International Equity Flows and Returns: A Quantitative Equilibrium Approach*

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Abstract

This paper considers the role of foreign investors in developed-country equity markets. It presents a quantitative model of trading that is built around two new assumptions: (*i*) both the foreign and domestic investor populations contain investors of different sophistication, and (*ii*) investor sophistication matters for performance in both public equity and private investment opportunities. The model delivers a unified explanation for three stylized facts about US investors' international equity trades: (*i*) trading by US investors occurs in bursts of *simultaneous* buying and selling, (*ii*) Americans build and unwind foreign equity positions gradually and (*iii*) US investors increase their market share in a country when stock prices there have recently been rising. The results suggest that heterogeneity *within* the foreign investor population is much more important than heterogeneity of investors across countries.

JEL Classification: F30, G12, G14, G15.

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1 Introduction

The role of foreign investors in financial markets is an important unresolved issue in international finance. Does participation of foreigners destabilize a stock market, or does it make that market more efficient? Or does participation of foreigners not really change how the market operates? An answer to these questions must take a stand on motives for trade, and hence on how investors differ. Existing literature on international equity markets argues that *cross-country* heterogeneity of investors is important: foreign investors are homogenous, but they know less about domestic stocks than local investors. This paper reconsiders the link between differences in investor sophistication and international equity flows using a dynamic general equilibrium model that is calibrated to data from the G7 countries.

We make two new assumptions. First, we allow for *within-country* differences in investor sophistication. This assumption is particularly suitable for modern industrial-country stock markets, where the best (and worst) foreign and local traders tend to have very similar backgrounds and skills. It is also supported by recent empirical studies on individual trading behavior and performance.[1] Our second assumption is that sophistication is not only reflected in better information about stocks, but also in higher ability to locate off-market private investment opportunities. This is in the spirit of Merton's (1987) investor recognition hypothesis: some investors scan the economy more carefully for investment opportunities than others. Sophisticated investors should thus not only be better at market research, but they should also be more likely to find good deals off the stock market that are not recognized by other investors.

Under these assumptions, asking about the role of foreign investors is essentially asking whether within-country or cross-country differences in sophistication are more important. To provide a quantitative answer, we construct a model of the stock market in a small open economy, with both types of heterogeneity present. We then calibrate this model to quarterly data on dividends, returns, volume, and US investors' aggregate gross and net trades in the G7 countries. Our main finding is that *within-country heterogeneity is much more important than cross-country heterogeneity.* We do find that foreign and domestic investor populations differ: in line with previous literature, the average US-based participant in a foreign market appears somewhat less sophisticated than the average local participant. However, for all countries, a model that matches the data well must have the property that cross-country differences between average trades

[1] We provide a detailed review of the literature in Section 2.

are much smaller than within-country differences between trades of sophisticated and unsophisticated investors.

We verify that our calibrated models account for key stylized facts on the joint distribution of quarterly equity flows and returns. In particular, our approach delivers a unified explanation for two regularities that are prominent in the empirical literature. On the one hand, it generates realistic amounts of *flow momentum* – persistence in net purchases of foreign equity by US investors. In all G7 country stock markets, Americans build and unwind foreign positions gradually: a net purchase of foreign equity by US investors in some quarter predicts further net purchases at least over the following 2 quarters. On the other hand, net flows exhibit *return chasing* – both current and lagged local stock returns are positively correlated with current net purchases by US investors, normalized by foreign market capitalization. US investors thus chase returns: when they see foreign stock prices increase, they buy foreign shares from local investors.

Persistence and return chasing are both facts about *net* equity flows, the series that existing literature has focused on. Net flows are due to cross-country heterogeneity. Within-country heterogeneity matters for *gross* flows. To see this, consider a shock that makes sophisticated investors buy shares from unsophisticated investors. This shock will generate a burst of *simultaneous* buying and selling by the population of Americans, which contains members of both groups. Within-country heterogeneity thus induces substantial positive contemporaneous correlation in US investors' aggregate gross purchases and sales of foreign equity. We document this new stylized fact for all G7 countries.

To see how our model accounts for the stylized facts, it is helpful to first clarify why investors trade. One motive for trade is *risk sharing*. Payoffs from private opportunities tend to be high in booms, when stock prices also rise. As a result, sophisticated investors who find good opportunities will try to sell stocks to share business cycle risk with unsophisticated investors. The second motive for trade is *disagreement* about expected stock returns. Disagreement occurs in equilibrium because stock prices do not reveal all of sophisticated investors' information. Some of this information is about the local business cycle. However, there are also signals about expected private returns that are orthogonal to the local business cycle. Unsophisticated investors cannot tell whether stock prices move because of business cycle information or because of other signals that are only relevant for private opportunities.

Now consider the beginning of a typical boom in our small open economy. As good news about the business cycle arrives, all investors update their assessment of future cash flows and stock prices begin to rise. At the same time, sophisticated investors increasingly locate profitable off-market opportunities. To exploit private opportunities without unduly increasing exposure to business cycle risk, they begin to sell stocks. With heterogeneous investor populations, this generates both volume and, in international data, a burst of gross trading activity. Moreover, since the average American is less sophisticated than the average local investor, the US population is buying foreign stocks as prices are rising.

The above risk-sharing trades are slowed down by disagreement: unsophisticated investors who have less information about the state of the business cycle are initially less optimistic and will only buy stocks at a discount. However, a string of favorable returns can help convince them that a boom is under way. This predictably leads to more net purchases by unsophisticated investors and hence more net purchases by Americans. In contrast, sophisticated investors sell more and more stocks as the peak of the boom is approached. Only as the economy weakens and profitable private opportunities dry up do sophisticated investors return to the market. Again, the transition is slow as unsophisticated investors, who were overly optimistic at the peak, gradually revise their opinion.

The calibrated models do a good job in matching the autocorrelation functions of US investors' net purchases in the different countries.[2] Indeed, the models predict not only flow momentum (positive autocorrelation at short horizons of 1-3 quarters), but also *flow reversal*, that is, negative autocorrelation at longer horizons (5-7 quarters). This prediction derives from business cycle swings in trading – momentum and reversal are also features of the persistent component of dividends. In the data, there is strong evidence for flow reversal in Canada, France and Germany, and somewhat weaker evidence for Japan and Italy. By and large, the models also do a decent job for the cross-correlogram of flows and returns.

Return chasing is often cited as an example of irrational behavior by foreign investors. This view was countered by Bohn and Tesar (1996) who constructed estimates of expected local returns based on public information. They showed that American investors tend to buy precisely when these expected returns are high. To further assess the performance of our model, we replicate the Bohn-Tesar exercise in our model economies. We consistently find that the calibrated models also predict positive correlation between expected returns conditional on public information and net purchases by US investors: the unsophisticated foreign investors in our models. This provides further support for our model and for a

[2] The only exception is the UK. We suspect that this failure of the model is due to the importance of London as an international financial center and the associated known problems with flow data for the UK. This is discussed further below.

rational view of return chasing.

The ability of our model to match the dynamics of equity flows relies on two features that distinguish it from most other asymmetric information setups. First, there are no noise traders. Many models use serially independent supply shocks as a device to guarantee disagreement between traders in a rational expectations equilibrium. The first difference of these supply shocks is interpreted as noise trades. However, the first difference of a serially independent process is a negatively autocorrelated MA(1) process. By construction, noise trades are thus reversed after one period. This implies that they induce *negative* serial correlation in net purchases, a fact not observed in the data.

In contrast, in our model disagreement arises from an interplay of imperfect and asymmetric information. The true state of the business cycle is not perfectly observed by *any* investor. Since private opportunities are more profitable in booms, a high realized private return is a 'good' private signal about the business cycle, and hence about future dividends on stocks. This induces positive correlation between *unexpected* private returns and stock returns. As a result, sophisticated investors' portfolio demand for stocks, and hence stock prices, also depend on news about private opportunities that are orthogonal to the business cycle. Unsophisticated investors are unable to distinguish such news from business cycle shocks, which ensures disagreement. Since this mechanism relies on the imperfect observation of persistent factors, it is consistent with persistent trading activity.

Second, our model is based on fundamentals (the estimated dividend process) that exhibit momentum and reversal. It is often taken for granted that asymmetric information trivially generates serial correlation in flows regardless of what fundamentals look like. We show that this intuition is misleading: flow momentum does not obtain when the shocks that generate trade revert to the mean too quickly. In our model, flow momentum obtains because trades are driven by business cycle shocks that have a hump-shaped impulse response function.[3]

The argument that asymmetric information produces flow momentum is often made in finite horizon models of dynamic trading. Suppose that, in such a model, informed and uninformed investors initially disagree. Then there will typically be a string of trades in

[3] It is worth pointing out that the persistence of US net purchases, which can be positive or negative, is harder to explain than the persistence of volume, which involves an absolute value. For example, a sequence of iid noise trader holdings would induce persistent volume, but successive net trades by investors would be negatively serially correlated. Similarly, the trading volume model of Wang (1994) which is based on AR(1) fundamentals, generates persistent volume, but negative serial correlation in flows between investor types.

the same direction, as disagreement is gradually resolved through learning by uninformed investors. It thus appears that asymmetric information generates momentum in flows. However, this is only *conditional* momentum, *given* the initial disagreement. In the data, what matters is unconditional momentum, reflected in the unconditional autocorrelation of net purchases. When the latter is calculated in a model, it matters how the economy reached the initial state of disagreement. If this occurs through a shock that quickly reverts to the mean, trades are also quickly reversed in equilibrium, and there is *negative* unconditional autocorrelation!

The paper is organized as follows. Section 2 discusses the related literature. Section 3 presents the model of equity trading. Section 4 discusses the properties of equilibrium stock flows and returns. Section 5 discusses the data used in documenting the facts and in the calibration. Section 6 presents the calibration and the quantitative results. Technical details on detrending the data, estimating the dividend process and solving the model are in the Appendix.

2 Related Literature

While there is a large empirical literature on the joint distribution of international equity flows and returns, there are relatively few theoretical studies (for a survey, see Stulz 1999.) We discuss both in turn.

Empirical Work

We document a strong positive contemporaneous correlation of gross purchases and sales of US investors. This new stylized fact is important, because it rules out a large class of models in international economics and finance in which representative agents live in different countries and trade country-stock indices with each other (or accumulate aggregate capital stocks).[4] The prevalence of bursts of gross trading activity suggests that this highly aggregated view is not an appropriate way to think about capital flows. In our model, gross trading activity is instead explained by heterogeneity of investor populations.

The two other stylized facts we emphasize, flow momentum and return chasing, are well known. Bohn and Tesar (1996) have documented persistence in the aggregate US data that are also the basis for our calibration. Froot and Donohue (2002) have recently

[4]The only way for such models to be consistent with the flow data would be a strong time aggregation effect. However, Albuquerque et al. (2003) document that positive correlation between gross purchases and sales also exists at the monthly frequency.

examined persistence in international trades by individual mutual funds. Their analysis shows that the source of persistence in aggregate mutual fund investment is asynchronous trading across funds into individual countries. This result highlights the role of investor heterogeneity also emphasized in our model.

Bohn and Tesar (1996) first pointed out the return chasing phenomenon. Their paper documents positive contemporaneous correlation of flows and return at the quarterly frequency. Later work (Bohn and Tesar 1995, Brennan and Cao 1997, Choe et al. 1999, Froot et al. 2001) has shown that a lot of the contemporaneous correlation over longer periods is due to positive correlation of flows with lagged returns at higher frequencies. Our model captures both features: there is contemporaneous correlation between flows and returns, *and* returns predict flows. This suggests that the effects we identify could also be of interest for models calibrated to higher frequency data.

Evidence on investor heterogeneity comes from the literature on individual investor performance. There now exists a large number of studies that use data on individual trades to ask whether local investors outperform foreigners or vice versa. This literature has not been conclusive, with strong results in both directions, depending on the time period and the data set used.[5] This is what one would expect if there is indeed within-country investor heterogeneity. In addition, some studies have provided direct evidence on heterogeneity. In Finnish data, Grinblatt and Keloharju (2000) find differences in trading behavior and performance between domestic household investors and domestic institutions. Choe, Kho, and Stulz (2001) analyze the trading behavior of foreign investors (US and others) and domestic institutions and individuals around days of significant abnormal returns and days of large buying or selling activity in Korea. They find that foreign investors trade at worse prices relative to domestic individuals, but not relative to domestic institutions.

Theoretical work

The structure of our model is similar to that in Wang's (1994) seminal paper on trading volume. In Wang's model, some agents who obtain private information also

[5] For studies that suggest an advantage of domestic traders, see Frankel and Schmukler (1996) for Mexico and Hau (2001) for Germany. Hamao and Mei (2001) find no significant evidence that foreigners are able to time the Japanese stock market. In contrast, Karolyi (1999) documents that foreign investors outperform domestic investors in Japan. Grinblatt and Keloharju (2000) obtain the same result for Finland. Seasholes (2000) finds that foreign investors in Taiwan systematically accumulate assets before positive earnings announcements and systematically sell assets before negative earnings announcements. Froot and Ramadorai (2001) show that unexpected inflows into closed-end funds cause an increase in the prices of both the net asset value of the fund and that of the fund itself, indicating that foreign investors have significant private information.

invest in a private asset. While the expected returns on the private asset are perfectly observed by informed investors and independent of dividends, a non-revealing rational expectations equilibrium obtains if dividends are correlated with unexpected returns on the private asset. In contrast, our model relies on imperfect information by all investors and on a more general factor structure required to match the data. This gives rise to a different argument for nonrevelation, as discussed above.

There are many models of foreign equity holdings, in particular of equity home bias (for a survey, see Lewis 1999.) However, the theoretical literature on *flows* is relatively recent. To our knowledge, there is no prior theoretical work on gross flows and their connection to volume and net flows. Brennan and Cao (1997) started the literature on *net flows.* They emphasized the contemporaneous correlation of net flows and returns. In their model, foreign investors are less informed than domestic investors. This not only generates home bias, but it also implies that foreign investors react more to public information. If private information accumulates slowly, their model predicts positive contemporaneous correlation of foreigners' net purchases and returns, as in the data. The overreaction effect stressed by Brennan and Cao is also present in our model: unsophisticated investors mistake a temporary shock to dividends for a persistent shock and become net buyers. However, since this type of shock is temporary, it is quickly reversed and contributes negatively to the autocorrelation of flows. For our calibrated models, variance decompositions show that this limits the contribution of temporary dividend shocks relative to the persistent business cycle shocks discussed above.

Brennan and Cao (1997) do not analyze the flow dynamics implied by their model. Similarly, Coval (1999), who studies a quantitative two-country model with asymmetrically informed investors does not use his model to consider any of the stylized facts we look at. Hau and Rey (2002) develop a model of international equity flows in the presence of exchange rate risk and a price-elastic supply of foreign exchange according to which a Euro appreciation (say relative to the US dollar) decreases the excess supply of euros. Their model does well in explaining correlations between currency and equity returns. However, it fails to deliver positive contemporaneous correlation between foreign investors' net purchases and local returns. This is because foreign investors sell local equities when local equity returns are high, but local currency returns are low. Griffin et al. (2002) study a two-country model to explain the daily behavior of flows and returns in emerging markets. They generate return chasing by assuming that foreigners have what they call 'extrapolative expectations'. They argue that such expectations could be caused by irrational or updating behavior. In our model, the rational expectations of unsophisticated investors endogenously have the 'extrapolative' property. As described above, this rational return chasing implies that our model is also consistent with the fact that foreign investors' net purchases are positively correlated with expected returns conditional on public information as measured by econometricians.

3 The Model

In this section, we first present a model of a small open economy in which sophisticated and unsophisticated investors trade stocks. We then derive expressions for various statistics of trading activity when investors belong to two heterogeneous populations identified by nationality. In particular, the population of US investors will contain both sophisticated and unsophisticated investors.

3.1 Setup

Preferences

There is a continuum of infinitely-lived investors. A fraction ν_U of investors is unsophisticated (indexed by U), while a fraction $1 - \nu_U$ is sophisticated (indexed by S). Investors have identical expected utility preferences that exhibit constant absolute risk aversion (CARA). At time t, an investor of type $i = U, S$ ranks contingent consumption plans $\{c_l^i\}_{l=t}^{\infty}$ according to

$$-E\left[\sum_{l=t}^{\infty} \beta^{(l-t)} \exp^{-\gamma c_l^i} |\mathcal{I}_t^i\right], \tag{1}$$

where $\beta < 1$ is the discount factor, $\gamma > 0$ is the coefficient of absolute risk aversion and $\mathcal{I}_t^i$ is the information set at time t, to be specified below.

Investment Opportunities

There are three assets that are available to all investors. First, a risk-free bond pays a constant gross rate of return of R_f. Second, a risky "world asset" pays a simple excess return of R_t^W in period t. Third, all investors participate in the domestic stock market. The single asset traded in this market is a claim to the dividend stream $\{D_t\}$. At date t, shares trade at a per-share ex-dividend price of P_t, and hence deliver a per-share excess return of $R_t^D = P_t + D_t - R_f P_{t-1}$. A single share is traded every period. A fourth asset is accessible to sophisticated investors alone; we refer to it as a private investment opportunity and denote its simple excess return by R_t^B.

Dividends and asset returns are subject to both persistent and transitory shocks. Let F_t^D denote the persistent component of dividends. Returns on private opportunities are predictable, and the expected return is correlated with dividends. Other fluctuations in the expected return on the private opportunity are summarized by a state variable F_t^B, independent of F_t^D, that we label the "off-market factor." Both state variables can depend on two lags of themselves. Letting $\mathbf{F}_t = \left(F_t^D, F_{t-1}^D, F_t^B, F_{t-1}^B\right)'$, the distribution of dividends and returns is summarized by:

$$\begin{aligned} D_t &= \bar{D} + F_t^D + \varepsilon_t^D && (2) \\ R_t^B &= \bar{R}^B + \eta_D F_{t-1}^D + \eta_B F_{t-1}^B + \varepsilon_t^B && (3) \\ R_t^W &= \bar{R}^W + \varepsilon_t^W && (4) \\ \mathbf{F}_t &= \boldsymbol{\rho}\mathbf{F}_{t-1} + \boldsymbol{\varepsilon}_t^F. && (5) \end{aligned}$$

Bold-faced letters denote vectors and matrices, and variables with bars denote unconditional means. All shocks are components of the vector process $\boldsymbol{\varepsilon}_t := \left(\boldsymbol{\varepsilon}_t^{F\prime}, \varepsilon_t^D, \varepsilon_t^W, \varepsilon_t^B, \varepsilon_t^y\right)'$ that is serially uncorrelated and normally distributed with mean zero and covariance matrix $\boldsymbol{\Sigma}_{\varepsilon\varepsilon}$. In addition, the matrices $\boldsymbol{\rho}$ and $E\left(\boldsymbol{\varepsilon}_t^F \boldsymbol{\varepsilon}_t^{F\prime}\right)$ are block diagonal and $\boldsymbol{\varepsilon}_t^F$ is uncorrelated with all other shocks. The shock ε_t^y is described below.

