Strategic Investors and Exchange Rate Dynamics

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Abstract

We study how the exchange rate dynamics are influenced by the presence of heterogeneous investors with varying degrees of price impact. Leveraging data from the U.S. Commodity Futures Trading Commission (CFTC) on investors' currency positions, we show that foreign exchange rate markets display a significant level of concentration. We develop a monetary model of exchange rate determination that incorporates heterogeneous investors with different degrees of price impact. Our model predicts that the presence of price impact amplifies the exchange rate's response to non-fundamental shocks while dampening its response to fundamental shocks. As a result, investors' price impact contributes to the disconnect of exchange rates from fundamentals, increases the excess volatility of exchange rates, and makes excess return more predictable. We provide empirical evidence in line with our theoretical predictions, using data on trading volume concentration from the US CFTC foreign exchange rate market for 10 currencies spanning from 2006 to 2016. The potential impact of investors' heterogeneity in price impact is quantitatively similar to the effect of a competing, well-established micro friction at investor level - information heterogeneity.

JEL Codes: F31, G11, G15

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1 Introduction

Three well-known puzzles in international economics are the limited explanatory power of macroeconomic fundamentals in accounting for exchange rate fluctuations (the exchange rate determination puzzle), the excessive volatility of exchange rates relative to fundamentals (the excess volatility puzzle), and the failure of uncovered interest parity (the UIP puzzle) (Meese and Rogoff, 1983; Obstfeld and Rogoff, 2000; Fama, 1984).[1] Recent evidence from the microstructure approach to exchange rates suggests that investor heterogeneity plays a crucial role in understanding exchange rate dynamics and determination. For example, these puzzles can be explained by the rational confusion arising from information heterogeneity (Bacchetta and Van Wincoop, 2006). Similarly, exchange rate behavior is linked to order flow, which, in turn, is associated with the heterogeneity among investors (Lyons et al., 2001; Evans and Lyons, 2006). This paper investigates how the presence of large investors who internalize the impact of their trading on currency prices can potentially influence exchange rate fluctuations.
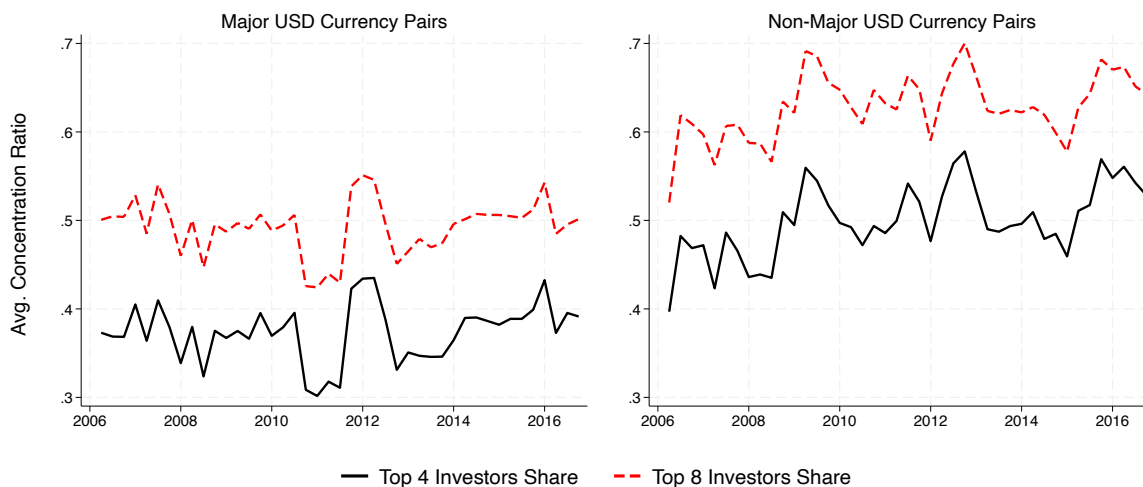
Foreign exchange markets are historically characterized by an high degree of concentration, with a relatively small number of investors holding a substantial presence in the markets through their currency positions. Figure 1 reports the average concentration ratios by currency groups (major and non-major currencies), computed as the share of net open interest positions held by the largest four and eight investors operating the principal foreign exchange markets from 2006 to 2016.[2] Two facts stand out. Firstly, the eight (four) largest entities collectively held approximately 50% to 70% (40% to 60%) of the open interest positions in the foreign exchange market. Secondly, non-major USD currency pairs are notably more concentrated, by about 20%, compared to major ones.[3] Figure 1 suggests the potential

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[1] Meese and Rogoff (1983) show that macroeconomic models have lower predictive power compared to a random walk model. Similarly, Obstfeld and Rogoff (2000) show that exchange rates exhibit significantly more fluctuations than their underlying fundamentals.

[2] Appendix A provide more information on the data.

[3] Figure 3 in Appendix A shows the concentration ratios for all individual currencies from 2006 to 2016. The Brazilian Real, Russian Ruble, and New Zealand Dollar are the currency pairs with the highest concentration, while the Euro and Canadian Dollar exhibit the lowest. Figure 4 in Appendix A shows qualitatively similar patterns when concentration is measured by the number of entities trading each currency (on average, 10 to 25 entities actively trade, with more traders active in major currency markets). The high concentration measured here aligns with other pieces of evidence, such as the BIS Triennial Survey of Foreign Exchange Markets or the NY FED OTC Foreign Exchange Market Survey. However, these surveys are limited in their scope, frequency of observation, or coverage. The leading foreign exchange market survey, conducted by Euromoney and covering global markets, reveals that around 25 entities transact 70% of the total turnover. Additional information can be found

Figure 1: Market Concentration – U.S. CFTC

Major USD Currency Pairs   Non-Major USD Currency Pairs

—— Top 4 Investors Share   – – Top 8 Investors Share

Notes: The figure shows the average concentration ratio of net open interest positions help by asset managers, institutional investors, and leveraged funds across currencies, divided between major and non-major currency groups. We consider the share held by the eight and the four largest entities in each market. Concentration ratios are computed on 'Net Position', meaning that are calculated after offsetting each trader's long and short positions. Major currency pairs consist of the United States Dollar paired with the Euro, British Pound, Japanese Yen, and Swiss Franc. Non-Major currency pairs include the United States Dollar paired with the Australian Dollar, Canadian Dollar, New Zealand Dollar, Mexican Peso, Brazilian Real, and Russian Ruble. The data is sourced from the U.S. Commodity Futures Trading Commission (CFTC) and spans from 2006 to 2016, with quarterly averages for each currency pair. Appendix A provides additional details regarding the data used.

for individual investors to influence currency prices (Kyle, 1985).[4]

    We embed heterogeneity in price impact into a two-country, dynamic monetary model of exchange rate determination to analyze the potential effects of strategic behavior on exchange rate fluctuations. In our theoretical framework, investors face an international portfolio choice problem with noise shocks. Departing from the conventional assumption of price-taking investors, we introduce a continuum of investors with varying degrees of price impact. One group of investors is atomistic and competitive, acting as price takers, while the remaining group consists of a finite number of strategic investors with non-zero market power, who behave oligopolistically and internalize the effects of their trading decisions on

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[4]This potential is not just theoretical. The 2013 London FX fixing scandal, the 2015 Swiss franc peg removal, and the 2016 British pound flash crash all demonstrate how concentrated trading flows of large traders can significantly impact currency markets, leading to substantial price movements and market disruptions. Despite significant institutional reforms implemented in 2015, there are indications that market manipulation may not have completely ceased (Osler, 2014; Osler et al., 2016; Cochrane, 2015).

equilibrium prices. In equilibrium, the exchange rate is determined as a weighted average of fundamentals, such as interest rate differentials, and noise shocks, with the weights depending on market structure and the average size of strategic investors.

We present a set of theoretical predictions on how strategic investors influence exchange rate dynamics. First, the presence of strategic investors amplifies the exchange rate's response to noise shocks while dampening its response to fundamental shocks, thereby exacerbating the excess volatility puzzle. In the model, a positive noise shock decreases the residual demand for foreign assets, driving up their price and the exchange rate, without changes in fundamentals. Conversely, a negative fundamental shock increases the excess returns on foreign assets, resulting in an appreciation of the foreign currency. Strategic investors, aware of their price impact, adjust their trading positions less aggressively, which amplifies the effect of noise shocks and weakens the impact of fundamental shocks on the exchange rate.

Our theoretical framework predicts that heterogeneity in price impact can contribute to exchange rate predictability, the exchange rate disconnect and the excess volatility of the exchange rate relative to fundamentals. First, in the model, systematic deviations from Uncovered Interest Parity (UIP) arise due to a non-zero net supply of foreign assets. Strategic behavior amplifies UIP deviations, making the Fama coefficient more negative and reflecting a stronger influence of interest rate differentials on excess returns and risk premiums. Second, the presence of strategic investors leads to a reduction in the information loading factor of the exchange rate (reduced informativeness), meaning that the exchange rate provides less information about underlying fundamentals. Lastly, by increasing the importance of the noise component in exchange rate dynamics, the presence of strategic investors contributes to the heightened volatility of exchange rates compared to underlying fundamental factors, as fundamental factors exhibit lower volatility compared to noise shocks.

We empirically validate the theoretical predictions of the model using a panel of 10 currencies spanning from 2006 to 2016. We leverage the variation in market concentration across currencies and time to test the implications of our theory. For this purpose, we combine daily exchange rate data with currency-level concentration data from the U.S. Commodity Futures Trading Commission (CFTC). Our empirical results show that, consistent with the theoretical predictions, a currency traded in a market with a 10% higher share of strategic investors exhibits an 18% lower predictive power compared to the average predictive power in the data. Similarly, a currency traded in a market with a 10% higher share of strategic investors exhibits an excess volatility ratio that is 12% higher than the average ratio.

We assess the potential impact of strategic investors on exchange rates by calibrating a

benchmark model with strategic investors and comparing it to a competitive model. Under reasonable parameters, we show that the presence of strategic investors may significantly influence exchange rate disconnect. However, while strategic investors and heterogeneity in price impact may theoretically exacerbate the forward premium and excess volatility puzzles, they explain only a moderate portion of the puzzles. Abstracting from the heterogeneity in price impact increases the connection between fundamentals and exchange rates by 14%, while it accounts for a moderate increase in excess return predictability and exchange rate volatility of approximately 6%. In the sensitivity analysis, we show that the impact of investors' heterogeneity in price changes on exchange rate dynamics can substantially increase for stronger magnitudes of strategic behavior, supporting the idea that investor-level features may be quantitatively relevant for aggregate dynamics.

Lastly, we extend our theoretical framework to incorporate another well-established dimension of investors' heterogeneity: dispersed information, in the spirit of Nimark (2017) and Bacchetta and Van Wincoop (2006). Information heterogeneity contributes to the disconnect between exchange rates and fundamentals, as well as to excess volatility. Due to rational confusion, investors are uncertain whether exchange rate movements are driven by noise shocks or fundamental shocks, which amplifies the impact of noise shocks while dampening the effects of fundamental shocks.

We asses the joint impact of these two dimensions of heterogeneity and compare the impact of strategic behavior on exchange rate dynamics with the effects of information heterogeneity. We construct counterfactual exchange rates by filtering the underlying states, and removing one dimension of heterogeneity and examining the resulting dynamics. In our benchmark calibration, investors' heterogeneity influences the dynamics of exchange rates, increasing the exchange rate disconnect by 24% and the excess volatility by 13%. Moreover, each dimension of heterogeneity is quantitatively relevant, with the heterogeneity in price impact accounting for 62% of the additional volatility and 35% of the additional disconnect attributed to investors' heterogeneity. Thus, heterogeneity in price impact appears to be more relevant in explaining exchange rate excess volatility, underscoring the importance of jointly considering both dimension in the analysis of exchange rate markets. Furthermore, the two dimensions of heterogeneity reinforce each other: as strategic investors trade less, strategic behavior reduces the informativeness of the exchange rate, making prices more dispersed for any level of information heterogeneity.

1.1 Related literature

Our work contributes to the microstructure approach to exchange rates by focusing on the heterogeneity of investors' price impact. Recent evidence from this literature highlight the importance of investor heterogeneity in understanding exchange rate dynamics and determination. For instance, the exchange rate determination puzzle, the excess predictability puzzle and the excess volatility puzzle can be explained by the rational confusion resulting from information heterogeneity among investors (Bacchetta and Van Wincoop, 2006; Candian and De Leo, 2022; Stavrakeva and Tang, 2020). Furthermore, exchange rate behavior is linked to order flow, which, in turn, is associated with the heterogeneity among investors (Lyons et al., 2001; Evans and Lyons, 2006). However, despite extensive evidence that foreign exchange rate markets are highly concentrated and atomistic price-taking investors are hardly realistic, the literature has ignored the potential heterogeneity in price impact (Osler, 2014; Osler et al., 2016; Cochrane, 2015). A notable exception is the work in Corsetti et al. (2004) and Corsetti et al. (2002), which theoretically studies the role that large investors have in speculative attacks in the foreign exchange markets. Differently to them, we focus on exchange rate determination and puzzles by incorporating heterogeneity in price impact, drawing on the modeling approach of Kyle (1989) and Kacperczyk et al. (2018), which has not been previously applied in the context of exchange rate markets.

This paper contributes to the rich literature on the determination and dynamics of exchange rates in the presence of frictions. Prior work explores various types of frictions, including informational frictions (Evans and Lyons, 2002; Bacchetta and Van Wincoop, 2006), infrequent portfolio adjustment (Bacchetta and Van Wincoop, 2010, 2019), imperfect and frictional markets (Gabaix and Maggiori, 2015; He and Krishnamurthy, 2013). To the best of our knowledge, our work is the first to specifically focus on this aspect of the market structure – the presence of strategic investors and heterogeneity in price impact – for the determination of the exchange rate.

This paper also relates to the vast literature attempting to explain major puzzles in international economics, both theoretically and empirically. We contribute by providing a new rationale, based on strategic behavior and price impact, for the failure of macroeconomic fundamentals to predict exchange rates and the large volatility of the exchange rate relative to fundamentals (Meese and Rogoff, 1983; Obstfeld and Rogoff, 2000; Engel and Zhu, 2019). We also show that the presence of strategic behavior and excess predictability interact (Fama, 1984). Although we do not propose novel explanations for UIP deviations, the

presence of strategic investors can account for currency level differences in UIP deviations. Moreover, we empirically study cross-currency differences in exchange rate puzzles and dynamics, which have been relatively unexplored, and find that different levels of price impact can explain cross-currency differences in a panel of 10 currencies.

The rest of the paper is organized as follows. Section 2 introduces the theoretical framework and explains the fundamental mechanism of strategic behavior. In Section 3, we discuss the main implications for the dynamics of the exchange rate and provide empirical evidence that supports the theoretical predictions. Section 4 expands the basic framework to incorporate information heterogeneity and quantifies the respective contributions of each mechanism. Finally, Section 5 presents the conclusion. Any proofs, derivations, and robustness analyses that were omitted can be found in the Appendices.

2 A Monetary Model with Strategic Investors

We propose a framework that incorporates strategic behavior in the spirit of Kyle (1989) and Kacperczyk et al. (2018) into a standard two-country, discrete time, general equilibrium monetary model of exchange rate determination (Mussa, 1982; Jeanne and Rose, 2002). We study the implications of strategic behaviour in the context of a monetary model, as it is well-suited for analyzing short-term exchange rate variations. In the baseline model, we assume that agents have rational expectations about the dynamics of the exchange rate to isolate the key mechanism. In Section 4, we extend the model allowing for dispersed information, following Bacchetta and Van Wincoop (2006).

