Economic Indictators [MEI]) databases. Some series were obtained from national statistics agencies (NatS), Global Insight (GI), and the European Central Bank (ECB).

America

Brazil

1	NatS	SCN4_PIBPMAS4	1983:4–2005:2	5	Real Gross Domestic Product, SA (average 1990 = 100)
2	IFS	L64A@C223.M	1983:4–2005:2	5	Consumer Price Index
3	IFS	L60B@C223.Q	1983:4–2005:2	1	Interest Rate, Money Market Rate

Canada

4	GI	CANSIM 3800002	1983:4–2005:2	5	Real Gross Domestic Product (GDP), Chained $1,997, SAAR
5	IFS	L64@C156.M	1983:4–2005:2	5	Consumer Price Index
6	IFS	L60C@C156.Q	1983:4–2005:2	1	Interest Rate, Treasury Bill Rate
7	IFS	L61@C156.Q	1983:4–2005:2	1	Interest Rate, Govt. Bond Yield, Long Term > 10 years

Mexico

8	NatS		1983:4–2005:2	5	Real Gross Domestic Product, MIL. 1993 Mexican Pesos
9	IFS	L64@C273.M	1983:4–2005:2	5	Consumer Price Index
10	IFS	L60C@C273.Q	1983:4–2005:2	1	Interest Rate, Treasury Bill Rate

Europe

France

11	ECB	ESA.Q.FR.Y.0000.B1QG00.1000.TTTT.Q.N.A	1983:4–2005:2	5	Real Gross Domestic Product

12	IFS	L64@C132.M	1983:4–2005:2	5	Consumer Price Index
13	IFS	L60C@C132.Q	1983:4–2005:2	1	Interest Rate, Treasury Bill Rate, 3 months
14	IFS	L61@C132.Q	1983:4–2005:2	1	Interest Rate, Govt. Bond Yield, Long Term
Germany					
15	GI	L99BV&R@C134.Q	1983:4–2005:2	5	Real Gross Domestic Product, Index (2000 = 100)
16	IFS	L64D@C134.M	1983:4–2005:2	5	Consumer Price Index (combined with L64@C134.M)
17	IFS	L60C@C134.Q	1983:4–2005:2	1	Interest Rate, Treasury Bill Rate
18	IFS	L61@C134.Q	1983:4–2005:2	1	Interest Rate, Govt. Bond Yield, Long Term
Italy					
19	ECB	ESA.Q.IT.Y.0000. B1QG00.1000. TTTT.L.N.A	1983:4–2005:2	5	Real Gross Domestic Product, chain linked
20	IFS	L64@C136.M	1983:4–2005:2	5	Consumer Price Index
21	IFS	L60C@C136.Q	1983:4–2005:2	1	Interest Rate, Treasury Bill Rate
22	IFS	L61@C136.Q	1983:4–2005:2	1	Interest Rate, Govt. Bond Yield, Long Term
Netherlands					
23	ECB	ESA.Q.NL.Y.0000. B1QG00.1000. TTTT.Q.N.A	1983:4–2005:2	5	Real Gross Domestic Product, constant prices
24	IFS	L64@C138.M	1983:4–2005:2	5	Consumer Price Index
25	IFS	L61@C138.Q	1983:4–2005:2	1	Interest Rate, Govt. Bond Yield
					United Kingdom
26	ECB	ESA.Q.GB.Y.0000. B1QG00.1000. TTTT.Q.N.A	1983:4–2005:2	5	Real Gross Domestic Product, constant prices
27	IFS	L64@C112.M	1983:4–2005:2	5	Consumer Price Index
28	IFS	L60C@C112.Q	1983:4–2005:2	1	Interest Rate, Treasury Bill Rate
29	IFS	L61@C112.Q	1983:4–2005:2	1	Interest Rate, Govt. Bond Yield, Long Term
Asia					
China[14]					
30	DRI	JGDPRZNS@ CH.Q		*	Real Gross Domestic Product, constant prices
31	IFS	L60L@C924.Q	1983:4–2005:2	1	Interest Rate, Deposit Rate
Hong Kong					
32	IFS	L99B&P&W@ C532.Q	1983:4–2005:2	5	Real Gross Domestic Product, 2000 prices
33	IFS	L64@C532.M	1983:4–2005:2	5	Consumer Price Index
34	DRI	RMIB3S@HK.M	1983:4–2005:2	1	Interest Rate, Interbank Offered Rate

14. For China, real GDP numbers are based on GDP growth numbers from declarative referential integrity (DRI) database and estimates of the level of GDP from Abeysinghe and Gulasekaran (2004). Consumer Price Index: no series starting in 1984 found.

