

Can Portfolio Rebalancing Explain the Dynamics of Equity Returns, Equity Flows, and Exchange Rates?

By HARALD HAU AND HÉLÈNE REY*

Portfolio rebalancing motives are an old topic in exchange-rate theory (Pentti Kouri, 1982; William H. Branson and Dale W. Henderson, 1985). While the earlier literature mostly lacks modern microfoundations, its emphasis on capital markets resonates more than ever with the stylized facts of international finance. Gross capital flows and particularly equity flows have grown tremendously over the last two decades.¹ And these equity portfolio flows have arguably become an important determinant of the short-run supply and demand of foreign-exchange (FX) balances.

This paper examines whether the data on equity returns, equity flows, and exchange-rate returns are supportive of a portfolio rebalancing channel. We argue that the portfolio rebalancing channel implies a set of conditional correlations between these variables which can be confronted with the data. Equity-return and exchange-rate data are straightforward to obtain. The best public data on international equity flows come from the U.S. Treasury (TIC data) and measure bilateral flows between the United States and a large number of foreign countries. We focus here on the five largest equity markets outside the United States, namely, France, Germany, Japan, Switzerland, and the United Kingdom for the period January 1990–September 2003.

A basic econometric problem with any system of simultaneously determined variables is

the identification of primitive shocks. Frequently this problem is addressed by imposing a causal ordering between variables. It is assumed that shocks to variables of lower ordering do not contemporaneously influence variables of higher order (Choleski decomposition). But for a monthly data frequency and the inclusion of two price processes, namely, equity returns and exchange-rate returns, any such causal structure is highly implausible. We therefore take a new identification approach which does not impose any zero restrictions. This method was previously used by Harald Uhlig (2001) and Fabio Canova and Gianni De Nicolò (2002). Identification is achieved by a grid search over the space of all feasible decompositions of the variance–covariance matrix and selection of the particular one which is most in accordance with our theoretical priors. In other words, we search for the moving-average (MA) representation of the data process which accords best with the conditional correlations obtained under the hypotheses of the portfolio rebalancing channel.

We find that the data are consistent with an important role for the portfolio rebalancing channel. Our preferred variance–covariance decomposition shows that global investors repatriate foreign equity wealth after its appreciation either because of foreign-equity excess returns (H1) or after an unexpected appreciation of the foreign currency (H2). Moreover, these equity flows move the exchange rate in line with a price-inelastic supply of foreign-exchange balances. Portfolio flow shocks appreciate the foreign-exchange rate and create foreign-equity-market excess returns (H3).

I. Literature

The empirical analysis here is closely related to recent theoretical work by Hau and Rey (2002), which provides microfoundations to the

* Hau: Department of Finance, Boulevard de Constance, 77305 Fontainebleau Cedex, France (e-mail: harald.hau@insead.edu); Rey: Department of Economics and Woodrow Wilson School, Princeton University, Princeton, NJ 08544 USA (e-mail: hrey@princeton.edu). We are grateful to the Fondation Banque de France for financial support.

¹ While gross cross-border transactions in bonds and equities for the United States were equivalent to only 4 percent of GDP in 1975, this share increased to 100 percent in the early 1990's and grew to 245 percent by 2000.

portfolio balance theory.² Our dynamic equilibrium framework in that paper characterizes the joint dynamics of equity returns, equity flows, and exchange-rate returns induced by realistic constraints on the FX risk-trading possibilities of international investors. According to survey evidence, international investors hedge only a minor proportion of their actual FX risk. Differential equity-market performance then induces dynamic portfolio rebalancing, which in turn can move exchange rates. In Hau and Rey (2002) we also document that the unconditional correlation structure between relative equity returns, exchange-rate returns, and equity flows is supportive of such a portfolio rebalancing channel (see tables 2–6 in Hau and Rey [2002]). The present paper extends this work to the conditional correlation structure in a VAR framework.

Similar work features in a recent study by Gregorios Souriounis (2003), who uses data on net equity and bond flows, equity returns, interest rates, and exchange rates to uncover dynamic links between capital flows and exchange-rate movements. Souriounis documents that equity flows rather than bond flows are important in explaining exchange rates. However, his identification assumptions are not grounded in theory. Other empirical work by Kenneth Froot and Tarun Ramadorai (2002) uses proprietary data on daily institutional investor currency flows. They find that these flows are highly correlated with contemporaneous and lagged exchange-rate changes.