2.1 Basic Set-up

There are two economies, Home and Foreign, both producing the same good. Variables referring to Foreign are indicated with a star. We assume that purchasing power parity holds, so that:

$$p_t = p_t^\star + s_t,$$

where s_t is the log nominal exchange rate, p_t $(p_t^\star)$ the log price level in the Home (Foreign) country. The exchange rate is defined as the value of the foreign currency in term of domestic currency, and an increase in the exchange rate reflects an appreciation of the foreign currency. There are three assets: one-period nominal bonds issued by both Home and Foreign with

interest rates i_t and $i_t^\star$, respectively, and a risk-free technology with fixed real return r. The latter is infinitely supplied while bonds are in fixed supply in their respective currency. We follow Bacchetta and Van Wincoop (2010) and assume asymmetric monetary rules between the two countries. The Home central bank commits to a constant price level, $p_t = 0$, which implies that the domestic interest rate is equal to the risk free technology, $i_t = r$. On the other hand, the monetary policy in Foreign is stochastic, $i_t^\star = -u_t$ where

$$u_t = \rho_u u_{t-1} + \sigma_u \epsilon_t^u \qquad \epsilon_t^u \sim N(0,1) \tag{1}$$

is the Foreign monetary policy shock. Thus, the interest rate differential is defined as

$$i_t - i_t^\star = u_t + r,$$

implying that the dynamics of the exchange rate are solely influenced by the monetary policy of the Foreign country.[5] In our model, we refer to a shock in the Foreign monetary policy as a fundamental shock.

There is a continuum of investors of mass one. We assume there are overlapping generations of investors that live for two periods and make only one investment decision. We abstract away from saving decisions by assuming that investors derive utility only from their end-of-life wealth (Bacchetta and Van Wincoop, 2006, 2010). Investors in both countries are born with an exogenous endowment, ω, and have the possibility to invest in nominal bonds and the risk free technology. We assume that Foreign country is infinitesimally small, implying that the market equilibrium is determined by the investors located in the Home country. There are two type of investors: strategic (S) and competitive (C). A mass $1 - \lambda$ of investors consists of standard atomistic price-takers investors. The remaining segment, with size λ, consists of a finite number N of strategic investors. Each strategic investors has a positive mass, λ_i, with $\sum_i^N \lambda_i = \lambda$. Notably, strategic investors internalize their effect on asset prices, operating as an oligopoly.

Investor j maximizes mean-variance preferences over next period wealth, w_{t+1}^j, by allo-

cating their initial endowment between domestic and foreign bonds:

$$\max_{b_t^j} \quad \mathbb{E}_t^j(w_{t+1}^j|\Omega_t^j) - \frac{\rho}{2}\operatorname{Var}_t^j(w_{t+1}^j|\Omega_t^j) \tag{2}$$

$$\text{s.t. } w_{t+1}^j = (\omega - b_t^j)i_t + (i_t^\star + s_{t+1} - s_t)b_t^j, \tag{3}$$

where b_t^j represents the foreign bond holdings, ρ the rate of risk aversion and Ω_t^j the informa-
tion set of investor j at time t. i_t and $i_t^\star + s_{t+1} - s_t$ are the log-linearized returns of domestic
and foreign bonds, respectively. Under PPP and the monetary policy assumptions above,
we have that $p_t^\star = -s_t$, implying that both returns are expressed in real terms. The only
difference between the two assets is that the return on foreign bonds is stochastic.[6] We as-
sume that agents have symmetric rational expectations about the dynamics of the exchange
rate, $\Omega_t^j = \Omega_t$.

Investors' demand schedule and portfolio allocation vary depending on their type. Strate-
gic investors internalize the effects that their demand has on equilibrium prices (more pre-
cisely, on the equilibrium exchange rate), while competitive investors do not. In Appendix
B, we show that the optimal demand for foreign bonds by investor j is as follows:

$$b_t^j = \begin{cases} \dfrac{\mathbb{E}_t s_{t+1} - s_t + i_t^\star - i_t}{\rho\sigma_t^2}, & \text{for } j = C \\[4mm] \dfrac{\mathbb{E}_t s_{t+1} - s_t + i_t^\star - i_t}{\rho\sigma_t^2 + \frac{\partial s_t}{\partial b_t^S}}, & \text{for } j = S \end{cases} \tag{4}$$

where σ_t^2 is the variance of the exchange rate change, $\operatorname{Var}_t(s_{t+1}-s_t)$. We focus on a stochastic
steady state where the variance σ_t^2 is time-invariant.

Investors' demand for foreign bonds depends positively on the expected excess return,
$q_{t+1} \equiv \mathbb{E}_t s_{t+1} - s_t + i_t^\star - i_t$. On the other hand, it depends negatively on the variance of the
exchange rate, σ_t^2, and on investors' risk aversion, ρ. Note that strategic behavior, captured
by investors' own price impact $\frac{\partial s_t}{\partial b_t^S}$, reduces investors' demand of foreign bonds for every
level of excess return. Given a total supply of foreign bond B, the price impact of a strategic
investor i is

$$\frac{\partial s_t}{\partial b_t^{S,i}} = \frac{\lambda_i \rho \sigma_t^2}{B\rho\sigma_t^2 + (1-\lambda)} > 0, \tag{5}$$

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[6]$p_t = 0$ implies $i_t = r$. Similarly, $p_t^\star = -s_t$ implies that the return on foreign bonds, $i_t^\star + s_{t+1} - s_t$, is
expressed in real terms as well.

which is positive, increasing in the mass of the investor, λ_i, and decreasing in the fraction of atomistic investors $1 - \lambda$. The individual price impact becomes $\frac{1}{N} \frac{\lambda \rho \sigma_t^2}{B \rho \sigma_t^2 + (1-\lambda)}$ in the case strategic investors are symmetric and have the same mass, $\lambda_i = \frac{\sum_i \lambda_i}{N} = \frac{\lambda}{N}$.[7] The structure of the market determines the magnitude of the price impact and, consequently, the relevance of strategic behavior: the magnitude of the individual price impact is negatively affected by the number of strategic traders, N, and positively related to the size of the strategic segment, λ. Therefore, the price impact is larger in more concentrated markets characterized by a lower N and/or higher λ.[8]

In addition to strategic and competitive investors, we introduce another group of investors referred to as noise traders. As is standard, their presence allows to match key empirical moments of exchange rates, such as exchange rate volatility, disconnect and deviations from UIP (Kyle, 1989; Bacchetta and Van Wincoop, 2006, 2010). Following Bacchetta and Van Wincoop (2010), we assume that the demand of noise traders for foreign bonds is exogenous and given by:

$$X_t = (\bar{x} + x_t)\bar{W},$$

where $\bar{W}$ is the steady state aggregate financial wealth in the Home economy, $\bar{x}$ is a constant and x_t follows the following exogenous process:

$$x_t = \rho_x x_{t-1} + \sigma_x \epsilon_t^x \qquad \epsilon_t^x \sim N(0,1).$$

In the stochastic steady state, the demand for foreign assets absorbed by noise traders is equal to $\bar{x}\bar{W}$. Deviations from this steady state are driven by x_t, which is interpreted as a noise shock and is orthogonal to the fundamental shock u_t in Equation (1). Positive shocks to x_t increase the desire for foreign assets, leading the foreign currency to appreciate without movements in the interest rate differential.

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[7]In our analysis, we focus on the case of symmetric strategic investors due to the unavailability of comprehensive investor-level market share data. Importantly, all qualitative predictions are not altered by the symmetry assumption. See Appendix B for the derivation of the analytic expression of the price impact.

[8]In our international portfolio model, strategic investors have a lower price impact on the equilibrium price of an asset compared to a closed-economy version. This is due to the presence of valuation effects on the supply of assets once denominated in domestic currency. By internalizing the effect that their demand has on the exchange rate, strategic investors also take into account how the value of the supply of foreign assets denominated in domestic currency varies when the exchange rate changes. This is reflected by the presence of B, the total supply of foreign assets, at the denominator of Equation (5). See Appendix B for additional details.

Equilibrium and Basic Mechanism We derive an expression for the equilibrium exchange rate by combining the demand schedules of investors and the market clearing condition of the foreign bond market. The market clearing condition is given by:[9]

$$(1-\lambda)b_t^C + \sum_i^N \lambda_i b_t^{S,i} + X_t = Be^{s_t}, \tag{6}$$

where the left hand side represents the total demand of foreign bonds from competitive investors, strategic investors and noise traders, and the right hand side represents the (constant) supply of foreign bonds, B, denominated in domestic currency.

We define the concept of equilibrium in our model as follow: for a history of fundamental and noise shocks $\{\varepsilon_t^{\Delta i}, \varepsilon_t^x\}_{t=0}^{-\infty}$, an equilibrium path is a sequence of portfolio allocations, $\{b_t^C, \{b_t^{S,i}\}_{i=1}^N\}$, and foreign bond price (exchange rate), $\{s_t\}$, such that investors optimally choose their portfolio allocation and the market clearing condition holds.

The model allows us to derive an explicit solution for the exchange rate s_t from the market clearing condition in Equation (6):

$$s_t = \underbrace{(1-\mu)\left(\frac{\bar{x}}{b}-1\right)}_{\text{constant}} + \underbrace{\mu\left(\mathbb{E}_t s_{t+1} + i_t^\star - i_t\right)}_{\text{fundamental}} + \underbrace{(1-\mu)\frac{1}{b}x_t}_{\text{noise}}, \tag{7}$$

where $b = \frac{B}{W}$ and $\mu = \frac{1}{1+\Phi(\lambda,N)}$ with $\Phi(\lambda,N) = \frac{B\rho\,\mathrm{Var}_t(s_{t+1})\left(1+B\rho\,\mathrm{Var}_t(s_{t+1})-\lambda\frac{N-1}{N}\right)}{\left(1+B\rho\,\mathrm{Var}_t(s_{t+1})-\lambda\frac{N-1}{N}\right)-\frac{\lambda^2}{N}}$. The exchange rate follows a forward looking auto-regressive process with drift, where the constant term depends on a set of parameters and the stochastic component depends on future fundamental and noise shocks. By further manipulating Equation (7), it can be shown that the exchange rate s_t can be written as follows:

$$s_t = \mu\sum_{k=0}^\infty \mu^k\left(i_{t+k}^\star - i_{t+k}\right) + \frac{1-\mu}{b}\sum_{k=0}^\infty \mu^k\left(x_{t+k}\right). \tag{8}$$

The exchange rate is a weighted average of current and future fundamental shocks $(i_{t+k}^\star - i_{t+k})$ and noise shocks (x_{t+k}). The weight μ quantifies the amount of information about the

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[9]The market clearing for the domestic bond is not explicitly considered because domestic bonds are perfectly substitutable with the risk free technology, which is infinitely supplied. Furthermore, in a monetary model, a market clearing condition for the money market would also be required. Bacchetta and Van Wincoop (2006) and Bacchetta and Van Wincoop (2010) assume that investors generate a money demand (independent of their portfolio decision) and that money supply accommodates it under the exogenous rule for interest rates. We do not explicitly model the money market in order to limit notation, leaving it in the background.

fundamental conveyed by the exchange rate. Notably, the informativeness of the exchange rate decreases when strategic investors operate in the foreign bond market (higher λ or lower N imply higher Φ and, thus, lower μ). When there is a higher proportion of strategic investors (higher λ) or a lower number of strategic traders (lower N), investors' demand declines because of the stronger price impact. Therefore, the demand from noise traders becomes relatively more important in determining the exchange rate.[10] [11]

2.2   Theoretical Predictions

We illustrate the theoretical implications of strategic behavior for exchange rate dynamics. Specifically, we show that the presence of strategic investors may increase exchange rate volatility, exacerbate the disconnect between the exchange rate and underlying fundamentals, and lead to larger deviations from uncovered interest parity (UIP). Appendix B provides the proofs for each proposition.

Response to Shocks   In the model, an increase in the exchange rate arises due to either a positive noise shock or a negative fundamental shock. A positive noise shock, interpreted as either an increase in demand or a decrease in the supply of foreign assets, reduces the residual demand for these assets. This leads to a rise in the price of foreign assets and an appreciation of the exchange rate, despite no change in the underlying fundamentals. As the exchange rate increases, the excess return falls below its steady state, causing investors to reduce their foreign asset holdings and rebalance their portfolios in favor of domestic assets. Conversely, a negative fundamental shock, caused by contractionary monetary policy in the foreign country, reduces the interest rate differential, and directly increases the excess return on holding foreign assets. This is turn boosts investors' demand for foreign assets, leading to an appreciation of the foreign currency.

Proposition 1 (Response to Shocks). *An increase in the size of strategic investors amplifies the response of the exchange rate to noise shocks while dampening the response to fundamental shocks.*

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[10]When traders recognize that the residual supply curve is upward-sloped, quantities are restricted and less elastic. Therefore, prices become less informative. This aligns with the key intuition from Kyle (1989).

[11]The informativeness parameter, μ, relates to the magnification factor in Bacchetta and Van Wincoop (2006). In their work, information dispersion among investors reduces the information content of exchange rates by amplifying the impact of noise traders. As in their work, the behavior of the parameter μ plays a crucial role in the amplification mechanism examined here.

Proposition 1 states that these mechanisms are amplified in response to a noise shock and dampened in response to a fundamental shock when strategic investors are present in the market. To see this, consider the law motion of the exchange rate in Equation (7). s_t can be rewritten as a forward looking sum of fundamentals and noises as follow:

$$s_t = -\mu \sum_{k=0}^{\infty} \mu^k \left(\Delta i_{t+k} \right) + \frac{1-\mu}{b} \sum_{k=0}^{\infty} \mu^k \left(x_{t+k} \right), \tag{9}$$

where $\Delta i_{t+k} = i_{t+k} - i_{t+k}^{\star}$, and Δi_{t+k} and x_{t+k} represent the fundamental and noise components, respectively. The exchange rate's response to a unit shock in noise ε_x and fundamental ε_u components is given by:

$$\mathbb{E} \left(\Delta s_t | \varepsilon_u = -1 \right) = \frac{\mu}{1 - \mu \rho_u}, \qquad \mathbb{E} \left(\Delta s_t | \varepsilon_x = 1 \right) = \frac{(1-\mu)}{(1 - \mu \rho_x) b}. \tag{10}$$

Since μ is decreasing (increasing) function of the size of strategic investor λ in the market, then the response of the exchange rate to a unit shock in fundamental is dampened while noise shock are amplified as λ increases. Figure 8 in Appendix D provides a graphical representation on the impulse response functions.

Economically, this occurs because strategic investors, who internalize the negative impact their trades have on prices, consistently respond less aggressively to aggregate shocks, which affects the sensitivity of foreign asset demand. Therefore, in a world where investors behave strategically, the decline in demand for foreign assets in response to a noise shock is less pronounced compared to a competitive benchmark. The smaller decline in the demand for foreign bonds, due to strategic behavior, exerts additional upward pressure on the price of foreign bonds, thereby amplifying the effect of noise shocks on the exchange rate.

Conversely, in response to a fundamental shock, strategic investors increase their demand for foreign assets less than they would in a competitive market, again making total demand less sensitive to fundamental shocks. In this strategic environment, investors internalize their price impact, leading to a smaller increase in their holdings of foreign assets. As a result, the price of foreign assets rises less than it would in a competitive market, dampening the effect of the fundamental shock on the exchange rate.

Excess Return Predictability   An empirically robust evidence in exchange rate dynamics is the predictability of excess returns, commonly referred to as deviations from the Uncovered Interest Parity (UIP) (Fama, 1984). Our model predicts systematic deviations from

UIP due to a non-zero net supply of foreign assets, regardless of the presence of strategic investors.

Proposition 2 (Excess Return Predictability). *Excess returns is more predictable as the size of strategic investors in the market increases.*

Proposition 2 states that strategic behavior amplifies these UIP deviations compared to a competitive market. To illustrate this, define the 1-period excess return $q_{t+1} = s_{t+1} - s_t - (i_t - i_t^*)$, and consider the corresponding one-period Fama regression:

$$q_{t+1} = \alpha + \beta^{\text{Fama}}(i_t - i_t^\star) + \epsilon_t, \tag{11}$$

where the coefficient, β^{Fama}, reflects deviations from the UIP theory. If UIP holds, the coefficient of the Fama regression is expected to be zero. However, in empirical studies, the Fama coefficient is systematically different from zero and negative. Based on Equation (11), the coefficient β^{Fama} is:

$$\beta^{\text{Fama}} \equiv \frac{\text{Cov}(q_{t+1}, i_t - i_t^*)}{\text{Var}(i_t - i_t^*)} = -(1 - \mu)\frac{1}{1 - \mu\rho_u} \in (-1, 0), \tag{12}$$

which is negative, in line with empirical findings, and decreases as strategic behavior increases. In other words, when there are strategic investors, changes in the interest rate differential have a stronger impact on the excess return, and consequently on the risk premium.