Information

At date t, all investors know past and present stock prices and dividends as well as returns on the world asset. The unsophisticated investors have no additional information, that is, $\mathcal{I}_t^U = \left\{P_{t-l}, D_{t-l}, R_{t-l}^W\right\}_{l=0}^{\infty}$. Sophisticated investors not only know $\mathcal{I}_t^U$, but they also observe: (i) past and present returns on their private opportunities; (ii) the factor F_t^B; and (iii) a signal $y_t^S = F_t^D + \boldsymbol{\varepsilon}_t^y$ about the persistent component of dividends, where $\boldsymbol{\varepsilon}_t^y$ is uncorrelated with all other shocks. All sophisticated investors observe the same signals. They thus share the information set $\mathcal{I}_t^S = \left\{P_{t-l}, D_{t-l}, R_{t-l}^W, R_{t-l}^B, F_{t-l}^B, y_{t-l}^S\right\}_{l=0}^{\infty}$.

Portfolio Choice

The budget constraint of investor i at date t is

$$w_{t+1}^i = R_f\left(w_t^i - c_t^i\right) + \boldsymbol{\psi}_t^{i\prime}\mathbf{R}_{t+1}^i, \qquad (6)$$

where w_t^i is beginning-of-period wealth and where the vectors $\boldsymbol{\psi}_t^i$ and $\mathbf{R}_t^i$ denote holdings and returns of assets that are available to investor i. In particular, for sophisticated investors $\boldsymbol{\psi}_t^S = \left(\theta_t^S, \psi_t^{WS}, \psi_t^{BS}\right)'$ and $\mathbf{R}_t^S = \left(R_t^D, R_t^W, R_t^B\right)'$, and for unsophisticated investors $\boldsymbol{\psi}_t^U = \left(\theta_t^U, \psi_t^{WU}\right)'$ and $\mathbf{R}_t^U = \left(R_t^D, R_t^W\right)'$. Here, θ_t^S and θ_t^U denote the number of local stocks held by sophisticated and unsophisticated investors, respectively. Investor i chooses contingent plans for consumption $\{c_l^i\}_{l=t}^{\infty}$ and asset holdings $\{\boldsymbol{\psi}_l^i\}_{l=t}^{\infty}$ to maximize expected utility (1), conditional on the information set $\mathcal{I}_t^i$ and the budget constraint (6).

Equilibrium

A rational expectations equilibrium is a collection of stochastic processes $\{c_t^U, c_t^S, \boldsymbol{\psi}_t^U, \boldsymbol{\psi}_t^S, P_t\}$ for consumption, asset holdings and the domestic stock price such that: (i) both types of agents choose optimal portfolios and consumption given prices; and (ii) the domestic stock market clears:

$$\nu_U \theta_t^U + (1 - \nu_U)\,\theta_t^S = 1. \tag{7}$$

A key feature of this equilibrium is that agents look at current and past prices to update their beliefs about variables they do not observe. In particular, unsophisticated investors will try to learn from prices about the return on private opportunities and the signal y_t^S received by sophisticated investors about the persistent component of dividends.

International Equity Flows

To apply the model to data on US investors' trades in international markets, we assume that there are two investor nationalities: US investors, who have accounts in the US, and local investors. The US and local populations both contain sophisticated and unsophisticated types. Let ν^* denote the measure of US investors and let ν_U^* denote the fraction of unsophisticated US investors relative to all US investors. Aggregate US holdings of the local asset are given by

$$\theta_t^* = \nu^* \left[\nu_U^* \theta_t^U + (1 - \nu_U^*)\,\theta_t^S\right].$$

Trade is only due to the heterogeneity of sophisticated and unsophisticated investors. The market clearing condition (7) thus implies that we can write all relevant statistics in terms of the holdings or trades of just one type. We choose to express everything in terms of unsophisticated investors' holdings. For example, US holdings of local equities can be written as

$$\theta_t^* = \nu^* \left[\frac{1 - \nu_U^*}{1 - \nu_U} + \frac{\nu_U^* - \nu_U}{1 - \nu_U}\theta_t^U\right]. \tag{8}$$

Remarks

Our model differs from standard small open-economy models, in that the expected return on the domestic stock market is endogenous, while the riskless rate, the world asset return and the return on the off-market asset are taken as exogenous. In other words, we do not assume that there is one (exogenous) pricing kernel that can be used to price all assets. The simplest way to interpret our setup is that there is market segmentation. The domestic market is used by domestic investors as well as by a subset of US investors who are themselves small relative to the US market. The world asset (the US stock market index, say) is priced by the majority of US investors who do not participate in the country under consideration.

Our approach thus *assumes* that equity home bias exists, and that it exists because of limited American participation in foreign markets. Our goal here is not to explain the world distribution of holdings of all assets, but trades in the stock market under consideration, conditional on home bias. We thus only model participants in that market explicitly. We also make the simplifying assumption that the world return is unpredictable and that shocks ε_t^W to the world return are independent of all other shocks in $\boldsymbol{\varepsilon}_t$. This assumption is counterfactual for industrial countries, and it could be relaxed to accommodate a common factor in returns and fundamentals.[6] However, while it is not clear that this extension is important for the properties of *flows* we are interested in here, the mechanisms stressed below would still be present in the richer model. Moreover, Bohn and Tesar (1996) document that there is only a weak relationship between US investors' international equity flows and US equity returns, which suggests that our mechanism would still be first order for flows.

We have referred to the fourth asset broadly as "private investment opportunities". These opportunities (i) become available to a subset of market participants that is also well-informed about the market itself; and (ii) are too costly to observe and access for all other market participants. Examples of such opportunities are private equity, real estate, foreign exchange or derivatives markets. Importantly, our story does not require that the type of opportunity always be the same. All that matters is that, from time to time, the well-informed part of the population discover some new way to invest that is not known to everybody.

Lack of knowledge by unsophisticated investors has several possible interpretations. One possibility is that the private opportunity is secret. More generally, one can think of unsophisticated investors as people who only concentrate on a subset of the available public information. Even though in principle there may be data on the latest investment opportunity that sophisticated investors exploit, unsophisticated investors, who are not

[6] See Dumas et al. (2002) for a model of world stock returns and output that emphasizes cross-country correlation.

sure where to look, prefer to focus just on stock market information that they know how to process. In our model, they process this information optimally: they know the stochastic processes for prices and update their beliefs by Bayes' rule. The ability of sophisticated investors to recognize investment opportunities that are not readily (or costlessly) available to unsophisticated investors is also present in Merton (1987) and Shapiro (2002).

An important feature of our setup is that sophisticated investors have better information about the persistent component of dividends. Sophisticated investors are thus agents who are better at analyzing medium-term prospects. An alternative assumption would have been to allow the signal to depend on future dividends. In that case, the signal would not only provide information about the long-run path of dividends, but also about short-term fluctuations in dividends. More trades based on private information would exist as sophisticated investors mistakenly responded to short run fluctuations in dividends, inducing more negative serial correlation in flows. In our calibration below, we decompose our estimated dividend process into a persistent and a transitory component. The precision of the signal y_t^S then regulates the knowledge of sophisticated investors relative to unsophisticated investors on the persistent component.

3.2 Stationary Equilibria

Let $\hat{\mathbf{F}}_t^i = E\left[\mathbf{F}_t | \mathcal{I}_t^i\right]$ denote investor i's conditional expectation of the vector $\mathbf{F}_t$ that drives persistent movements in fundamentals. Since $\mathcal{I}_t^U \subset \mathcal{I}_t^S$, the law of iterated expectations implies $\hat{\mathbf{F}}_t^U = E\left[\hat{\mathbf{F}}_t^S | \mathcal{I}_t^U\right]$. In other words, $\hat{\mathbf{F}}_t^U$ is the unsophisticated investors' expectation of what sophisticated investors expect $\mathbf{F}_t$ to be. We focus on equilibria in which the price can be written as a linear function of these expectations:

$$P_t = \bar{\pi} + \boldsymbol{\pi}_S' \hat{\mathbf{F}}_t^S + \boldsymbol{\pi}_U' \hat{\mathbf{F}}_t^U, \tag{9}$$

for some constants $\bar{\pi}$, $\boldsymbol{\pi}_S$, and $\boldsymbol{\pi}_U$.

Theorem 1 *There exists a rational expectations equilibrium such that the price satisfies (9). Equilibrium prices and asset holdings are stationary. Investor i's equilibrium stock holdings take the form*

$$\theta_t^i = \bar{\theta}^i + \boldsymbol{\Theta}^i \hat{\mathbf{F}}_t^U. \tag{10}$$

The equilibrium has two important properties. First, equilibrium prices do not reflect the true values of the persistent components of dividends or private returns, but only investors' perceptions of them. In contrast, in Wang (1994) some investors have full information. Second, holdings of both sophisticated and unsophisticated investors only depend on unsophisticated investors' estimates of the persistent factors $\hat{\mathbf{F}}_t^U$. Trading of sophisticated investors thus differs from trading of unsophisticated investors because of the weights placed on each of these factors. We return to this below.

We now sketch the main argument for the theorem, while a complete proof is relegated to the appendix. Consider first the agents' payoff-relevant information. Suppose the information sets $\mathcal{I}_t^i$ contain only normal random variables. This implies normality of the conditional expectations $\hat{\mathbf{F}}_t^i$, and, if the price satisfies (9), also of all per-share returns. It follows that $\boldsymbol{\phi}_t^S = \left(\hat{\mathbf{F}}_t^{S\prime}, \hat{\mathbf{F}}_t^{U\prime}\right)'$ is a sufficient statistic for forecasting all future returns, given the information set $\mathcal{I}_t^S$.

Similarly, $\boldsymbol{\phi}_t^U = \hat{\mathbf{F}}_t^U$ is a sufficient statistic for forecasting returns given the information set $\mathcal{I}_t^U$. This includes one-step-ahead returns, since the current price can be written as a function of $\hat{\mathbf{F}}_t^U$. Indeed, unsophisticated investors know $\hat{\mathbf{F}}_t^U$, so that observing the price is the same as observing the signal

$$y_t^U = P_t - \bar{\pi} - \boldsymbol{\pi}_U' \hat{\mathbf{F}}_t^U = \boldsymbol{\pi}_S' \hat{\mathbf{F}}_t^S.$$

But then $\boldsymbol{\pi}_S' \hat{\mathbf{F}}_t^U = E\left[\boldsymbol{\pi}_S' \hat{\mathbf{F}}_t^S | \mathcal{I}_t^U\right] = \boldsymbol{\pi}_S' \hat{\mathbf{F}}_t^S$ and we can write the price as $P_t = \bar{\pi} + \left(\boldsymbol{\pi}_S' + \boldsymbol{\pi}_U'\right) \hat{\mathbf{F}}_t^U$. It follows that the state vector $\boldsymbol{\phi}_t^i$ captures the payoff-relevant information of investor i's consumption-savings and portfolio choice problem.

An important feature of exponential utility is that optimal portfolios are independent of wealth and linear in the agents' state vector. The coefficients $\overline{\boldsymbol{\theta}}^i$ and $\boldsymbol{\Theta}^i$ will typically depend on the distribution of the exogenous variables as well as the price coefficients $\bar{\pi}, \pi_U$ and π_S. The equilibrium condition requires that the price coefficients satisfy:

$$\begin{aligned} \nu_U \bar{\theta}^U + (1 - \nu_U)\, \bar{\theta}^S &= 1 \\ \nu_U \boldsymbol{\Theta}^U + (1 - \nu_U)\, \boldsymbol{\Theta}^S &= \mathbf{0}. \end{aligned}$$

Finding an equilibrium thus boils down to solving a nonlinear system of equations in the price coefficients.

4 Characterizing Equilibrium Flows and Returns

In this section, we derive some properties of equilibria analytically. We first discuss how beliefs evolve and why disagreement can persist in equilibrium. We then establish properties of stock prices. Finally, we calculate statistics that we use below to calibrate the model and evaluate its account of the stylized facts.

4.1 The Evolution of Beliefs

In our model, investors continually learn about the state of the business cycle and the availability of private opportunities from observing prices, dividends and private signals. Since all state variables are normal and homoskedastic, the evolution of investors' beliefs can be described by tracking conditional expectations, using the Kalman filter. The resulting equations clarify why disagreement can arise in equilibrium and how different agents over- or under-estimate shocks.

Filtering

Sophisticated investors learn about the state of the business cycle by observing dividends, returns on their private opportunities as well as their private signal. They do not learn from the price since they already know $\hat{\mathbf{F}}_t^S$ and hence $\hat{\mathbf{F}}_t^U$. We collect their relevant observables in a vector $\mathbf{o}_t^S = \left(D_t - \bar{D},\ y_t^S,\ R_t^B - \bar{R}^B - \eta_B F_{t-1}^B\right)$ that can be represented as

$$\mathbf{o}_t^S = \mathbf{M}^{oSF}\mathbf{F}_{t-1} + \mathbf{M}^{oS\varepsilon}\varepsilon_t. \tag{11}$$

Note that because the world return R_t^W is uncorrelated with everything else it does not add any relevant information. Equations (5) and (11) form a state-space system. Sophisticated investors' conditional expectation of the state vector, $\hat{\mathbf{F}}_t^S$, then takes the form

$$\begin{aligned}\hat{\mathbf{F}}_t^S &= \boldsymbol{\varrho}\hat{\mathbf{F}}_{t-1}^S + \mathbf{K}^S\left(\mathbf{o}_t^S - \mathbf{M}^{oSF}\hat{\mathbf{F}}_{t-1}^S\right) \\ &= \boldsymbol{\varrho}\hat{\mathbf{F}}_{t-1}^S + \hat{\boldsymbol{\varepsilon}}_t^S,\end{aligned} \tag{12}$$

where $\mathbf{K}^S$ is a steady-state Kalman gain matrix. The matrix $\mathbf{M}^{oS\varepsilon}$ allows errors in the observation equation (11) to be correlated with errors in the state equation (12).

Unsophisticated investors obtain valuable information from dividends as well as from the signal y_t^U contained in prices, so that $\mathbf{o}_t^U = \left(D_t - \bar{D},\ y_t^U\right)$. These variables[7] can be represented using $\hat{\mathbf{F}}_t^S$:

$$\mathbf{o}_t^U = \mathbf{M}^{oUF}\hat{\mathbf{F}}_{t-1}^S + \mathbf{M}^{oU\varepsilon}\hat{\boldsymbol{\varepsilon}}_t^S. \tag{13}$$

Equations (12) and (13) form the state space system of unsophisticated investors. Their conditional expectation, and hence their state variable $\boldsymbol{\phi}_t^U$, can be written as

$$\begin{aligned}\hat{\mathbf{F}}_t^U &= \boldsymbol{\varrho}\hat{\mathbf{F}}_{t-1}^U + \mathbf{K}^U\left(\mathbf{o}_t^U - \mathbf{M}_{t-1}^{oUF}\hat{\mathbf{F}}_{t-1}^U\right) \\ &= \left(\boldsymbol{\varrho} - \mathbf{K}^U\mathbf{M}^{oUF}\right)\hat{\mathbf{F}}_{t-1}^U + \mathbf{K}^U\mathbf{M}^{oUF}\hat{\mathbf{F}}_{t-1}^S + \mathbf{K}^U\mathbf{M}^{oU\varepsilon}\hat{\boldsymbol{\varepsilon}}_t^S.\end{aligned} \tag{14}$$

[7] The matrices are $M^{oUF} = \begin{pmatrix} \boldsymbol{\pi}'_S\boldsymbol{\rho} \\ \mathbf{M}_{1\cdot}^{oSF} \end{pmatrix}$ and $M^{oU\varepsilon} = \begin{pmatrix} \boldsymbol{\pi}'_S \\ \mathbf{e}_1 \end{pmatrix}$, where $\mathbf{e}_1$ is the first unit vector.

Finally, the law of motion of sophisticated investors' state variable $\boldsymbol{\phi}_t^S$ is summarized by (12) and (14).

Non-revealing Prices

Since the stock price acts as a signal, the information structure in the model is endogenous. We say that investors *agree about the stock market* if their conditional distributions of future stock payoffs are the same.[8] This is certainly true in the symmetric information benchmark, where investors are assumed to agree on all state variables: $\hat{F}_t^U = \hat{F}_t^S$. However, agreement about the stock market could also arise endogenously in our asymmetric information setup if prices were to reveal all relevant information about stocks.

Agreement about the stock market cannot occur in the linear equilibrium of Theorem 1. In our setup, equilibria are non-revealing, because (i) the sophisticated investor does not perfectly observe the business cycle component F_t^D, and (ii) the expected private return depends on F_t^D. Private returns R_t^B are a signal of the state of the business cycle and surprise changes in R_t^B change the conditional expectations $\hat{F}_t^{D,S} = E\left[F_t^D | \mathcal{I}_t^S\right]$ and $\hat{F}_{t-1}^{D,S}$. Because prices depend (at least) on these variables, sophisticated investors must perceive *unexpected* returns on stocks and private opportunities as correlated.[9] This implies that the price cannot be independent of *expected* private returns, and hence $\hat{F}_t^{B,S}$.

With a price that depends on both $\hat{F}^{D,S}$ and $\hat{F}^{B,S}$, unsophisticated investors cannot distinguish signals about the business cycle from signals relevant to private returns only. Suppose initially agents were in agreement: $\hat{F}_{t-1}^U = \hat{F}_{t-1}^S$. By (12), sophisticated investors then update according to the 4-dimensional innovation vector $\hat{\varepsilon}_t^S$. Unsophisticated investors observe only the pair $\left(\pi_S' \hat{\varepsilon}_t, \hat{\varepsilon}_{t,1}^S\right)$. For example, high prices could signal either good news about dividends or bad news about private return opportunities.

Disagreement about the State of the Business Cycle

Investors' opinions about the state of the business cycle, $\left(\hat{F}_t^{D,i}, \Delta \hat{F}_t^{D,i}\right)$, $i = U, S$, are key determinants of equilibrium flows and returns. The Kalman filter equations show how these conditional expectations react to shocks. We say that an investor *overreacts* (underreacts) to a shock if $\hat{F}^{D,i}$ moves more (less) than the actual state variable F^D. As

[8] Agreement about the stock market is thus weaker than symmetric information. It already obtains if $\hat{F}_t^{D,U} = \hat{F}_t^{D,S}$ and the stock price is independent of $\hat{F}^{B,S}$ and $\hat{F}^{B,U}$, even though unsophisticated investors do not know about private returns (which are not relevant to them).

