International Capital Flows under Dispersed Private Information

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Abstract

It is well established that private information is critical to our understanding of asset prices. In this paper we argue that it should also affect international capital flows and use a simple two-country DSGE model to illustrate its impact. We show that private information (i) increases the volatility of both net and gross capital flows, (ii) leads to a high correlation between capital inflows and outflows, (iii) leads to a disconnect of capital flows from observed macro fundamentals and (iv) implies that capital flows contain information about the future macro fundamentals.

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1 Introduction

Observed fundamentals have limited explanatory power for changes in asset prices. This puzzling disconnect is well known for both exchange rates and equity prices.\(^1\) The literature highlights the presence of dispersed private information across agents as an explanation. Asset prices then contain information about future asset payoffs (through private signals) that is not reflected in publicly observed fundamentals. In addition, the combination of the information content of asset prices and even small non-informational trades (e.g. noise trade or liquidity trade) can lead to a very large impact of non-informational trades on asset prices (e.g. Bacchetta and van Wincoop 2006, Gennai and Leland 1990, Romer 1993). For example, a higher asset price resulting from noise trade can rationally cause all investors to infer that others have private information about better future fundamentals. This leads all investors to be more optimistic about future fundamentals even if no one has favorable signals about them. The information content of asset prices beyond publicly observed fundamentals has been a central theme in a large literature on asset prices with private information.\(^2\)

In this paper we focus on international capital flows. As capital flows and asset prices both reflect portfolio choice, the dispersed private information that affects asset prices should similarly affect capital flows. We use a simple two-country DSGE model to illustrate the impact of private information on gross and net capital flows (current account). We show that, just like for asset prices, dispersed information leads to a disconnect between capital flows and observed fundamentals and implies that capital flows contain information about future fundamentals. We also show that private information increases the volatility of capital flows and leads to a higher correlation between capital inflows and outflows.

We stress from the outset that our objective is limited to illustrating the impact of dispersed information on international capital flows at a theoretical level. We make no claims about the quantitative importance of dispersed information for international capital flows. While a numerical illustration of our model shows that the impact can be large, the model is too simple to draw general conclusions and

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\(^1\) The October 1987 stock market crash saw a 20\% drop in the stock price without any obvious news. Cutler et.al. (1989) find that most of the largest stock prices changes in 1946-1987 are hard to relate to public news. Roll (1988), French and Roll (1986) and Romer (1993) provide further evidence on this disconnect for equity prices.

\(^2\) See Brunnermeier (2001) for a review of the literature.
more thorough empirical work is needed. Early work on the impact of dispersed information on asset prices has also been entirely theoretical (see Brunnermeier, 2001). In addition, we do not claim that the mechanisms through which private information impacts capital flows in our model are the only possible ones. There may be other mechanisms leading to qualitatively similar results. We will discuss some of them. Finally, introducing dispersed information into a DSGE open economy model raises many technical issues associated with the solution method. In order to keep the paper focused on international capital flows, we leave a full discussion of the solution method to a companion paper, Tille and van Wincoop (2012).

We consider three versions of the model that only differ in their information structure. In each version agents make saving, investment and portfolio decisions. The model is driven by standard productivity shocks. The general equilibrium aspect is important when analyzing capital flows. Portfolio shifts across countries affect relative asset prices, which affect expected returns, which in turn feed back to portfolio flows. Expected returns, risk associated with asset returns, and capital flows are all determined jointly in the model.

The first version, which we refer to as the standard model, assumes that agents receive no signals about future productivity innovations. This is a useful starting point as the existing literature on international capital flows relies on models of this type.3 The second version introduces private signals about next period’s productivity innovations, and we refer to it as the private signals model. Apart from private signals, it includes another feature familiar from noisy rational expectations (NRE) asset pricing models, namely non-informational trade (noise) that prevents asset prices from revealing the private information. The last version only differs in that we replace the private signals about future productivity with publicly observed signals about future productivity, and we refer to it as the public signals model. Our focus is on the private signals model, which we contrast to the other two versions to show the role of private information.

The paper is related to a small literature that introduces NRE asset pricing features into open economy models. These include Albuquerque, Bauer and Schneider (2007,2009), Bacchetta and van Wincoop (2004,2006), Brennan and Cao (1997), Gehrig (1993) and Veldkamp and van Nieuwerburgh (2009). These papers focus

3For some recent papers on gross and net capital flows in two-country DSGE models see Devereux and Sutherland (2010), Evans and Hnatkovska (2005) and Tille and van Wincoop (2010a,b).
on a variety of issues, ranging from exchange rate puzzles to international portfolio home bias and the relationship between asset returns and portfolio flows. Together they show that information dispersion within and across countries can tell us a lot about a wide range of stylized facts related to international asset prices and portfolio allocation.

A limitation of these models is that they are not suited to study aggregate capital inflows and outflows or even net capital flows. They are linear partial equilibrium models, in contrast to the DSGE open economy models of international capital flows. There is always a riskfree asset that is in infinite supply in an unspecified location.4 There is no saving or investment, so literally net capital flows are zero.

The paper is organized as follows. Section 2 describes the model. Section 3 discusses the implications for asset prices and capital flows. Section 4 provides a numerical illustration and Section 5 concludes.

2 The Model

We consider a two-country DSGE model that we purposely keep very simple. There is just one numeraire good that is produced in the Home and Foreign countries. There are two assets, one for each country. We adopt a simple OLG setup to simplify consumption and portfolio decisions. The model is driven by standard country-specific productivity shocks. We first describe the features that are common to the three versions of the model, and then describe the information structure and non-informational trade that differs across them.

2.1 Production, Investment and Assets

The good is produced using a constant returns to scale technology in labor and capital:

\[ Y_{i,t} = A_{i,t} K_{i,t}^{1-\omega} N_{i,t}^{\omega} \; ; \; i = H, F \]  

where \( H \) and \( F \) denote the Home and Foreign country respectively. \( Y_i \) is the output in country \( i \), \( A_i \) is a country-specific exogenous stochastic productivity

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4Even when assets with a riskfree return exist (e.g. Treasury bills), in a general equilibrium framework the demand for such assets must equate their finite supply.
term, $K_i$ is the capital input and $N_i$ the labor input that we normalize to unity. Log productivity follows an autoregressive process:

$$a_{i,t+1} = \rho a_{i,t} + \varepsilon_{i,t+1} \quad i = H, F$$

where $\varepsilon_{i,t+1}$ has a $N(0, \sigma^2_n)$ distribution that is known by all agents. Innovations are uncorrelated across countries.

The dynamics of the capital stock reflects depreciation at a rate $\delta$ and investment $I_{i,t}$:

$$K_{i,t+1} = (1 - \delta) K_{i,t} + I_{i,t} \quad i = H, F$$

(2)

A share $\omega$ of output is paid to labor, with the remaining going to capital. The wage rate in country $i$ is then

$$W_{i,t} = \omega A_{i,t} (K_{i,t})^{1-\omega} \quad i = H, F$$

(3)

Capital is supplied by a competitive installment firm. In period $t$ the firm produces $I_{i,t}$ units of new capital and sells them at a price $Q_{i,t}$. The production of $I_{i,t}$ units of capital good entails a quadratic adjustment cost and requires the following amount in units of the consumption good:

$$I_{i,t} + \frac{\xi (I_{i,t} - \delta K_{i,t})^2}{2 K_{i,t}}$$

(4)

The profit of installing $I_{i,t}$ units of capital in country $i$ is then $Q_{i,t} I_{i,t}$ minus the cost (4). Profit maximization by the installment firm implies a standard Tobin’s Q relation:

$$\frac{I_{i,t}}{K_{i,t}} = \delta + \frac{Q_{i,t} - 1}{\xi}$$

(5)