In our theoretical framework, as strategic investors' positions become less elastic to aggregate shocks, the market requires larger movements in the risk premium to incentivize investors to take larger positions. An increase in the size of strategic investors, λ, reduces market risk appetite, further necessitating a higher risk premium to absorb the net supply of foreign assets. This makes the excess return more responsive to changes in fundamentals, increasing its predictability. We can re-write the excess return as:

$$\mathbb{E}_t q_{t+1} \approx \Phi\left(Be^{s_t} - X_t\right) \tag{13}$$

The right-hand side represents the deviation from UIP, which can be interpreted as the risk premium required by investors for holding a foreign asset. The risk premium depends on two components: the net supply of foreign assets and the size of non-competitive investors, captured by Φ, which increases with the size of strategic investors, λ. The first component

drives the deviation from UIP in the model, while the second component, Φ, amplifies the UIP deviation.[12]

Exchange Rate Excess Volatility There is extensive evidence showing that exchange rates exhibit higher volatility compared to fundamentals, which is commonly referred to as the "excess volatility puzzle" (Obstfeld and Rogoff, 2000; Engel and Zhu, 2019). This puzzle provides evidence of the significant role of non-fundamental components in explaining exchange rate dynamics in the data.

Proposition 3 (Exchange Rate Excess Volatility). *Given standard parametrization, the noise component accounts for a large share of exchange rate variance. Thus, an increase in the size of strategic investors makes the exchange rate more volatile relative to fundamentals.*

Proposition 3 states that if variations in exchange rates are mainly driven by noise, strategic investors contribute to the excess volatility of the exchange rate relative to fundamentals. By manipulating Equation (8), we derive an expression for the unconditional variance of the exchange rate as a combination of the variances of both fundamental and noise shocks:

$$\text{Var}(s_t) = \frac{\mu^2}{(1-\mu\rho_u)^2} \left[\frac{1}{1-\mu^2} + \frac{\rho_u^2}{1-\rho_u^2} \right] \sigma_u^2 + \frac{(1-\mu)^2}{(1-\mu\rho_x)^2 b^2} \left[\frac{1}{1-\mu^2} + \frac{\rho_x^2}{1-\rho_x^2} \right] \sigma_x^2. \quad (14)$$

We compute the excess volatility of the exchange rate as the ratio of the volatility of the exchange rate in Equation (14) to the volatility of the fundamental, $\frac{\sigma_u}{\sqrt{1-\rho_u^2}}$ (Engel and Zhu, 2019). This is increasing in λ if and only if:

$$\frac{\text{Var}(x_t)}{\text{Var}(\Delta i_t)} \frac{1}{b^2} > \left[\frac{(1+\mu^2\rho_x)(1-\rho_x)}{\mu(1+\mu\rho_u)(1-\mu^2) + \mu^3(1-\rho_u^2)} \frac{(1-\mu\rho_u)^2(1-\mu)^2}{(1-\mu\rho_x)^2} \right]^{-1}. \quad (15)$$

This suggests that the unconditional variance of the exchange rate increases with the share of strategic investors when the variance of the noise shock is sufficiently high relative to the variance of the fundamental process.

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[12]Appendix B generalizes the result in Proposition 2 showing that the Fama coefficient is monotonically increasing in the time horizon k, and approaching zero for $k = \infty$. Therefore, our model does not explain the predictability reversal puzzle documented in Bacchetta and Van Wincoop (2010) and Engel (2016), which shows that expected excess returns reverse sign at longer horizons. This limitation is anticipated, as our focus is on an amplification mechanism without portfolio adjustment frictions (Bacchetta and Van Wincoop, 2010, 2019).

Intuitively, this occurs because the presence of strategic investors reduces the informativeness of the exchange rate, placing relatively more weight on the noise component. Given standard parametrization, the noise component is more volatile than the fundamental component.[13] Thus, when exchange rates are primarily driven by noise, strategic investors contribute to the increased volatility observed in the exchange rate.

Exchange Rate Disconnect   One of the most well-established empirical findings in exchange rate dynamics is the disconnect between exchange rates and fundamentals (Meese and Rogoff, 1983; Cheung et al., 2005; Rossi, 2013). Specifically, variations in the interest rate differential explain only a small portion of the changes in exchange rates.

Proposition 4 (Exchange Rate Disconnect). *Given standard parametrization, the disconnect between the exchange rate and fundamentals increases in the presence of strategic investors.*

To measure the disconnect, we assess the explanatory power of the following regression equation:

$$s_{t+1} - s_t = \alpha + \beta(i_t - i_t^\star) + \varepsilon_{t+1}, \tag{16}$$

where $i_t - i_t^\star$ represents the fundamental driver of the one-period exchange rate change $s_{t+1} - s_t$. The proportion of variance in exchange rate changes explained by fundamentals is:

$$R^2 = \frac{\text{Var}(\Delta i_t)}{\text{Var}(\Delta s_{t+1})} \left[1 + \beta^{Fama} \right]^2 \tag{17}$$

The R^2 coefficient depends on two factors: the ratio of the variance of the fundamental to the variance of exchange rate changes, and the Fama coefficient from Proposition 2. Given standard parametrization, an increase in the size of strategic investors raises exchange rate volatility, reducing the first term in Equation (17). Simultaneously, an increase in the size of strategic investors makes the exchange rate more predictable, reducing the second term. The two effects together unambiguously make the exchange rate more disconnected from fundamentals. The main intuition relies again on the fact that strategic investors reduce the informativeness of the exchange rate, placing relatively more weight on the noise component.

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[13]The quantitative assessment in Section 3 and Appendix B show that, monotonicity is satisfied for any reasonable calibration, although the effect of strategic behavior is not necessarily monotonic from a theoretical perspective.

Figure 2: Testing Model Predictions
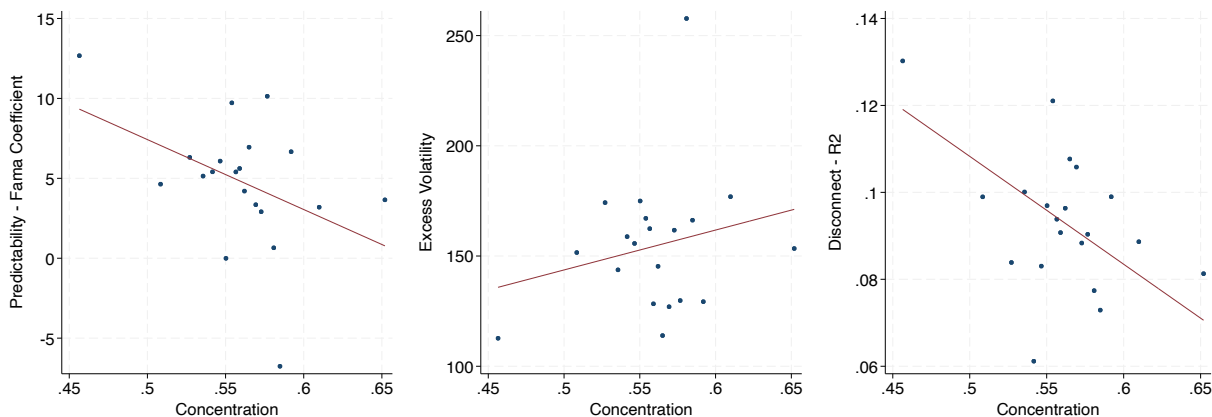
Notes: The figure plots the positive relationship between the level of strategic behavior and the excess return predictability (left panel), the excess volatility (central panel), and the disconnect (right panel) of the exchange rate in the actual data. Concentration is the share of open interest held by the top eight traders in the future FX market. Data is from the U.S. CFTC spanning from 2006 to 2016. Exchange rate predictability is represented by the regression coefficient from the Fama regression in Equation (11). The exchange rate disconnect is measured using the R^2 from the regression in Equation (16), while excess volatility is calculated as the ratio of exchange rate volatility (from Equation (14)) to the volatility of the interest rate differential. To measure predictability, excess volatility, and disconnect, we use 2-year rolling window regressions based on monthly average exchange rate data. The resulting data are demeaned at the currency and year levels, and the Fama coefficient, excess volatility ratio, and disconnect values are winsorized at the 1% level. The South African Rand is excluded from the set of 11 currencies. The estimated coefficients are reported in Table 8 in Appendix D, while Appendix A provides further details on the data used.

2.3   Testing Predictions

We leverage the heterogeneity in market concentration across currencies to test the implications of our theory. The model delivers three distinct testable relationships between exchange rate dynamics and the level of strategic behavior: (i) currencies with a larger presence of strategic investors are more predictable; (ii) higher levels of strategic behavior result in greater excess volatility in exchange rates; and (iii) the disconnect between exchange rates and fundamentals increases with the level of strategic behavior. We test model's predictions using a set of 10 currencies merged with the U.S. CFTC transaction data, available since June 2006 to December 2016.[14]

We use the concentration ratio of the top eight investors, as reported by the U.S. CFTC, as our proxy of strategic behavior in the foreign exchange market (λ).[15] We correlate this

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[14]We exclude the South African Rand from our analysis due to a limited number of time observations in the CFTC dataset. To reduce noise in weekly transactions, we aggregate the data to a monthly level.

[15]The assumption is that variations in concentration ratios between currencies may reflect differences in

information with time-varying metrics of exchange rate disconnect, predictability and excess volatility. We utilize a 2-year rolling window with monthly exchange rate data to create time-varying indexes for exchange rate predictability, disconnect and excess volatility. We measure exchange rate predictability as the coefficient on the interest rate differential from the Fama regression in Equation (11), exchange rate disconnect using the R^2 from the regression in Equation (16), and excess volatility as the ratio of exchange rate volatility (from Equation (14)) to the volatility of the interest rate differential. The panel nature of our dataset enable us to incorporate currency and year fixed effects, mitigating potential concerns regarding spurious correlation and strengthening the validity of the empirical evidence.[16]

Figure 2 provides evidence that are consistent with the predictions of our theoretical framework. The left panel shows that, on average, currencies with more concentrated trading flows, held by fewer investors, tend to be more predictable. The middle panel documents a strong, positive, and statistically significant relationship between our measure of strategic behavior in exchange rate markets and the excess volatility of exchange rates. Finally, the right panel reveals that as the presence of strategic investors in the market increases, currencies become more disconnected from fundamentals, as indicated by the decreasing estimated R^2.

Table 8 in Appendix D reports the estimated coefficients along with the corresponding standard errors, clustered at the country level. We find that a currency traded in a market with a 10% higher concentration ratio exhibits an excess volatility ratio that is approximately 12% higher than the sample average. Similarly, a currency traded in a market with a 10% higher concentration ratio exhibits 18% lower predictive power compared to the average R^2 observed in the sample.

3   Quantitative Assessment

In this section, we investigate the potential impact of strategic investors on exchange rates. We begin by illustrating the key implications of the model using a benchmark parameterization. Then, we examine how the main results are influenced by the model's parameters.

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the presence and influence of traders who engage in strategic trading.

[16]The results remain unchanged when we increase the rolling window size to 3 and 4 years, and using different proxies for strategic behavior, such as the number of active traders.

Table 1: Benchmark Parametrization

Parameters	Value	Target
ρ	50	Bacchetta and Van Wincoop (2019)
b	0.333	Home Bias
ρ_u	0.85	Average persistence AR(1) Δi_t
σ_u	0.005	Average StD innovation AR(1) Δi_t
σ_t	0.028	σ_t (Volatility ER change)
ρ_x	0.9	ER Random Walk/Average Disconnect
λ	0.572	Net concentration ratio (Top 8) – US CFTC
N	8	Number of traders related to λ – US CFTC
σ_x	0.132	Average StD ER change

Notes: The table summarizes the parametrization used in the basic framework. For each parameters, we report the value used in the model, the corresponding moment and data used to calibrate, and, if applicable, the target moment used to estimate it. Appendix A provides additional information on the data used.

3.1 A Benchmark Calibration

The parameters of the benchmark case are reported in Table 1. To calibrate the model, we use data on 18 exchange rates, all defined against the USD, from 1993 to 2019 at a monthly frequency.[17] Without loss of generality, we set $\bar{r} = 0$, so that the $i_t - i_t^\star = u_t$. Assuming covered interest rate parity holds, we compute the one-month interest rate differential as the difference between the one-month forward and the spot exchange rate. We assume that the fundamental, u_t, follows an AR(1) process. We estimate the volatility and the persistence of the fundamental process for each currency using interest rate differentials, and calibrate σ_u and ρ_u to match the average volatility and persistence across currencies. This yields $\sigma_u = 0.005$ and $\rho_u = 0.85$. The variance of the exchange rate change, σ_t, is assumed to be constant over time and calibrated to match the average standard deviation of the one-period exchange rate change across currencies, which is 0.028.

As standard in this literature, the process governing the demand of noise traders, x_t, is calibrated to match exchange rate dynamics. The persistence of the noise shock, ρ_x, is set equal 0.9 which is high enough to ensure the exchange rate behavior is sufficiently close to a random walk. The volatility of the noise process, σ_x, is chosen to match the volatility

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[17]We consider the following currencies: Euro, Japanese Yen, Argentinian Peso, Brazilian Real, Canadian Dollar, Swiss Franc, Australian Dollar, Chilean Peso, Indian Rupee, Mexican Peso, British Pound, South African Rand, Russian Ruble, Swedish Krona, Turkish Lira, New Zeland Dollar, Singapore Dollar, Norwegian Krone. See Appendix A for additional details on data.

of the one-period change in exchange rate. However, Equation (8) shows that exchange rate dynamic depends on the underlying market structure. Therefore, we first calibrate the parameters controlling the magnitude of the strategic behavior, λ and N, and then σ_x. To this end, we use data from the U.S. Commodity Futures Trading Commission, and set $N = 8$ and $\lambda = 0.572$, which is the average concentration ratio of the top eight traders in the currency market (Figure 1). Given the values for λ and N, we estimate $\sigma_x = 0.133$.[18]

Lastly, we set b, the inverse home bias measure, equal to 0.33, indicating that foreign assets account for one third of the total domestic financial wealth. This value is an approximate average obtained from the IMF IIPS dataset (Bacchetta and Van Wincoop, 2019).[19] Moreover, we follow Bacchetta and Van Wincoop (2019) and set the rate of relative risk aversion, ρ, to 50.[20]

We perform a counterfactual exercise to evaluate the potential impact of strategic behavior on exchange rates. We solve the model under the benchmark parametrization to generate a set of moments that summarize exchange rate dynamics using simulated data. We then quantify the impact of strategic investors by comparing these results to those from the competitive scenario. For each model specification, we run 1,000 simulations, each consisting of 6,000 periods, with a burn-in of 3,000 periods. To evaluate the significance of the theoretical results, we compare them with the cross-sectional variation in the corresponding moments across currencies in the actual data. Table 2 presents the results of the counterfactual exercises (Panel A) alongside the mean and standard deviation of the corresponding moments calculated from actual data across currencies (Panel B).

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[18]Figure 7 in Appendix D shows a negative relationship between strategic behavior (N and λ) and σ_x, given a target exchange rate volatility. In other words, accounting for strategic investors in the market reduces the implied volatility of noise traders needed to match exchange rate volatility, as strategic investors amplify the effects of noise.

[19]Without loss of generality, the supply of foreign assets, B, is normalized to one. In order to ensure model consistency, we set ω, the initial endowment of each investor, equal to 3. This choice is derived from the relationship $b = \frac{B}{\bar{W}}$. By calibrating b and normalizing B, we determine that $\bar{W} = 3$. Total financial wealth in equilibrium is equal to the initial endowment.

[20]In the model, currency premia arise solely from investors' risk aversion, which would be relatively small for typical levels of risk aversion. However, our results are qualitatively robust when considering different levels of risk aversion, as shown in the sensitivity analysis.