[9] Here we do not require correlation between dividend shocks and unexpected returns on private opportunities under the true distribution. This is in contrast to Wang (1994), where this correlation is key to obtaining nonrevelation. His model does not have the features (i) and (ii) stressed above.

a general rule, inference about slow-moving state variables from data contaminated by temporary noise induces overreaction to temporary shocks, but underreaction to persistent shocks to the state variable. In our model, both types of investors have imperfect information about F^D and will thus overreact to ε_t^D and ε_t^B, but underreact to ε_t^{FD}.

With asymmetric information, shocks also induce disagreement. For example, consider a positive shock ε_t^{FD} to the *persistent* component of dividends. The shock is reflected in the dividend, which is observed by both investors. Sophisticated investors obtain additional information about the shock from their private signal. Unsophisticated investors, however, only see the indirect signal contained in the price. In a non-revealing equilibrium, the indirect signal is contaminated by other shocks. Sophisticated investors therefore underreact less: they end up underestimating F_t^D by less than unsophisticated investors. As a result, sophisticated investors become more optimistic. The opposite result obtains in response to a positive *temporary* shock to dividends. In response to such a shock, both investors see the dividend increase, but now sophisticated investors do not see an unusual movement in their private signal. This causes them to assign lower probability to the fact that F_t^D has moved. As a result, unsophisticated investors become more optimistic.

A positive persistent shock to private returns is fully observed by sophisticated investors. However, unsophisticated investors see only a noisy signal of the shock through a lower stock price. Since the lower price could have been also caused by a negative business cycle shock, unsophisticated investors end up underestimating the business cycle, increasing disagreement. Finally, a temporary shock to private returns will generate a noisy signal of the business cycle to sophisticated investors (as they observe the private return) and to unsophisticated investors (as they observe the stock price move.) Such a shock causes sophisticated investors to underestimate the business cycle by more if unexpected shocks to dividends and private returns are positively correlated.

4.2 Optimal Portfolio Choice

The appendix solves investor i's consumption and portfolio choice problem for $i = U, S$, given the law of motion for ϕ_t^i. The value function is

$$V\left(w_t^i; \boldsymbol{\phi}_t^i\right) = -\exp\left[-\kappa^i - \tilde{\gamma} w_t^i - \mathbf{u}_i' \boldsymbol{\phi}_t^i - \frac{1}{2} \boldsymbol{\phi}_t^{i\prime} \mathrm{U}_i \boldsymbol{\phi}_t^i\right], \tag{15}$$

where $\tilde{\gamma} = \gamma (R_f - 1) / R_f$. Risk averse investors not only care about fluctuations in wealth, but also about changes in beliefs, captured by the state vector $\boldsymbol{\phi}_t^i$. With this value function, portfolio demand is linear in investors' state variables.

To gain intuition about equilibrium holdings and trades, let $X_{t+1} = P_{t+1} + D_{t+1}$ denote the *payoff* on stocks, and define the conditional moments $\sigma_U^2 = var_t^U(X_{t+1})$, $\sigma_S^2 = var_t^S(X_{t+1})$, $\sigma_B^2 = var_t^S\left(R_{t+1}^B\right)$ and $\rho_S = corr_t^S\left(X_{t+1}, R_{t+1}^B\right)$, where conditional distributions *adjusted* for agents' taste of future large state variables ($\boldsymbol{\phi}_t^i$) are used for both agents (this is spelt out in detail in the appendix.) We then have

$$\theta_t^U = \frac{1}{\gamma\sigma_U^2}\left(\underbrace{E_t^U X_{t+1} - R_f P_t}_{\text{myopic demand}} + \underbrace{\bar{h}^U + \mathbf{H}^U \boldsymbol{\phi}_t^U}_{\text{hedging demand}}\right), \tag{16}$$

$$\theta_t^S = \frac{1}{\gamma\sigma_S^2\left(1-\rho_S^2\right)}\left(\underbrace{E_t^S X_{t+1} - R_f P_t - \rho_S \frac{\sigma_S}{\sigma_B} E_t^S R_{t+1}^B}_{\text{myopic demand}} + \underbrace{\bar{h}^S + \mathbf{H}^S \boldsymbol{\phi}_t^S}_{\text{hedging demand}}\right). \tag{17}$$

The first term in equations (16) and (17), often called myopic demand, captures responses to changes in one-period-ahead expected excess returns. Unsophisticated investors' myopic demand is simply proportional to expected per share stock returns. In contrast, as long as stock and private returns are correlated, sophisticated investors' myopic demand also depends on expected private returns. In our numerical examples, stocks and private opportunities are substitutes ($\rho_S > 0$) since they move together with the business cycle. This tends to lower sophisticated investors' demand for stocks.

The second term in equations (16) and (17) reflects intertemporal hedging demand. This demand is due to the investors' concern with movements in the state variables $\boldsymbol{\phi}_t^i$. Investor i effectively behaves as if he was holding a portfolio of nontradable assets with return vector $\boldsymbol{\phi}_{t+1}^i$. Under this interpretation, the time-varying vector of shares held in each state variable is $\mathbf{u}_i + \mathbf{U}_i' E^i\left[\boldsymbol{\phi}_{t+1}^i | \boldsymbol{\phi}_t^i\right]$. Since investors fear states of poor investment opportunities, they favor assets that pay off in precisely these states: the average hedging demand $\bar{h}^i$ is particularly high for such assets. Moreover, since investors desire unusually good opportunities, their exposure to a state variable increases if that state variable is expected to take on unusually large values.[10] This gives rise to the time-varying hedging demand $\mathbf{H}^i \boldsymbol{\phi}_t^i$.

[10] More generally, with a vector of state variables, exposure to, say, the first element increases if complementary elements are expected to be high. Complementary elements are those for which the product with the first element yields high utility.

4.3 Equilibrium Prices, Predictability and Hedging

In our numerical results below, (i) the local stock price P_t depends strongly and positively on the level and change in the local business cycle $\left(\hat{F}_t^{D,i}, \Delta\hat{F}_t^{D,i}\right)$, (ii) P_t depends weakly and negatively on the level and change in the off-market factor $\left(\hat{F}_t^{B,i}, \Delta\hat{F}_t^{B,i}\right)$, and (iii) considerations of intertemporal hedging are crucial to understand the behavior of sophisticated investors, while they are largely irrelevant for unsophisticated investors. These properties of the model are closely connected. To see this, it is helpful to first write P_t as a weighted average of two hypothetical stock prices P_t^U and P_t^S that would arise in economies inhabited by only one type of agent.

Decomposition of the Stock Price

Using (16), (17) and the market clearing condition (7) for local stocks, we obtain:[11]

$$\begin{aligned} P_t &= \tilde{\nu}_U P_t^U + (1-\tilde{\nu}_U) P_t^S \\ P_t^U &= \beta E_t^U X_{t+1} - \beta\left[\gamma\sigma_U^2 - \left(\bar{h}^U + \mathbf{H}^U \boldsymbol{\phi}_t^U\right)\right] \\ P_t^S &= \beta E_t^S X_{t+1} - \beta\left[\gamma\sigma_S^2\left(1-\rho_S^2\right) - \left(\bar{h}^S + \mathbf{H}^S \boldsymbol{\phi}_t^S\right)\right] - \beta\rho_S \frac{\sigma_S}{\sigma_B} E_t^S R_{t+1}^B. \end{aligned} \quad (18)$$

The price P_t^U is the price in a representative-agent model with no private opportunities: it equals the present discounted payoff minus a risk premium – the constant myopic premium $\beta\gamma\sigma_U^2$, less the intertemporal hedging demand. This suggests that *the presence of unsophisticated investors reduces the time variation in risk premia.* Indeed, since unsophisticated investors have no access to private opportunities, their hedging demand can only come from predictability of excess local stock returns. If expected excess returns are close to constant, the same is true for the hedging demand. The price can be determined by solving forward the equation for P_t^U (with $X_t = D_t + P_t^U$). It follows that price changes mostly reflect changes in the expected future dividends, and expected excess returns must indeed be close to constant. This logic implies low predictability for an actual representative-agent economy with unsophisticated investors. The result carries over to our model if the number of unsophisticated investors is large enough.

The price P_t^S is the price in an economy where all stockholders are entrepreneurs who run a private business in addition to investing in the stock market. The risk premium now contains an additional myopic component that depends on the time-varying expected private return. Since the perceived correlation ρ_S of stock returns with private returns

[11] Of course, the payoffs and the distribution of the state variables would be different in the hypothetical representative-agent economies. The point here is that the *structure* of the price equations is the same.

is positive in the equilibria we consider, this premium is also positive.[12] Equation (18) clarifies how *predictability in private returns can spill over to the stock market to produce time variation in expected stock returns.* With $\rho_S > 0$, sophisticated investors who face temporarily high expected private returns will want less exposure to business cycle risk common to both assets, and hence demand higher risk premia on stocks. This also explains why for them the relevant payoff variance is only the portion that is orthogonal to private returns, $\sigma_S^2 (1 - \rho_S^2)$. In addition, since entrepreneurs optimize dynamically, their hedging demand depends on the correlation of stock returns with future investment opportunities. This can further contribute to time variation in risk premia.

The weight $\tilde{\nu}_U$ on the unsophisticated price P_t^U depends on the ability of unsophisticated investors to move the market. Therefore, $\tilde{\nu}_U$ depends not only (positively) on the number of unsophisticated participants, but also on their average stock holdings relative to sophisticated investors. Relative holdings in turn are directly related to the relative precision of information about stock payoffs. If unsophisticated investors perceive much more uncertainty about stocks ($\sigma_U^2 >> \sigma_S^2$), they will hold a lower market share. Formally, we have

$$\tilde{\nu}_U = \frac{\nu_U / \sigma_U^2}{\nu_U / \sigma_U^2 + (1 - \nu_U) / \sigma_S^2 (1 - \rho_S^2)}.$$

If information is symmetric and private returns are independent of stock returns, we have $\tilde{\nu}_U = \nu_U$. More generally, $\tilde{\nu}_U$ becomes larger as σ_S^2 / σ_U^2 rises and ρ_S^2 falls.

Stock-Price Variation and the Business Cycle

A simple thought experiment now shows why the business cycle state variables $\hat{F}_t^{D,i}$ and $\Delta \hat{F}_{t-1}^{D,i}$ are typically much more important for equilibrium stock price movements and predictability than the orthogonal off-market factors F_t^B and ΔF_{t-1}^B that only change expected private returns. We conjecture properties for the price function for period $t+1$ that determine payoffs X_{t+1} and then verify the same properties for the price P_t in (18). Suppose that the future stock price P_{t+1} depends positively on the perceived state of the business cycle $\hat{F}_t^{Di}$ as well as the perceived change $\Delta \hat{F}_t^{Di}$ for $i = U, S$. Suppose also that P_{t+1} depends less, and negatively, on $\hat{F}_t^{Bi}$ as well as the perceived change $\Delta \hat{F}_t^{Bi}$ for $i = U, S$.

That P_t^i today should also depend positively on $\hat{F}_t^{D,i}$ and $\Delta \hat{F}_t^{D,i}$ comes from the fact that expected payoffs in P_t^i depend positively on $\hat{F}_t^{D,i}$ and $\Delta \hat{F}_t^{D,i}$ and that these factors are persistent. However, there are three counteracting effects. The first effect comes from

[12] The literature on the equity premium has recently argued that $\rho_S > 0$ because private equity returns are correlated with the business cycle. See, for example, Heaton and Lucas (2000).

the risk premium in P_t^U, if there is enough predictability of stock returns in equilibrium. The other two effects occur because a boom today also signals higher private returns tomorrow, and increases sophisticated investors' risk premium on local stocks (through P_t^S). The risk premium increases via the myopic demand because of the substitutability across assets and via a lower hedging demand because sophisticated investors' exposure to these state variables (which are positively correlated with stock returns) also increases. Although these counteracting effects exist, it is plausible that there are equilibria in which they are outweighed by the present value effect. This will certainly be true if the number of unsophisticated investors is large enough.

The impact of shocks to $\left(\hat{F}_t^{B,S}, \Delta\hat{F}_t^{B,S}\right)$ on prices is limited by the fact that the direct and the hedging demand effect on the risk premium are offsetting. Indeed, an increase in $\hat{F}_t^{B,S}$ raises the risk premium since it increases the current expected private return. At the same time, persistence in $\left(\hat{F}_t^{B,S}, \Delta\hat{F}_t^{B,S}\right)$ implies that high current values of these variables increase investors' exposure to them in the future. Since they are negatively correlated with stock returns, this increases the hedging demand for stocks and reduces the risk premium. In all our calibrations, the direct effect dominates so that the negative dependence of prices on these factors is validated. However, the price coefficients are much smaller than for the business-cycle variables. Stock market booms are thus essentially driven by expectations of future cash flows. In particular, essentially all predictability in equilibrium stock returns can be traced to business-cycle movements.

4.4 Equilibrium Flows and Returns

In this subsection, we decompose equilibrium trades into disagreement and risk sharing components. We then show how these motives for trade impact key statistics of the joint distribution of flows and returns that speak to the stylized facts we are interested in.

Motives for Trade: Disagreement and Risk Sharing

Substituting expression (18) for the equilibrium stock price back into the portfolio demand formula (16) for unsophisticated investors, we obtain equilibrium flows:

$$\begin{aligned}\Delta\theta_t^U &= \frac{1-\tilde{\nu}}{\beta\gamma\sigma_U^2}\left(\Delta P_t^U - \Delta P_t^S\right) \qquad (19)\\ &= \frac{(1-\tilde{\nu})}{\gamma\sigma_U^2}\left[\underbrace{\Delta E_t^U X_{t+1} - \Delta E_t^S X_{t+1}}_{\text{Disagreement}} + \underbrace{\rho_S\frac{\sigma_S}{\sigma_B}\Delta E_t^S R_{t+1}^B}_{\text{Segmentation}} + \underbrace{\mathbf{H}^U\Delta\boldsymbol{\phi}_t^U - \mathbf{H}^S\Delta\boldsymbol{\phi}_t^S}_{\text{Hedging demands}}\right].\end{aligned}$$

Trading volume and international equity flows are thus driven by relative changes in the two types' valuations, captured by the hypothetical prices P_t^U and P_t^S. Differences in valuations arise for two reasons. The first is simply disagreement about future payoffs: unsophisticated investors are net buyers in periods when they become relatively more optimistic than sophisticated investors.

Second, there is trade due to changes in the need for risk sharing. When sophisticated investors perceive higher expected returns on private opportunities, they prefer to reduce exposure to the business cycle. They thus sell the local asset, and unsophisticated investors buy. The effect is not limited to the myopic demand for stocks: the intertemporal hedging demand will typically also change. As discussed above, the key differences in hedging needs across types arise precisely from the presence of private opportunities.

Flow Momentum, Reversal and Volatility

To examine flow momentum and reversal, we calculate the autocorrelation function of US investors' net purchases of local equities. From (8), these net purchases are proportional to net purchases by unsophisticated investors:

$$\Delta\theta_t^* = \theta_t^* - \theta_{t-1}^* = \nu^* \frac{\nu_U^* - \nu_U}{1 - \nu_U} \Delta\theta_t^U. \tag{20}$$

The n-th autocorrelation of US net purchases satisfies $\rho_n\left(\Delta\theta_t^*\right) = \rho_n\left(\Delta\theta_t^U\right) = \rho_n\left(\Delta\theta_t^S\right)$. The emergence of flow momentum and flow reversal in equilibrium is thus independent of the population parameters: it depends only on the properties of trade across investor types. In other words, the dynamics of US investors' net purchases is characterized by the disagreement and risk sharing motives.

However, the composition of investor populations matters for the volatility of flows, a fact that is used in our calibration strategy. The standard deviation of net purchases is proportional to $|\nu_U^* - \nu_U|$, a measure of population heterogeneity:

$$\sigma\left(\Delta\theta_t^*\right) = \nu^* \frac{|\nu_U^* - \nu_U|}{1 - \nu_U} \sigma\left(\Delta\theta_t^U\right).$$

In the knife-edge case where the US population is a scaled version of the total population ($\nu_U^* = \nu_U$), holdings of US investors are constant and net flows are zero. Of course, there can still be substantial gross flows if the population of US investors is heterogeneous with respect to investor sophistication.

Return Chasing

We examine the relationship between flows and returns in two ways. First, we consider the cross-correlogram of US investors' net purchases and local returns. By (20), correlation of flows and returns depends on population parameters only to the extent that they determine which group is tracked by US investors:

$$\rho\left(\Delta\theta_t^*, R_{t-j}^D\right) = \text{sign}\left(\nu_U^* - \nu_U\right)\rho\left(\Delta\theta_t^U, R_{t-j}^D\right).$$

Whenever $\nu_U^* > \nu_U$, there are proportionately more unsophisticated investors in the population of US international investors than in the local population. Holdings and net purchases of US investors are then perfectly correlated with those of unsophisticated investors. In contrast, when $\nu_U^* < \nu_U$, US investors track sophisticated investors.

A second way to formally examine return chasing is to examine the risk premium measured by an econometrician who constructs estimates of expected returns conditional on public information. The econometrician will thus recover $E_t^U R_{t+1}^D$ which can then be related to equilibrium trades (19).

Bursts of Gross Trading Activity

To determine properties of US investors' gross trading activity, it is helpful to first calculate moments of aggregate trading volume in the local market. A natural measure of volume is the turnover of shares. Since every trade is an exchange of shares between the two types of investors, we can define trading volume as:

$$VOL_t := \nu_U \left|\Delta\theta_t^U\right| = \left(1-\nu_U\right)\left|\Delta\theta_t^S\right|.$$

With normally distributed holdings, there are closed form expressions for the mean and standard deviation of volume, $\mu\left(VOL_t\right) = \nu_U\sqrt{2/\pi}\sigma\left(\Delta\theta_t^U\right)$ and $\sigma\left(VOL_t\right) = \sqrt{\frac{\pi-2}{2}}\mu\left(VOL_t\right).$

Gross purchases by US investors in period t are determined by which type of investor is a net buyer during the period. Let $\mathbf{1}_{\Delta\theta_t^U>0}$ denote the indicator function for the event that unsophisticated investors are net buyers, that is, $\Delta\theta_t^U > 0$. Mean gross purchases by US investors are given by

$$\begin{aligned}\mu\left(GP_t^*\right) &= \nu^* E\left[\mathbf{1}_{\Delta\theta_t^U>0}\nu_U^*\Delta\theta_t^U + \mathbf{1}_{\Delta\theta_t^U<0}\left(1-\nu_U^*\right)\Delta\theta_t^S\right] \\ &= \frac{1}{2}\nu^*\left(\frac{\nu_U^*}{\nu_U} + \frac{1-\nu_U^*}{1-\nu_U}\right)\mu\left(VOL_t\right).\end{aligned}$$

Mean gross purchases are thus proportional to mean volume. The model also predicts that mean gross sales are equal to mean gross purchases, since the mean of net purchases is zero.