There is a Home asset and a Foreign asset, which are claims on respectively a unit of Home capital and Foreign capital. The price of the country $i$ asset is equal to the cost of purchasing one unit of capital from the installment firm, $Q_{i,t}$. An investor purchasing the asset at the end of period $t$ gets a dividend of $(1 - \omega) Y_{i,t+1}/K_{i,t+1}$ in period $t+1$, and can sell the remaining $1 - \delta$ units of capital at a price $Q_{i,t+1}$. The returns on Home and Foreign assets are then

$$R_{H,t+1} = \frac{(1 - \omega) A_{H,t+1} (K_{H,t+1})^{-\omega} + (1 - \delta) Q_{H,t+1}}{Q_{H,t}}$$

(6)

$$R_{F,t+1} = \frac{(1 - \omega) A_{F,t+1} (K_{F,t+1})^{-\omega} + (1 - \delta) Q_{F,t+1}}{Q_{F,t}}$$

(7)
2.2 Consumption and Portfolio Choice

We adopt an overlapping generation structure where agents live for two periods and only work in the first period. In each country, each generation consists of a unit mass of individual agents that we index by $j$. A young Home agent at time $t$ chooses her consumption and portfolio to maximize

$$
\ln \left( C_{y,t}^{Hj} \right) + \beta E_t \ln \left( C_{o,t+1}^{Hj} \right)
$$

where $C_{y,t}^{Hj}$ is consumption when young and $C_{o,t+1}^{Hj}$ is consumption when old.

We assume that agents face a cost of investing abroad. This cost is a standard device in the literature to generate portfolio home bias. In our analysis a time-varying cost of investment abroad also serves as a source of non-informational trade (or noise) familiar from NRE models, an aspect that differs across the three versions of the model and will be discussed below. In general the cost can vary across countries, time and individual agents. A Home agent $j$ investing in the Foreign asset at time $t$ only gets a return $e^{-\tau_{Hj,t}} R_{F,t+1}$, and similarly a Foreign agent $j$ receives a return $e^{-\tau_{Fj,t}} R_{H,t+1}$ when investing in the Home asset.

The Home agent maximizes (8) subject to the budget constraint and portfolio return,

$$R_{t+1}^{p,Hj}:
C_{o,t+1}^{Hj} = (W_{H,t} - C_{y,t}^{Hj}) R_{t+1}^{p,Hj}
R_{t+1}^{p,Hj} = z_{Hj,t} R_{H,t+1} + (1 - z_{Hj,t}) e^{-\tau_{Hj,t}} R_{F,t+1}
$$

where $z_{Hj,t}$ is the fraction of wealth invested in the Home asset.

The intertemporal consumption Euler equation implies

$$C_{y,t}^{Hj} = \frac{1}{1 + \beta} W_{H,t}
$$

Consumption is a constant fraction of labor income, which is identical across agents in a given country, and so is saving:

$$S_{y,t}^{Hj} = \frac{\beta}{1 + \beta} W_{H,t}
$$

The portfolio Euler equation is

$$E_t^H \left( R_{t+1}^{p,Hj} \right)^{-1} \left( R_{H,t+1} - e^{-\tau_{Hj,t}} R_{F,t+1} \right) = 0
$$
(12) equates the expected discounted return (the expected product of the asset pricing kernel and asset return) across assets. The asset pricing kernel is the marginal utility of future consumption, which is inversely proportional to the return on the agent’s portfolio.

Foreign agents face an analogous decision problem with portfolio return

\[ R_{t+1}^{p,Fj} = z_{Fj,t} e^{-\tau_{Fj,t}} R_{H,t+1} + (1 - z_{Fj,t}) R_{F,t+1} \]  

(13)

The corresponding optimality conditions for a Foreign investor are

\[ C_{Fj}^{y} = \frac{1}{1 + \beta} W_{F,t} \]  

(14)

\[ E_{t}^{F} \left( R_{t+1}^{p,Fj} \right)^{-1} \left( e^{-\tau_{Fj,t}} R_{H,t+1} - R_{F,t+1} \right) = 0 \]  

(15)

### 2.3 Asset Market Clearing

We denote the financial wealth in country \( i \), which is equal to saving by the young, as \( W_{i,t}^{F} = \beta W_{i,t}/(1 + \beta) \). Asset market clearing requires that the value of capital in a country is equal to portfolio demand by all young agents worldwide. The asset market clearing conditions are then

\[ Q_{H,t} K_{H,t+1} = W_{H,t}^{F} z_{H,t} + W_{F,t}^{F} z_{F,t} \]  

(16)

\[ Q_{F,t} K_{F,t+1} = W_{H,t}^{F} (1 - z_{H,t}) + W_{F,t}^{F} (1 - z_{F,t}) \]  

(17)

where \( z_{H,t} = \int_{0}^{1} z_{H,j,t} dj \) and \( z_{F,t} = \int_{0}^{1} z_{F,j,t} dj \) denote the average portfolio shares among agents in the respective countries. We can omit the world goods market clearing condition due to Walras’ law.

### 2.4 Information Structure and Non-Informational Trade

We complete the description of the model by describing the information structure and non-informational trade, where the three versions of the model differ. In the standard model all agents only know the unconditional distribution of productivity innovations \( \varepsilon_{i,t+1} \). We also abstract from non-informational or noise trade as this is absent in standard DSGE models. \( \tau_{H,j,t} \) and \( \tau_{F,j,t} \) are equal to a constant \( \tau \).

In the private signals model each agent also receives private signals about next period’s productivity innovations. In addition there is non-informational trade
due to time-variation in the cost of investing abroad ($\tau_{H,j,t}$ and $\tau_{F,j,t}$) that is not observable in the aggregate. We describe this cost in more detail below. The *public signals* model only differs from the private signals model in that all agents receive the same signals on future innovations. We now describe these last two versions of the model in greater detail.

### 2.4.1 Private Signals Model

The private signals model is the main focus of the paper. It contains the two key elements of NRE models: private information about future fundamentals and noise that prevents asset prices from revealing the private information.

Each agent receives private signals about next period’s productivity innovations in both countries. The signals observed by Home agent $j$ about respectively the Home and Foreign productivity innovation are:

$$
\begin{align*}
\nu_{j,t}^{H,t} &= \varepsilon_{H,t+1}^{H,t} + \epsilon_{j,t}^{H,t} \\
\epsilon_{j,t}^{H,t} &\sim N \left( 0, \sigma_{HH}^2 \right)
\end{align*}
$$

(18)

$$
\begin{align*}
\nu_{j,t}^{H,F} &= \varepsilon_{F,t+1}^{H,F} + \epsilon_{j,t}^{H,F} \\
\epsilon_{j,t}^{H,F} &\sim N \left( 0, \sigma_{HF}^2 \right)
\end{align*}
$$

(19)

Each signal consists of the true innovation and a stochastic error. Similarly, agent $j$ in the Foreign country observes the signals:

$$
\begin{align*}
\nu_{j,t}^{F,H} &= \varepsilon_{H,t+1}^{F,H} + \epsilon_{j,t}^{F,H} \\
\epsilon_{j,t}^{F,H} &\sim N \left( 0, \sigma_{HH}^2 \right)
\end{align*}
$$

(20)

$$
\begin{align*}
\nu_{j,t}^{F,F} &= \varepsilon_{F,t+1}^{F,F} + \epsilon_{j,t}^{F,F} \\
\epsilon_{j,t}^{F,F} &\sim N \left( 0, \sigma_{HH}^2 \right)
\end{align*}
$$

(21)

As is standard in NRE models, we assume that the errors of the signals average to zero across investors in a given country ($\int_0^1 \epsilon_{j,t}^{H,H} \, dj = \int_0^1 \epsilon_{j,t}^{H,F} \, dj = 0$).