Table 2: Potential Impact of Strategic Investors on Exchange Rates

Panel A: Moments from Simulated Exchange Rate Data	(1) Response to Shock Noise (Fundamental)	(2) Fama Coefficient	(3) Exchange Rate Volatility (St.D.)	(4) Exchange Rate Disconnect
Competitive (Atomistic investors)	14.66 (-0.088)	-0.204	0.259	0.083
Strategic (Avg. investor 7%)	15.506 (-0.087)	-0.217	0.274	0.073
Periods per Simulation	6000	6000	6000	6000
Burn-in Periods	3000	3000	3000	3000
Number of Simulations	1000	1000	1000	1000
Panel B: Moments from Actual Exchange Rate Data		Fama Coefficient	Exchange Rate Volatility (St.D.)	Exchange Rate Disconnect
Monthly Avg. Across Currencies (St.D.)		-0.603 (1.317)	0.344 (0.353)	0.030 (0.065)
Weekly Avg. Across Currencies (St.D.)		-0.490 (0.780)	0.341 (0.339)	0.036 (0.064)
Years per Currency		1993-2019	1993-2019	1993-2019
Number of Currencies		18	18	18

Notes: Panel A reports the impact of strategic investors on exchange rate dynamics using simulated data, with results for the competitive and benchmark models in the first and second rows, respectively. Column (1) shows the exchange rate response to a one-standard-deviation noise and fundamental shock, expressed as a percentage deviation from the steady state (e.g., 1 indicates a 1% deviation). Column (2) displays the Fama regression beta, indicating deviations from uncovered interest parity. Column (3) reports exchange rate volatility (standard deviation), and Column (4) provides the estimated R^2 from the disconnect regression in the simulated data. Panel B shows the average and standard deviation of equivalent moments from actual exchange rate data at monthly and weekly frequencies. The results in Panel A are based on 1,000 simulations, each running for 6,000 periods with a 3,000-period burn-in. All other parameters are constant across scenarios; see Table 1 for details. Appendix A provides further data information, and Appendix C outlines the estimation procedure.

Response to Shocks Column (1) of Table 2 shows that strategic investors significantly amplify the impact of noise shocks on exchange rates, while their influence on fundamental shocks remains minimal. In the competitive scenario, a noise shock raises the exchange rate by approximately 14.6% above its steady state. When strategic investors with an average market share of 7% are introduced, this response increases to 15.5%, representing a 5.8% rise over the competitive benchmark. In contrast, the dampening effect of strategic investors on fundamental shocks is negligible. The cumulative impulse response to a fundamental shock changes marginally, from -0.088% in the competitive scenario to -0.087% with strategic investors - a variation of approximately 1%.

Overall, these results suggest that strategic investors can significantly amplify short-term, noise-driven exchange rate fluctuations, potentially increasing volatility, while their impact on fundamental-driven movements remains limited. The key intuition lies in Equation (10). The stronger effect of strategic investors on the transmission of noise fluctuations is due, on the one hand, to the greater persistence of the noise component (ρ_x) compared to the persistence of the fundamental process (ρ_u), and, on the other hand, to the relatively large size of noise trading, captured by the home bias parameter b.

Exchange Rate Puzzles Table 2 shows that, under reasonable parameters, the model is able to reproduce key untargeted moments of exchange rate dynamics. Panel B of Table 2 shows that, in the data, the average Fama coefficient across countries is approximately -0.6, exchange rate volatility is 0.35, and the disconnect R^2 coefficient is 0.03. Using simulated data from the model, we estimate a Fama coefficient, exchange rate volatility, and a disconnect R^2 coefficient of -0.22, 0.27, and 0.07, respectively – values that very close to the corresponding moments in the data, suggesting the model's ability to replicate key features of the economy.

We show that the presence of strategic investors may significantly influence exchange rate disconnect, while having a moderate impact on excess return predictability and exchange rate volatility.[21] In line with our theoretical predictions, Column (5) in Panel A shows that abstracting from the heterogeneity in price impact increases the connection between fundamentals and exchange rates. The R^2 of the disconnect regression rises from 0.073 in the benchmark scenario with strategic investors to 0.083 in a competitive market, a 14% increase, suggesting that strategic investors can meaningfully reduce the disconnect between exchange rates and fundamentals. Column (3) and Column (4) in Panel A show that the presence of strategic investors has a smaller quantitative relevance for excess return predictability and exchange rate volatility. The Fama coefficient shifts from -0.204 in the competitive scenario to -0.217 in the benchmark case, representing an approximately 6% more negative UIP coefficient. Similarly, the presence of strategic investors increases exchange rate volatility by approximately 6% compared to the competitive scenario. These results suggest that, while strategic investors and heterogeneity in price impact may theoretically exacerbate the forward premium and excess volatility puzzles, they explain only a moderate portion of the puzzles.

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[21]To measure excess volatility, we directly examine the volatility of the exchange rate. This is without loss of generality because the denominator of the excess volatility ratio – the volatility of the fundamental – remains constant across all counterfactual scenarios.

3.2 Sensitivity Analysis

Table 3 presents the sensitivity analysis results. We examine how variations in key model parameters influence exchange rate dynamics in the presence of strategic investors, focusing on two unobservable parameters: the size of strategic investors (λ) and risk aversion (ρ). In the benchmark case, we calibrate the size of strategic investors to match the average concentration ratio observed across currencies, and we follow the existing literature to set risk aversion. While the concentration ratio reflects market power distribution, it may not fully capture strategic behavior nuances. For instance, large investors may avoid strategic actions due to factors like regulation, while smaller, sophisticated traders could act strategically despite their smaller market share.[22] Therefore, we explore the sensitivity of our benchmark results using different values for λ. Similarly, risk aversion reflects investors' risk tolerance. Highly risk-averse investors tend to adopt conservative strategies to minimize losses, reducing their willingness to take large positions or engage in actions that amplify price movements. This could dampen the overall impact of strategic investors on exchange rates. As a result, even with significant market power, high risk aversion can limit an investor's strategic influence. We replicate the counterfactual exercises in the benchmark case, exploring both low and high values for these parameters.

When the size of strategic investors is reduced to 5% ($\lambda/N = 5\%$), their ability to influence the market diminishes, leading to a significant decrease in the exchange rate's response to noise shocks, which drops to 2.1%. In the long run, exchange rates become only 2% more volatile in the presence of strategic investors, and compared to the competitive model, the R^2 is only 4.7% lower. In contrast, when the size of strategic investors increases to 9% ($\lambda/N = 9\%$), their impact becomes much more pronounced. The response to noise shocks rises sharply to 12.8%, reflecting a greater sensitivity to market noise. This larger size also results in a 14.4% more negative Fama coefficient relative to the benchmark case, signaling a greater deviation from uncovered interest parity (UIP). Finally, exchange rate volatility increases by 12.3% compared to the competitive model, and the disconnect from fundamentals worsens, with the R^2 dropping by 24%. Figure 9 in Appendix D provides further analysis across the full range of λ, shedding light on how the size of strategic investors affects key moments.

When risk aversion is low ($\rho = 30$), strategic investors behave more aggressively, leading to an increased response to noise shocks, which rises to 6.8%. The higher risk appetite also

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[22]Additionally, the concentration ratio doesn't account for differences in investor objectives or time horizons, which can also influence strategic behavior.

Table 3: Sensitivity Analysis

Moments from Simulated Data (% Deviation from Competitive Model)	(1) Response to Shock Noise (Fundamental)	(2) Fama Coefficient	(3) Exchange Rate Volatility (St.D.)	(4) Exchange Rate Disconnect
Benchmark Case	0.058 (0.017)	-0.064	0.055	-0.122
Size Strategic Investors				
Low ($\lambda/N = 5\%$)	0.021 (0.006)	-0.024	0.02	-0.047
High ($\lambda/N = 9\%$)	0.128 (0.038)	-0.144	0.123	-0.247
Risk Adversion				
Low ($\rho = 30$)	0.068 (0.011)	-0.073	0.061	-0.117
High ($\rho = 70$)	0.05 (0.021)	-0.057	0.049	-0.118
Periods per Simulation	6000	6000	6000	6000
Burn-in Periods	3000	3000	3000	3000
Number of Simulations	1000	1000	1000	1000

Notes: The table reports the impact of strategic investors on exchange rate dynamics as percentage deviations from the competitive model using simulated data (e.g., 0.01 unit indicates a 1% deviation from the competitive model). For comparison, the first row presents the impact of strategic investors on exchange rate moments in the benchmark case. Each column reports percentage deviations from the competitive model. Column (1) shows the amplification or dampening of the exchange rate response to a one-standard-deviation noise and fundamental shock. Column (2) reports the percentage deviation in the Fama regression beta. Column (3) reports the percentage deviation in exchange rate volatility, measured by the standard deviation, and Column (4) provides the percentage deviation in the estimated R^2 from the disconnect regression. The results are obtained from 1,000 simulations, with each iteration running for 6,000 periods and a burn-in of 3,000 periods. All the other parameters are held constant across scenarios; see Table 1 for details.

drives up exchange rate volatility, which climbs to 6.2% above the competitive level, and contributes to relatively more predictable exchange rates. In contrast, when risk aversion is higher ($\rho = 70$), strategic investors adopt more conservative strategies, reducing the response to noise shocks to 5.0%. This moderation in behavior results in lower volatility, which decreases to 4.9% above the competitive, and a slighter smaller deviation from UIP. These findings highlight that risk aversion directly influences the degree to which strategic investors impact exchange rate dynamics. Lower risk aversion leads strategic investors to take more aggressive positions, amplifying noise and volatility, and increasing the disconnect from fundamentals. Conversely, higher risk aversion restrains their strategic actions, reducing their influence on market volatility and bringing exchange rates closer to fundamentals.

4 Extending the Model with Dispersed Information

We now compare the effects of heterogeneity in price impact have on excess volatility and disconnect to the effects of another well-established dimension of heterogeneity: investors' information heterogeneity. Dispersed information arising from heterogeneous information sets may leads to higher exchange rate disconnect and excess volatility (Bacchetta and Van Wincoop, 2006; Evans and Lyons, 2002), representing a competing mechanism with heterogeneity in price impact. To assess the relevance of these two competing dimensions of heterogeneity, we extend the basic framework presented in Section 2 by relaxing the full information assumption and including information heterogeneity based on Nimark (2017). Through the lens of our model, we quantitatively evaluate the relative importance of strategic behavior and information heterogeneity in driving the dynamics of exchange rates.

Model   The model incorporates all standard elements of an exchange rate monetary model, along with the strategic behavior described in Section 2. However, in contrast to the basic framework, we assume that investors possess imperfect knowledge of the shocks affecting the economy, resulting in dispersed information. The remaining structure of the economy remains the same.

The main implication of information heterogeneity is that the optimal demand for foreign bonds by investor j at time t now depends on their individual information set, $\Omega_t(j)$:

$$
b_t^j = \begin{cases} \dfrac{\mathbb{E}_t(s_{t+1}|\Omega_t(j)) - s_t + i_t^\star - i_t}{\rho\sigma_t^2} & \text{if } j = C \\[4mm] \dfrac{\mathbb{E}_t(s_{t+1}|\Omega_t(j)) - s_t + i_t^\star - i_t}{\rho\sigma_t^2 + \frac{\partial s_t}{\partial b_t^S}} & \text{if } j = S \end{cases} \tag{18}
$$

where the excess return, $q_{t+1} = E_t(s_{t+1}|\Omega_t(j)) - s_t + i_t^\star - i_t$, and the variance of the exchange rate change, σ_t^2, are now conditional to the information set at time t, $\Omega_t(j)$. In contrast to the basic framework, we assume that σ_t^2 is endogenous but common to all investors, implicitly assuming that investors have the same capacity to process information. Despite the presence of information heterogeneity, the main implication of strategic behavior still holds true. Specifically, the own price impact reduces the demand of strategic investors for any given level of excess return.

Information Structure The information structure in our model follows Nimark (2017), and generalize the case in Singleton (1987) and Bacchetta and Van Wincoop (2006). Investors form expectation regarding the future price of the foreign bond (exchange rate) by observing their private signal about the fundamental, as well as the history of the exchange rate. Formally, investors' information set is given by:

$$\Omega_t(j) = \{f_{t-T}(j), s_{t-T} : T \geq 0\},$$

where

$$f_t(j) = \Delta i_t + \eta_t(j) \text{ where } \eta_t(j) \sim N\left(0, \sigma_\eta^2\right)$$

represents the private signal about fundamentals. Therefore, investors have imperfect knowledge about the history of shocks that affect the economy because they observe an unbiased signal $f_t(j)$ regarding Δi_t, with an idiosyncratic measurement error $\eta_t(j)$. Investors are unable to perfectly observe the path of the foreign interest rate, and cannot deduce the fundamental component from observing the exchange rate due to the presence of unobserved transitory noise shock x_t (Admati, 1985). The private signal, $\eta_t(j)$, implies that investors have different expectations about foreign Central Bank's operating procedures. Consequently, the need to 'forecast the forecasts of others' (infinite regress problem) arises due to information dispersion.

The key distinction with Singleton (1987) and Bacchetta and Van Wincoop (2006) lies in the nature of private signals, which are not short-lived. In other words, innovations to the fundamental process are not perfectly and publicly observed after a finite number of periods. Short-lived private information allows to derive a finite dimensional state representation, overcoming the infinite regress problem. The solution method proposed by Nimark (2017) and used here enables us to solve our model while relaxing the assumption made by Singleton (1987).

Dispersed Information and Exchange Rate Dynamics Similarly to the presence of strategic behavior in our basic framework, the presence of dispersed information also amplifies the effects of noise shocks on the exchange rate while dampening the effects of fundamental shocks.[23] Information heterogeneity leads to rational confusion, which means that investors always revise their expectations whenever the exchange rate changes, independently of the underlying shock. This confusion arises because investors are uncertain whether the fluc-

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[23]See Appendix C for a formal definition of equilibrium solution in this class of models.

tuations in the exchange rate are driven by noise shocks or fundamental shocks. It follows that, after a negative fundamental shock, investors' expectation do not fully react because part of the response of exchange rates is attributed to the noise component. As a result, the response of exchange rate to a fundamental shock is dampened. Similarly, the response to a positive noise shock is amplified because the upward movements in the exchange rate are mistakenly confused with a negative change in fundamentals. This rational confusion adds further upward pressure on the exchange rate.[24] This indicates that these two dimension of heterogeneity have similar qualitative implications for the dynamics of the exchange rate, albeit through different mechanisms. Strategic behavior reduces the sensitivity of investors' demand for foreign assets, while information heterogeneity leads to rational confusion.

Parametrization We extend the parametrization of the basic framework in Table 1 to account for the presence of dispersed information. We leverage the data on exchange rate expectations from the ECB Professional Forecasters survey to calibrate the volatility of the private signal, σ_η. The survey runs at quarterly frequency since 2002 and contains information on professional forecasters' expectations for the euro-dollar exchange rate at various horizons. Figure 5 in Appendix D reports the distribution of the demeaned, same-quarter exchange rate expectations. It exhibits a significant dispersion, with a standard deviation of approximately 0.02, indicating the presence of information heterogeneity among investors.[25] We estimate the volatility of the exchange rate change and the median dispersion in the same-quarter exchange rate forecasts across quarters using simulated methods of moments. This yields $\sigma_x = 0.024$ and $\sigma_\eta = 0.006$. Table 9 in Appendix D summarizes the parametrization.

Quantitative Analysis We utilize the model that incorporates the two dimensions of heterogeneity to assess which dimension of heterogeneity is potentially relatively more important. We assume that the model embedding both strategic behavior and dispersed information represents the actual data, and decompose the contributions of both elements to the dynamics of the exchange rate. We filter the underlying states and conduct three different counterfactual scenarios: i) a competitive, full-information rational expectation

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[24]As standard in this class of models, the model produces endogenous persistence due to the time it takes for rational confusion to be resolved. This means that average and higher-order expectations gradually converge to the rational expectation benchmark based on full information over time. Figure 11 in Appendix D provides a graphical representation of the impulse-response functions.

[25]Table 7 in Appendix A provides additional measures of the dispersion of exchange rate expectation across horizon and time periods.