Japan					
35	IFS	L99BV&R@C158.Q	1983:4–2005:2	5	Real Gross Domestic Product, 2000 prices
36	IFS	L64@C158.M	1983:4–2005:2	5	Consumer Price Index
37	MEI	JPN.IR3TCD01.ST	1983:4–2005:2	1	Interest Rate, 3-months' rates on CDs
38	IFS	L61@C158.Q	1983:4–2005:2	1	Interest Rate, Govt. Bond Yield, Long Term
Korea					
39	GI	GDPR@KO.Q	1983:4–2005:2	5	Real Gross Domestic Product, 2000 prices
40	IFS	L64@C542.M	1983:4–2005:2	5	Consumer Price Index
41	IFS	L61@C542.Q	1983:4–2005:2	1	Interest Rate Yield on National Housing Bond
Malaysia					
42	IFS	L99BV&P@C548.Q	1983:4–2005:2	5	Real Gross Domestic Product, 2000 prices
43	IFS	L60C@C548.Q	1983:4–2005:2	1	Interest Rate, Treasury Bill Rate, 3 months
Singapore					
44	GI	GDPR@SI.Q	1983:4–2005:2	5	Real Gross Domestic Product, 2000 prices
45	IFS	L64@C576.M	1983:4–2005:2	5	Consumer Price Index
46	IFS	L60C@C576.Q	1983:4–2005:2	1	Interest Rate, Treasury Bill Rate
Taiwan					
47	NatS		1983:4–2005:2	5	Real Gross Domestic Product, 2001 prices
48	DRI	CPI@TA.M	1983:4–2005:2	5	Consumer Price Index
49	DRI	RMCP180S@TA.Q	1983:4–2005:2	1	Interest Rate, Commercial Papers, 3–6 months, sec. mkt.

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Comment Lucrezia Reichlin

Domestic and International Factors

The chapter addresses the difficult, but very topical question of whether globalization has affected the transmission mechanism of U.S. monetary policy and, in particular, whether it has made it less effective.

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The chapter relies partly on data analysis and partly on a counterfactual Vector Auto Regression (VAR) exercise. In both cases the authors exploit information from two large data sets, one containing U.S. data (the domestic panel) and the other providing data on the rest of the world (the foreign panel).

A distinctive feature of the analysis is that the authors rely on factor analysis techniques in order to exploit information from the large data sets. The authors extract common domestic factors (denoted by Ct) from the domestic panel and common foreign factors (denoted by C_t^*) from the foreign panel via principal components. They then study the impact of foreign factors on domestic variables from a variety of perspectives.

The particular questions analyzed in the chapter are the following:

1. How much of the variance of key U.S. economic time series is captured by C_t and how much by C_t^* (exercise 1)?
2. Has the importance of C_t^* increased over time (exercise 2)?
3. Do common foreign factors C_t^* Granger-cause domestic factors C_t and is the Granger causality relationship stable over time (exercise 3)?
4. Do global forces mitigate the effects of U.S. monetary policy more than they used to do? This analysis is carried out by mean of a structural VAR on the factors (a factor-augmented vector autoregression [FAVAR] in the spirit of Bernanke, Boivin, and Eliasz [2005])(exercise 4).

My discussion raises a fundamental conceptual problem in the methodology proposed by the chapter. I will show two examples, one where national and foreign factors are perfectly correlated and the other where they are not. The examples show that the proportion of the variance of observable domestic variables explained by foreign factors is not interpretable even when controlling for the correlation between domestic and foreign factors. My examples also imply that Granger causality tests, as those proposed in exercise 3, are not informative on the role of global forces in national dynamics. By the same reasoning, neither is the VAR exercise proposed in exercise 4.