5 Data

In this section we describe the data and explain how they are compared to model output. We focus on quarterly data from the G7 countries – apart from the US, these are Germany, Japan, UK, France, Canada, and Italy – over the period 1977:1 through 2000:3. We have selected these countries since they best fit the assumptions of our model. First, flows and returns in these countries are likely to be driven by stable economic relationships.[13] In contrast, the on-going process of liberalization of equity markets in developing countries may lead to capital flows that are driven by changing risk-sharing opportunities or declining transactions costs. In addition, the absence of trading frictions in our model is more at odds with the institutional environment of emerging markets (for a survey of emerging-markets finance, see Bekaert and Harvey 2003.)

5.1 Dividends

We use data on the dividend yield and the price index of Datastream's international stock market indices, with all variables converted to constant US dollars. Not surprisingly, per-share dividends exhibit a trend. To obtain a stationary forcing process $\{D_t\}$ for our model, we follow Campbell and Kyle (1994) in removing an exponential trend. This is described in detail in the Appendix, where we show that it is consistent with our normalization of flows, discussed below.

Table 1 presents key first and second moments of detrended dividends. We have chosen units such that the price index in 1977:1 equals market capitalization. Mean dividends thus reflect the sizes of the different stock markets. Strictly speaking, we assume that the true dividend process follows a truncated normal distribution. The model approximates this truth by modelling the dividend as normally distributed in levels. The table confirms that the approximation is very sensible as mean dividends are more than 3.5 standard deviations above zero for all countries except Italy.

[13] While there has been some increase in correlation of stock index returns recently, Brooks and Del Negro (2002) argue that this is a tenporary phenomnenon connected to an "IT bubble", rather than a permanent shift in market structure.

Table 1. Summary Statistics of Dividends.

Country	$\mu(D)$	$\sigma(D)$	$\rho_1(D)$
CAN	4.89	0.34	0.93
FRA	2.19	0.47	0.96
GER	5.50	1.41	0.97
ITA	0.57	0.27	0.98
JAP	14.81	2.87	0.98
UK	12.91	2.23	0.92
US	91.51	3.61	0.90

NOTES: Mean μ, standard deviation σ and first autocorrelation ρ_1 of detrended, seasonally-adjusted dividends, deflated by US CPI; 1977:1-2000:3.

Preliminary specification analysis of the dynamic behavior of dividends reveals two features. First, the autocorrelation function switches from positive to negative values after three to four quarters. Second, while the first two partial autocorrelation coefficients are significant for all countries except Canada, all countries exhibit several significant partial autocorrelation coefficients beyond the first two. To accommodate both properties in a parsimonious way we follow the system (2)-(5) above, and decompose dividends into a persistent cyclical component, captured by an AR(2) process, and a transitory shock:

$$\begin{aligned} D_t &= \bar{D} + F_t^D + \varepsilon_t^D \\ F_t^D &= a_1 F_{t-1}^D + a_2 F_{t-2}^D + \varepsilon_t^{FD}, \end{aligned} \tag{21}$$

where ε_t^D and ε_t^{FD} are uncorrelated i.i.d. sequences of shocks with zero mean and standard deviations σ_{ε^D} and $\sigma_{\varepsilon^{FD}}$, respectively. Here F_t^D captures the oscillatory behavior of the correlogram that is typical of variables affected by the business cycle. The presence of the transitory noise ε_t^D that cannot be distinguished from the underlying business cycle movement implies that lags longer than two are still helpful in forecasting dividends.

To estimate this process, we use the fact that it permits an ARMA(2,2) representation

$$\left(D_t - \bar{D}\right) = a_1\left(D_{t-1} - \bar{D}\right) + a_2\left(D_{t-2} - \bar{D}\right) + u_t + \lambda_1 u_{t-1} + \lambda_2 u_{t-2},$$

where u_t is an i.i.d. sequence of shocks with standard deviation σ_u, and where the parameters satisfy a set of nonlinear constraints. Details of the estimation procedure are contained in the Appendix, where we also provide expressions for σ_{ε^D} and $\sigma_{\varepsilon^{FD}}$ in terms of the ARMA(2,2) parameters. Table 2 lists the estimation results together with some properties of the estimated dividend process.

Table 2. Estimated Dividend Process.

	a_1	a_2	$\sigma_{\varepsilon^{FD}}$	$\sigma_{\varepsilon^{D}}$	$\sigma\left(F^D\right)$	$\rho_1\left(\Delta F^D\right)$	*Roots*	$\rho_1\left(\Delta D\right)$
CAN	1.859	−0.896	0.036	0.073	0.409	0.88	1.04±0.20i	−0.002
FRA	1.369	−0.420	0.110	0.026	0.458	0.39	1.11;2.15	0.327
GER	1.734	−0.773	0.143	0.183	1.095	0.75	1.12±0.19i	0.217
ITA	1.685	−0.708	0.031	0.170	0.272	0.70	1.12;1.26	0.454
JAP	1.212	−0.275	0.783	0.031	2.988	0.24	1.10;3.30	0.248
UK	1.223	−0.294	0.572	0.031	2.403	0.26	1.12;3.04	0.252
US	1.679	−0.747	0.698	0.818	3.836	0.71	1.12±0.28i	0.088

NOTES: *Roots* are computed for the autoregressive polynomial of F_t^D.

The persistent component F_t^D is stationary: the roots of the autoregressive polynomial are outside the unit circle. In most countries, the roots are complex, which accounts for oscillations in the correlogram. In addition, the persistent component has persistent differences. Indeed, the process of changes in F_t^D satisfies

$$\Delta F_t^D = (-a_2)\,\Delta F_{t-1}^D - (1 - a_1 - a_2)\,F_{t-1}^D + \varepsilon_t^{FD}.$$

For all countries, we have that $0 < (-a_2) < 1$ and that $(1 - a_1 - a_2)$ is a small positive number. After a shock hits, two counteracting effects are at work. First, any change in a certain direction leads to more changes in the same direction, although at a decreasing rate since $(-a_2) < 1$. If this was the only effect, the level F_t^D would be nonstationary. However, the second term causes mean reversion in the level by pulling F_t^D towards its mean of zero whenever it is positive, and by pulling it up when it is negative. For the impulse response of the level, the first effect dominates early on, before the second effect takes over. The result is a hump-shaped impulse response function.

Because it is so persistent, the persistent component explains almost all the variation in dividends: its share of total variance is larger than 96% for all countries except Italy. For 3 of the 7 countries, the volatilities of the shocks hitting the persistent component in any given quarter is also higher than that of transitory shocks. Still, changes in dividends are typically less persistent than changes in the persistent component. Changes in dividends can be decomposed into changes in F_t^D, which are positively serially correlated, and changes in the temporary component, which are negatively serially correlated and thus reduce overall persistence.

5.2 Equity Flows

5.2.1 Data Sources

We obtain data on the international equity flows of US investors from the Treasury International Capital (TIC) reporting system of the US Treasury.[14] Financial institutions (banks, bank holding companies, securities brokers, dealers, and non-banking enterprises) must report to the Treasury, each month, by country, on all of their transactions with foreigners in long-term securities (e.g. stocks and bonds) by country if their aggregate purchases or sales total more than US $2 million in the month. As a result, the Treasury receives comprehensive data on cross-border equity transactions for most US investors. The Treasury collects data by geographic center and not by the country of origin of the security. This means that the data can be unrepresentative for countries that contain large international financial centers such as the UK. Warnock and Cleaver (2002) examine the TIC data in detail and find that transactions to the UK are overstated while transactions to other countries are understated. The typical example of this is the purchase by US investors of stock from, say, an Italian company issuing securities in the Euro-equity market through banks in London, which is recorded as a sale of UK equity.

Data on the volume of trading are from Datastream's Global Equity Indices and gives the aggregation of the number of shares traded multiplied by the closing price for each stock. Finally, we obtain data on equity holdings from the Report on US Holdings of Foreign Long-Term Securities, issued jointly by the US Treasury and the Federal Reserve Board. The report is based on TIC data and the 1997 benchmark survey of US investors.

5.2.2 Matching Model and Data Flows

Both flow and volume data record sums over all transactions in a given month or quarter; the TIC database does not provide guidance on which days, and hence at what prices, the transactions took place. In contrast, our discrete time model makes predictions about holdings at a point in time. To match model-implied changes in holdings to flow data, we need to normalize the latter. One convenient way to do this is to divide flows by total market capitalization at the beginning of the period. To see why this makes sense, suppose that there are n dates between t and $t+1$ at which transactions are recorded. Let x_i denote the fraction of the net change $\theta_t^* - \theta_{t-1}^*$ in US investors' holdings that takes place at date t_i (with θ_t^* measured as a fraction of outstanding shares). Then normalized

[14] There are a number of related studies that use the same data set (Tesar and Werner 1993, 1995; Bohn and Tesar 1996a,b; Brennan and Cao 1997; Albuquerque et al. 2003). See Froot et al. (2001) and Levich (1994) for a description of limitations/advantages of US Treasury data.

net flows are given by

$$NF_t = \frac{1}{\tilde{P}_t}\left(\theta_t^* - \theta_{t-1}^*\right)\sum_{i=1}^{n} x_i \tilde{P}_{t_i} = \left(\theta_t^* - \theta_{t-1}^*\right)\sum_{i=1}^{n} x_i \frac{\tilde{P}_{t_i}}{\tilde{P}_t},$$

where $\tilde{P}_t$ is the undetrended local stock price. (The appendix shows that this normalization is consistent with exponential detrending of dividend levels.)

Normalized flows are thus equal to the change in holdings multiplied by a weighted average of within-month capital gains. In what follows, we match normalized net flows to the first term, $(\theta_t^* - \theta_{t-1}^*)$. This match is exact if all transactions take place on the first day of the month, that is, $t_1 = t$, $x_1 = 1$ and $x_i = 0$ for $i > 1$. Some evidence on the importance of the resulting bias can be obtained by comparing results to the polar opposite case, when flows are normalized by the end-of-period market capitalization (i.e. $t_n = t + 1$ and $x_n = 1$). In terms of our stylized facts, this change somewhat reduces both the contemporaneous correlation of flows and returns and the persistence of flows, but the effect is on the order of a few percentage points for all countries. We conclude that the normalization is reasonable.

It is well known that turnover (that is, the ratio of trading volume to market capitalization), exhibits an increasing trend. Not surprisingly, the same is true for gross flows to and from all our countries, after they have been normalized by market capitalization. Our model does not allow for this type of trend in trading activity: equilibrium holdings, and hence their differences, are stationary. However, this need not affect the model's relevance for stylized facts about *net* flows. Indeed, it is plausible that much of the trend in trading activity is due to features of the trading process that have been simplified away in the model, but that are not germane to the behavior of net flows.[15]

Of course, if our model is correct, not all of the gross flows are unrelated to net flow movements. In our calibration, we thus insist on obtaining moments for our model-implied stationary turnover series that are in the ballpark of values observed in the data. In particular, we calibrate the expected value of turnover to the average turnover over the

[15] First, the actual population of US investors does not consist of long-lived agents that do not have any idiosyncratic liquidity needs. Trades due to finite investment horizons or other liquidity reasons need not affect net flows as long as they average out across investors. They will, however, be recorded as gross flows and volume. Since their frequency is arguably increasing with the increase in market participation, this might account for the trend in the gross measures. A second candidate reason for trends is rebalancing across different securities. We assume throughout that there is a single (index) security that all investors hold. In fact, there are many stocks, and agents who hold an index rebalance as market weights change. Rebalancing does not add to net flows, but it is recorded as gross flows. It is also likely more frequent as share repurchases and issues have become more common in recent years.

years 1995-2000. We then compare other model moments to similar long-run averages from the data.

5.2.3 Summary Statistics

Table 3a presents summary statistics for net purchases of stocks abroad by US investors as well as excess returns on domestic indices for the countries we consider. The mean excess returns in this table are based on detrended data, which means that the effects of dividend growth are already removed. This explains why excess returns are smaller than the mean equity premia usually reported from raw data and why Sharpe ratios implied by the table are unusually low. In our set of countries, changes in American investors' holdings are small relative to total market capitalization. Within a given quarter, it is rare to see a change in position of more than one percent of market capitalization.

TABLE 3A. EXCESS RETURNS AND NET-FLOWS.

	Excess Returns (%)		Net Inflows (%)			
	$\mu\left(R^D\right)$	$\sigma\left(R^D\right)$	$\mu\left(NF^*\right)$	$\sigma\left(NF^*\right)$	$\rho_1\left(NF^*\right)$	$\rho(R^D, NF^*)$
CAN	1.4	8.1	0.17	0.37	0.52	0.27
FRA	1.5	11.7	0.15	0.28	0.46	0.17
GER	0.7	9.8	0.03	0.14	0.35	0.28
ITA	0.9	15.0	0.05	0.31	0.16	0.13
JAP	0.8	13.0	0.05	0.13	0.45	0.40
UK	0.8	9.3	0.12	0.24	0.51	0.16
US	1.9	7.4	–	–	–	–

NOTES: Means μ, standard deviations σ and first autocorrelations ρ_1 for Excess Returns (log quarterly US$ returns minus 3-month T-bill rate) and Net Inflows (net purchases of foreign stocks by US investors, normalized by beginning-of-period market capitalization). $\rho\left(R^D, NF^*\right)$ is the contemporaneous correlation coefficient of Excess Returns and Net Inflows. Quarterly data, 1977:2-2000:3.

The table documents two key stylized facts about the joint distribution of net inflows and excess returns. First, net inflows are persistent. The first autocorrelation coefficient ranges between .16 for Switzerland to .52 for Canada. In all countries but Italy, it is statistically significant at the 5% level. The persistence of net inflows is not due to trends. Figure 1 plots the net inflow series for all our countries. It is apparent that the main feature is slow transitions from periods of high to low net inflows.[16] For

[16] It is notable that for some countries, such as Germany and Italy, there is a marked change in volatility between the late 70s and early 80s and more recent years. This reflects an increase in overall trading activity. However, this effect does not induce a trend in the mean of net inflows.

example, American investors were pulling money out of the French stock market in the late 1970s and reinvested it there again in the mid-1980s. They did essentially the converse in the Netherlands: positions that were built slowly over the late 70s and early 80s were unwound between 1983 and 1986. The second fact is that the contemporaneous correlation between domestic excess stock returns (measured in US dollars) and net inflows from the US is strongly positive.

Table 3b collects summary statistics for holdings, gross flows and volume. US investors hold significant fractions of the market in all of our countries except Italy. Gross purchases and sales are of the same order of magnitude in all the countries. The stylized fact that gross sales and purchases are highly positively correlated holds both in the time series for every countries and in the cross section of countries. Importantly, the time series results do not only reflect trend behavior. While there are trends in gross flows over the whole sample, behavior over a five year period is mostly driven by volatility that is common to both series. Figure 2 illustrates this for the countries in our sample. Finally, volume, measured here by the value of all trades divided by market capitalization, varies widely across countries. However, it is interesting that holdings of US investors appear to turn over *less* frequently than holdings of other investors within the country. This is true for all but two of our countries, Canada and the UK being the exceptions. This fact will be of interest in our calibration below.

Table 3b. Holdings, Turnover and Gross Flows.

	US Holdings (%)	Volume (%)		Gross Flows (%)		
	h^*	$\mu(VOL)$	$\sigma(VOL)$	$\mu(GP^*)$	$\mu(GS^*)$	$\rho(GP^*, GS^*)$
CAN	14.3	14.1	2.7	3.2	3.0	0.97
FRA	12.7	16.0	3.4	0.9	0.9	0.62
GER	9.9	51.6	13.2	1.0	1.0	0.87
ITA	1.1	86.2	35.1	0.8	0.8	0.60
JAP	39.0	4.8	2.7	0.9	0.8	0.91
UK	12.4	3.9	2.1	4.5	4.5	0.95

NOTES: US holdings are a fraction of local market capitalization, as of 12/31/1999. Volume is total value of shares traded divided by market capitalization. Gross purchases (GP) and gross sales (GS) are divided by market capitalization. All gross flow and volume statistics are averages over 1995:1-2000:3.

6 Quantitative Analysis

In this section, we first describe how we calibrate the model to dividend and flow data. The procedure outlined in Subsection 6.1 applies to all countries in our sample. We then provide some further model statistics not used in the calibration and compare them to the data. Finally, we use structural impulse responses and variance decomposition analysis to interpret our findings.

6.1 Calibration

Preferences

One period in the model corresponds to one quarter. We choose an annual discount rate of 4 percent, that is, $\beta = 0.9901$. The coefficient of absolute risk aversion is set to $\gamma = 10$.

Investment Opportunities

Local dividends and world asset returns are taken directly from the data. For dividends, we use the detrended process estimated in Subsection 5.1. From (4), we assume that the world return is unpredictable and uncorrelated with local dividends. Its mean and standard deviation are matched to the US stock market return: $\bar{R}^W = 0.0187$ and $\sigma_W = 0.074$.

It is difficult to construct an observable counterpart of the returns on private investment opportunities. Our strategy is to first impose a number of a priori plausible restrictions that give rise to a two-parameter family of processes, with the free parameters η_D and η_B introduced in (3). We then fix the remaining parameters to match selected moments on stock market trading activity. We impose throughout that the unconditional mean and variance of private returns are the same as those of the return on the world asset. In addition, we allow for three specific features of private returns.

First, private returns can be predictable. Predictability has been documented in many securities markets and it is certainly prevalent for non-traded assets, where returns need not be competed away quickly. Second, both the predictable and the unpredictable component of returns may be correlated with the local business cycle. In our model, the latter is captured by dividends. Third, there may be persistent factors other than the local business cycle that affect expected private returns. This feature is of interest since some opportunities chased by sophisticated investors active in the local markets may in fact be located in other countries.

According to (3), the first component of private expected returns is proportional to the persistent component of local dividends F_t^D. The second component is driven by a process F_t^B that is independent of F_t^D and also has an AR(2) structure. We impose that it captures oscillations at business-cycle frequencies by setting the AR(2) parameters equal to those of the persistent component in US dividends. As a normalization, the variance of shocks to F_t^B is set equal to that of F_t^D. The overall volatility of expected returns and the relative importance of the local business cycle is then governed by the parameters η_D and η_Z.

In our baseline calibration, we also fix $\rho\left(\varepsilon^B, \varepsilon^D\right) = .5$ and $\sigma_y^2 = .1$. Sensitivity analysis has shown that the performance of the model does not depend strongly on these values. Once they are fixed, and given values for η_D and η_Z, the variance of unexpected returns $\sigma_{\varepsilon^B}^2$ must be chosen to ensure that the unconditional variance of private returns matches that of the world asset return. Our specification of investment opportunities thus leaves two degrees of freedom that can be used to match statistics of trading activity.[17]

Matching Flow Moments

In total, we are left to choose five parameters: the fractions ν_U, ν^* and ν_U^* that govern the composition of the investor population and the numbers η_D and η_B that govern the volatility and business cycle correlation of private returns. We select these parameters in order to best match five moments of trading activity: mean volume, mean local holdings and mean gross purchases by US investors as well as the standard deviation and the first autocorrelation of net purchases by US investors. In addition, we use the positive sign of the contemporaneous correlation of US net purchases and returns to provide guidance on which type of investors is more prevalent in the US investor population. The relevant model statistics are defined in Subsection 4.4 and their observable counterparts are explained in Subsection 5.2.