Table 4: Disconnect and Volatility Decomposition

Mass Strategic Investors (%)	Extra Disconnect (%)	% Share Strategic Behavior	% Share Dispersed Information	Non linearity
0.00	16.76	0.00	100.00	0.00
20.00	17.18	2.97	96.88	0.15
40.00	18.91	13.74	85.59	0.67
60.00	23.57	34.65	63.79	1.56
80.00	37.67	65.42	32.14	2.44
Mass Strategic Investors (%)	Extra Volatility (%)	% Share Strategic Behavior	% Share Dispersed Information	Non linearity
0.00	5.18	0.00	100.00	0.00
20.00	5.66	8.90	91.00	0.11
40.00	7.62	33.70	65.92	0.39
60.00	12.87	62.81	36.57	0.62
80.00	28.61	85.72	13.74	0.53

Notes: The table reports the contribution of strategic behavior and dispersed information to the exchange rate disconnect (top panel) and the excess volatility (bottom panel) for different value of λ (first column). Exchange rate disconnect is measured using the RMSE of a standard, one-period disconnect pooled regression, Equation (16). Excess volatility is measured using the standard deviation of the exchange rate. The second column reports the extra disconnect and volatility of the full model relative to a benchmark economy that abstract away from both dispersed information and strategic behavior ($\lambda = 0$ and $\sigma_\eta = 0$). The third and fourth columns report the share of the extra disconnect and volatility due to dispersed information and strategic behavior, respectively. The former (latter) is computed comparing RMSE/volatility in the benchmark economy to the RMSE/volatility from an economy without strategic behavior, $\lambda = 0$ and $\sigma_\eta > 0$ (without dispersed information, $\lambda > 0$ and $\sigma_\eta = 0$). The last column reports the discrepancy due to the non-linear interaction between dispersed information and strategic behavior. We exclude the Argentinian Peso from calculation. Appendix A provides additional information on the data. Appendix C provides additional information on the estimation and filtering procedure.

benchmark economy without strategic investors and dispersed information ($\lambda = \sigma_\eta = 0$); ii) an economy where investors have dispersed information but are not strategic ($\lambda = 0$ and $\sigma_\eta > 0$); iii) an economy where investors are strategic and have full-information ($\lambda > 0$ and $\sigma_\eta = 0$). We perform the decomposition for different initial level of strategic behavior ($\lambda \in \{0, 0.2, 0.4, 0.6, 0.8\}$), given the measurement noise in our proxy for strategic behavior.[26] We focus on the exchange rate disconnect, which is measured by the RMSE of the disconnect regression in Equation (16), and the exchange rate excess volatility, which is measured by the volatility of the exchange rate.

Table 4 shows that investors' heterogeneity can have significant impact on exchange rate dynamics, and the relative importance of each dimension of heterogeneity greatly depends on the degree of strategic behavior in the market. Investors' heterogeneity increases exchange

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[26]See Appendix C for additional details on the filtering algorithm.

rate disconnect by 16% to 38% and volatility by 6% to 29%, playing a quantitatively significant role in shaping exchange rate dynamics, as highlighted in previous studies (Evans and Lyons, 2002; Bacchetta and Van Wincoop, 2006, 2010, 2019).[27]

By comparing the competitive rational expectation model to an economy with only one dimension of heterogeneity, we show that the specific contributions of each individual dimension to exchange rate dynamics depends on the degree of strategic behavior. As λ increases, the contribution of strategic behavior rises from 3% to 66% for disconnect and from 9% to 86% for excess volatility. It's worth noting that the marginal effect of λ on the additional disconnect is lower than on additional volatility, suggesting that dispersed information appears to be more relevant in explaining exchange rate disconnect, regardless of the size of strategic investors in the market. Meanwhile, heterogeneity in price impact has a relatively more pronounced effect on excess volatility dynamics. These results highlight the quantitative relevance of both dimensions of investors' heterogeneity and underscore the importance of considering them in the analysis of exchange rate markets.

The final column in Table 4 shows that the response of the exchange rate in a model that incorporates both dispersed information and strategic behavior is not simply the sum of the individual mechanisms. Instead, there is a non-linear interaction between the two. For each value of λ, this non-linear interaction, accounting for approximately 0.1% to 2.5% of the overall effect, demonstrates that the two mechanisms reinforce each other. The idea is that strategic behavior leads to greater price dispersion regardless of the quality of the signal, σ_η. This, in turn, reduces the weight that investors assign to their signals and amplifies the impact of noise shocks while dampening the impact of fundamental shocks.[28]

5   Conclusion

The heterogeneity in price impact and concentration in the foreign exchange rate markets may play an important role in understanding exchange rate dynamics.

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[27]The economic relevance of the contribution of investors' heterogeneity extends beyond the changes in predictive power or in volatility, which may be relatively small in absolute terms. By influencing exchange rate dynamics, investors' heterogeneity has far-reaching implications fir carry trade return, invoicing choices, relative international prices, trade patterns, and other aggregate macro variables (Boz et al., 2020; Itskhoki and Mukhin, 2021; Lustig et al., 2019).

[28]In Figure 10 in Appendix D, we show the simulated price dispersion for different levels of strategic behavior and signal quality. Note that when the quality of the signal is sufficiently low (high σ_η), the volatility of the exchange rate may no longer increase. As the signal quality deteriorates, less importance is given to the fundamental component. This leads to a situation where the exchange rate becomes less informative, resulting in a reduction in the amplification of the noise component (Bacchetta and Van Wincoop, 2006).

In this paper, we explore the implication of strategic behavior within a simple monetary model of exchange rate determination. We show that strategic behavior reduces the informativeness of the exchange rate by amplifying the response to non-fundamental shocks while dampening the response to fundamental shocks. As a result, heterogeneity in price impact helps to explain the weak empirical link between fundamentals and exchange rates, as well as the excess volatility observed in exchange rate movements.

Although our model is stylized to derive fundamental insights and analytic results, we provide empirical evidence supporting the theoretical predictions using a panel of 10 currencies. Furthermore, we extend the theoretical framework by including a competing dimension of investors' heterogeneity, namely information dispersion. We show that strategic behavior has a quantitative impact on influencing exchange rate dynamics similar to a well-established dimension of heterogeneity, information dispersion.

This paper represents a step forward in incorporating microstructure institutions in the analysis of exchange rate dynamics. Our framework is tractable and can be integrated into macro models of exchange rate determination. As shown in previous literature, the introduction of investor heterogeneity qualitatively and quantitatively alters conclusions regarding optimal monetary and exchange rate policies. It also calls for additional efforts in documenting and studying investors' heterogeneity in foreign exchange rate markets.

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Appendix

A   Empirics

A.1   Data

We use three main sources of data:

- We use data on 18 currencies from December 1993 to December 2019. The currencies considered are: Euro, Japanese Yen, Argentinian Peso, Brazilian Real, Canadian Dollar, Swiss Franc, Australian Dollar, Chilean Peso, Indian Rupee, Mexican Peso, British Pound, South African Rand, Russian Ruble, Swedish Krona, Turkish Lira, New Zealand Dollar, Singapore Dollar, Norwegian Krone. The panel is not balanced.

  We obtain data for the spot and one-month forward exchange rates at a daily frequency from Datastream and Thompson Reuters. All exchange rates are defined against the US Dollar. To calculate the one-month interest rate, we took the difference between the logarithm of the one-month forward exchange rate and the logarithm of the spot exchange rate. We then computed monthly averages for the spot exchange rates and the one-month interest rate differentials.

- We use data from the U.S. Commodity Futures Trading Commission (CFTC) on investors' currency positions. The U.S. Commodity Futures Trading Commission (CFTC) data provides detailed information on several aspects within the currency futures market, including net open interest positions held by asset managers, institutional investors, and leveraged funds, as well as measures of concentration and the number of reportable traders. Data is reported on a weekly basis and spans the years 2006 to 2016 for 11 currency pairs. These pairs include both major and non-major USD currency pairs, reflecting the diversity of assets traded within the currency futures market. Major currency pairs typically involve the U.S. dollar and another major global currency, such as the Euro or Japanese Yen, while non-major pairs may involve currencies from emerging markets or smaller economies. Table 5 in Appendix A reports summary statistics on key variables. Figures **??**, 3 and 4 in Appendix A respectively show the net open positions, the concentration ratio, and the number of reportable traders in the future FX market per currency and trader group.

- We use data on exchange rate expectations from the ECB Professional Forecasters survey. The survey runs at quarterly frequency since 2002Q1 until 2020Q4. It provides information on the expectations of professional forecasters regarding the euro-dollar exchange rate at different time horizons, including the current quarter and one to four quarters ahead. The dataset includes exchange rate forecasts from approximately forty professional forecasters.

A.2 Additional Figures and Tables

Table 5: Summary Statistics - Key Variables from CFTC dataset

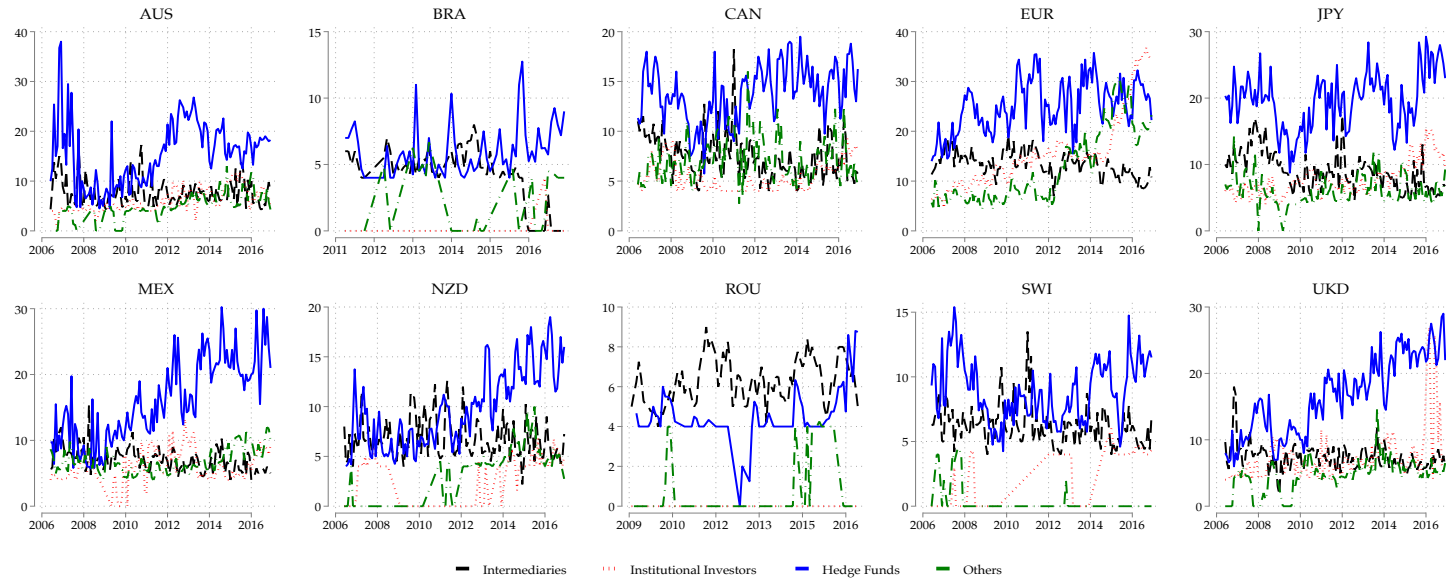|	Currency										
	AUS	BRA	CAN	EUR	JPY	MEX	NZD	ROU	SWI	UKD	Total
Imbalances (Mil USD): Intermediaries	-16.180	-6.440	-12.658	28.322	18.114	-32.066	-6.517	-7.947	5.379	22.880	-0.136
Institutional Investors	-7.799	2.060	2.166	-5.080	11.954	17.415	-1.776	1.024	-0.632	-22.889	-0.544
Hedge Funds	24.303	3.980	-1.949	-26.026	-20.759	15.297	7.938	5.004	-3.839	10.270	1.152
Others	-4.234	0.303	5.850	9.987	2.196	-2.221	-0.283	0.969	0.263	-7.536	0.530
Concentration: Top 4 (Net)	0.433	0.699	0.368	0.295	0.392	0.537	0.553	0.566	0.411	0.396	0.448
Top 8 (Net)	0.564	0.795	0.484	0.399	0.513	0.680	0.704	0.676	0.537	0.523	0.572
Number: Intermediaries	7.788	4.693	7.448	13.411	8.921	7.075	6.764	6.327	6.180	7.272	7.830
Institutional Investors	6.115	0.084	5.428	15.684	7.773	6.200	2.744	0.000	1.974	7.333	6.442
Hedge Funds	15.614	6.129	13.881	25.069	19.697	16.122	9.867	4.883	8.898	16.649	14.738
Others	5.361	2.340	7.266	12.580	6.352	6.866	4.201	0.482	0.199	5.114	5.952

Notes: Report the means of the main variables in the CFTC dataset by currency pair. Net open interest positions are in millions of dollars ($), concentration ratios are expressed in percentages, and the number of traders is in count. The reported mean statistic is calculated based on a panel of weekly observations spanning from 2006 to 2018.

Figure 3: Concentration Ratios by Currency Pairs
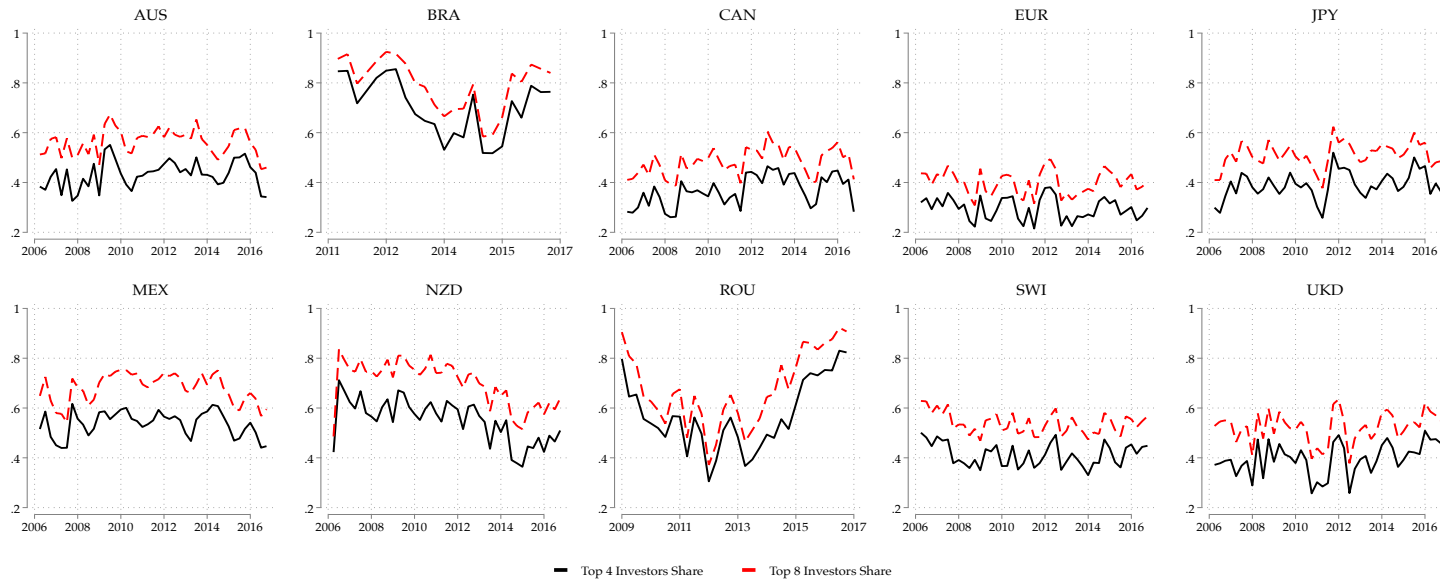
Notes: The figure shows the average percentages of open interest held, referred to as Concentration Ratios, by the largest four (black line) and eight (red line) reportable traders in the future FX market by currency pair. These concentration ratios are based on 'Net Position' and are calculated after offsetting each trader's equal long and short positions. The data is sourced from the U.S. Commodity Futures Trading Commission (CFTC) and spans from 2006 to 2016. Data are quarterly averages for each currency pair. Appendix A provides additional details regarding the data used.