The recent empirical literature on exchange rates has highlighted a variable called currency order flow (purchaser-initiated trades minus seller-initiated trades) as strongly correlated with exchange rate returns (Dagfinn Rime, 2001; Martin Evans and Richard Lyons, 2002, 2003a; Hau et al., 2002; William Killeen et al., 2002). Order flow is sometimes interpreted as the variable through which dispersed information is aggregated and impounded in the price (Lyons, 2001; Evans and Lyons, 2003b). Yet simple portfolio shifts could also give rise to order flow without any role for information

asymmetries. Within the portfolio-rebalancing framework and conditional on exogenous equity return and exchange-rate shocks, it is plausible that net capital flows and order flows are closely aligned. Conditional on an exogenous appreciation of his foreign wealth for example, the home investor is likely to initiate the selling of foreign assets as well as the selling of foreign currency balances.

II. Theoretical Hypotheses

This section outlines three hypotheses with respect to the dynamics of equity returns, equity portfolio flows, and exchange-rate returns. Equity returns are measured as the monthly equity-return differential (in local currency) between the foreign equity-market index and the U.S. (home) equity-market index, namely, $y_1 = ER = R(f) - R(h)$. We define equity portfolio flows as the net purchase of foreign equity by home residents minus the net purchases of home equity by foreign residents. We scale this net portfolio flow by the total equity transaction volume between home and foreign residents in both markets, and denote it by $y_2 = FL$. Finally, exchange rate return $y_3 = FX$ is defined as positive for a dollar appreciation.

Our first hypothesis concerns equity price innovations.

H1) Portfolio Rebalancing Due to Equity Price Shocks: Foreign equity-market appreciations relative to the home equity market induce a portfolio rebalancing in which the home investor reduces his foreign equity holdings in order to reduce his exchange-rate risk exposure. This results in foreign-equity outflows and a dollar appreciation.

Important for this portfolio rebalancing effect under differential return shocks is that exchange-rate risk matters for the global investor. In a world in which all exchange-rate risk is perfectly hedged (and eliminated), the global investor generally holds the world equity market, and any increase in the value of foreign equity in this world-market portfolio should not trigger any portfolio rebalancing. But exchange-rate exposure under imperfect risk-trading reduces the benefit of foreign investment. If the share of wealth in foreign assets increases, the

² See also Anna Pavlova and Roberto Rigobon (2003) for related work on optimal dynamic international equity holdings. Exchange-rate determination in their setup is based on relative good prices and not on equity flows themselves.

home resident may seek to reduce his increasing FX risk exposure by selling foreign shares to foreign residents who do not face the corresponding FX risk. This aspect is formally modeled in Hau and Rey (2002), where the exchange rate and equity returns are endogenously determined under optimizing investor behavior. The model implies a negative contemporaneous correlation between the foreign excess returns in the equity market and the portfolio inflows into the foreign country. Formally, let s_1 , s_2 , and s_3 denote three primitive shocks to the vector $\mathbf{y} = (y_1, y_2, y_3)$; then, the contemporaneous correlation between y_1 and y_2 conditional on shock s_1 can be signed as $\rho_{12|s_1} < 0$. The equity portfolio flow from the foreign to the home country may also impact the equilibrium exchange rate. Repatriation of foreign equity wealth will tend to increase the demand for dollar balances and should appreciate the dollar if the currency supply is price-inelastic. We can interpret the strong correlation between the exchange-rate changes and FX order flow as supporting a relatively low supply elasticity in the FX market. Such a limited supply elasticity may reside in limits to intertemporal arbitrage even in a relatively liquid market as the FX market. The portfolio-balance effect should therefore produce a positive correlation between foreign excess equity returns and exchange-rate (dollar) appreciations; hence, $\rho_{13|s_1} > 0$.

The second hypothesis concerns exchange rate innovations.

H2) Portfolio Rebalancing Due to Exchange-Rate Shocks: A foreign-country currency appreciation increases the dollar share of assets in the foreign market. The higher overall FX risk exposure for home (U.S.) residents may induce foreign equity-market outflows. Also, the foreign outflows should produce negative foreign-equity excess returns (where returns are measured in local currency).