Table 4 lists the parameter values of the baseline calibration for all countries together with data and model values of the target moments. By and large, the target moments are matched tightly, although the model understates mean volume in Germany, Japan, Italy and the UK. The parameter values for the expected off-market return process are similar across countries. The business cycle component is most important in Italy, the country where the persistent component accounts for less of the dividend variance (cf. Table 2). In contrast, the off-market factor F_t^B plays a larger role in driving private returns available to investors in the Canadian stock market. This is needed in order to

[17] This assumption is not really restrictive, since F_t^B is not directly linked to observables. It could simply be interpreted as sophisticated investors' *perceived* expected returns.

increase trading volume (see 19).

For Japan, Italy and U.K., the model generates small volatility of unsophisticated investors' flows, which brings down the volatility of trading (see Subsection 4.4). Nonetheless, the model can still match the volatility of US investors' flows as long ν_U^* is sufficiently larger than ν_U (see (20)). For Germany the model generates average trading volume comparable with other countries, but the data indicates much larger volume. In contrast, the model performs well in predicting mean gross purchases in these markets. The lone exception is the UK: this may be due to the UK being a large international financial center (see Levich 1994).

With the exception of Japan and the U.K., the average international US investor is sophisticated: $\nu_U^* < 0.5$. However, for all countries $\nu_U < \nu_U^*$, meaning that the average US international investor is less sophisticated than the average local investor. Being relatively less sophisticated means that aggregate net flows of US investors are proportional to unsophisticated investors' net flows (see 20). This fact is consistent with the view that US investors have worse private information than local investors, usually associated with the existence of a home bias. Importantly, Table 4 indicates that cross-country heterogeneity observed in the difference $\nu_U - \nu_U^*$ is not as significant as within-country heterogeneity measured by $\nu_U - 0.5$. Trading is thus not motivated by differences in population across countries, but by differences in investor populations within countries as would be expected in G7 economies.

Table 4. Parameters and Calibrated Moments

	France		Canada		Germany		U.K.		Japan		Italy	
Parameters												
Private Returns	η_D	η_B	η_D	η_B	η_D	η_B	η_D	η_B	η_D	η_B	η_D	η_B
	0.085	0.087	0.070	0.294	0.045	0.054	1e-4	0.011	0.001	0.010	0.110	0.120
# Unsophisticated		ν_U		ν_U		ν_U		ν_U		ν_U		ν_U
		0.40		0.38		0.35		0.40		0.80		0.01
US Population	ν^*	ν_U^*	ν^*	ν_U^*	ν^*	ν_U^*	ν^*	ν_U^*	ν^*	ν_U^*	ν^*	ν_U^*
	0.124	0.43	0.14	0.41	0.10	0.37	0.12	0.80	0.39	0.84	0.01	0.40
Moments	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model
$\mu(\theta^*)$ in %	12.7	12.7	14.3	14.3	9.9	9.9	12.4	12.4	39.0	39.0	1.1	1.1
$\sigma(\Delta\theta^*)$ in %	0.28	0.28	0.37	0.37	0.14	0.14	0.24	0.24	0.13	0.13	0.31	0.31
$\rho_1(\Delta\theta^*)$	0.46	0.46	0.52	0.52	0.35	035	0.51	0.32	0.45	0.25	0.16	0.16
$\mu(VOL)$ in %	16.9	16.7	14.1	14.1	51.6	12.3	3.9	0.95	4.8	1.0	86.2	1.0
$\mu(GP^*)$ in %	0.9	2.1	3.2	2.0	1.0	1.2	4.5	0.13	0.9	0.4	0.8	0.13

6.2 Further Predictions for Flows and Returns

Out of the four stylized facts we set out to explain, only the persistence of net flows (as reflected in $\rho\left(\Delta\theta_t^U, \Delta\theta_{t-1}^U\right)$) was directly used to calibrate the model. Table 5 reports further data and model statistics not used in the calibration relevant to the other stylized facts. In addition, Figures 3 and 4 present graphs of the entire cross-correlogram of returns and flows and the autocorrelogram of flows for the six countries in our sample.

Simultaneous Buying and Selling

The model produces high positive contemporaneous correlation between gross purchases and gross sales. Gross trading activity of US investors thus occurs in bursts of simultaneous buying and selling. The fact that we overpredict these bursts of trading could be due to transitory idiosyncratic shocks that are recorded as gross flows. The UK and Italy are the only two countries for which the model predicts a negative correlation between purchases and sales of local stocks by US investors.

Flow Continuation and Flow Reversal

The first column in Figures 3 and 4 presents the autocorrelogram of US investors' net purchases (equivalently, that of unsophisticated investors' net purchases) with 90% confidence bands computed with Newey-West errors. It is remarkable how well the model captures the J-curve pattern evident in the data. The J-curve pattern displays flow continuation up to 3 (and sometimes 4) lags and flow reversal at lags 5 and 6. The data further displays a cyclical pattern with the flow correlations increasing again after lag 6. This is also captured in the model–as a virtue of the AR(2) processes estimated for dividends–though at longer horizons. Only the U.K. and Japan display significantly more persistence in the short run in the data than in the model.

Return Chasing

Return chasing behavior is apparent both from Table 5 and from the cross-correlograms in the second column of Figures 3 and 4. The model somewhat overpredicts the contemporaneous correlation of returns and net purchases for France, the U.K. and Italy, while the performance for Canada, Germany and Japan is quite satisfactory. Moreover, the model captures the tent-shape curve around the contemporaneous correlation displayed in the data. The model matches well the significant return chasing in France and Germany, and the absence thereof in Italy. It misses the correlation of lagged returns and current flows for the U.K., Canada and Japan. However, it captures the qualitative feature of cyclicality in the correlation of lagged returns and flows: low and negative at 2 and 3 lags, and increasing after lags 4 or 5.

The model also generates positive correlation between net purchases by US investors and expected returns based on public information: $\rho\left(\Delta\theta_t^*, E_t^U R_{t+1}^D\right) > 0$. This is consistent with evidence presented by Bohn and Tesar (1996) for our set of countries. These authors estimate expected returns using a comprehensive set of instruments that proxies the public information set. They then show that US investors move into a market when their fitted expected returns are high.

Other Statistics

The value of $\mu(VOL)$ was calibrated to the data which means that in our model $\sigma(VOL) = .7(5) \times \mu(VOL)$. The model predicts that $\mu(VOL) > \sigma(VOL)$ which is robust across all countries. The exact quantitative performance of the model varies considerably across countries. The model does well for Germany, but overpredicts the volatility of trading volume by a factor of 3 for France and Canada. The model significantly underpredicts volatility in trading volume for Italy (see Table 4). With the exception of Japan, current flows predict one quarter ahead returns both in the data and in the model. For Japan, both the data and the model display a negative correlation between flows and future returns.

Finally, the model exhibits both an equity premium puzzle and a volatility puzzle for price levels (not documented), two common weaknesses of macroeconomic asset pricing models discussed in detail by Campbell (2001). These results are not entirely surprising, since, for technical reasons, our model features constant discount rates. The frictions we introduce thus cannot produce highly amplified effects on price levels.

Table 5. Non-calibrated Moments

	France		Canada		Germany		U.K.		Japan		Italy	
	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model
$\rho\left(NF_t^*, R_t^D\right)$	0.17	0.37	0.27	0.14	0.28	0.27	0.16	0.28	0.40	0.42	0.13	0.64
$\rho\left(NF_t^*, E_t^U R_{t+1}^D\right)$	+	0.15	+	0.17	+	0.20	+	0.21	+	0.26	+	0.20
$\sigma\left(VOL_t\right)$ in %	3.1	12.6	2.7	10.7	13.2	9.3	2.1	0.7	2.7	0.8	35.1	0.8
$\rho\left(GP_t^*, GS_t^*\right)$	0.63	0.98	0.97	0.97	0.87	0.99	0.95	-0.17	0.91	0.89	0.60	-0.44

NOTES: Data for $\rho\left(NF_t^*, E_t^U R_{t+1}^D\right)$ was taken from Table 2 in Bohn and Tesar (1996).

6.3 Interpretation

To provide intuition for our numerical results, we now discuss the role of various structural shocks in generating the stylized facts we are interested in. As a representative example, we focus on the French stock market.

Impulse Responses and Variance Decomposition

An impulse response function describes the dynamic response of equilibrium prices and trades to a one-time structural shock. We normalize the size of the shock to one standard deviation. Impulse response functions are easily calculated from the model's stationary vector autoregressive representation.[18] Figures 5-7 respectively plot the model's response to an innovation to the persistent component of local dividends (the "business cycle shock" ε_t^{FD}), to a transitory shock to dividends ε_t^{D} and to an innovation to the off-market factor ε_t^{FB}. Each figure displays information on the following group of variables: the local stock price P_t, the forecast errors on the business cycle by both investor types, $F_t^D - \hat{F}_t^{DS}$ and $F_t^D - \hat{F}_t^{DU}$ (plotted together in the second graph of the first row), the local per-dollar stock return, unsophisticated investors' net purchases and conditional one-quarter-ahead forecasts of the local stock return.

Not all of the structural shocks discussed above are equally important for a given model statistic. To quantify the role of the different shocks, we provide variance decompositions of key second moments. Figure 8 plots the contribution of every shock to the covariance of unsophisticated investors' flows and returns, the covariance of unsophisticated investors' current and lagged flows, the covariance of unsophisticated investors' flows and their expected returns (the return chasing effect) and the covariance of current and lagged stock returns. We omit the shocks to sophisticated investors' private signal and to transitory off-market returns as they have a minimal direct contribution to these moments.

Return Chasing and the Business Cycle

Persistent local business cycle shocks induce return chasing. The variance decompositions show that ε_t^{FD} accounts for most of the correlation of flows with both current and past returns. While temporary dividend shocks contribute to the contemporaneous correlation, they actually have a small negative effect on the lagged correlation. Shocks

[18] Let $\mathbf{x}_t = \left(F_t^D, F_{t-1}^D, \boldsymbol{\phi}_t^s, D_t, R_t^W, R_t^B\right)'$. It can be verified that the vector $\mathbf{x}_t$ has a first-order vector autoregressive representation where the errors are the economy's structural shocks and that this characterization of $\mathbf{x}_t$ fully describes the equilibrium of the model. Any variable in the economy, such as asset holdings and flows or realized and expected returns, can be easily constructed from $\mathbf{x}_t$.

to the off-market factor are largely irrelevant for return chasing.

The impulse response to a positive innovation ε_t^{FD} is shown in Figure 5. On impact, prices increase in response to higher current dividends and future expected payouts. Unsophisticated investors observe these public signals. They underreact to the shock since they cannot be sure that F_t^D has actually moved. Sophisticated investors underreact by less as they have more signals to rely on. Disagreement trading by itself would thus lead the more optimistic sophisticated investors to buy shares. However, improved private opportunities also trigger risk sharing trades. Both the myopic and the hedging demand of sophisticated investors decrease as they try to get rid of tradable business cycle risk. Overall, the risk sharing effect dominates: sophisticated investors sell the domestic stock market as prices rise, which contributes to positive contemporaneous correlation of net purchases and returns.

The high stock return that obtains on impact is followed by further net purchases by unsophisticated investors, before reversal sets in. In fact, for about three quarters after the impact effect, disagreement and risk sharing trades go in the same direction, generating pronounced return chasing. On the one hand, disagreement is reduced as unsophisticated investors learn the nature of the shock. This encourages them to buy. On the other hand, business cycle momentum creates more private opportunities. Sophisticated investors' incentive to sell shares thus also increases, at least in the short run. After about three quarters, reversal sets in. The disagreement effect weakens as unsophisticated have learned the nature of the shock. At the same time, the return on private opportunities begins to revert to the mean. As a result, sophisticated investors return to the stock market. Importantly, both return chasing and the eventual reversal are predictable consequences of the initial shock (and concomitant high return). This effect thus explains the observed oscillations in the cross-correlogram.

Transitory shock to dividends contribute only to contemporaneous correlation of flows and returns. In response to such a shock (shown in Figure 6), both types of investors see dividends increase and assign positive probability to the shock being persistent. However, unsophisticated investors become more optimistic than sophisticated investors because they have fewer signals about the persistent component F_t^D. They expect a continuation of high prices and future positive returns and buy the local stock market. In contrast, sophisticated investors are less optimistic and sell the local stock market. The impact effect of the shock induces a positive correlation between unsophisticated investor flows and returns. However, after the impact, trades driven by a transitory shock are quickly reversed as investors correct their forecast errors. Too large a contribution from these shocks would thus prevent the model from matching the positive correlation of net purchases with lagged returns.

Flow Momentum, Reversal and Risk Sharing

The autocorrelation of flows is mainly driven by both business cycle shocks and shocks to the off-market factor. For both types of shock the major motive of trade is risk sharing: as off-market opportunities improve, sophisticated investors try to shed tradable business-cycle risk in order to load up on nontradable risk. The impulse response of flows to the two shocks is thus similar in shape.

Initially, there is a fair amount of disagreement: unsophisticated investors underestimate the actual state of the business cycle. While this is due to underreaction after an F_t^D shock (see Figure 7), it is due to *overreaction* after an F_t^B shock (see Figure 5). In the latter case, unsophisticated investors only see a drop in prices, which they will partly attribute to a downturn in the local business cycle and partly to the F_t^B shock. Since prices must fall on impact to entice unsophisticated investors to buy, the F_t^B shock contributes negatively to the contemporaneous correlation of flows and returns.

Disagreement makes it costly for sophisticated investors to sell early on. However, as the shock persists, investors learn the nature of the shock and the forecast error is reduced. Sophisticated investors keep leaving the stock market, generating persistent flows. Importantly, only persistent shocks are able to generate persistence in flows and returns. Transitory shocks to dividends produce very quick reversals of flows that translate into negatively serially correlated flows. This constrains the model's ability to generate the observed trading patterns: calibrations that create a bigger role for transitory shocks improve the model's performance in generating a positive correlation $\rho\left(\Delta\theta_t^U, R_t^D\right)$, but worsen the model's performance in terms of flow persistence.

Appendix

A Proof of Theorem 1

In this appendix we provide the complete proof of Theorem 1 in the main text. In the equilibrium that we analyze, the local equity asset price depends on factor realizations and beliefs of unsophisticated investors on these factors:

$$P_t = \bar{\pi} + \boldsymbol{\pi}'_S \hat{\mathbf{F}}_t^S + \boldsymbol{\pi}'_U \hat{\mathbf{F}}_t^U.$$

The vector $\mathbf{o}_t^U$ defined in the text gives the vector of unsophisticated investors' observable variables, i.e., the local dividend and price and the world return. Unsophisticated investors do not see the return on sophisticated investors' private opportunities. Applying the Kalman filter on unsophisticated investors' problem yields:

$$\hat{\mathbf{F}}_t = \boldsymbol{\varrho} \hat{\mathbf{F}}_{t-1} + \mathbf{K}^U \hat{\mathbf{u}}_t^U, \tag{22}$$

with

$$E_t \left[\hat{\mathbf{u}}_t' \hat{\mathbf{u}}_t \right] = \mathbf{M}^{oUF} E_t \left[\left(\mathbf{F}_{t-1} - \hat{\mathbf{F}}_{t-1}^U \right) \left(\mathbf{F}_{t-1} - \hat{\mathbf{F}}_{t-1}^U \right)' \right] \mathbf{M}^{oUF\prime} + \mathbf{M}^{oU\varepsilon} E \left[\boldsymbol{\varepsilon}_t \boldsymbol{\varepsilon}_t' \right] \mathbf{M}^{oU\varepsilon\prime}. \tag{23}$$

We can now construct unsophisticated investors' state vector $\boldsymbol{\phi}_t^U = \hat{\mathbf{F}}_t^U$ and use (22) and (23) to derive its law of motion:

$$\boldsymbol{\phi}_{t+1}^U = \boldsymbol{\Phi}^U \boldsymbol{\phi}_t^U + \mathbf{M}^{\phi\varepsilon U} \boldsymbol{\varepsilon}_{t+1}^{\phi U}.$$

Repeating the same process for sophisticated investors' conditional forecasts $\hat{\mathbf{F}}_t^S$ we have $\boldsymbol{\phi}_t^S = \left(\hat{\mathbf{F}}_t^{S\prime}, \hat{\mathbf{F}}_t^{U\prime} \right)'$:

$$\boldsymbol{\phi}_{t+1}^S = \boldsymbol{\Phi}^S \boldsymbol{\phi}_t^S + \mathbf{M}^{\phi\varepsilon S} \boldsymbol{\varepsilon}_{t+1}^{\phi S}.$$

Let us turn to the decision problem of both investors. Write returns as

$$\mathbf{R}_{t+1}^i = \bar{\mathbf{R}}^i + \mathbf{M}^{R\phi i} \boldsymbol{\phi}_t^i + \mathbf{M}^{R\varepsilon\phi i} \boldsymbol{\varepsilon}_{t+1}^{\phi i},$$

for each investor. Guess that investors' i value function is of the form

$$V \left(w_t^i; \boldsymbol{\phi}_t^i \right) = -\exp \left[-\kappa^i - \tilde{\gamma} w_t^i - \mathbf{u}_i' \boldsymbol{\phi}_t^i - \frac{1}{2} \boldsymbol{\phi}_t^{i\prime} \mathbf{U}_i \boldsymbol{\phi}_t^i \right].$$