Figure 4: Number of Traders by Currency Pairs

Notes: The figure shows the numbers of reportable traders in the future FX market by currency pair. For each currency pair, we report the number of Dealers (black dashed line), Institutional Investors (red dotted line), Hedge Funds (blue line) and Other Reportable Traders (green dashed line). The data is sourced from the U.S. Commodity Futures Trading Commission (CFTC) and spans from 2006 to 2016. Data are quarterly averages for each currency pair. Appendix A provides additional details regarding the data used.

**Table 6:** Summary Statistics - Exchange Rates

Panel A. Monthly frequency

Variables	Mean	SD	Min	Max	N
Exchange rate return (in %)	0.334	0.548	-0.130	1.910	18
Exchange rate level volatility (StD)	0.344	0.353	0.115	1.367	18
Volatility of exchange rate changes (StD)	0.029	0.012	0.013	0.055	18
Fama coefficient (UIP)	-0.603	1.317	-2.688	2.357	18
R-Squared (Exchange rate disconnect)	0.030	0.065	0.000	0.265	18

Panel B. Weekly frequency

Variables	Mean	SD	Min	Max	N
Exchange rate return (in %)	0.077	0.127	-0.030	0.442	18
Exchange rate level volatility (StD)	0.342	0.350	0.115	1.351	18
Volatility of exchange rate changes (StD)	0.014	0.006	0.006	0.030	18
Fama coefficient (UIP)	-0.493	0.789	-1.479	1.194	18
R-Squared (Exchange rate disconnect)	0.037	0.064	0.000	0.261	18

Notes: The table presents summary statistics for various moments of exchange rates across different currencies. Panel A. reports statistics calculated at a monthly frequency, while Panel B. reports statistics calculated at a weekly frequency. We calculated the moments for each currency individually and then compiled a table to summarize the variation of these moments across currencies. The data cover the period from 1993 to 2019 for 18 currencies as described in Appendix A.

Figure 5: Distribution Exchange Rate Expectations
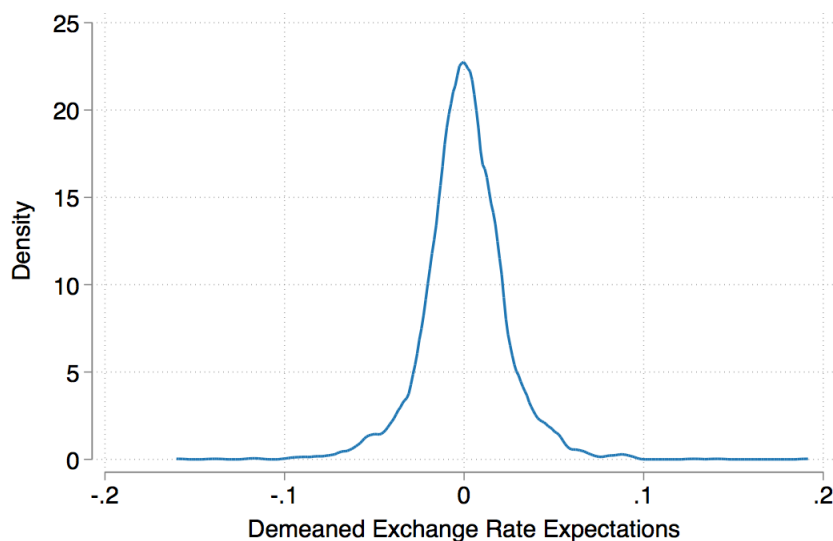
Notes: The figure shows the distribution of the same-quarter EUR/USD exchange rate expectations from the ECB Professional Forecasters survey. Data covers the period from 2002Q1 to 2020Q4 and is collected at a quarterly frequency Expectations are in log and demeaned at the quarterly frequency. Table 7 in Appendix A provides additional measures of the dispersion of exchange rate expectation across horizon and time periods.

Table 7: Summary Statistics - Expectation Dispersion

	Whole Sample	Average across Quarters	Median across Quarters
Same Quarter	0.028	0.024	0.020
Across all Horizons	0.041	0.038	0.035

Notes: The table reports the standard deviation of EUR/USD exchange rate expectations from the ECB Professional Forecasters survey. Data covers the period from 2002Q1 to 2020Q4 and is collected at a quarterly frequency for various horizons ranging from the same quarter to one year ahead. The expectations are expressed in logarithmic form to maintain consistency with the log-linearized model. Expectations are demeaned at the quarterly-horizon level. The first row focuses on same-quarter expectations, while the second row considers all horizons pooled together. The first column reports the dispersion (standard deviation) in exchange rate expectations across the whole sample period. The second and third columns compute the dispersion for each quarter and report the average and median dispersion across all quarters, respectively.

B Derivations

B.1 Derivation Demand Functions - Rational Expectation Case

Each investor j solves the following problem:

$$\max_{b_t^j} \mathbb{E}_t^j(w_{t+1}^j | \Omega_t^j) - \frac{\rho}{2} Var_t^j(w_{t+1}^j | \Omega_t^j)$$

$$\text{s.t. } w_{t+1}^j = (\omega - b_t^j) i_t + (i_t^\star + s_{t+1} - s_t) b_t^j$$

We assume that investors have symmetric rational expectation information sets, so that all j indexes on expectation and variance are dropped. We take the derivative of the objective function w.r.t. b_t^j. If the investor is strategic $(j = S)$, they internalize the effect of their demand on the exchange rate. Thus, the demand schedule is:

$$b_t^{S,i} = \frac{\mathbb{E}_t(s_{t+1}) - s_t + i_t^\star - i_t}{\rho Var_t(s_{t+1}) + \frac{\partial s_t}{\partial b_t^{S,i}}},$$

where the $\frac{\partial s_t}{\partial b_t^j}$ represents the price impact. If the investor is competitive $(j = C)$, the demand schedule follows a standard mean-variance specification:

$$b_t^C = \frac{\mathbb{E}_t(s_{t+1}) - s_t + i_t^\star - i_t}{\rho Var_t(s_{t+1})}.$$

We can now derive an expression for the price impact of a strategic investor. Assume there are N strategic investors, each with positive mass λ_i. Then, the market clearing condition for the foreign bond market is:

$$(1 - \lambda) b_t^C + \sum_i^N \lambda_i b_t^{S,i} + (x_t + \bar{x}) \bar{W} = B(1 + s_t).$$

Substituting the demand schedule and applying the Implicit function theorem, we can write:

$$(1 - \lambda) \frac{\partial b_t^C}{\partial s_t} \frac{\partial s_t}{\partial b_t^{S,i}} + \lambda_i = B \frac{\partial s_t}{\partial b_t^{S,i}}$$

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Thus:

$$\frac{\partial s_t}{\partial b_t^{S,i}} = \frac{\lambda_i}{B - (1-\lambda)\frac{\partial b_t^C}{\partial s_t}} \qquad \text{with } \frac{\partial b_t^C}{\partial s_t} \equiv -\frac{1}{\rho Var_t(s_{t+1})}$$

Therefore:

$$\frac{\partial s_t}{\partial b_t^{S,i}} = \frac{\lambda_i \rho Var_t(s_{t+1})}{B\rho Var_t(s_{t+1}) + (1-\lambda)} \equiv \frac{1}{N}\frac{\lambda\rho\sigma_t^2}{B\rho\sigma_t^2 + (1-\lambda)} > 0$$

where the last equality holds in case of a symmetric oligopoly (i.e. $\lambda_i = \frac{\lambda}{N}\forall i$). The price impact is positive for $\forall(B, \lambda, N, \lambda_i, \rho, \sigma)$.

Lastly, in international portfolio choice models, the value of the supply of foreign assets in domestic currency (indirectly) depends on the value of the exchange rate when foreign assets are denominated in foreign currency. Differently from standard models of strategic trading (Kyle, 1989), strategic investors internalize not only their price effect on the quantity demanded but also on the quantity (value) supplied. Compared to closed economy models or cases in which foreign assets are denominated in domestic currency, the presence of this valuation effect on the supply implies a weakly lower price impact. Let pi^F and pi^D be the price impact on a foreign and a domestic asset, respectively.

$$pi^F \equiv \frac{\partial s_t}{\partial b_t^{S,i}} = \frac{\lambda_i\rho\sigma_t^2}{B\rho\sigma_t^2 + (1-\lambda)} \qquad pi^D \equiv \frac{\partial p_t}{\partial b_t^{S,i}} = \frac{\lambda_i\rho\sigma_t^2}{(1-\lambda)}$$

where p_t is the price of the domestic asset. It is easy to show that $pi^F \leq pi^D$ $\forall(B, \rho, \sigma_t^2, \lambda_i, \lambda)$. The intuition is fairly simple. The increase in the price of a currency (foreign currency appreciates) increases the nominal value of the supply of foreign assets when denominated in domestic currency. The supply shift dampens the initial rise in price, reducing the magnitude of the price impact. The overall effect of tradings on the exchange rate is lower due to the presence of a valuation effect. In other words, the residual net demand faced by strategic investors is more elastic than in a case with no valuation effects. The main implication is that strategic investors still reduce their exposure to foreign assets compared to competitive investors but not as much as in the case there was no valuation effect.

B.2 Effect of Strategic Behavior on Noise and Fundamental Shock

The presence of strategic investors amplifies (dampens) the response of the exchange rate to noise (fundamental) shocks.

Proof. Consider the law motion of the exchange rate in Equation (7). s_t can be rewritten as a forward looking sum of fundamentals and noises as follow:

$$s_t = -\mu \sum_{k=0}^{\infty} \mu^k (\Delta i_{t+k}) + \frac{1-\mu}{b} \sum_{k=0}^{\infty} \mu^k (x_{t+k}),$$

where $\Delta i_{t+k} = i_{t+k} - i^{\star}_{t+k}$. Therefore, the response of the exchange rate to a unit shock in noise and fundamental at impact is:

$$\mathbb{E}(s_{t+j}, j=0) = \begin{cases} \dfrac{\mu}{1-\mu\rho_u}, & \text{for } \varepsilon_u = -1 \\[3mm] \dfrac{(1-\mu)}{(1-\mu\rho_x)b}, & \text{for } \varepsilon_x = 1 \end{cases}$$

Taking the derivative w.r.t. μ, we find:

$$\frac{\partial \mathbb{E}(s_{t+j}, j=0)}{\partial \mu} = \begin{cases} \dfrac{1}{(1-\mu\rho_u)^2} > 0 \\[3mm] -\dfrac{(1-\rho_x)}{(1-\mu\rho_x)^2 b^2} < 0 \end{cases}$$

Since μ is decreasing (increasing) function of λ (N), the response of the exchange rate to a unit shock in fundamental is dampened while noise shock are amplified as λ increases (N decreases). ■

B.3 Excess Return Predictability

Strategic behavior amplifies these UIP deviations compared to a competitive market.

Proof. Define the one-period excess return as $q_{t+1} = s_{t+1} - s_t - (i_t - i^*_t)$. The one-period Fama regression is given by:

$$q_{t+1} = \alpha + \beta(i_t - i^{\star}_t) + \epsilon_t$$

Now, consider the law of motion for the exchange rate, from Equation 7:

$$s_t = \mu \left[E_t \left(s_{t+1} \right) + i_t^\star - i_t \right] + (1 - \mu) \frac{\bar{x}}{b} + (1 - \mu) \frac{1}{b} x_t,$$

where only the first term depends on fundamentals. By manipulating this equation, we can derive the j-period change in the exchange rate as follows:

$$\Delta s_{t+j} = -\mu \sum_{k=0}^{\infty} \mu^k \left(\Delta i_{t+j+k} - \Delta i_{t+k} \right).$$

Using Δs_{t+1}, we can then calculate the Fama coefficient is given by:

$$\beta_1 = \frac{\text{Cov} \left(\Delta s_{t+1} - \Delta i_t; \Delta i_t \right)}{\text{Var}(\Delta i_t)} = \left[\text{Cov} \left(-\mu \sum_{k=0}^{\infty} \mu^k \left(\Delta i_{t+k+1} - \Delta i_{t+k} \right); \Delta i_t \right) - \text{Var} \left(\Delta i_t \right) \right] / \text{Var}(\Delta i_t)$$

$$= \left[-\mu \sum_{k=0}^{\infty} \mu^k \text{Cov} \left(\Delta i_{t+k+1} - \Delta i_{t+k}; \Delta i_t \right) - \text{Var} \left(\Delta i_t \right) \right] / \text{Var}(\Delta i_t)$$

$$= \left[-\mu \sum_{k=0}^{\infty} \mu^k \rho_u^k (\rho_u - 1) \text{Var}(\Delta i_t) - \text{Var}(\Delta i_t) \right] / \text{Var}(\Delta i_t)$$

$$= -(1 - \mu) \frac{1}{1 - \mu \rho_u} < 0,$$

which is negative for each value of μ and increasing (decreasing) in μ (in λ). ∎

Predictability J-Periods Ahead Predictability reversal does not arise in our model, differently from Bacchetta and Van Wincoop (2010) and Engel (2016). Formally define the j-period ahead excess return as $q_{t+j} = s_{t+j+1} - s_{t+j} - (i_{t+j} - i_{t+j}^*)$, and consider the following regression:

$$q_{t+j} = \alpha + \beta_j (i_t - i_t^*) + \epsilon_{t+j}. \tag{19}$$

The coefficient of interest, β_j, is:

$$\beta_j = \frac{\text{Cov}(q_{t+j}, \Delta i_t)}{\text{Var}(\Delta i_t)}$$

$$\frac{1}{\text{Var}(\Delta i_t 9} \left(\text{Cov}(\Delta s_{t+j}, \Delta i_t) - \text{Cov}(\Delta i_{t+j-1}, \Delta i_t) \right)$$

$$\frac{1}{\text{Var}(\Delta i_t)} \left[\text{Cov}\left(-\mu \sum_{k=0}^{\infty} \mu^k \left(\Delta i_{t+k+j} - \Delta i_{t+k+j-1} \right); \Delta i_t \right) - \text{Cov}\left(\Delta i_{t+j-1}, \Delta i_t \right) \right]$$

$$\frac{1}{\text{Var}(\Delta i_t)} \left[\left(-\mu \sum_{k=0}^{\infty} \mu^k \text{Cov}\left(\Delta i_{t+k+j} - \Delta i_{t+k+j-1} \right); \Delta i_t \right) - \text{Cov}\left(\Delta i_{t+j-1}, \Delta i_t \right) \right]$$

$$-\mu \sum_{k=0}^{\infty} \mu^k (\rho_u^{k+j} - \rho_u^{k+j-1}) - \rho_u^{j-1}$$

$$-\mu \rho_u^{j-1} (\rho_u - 1) \frac{1}{1 - \mu \rho_u} - \rho^{j-1} = -\rho^{j-1} \frac{1 - \mu}{1 - \mu \rho_u} \leq 0.$$

Lastly, notice that $\frac{\partial \beta_j}{\partial j} = -(j-1)\rho_u^{j-1} \left(\frac{1-\mu}{1-\mu\rho_u} \right) < 0$. Therefore, for $j \to \infty$, the coefficient $\beta_j \to 0$ monotonically, excluding any reversal.[29]

B.4   Non-Monotonicity of Excess Volatility

The unconditional volatility of the exchange rate is non-monotonic in the presence of strategic investors.

Proof. Consider the law of motion of the exchange rate, Equation 7, and substitute the process for fundamental and noise:

$$s_t = -\mu \sum_{k=0}^{\infty} \sum_{j=0}^{\infty} \mu^k \rho^j \varepsilon_{t+k-j}^u + \frac{1-\mu}{b} \sum_{k=0}^{\infty} \sum_{j=0}^{\infty} \mu^k \rho_x^j \varepsilon_{t+k-j}^x.$$

After some algebra, s_t can be written as summation of its backward and forward components:

$$s_t = -\frac{\mu}{1 - \mu \rho_u} \left[\sum_{k=0}^{\infty} \mu^k \varepsilon_{t+k}^u + \sum_{k=1}^{\infty} \rho_u^k \varepsilon_{t-k}^u \right] + \frac{1-\mu}{b(1 - \mu \rho_u)} \left[\sum_{k=0}^{\infty} \mu^k \varepsilon_{t+k}^x + \sum_{k=1}^{\infty} \rho_x^k \varepsilon_{t-k}^x \right].$$

---

[29]This is not surprising considering the absence of any friction, such as infrequent portfolio adjustment (Bacchetta and Van Wincoop, 2010, 2019).