Does Globalization Matter? The Econometric Strategy of the Chapter

Let us summarize the steps of the authors' methodology.

Step 1: Extract the Factors

The $K \times 1$ vector of the U.S. factors is extracted from the $N \times 1$ vector of the U.S. data assuming that the data follow the process:

$$X_t = \Lambda C_t + e_t.$$

Similarly, the $K^* \times 1$ vector of the foreign factors C_t^* can be extracted from the $N^* \times 1$ vector of foreign variables assuming:

$$X_t^* = \Lambda^* C_t^* + e_t^*.$$

Exercises 1 and 2 are based on step 1 and consist of computing the proportion of the variance of observable variables X_t to be attributed to C_t^* and C_t.

Step 2: VAR on the Factors

The relationship between foreign and domestic factors is estimated via the following VAR:

$$\begin{pmatrix} C_t^* \\ C_t \end{pmatrix} = \begin{pmatrix} \Psi_{11}(L) & \Psi_{12}(L) \\ \Psi_{21}(L) & \Psi_{22}(L) \end{pmatrix} \begin{pmatrix} C_{t-1}^* \\ C_{t-1} \end{pmatrix} + \begin{pmatrix} u_t^* \\ u_t \end{pmatrix}.$$

They are interested in studying Granger causality of past C_t^* on C_t (exercise 3) and in computing the effect of the identified domestic monetary policy shock on the basis of an unrestricted VAR in which past foreign factors are allowed to affect domestic factors and a restricted VAR in which that effect is set to zero (exercise 4).

In particular, exercise 3 consists of testing the hypothesis that $\Psi_{21}(L) = 0$. If it were to prove impossible to reject the hypothesis, we would conclude that foreign factors did not help in forecasting domestic factors. In exercise 4 the restricted VAR is constrained so as $\Psi_{21}(L) = 0$. The idea of the experiment is that, if results based on the restricted VAR were significantly different than those based on the restricted specification, one would conclude that globalization had affected the transmission mechanism of the monetary policy shock. Vice-versa, if results were the same, we would conclude that globalization did not matter.

The next sections will review critically the methodology.

Example 1: Autarky and Globalization

Consider a simple barter economy with two geographical areas: the United States (domestic economy) and the rest of the world, with the variables of the latter being indicated by a star superscript. Let us denote the difference in the log of real consumption per capita as Δy_t and the real interest rate as r_t. The equilibrium conditions in this barter economy are given by the following Euler equations:

$$\mathrm{E}_t \Delta y_{t+1}^* = \gamma^* r_t^*,$$

where E_t is the expectation operator at time t and γ is the elasticity of intertemporal substitution.

Under autarky, the rate r_t that clears the U.S. capital market is determined at the U.S. level and the United States can be considered an island in the economic sense.

Under globalization, the rate r_t that clears the world capital market is determined at the world level so as to fulfill the equilibrium condition:

$$\frac{E_t \Delta y^*_{t+1}}{\gamma^*} = \frac{E_t \Delta y_{t+1}}{\gamma}.$$

At equilibrium, we will have $r_t = r_t^* = r_t^W$ and from the Euler equations expected domestic consumption is:

$$E_t \Delta y_{t+1} = \gamma r_t^W.$$

This expression shows that domestic variables reflect information on foreign variables since the domestic interest rate equals the world interest rate. In general, any domestic macroeconomic variables reflecting expected consumption must contain information on the world interest rate and therefore have a global component.

The point can also be understood from the budget constraint, which is derived from the intertemporal theory of the current account. There, the current account ca_t is the discounted sum of future expected net output no_t and the future discounted sum of world interest rates:

$$ca_t = -\sum_{j=1}^{\infty} \beta^j E_t \Delta no_{t+j} + \gamma \sum_{j=0}^{\infty} \beta^j E_t r_{t+j}^W.$$

The expression implies that the information on the world interest rate is already contained in the current account data. The U.S. panel used by the authors, for example, contains current account data and the domestic factors must therefore be correlated with national factors as in fact they are.