Define $\mathbf{\Omega}^i = \left(\mathbf{M}^{\phi\varepsilon i\prime}\mathbf{U}_i\mathbf{M}^{\phi\varepsilon i} + \left(\mathbf{\Sigma}^i_{\phi\phi}\right)^{-1}\right)^{-1}$ where $\mathbf{\Sigma}^i_{\phi\phi} = E\left[\boldsymbol{\varepsilon}^{\phi i}_t \boldsymbol{\varepsilon}^{\phi i\prime}_t\right]$. We have that (superscript i dropped for simplicity):

$$
\begin{aligned}
E_t V\left(w_{t+1}, \boldsymbol{\phi}_{t+1}\right) &= -\frac{\left(\det \mathbf{\Sigma}_{\phi\phi}\right)^{-\frac{1}{2}}}{\left(\det \mathbf{\Omega}\right)^{-\frac{1}{2}}} \exp\left(-\kappa - \tilde{\gamma}\left(R_f\left(w_t - c_t\right) + \boldsymbol{\psi}_t'(\bar{\mathbf{R}} + \mathbf{M}^{R\phi}\boldsymbol{\phi}_t)\right)\right) \\
& \exp\left(-\frac{1}{2}\boldsymbol{\phi}_t'\mathbf{\Phi}' U \mathbf{\Phi}\boldsymbol{\phi}_t - \mathbf{u}'\mathbf{\Phi}\boldsymbol{\phi}_t\right) \\
& \exp\left(\frac{1}{2}\left(\tilde{\gamma}\boldsymbol{\psi}_t'\mathbf{M}^{R\varepsilon\phi} + \left(\boldsymbol{\phi}_t'\mathbf{\Phi}'\mathbf{U} + \mathbf{u}'\right)\mathbf{M}^{\phi\varepsilon}\right)\mathbf{\Omega}\left(\tilde{\gamma}\mathbf{M}^{R\varepsilon\phi\prime}\boldsymbol{\psi}_t + \mathbf{M}^{\phi\varepsilon\prime}\left(\mathbf{U}\mathbf{\Phi}\boldsymbol{\phi}_t + \mathbf{u}\right)\right)\right).
\end{aligned}
$$

Solving for the optimal portfolio we obtain:

$$
\begin{aligned}
\boldsymbol{\psi}_t &= \tilde{\gamma}^{-1}\left(\mathbf{M}^{\psi\psi}\right)^{-1}\left(\overline{\mathbf{M}}^{\psi} + \mathbf{M}^{\psi\phi}\boldsymbol{\phi}_t\right) \\
&= \overline{\boldsymbol{\psi}} + \mathbf{\Psi}\boldsymbol{\phi}_t,
\end{aligned}
$$

where the matrices are given by $\overline{\mathbf{M}}^{\psi\prime} = \bar{\mathbf{R}}' - \mathbf{u}'\mathbf{M}^{\phi\varepsilon}\mathbf{\Omega}\mathbf{M}^{R\varepsilon\phi\prime}$, $\mathbf{M}^{\phi\psi\prime} = \mathbf{M}^{R\phi\prime} - \mathbf{\Phi}'\mathbf{U}\mathbf{M}^{\phi\varepsilon}\mathbf{\Omega}\mathbf{M}^{R\varepsilon\phi\prime}$, and $\mathbf{M}^{\psi\psi} = \mathbf{M}^{R\varepsilon\phi}\mathbf{\Omega}\mathbf{M}^{R\varepsilon\phi\prime}$. The first term (i.e., $\tilde{\gamma}^{-1}\left(\mathbf{M}^{\psi\psi}\right)^{-1}\mathbf{M}^{R\phi}$) in matrix $\mathbf{\Psi}$ gives the myopic demand of the investor whereas the second term (i.e., -$\tilde{\gamma}^{-1}\left(\mathbf{M}^{\psi\psi}\right)^{-1}\mathbf{M}^{R\varepsilon\phi}\mathbf{\Omega}\mathbf{M}^{\boldsymbol{\phi\varepsilon\prime}}\mathbf{U}\mathbf{\Phi}$) gives the hedging demand of the investor.

From the value function $V\left(w^i_t; \boldsymbol{\phi}^i_t\right)$ we see that risk averse investors not only care about fluctuations in wealth, but also about changes in beliefs, captured by the state vector $\boldsymbol{\phi}^i_t$. The quadratic term reflects investors' taste for 'unusual' investment opportunities. Intuition for this effect can be obtained by thinking about the case of one state variable. $\mathbf{U}_i$ is then a positive number and continuation utility is higher the further $\boldsymbol{\phi}^i_t$ is from its mean of zero. Since $\boldsymbol{\phi}^i_t$ is payoff relevant, it drives expected returns at some time in the future. An unusual value signals that above average expected returns will be available, by either going long or short.

We can now describe in detail the coefficients of the optimal portfolio policy $\boldsymbol{\psi}^i_t = \overline{\boldsymbol{\psi}}^i + \mathbf{\Psi}^i\boldsymbol{\phi}^i_t$. We have

$$
\begin{aligned}
\boldsymbol{\psi}^i_t &= \tilde{\gamma}^{-1}\tilde{\mathbf{\Sigma}}^{-1}_{R^iR^i}E^i\left(\mathbf{R}^i_{t+1}|\boldsymbol{\phi}^i_t\right) \\
&\quad -\tilde{\gamma}^{-1}\tilde{\mathbf{\Sigma}}^{-1}_{R^iR^i}Cov\left(\left(\mathbf{u}_i' + E^i\left[\boldsymbol{\phi}^i_{t+1}|\boldsymbol{\phi}^i_t\right]'\mathbf{U}_i\right)\boldsymbol{\phi}^i_{t+1}, \mathbf{R}^i_{t+1}|\boldsymbol{\phi}^i_t\right), \qquad (24) \\
&= \tilde{\gamma}^{-1}\tilde{\mathbf{\Sigma}}^{-1}_{R^iR^i}\left(E^i\left(\mathbf{R}^i_{t+1}|\boldsymbol{\phi}^i_t\right) + (\bar{\mathbf{h}}^i + H^s\boldsymbol{\phi}^i_t)\right)
\end{aligned}
$$

where the matrix $\tilde{\mathbf{\Sigma}}_{R^iR^i} = \mathbf{M}^{R\phi i}\left(Var\left(\boldsymbol{\phi}^i_{t+1}|\boldsymbol{\phi}^i_t\right)^{-1} + \mathbf{U}_i\right)^{-1}\mathbf{M}^{R\phi i\prime}$ is a transformation of the conditional covariance matrix of returns, and $\mathbf{M}^{R\phi i}$ is such that $\mathbf{R}^i_t = \mathbf{M}^{R\phi i}\boldsymbol{\phi}^i_t$. We use this decomposition in the main text.

Solving for the optimal consumption level and the value function we get that for given price function, optimality requires that the following constraints are met: $\tilde{\gamma} = \gamma \frac{R_f - 1}{R_f}$, and

$$\begin{aligned} \kappa &= -\log\left(\frac{R_f}{R_f - 1}\right) \\ &\quad -\frac{1}{R_f - 1}\frac{1}{2}\left(\log\left(\frac{\det \mathbf{\Omega}}{\det \mathbf{\Sigma}_{\phi\phi}}\right) + \mathbf{u}'\mathbf{M}^{\phi\varepsilon}\mathbf{\Omega}\mathbf{M}^{\phi\varepsilon\prime}\mathbf{u} - \overline{\mathbf{M}}^{\psi\prime}\left(\mathbf{M}^{\psi\psi}\right)^{-1}\overline{\mathbf{M}}^{\psi}\right) \\ \mathbf{u} &= \frac{1}{R_f}\left(\overline{\mathbf{M}}^{\phi} + \mathbf{M}^{\psi\phi\prime}\left(\mathbf{M}^{\psi\psi}\right)^{-1}\overline{\mathbf{M}}^{\psi}\right) \\ \mathbf{U} &= \frac{1}{R_f}\left(\mathbf{M}^{\phi\phi} + \mathbf{M}^{\psi\phi\prime}\left(\mathbf{M}^{\psi\psi}\right)^{-1}\mathbf{M}^{\psi\phi}\right), \end{aligned}$$

with $\overline{\mathbf{M}}^{\phi\prime} = \mathbf{u}'\left(\mathbf{I} - \mathbf{M}^{\phi\varepsilon}\mathbf{\Omega}\mathbf{M}^{\phi\varepsilon\prime}\mathbf{U}\right)\mathbf{\Phi}$ and $\mathbf{M}^{\phi\phi} = \mathbf{\Phi}'\mathbf{U}\left(\mathbf{I} - \mathbf{M}^{\phi\varepsilon}\mathbf{\Omega}\mathbf{M}^{\phi\varepsilon\prime}\mathbf{U}\right)\mathbf{\Phi}$.

Finally, to solve for an equilibrium let $\mathbf{\Theta}^S_{\hat{F}^S}$ be the part of the first row of $\mathbf{\Psi}^S$ that is associated with $\hat{\mathbf{F}}^S_t$, $\mathbf{\Theta}^U$ be the first row of $\mathbf{\Psi}^U$ and $\bar{\theta}^i$ be the mean local asset demand by investor i. In equilibrium we require that

$$\begin{aligned} \Delta\bar{\theta}^U + (1-\Delta)\,\bar{\theta}^S &= 1, \\ \Delta\mathbf{\Theta}^U + (1-\Delta)\,\mathbf{\Theta}^S_{\hat{F}} &= \mathbf{0}. \end{aligned}$$

B Detrending

Data on dividends and flows exhibit trends, while our quantitative exercise explores a detrended economy. We now outline a consistent approach to detrending dividends and flows. To fix ideas, consider the following stylized view of the stock market. There are N firms, each with a single share, paying the same (per-share) dividend $\tilde{D}_t$ and having the same (per-share) price $\tilde{P}_t$. Dividends grow at an exponential rate η. The parameter η thus captures trend firm productivity growth, which benefits owners through dividends.

An observed aggregate price index records the change in the value of the average firm, $\tilde{P}_t/\tilde{P}_{t-1}$. This change in valuation has two components: capital gains that arise from fluctuations in the firm's *stationary* price P_t/P_{t-1} and the growth in prices built in from productivity growth:

$$\tilde{P}_t/\tilde{P}_{t-1} = e^{\eta} P_t/P_{t-1}.$$

The observed dividend yield is $\delta_t = \tilde{D}_t/\tilde{P}_t = D_t/P_t$. A natural way to remove the trend from dividends is to exponentially detrend the measure $\delta_t\tilde{P}_t$. The observed holdings of the domestic equity index by investor i are $\tilde{P}_t\tilde{\theta}^i_t$. The observed market capitalization at the end of period t is the combined value of all plants, $\tilde{M}_t = \tilde{P}_t N$. The normalization of holdings by beginning-of-period market capitalization is thus a natural way to remove the exponential trend in holdings. The normalized holdings are:

$$\theta_t^i = \frac{\tilde{\theta}_t^i \tilde{P}_t}{\tilde{M}_t} = \frac{\tilde{\theta}_t^i}{N}.$$

There is an explicit connection between dividends and equilibrium holdings before and after detrending. We can summarize an economy driven by trending exogenous variables by a tuple $\mathcal{E} = \left(\tilde{R}_f, N, \left(\tilde{D}_t, \tilde{R}_t^W, \tilde{R}_t^B\right)_{t=0}^{\infty}\right)$. Suppose that $\tilde{D}_t = e^{\eta t} D_t$ and that $\left(\tilde{P}_t, \tilde{\theta}_t, \tilde{\psi}_t^W, \tilde{\psi}_t^B, \tilde{c}_t\right)$ is an equilibrium of $\mathcal{E}$, where we suppress the indices for the different types of agent. It can be verified that the tuple

$$\left(P_t, \theta_t, e^{-\eta t}\tilde{\psi}_t^W / N, e^{-\eta t}\tilde{\psi}_t^B, e^{-\eta t}\tilde{c}_t\right),$$

is an equilibrium of the detrended economy

$$\mathcal{E}_\eta = \left(\tilde{R}_f e^{-\eta}, 1, \left(D_t, e^{-\eta}\tilde{R}_t^W, e^{-\eta}\tilde{R}_t^B\right)_{t=0}^{\infty}\right).$$

In our quantitative exercise, we consider a detrended economy. We determine a stationary dividend process D_t as the residuals in a regression of average firm dividends on a time trend,

$$\log\left(\delta_t \tilde{P}_t\right) = E\left[\log D_t\right] + \eta t + \left(\log D_t - E\left[\log D_t\right]\right). \tag{25}$$

We then match the equilibrium flows to observed flows normalized by market capitalization. In the light of the above result, this ensures consistent detrending of dividends and flows.

We also need to select an interest rate R_f and a return process R_t^W for the detrended economy. Here we use the observed average interest rate and US stock return. In terms of the above notation, we are thus analyzing the economy $\mathcal{E}_0$. Given our data, this is preferable to considering the economy $\mathcal{E}_{\hat{\eta}}$ where $\hat{\eta}$ is the growth rate estimate from (25). The reason is that, in a small sample such as ours, $\hat{\eta}$ is driven by medium term developments and does not reflect the long run average growth rate. In particular, in our sample $\hat{\eta}$ exceeds the average real riskless interest rate. We are thus not likely to learn much by considering equilibrium flows from $\mathcal{E}_{\hat{\eta}}$. At the same time, the result of the previous paragraph shows that the only role of the trend growth rate η is to shift *all* returns. This suggests that the behavior of the correlations we are interested in will be similar across all economies $\mathcal{E}_\eta$ for η reasonably small.

C The Dividend Process

In this section, we fill in the details of how we estimate the dividend process. We derive conditions under which a general ARMA(2,2) process permits a representation of the type we assume for our dividend process:

$$\begin{aligned} F_t^D &= a_1 F_{t-1}^D + a_2 F_{t-2}^D + \varepsilon_t^{FD}, \\ D_t &= \bar{D} + F_{t-1}^D + \varepsilon_t^D, \end{aligned} \tag{26}$$

where ε_t^{FD} and ε_t^D are serially uncorrelated and independent random variables with zero mean and variances $\sigma^2_{\varepsilon^{FD}}$ and $\sigma^2_{\varepsilon^D}$, respectively. To prove our result we need to compare the correlogram of dividends under the two representations. Consider first the representation (26). The correlogram of the persistent component F_t^D is summarized by

$$\begin{aligned} \sigma^2\left(F_t^D\right) &= \left(1 - a_1^2 - a_2^2 - \frac{2a_2 a_1^2}{1-a_2}\right)^{-1} \sigma^2_{\varepsilon^{FD}}, \\ \sigma\left(F_t^D, F_{t-1}^D\right) &= \frac{a_1}{1-a_2}\sigma^2\left(F_t^D\right), \\ \sigma\left(F_t^D, F_{t-2}^D\right) &= a_1\sigma\left(F_t^D, F_{t-1}^D\right) + a_2\sigma^2\left(F_t^D\right) \\ &= \left(\frac{a_1^2}{1-a_2} + a_2\right)\sigma^2\left(F_t^D\right), \\ \sigma\left(F_t^D, F_{t-s}^D\right) &= a_1\sigma\left(F_t^D, F_{t-s+1}^D\right) + a_2\sigma\left(F_t^D, F_{t-s+2}^D\right);\ s \geq 3. \end{aligned}$$

The correlogram of the dividend process is thus given by

$$\begin{aligned} \sigma^2\left(D_t - \bar{D}\right) &= \sigma^2\left(F_t^D\right) + \sigma^2_{\varepsilon^D}, \\ \sigma\left(D_t - \bar{D}, D_{t-1} - \bar{D}\right) &= \sigma\left(F_t^D, F_{t-1}^D\right) \\ &= \frac{a_1}{1-a_2}\left[\sigma^2\left(D_t - \bar{D}\right) - \sigma^2_{\varepsilon^D}\right], \\ \sigma\left(D_t - \bar{D}, D_{t-2} - \bar{D}\right) &= \sigma\left(F_t^D, F_{t-2}^D\right) \\ &= a_1\sigma\left(D_t - \bar{D}, D_{t-1} - \bar{D}\right) + a_2\left[\sigma^2\left(D_t - \bar{D}\right) - \sigma^2_{\varepsilon^D}\right], \end{aligned}$$

as well as, for every $s \geq 3$,

$$\begin{aligned} \sigma\left(D_t - \bar{D}, D_{t-s} - \bar{D}\right) &= \sigma\left(F_t^D, F_{t-s}^D\right) \\ &= a_1\sigma\left(D_t - \bar{D}, D_{t-s+1} - \bar{D}\right) + a_2\sigma\left(D_t - \bar{D}, D_{t-s+2} - \bar{D}\right). \end{aligned}$$

Now consider a general ARMA(2,2) process

$$D_t - \bar{D} = a_1\left(D_{t-1} - \bar{D}\right) + a_2\left(D_{t-2} - \bar{D}\right) + u_t + \lambda_1 u_{t-1} + \lambda_2 u_{t-2},$$

where u_t is serially uncorrelated with mean zero and variance σ_u^2. Squaring both sides and taking expectations, we have

$$\begin{aligned}\sigma^2\left(D_t-\bar{D}\right) &= a_1^2\sigma^2\left(D_{t-1}-\bar{D}\right)+a_2^2\sigma^2\left(D_{t-2}-\bar{D}\right)+\sigma_u^2\left(1+\lambda_1^2+\lambda_2^2\right)\\ &\quad +2a_1\lambda_1\sigma\left(D_{t-1}-\bar{D},u_{t-1}\right)+2a_1\lambda_2\sigma\left(D_{t-1}-\bar{D},u_{t-2}\right)\\ &\quad +2a_2\lambda_2\sigma\left(D_{t-2}-\bar{D},u_{t-2}\right)+2a_1a_2\sigma\left(D_t-\bar{D},D_{t-1}-\bar{D}\right).\end{aligned}$$

In addition, multiplying both sides by $\left(D_{t-1}-\bar{D}\right)$ and taking expectations, we have

$$\begin{aligned}\sigma\left(D_t-\bar{D},D_{t-1}-\bar{D}\right) &= \sigma\left(a_1\left(D_{t-1}-\bar{D}\right)+a_2\left(D_{t-2}-\bar{D}\right)+\lambda_1u_{t-1}+\lambda_2u_{t-2},D_{t-1}-\bar{D}\right)\\ &= \frac{a_1}{1-a_2}\sigma^2\left(D_t-\bar{D}\right)+\frac{\lambda_1+\lambda_2\lambda_1+\lambda_2a_1}{1-a_2}\sigma_u^2. \qquad (27)\end{aligned}$$

Finally, multiplying by $\left(D_{t-2}-\bar{D}\right)$ and taking expectations, we obtain

$$\sigma\left(D_t-\bar{D},D_{t-2}-\bar{D}\right)=a_1\sigma\left(D_t-\bar{D},D_{t-1}-\bar{D}\right)+a_2\sigma^2\left(D_t-\bar{D}\right)+\lambda_2\sigma_u^2. \qquad (28)$$

The variance can be solved out in terms of parameters only:

$$\begin{aligned}\sigma^2\left(D_t-\bar{D}\right) &= \sigma_u^2\left(1-a_1^2-a_2^2-\frac{2a_1^2a_2}{1-a_2}\right)^{-1}\\ &\quad\times\left(1+\lambda_1^2+\lambda_2^2+2a_1\lambda_1+2a_1^2\lambda_2+2a_1\lambda_2\lambda_1+2a_2\lambda_2+2a_1a_2\frac{\lambda_1+\lambda_2\lambda_1+\lambda_2a_1}{1-a_2}\right).\end{aligned}$$