Thus, the unconditional variance of the exchange rate is:

$$\text{Var}(s) = \frac{\mu^2 \sigma_u^2}{(1 - \mu\rho_u)^2} \left[\frac{1}{1 - \mu^2} + \frac{\rho_u^2}{1 - \rho_u^2} \right] + \frac{(1 - \mu)^2 \sigma_x^2}{(1 - \mu\rho_x)^2 b^2} \left[\frac{1}{1 - \mu^2} + \frac{\rho_x^2}{1 - \rho_x^2} \right],$$

which is a combination of the variances of fundamental and noise shocks. Taking the derivative of $\text{Var}(s)$ w.r.t. μ, we find:

$$\frac{\partial \text{Var}(s)}{\partial \mu} = \frac{\mu \sigma_u^2}{(1 - \mu\rho_u)^3} \left[\frac{1}{1 - \mu^2} + \frac{\rho_u^2}{1 - \rho_u^2} \right] + \frac{\mu^3 \sigma_u^2}{(1 - \mu\rho_u)^2 (1 - \mu^2)^2} - \frac{(1 - \mu)(1 - \rho_x)\sigma_x^2}{(1 - \mu\rho_x)^3 b^2} \left[\frac{1}{1 - \mu^2} + \frac{\rho_x^2}{1 - \rho_x^2} \right] + \frac{\mu(1 - \mu)^2 \sigma_x^2}{(1 - \mu\rho_x)^2 (1 - \mu^2)^2 b^2}.$$

The unconditional volatility of the exchange rate is increasing in λ iff:

$$\frac{(1 + \mu\rho_x)\sigma_x^2}{(1 - \mu\rho_x)^2 (1 + \mu)(1 + \rho_x) b^2} - \frac{\mu \sigma_x^2}{(1 - \mu\rho_x)^2 (1 + \mu)^2 b^2} >$$
$$\frac{\mu \sigma_u^2}{(1 - \mu\rho_u)^2} \frac{(1 + \mu\rho_u)}{(1 - \mu^2)(1 - \rho_u^2)} + \frac{\mu^3 \sigma_u^2}{(1 - \mu\rho_u)^2 (1 - \mu^2)^2},$$

that can be rewritten as follows:

$$\frac{\text{Var}(x)}{\text{Var}(\Delta i)} \frac{1}{b^2} > \left[\frac{(1 + \mu^2\rho_x)(1 - \rho_x)}{\mu(1 + \mu\rho_u)(1 - \mu^2) + \mu^3(1 - \rho_u^2)} \frac{(1 - \mu\rho_u)^2 (1 - \mu)^2}{(1 - \mu\rho_x)^2} \right]^{-1}. \tag{20}$$

$\blacksquare$

Equation (20) suggests that the unconditional variance of the exchange rate increases as λ increases when the variance of the noise shock is sufficiently high compared to the variance of the fundamental process.

The non monotonic case is not relevant given standard parametrizations, including ours. Let define $\underline{\sigma_x}$ as the minimum value of the volatility of the noise process at which the relationship between the level of strategic behavior and exchange rate variance becomes non-monotonic. Figure 6 shows the value of $\underline{\sigma_x}$ for different combinations of N and λ. In our calibration, we find that the volatility of the noise shock should be at least 75% lower in order to break the monotonic relationship between strategic behavior (λ and/or N) and the unconditional variance of the exchange rate. In cases where λ or N take on other values, he minimum value of σ_x is at least 50% lower compared to the value implied by Figure 7 in Appendix D. For instance, in a market with a high level of strategic behavior

Figure 6: $\underline{\sigma_x}$ for different combinations of N and λ.
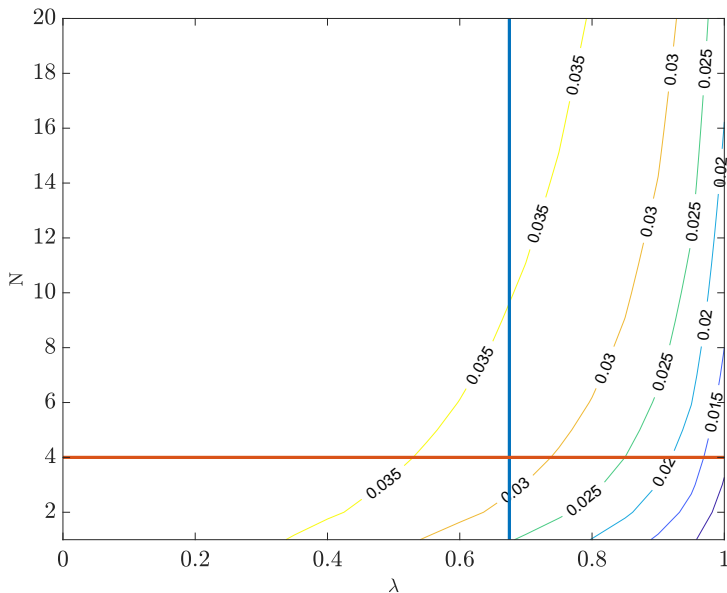
Notes: The figure shows the minimum value of the volatility of the noise process, σ_x, that guarantees that the volatility of the exchange rate is monotonically increasing in the presence of strategic behavior (higher λ and/or lower N). The threshold is computed using Equation (20). We compute the minimum value of σ_x for different levels of λ and N. The horizontal and vertical lines pin down the combination of λ and N used in the parametrization of the basic framework. Remaining parameters are constant, see Table 1.

(λ approximately 1), we find that σ_x is approximately 0.05. However, monotonicity in the relationship between strategic behavior and unconditional variance breaks if σ_x falls below 0.025.

Furthermore, it is important to note that the threshold value mentioned earlier is dependent on the parameters ρ_x, ρ_u and b. The robustness of the monotonic relationship between strategic behavior and unconditional variance is also guaranteed by the conservative nature of our calibration. In standard calibrations, only more persistent noise processes or less persistent fundamental processes would align with the observed data. Similarly, higher values of home bias (lower b) would be consistent with the data. Higher values of ρ_x, lower values of ρ_u and lower b all contribute to reducing the threshold, thereby relaxing the condition for monotonicity.

B.5 Exchange Rate Disconnect

The effect of strategic investors on exchange rate disconnect is ambiguous.

Proof. Define the exchange rate change as $\Delta s_{t+1} = s_{t+1} - s_t$ and the interest rate differential as Δi_t. The exchange rate disconnect can be measured by the R^2 of the following regression:

$$\Delta s_{t+1} = \alpha + \beta \Delta i_t + \varepsilon_t$$

The R^2 is given by:

$$R^2 = \mathrm{Corr}(\Delta s_{t+1}, \Delta i_t)^2 = \frac{\mathrm{Cov}(\Delta s_{t+1}, \Delta i_t)^2}{\mathrm{Var}(\Delta s_{t+1})\,\mathrm{Var}(\Delta i_{t+1})} = \left[\frac{\mathrm{Cov}(\Delta s_{t+1}, \Delta i_t)}{\mathrm{Var}(\Delta i_t)}\right]\left[\frac{\mathrm{Cov}(\Delta s_{t+1}, \Delta i_t)}{\mathrm{Var}(\Delta s_{t+1})}\right].$$

Adding and subtracting $\mathrm{Var}(\Delta i_t)$ in the numerator, we have:

$$R^2 = \left[\frac{\mathrm{Cov}(\Delta s_{t+1} - \Delta i_t, \Delta i_t)}{\mathrm{Var}(\Delta i_t)} + 1\right]\left[\frac{\mathrm{Cov}(\Delta s_{t+1} - \Delta i_t, \Delta i_t) + \mathrm{Var}(\Delta i_t)}{\mathrm{Var}(\Delta s_{t+1})}\right],$$

$$= \left[\frac{\mathrm{Cov}(\Delta s_{t+1} - \Delta i_t, \Delta i_t)}{\mathrm{Var}(\Delta i_t)} + 1\right]\frac{\mathrm{Var}(\Delta i_t)}{\mathrm{Var}(\Delta s_{t+1})}\left[\frac{\mathrm{Cov}(\Delta s_{t+1} - \Delta i_t, \Delta i_t)}{\mathrm{Var}(\Delta i_t)} + 1\right].$$

Since the covariance term is the Fama coefficient β^{Fama}, it follows that:

$$R^2 = \frac{\mathrm{Var}(\Delta i_t)}{\mathrm{Var}(\Delta s_{t+1})}\left[1 + \beta^{Fama}\right]^2.$$

∎

C Model of Dispersed Information

C.1 Equilibrium

We extend the definition of equilibrium of the basic framework discussed in Section 2 to incorporate the presence of dispersed information. In the extended framework, an equilibrium path is defined as a sequence of quantities $\{b_t(j)\}$ and foreign currency (asset) price $\{s_t\}$ that satisfy the following conditions: given an history of shocks $\{\varepsilon_t^x\}_{t=0}^{-\infty}$ and signals about fundamentals $\{f_t(j)\}_{t=0}^{-\infty}$, investors optimally choose their portfolios, and the market clearing condition is upheld.

The effect of strategic behavior on the exchange rate, as well as its mechanism, extends to the model with dispersed information as in the basic framework. Combining the market clearing condition with investors' demand schedules, we can derive the following expression for the exchange rate:

$$s_t = (1 - \mu)\left(\frac{\bar{x}}{b} - 1\right) + \mu\left(\int \mathbb{E}\left[s_{t+1} \mid \Omega_t(j)\right] dj\right) - \mu\left(i_t - i_t^\star\right) + (1 - \mu)\frac{1}{b}x_t, \qquad (21)$$

where μ and Φ are defined as in the basic framework, with the former decreasing in the presence of strategic investors (decreasing in λ and increasing in N).

In the presence of dispersed information, a closed-form solution for the exchange rate is not available since it depends on higher-order expectations regarding the fundamental:

$$s_t = \mu \sum_{k=0}^{\infty} \mu^k \left[i_{t+k} - i_{t+k}^\star\right]_t^{(k)} + \frac{1 - \mu}{b}x_t, \qquad (22)$$

where $\left[i_{t+k} - i_{t+k}^\star\right]_t^{(k)}$ denotes the average expectation in period t of the average expectation in period t+1, and so on, of the average expectation in period t+k-1 of k period ahead fundamentals, that is, $\left[i_{t+k} - i_{t+k}^\star\right]_t^{(k)} = \underbrace{\int \mathbb{E}_t \ldots \left[\int \mathbb{E}_{t+k-1}\left(i_{t+k} - i_{t+k}^\star\right) dj\right] \ldots dj}_{k}$ for any integer

k > 0. In the case of dispersed information, the informativeness parameter μ represents the weight assigned to higher-order expectations regarding future fundamentals in influencing exchange rate dynamics.

To account for higher order expectations, we assume that agents have rational expectations about how other agents form their own expectations, and that this information is

common knowledge. Using this assumption, we compute the dynamics of the exchange rate while accounting for expectations of arbitrarily high orders. Denoting the hierarchy of expectations about fundamentals with $\Delta i_t^{(0:k)}$, which is the vector of average expectations on Δi_t of any order from zero to k, we show below that the exchange rate s_t can be expressed as:[30]

$$s_t = v_0 \Delta i_t^{(0:k)} + \frac{1-\mu}{b} x_t \tag{23}$$

where v_0 is a vector of k weights associated to higher order expectations. In contrast to the baseline model, an aggregate shock in this model affects the exchange rate not only directly, but also through higher order expectations $\Delta i_t^{(1:k)}$.

C.2   Solution Method

We solve the model with higher order expectations using the recursive solution algorithm in Nimark (2017). We approximate the equilibrium of the model to an arbitrary precision with finite number of higher order expectations $\bar{k} < \infty$.

We recursively computes the exchange rate process and the law of motion of the expectations hierarchy for arbitrarily high orders of expectations following these steps:

Step 1. Define the zero order process ($k = 0$) for the exchange rate s_t as a function of the current fundamentals $\Delta i_t^{(0)}$:

$$
\begin{aligned}
s_t &= G_k \Delta i_t^{(0)} + R_1 \mathbf{w_t} \\
\Delta i_t^{(0)} &= M_k \Delta i_{t-1}^{(0)} + N_k \mathbf{w_t}
\end{aligned}
$$

where $\mathbf{w_t}$ is the vector of aggregate shocks, including both fundamental and noise shocks; R_1 and N_k represent the variance matrices associated with the zero-order state space representation; the matrix $G_k \equiv G_0 = -\mu$, and $M_k \equiv M_0 = \rho$ are stored separately in the zero-iteration period.

Because investors learn from the exchange rate s_t, the measurement equation for investor

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[30]There exist other approaches that rely on the fact that average first-order expectations about the endogenous variables can be computed given the guessed laws of motion of the endogenous variables by using the assumption of rational expectations. We find the approach in Nimark (2017) more reliable and fast to implement.

j at time t includes a noisy signal about Δi_t as well as s_t:

$$\mathbf{s_{j,t}} = D_0 \Delta i_t^{(0:k)} + R_1 \mathbf{w_t} + R_2 w_{j,t} \quad w_{j,t} \sim N(0, I)$$

where $D_0 = [1, G_0]'$ and $w_{j,t}$ is the idiosyncratic noise shock.

Step 2. Using the measurement equation and the law of motion of hierarchy, compute the Kalman gain K_k for the kth step, as well as the matrices M_{k+1} and N_{k+1}:

$$M_{k+1} = \begin{bmatrix} M_0 & \mathbf{0}_{q \times kq} \\ \mathbf{0}_{kq \times q} & \mathbf{0}_{kq \times kq} \end{bmatrix} + \begin{bmatrix} \mathbf{0}_{q \times kq} & \mathbf{0}_{q \times q} \\ K_k D_k M_k & \mathbf{0}_{kq \times q} \end{bmatrix} + \begin{bmatrix} \mathbf{0}_{q \times q} & \mathbf{0}_{q \times kq} \\ \mathbf{0}_{kq \times q} & (I - K_k D_k) M_k \end{bmatrix}$$

$$N_{k+1} = \begin{bmatrix} N_0 \\ (K_k D_k N_k + K_k R_1) \end{bmatrix}.$$

to get the kth step law of motion

$$\Delta i_t^{(0:k)} = M_{k+1} \Delta i_{t-1}^{(0:k)} + N_{k+1} \mathbf{w_t}, \quad \mathbf{w_t} \sim N(0, I)$$

where the matrix D_k is defined as:

$$D_k = \begin{bmatrix} 1 & \mathbf{0}_{q \times kq} \\ & G_k \end{bmatrix}$$

Step 3. The k-order process for the exchange rate s_t^{k+1} is:

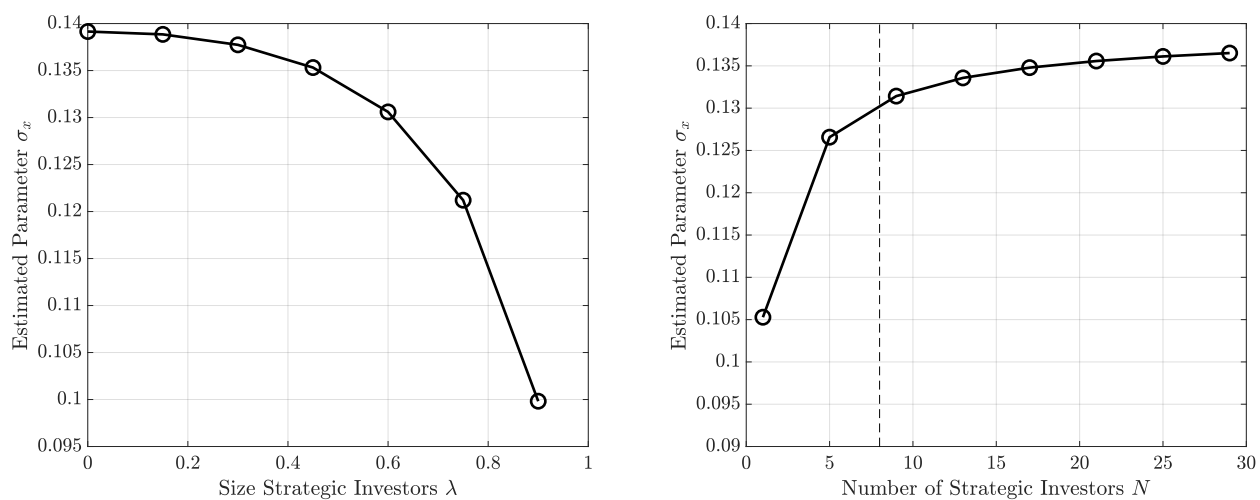$$s_t^{k+1} = G_{k+1} \Delta i_t^{(0:k+1)} + R_1 w_t$$

where

$$G_{k+1} = G_0 + \mu G_k M_k H_{k+1} \quad \text{and} \quad H_k \equiv \begin{bmatrix} \mathbf{0}_{(kq) \times q} & I_{kq} \end{bmatrix}$$

Step 4. Repeat Steps $2 - 3$ for $k = 1, 2, ..., \bar{k}$ where the number of iterations $\bar{k}$ can be chosen to achieve any desired degree of accuracy.