As for the first hypothesis, the portfolio-rebalancing effect here relies again on imperfect FX risk-trading. The portfolio weights shift here not because of differential equity-market performance, but because of the exchange-rate change itself. Otherwise the logic is identical. The home resident holds an increasing amount of FX risk exposure after the foreign apprecia-

tion. He may therefore be less willing to hold these foreign assets, and therefore we should observe foreign-equity outflows. Hence, conditional on primitive shocks to the exchange rate (s_3), we should observe a positive correlation between portfolio flows and exchange-rate returns or $\rho_{23|s_3} > 0$. The second part of the hypothesis consists of this price-pressure effect on relative equity-market returns. Foreign-equity index returns (measured in foreign currency) should be lower than U.S. (home) index returns. Formally, we obtain (conditional on an exchange-rate shock) a positive contemporaneous correlation between the exchange-rate returns and the foreign-market excess return, that is, $\rho_{13|s_3} > 0$.

The third hypothesis concerns net equity flow innovations:

H3) Exchange Rate and Excess Return Changes Due to Equity Flow Innovations: Equity-flow innovations change the demand for currency balances and for equity. Foreign equity-market inflows appreciate the foreign currency relative to the home currency and induce excess returns in the foreign equity market.

This hypothesis depends again on a price-inelastic supply of currency balances and equity. Such limited supply elasticity can be the consequence of limited arbitrage in the FX and equity markets. Conditional on an equity-flow shock, s_2 , we expect a negative correlation between the net foreign-equity flow and the exchange-rate return as well as a positive correlation between the equity flow and the foreign excess returns. Formally, we have $\rho_{23|s_2} < 0$ and $\rho_{21|s_2} > 0$.

III. Identification Based on Correlation Priors

Identification of a VAR is typically achieved by imposing a causal relationship between the variables of the data vector. Assume for example that, for a particular ordering of the variables, primitive shocks to one variable affect only those higher up in the ordering, but not the reverse. Then the appropriate decomposition into primitive shocks is given by a lower triangular matrix (Choleski decomposition). But imposing such a structure is often inappropriate. It is particularly inappropriate if two or more of

the variables are financial price variables like equity returns and exchange-rate returns. Any equilibrium system will typically feature a reciprocal interaction between price variables even in the short run. Moreover, the equity-flows data are available only at the monthly frequency. This makes any causal ordering even more problematic. Even capital flows may react to price changes over a monthly frequency. Following Uhlig (2001) and Canova and De Nicolo (2002), we therefore choose to adopt a less restrictive approach to the identification problem. Instead of imposing any particular identification structure, we search over all feasible MA representations of the data and choose the particular one that is most aligned with a set of theoretical correlation priors.

Formally, let the Wold MA representation of the system be

$$\mathbf{y}_t = \boldsymbol{\phi} + \mathbf{B}(L)\boldsymbol{\eta}_t \quad \boldsymbol{\eta}_t \sim (0, \boldsymbol{\Sigma})$$

where \mathbf{y}_t is the 3×1 vector, $\boldsymbol{\phi}$ a constant and $\mathbf{B}(L)$ a matrix polynomial in the lag operator. All orthogonal decompositions of a Wold MA representation with contemporaneously uncorrelated shocks featuring a unit variance-covariance matrix are of the form

$$\mathbf{y}_t = \boldsymbol{\phi} + \mathbf{C}(L)\mathbf{e}_t \quad \mathbf{e}_t \sim (0, \mathbf{I})$$

where $\mathbf{C}(L) = \mathbf{B}(L)\tilde{\mathbf{P}}$, $\mathbf{e}_t = \tilde{\mathbf{P}}^{-1}\boldsymbol{\eta}_t$, and $\tilde{\mathbf{P}}\tilde{\mathbf{P}}' = \boldsymbol{\Sigma}$. One such matrix $\tilde{\mathbf{P}}$ is the lower triangular matrix \mathbf{P} of the Choleski decomposition. But we can certainly generate other orthogonal decompositions of the matrix $\boldsymbol{\Sigma}$ and therefore other MA representations in primitive shocks \mathbf{e}_t . To search for all feasible MA representations, we define three elementary Jacobi rotations \mathbf{R}_{θ_1} , \mathbf{R}_{θ_2} , and \mathbf{R}_{θ_3} with respect to three lower triangular elements (for $-\pi/2 < \theta_i < \pi/2$). The first of these rotations (with respect to matrix element (2, 1)) is given by

$$\mathbf{R}_{\theta_1} = \begin{pmatrix} \cos(\theta_1) & -\sin(\theta_1) & 0 \\ \sin(\theta_1) & \cos(\theta_1) & 0 \\ 0 & 0 & 1 \end{pmatrix}.$$