Our setup is symmetric as the variance of signals on domestic productivity is the same for agents in the two countries, and so is the variance of signals on productivity abroad. We allow for an information asymmetry with agents receiving more precise signals about shocks in their own country than abroad: $\sigma_{HH}^2 \leq \sigma_{HF}^2$.

A substantial literature has documented information differences across countries, with local investors having more reliable information than foreign investors.\(^5\)

\(^5\)See for example Bae, Stulz and Tan (2008), who document that earnings forecasts are more precise for local than foreign analysts. Leuz, Lins and Warnock (2009) provide evidence that agency problems are better monitored by locals. Ahearne et.al. (2004) find that home bias of U.S. investors relative to other countries is significantly reduced when the stock of foreign countries is traded on centralized exchanges. This reduces information barriers as a result of
Noise or non-informational trade is the other central ingredient of NRE models. It prevents the asset price from revealing aggregate private information about a future fundamental. It usually takes the form of exogenous "noise" or "liquidity" trade unrelated to portfolio optimization. Some papers have introduced the noise endogenously in various forms of hedge trade and liquidity trade.\(^6\)

Although the precise source of the noise does not matter for the results, here we introduce it through a time-varying cost of investing abroad. The average cost faced by Home investors in period \(t\) is \(\tau_{H,t} = \int_0^1 \tau_{H,j,t} d\tau = \tau (1 + \varepsilon^*_t)\), where \(\varepsilon^*_t\) has a \(N(0, \theta \sigma^2_n)\) distribution. We assume that \(\tau_{H,j,t}\) is an infinitely noisy signal of \(\tau_{H,t}\), so that an agent cannot infer the value of the average cost from her own cost. This assumption can be relaxed but simplifies the analysis.\(^7\) The average cost in the Foreign country is \(\tau_{F,t} = \int_0^1 \tau_{F,j,t} d\tau = \tau(1 - \varepsilon^*_t)\), which is also unobserved. The average cost across all agents therefore remains constant at \(\tau\), while the difference across the two countries is \(\tau^D_t = \tau_{H,t} - \tau_{F,t} = 2\tau\varepsilon^*_t\). That difference is the noise in our model. An increase in \(\varepsilon^*_t\) leads to a portfolio shift towards the Home asset as it is relatively more expensive for Home agents to invest abroad than for Foreign agents. Such unobserved portfolio shifts prevent the relative asset price from fully revealing private information about future relative productivity.

### 2.4.2 Public Signals Model

In the public signals model all agents receive the same signals about future productivity:

\[
\begin{align*}
\nu^H_t &= \varepsilon_{H,t+1} + \varepsilon^H_t \\
\nu^F_t &= \varepsilon_{F,t+1} + \varepsilon^F_t
\end{align*}
\]

The signal errors \(\varepsilon^H_t\) and \(\varepsilon^F_t\) each have a \(N(0, \theta^2_v)\) distribution and are uncorrelated. The public signals model has in common with the standard model that expectations the regulatory and accounting burden imposed on such foreign firms. Portes and Rey (2005) find that "the geography of information is the main determinant of the pattern of international (financial) transactions", documenting the effect of a variety of informational frictions on cross-border equity flows. Kang and Stulz (1997) document that investors tend to invest in foreign firms for which information barriers are lower (large firms with good accounting performance, low unsystematic risk and low leverage).


\(^7\)See Bacchetta and van Wincoop (2006) for a similar assumption.
are only conditioned on publicly available information. The difference is that the public information set is somewhat expanded in the public signals model.

Public signals are the only feature that differs between the private and public signals models. Noise or non-informational trade is assumed to be the same as in the private information model. This allows us to highlight the impact of private information about future fundamentals by comparing the two versions of the model as all other aspects of the two models are identical.

2.5 Solution and Orders

Given the optimal expressions for consumption and investment, an equilibrium of the model is defined as a solution for the two asset prices and portfolio shares such that portfolio Euler equations (12) and (15) are satisfied and asset markets clear. In the standard model asset prices and portfolio shares \( z_{H,t} \) and \( z_{F,t} \) depend on the publicly observed state variables

\[
S_t = (a^D_t, a^A_t, k^D_t, k^A_t)
\]  

(24)

Lower case letters denote logs, \( D \) stands for the difference across countries and \( A \) for the average. In the private signals model asset prices and average portfolio shares also depend on the unobservables \( \varepsilon^D_{t+1}, \varepsilon^A_{t+1} \) and \( \varepsilon^r_t \) through the private signals and noise. In the public signals model the solution depends on \( S_t, \) together with \( v^D_t \) and \( v^A_t \) (the difference and average of the public signals) and \( \varepsilon^r_t \).

As emphasized in the introduction, we leave a discussion of the solution method to a companion paper and only present the results. We focus on the first-order solution of asset prices and capital flows in the next section. However, the first-order solution for capital flows depends on higher-order components of certain variables. It is therefore useful to clarify what we mean by the order-component of a variable. Any variable \( x_t \) can be decomposed into components of all orders. The zero-order component, denoted \( x(0) \), is the level of \( x_t \) when shocks become infinitesimally small (\( \sigma_a \to 0 \)). Notice that the variance of the noise shock relative to the productivity shock remains constant at \( \theta \) regardless of the value of \( \sigma_a \). The first-order component \( x_t(1) \) is linear in model innovations, or in the standard deviation \( \sigma_a \) of model innovations. The second-order component \( x_t(2) \) depends linearly on the product of two model innovations (or the square of a single innovation) or the
variance or covariance of innovations. Higher orders are defined analogously.\textsuperscript{8}

Capital flows depend critically on the optimal portfolio shares, which in turn depend on expected returns and risk. The role of orders in this regard is easiest to understand in a simple mean-variance portfolio choice framework where the portfolio share depends on the expected excess return divided by the variance of the excess return. Only small third-order changes in expected returns are then needed to generate first-order shifts in portfolio shares since the expected excess return is divided by a second-order variance. First-order shifts in portfolio shares also depend on third-order changes in the variance of the excess return. While one can think of a variance as second-order, movements in a variance due to model shocks are at least third-order. The first-order solution of capital flows therefore depends on third-order components of the expectation and variance of the excess return.

3 Asset Prices and Capital Flows

This section presents and discusses the first-order solution of asset prices and capital flows, leaving all algebraic derivations to a Technical Appendix. For asset prices we discuss the average log asset price $q^A_t$ across the two countries and the difference in log asset prices $q^D_t$. For capital flows we discuss gross as well as net capital flows. We focus on the private signals model and draw comparisons to both the standard and public signals model.

3.1 Asset Prices

The average asset price is the same for all three versions of the model:

$$q^A_t(1) = \frac{\xi}{1 + \xi} (a^A_t(1) - \omega k^A_t(1))$$ (25)

The asset price depends on the publicly observed state variables $a^A_t$ and $k^A_t$ and is not affected by private or public signals about future productivity. Intuitively, the global asset price is driven by global asset demand, which in turn depends on

\textsuperscript{8}The signal errors are not treated as shocks to the model (they average to zero), so $\sigma_{HH}$ and $\sigma_{HF}$ are zero-order constants like all other model parameters (see Tille and van Wincoop (2012) for a more detailed discussion).
global saving. Global saving is proportional to global labor income and therefore does not depend on signals about future productivity.\textsuperscript{9}

The relative asset price in the private signals model is

\[
a_t^D(1) = \alpha_{1,qD}(0) a_t^D + \alpha_{3,qD}(0) k_t^D(1) + \alpha_{5,qD}(0) \left( \varepsilon_{t+1}^D + 0.5\lambda \varepsilon_t^* \right)
\]

where $\alpha_{i,qD}(0)$ and $\lambda$ are zero-order constants. The relative asset price depends on the publicly observed state variables $a_t^D$ and $k_t^D$ as well as on the unobserved future relative productivity innovation $\varepsilon_{t+1}^D$ and noise $\varepsilon_t^*$. The expression is the same in the other two variants of the model, except for the last term in (26) which depends on the unobservables. That term is absent in the standard model and is replaced with a term linear in $v_t^D = v_t^H - v_t^F$ in the public signals model.