The first and second covariances are then given by (27) and (28) and all further covariances (for $s\geq 3$) follow the recursion

$$\sigma\left(D_t-\bar{D},D_{t-s}-\bar{D}\right)=a_1\sigma\left(D_t-\bar{D},D_{t-s+1}-\bar{D}\right)+a_2\sigma\left(D_t-\bar{D},D_{t-s+2}-\bar{D}\right).$$

It is clear that if a given ARMA(2,2) process is to have the representation (26), the autoregressive coefficients must be the same in both representations. Moreover, since the recursions for all covariances beyond lag 2 are identical, a representation of the type (26) exists if there exist $\sigma^2_{\varepsilon^{FD}},\sigma^2_{\varepsilon^D}>0$ such that the variance and the first two covariances are matched, which require that:

$$\begin{aligned}&\sigma_u^2\left(1+\lambda_1^2+\lambda_2^2+2a_1\lambda_1+2a_1^2\lambda_2+2a_1\lambda_2\lambda_1+2a_2\lambda_2+2a_1a_2\frac{\lambda_1+\lambda_2\lambda_1+\lambda_2a_1}{1-a_2}\right)\\ &= \sigma^2_{\varepsilon^{FD}}+\sigma^2_{\varepsilon^D}\left(1-a_1^2-a_2^2-\frac{2a_2a_1^2}{1-a_2}\right),\end{aligned}$$

$$\left(\lambda_1+\lambda_2\lambda_1+\lambda_2a_1\right)\sigma_u^2=-a_1\sigma^2_{\varepsilon^D},$$

$$\lambda_2\sigma_u^2 = -a_2\sigma_{\varepsilon^D}^2.$$

The first and last equations can be used to calculate the implied values of $\sigma_{\varepsilon^D}^2$ and $\sigma_{\varepsilon^{FD}}^2$ and obtain two inequality constraints on the ARMA(2,2) parameters:

$$\begin{aligned}
\sigma_{\varepsilon^D}^2 &= -\frac{\lambda_2}{a_2}\sigma_u^2 > 0, \\
\sigma_{\varepsilon^{FD}}^2 &= \sigma_u^2\left[1+\lambda_1^2+\lambda_2^2+2a_1\lambda_1+2a_1^2\lambda_2+2a_1\lambda_2\lambda_1+2a_2\lambda_2\right. \\
&\quad \left. +2a_1a_2\frac{\lambda_1+\lambda_2\lambda_1+\lambda_2 a_1}{1-a_2}+\frac{\lambda_2}{a_2}\left(1-a_1^2-a_2^2-\frac{2a_2a_1^2}{1-a_2}\right)\right] > 0.
\end{aligned} \tag{29}$$

The second equation implies the additional constraint

$$0 = a_2\lambda_1\left(1+\lambda_2\right) - a_1\lambda_2\left(1-a_2\right). \tag{30}$$

In a first estimation step, we impose (30), but do not impose the inequality constraint. The inequalities are not binding in all countries except for Japan and UK. For these countries, we impose $\sigma_{\varepsilon^D}^2 = 0.001$, and reestimate the restricted ARMA(2,2) process. Setting the variance of transient shocks to dividends equal to zero implies that there are no trades based on private information as the equilibrium is fully revealing.

Table 6 below presents the estimates for the restricted ARMA(2,2) process. These estimates are then used to produce Table 2 in the main text according to the formulas in (29). The estimated ARMA(2,2) produces statistically significant estimates of the autoregressive parameters a_1 and a_2 most all countries (except for Japan's a_2) and of the moving average parameters λ_1 and λ_2 as well (except for France and Japan). Estimates of σ_u^2 are also significant in all cases except for Canada. Finally, the constraint (30) is not rejected in 3 out of 7 countries at the usual 5% significance level and is barely rejected in the case of the US.

Table 6. estimates of ARMA(2,2) process.

	a_1	a_2	λ_1	λ_2	σ_u^2	$\chi_{(1)}$/p-value
CAN	1.859	−0.896	−1.051	0.365	0.013	4.499
	6.59	−3.94	−4.23	2.91	0.78	0.033
FRA	1.369	−0.420	−0.092	0.020	0.014	5.327
	33.39	−20.60	−0.64	0.62	5.42	0.020
GER	1.734	−0.773	−0.803	0.253	0.101	2.608
	19.47	−8.99	−4.92	3.80	6.18	0.106
ITA	1.685	−0.708	−0.398	0.108	0.001	30.41
	51.41	−32.03	−4.94	4.47	8.28	0.000
JAP	1.212	−0.275	−0.002	0.0004	0.786	2.768
	4.884	−0.295	−0.815	0.272	3.141	0.096
UK	1.223	−0.294	−0.003	0.0005	0.575	2.089
	16.408	−5.464	−9.349	6.125	8.212	0.148
US	1.679	−0.747	−0.754	0.237	2.100	3.846
	6.60	−3.18	−2.02	1.55	9.48	0.049

NOTES: For each country, the second row gives t-statistics on the corresponding estimates. $\chi_{(1)}$ and p-values are given for the non-linear constraint (30).

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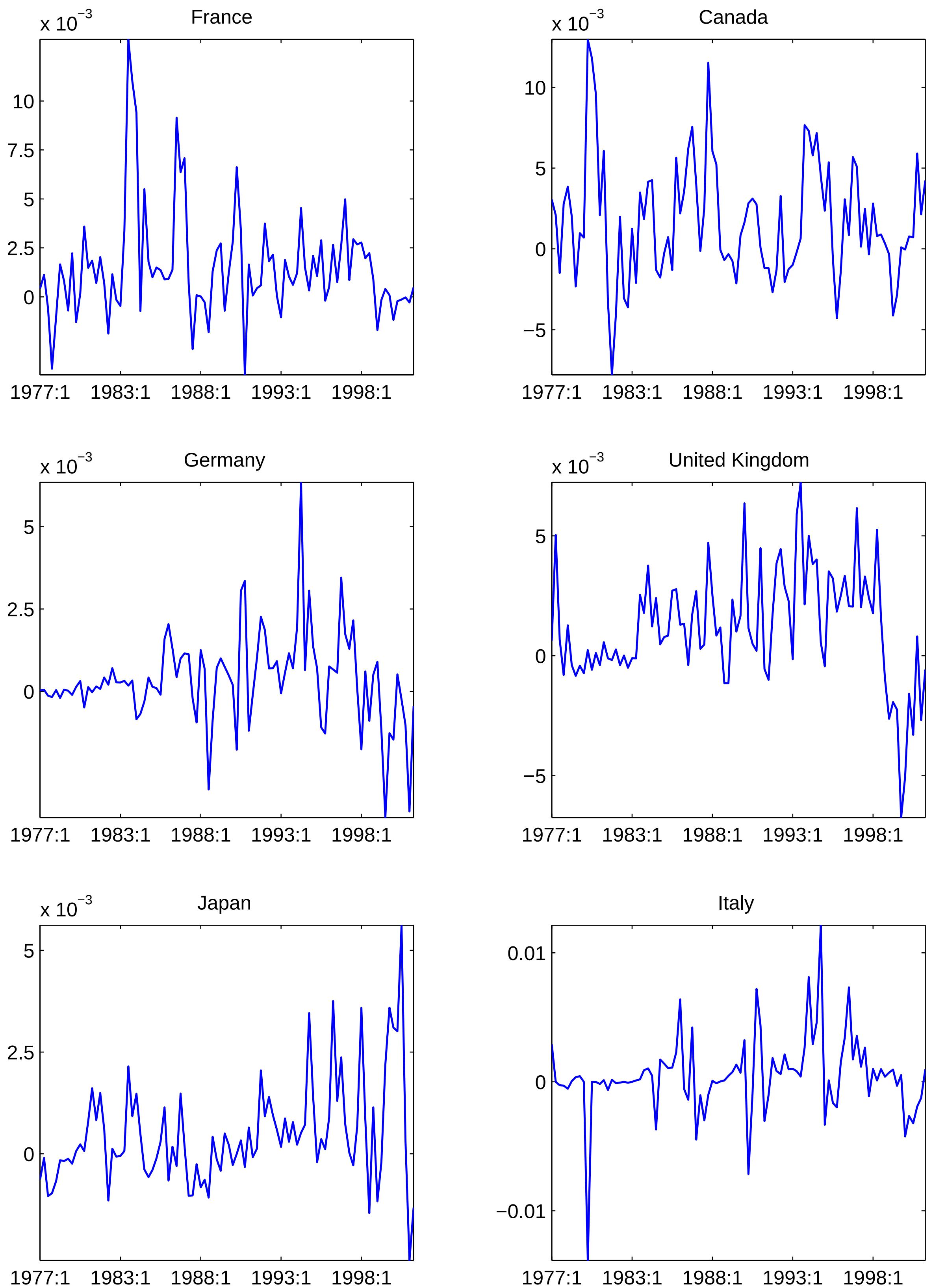

Figure 1: Net purchases by US investors as a fraction of local market capitalization.

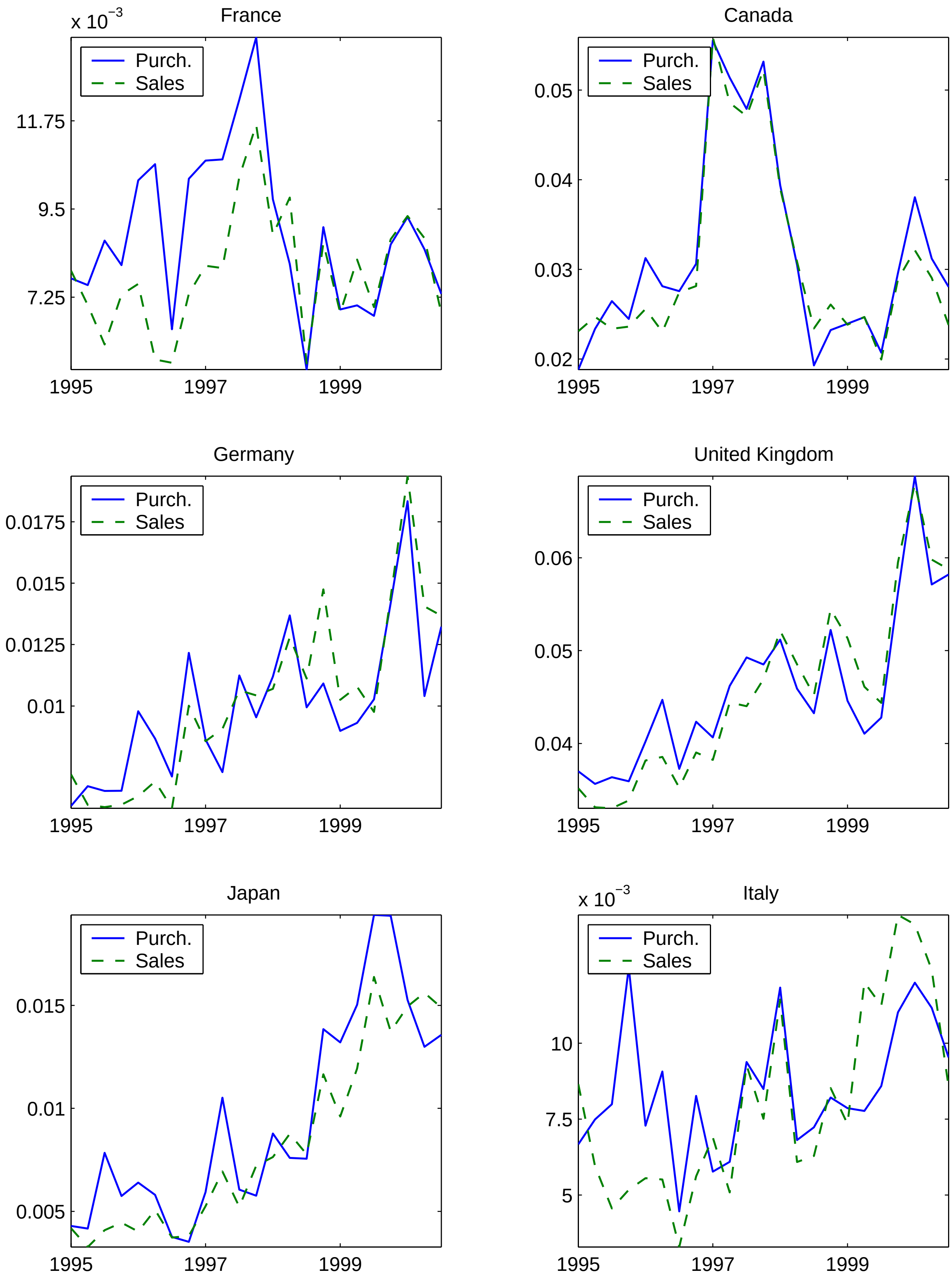

Figure 2: US investors gross purchases and sales of foreign equities.

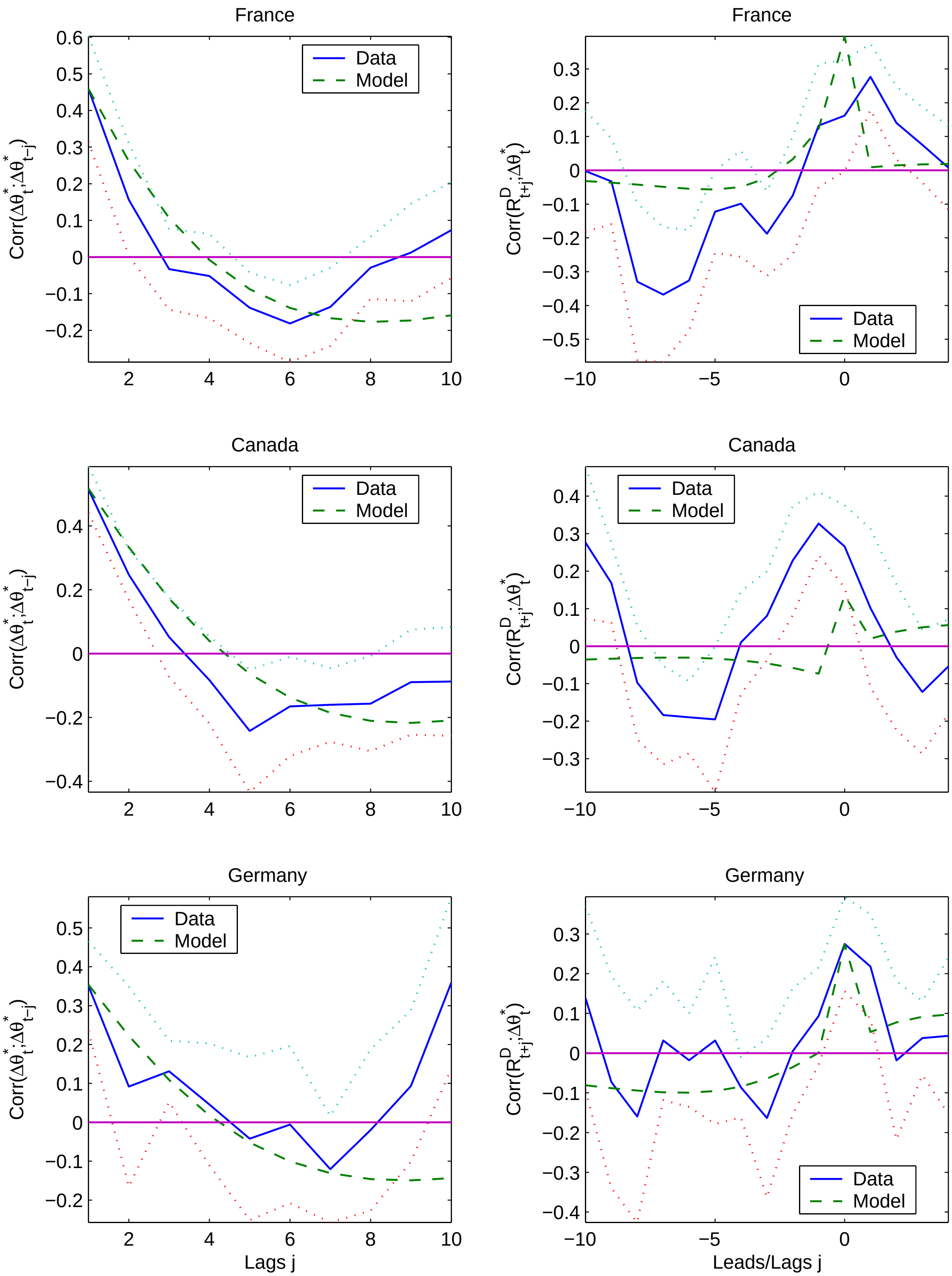

Figure 3: Autocorrelogram of flows and cross-correlogram of returns and flows: France, Canada and Germany. Notes: $\Delta\theta_t^{D*}$ is net-purchases of the local asset by US investors; R_t^D is the current return on the local asset. Dotted lines are 90 percent confidence bands.

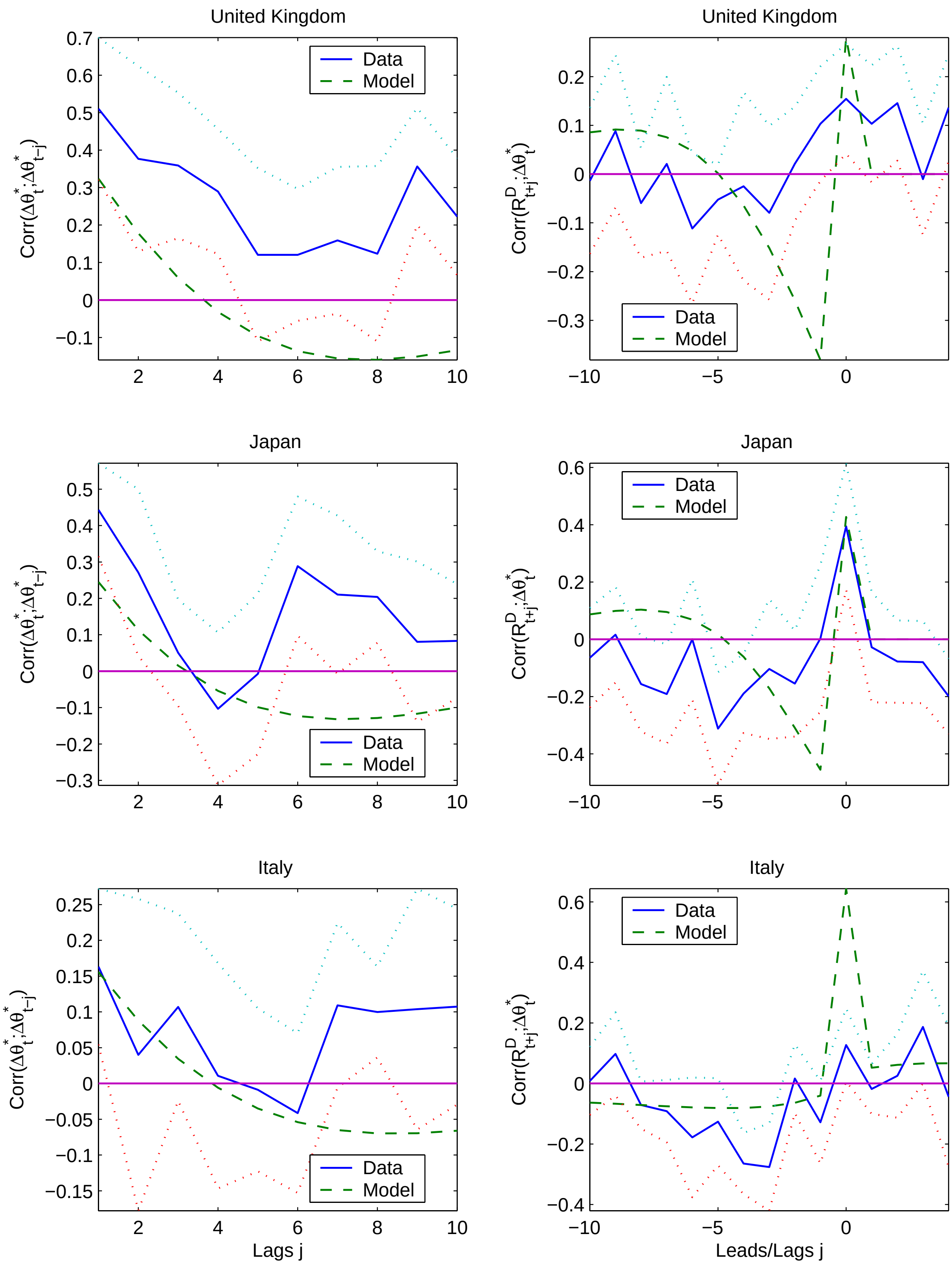

Figure 4: Autocorrelogram of flows and cross-correlogram of returns and flows: U.K., Japan and Italy. Notes: $\Delta\theta_t^*$ is net-purchases of the local asset by US investors; R_t^D is the current return on the local asset. Dotted lines are 90 percent confidence bands.