The two other elementary rotations \mathbf{R}_{θ_2} and \mathbf{R}_{θ_3} place the sine function in matrix elements (3, 1)

and (3, 2), respectively (see the supplement on the AEA web site for details). Any joint rotation $\mathbf{R} = \mathbf{R}_{\theta_1}\mathbf{R}_{\theta_2}\mathbf{R}_{\theta_3}$ fulfills $\mathbf{R}\mathbf{R}' = \mathbf{I}$. Hence, $\mathbf{P}\mathbf{R}$ also represents a decomposition of $\boldsymbol{\Sigma}$ into primitive shocks, and $\mathbf{C}(L) = \mathbf{B}(L)\mathbf{P}\mathbf{R}$ is the corresponding MA representation of \mathbf{y}_t . We implement a grid search over all feasible combinations of Jacobi rotations and retain the particular representation $\mathbf{C}^*(L) = \mathbf{B}(L)\mathbf{P}\mathbf{R}^*$ that corresponds best to our theoretical priors.

The theoretical considerations of the previous section imply different sign restrictions $k = 1, 2, \dots, 6$ for the conditional correlations of the \mathbf{y}_t variables. The conditional contemporaneous correlation $\rho_{ij|s}(\mathbf{R})$ between variables y_{it} and y_{jt} follows directly from the MA representation in orthogonalized errors as

$$\rho_{ij|s}(\mathbf{R}) = \frac{(\mathbf{C}^i(L)s)(\mathbf{C}^j(L)s)}{\sqrt{(\mathbf{C}^i(L)s)^2(\mathbf{C}^j(L)s)^2}}.$$

In order to measure correspondence with the theoretical priors, we define a penalty function $f(k, \mathbf{R})$ which assigns a penalty term whenever the empirical conditional correlation does not correspond to the theoretical one. For simplicity, we choose a linear penalty function which takes on the value of $f(k, \mathbf{R}) = -\rho_k(\mathbf{R})$ if the predicted conditional correlation is positive and $f(k, \mathbf{R}) = \rho_k(\mathbf{R})$ if the predicted conditional correlation is negative. Opposite signs for the theoretical and the empirical correlation therefore carry a strong penalty. A particular rotation matrix \mathbf{R}^* provides the most successful identification with an MA representation $\mathbf{C}^*(L) = \mathbf{B}(L)\mathbf{P}\mathbf{R}^*$ if \mathbf{R}^* minimizes the sum of the penalty terms $\sum_{k=1}^6 f(k, \mathbf{R})$ (see the supplement on the AEA web site for the global properties of the penalty function).

The identification approach here based on theoretical priors is not without circularity. We start out by postulating six contemporaneous conditional correlations which we sign. We then choose a decomposition of the variance-covariance matrix which maximizes the signed sum of the correlations subject to the constraint that the elementary shocks still have to generate the variance-covariance matrix of the data process. In this sense we pick the "most theory favorable" identification. But this does not