Let us now examine the VAR implied by our simple example.[1]

Assume that the world interest rate follows an exogenous AR(1) process:

$$r_t^W = \rho r_{t-1}^W + u_t,$$

where u_t is an exogenous shock that may depend on domestic and foreign shocks. The VAR representation of the solution to the model is:

$$\begin{pmatrix} y_t^* \\ y_t \end{pmatrix} = \begin{pmatrix} \rho & 0 \\ 0 & \rho \end{pmatrix} \begin{pmatrix} y_{t-1}^* \\ y_{t-1} \end{pmatrix} + \begin{pmatrix} -\gamma/(1-\rho) \\ -\gamma^*/(1-\rho) \end{pmatrix} u_t.$$

This is a case in which Ψ_{21} in the authors' VAR is equal to zero at all lags and consumption in the rest of the world does not statistically affect U.S. consumption (foreign variables/factors do not Granger-cause domestic variables/factors). The procedure proposed by the authors would lead to the conclusion that the rest of the world consumption has no impact on domestic consumption.

However, as we have seen, this conclusion is clearly wrong: when the foreign interest rate moves, foreign consumption moves as well and the world interest rate changes in order to restore the world equilibrium, therefore

1. I thank Boivin and Giannoni for making the relationship of my example and their VAR explicit in correspondence related to the discussion of their chapter.

affecting domestic consumption. Notice that, since the restricted model is the same as the unrestricted model, the inclusion of foreign variables will not alter the transmission mechanism, although the structure of the model implies that under autarky, unlike under globalization, foreign factors do not affect domestic factors. Granger-causality will be rejected statistically because expected consumption already incorporates information on the world interest rate and, as a consequence, foreign factors have no additional marginal forecasting power.

It is clear that in this case, the coefficients $\Psi_{21}(L)$ provide no information on the effect of international factors on domestic variables.

The general problem is that observed domestic variables are the result of a general equilibrium process that reflects changes in both domestic and foreign forces. Domestic dynamic, therefore, incorporates the effect of foreign forces. The only way to disentangle domestic and foreign forces is to identify domestic and foreign shocks or to estimate the deep parameters of a structural model. From estimates of the effect of foreign variables (or foreign factors) on domestic variables (or domestic factors) there is nothing to learn.

The same point can be explained from the statistical point of view.

Let us go back to the VAR on factors estimated by the authors and described here in this section. Notice that the coefficients $\Psi_{ij}(L)$ have the same interpretation as partial correlation coefficients: $\Psi_{21}(L)$ reveals the dynamic effect of the past of C_t^* on C_t once we have netted out the effect of the past values of C_t.

In the limit case in which C_t and C_t^* are entirely driven by a global component, as in the previous example, this coefficient would be zero and we would be led to the wrong conclusion that international factors have no effect on domestic factors. If, on the other hand, the correlation were not perfect, the estimates of the coefficients would reveal the effect of foreign-specific forces on domestic factors, rather than the effect of foreign factors (global and foreign-specific) on domestic factors.

Notice that the fact that we cannot identify the effect of global forces on the transmission mechanism of monetary policy has nothing to do with whether the coefficients of the VAR are identified (rank condition discussed by the authors in the text). This is simply the consequence of the fact that the factors, as the variables themselves, contain both global and region-specific components.

Obviously, this discussion applies whether we are focusing on a VAR on observed domestic and foreign variables or on a VAR on unobserved factors as done by the authors.

Example 2: Sectoral Output

To provide more intuition for my point, let me propose a different example.

Suppose that output $y_{k,t}$ in each of K sectors of the U.S. economy evolves according to

$$y_{k,t} = A_k(L)y_{k,t-1} + B_k(L)x_{k,t} + u_{k,t},$$

where $x_{k,t}$ denotes exports of sector k (to all countries), and $u_{k,t}$ is a domestic demand disturbance specific to sector k. Suppose also that foreign country j's imports of goods produced by sector k of the U.S. economy are equal to

$$x^j_{k,t} = \theta^j \gamma_k Y^*_{j,t},$$

where $Y^*_{j,t}$ is the national income of country j in period t, θ^j is the marginal propensity to import U.S. goods of country j, and k is the fraction of imports from the United States that are purchased from sector k (assumed to be the same for each of the foreign countries). Total exports of a given U.S. sector are then equal to

$$x^j_{k,t} = \sum_{J=1}^{J} x^j_{k,t}.$$

Finally, suppose, for simplicity, that the evolution of the variables $Y^*_{j,t}$ is driven purely by "foreign" disturbances, unrelated to developments in the United States.