The sensitivity of the relative asset price to the unobserved future fundamental $\varepsilon_{t+1}^D$ and the unobserved noise $\varepsilon_t^*$ is familiar from standard linear NRE models in finance. As agents act on their private information, $\varepsilon_{t+1}^D$ naturally affects the equilibrium relative asset price because $\varepsilon_{t+1}^D = \int_0^1 v_{j,t}^H dJ - \int_0^1 v_{j,t}^F dJ = \int_0^1 v_{j,t}^{F,H} dJ - \int_0^1 v_{j,t}^{F,F} dJ$. The asset price is also affected by exogenous portfolio shifts due to the unobserved noise $\varepsilon_t^*$.

While we allow for noise shocks $\varepsilon_t^*$ in the public signals model as well, they do not affect the relative price to the first-order because there are no private signals. While it directly leads to a first-order shift in portfolios, this is offset by a third-order change in the relative asset price to clear the asset markets. This is because, as discussed in Section 2.5, third-order changes in the expected excess return will generate first-order portfolio shifts. The noise shock is similar to a relative asset supply shock, which leads to a change in the risk premium. Such changes in risk are at least third-order.

In the private signals model by contrast the noise $\varepsilon_t^*$ does affect the relative asset price to the first-order. This is due to an amplification effect that is well known in the standard NRE literature. This effect, which Bacchetta and van Wincoop (2006) refer to as “rational confusion”, occurs when agents use asset prices as a source of information about future productivity. An increase in $\varepsilon_t^*$ leads to a portfolio shift towards the Home asset, which raises its relative price. Due to the information content of the relative asset price about $\varepsilon_{t+1}^D$ agents then rationally

\textsuperscript{9}This is a result of the assumed log utility of consumption. In a more general version without log utility saving will depend on the expected portfolio return, which depends on signals about future productivity. See Section 3.4 for a discussion of this case.
increase their expectation of relative future Home productivity. This in turn leads to a further increase in the relative asset price and therefore amplifies the impact of the noise.

Gennotte and Leland (1990) show that such amplification effects can be very large in practice. They provide evidence that during the U.S. stock market crash of October 19, 1987, the impact of non-informational trade on the U.S. stock price was amplified by a factor greater than 100 as a result of the information content of the stock price.

Private information disconnects asset prices from observed macro fundamentals. In both the standard and public signals models, asset prices only depend on publicly observed fundamentals, namely $a^D_t$, $k^D_t$, as well as $v^D_t$ in the public signals model. This is not the case in the private signals model. The disconnect occurs both through the unobserved future fundamental $\varepsilon^D_{t+1}$ that affects the relative price through private signals and through the amplified first-order impact of the noise $\varepsilon^*_t$ that is also due to private information. Another impact of private information is that the relative asset price contains information about the future fundamental $\varepsilon^D_{t+1}$ that is not contained in any of the publicly observed macro fundamentals. Finally, private information raises asset price volatility because of the amplification of the noise $\varepsilon^*_t$.

### 3.2 Capital Flows

We now turn to capital flows. Gross capital outflows are purchases of the Foreign asset by Home agents while gross capital inflows are purchases of the Home asset by Foreign agents. We normalize capital flows by the zero-order component $W^F(0)$ of financial wealth. We first present expressions for the first-order components of capital inflows and outflows. They have four parts, which are related to saving, expected returns and risk. We then discuss these four components in more detail, relating them to observed and unobserved macro fundamentals and highlighting the impact of private information.
3.2.1 Expressions for capital flows

The first-order components of capital outflows and inflows, relative to \( W^F(0) \), are

\[
\text{outflows}_t(1) = -\frac{1}{2} \frac{\Delta [ \tilde{E}_t^H er_{t+1} ] (3) - \Delta [ \tilde{E}_t^F er_{t+1} ] (3) + (1 - z_H(0)) s^H_t (1)}{\text{var}_t(\text{er}_{t+1})/2} \\
- \frac{\Delta \tilde{E}_t^A er_{t+1}(3)^{IS}}{\text{var}_t(\text{er}_{t+1})/2} + \frac{z^D(0) \Delta [ \text{var}_t(\text{er}_{t+1}) ] (3)}{2 \text{var}_t(\text{er}_{t+1})/2} \tag{27}
\]

\[
\text{inflows}_t(1) = -\frac{1}{2} \frac{\Delta [ \tilde{E}_t^H er_{t+1} ] (3) - \Delta [ \tilde{E}_t^F er_{t+1} ] (3) + (1 - z_H(0)) s^F_t (1)}{\text{var}_t(\text{er}_{t+1})/2} \\
+ \frac{\Delta \tilde{E}_t^A er_{t+1}(3)^{IS}}{\text{var}_t(\text{er}_{t+1})/2} + \frac{z^D(0) \Delta [ \text{var}_t(\text{er}_{t+1}) ] (3)}{2 \text{var}_t(\text{er}_{t+1})/2} \tag{28}
\]

Before discussing these terms, we first describe some notation. We denote the excess return on the Home asset by \( er_{t+1} = r_{H,t+1} - r_{F,t+1} \). \( \tilde{E}_t^A \) refers to the average expectation across all agents worldwide, while \( \tilde{E}_t^H \) and \( \tilde{E}_t^F \) refer to the average expectation across respectively Home and Foreign agents. \( \Delta x_t = x_t - x_{t-1} \) is the change of \( x_t \) relative to the previous period. \( z_H(0) \) is the zero-order component of the average portfolio share invested in the Home country by Home agents. It is equal to \( z_H(0) = 0.5 + 0.5 z^D(0) \), where \( z^D(0) = z_H(0) - z_F(0) \) is a measure of home bias, i.e. the average portfolio share invested in Home assets by Home agents minus that by Foreign agents. This zero-order home bias depends on the friction \( \tau \): \( z^D(0) = 2\tau/\text{var}_t\text{er}_{t+1}/2 \). \( s^H_t \) and \( s^F_t \) are Home and Foreign saving scaled by \( W^F(0) \). Finally, \( \tilde{E}_t^A er_{t+1}(3)^{IS} \) refers to the part of third-order component of the equilibrium expected excess return that is related to changes in investment and saving. This is discussed in further detail below.

Note that the first, third and fourth terms in (27) and (28) are ratios of third to second-order terms. As discussed in Section 3.1, the first-order component of capital flows depends on third-order changes in expected returns and risk (the variance of the excess return).

3.2.2 The four drivers of capital flows

We now turn to a discussion of each of the four drivers of capital flows on the right hand side of (27) and (28). We focus on the economic intuition and contrast the role of observed and unobserved fundamentals. Similar to asset prices, private
information makes capital flows sensitive to the unobservables $\varepsilon_{t+1}^D$, $\varepsilon_{t+1}^A$ and $\varepsilon_{t+1}^\tau$. This leads to a disconnect of capital flows from publicly observed fundamentals, predictive content of capital flows for future fundamentals, and increased volatility of capital flows. In Figure 1 we graphically display the channels through which the unobservables impact capital flows.

**Differences in Expected Returns across Countries**

The first term on the right hand side of (27) and (28) is specific to the private signals model. It represents the difference in the average expected excess return by Home agents relative to Foreign agents. This term is zero in the standard and public signals models. In the private signals model it is equal to

$$[\bar{E}_{H,t}e_{rt+1}](3) - [\bar{E}_{F,t}e_{rt+1}](3) = \delta_2 \sigma^2_a \left[ \frac{1}{\sigma_{HH}^2} - \frac{1}{\sigma_{HF}^2} \right] \varepsilon_{t+1}^A$$

(29)

where $\delta_2$ is a positive zero-order constant.