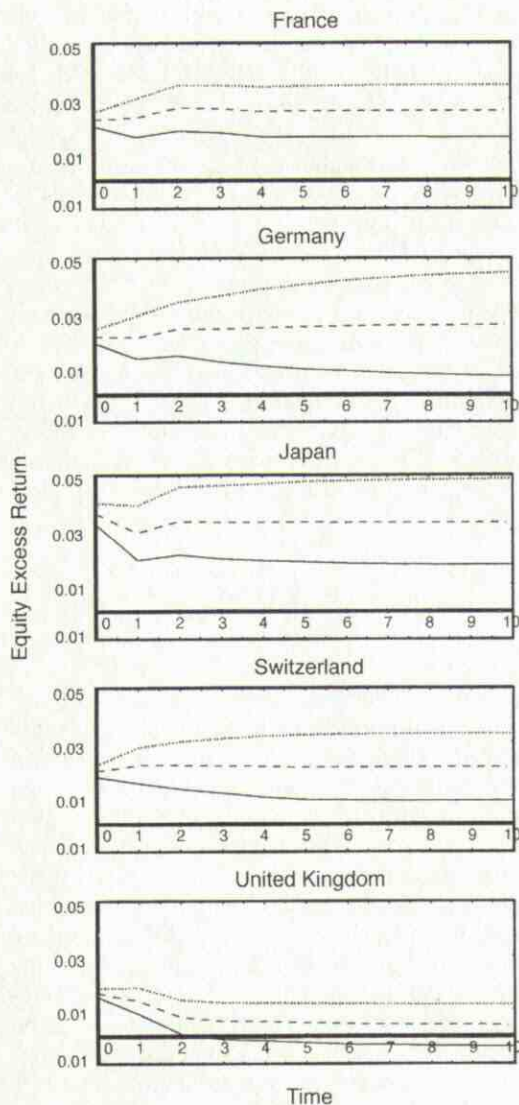


FIGURE 1. CUMULATIVE IMPULSE-RESPONSE FUNCTIONS OVER 10 MONTHS OF A FOREIGN-EQUITY EXCESS-RETURN SHOCK ON EQUITY EXCESS RETURNS

Note: Confidence intervals of two standard deviations are shown.

predetermine the results. The decomposition of the variance-covariance matrix uses only three free parameters (three rotation angles) to fit a total of six theoretical moments. Rejection of one or more of the six conditional correlation implications by the data is therefore possible.

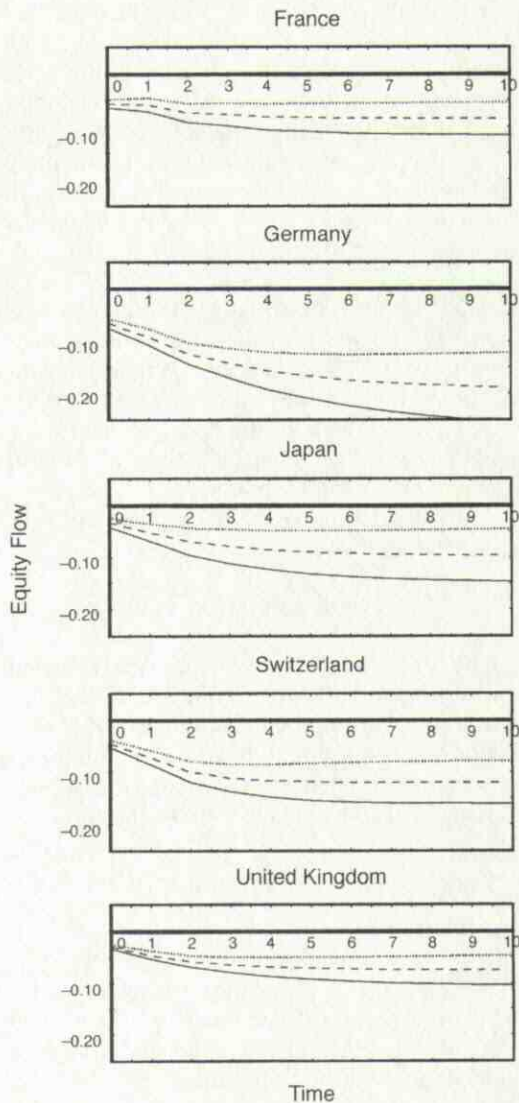


FIGURE 2. CUMULATIVE IMPULSE-RESPONSE FUNCTIONS OVER 10 MONTHS OF A FOREIGN-EQUITY EXCESS-RETURN SHOCK ON U.S. EQUITY OUTFLOWS INTO THE FOREIGN COUNTRY

Note: Confidence intervals of two standard deviations are shown.

As a robustness check, we also examine whether each conditional moment in the penalty function is necessary for obtaining the corresponding empirical moment. We therefore drop consecutively one of the six conditional moments in the penalty function and reproduce the impulse response on the reduced set of priors.