It follows that the evolution of each of the sectors of the U.S. economy can be written as

$$y_{k,t} = A_k(L)y_{k,t-1} + \gamma_k B_k(L)X_t + u_{k,t},$$

where

$$X_t = \sum_{j=1}^{J} \theta^j Y^*_{j,t}.$$

Suppose that the "domestic" data set consists of the sectoral outputs $\{y_{k,t}\}$ for each of the K sectors of the U.S. economy, while the "foreign" data set consists of the levels of national income $\{Y^*_{j,t}\}$ for some K^* of the J foreign countries. On the assumption that there are not too many important common factors among the domestic demand disturbances $\{u_{k,t}\}$, the authors' procedure would identify the variable X_t as one of the "domestic" common factors. At the same time, X_t may not be among, or even too closely correlated with, the few largest "foreign" common factors. While our assumptions imply that X_t is purely a function of "foreign" disturbances, it need not be well explained by the several most important factors extracted from the foreign data set. For, while those factors are constructed so as to explain as much as possible of the variation in the variables in the foreign data set as a whole, they need not explain a great deal of the variation in any individual variable in the foreign data set. The fact that the particular linear combination of foreign variables represented by X_t happens to be important for the U.S. economy is no reason for the variables that best explain it to have been selected among the small number of leading "foreign factors." Indeed, X_t need not even be part of the foreign data set, if that data set happens not

to include all the important importers of U.S. products, or if it happens to aggregate regions with different marginal propensities to import from the United States as single foreign national income series.

This simple example shows that the mere fact that factors are extracted from a set of U.S. time series need not mean that the variables in question are not substantially affected by foreign disturbances; in the example, X_t is one of the "domestic factors," but 100 percent of the variation in this variable is due to foreign disturbances. Moreover, one cannot control for this problem simply by checking to what extent the "domestic factors" are correlated with the small number of leading "foreign factors" identified through the authors' procedure; one could find that X_t is little explained by variation in those few foreign factors, even though it is actually entirely a function of foreign disturbances. In this example, no foreign variables other than the history of X_t are of any relevance whatsoever to forecasting any of the variables in the "domestic" data set. Thus, if X_t is among the "domestic factors," one should not find any role for the identified "foreign factors" in improving forecasts of the domestic factors, after already conditioning on the past history of X_t and the other domestic factors themselves (we would reject Granger causality). Yet this would not imply that foreign developments have little effect on the evolution of the U.S. economy. It would be quite possible that a large fraction of the variation in every sector of the U.S. economy is due to variations in X_t, and hence ultimately to foreign disturbances, despite the finding that $\Psi_{21}(L) = 0$.

Reference

Bernanke, B., J. Boivin, and P. Eliasz. 2005. Measuring the effects of monetary policy: A factor augmented vector autoregressive (FAVAR) approach. *Quarterly Journal of Economics* 120 (1): 387–422.

Rejoinder Jean Boivin and Marc P. Giannoni

Our discussant criticizes the chapter on the grounds that "all exercises performed are difficult to interpret" because domestic factors C_t are affected jointly by domestic and foreign shocks.[1] She takes issue with our interpretation of "VAR based results with international variables" and concludes, on the basis of two simple polar examples, that "[i]n order to estimate the effect of global forces, we need to identify global shocks and their propagation."

Given that the discussant argues that her main critique of the chapter

1. This addendum constitutes a response to the main issues raised by our discussant, Lucrezia Reichlin, in her written discussion dated October 30, 2007.

"applies whether we are focusing on a VAR on observed domestic and foreign variables or a VAR on unobserved factors," we focus here on issues raised in the context of our conventional VAR. These issues are both about econometric identification and economic interpretation. A more detailed discussion of these points as well as a discussion of issues referring to the estimation of factors from large data sets are left in a separate note (posted on the authors' websites).