Under our assumption that $\sigma_{HH}^2 < \sigma_{HF}^2$, agents receive more precise signals about their domestic asset market. When productivity rises in both countries next period, all agents expect that productivity will increase by more in their own country because they have more precise information about their own productivity. As a result all agents expect the return on their own country’s asset to rise relative to that of the other country. This leads to increased portfolio home bias. Agents then sell assets abroad to purchase the domestic asset, and both capital inflows and outflows drop by an equal amount. Net capital flows (outflows minus inflows) remain unchanged and gross capital flows (outflows plus inflows) fall. This channel is represented on the right hand side of the chart in Figure 1.

**Portfolio Growth**

The second term on the right hand side of (27)-(28) represents portfolio growth, which measures outflows and inflows when Home and Foreign saving are invested abroad at the steady state portfolio share $1 - z_H(0)$. The portfolio growth component depends entirely on Home and Foreign saving, which can be written as

$$s_t^H(1) = s_t^A(1) + 0.5 s_t^D(1)$$

(30)

$$s_t^F(1) = s_t^A(1) - 0.5 s_t^D(1)$$

(31)

Average world saving only depends on observed state variables. It is equal to

$$s_t^A(1) = \Delta a_t^A(1) + (1 - \omega) \Delta k_t^A(1) - \Delta q_t^A(1)$$

(32)
The observed state variables $a^A_t$ and $k^A_t$ affect average wages and therefore world saving by the current young generation. These same variables one period ago affect dissaving by the current old generation. In addition the saving by the old generation is affected by the average asset price. A higher asset price implies higher wealth. This positive wealth effect raises consumption and lowers the saving of the old generation. But as we have seen in Section 3.1, the average asset price is determined by the same public information variables $a^A_t$ and $k^A_t$.

Relative saving is equal to

$$s^D_t(1) = \Delta a^D_t(1) + (1 - \omega)\Delta k^D_t(1) - z^D(0)\Delta q^D_t(1)$$

It depends not only on the observed state variables $a^D_t$ and $k^D_t$, which affect relative wages, but also on the relative asset price $q^D_t$. This again operates through a wealth effect. As long as there is positive portfolio home bias ($z^D(0) > 0$), an increase in the relative price of the Home asset raises the wealth of the old generation in the Home country relative to that in the Foreign country. This wealth effect raises relative consumption in the Home country and lowers relative saving.

The unobserved fundamentals $\varepsilon^D_{t+1}$ and $\varepsilon^D_t$ thus impact capital flows through the relative asset price, which affects saving through a wealth effect. An increase in either $\varepsilon^D_{t+1}$ or $\varepsilon^D_t$ raises the relative price of the Home asset, which lowers Home saving and raises Foreign saving. Through portfolio growth this leads to lower capital outflows and higher capital inflows, and thus a drop in net capital outflows. Gross capital flows (sum of inflows and outflows) do not change as the drop in outflows is equal to the increase in inflows. This effect is illustrated in Figure 1 through the relative asset price-saving-portfolio growth channel.

In the standard and public signals models the expressions for average and relative saving are unchanged, but the relative asset price only depends on the publicly observed fundamentals $a^D_t$, $k^D_t$ and $v^D_t$.

**Average Expected Excess Return**

The third term on the right hand side of (27)-(28) represents capital flows due to changes in the average expected excess return that is associated with changes in relative saving and investment. This is only a part of the total change in the expected excess return, which is

$$\Delta[\varepsilon^A_t er_{t+1}](3) = -\tau \Delta \varepsilon^A_t + [var_t(er_{t+1})](2)z_H(0)(1 - z_H(0))\Delta q^D_t(1)$$

$$+ \frac{1}{4} [var_t(er_{t+1})](2) \left[ s^D_t(1) - z^D(0)s^D_t(1) \right]$$

(34)
Three factors drive changes in the expected excess return. A higher relative friction of investing in the Home asset (a decrease in $\varepsilon_t^H$) lowers the demand for the Home asset. A higher equilibrium expected excess return on the Home asset is then needed to raise demand and clear the asset market. Notice however that this leads to no capital flows, as the change in the expected excess return simply brings asset demand back to its initial value. The second term captures a higher relative supply of the Home asset due to the higher relative price. To clear markets there needs to be a rise in the relative demand for the Home asset, which is accomplished by a higher equilibrium expected excess return on the Home asset. This also does not generate any capital flows as a rise in the relative asset price automatically leads to a portfolio shift towards the Home asset through valuation effects, without any need for capital flows.

The third and final term reflects investment and saving, and we denote it by $\Delta E_t^A cr_{t+1}(3)^{IS}$. Either an increase in Home relative investment $i_t^D$ or drop in Home relative saving $s_t^D$ leads the relative supply of the Home asset to be larger than relative demand. Asset markets then clear through a rise in the expected excess return on the Home asset. It is only this part of the expected excess return that affects capital flows.

The part of the change in the expected excess return due to saving and investment depends on relative saving and investment. We have already seen that relative saving depends on the relative asset price. The same is the case for relative investment through a standard Tobin’s Q expression:

$$i_t^D(1) = \frac{1}{\xi} q_t^D(1)$$  \hspace{1cm} (35)

This implies that the unobserved fundamentals $\varepsilon_{t+1}^D$ and $\tau_t^D$ impact capital flows again through the relative asset price. An increase in either $\varepsilon_{t+1}^D$ or $\tau_t^D$ raises the relative asset price, which lowers relative Home saving and raises relative Home investment. Both lead to an excess relative supply of the Home asset. The expected excess return on the Home asset then rises to clear asset markets, which leads to a portfolio shift to the Home asset. Capital outflows drop and capital inflows rise. Net capital outflows fall and gross capital flows remain unchanged. This effect is illustrated in Figure 1 through the relative asset price-saving/investment-expected return channel. This effect is again specific to private information, as in the standard and public signals models $\Delta E_t^A cr_{t+1}(3)^{IS}$ only depends on $a_t^D$, $k_t^D$ and $v_t^D$. 

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Time-Varying Risk

The last term in (27) and (28) represents capital flows due to changes in the variance of the excess return, captured by its third-order component. There is a tradeoff in the model between home bias due to the exogenous cost of investing abroad and the desire to reduce risk through diversification. An increase in the variance of the excess return makes portfolio diversification more attractive and therefore leads to an increase in both capital inflows and outflows.

In the standard and private signals models, the third-order component of the variance of the excess return takes the form

\[
\text{var}(er_{t+1})(3) = \delta_1 \sigma_n^2 S_t(1)
\]

where \(\delta_1\) is a 1 by 4 zero-order vector that depends on model parameters. The coefficients \(\delta_1\) on the observed state variables \(S_t\) differ between the standard and private signals models. In the public signals model there are additional terms that depend on \(v^D_t\) and \(v^A_t\). In all versions of the model therefore the variance of the excess return only depends on publicly observed state variables.