D   Additional Tables and Figures

D.1   Strategic Behavior and Noise Volatility

Figure 7: Relationship between Strategic Behavior and Noise Volatility

Notes: The figure shows the volatility of the noise component, σ_x, required to match the target volatility of the exchange rate change in the basic framework, for different levels of strategic behavior. The left panel considers different levels of strategic behavior in terms of λ for a number of strategic investors equal to $N = 4$. The left panel considers different levels of strategic behavior in terms of N for a total size of strategic investors equal to $\lambda = 0.675$. All other parameters are constant and summarized in Table 1.

## D.2   Impulse Response to a Noise and Fundamental Shock

Figure 8: Impulse Response to Exogenous Shocks
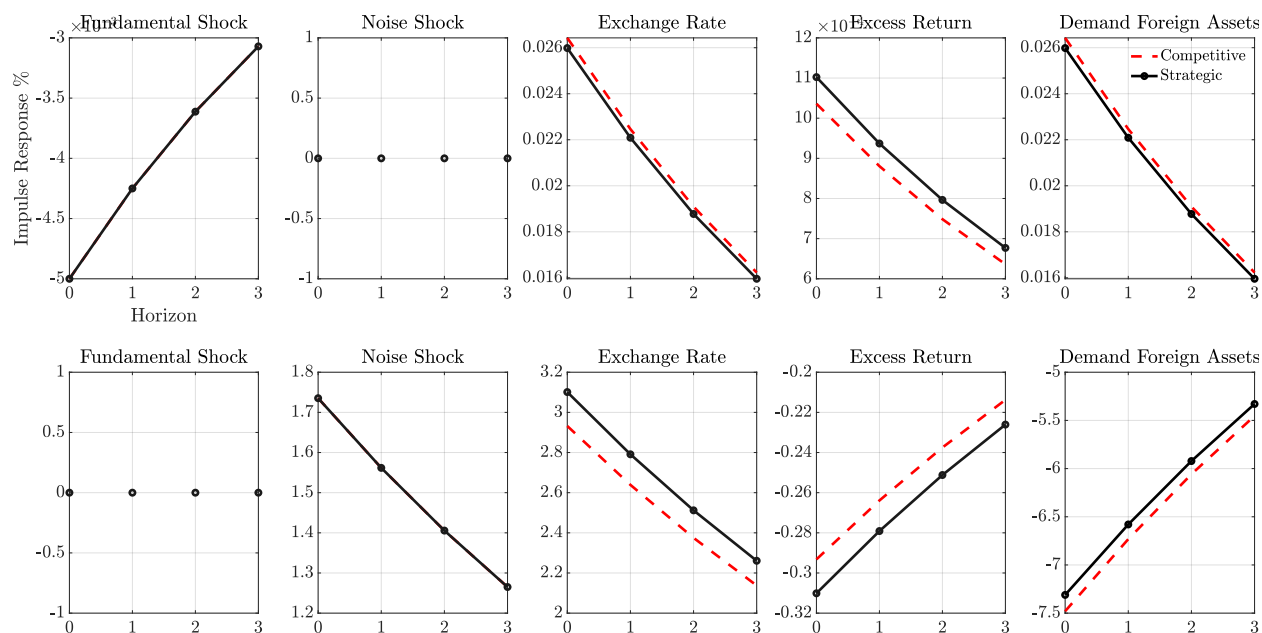
Notes: The top panel (bottom) shows the response to a two-standard deviation shock in fundamental and noise. The first and second columns show the dynamics of the exogenous shocks in fundamentals and noise, respectively. The third column shows the dynamics of the exchange rate. Column four shows the response of the realized excess return, defined as $q_{t+1} = s_{t+1} - s_t + i_t^\star - i_t$. The last column shows the response of the total demand of foreign assets, defined as $(1 - \lambda)b_t^C + \sum_i^N \lambda_i b_t^{S,i}$, where b_t^C and $b_t^{S,i}$ are defined according to Equation 4. The solid black line shows the response in the benchmark parametrization with strategic investors, $\lambda = 0.6$. The red dashed line shows the response in a competitive economy without strategic investors, $\lambda = 0$. Remaining parameters are common across scenarios, see Table 1.

D.3 Potential Impact of Strategic Investors

Figure 9: Exchange Rate Disconnect and Excess Volatility
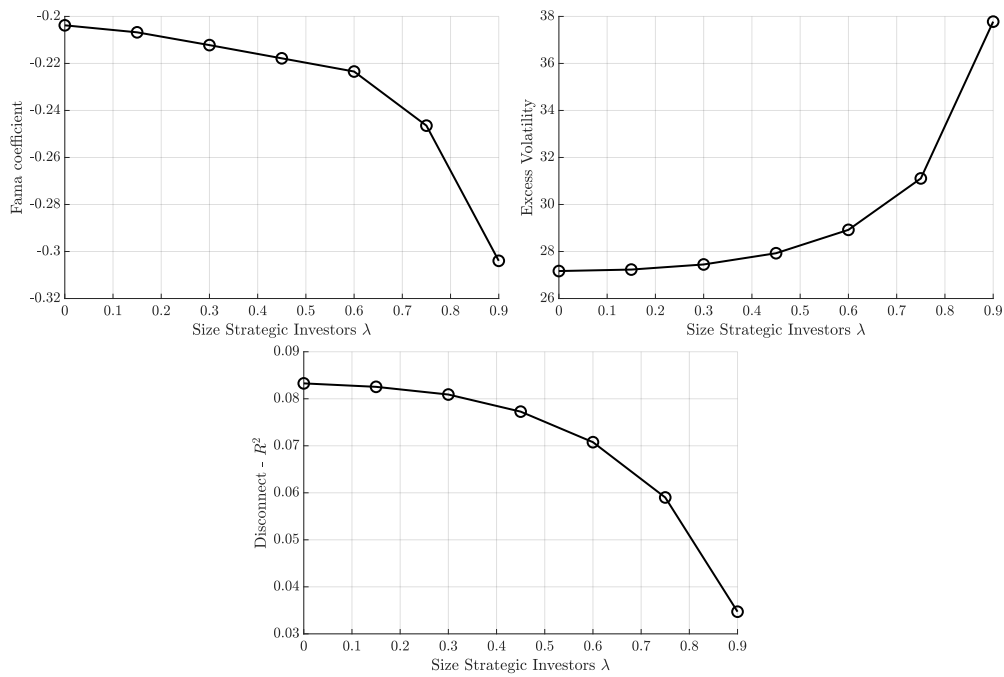
Notes: The figure shows the excess predictability coefficient from regression in Equation 11 (top left), the excess volatility ratio (top right), and the estimated R^2 of the disconnect regression in Equation 16 (bottom) using simulated data. We run 5000 simulations and, for each iteration, the model runs for 8000 periods with 3000 burn-in. Data are simulated for different levels of strategic behavior λ. Remaining parameters are common across scenarios, see Table 1.

D.4 Cross-Currency Model Predictions

Table 8: Testing Model Predictions

	(1) Fama Coefficient	(2) Excess Volatility	(3) Disconnect - R2
λ	-43.759***	180.925***	-0.248***
	(8.288)	(69.343)	(0.068)
Constant	29.304***	53.229	0.232***
	(4.684)	(38.980)	(0.038)
Currency & Year FEs	Yes	Yes	Yes
Observations	900	900	900

Notes: The table reports the relationship between λ and the variables of interest. λ represents the net concentration ratio by the top eight reporting traders operating in the future FX market. Variable of interest are: Fama coefficient (Column (1))), exchange rate excess volatility (Columns (2)); exchange rate disconnect/R^2 (Column (3)). The exchange rate disconnect is measured using the Adjusted R^2 from the regression in Equation (16), while excess volatility is calculated as the ratio of exchange rate volatility from Equation (14) to the volatility of the interest rate differential. λ is measured monthly from 2006 to 2016 using the U.S. CFTC data. To measure excess volatility and disconnect, we use a two-year periods rolling window and exchange rate data at monthly level. Values of the excess volatility ratio and disconnect are winsorized at 1%. All regressions include currency and year fixed effects. Standard errors in parenthesis are clustered at the currency level. Significance level:* p<0.10, ** p<0.05, *** p<0.01. Currencies considered are: Euro, Japanese Yen, Brazilian Real, Canadian Dollar, Swiss Franc, Australian Dollar, Mexican Peso, British Pound, Russian Ruble, and New Zeland Dollar. Appendix A provides additional information on the data used.

D.5 Parametrization Quantitative Model

Table 9: Parametrization Quantitative Model

	Value	Moment - Target	Data	Model
λ	0.675	Share transactions 1st quintile – NYFXC		
N	4	Number of investors 1st quintile – NYFXC		
ρ_u	0.85	Average persistence AR(1) Δi_t		
σ_u	0.005	Average StD innovation AR(1) Δi_t		
σ_t	0.028	Average StD ER change		
σ_η	0.006	Same Quarter Expectation Dispersion	0.02	0.01
σ_x	0.022	σ_t (Volatility ER change)	0.028	0.029
ρ_x	0.9	ER RW/Average Disconnect		
ρ	50	Average UIP level		
b	0.33	Home Bias		
$\bar{k}$	10			

Notes: The table summarizes the parametrization used in Section 4. For each parameters, we report the value used in the model, the corresponding moment and data used to calibrate, and, if applicable, the target moment used to estimate it. Appendix A provides additional information on the data used.

Figure 10: Exchange Rate Expectation - Dispersion
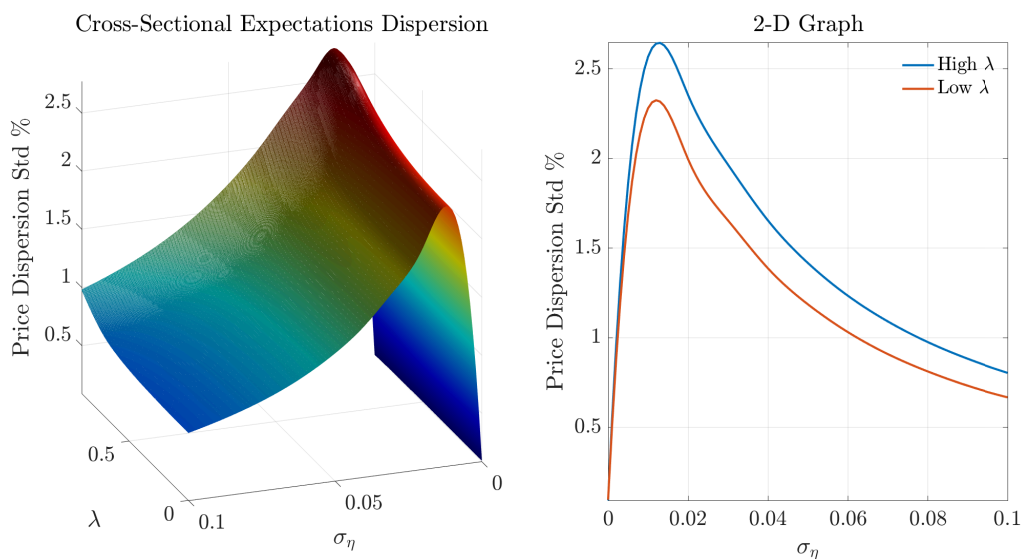
Notes: The figure shows the dispersion (standard deviation) across investors in the one-period exchange rate expectations for different level of strategic behavior (λ) and precision of the signal on fundamentals (σ_η) implied by the model in Section 4. The left panel shows the dispersion in expectations for values of $\lambda \in [0, 1]$, and $\sigma_\eta \in [0, 0.1]$. The right panel shows the dispersion in expectation for two levels of strategic behavior ("Low" with $\lambda = 0$, and "High" with $\lambda = 0.6$) and a precision of the signal σ_η between 0 and 0.1. The figure is generated for a representative calibration with $\sigma_u = 0.01$ and $\rho_x = 0$. All remaining parameters are reported in Table 9 in Appendix D.

D.6 Impulse Response under High Order Expectations (HOE)

Figure 11: Impulse Response to Exogenous Shocks
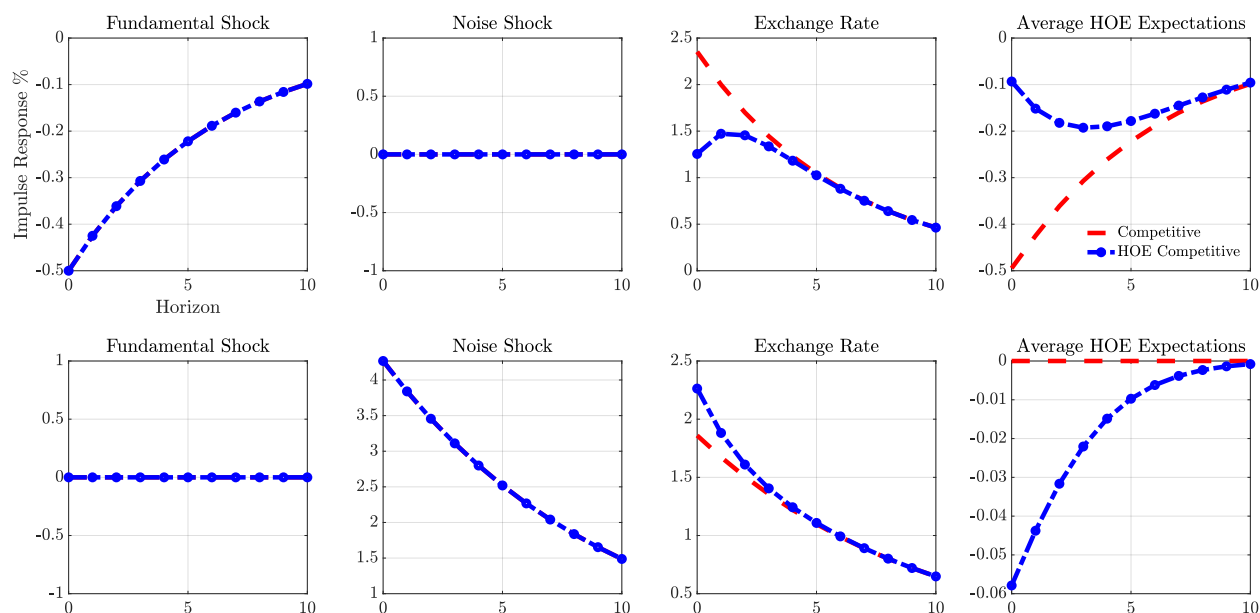
Notes: The top panel (bottom) shows the response to a fundamental (noise) shock. The first (second) column show the dynamics of a one standard deviation shock in fundamental (noise). The third column shows the dynamics of the exchange rate. The fourth column shows the response of the average first order ($k = 1$) expectation of future exchange rate defined in Equation (22). The blue dashed-dot line shows the response in an economy with dispersed information $\sigma_\eta > 0$. The red dashed line shows the response in an economy without dispersed information, $\sigma_\eta = 0$. In both scenario, markets are fully competitive ($\lambda = 0$). Remaining parameters are common across scenarios, see Table 9 in Appendix D.