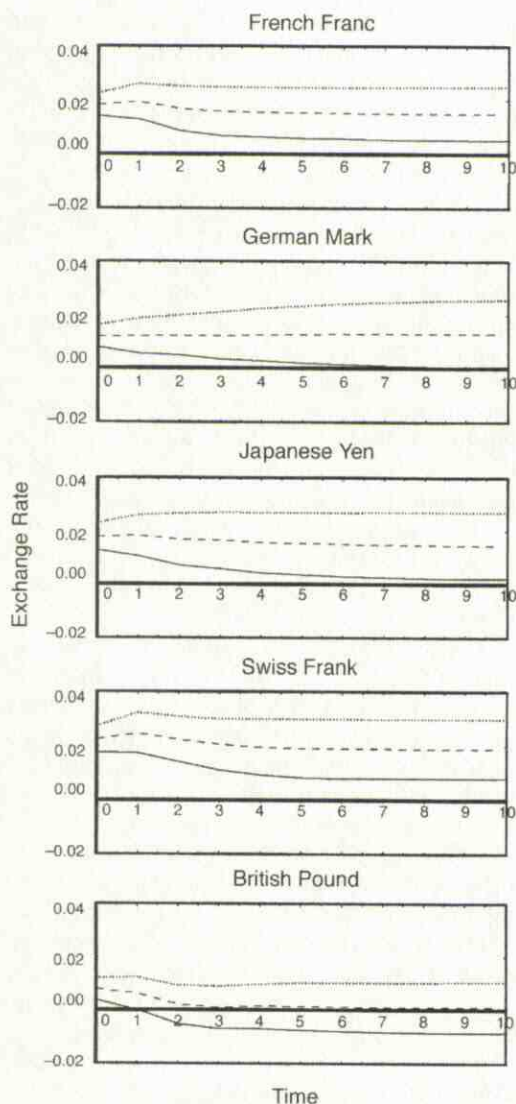


FIGURE 3. CUMULATIVE IMPULSE-RESPONSE FUNCTIONS OVER 10 MONTHS OF A FOREIGN-EQUITY EXCESS-RETURN SHOCK ON EXCHANGE-RATE RETURN FOR THE FIVE SAMPLE COUNTRIES

Note: Confidence intervals of two standard deviations are shown.

The impulse response functions do not change qualitatively.³ In particular, each sign of the conditional moment which is excluded from

³ The exception is Japan, for which the impulse responses of the equity excess return to the exchange-rate innovation changed from positive to negative when the correlation $\rho_{12|s_3}$ is dropped from the penalty function.

the penalty function is confirmed empirically in the data based on the remaining priors.

IV. Data

We focus our empirical analysis on bilateral equity flows between the United States and the five biggest equity markets, namely, France, Germany, Japan, Switzerland, and the United Kingdom. Our portfolio flow data come from the so-called TIC data base produced by the U.S. Treasury department. Available on a monthly frequency, the TIC data record equity transactions between U.S. residents and residents of foreign countries. The data have been carefully described by William L. Grier et al. (2001) and allow us to compute (for each of the above countries) net purchases of foreign equity by U.S. residents, as well as net purchases of U.S. equity by foreign residents. Furthermore, we can calculate the gross transaction volumes between U.S. (home) and foreign residents for both the home and foreign equity market. Since portfolio flows have enormously increased over the last decade, we use the combined bilateral gross equity trading volumes in both the home and the foreign markets as a denominator to scale net flows.⁴ Net equity flows from the United States are therefore stated in percentages of the gross bilateral equity transaction volume. The standard deviations for the net capital flows are 0.076 for France, 0.091 for Germany, 0.091 for Japan, 0.073 for Switzerland, and 0.04 for the United Kingdom.

The monthly equity return data come from the Morgan Stanley Capital International (MSCI) index and are calculated for end-of-month prices in the local currency. Similarly, exchange-rate returns are calculated based on U.S. dollar exchange rates at the end of each month where we use again MSCI data. A positive exchange rate return corresponds to a dollar appreciation relative to the foreign currency. We focus on the sample period January 1990–September 2003 (for a plot of the data, see the supplement on the AER web site).⁵ Underlying

⁴ Average monthly bilateral gross equity volume for the period 1990–2003 amounts to \$19.8 billion for France, \$9.8 billion for Germany, \$24.1 billion for Japan, \$11.8 billion for Switzerland, and \$95.8 billion for the United Kingdom.

⁵ URL: <http://www.aeaweb.org/aer/contents/>

this sample selection is the fact that global equity flows became very important in magnitude only in the 1990's. Due to the creation of the euro in 1999, the last four years of exchange-rate data coincide for France and Germany.