3.2.3 Summary of the Impact of Private Information

We have shown that in the private information model capital flows are affected by the unobserved macro fundamentals \(\varepsilon_{t+1}^D\), \(\varepsilon_{t+1}^A\) and \(\varepsilon_t^r\) through the first three drivers in (27) and (28). This disconnects capital flows from publicly observed macro fundamentals, just as is the case for asset prices. This is not the case in the standard and public signals models where capital flows only depend on the publicly observed state variables \(S_t\), \(v^D_t\) and \(v^A_t\). The impact of the unobserved fundamentals also increases capital flow volatility in the private information model. Moreover, capital flows contain information about the future fundamentals \(\varepsilon_{t+1}^D\) and \(\varepsilon_{t+1}^A\) that is not contained in the public information set. Net capital flows contain information about \(\varepsilon_{t+1}^D\) while gross capital flows contain information about \(\varepsilon_{t+1}^A\).\(^{10}\)

\(^{10}\)We have not used this information content of capital flows as a source of information of investors when computing expectations of \(\varepsilon_{t+1}^D\) and \(\varepsilon_{t+1}^A\). In practice the difficulty is that capital flows are observed both with substantial delay and with noise, which limits the use to investors. We could allow investors in our model to observe capital flows with noise. This makes no difference for net capital flows as the relative asset price contains the same information. For gross capital flows it allows investors to obtain another piece of information about \(\varepsilon_{t+1}^A\). But
Even though the noise $\varepsilon_t^A$ is present in the public signals model, it does not have a first-order impact on capital flows. This is for two reasons. First, it does not have a first-order impact on the relative asset price, as explained in Section 3.1. Second, even though a shock to $\varepsilon_t^A$ leads to a first-order portfolio shift that affects capital flows, this is completely undone by a shift in the equilibrium expected excess return.

### 3.3 Amplified Role of Public Information Due to Private Information

Our discussion so far focuses on the impact of private information through the unobserved macro fundamentals. But private information has the additional effect of also increasing the impact of public information on capital flows. This tends to further increase the volatility of capital flows.

We first illustrate this for gross capital flows. In the absence of private information gross capital flows depend positively on $\varepsilon_t^A$. An increase in $\varepsilon_t^A$ raises Home and Foreign saving, leading to an increase in both capital inflows and outflows through portfolio growth.\footnote{There is a slight offsetting effect as a rise in $\varepsilon_t^A$ lowers the variance of the excess return, which reduces inflows and outflows. But we find this effect to be very small, independent of the parameterization.} With private information a rise in $\varepsilon_t^A$ leads to an additional increase in capital flows through the expected return differential, which is the first term on the right-hand side of (27) and (28). From (27)-(28) and (29), the first component of capital flows depends positively on $\varepsilon_t^A - \varepsilon_{t+1}^A$. Intuitively, a rise in $\varepsilon_t^A$ at first leads to a retrenchment towards domestic markets at $t-1$ as investors anticipate a higher expected return on their domestic asset due to more precise local information. This is reversed at time $t$, leading to larger capital inflows and outflows. This amplification channel through the expected return differential is entirely a result of dispersed information.

We now turn to net capital flows, which depends positively on $\varepsilon_t^D$ in the absence of private information. An increase in $\varepsilon_t^D$ raises relative Home wages and therefore saving. This in turn leads to net capital outflows both through the portfolio growth and average expected return channels.\footnote{There is an offsetting effect through the relative asset price, which depends positively on...} With private information a rise as long as the information is noisy, it does not reveal $\varepsilon_{t+1}^A$ and therefore does not qualitatively change our results for gross flows either. It just adds another source of noise.
in $\varepsilon_t^D$ leads to an additional increase in net capital outflows. A rise in $\varepsilon_t^D$ already affects capital flows at time $t - 1$ through its impact on the relative asset price $q_{t-1}^D$. This lowers relative Home saving and raises relative Home investment at $t - 1$, which reduces net capital outflows through the portfolio growth and average expected return channels. This is reversed at time $t$, leading to higher net capital outflows. The amplified impact of $\varepsilon_t^D$ on net capital outflows thus operates through the private signals and their impact on the relative asset price.

When we draw a comparison between the private signals model and the public signals model, there is one dimension along which the weight on public information is reduced in the private signals model. The public information variables $v_t^D$ and $v_t^A$ only affect capital flows in the model with public signals.

### 3.4 Other Channels through which Dispersed Information Impacts Capital Flows

We have kept the model relatively simple for the sake of analytic tractability and transparency of the results. It is not difficult to generalize the model, at the cost of further complexity, and obtain additional channels through which dispersed information impacts capital flows. While in principle this can be done in many ways, we discuss a couple of such possibilities here.

A first extension is to relax the assumption of log utility. If we consider a rate of intertemporal substitution larger than 1, an increase in the future expected portfolio return raises saving by the young. Consider the impact of an increase in $\varepsilon_{t+1}^A$. Through the private signals this leads agents to increase their expected portfolio return and saving. This in turn raises the average asset price $q_t^A$. In order to prevent the average asset price from completely revealing $\varepsilon_{t+1}^A$ one needs to introduce another type of noise that affects the world asset supply or demand and therefore $q_t^A$. This can for example come from agent-specific time discount rate shocks that cannot be observed in the aggregate and affects world saving.

In such a setup an increase in $\varepsilon_{t+1}^A$, as well as the noise that impacts global saving, raises both Home and Foreign saving and boosts capital inflows and outflows. An increase in $\varepsilon_{t+1}^D$ raises relative Home saving as the relative portfolio return in $q_t^D$ and therefore on $\varepsilon_t^D$. A higher relative price lowers relative Home saving and raises relative Home investment. But we find that only for extreme parameter assumptions does this offset the effect through relative wages.
the Home country is expected to rise due to portfolio home bias. This impacts capital flows through both the portfolio growth channel and the expected return channel. Note that in this case the impact of $\varepsilon_{t+1}^D$ on capital flows does not just operate through the relative asset price as in Figure 1.

Another extension is to assume that agents work both periods of their life and when young have private information about their income when old. This provides an alternative channel through which future productivity innovations can impact saving today. The implications for capital flows should be similar to those discussed above for the case where the intertemporal elasticity of substitution differs from 1.

One could also consider unobserved shifts in risk-aversion. Similar to our assumption for the investment cost, we can assume that only individual agents know their own risk aversion, and cannot infer the average risk aversion from their own. An increase in average risk-aversion in both countries raises investors’ appetite for diversification and boosts both capital inflows and outflows. Gross capital flows are then driven by an unobserved current fundamental as opposed to the future fundamental $\varepsilon_{t+1}^A$.

An additional extension is to consider private information about fundamentals beyond the next period. In that case $\varepsilon_{t+s}^D$ and $\varepsilon_{t+s}^A$ for values of $s$ from 1 to $T$ affect capital flows, with $T$ possibly quite large. As shown by Bacchetta and van Wincoop (2006) in the context of exchange rates, this also implies an amplification of unobserved noise shocks that can be very persistent even if the shocks are transitory.

The extensions discussed above only scratch the surface of additional avenues of research. We have kept things simple in the model, but naturally there are a large number of other ways that dispersed information can affect capital flows. They all have in common that they disconnect capital flows from observed fundamentals, imply that capital flows contain information about future fundamentals beyond what can be learned from public information alone and increase the volatility of capital flows.

4 Numerical Illustration

In this section we complement our qualitative analysis with a numerical illustration of the differences between the three variants of the model. This shows that the
impact of private information can be quantitatively large even within the context of our simple model. We also discuss how the impact of private information is affected by some of the key parameters of the model.

4.1 Calibration

For parameters unrelated to information dispersion we either choose standard values or match basic model moments for 6 industrialized countries over the period 1977 to 2006 (the G7 minus Italy). We set the rate of depreciation at $\delta = 0.1$, the time discount rate at $\beta = 0.95$ and the labor share at $\omega = 0.7$. We set $\rho = 0.99$ as it is hard to distinguish between $\rho$ close to 1 and exactly 1 and the unit root case cannot be rejected by the data (e.g. Baxter and Crucini, 1995). We set $\sigma_a = 0.017$ so that the standard deviation of output growth in the model is equal to the average standard deviation of annual real GDP growth for the 6 countries, which is 1.7%. We set the adjustment cost parameter $\xi = 2.5$ in order to match the standard deviation of annual real investment growth relative to the standard deviation of annual real GDP growth. This ratio is 2.8 in the data when averaged across the 6 countries.