Discussion's Examples, Stochastic Singularity, and VARs

The discussion is essentially about the fact that when the correlation among macroeconomic variables is too high, it might not be possible to identify quantities of interest. To illustrate this point, the discussant provides *two examples* in which this correlation is so high in fact that the systems suffer from stochastic singularity. As the discussion mentions, the two proposed examples have the property that the foreign factors C_t^* *do not Granger cause* the domestic factors C_t, after controlling for past domestic variables. The discussant argues that the effects of foreign factors on domestic factors cannot be interpreted in these examples, and concludes from this that our results cannot be interpreted.

We fully agree with our discussant that *if* foreign factors *did not* Granger cause domestic factors, as is assumed in both examples, it would be difficult to identify and interpret our results (see sections 8.2.3, 8.3.3 and 8.4.1 of chapter). It is well known that VARs may be inadequate in such situations. Fortunately, this problem can be detected empirically, and it turns out that the data that we consider reject the hypothesis of stochastic singularity. Our chapter reports and discusses test results showing that foreign factors C_t^* *do Granger cause* the domestic factors C_t, after controlling for past domestic variables. As argued in the chapter, Granger causality from foreign factors to domestic factors in our empirical setup implies that the effect of foreign factors on domestic factors *can be properly identified* by the empirical strategy that we adopted. So, as interesting as the examples presented in the discussion might be, and despite their elegance, our findings suggest that they are not relevant in practice.

Can We Estimate the VAR Coefficients?

Aside from the issue just addressed, the discussion suggests that our empirical procedure might not identify the true effect of foreign variables on domestic variables. It is alleged that our VAR parameters are inconsistently estimated depending on whether the VAR residuals involve global (i.e., worldwide common shocks) or merely region-specific shocks. While this issue arises in multiple parts of the discussion, it appears most clearly in the section, "A Simple Statistical Point." That section refers to our general

formulation of the VAR for the factors C_t^* and C_t. To simplify the notation, and without loss of generality, let us reduce this system to a VAR(1) in the scalar variables C_t^*, C_t:

$$\begin{bmatrix} C_t^* \\ C_t \end{bmatrix} = \begin{bmatrix} \psi_{11} & \psi_{12} \\ \psi_{21} & \psi_{22} \end{bmatrix} \begin{bmatrix} C_{t-1}^* \\ C_{t-1} \end{bmatrix} + \begin{bmatrix} u_t^* \\ u_t \end{bmatrix}. \tag{1}$$

The reduced-form shocks u_t^* and u_t (assumed to be i.i.d. over time) may be driven both by a global (or "worldwide" common) shock g_t, and by region-specific shocks ε_t^*, ε_t (assumed to be uncorrelated across regions), say, in the following way:

$$\begin{bmatrix} u_t^* \\ u_t \end{bmatrix} = Fg_t + \begin{bmatrix} \varepsilon_t^* \\ \varepsilon_t \end{bmatrix}. \tag{2}$$

The coefficient ψ_{21} reveals the dynamic effect of the past foreign factor C_{t-1}^* on the domestic factor C_t, controlling for the past value of C_t.

The discussant claims that "in the limit case in which C_t and C_t^* are entirely driven by a global component [g_t, the coefficient ψ_{21}] will be zero and we would wrongly conclude that international factors have no effect on domestic factors." This raises issues of economic interpretation, which we discuss in the following section on economic interpretation, as well as econometric issues. The discussant furthermore argues that "[i]f the correlation [between C_t^* and C_t] is not perfect, the estimates of the coefficients will reveal the effect of foreign-specific forces on domestic factors, but not the effect of foreign factors (global plus foreign specific) on domestic factors." This is a claim that ordinary least squares (OLS) estimation of VAR parameters is not consistent. However, standard econometric results show that VAR coefficients, ψ_{ij}, can in general be consistently estimated and do not depend on the mixture of common (g_t) versus variable-specific shocks (ε_t^*, ε_t). In the detailed note mentioned previously, we show, using a simple simulated example, that our empirical procedure generally recovers the true coefficients.

Do We Need to Identify All Shocks?

The discussant criticizes our so-called exercise 4, in which we attempt to determine whether global forces mitigate the effects of U.S. monetary policy more than they used to. The discussant interprets this exercise as an attempt to identify how *worldwide common shocks* might have mitigated the effect of U.S. monetary policy. The discussant's main point is to argue that our strategy does not identify worldwide exogenous shocks, and hence, that it cannot shed light on the question.