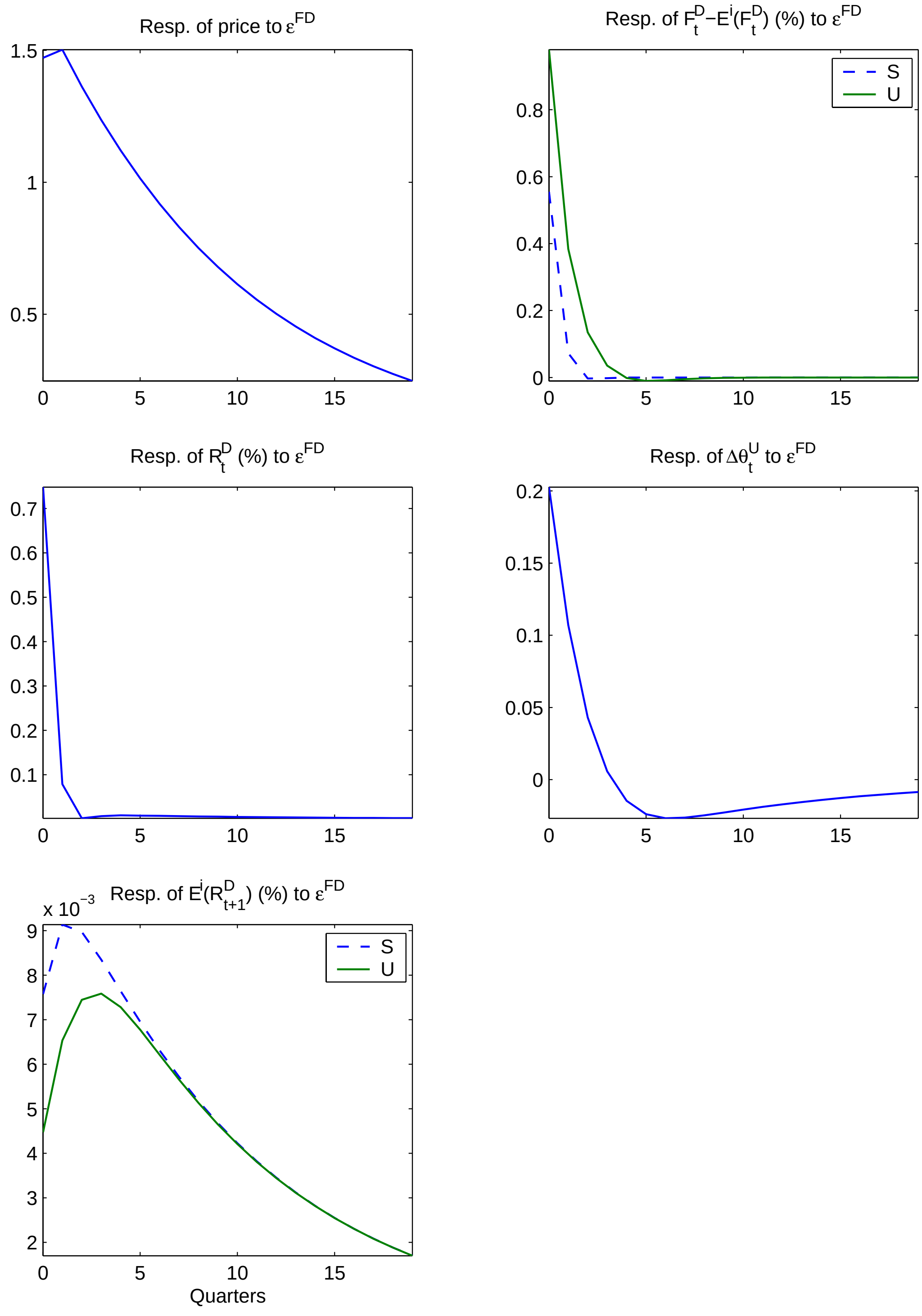

Figure 5: Impulse response function of the asymmetric information model to a persistent business cycle shock. Notes: $\Delta\theta_t^U$ is net-purchases of the local asset by unsophisticated investors; R_t^D is the current return on the local asset; $E_t^i R_{t+1}^D$ is the time t expectation by investors of type i of the time $t+1$ return on the local asset; $F_t^D - E_t^i F_t^D$ is the forecast error by investors of type i on the local business cycle factor.

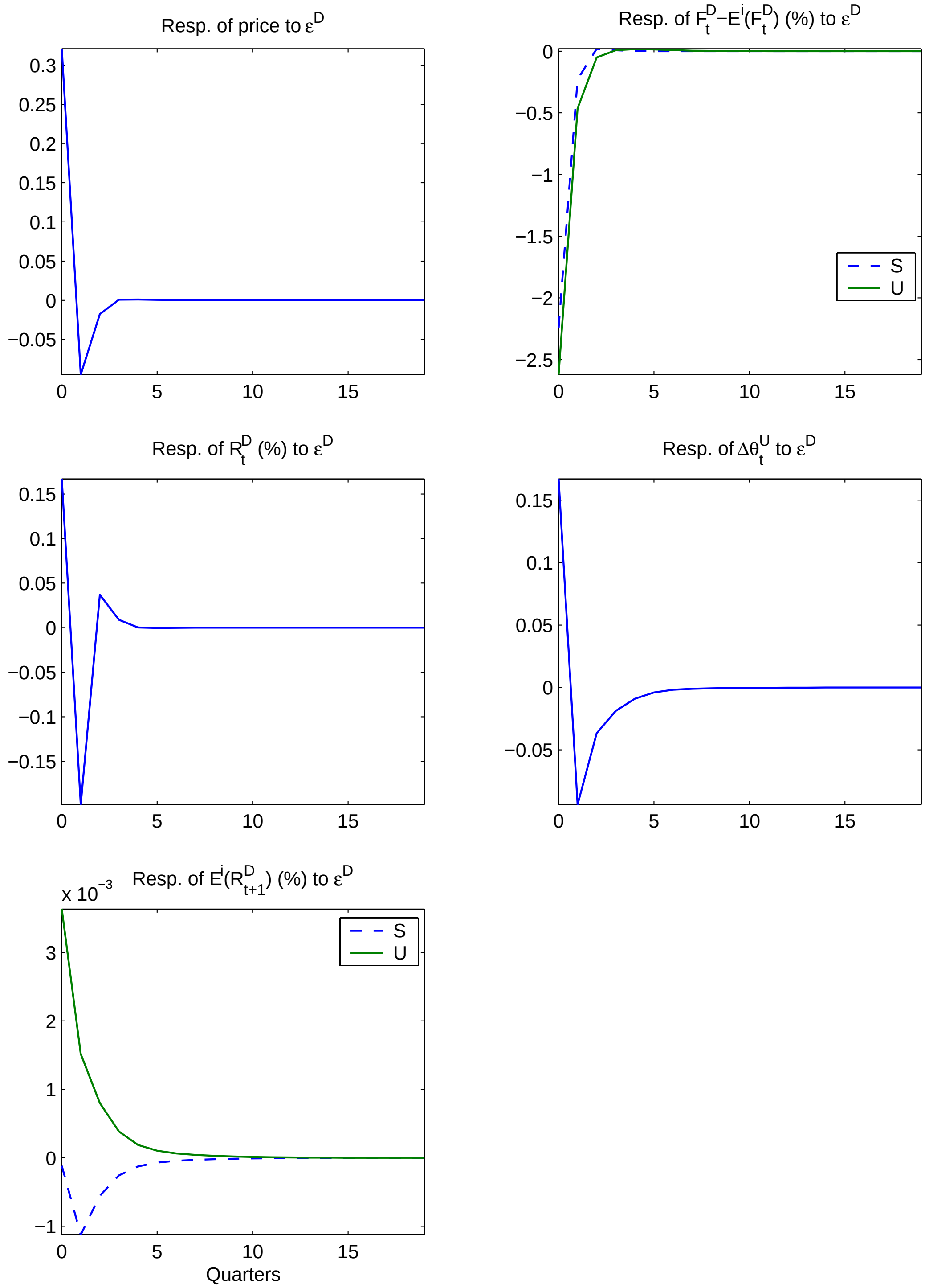

Figure 6: Impulse response function of the asymmetric information model to a transient business cycle shock. Notes: $\Delta\theta_t^U$ is net-purchases of the local asset by unsophisticated investors; R_t^D is the current return on the local asset; $E_t^i R_{t+1}^D$ is the time t expectation by investors of type i of the time $t+1$ return on the local asset; $F_t^D - E_t^i F_t^D$ is the forecast error by investors of type i on the local business cycle factor.

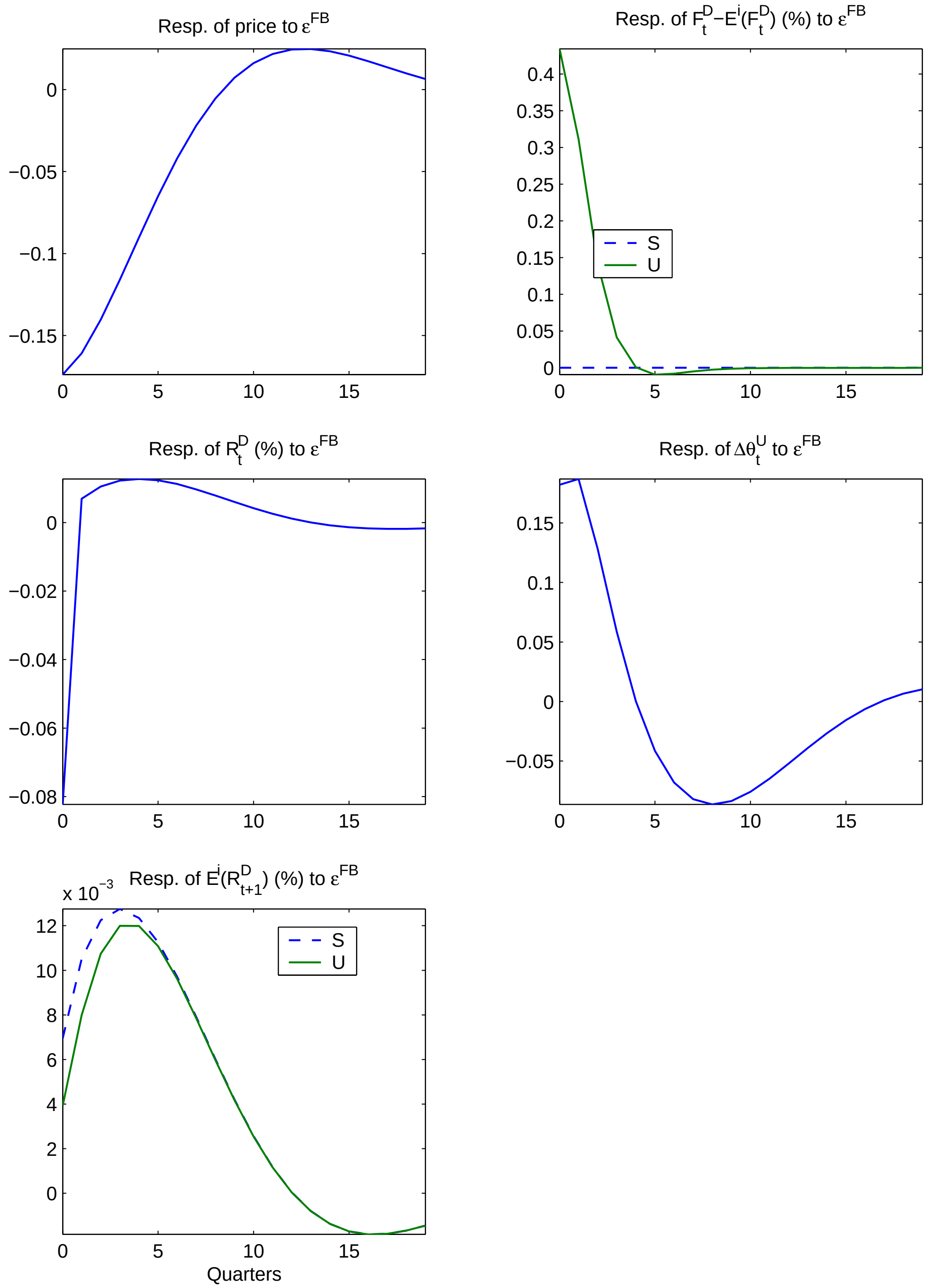

Figure 7: Impulse response function of the asymmetric information model to a persistent off-market shock. Notes: $\Delta\theta_t^U$ is net-purchases of the local asset by unsophisticated investors; R_t^D is the current return on the local asset; $E_t^i R_{t+1}^D$ is the time t expectation by investors of type i of the time $t+1$ return on the local asset; $F_t^D - E_t^i F_t^D$ is the forecast error by investors of type i on the local business cycle factor.

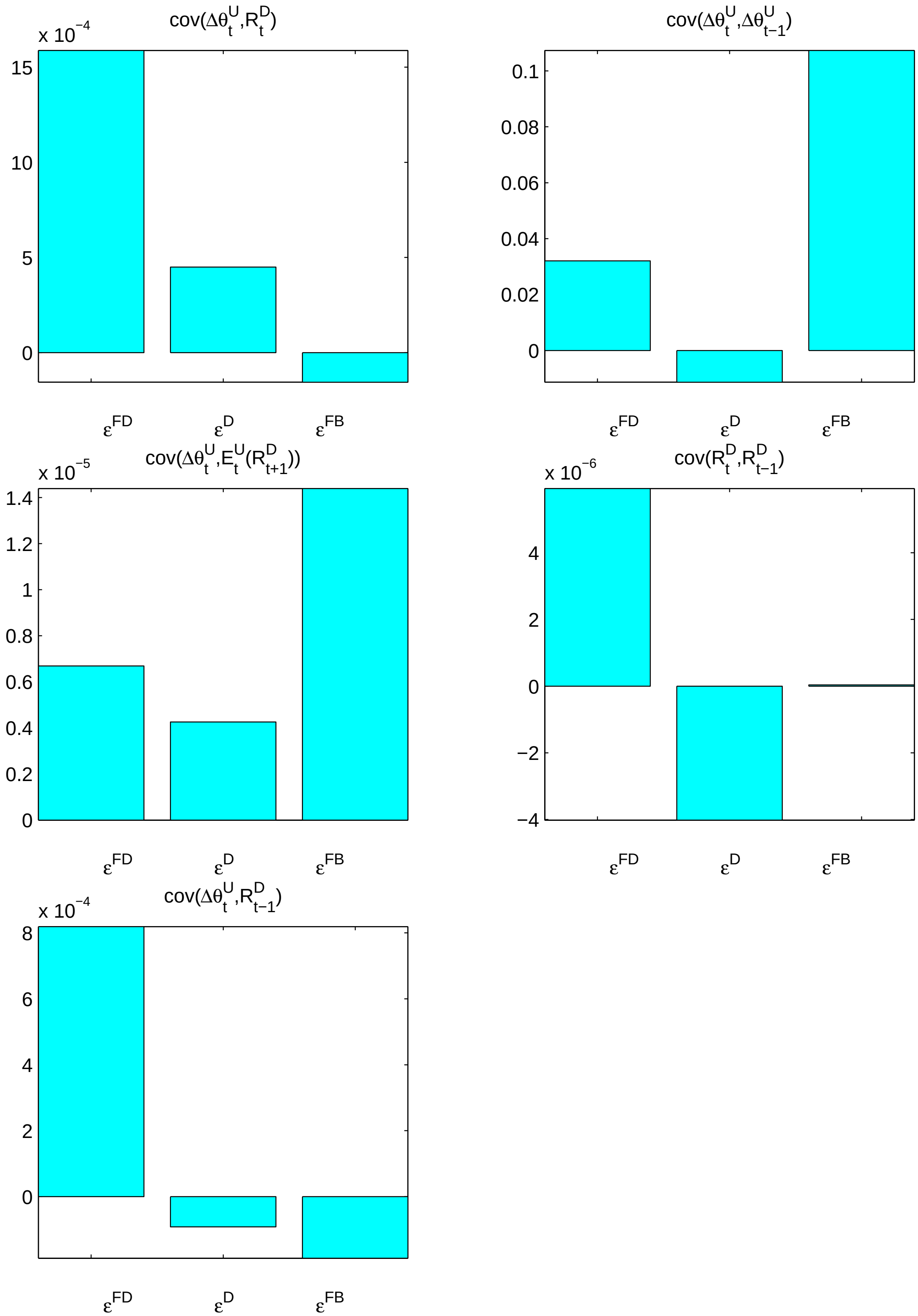

Figure 8: Variance decomposition in the asymmetric information model. Notes: $\Delta\theta_t^U$ is net-purchases of the local asset by unsophisticated investors; R_t^D is the return on the local asset; $E_t^U R_{t+1}^D$ is the time t expectation by unsophisticated investors of the time $t+1$ return on the local asset.