V. Results

We consecutively provide the results for innovations to the foreign-equity excess return, to the equity flows, and finally the exchange-rate return. All graphs represent the cumulative impulse-response functions over 10 months for a shock of one standard deviation. Shocks and impulse-response functions are always relative to the United States, where each of the five countries is represented by a different row. Using the standard criteria, we found that an AR(2) process provided a good fit to the data. A confidence band of two standard deviations was constructed based on 250 simulations of the data process.

Figures 1–3 provide the results for equity-return shocks. Figure 1 plots the impulse response of the equity-return shock on the excess return itself. Figure 2 plots the impulse response on the equity flows from the United States into each country, and the Figure 3 characterizes the impulse response on exchange-rate returns. Excess-return shocks are persistent over the 10-month period for all countries. Only for the United Kingdom is the persistence of the equity-return shock unclear. The role of foreign excess-return shocks on equity portfolio flows is depicted in Figure 2. Higher foreign equity-market returns compared to the U.S. market come with negative equity flows or equity flows from the foreign country to the United States. This evidence is in line with the portfolio-rebalancing channel where investors reduce their exchange-rate exposure if the foreign wealth share increases. This portfolio rebalancing occurs for all five countries and occurs slowly over a few months. The exchange-rate impact by contrast is immediate and positive in each case (Fig. 3). This means that the dollar appreciates as equity funds flow into the United States. Only with respect to the British pound can we not assert a long-run dollar appreciation. It is also interesting to look at the magnitude of the exchange-rate effect. For example, a 4-percent French equity excess return over a

month (one standard deviation) comes with an average 5-percent equity outflow from France to the United States, which amounts to approximately one billion dollars (relative to a monthly gross volume of 20 billion dollars) and leads to a 2-percent dollar appreciation.

It is also interesting to examine the impulse-response functions for an equity-flow innovation into the foreign country (see the supplement on the AEA website). The flow innovations produce persistent foreign equity-market excess returns in each of the five countries. The flow innovations are persistent as shown in the supplement, and so is their impact on the exchange rate. Portfolio outflows from the United States into the foreign equity market depreciate the dollar persistently and significantly in all five country cases. This result supports the idea that international-equity portfolio shocks move exchange rates and influence equity excess returns.

The third type of shock concerns exchange-rate innovations (the respective impulse-response functions are depicted in the supplement on the AEA web site). A dollar appreciation relative to the foreign currency leads to U.S. equity outflows into each of the five countries. This is again consistent with a portfolio balancing channel, where equity is reallocated away from the appreciating foreign market. At the same time the foreign market registers an excess return.

Finally, we can undertake a variance decomposition for the three variables. Equity-flow shocks and relative equity-return shocks explain between 10 and 20 percent of the exchange-rate variance. Moreover, this rate increases to 20 percent for all five countries in the subsample period 1997–2004. The variance decomposition does not depend on the identification procedure adopted here and highlights the new important role of equity markets for exchange-rate dynamics.

VI. Conclusions

This paper has investigated whether the international data on equity-market returns, equity portfolio flows, and exchange-rate returns are consistent with a dynamic rebalancing of foreign equity positions on the part of global investors. We hypothesized that a larger wealth share held in foreign assets after either foreign equity-market excess returns (H1) or a foreign

currency appreciation (H2) may trigger a reallocation of equity funds away from the foreign country to the United States and a simultaneous dollar appreciation. Underlying this mechanism is the increased FX exposure of the global investor if FX risk-trading is imperfect. Moreover, portfolio flow shocks into the foreign country directly depreciates the dollar and creates foreign-equity excess returns (H3).

We find that the data are consistent with all three of these hypotheses. To arrive at this conclusion, we use an identification procedure which does not require any causal ordering of the primitive shocks. The low-frequency nature of the portfolio flows and the inclusion of two price variables in the VAR appear inconsistent with any particular causal ordering. Instead, we undertake the variance-covariance decomposition in accordance with our theoretical priors concerning six different contemporaneous conditional correlations of the data process. We choose the particular MA representation in orthogonal shocks which is "most favorable" to the theory. This most favorable MA representation fulfills all three hypotheses for each of the five countries. The data are therefore consistent with an important role of the portfolio rebalancing channel to explain exchange-rate and equity returns. They are also consistent with a persistent exchange-rate and equity-price impact of equity-flow innovations.

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