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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 $r_t = r^*_t = r^W_t$ and from the Euler equations expected domestic consumption is:

$$E_t \Delta y_{t+1} = \gamma r^W_t.$$

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:

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

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:

$$r^W_t = \rho r^W_{t-1} + u_t,$$

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 $\Psi_{21}(L) = 0$.

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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.