This interpretation of our exercise and of our results is, however, inappropriate. As we emphasized in the chapter, the goal of our exercise 4 is *not* to determine the role of such worldwide shocks, but instead to determine

to what extent the transmission of U.S. monetary policy shocks on the U.S. economy depends on the subsequent adjustment of foreign variables, which we summarize by *endogenous* foreign factors (C_t^*).

To determine the effect of foreign variables on the transmission of U.S. monetary policy, we merely need to identify one shock: a monetary policy shock. This is done in our chapter by adopting a common recursive identification assumption. Clearly the validity of such an assumption is debatable, but once one accepts it, the exercise performed is well defined and entirely conventional in the VAR literature. As is common in the literature, *we do not need to identify all of the other exogenous shocks* to determine the effect of monetary policy shocks under this identifying assumption. We then perform a simple counterfactual experiment that involves shutting down the feedback effect of foreign endogenous variables on domestic variables. Clearly, as we recognize at the end of section 8.4.4, such an exercise is potentially subject to the Lucas critique, but this is not the object of the discussant's complaints.

In our setup, as is the case in the examples proposed by the discussant, worldwide common *shocks* are by construction orthogonal to the U.S. monetary policy shocks, and hence, do not contribute to the object of our interest (i.e., the transmission of U.S. monetary policy). While identifying worldwide shocks might be interesting for other exercises, it is not necessary to do so for the question in which we are interested.

It is important to note that there is nothing special about the international aspect of our VAR. Our exercise 4 is completely analogous to the exercises performed by many researchers using closed economy VARs to investigate the effect of systematic monetary policy. In such a context, the variables of the VAR are typically believed to be driven by common shocks such as productivity shocks. Yet again, in order to characterize the effects of monetary policy, it is not necessary to identify all shocks.

Economic Interpretation

Finally, the discussion claims that the coefficients ψ_{21} measuring the effect of foreign factors (C^*) on domestic factors (C), even if they could be perfectly estimated, do not provide any relevant information. For instance, in example 2 of the discussion, the true value of ψ_{21} is 0. The discussant thus concludes on this basis that "[t]he procedure proposed by the authors would assess that the rest of the world consumption has no impact on domestic consumption. However [. . .] this conclusion is clearly wrong [. . .] The coefficients [ψ_{21}] do not tell us anything about the effects of international factors on national variables."

The critique is unfortunately misguided. Nowhere in our chapter have we suggested that the rest of the world would, in such an example, have no effect on the domestic economy. In fact we do not assess the importance of foreign

factors for domestic factors on the basis of ψ_{21}. Instead, we do so by looking at R^2 statistics. Contrary to the discussant's claim, if the model of example 2 in the discussion were true, we would find that much of the variance of domestic consumption is strongly correlated with foreign consumption; in the case that the domestic and foreign elasticities of intertemporal substitution are equal ($\gamma = \gamma^*$), the R^2 statistics reported in table 8.1 of our chapter would be precisely 1 in this example, suggesting considerable comovement of foreign and domestic variables.

Does the coefficient ψ_{21} then provide any relevant information in that case? Certainly. Again, if the model of example 2 were true, the true value of ψ_{21} would be 0. This coefficient is used in the context of our exercise 4, for the characterization of the effect of foreign variables on the transmission of monetary policy. Having the coefficient ψ_{21} equal to 0 in this example simply reflects the fact that in response to a monetary policy shock, unexpectedly raising the domestic (and world) real interest rate by a given amount results in the *same* response of domestic consumption in the open economy as in the case of complete autarky (i.e., if there were no interaction with the rest of the world). This is precisely what the theoretical model proposed in example 2 of the discussion predicts, and it is also what our empirical procedure would conclude.

Our empirical strategy would thus have delivered the right answers in this example. As we argue in the more detailed note (posted on our website), our approach would also generally provide the right answer in example 1 of the discussion. The discussion's conclusion that "[t]he coefficients [ψ_{21}] do not tell us anything about the effects of international factors on national variables" is therefore inaccurate.