We choose the average cost $\tau$ of investment abroad in order to match the observed portfolio home bias in the data. The standard measure of portfolio home bias is

$$1 - \frac{\text{share of foreign equity in portfolio of domestic investors}}{\text{share of foreign equity in world portfolio}}$$

This corresponds to $z^D(0)$ in the steady state of our model, which depends on $\tau$. Fidora, Fratzscher and Thimann (2007) report this measure of home bias for a wide range of countries based on 2001-2003 data. This includes 5 of our industrialized countries (all but Canada). The average measure of home bias for those 5 countries is 0.73. They also report a measure of home bias for debt securities, which is virtually identical. We therefore set the cost $\tau$ of investment abroad such that the zero-order component of $z^D(0)$ in the model is equal to 0.73.\(^{13}\)

The remaining parameters relate to information dispersion. They are the standard deviations of the errors of the private signals $\sigma_{HH}$ and $\sigma_{HF}$ and the parameter $\theta$ that measures the volatility of the noise. Since it is hard to calibrate these parameters we illustrate their impact over a very wide range. In the benchmark

\(^{13}\)This implies that both countries invest a fraction 0.865 in domestic equity.
parameterization we set \((\sigma_{HH} + \sigma_{HF})/2 = 0.21, \sigma_{HF}/\sigma_{HH} = 1.5\) and \(\theta = 100\). In the Appendix we discuss some motivation for setting \((\sigma_{HH} + \sigma_{HF})/2 = 0.21\). It generates a standard deviation of the cross-sectional distribution of expected asset prices, scaled by the unconditional variance of asset price changes, which matches survey data for the United States and Japan. In the public signals model we set the variance \(\sigma_v^2\) of the signal errors such that the conditional variance of the excess return (second-order component) is the same as in the private information model. The standard model corresponds to the public signals model when public signals carry no information, i.e. when \(\sigma_v = \infty\).

4.2 Simulation Results

We simulate the model over 100,000 periods to produce moments related to capital flow volatility, the information content of capital flows as well as the disconnect between capital flows and observed fundamentals. These moments, along with the correlation between capital inflows and outflows, are reported in Table 1 for all three versions of the model. The table also reports the empirical moments for the 6 industrialized countries. In both the model and the data capital flows are divided by GDP and HP(10) filtered. For net capital flows we report volatility in the data based both on capital flows and the current account, with the latter being more reliable.

Even though our calibration is not based on any capital flow data, the top half of Table 1 shows that the private signals model generates a volatility of capital flows and a correlation between inflows and outflows that is broadly consistent with the data. The model and the data show similar values for the standard deviation of capital inflows and outflows (about 3%) and of gross capital flows (just below 6%). Net capital flows are a bit more volatile in the data (0.7% versus 0.5% in the model), and the correlation between capital inflows and outflows is somewhat lower in the data, albeit still very high (0.89 versus 0.99 in the model).

The bottom half of Table 1 is based on unfiltered capital flows from the private signals model, and illustrates the role of private information. There is a sizable disconnect between capital flows and public information as these account for only half of the variance of capital flows. The model also generates a substantial information content of both gross and net capital flows. One can measure this as the \(R^2\) of a regression of \(\varepsilon_{t+1}^A\) and \(\varepsilon_{t+1}^D\) on respectively gross and net flows. This
gives respectively 0.5 and 0.34. Note that publicly observed fundamentals \( S_t \) in the private information model have no explanatory power for \( \varepsilon_{t+1}^A \) and \( \varepsilon_{t+1}^D \), so this is entirely a result of private information.

These results from the private signals model stand in sharp contrast to those from the standard and public signals models. First, in both models capital flows are not disconnected from public information. Second, capital flows have no information content about future fundamentals. By information content we refer to an increase in the \( R^2 \) when adding capital flows to regressions of the future fundamentals on current publicly observed fundamentals. In the public signals model capital flows have predictive power for \( \varepsilon_{t+1}^A \) and \( \varepsilon_{t+1}^D \), but this is only through publicly observed fundamentals \( v_t^D \) and \( v_t^A \). Third, both models generate much less volatility in capital flows, especially for gross capital flows.

Finally, the standard and public signals model generate a strongly negative correlation between capital inflows and outflows. This largely reflects the time-variation in the expected excess return, as a higher expected excess return on Home assets raises capital inflows and reduces capital outflows. This has been a source of criticism by Broner et.al. (2010) of capital flows models with public information. By contrast, the large positive correlation between outflows and inflows in the private signals model is due to the first term in (27)-(28). The disagreement between Home and Foreign agents about expected returns can lead Home agents to switch to Foreign assets and Foreign agents to Home assets, which generates the positive co-movement between capital inflows and outflows.

The results show that private information can potentially have a very large impact on international capital flows in terms of their volatility, correlation, disconnect from observables and predictive content. However, we want to emphasize again that this is only an illustration specific to our simple model, and one should not draw any conclusions about the quantitative impact of private information on capital flows more generally. We discuss some ways to quantify this impact empirically in the conclusion.

4.3 Sensitivity to Dispersed Information Parameters

We now consider the sensitivity of our results to the three parameters related to private information, namely information dispersion \((\sigma_{HH} + \sigma_{HF})/2\) (Figure 2), information asymmetry \(\sigma_{HF}/\sigma_{HH}\) (Figure 3) and noise \(\theta\) (Figure 4). We vary each
of these over a very wide range: information dispersion \((\sigma_{HH} + \sigma_{HF})/2\) from 0 to 2, the information asymmetry \(\sigma_{HF}/\sigma_{HH}\) from 1 to 2, and the noise \(\theta\) from 1 to 1000. Each figure displays the standard deviation of gross capital flows (panel A), the standard deviation of net capital flows (panel B), the correlation between capital inflows and outflows (panel C), the extent of disconnect in capital flows, measured by the share of the variance of flows that is explained by unobserved fundamentals (panel D), and the predictive content of capital flows, measured by the \(R^2\) in a regression of \(\varepsilon_{t+1}^D\) and \(\varepsilon_{t+1}^A\) on net and gross capital flows, respectively (panel E).

**Information dispersion**

Private signals carry little information when the variance of the signal errors becomes very high. This significantly reduces the volatility of both gross and net capital flows (Figure 2, panels A and B). The correlation between capital inflows and outflows goes down as the private information becomes weaker (panel C). But even when \((\sigma_{HH} + \sigma_{HF})/2\) is equal to 2, which is ten times as high as estimated, the correlation remains positive at 0.46.

Not surprisingly, as private signals become weaker the disconnect of capital flows from observed fundamentals (panel D) and predictive power for future fundamentals (panel E) become weaker. This decline is more acute for net capital flows than for gross capital flows. As discussed in Section 3.3., gross capital flows depend on \(\varepsilon_t^A - \varepsilon_{t+1}^A\) through an information asymmetry across the countries. As private signals become weaker, it weakens the impact of both the observed fundamental \(\varepsilon_t^A\) and the future fundamental \(\varepsilon_{t+1}^A\). As the weight of the unobserved future fundamental \(\varepsilon_{t+1}^A\) in capital flows declines, therefore so does the weight of the observed fundamental \(\varepsilon_t^A\).

**International Information Asymmetry**

The extent of asymmetric information across countries \(\sigma_{HF}/\sigma_{HH}\) has little impact on net capital flows (Figure 3). We therefore focus our discussion on gross capital flows. It is through this information asymmetry that \(\varepsilon_{t+1}^A\) affects gross capital flows in our model. Not surprising therefore, the volatility of gross capital flows depends critically on the extent of this information asymmetry (panel A). Information asymmetry also matters for the correlation between capital inflows and outflows (panel C). As a result of the information asymmetry capital inflows
and outflows both drop when $\varepsilon_{t+1}^A$ rises, as agents retrench towards domestic assets about which they have more information and are therefore more optimistic. But we only need a small amount of information asymmetry to generate a high correlation between capital inflows and outflows, with the correlation reaching 0.8 even if we set $\sigma_{HF}/\sigma_{HH}$ as low as 1.1 (rather than the 1.5 in the benchmark).

