

## Addendum: Response to Discussion of Lucrezia Reichlin<sup>1</sup>

Our discussant criticizes the paper on the grounds that “all exercises performed are difficult to interpret” (p. 2). According to her, this problem arises because domestic factors  $C_t$  are affected jointly by domestic and foreign shocks. 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” (p. 7).

Given that the discussant argues that her main critique of the paper “applies whether we are focusing on a VAR on observed domestic and foreign variables or a VAR on unobserved factors” (p. 7), 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 (to be posted on the authors’ websites).

### 1 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 2.3, 3.3 and 4.1 of paper). 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 paper 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 paper, 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.

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

## 2 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 section 5 (“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  $C_t^*, C_t$ :

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

The reduced-form shocks  $u_t^*$  and  $u_t$  (assumed to be iid over time) may be driven both by a global (or “worldwide” common) shock  $g_t$  and by region-specific shocks  $\varepsilon_t^*, \varepsilon_t$  (assumed to be uncorrelated across regions), say in the following way:

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

The coefficient  $\psi_{21}$  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  $\psi_{21}$ ] will be zero and we would wrongly conclude that international factors have no effect on domestic factors” (p. 6). This raises issues of economic interpretation which we discuss in section 4 below, 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 OLS estimation of VAR parameters is not consistent. However standard econometric results show that VAR coefficients,  $\psi_{ij}$ , can in general be consistently estimated and do not depend on the mixture of common,  $g_t$ , versus variable-specific shocks,  $\varepsilon_t^*, \varepsilon_t$ . In the detailed note mentioned above, we show, using a simple simulated example, that our empirical procedure generally recovers the true coefficients.

## 3 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 US 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 US 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 paper, 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 US monetary policy shocks on the US 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 US monetary policy, we merely need to identify one shock: a monetary policy shock. This is done in our paper by adopting a common recursive identification assumption. Clearly the validity of such 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 don't 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 which involves shutting down the feedback effect of foreign endogenous variables on domestic variables. Clearly, as we recognize at the end of section 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 US monetary policy shocks, and hence do not contribute to the object of our interest, i.e., the transmission of US monetary policy. While identifying worldwide shocks might be interesting for other exercises, it is not necessary to do so for the question that we are interested in.

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.

## 4 Economic interpretation

Finally, the discussion claims that the coefficients  $\psi_{21}$  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  $\psi_{21}$  is 0. The discussant thus concludes on this basis that (on p. 6) “[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 [ $\psi_{21}$ ] do not tell us anything about the effects of international factors on national variables.”

The critique is unfortunately misguided. Nowhere in our paper have we suggested that the

rest of the world would, in such an example, have no effect on the domestic economy. In fact we don't assess the importance of foreign factors for domestic factors on the basis of  $\psi_{21}$ . 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 1 of our paper would be precisely 1 in this example, suggesting considerable comovement of foreign and domestic variables.

Does the coefficient  $\psi_{21}$  then provide any relevant information in that case? Certainly. Again if the model of example 2 were true, the true value of  $\psi_{21}$  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  $\psi_{21}$  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 the 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 [ $\psi_{21}$ ] do not tell us anything about the effects of international factors on national variables" is therefore inaccurate.