The extent of information asymmetry has very little effect on the extent of disconnect (panel D) and the predictive content of gross capital flows (panel E). A lower value of $\sigma_{HF}/\sigma_{HH}$, implying less information asymmetry across countries, reduces the impact of both $\varepsilon_{t+1}^A$ and $\varepsilon_t^A$ on gross capital flows. It proportionally reduces the impact of both observed and unobserved state variables.

**Noise**

A lower level of noise $\theta$ reduces the information asymmetry across countries as the relative asset price then contains more information about relative future productivity. This in turn reduces the impact of $\varepsilon_{t+1}^A$ on gross capital flows and therefore its volatility (Figure 4, panel A). The volatility of net flows by contrast is not much affected by the noise (panel B). There are two offsetting effects. On the one hand more noise implies that the relative asset price is more affected by the noise. On the other hand, the noise reduces the information content of the relative price, which limits the extent to which private information about $\varepsilon_{t+1}^D$ is aggregated into the relative price. So, while one unobserved fundamental ($\varepsilon_t^F$) generates more volatility of the relative asset price and net capital flows when $\theta$ rises, another unobserved fundamental ($\varepsilon_{t+1}^D$) does the opposite.

The correlation between inflows and outflows is insensitive to the noise (panel C). The noise also has little impact on the extent of disconnect in gross and net capital flows (panel D). While the noise has little impact on the predictive content of gross capital flows (panel E), it affects the predictive content of net flows. More noise implies a larger role for $\varepsilon_t^F$ relative to $\varepsilon_{t+1}^D$, which lowers the predictive content of net capital flows.

5 Conclusion

We investigate the impact of dispersed information on international capital flows within the context of a DSGE two-country model with dispersed private information. We show that dispersed information increases the volatility of both gross
and net capital flows, generates a large positive correlation between capital inflows and outflows, leads to a disconnect between capital flows and observed macro fundamentals, and makes capital flows a relevant source of information about future macro fundamentals. Our calibration exercise shows that all of these effects can be quantitatively large. In addition, we show that dispersed private information can also increase the impact of observed macro fundamentals on capital flows.

While we illustrate that the impact of dispersed information on international capital flows can be potentially large, we do not empirically estimate this aspect. Assessing the magnitude of the impact of dispersed information will be an important topic for future work. We see a number of possible ways to approach this. A first approach is to evaluate the extent of disconnect by regressing capital flows on observed (current and past) macro fundamentals. Similarly, one can conduct Granger causality tests to evaluate the predictive content of capital flows, controlling for current and past macro fundamentals.\textsuperscript{14}

An important drawback of this approach is that it is hard to distinguish between private signals and public signals that are omitted by the econometrician. An alternative approach is to directly measure the impact of private information on capital flows by using data on order flow, which is known to aggregate all private information in the market. This has been the approach followed by Evans and Lyons (2002) for exchange rates. One can for example use high frequency order flow data from equity and FX markets and consider the explanatory power for high frequency capital flow data, such as weekly data from State Street Corporation of institutional investor flows.

A final approach is to consider a more extensive calibration exercise. In this paper we have made several simplifying assumptions for the sake of tractability and transparency. Natural extensions include relaxing the OLG assumption, introducing other assets, such as bonds and money, allowing agents to have private information about fundamentals further into the future and different types of private information. Ultimately this should lead to better insight into the quantitative role that private information plays in accounting for various aspects of gross and net capital flow data.

\textsuperscript{14}In a previous draft of this paper we took a very preliminary shot at this approach, finding evidence of substantial disconnect for both gross and net capital flows and predictive content of particularly gross capital flows for the future world profit rate.
Appendix: Calibrating Information Dispersion

In this Appendix we provide some details regarding the calibration of dispersed information regarding future fundamentals. We set the average dispersion of private signals, \( (\sigma_{HH} + \sigma_{HF})/2 \), to generate a cross-sectional dispersion of expected asset price changes that matches the evidence from surveys of forecasters.

For this purpose we use a survey from the International Center for Finance at the Yale School of Management that reports expected stock price changes by a large number of financial institutions.\(^{15}\) The survey has data for two countries, the United States and Japan. For both countries the survey asks about expected percentage change in the stock price (respectively Dow Jones Industrial Index and Nikkei Dow) over the next 1, 3, and 12 months, with our parameterization focusing on the 1-year ahead forecasts.

For each country the survey is based on about 400 financial institutions. For Japan the survey is mailed to most of the major financial institutions, including 165 banks, 46 insurance companies, 113 security companies and 45 investment trust companies. For the U.S. about 400 randomly drawn institutions are selected from “Investment Managers” in the “Money Market Directory of Pension Funds and their Investment Managers”.

The survey starts in 1989 with six-month interval surveys until 1998, after which monthly surveys are conducted.\(^{16}\) We have collected the data through October 2004.

Since it is important to compare expectations at the same point in time, and financial institutions do not all respond to the survey on the same day, we only consider the cross sectional distribution of responses that take place on the same day. Moreover, we eliminate days were there were fewer than 5 responses.

The average cross-sectional standard deviation of the expected one-year percentage stock price change across respondents is 0.1278 for the U.S. and 0.1341 for Japan. This is scaled by the variance of stock price changes. Here we use historical numbers of the standard deviation of stock price changes from Jorion and Goetzmann (1999), which are respectively 0.1584 and 0.1579 for the U.S. and

\(^{15}\)We would like to thank the International Center for Finance for making these data available to us.

\(^{16}\)See Shiller et al. (1996) and http://icf.som.yale.edu/confidence.index/explanations.html for more details.
Japan. Our scaled measure of dispersion of expected stock price changes is then 4.99 for the U.S. and 5.23 for Japan.

In the model this scaled measure of dispersion of expected stock price changes is the standard deviation of $E_{t}^{H_{t}} q_{t+1}^{H}$ across investors, divided by the unconditional variance of $\Delta q_{t}^{H}$. We set $(\sigma_{HH} + \sigma_{HF})/2 = 0.21$, which leads to a scaled measure of dispersion of expected stock price changes of 5.0, close to that for both the U.S. and Japan.
References


Table 1: Capital Flow Moments

<table>
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<tr>
<th></th>
<th>Data</th>
<th>Model</th>
<th>Private Signals</th>
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<th>Public Signals</th>
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<td>Standard Deviations</td>
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<td>0.15</td>
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<td>2.99</td>
<td>2.99</td>
<td>0.05</td>
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<tr>
<td>gross capital flows</td>
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<tr>
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<td>0.46</td>
<td>0.09</td>
<td>0.29</td>
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<tr>
<td>current account</td>
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<td>0.46</td>
<td>0.09</td>
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<td>-0.90</td>
<td>-0.90</td>
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<td>Share of Variance Explained by Dispersed Information</td>
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<tr>
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<td>0</td>
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<tr>
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<tr>
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<tr>
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<td>0</td>
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</tbody>
</table>

Note: In the first column the table shows basic moments involving capital flows. Gross capital flows are defined as capital outflows plus capital inflows. Net capital flows are capital outflows minus capital inflows. All capital flow data are from the IMF International Financial Statistics (IFS). They are multiplied by the exchange rate to convert to the local currency and then divided by GDP (also from the IFS). These scaled capital flows are HP(10) filtered. The corresponding moments in the three versions of the model are in columns 2-4 based on the first-order component of capital flows divided by GDP. They are HP(10) filtered just as in the data. The moments reported only for the model in the lower half of the table are based on the raw first-order components of capital flows without applying a filter. The $R^2$ reported in the bottom two rows refers to the increase in the $R^2$ when adding capital flows to regressions of $\varepsilon_{t+1}^D$ and $\varepsilon_{t+1}^A$ on variables in the public information sets of the various models.