Hedging demand and foreign exchange risk premia

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Abstract

This paper develops and tests a model of unobservable risk premia in the foreign exchange market. Risk premia in our model arise from non-marketable income shocks that risk-averse agents hedge by trading foreign currency. We construct a proxy for currency hedging demand and find that it explains approximately 45% of the variation in currency returns at the monthly horizon. We find that hedging demand appears to Granger cause speculative flows. We also show that hedgers exhibit negative feedback behaviour. Our results show that correlation between order flow and currency returns is consistent with risk-sharing among market participants.

1. Introduction

Exchange rate economics has long struggled to reconcile the empirical behaviour of currency fluctuations with rational theories of exchange rate dynamics. Numerous studies (see Meese and Rogoff (1983) and Flood and Rose (1995)) have demonstrated the failure of models based on macroeconomic fundamentals to explain a significant proportion of the variation in exchange rates at horizons of one year or less.[2] Recent research applying tools from the market microstructure literature has been more successful in explaining currency dynamics in terms of order flows between various types of agents; see Lyons (2001) for a recent survey of the literature. The current interpretation of the results from the FX microstructure literature is somewhat counterintuitive. Many researchers take the observed correlation between order flow and currency returns as evidence that some traders have private information. The existence of asymmetric information in the currency market runs counter to the general perception that currency markets are among the most informationally efficient markets in existence.[3]

The key to reconciling the existence of asymmetric information with the perceived informational efficiency of the foreign exchange market lies in identifying the nature of the informational asymmetry. If certain traders have private information about the distribution of endowment shocks or changing risk appetites across the economy, then the market serves as a mechanism for distributing information to aid in the optimal allocation of risk across all agents as described by Hayek (1945). If, however, some traders have information regarding future statistical releases or central bank policy changes, the market is still serving as a mechanism to disseminate information, but the liquidity of the market may be quite low as other traders would be hesitant to trade against a better informed counterparty. A better understanding of the information structure in currency markets would give us a clearer picture of the role of speculators in the market: are they a stabilising influence as posited by Friedman or the scourge of financial markets as described by some leaders of emerging market countries?

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[2] There is evidence that standard macroeconomic models have significant explanatory power over longer horizons; see Flood and Taylor (1996).

[3] A recent BIS study estimates daily turnover in the spot foreign exchange market at USD 1.5 trillion. Also, past studies have shown that the over-the-counter currency markets trade billions of dollars with a bid-ask spread in the neighbourhood of a few hundredths of a cent.

This paper demonstrates that the observed relationships between trading variables and currency returns are completely consistent with a market where the only motive for trade is risk-sharing. We develop and test a simple model of the foreign exchange risk premium where non-marketable cash flows generate hedging demands from risk-averse agents. We derive equilibrium hedging demands and risk premia in an economy with two types of risk-averse agents: hedgers who face non-marketable risks, and liquidity providers who stand ready to share risk with the hedgers for the right price. Our empirical tests of the model make use of the fact that hedging demands are proportional to the foreign exchange risk premium. Using data from the currency futures markets, we construct a proxy for hedging demand in currency futures and test for the existence of unobservable systematic risk factors in five major currencies. The market for currency futures is a natural setting in which to test the implications of our model. First, the zero entry cost for futures, standardised contract specifications and relatively low transaction cost make these markets very liquid, attracting a wide variety of traders. Second, the open outcry nature of the futures pits adds a measure of transparency that serves to discourage informed speculators from entering these markets, allowing us to more accurately measure hedging flows. Lastly, the small size of the currency futures market relative to the entire over-the-counter market diminishes the likelihood of price pressure in the futures market affecting the aggregate market for spot foreign exchange.[4]

Our results affirm the interpretation of hedging demand as a proxy for risk premia. We find that, on average, hedging demand explains 45% of the variation in currency returns. To examine what might be driving this result, we consider the forecasting power of hedging demand over future realisations of bilateral trade balances and find that hedging demand has significant forecasting power over these flows for the Canadian dollar and Japanese yen. We then compare the performance of hedgers versus non-hedgers in the futures market. We find, intuitively, that hedgers tend to lose money to non-hedgers. These losses can be interpreted as compensation to speculators for insuring the hedgers. Along these lines, we also test causal relationships between hedging and speculative flows and find, consistent with the theory, that changes in hedging demand Granger cause changes in speculative demands in four of the five currencies at the weekly level. We also test to see if the observed effects could be due to some type of positive feedback trading on the part of hedgers, and find that hedgers actually tend to be negative feedback traders. Lastly, to see if these results are directly related to the findings of Evans and Lyons (2002), we compare hedging demands to data on customer order flow from a major international bank. We find that futures market hedging demand is not related to the aggregate order imbalance in customer order flow.

There is a vast literature which tries to explain the short-run variability of exchange rates. Previous studies of the foreign exchange risk premium[5] have examined the conditional variance of exchange rates as a proxy for risk premia (Domowitz and Hakkio (1985)), considered consumption-based CAPM models (Mark and Wu (1998)) and examined the possibility of "peso problem" effects (Evans (1996)).[6] The difficulty in identifying a risk premium in currency returns is analogous to the "equity premium" puzzle in the asset pricing literature. Observed fundamentals do not appear volatile enough to justify the volatility of floating exchange rates. Other attempts to identify the risk premium have used survey data on exchange rate forecasts of market participants to control for expectational errors (Frankel and Froot (1989)) and statistical models to identify time-varying risk premia (Baillie and Bollerslev (1994)). Some non-risk-related explanations of the forward discount bias include irrationality (Froot and Thaler (1990)), regime shifts driven by policy changes (Engel and Hamilton (1990)) and learning (Roberts (1995)).

This study is similar in spirit to recent research on the microstructure of the foreign exchange market and the literature on futures risk premia. Evans and Lyons (2002) show that signed order flow in the inter-dealer market possesses significant explanatory power for exchange rate returns, but their model is agnostic as to whether the results are driven by private information about future returns or

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4 The aggregate notional amount of outstanding positions in the currency futures market is USD 103 billion compared with USD 1.5 trillion in average daily volume for the spot foreign exchange market. Though spot-futures arbitrage may confound some results, even these flows should be minuscule relative to the entire market.

5 The literature on exchange rate risk premia is vast; see Engel (1996) for a recent survey.

6 The term "peso problem" refers to the possibility of agents attaching a small probability to some extreme event that has not yet been observed in the data. The term comes from the experience of the Mexican peso in the 1970s when agents appeared to expect a huge devaluation despite the fact that such an event had never been observed.

risk-sharing motives. This study extends this literature in two ways. First, the data set used here spans 15 years at a monthly frequency, providing a much more expansive study than any previous research using trading activity in the currency market. Second, by focusing on hedging demand, we are able to more clearly identify the link between currency returns, some macro fundamentals and time-varying risk premia. Research on futures risk premia is also closely related to this study. Bessembinder (1992) and de Roon et al (2000), testing a theory of futures pricing developed in Hirshleifer (1990), find that hedging pressure risk is priced in the futures market. We extend their results to show that the effects they observed appear to affect the broad market for foreign exchange.

This research has policy implications in the debate on the transaction taxes in the currency market; see Eichengreen et al (1995). The case for transaction taxes rests on the assumption that irrational traders can destabilise currencies by engaging in positive feedback strategies or herding together to drive exchange rates away from their fundamental values. Our results indicate that, at least for the major currency markets, the imposition of a transaction tax could have significant welfare implications for firms trying to hedge their exposures to currency risk.

This paper is organised as follows. Section 2 develops the model relating hedging demand and risk premia. Section 3 describes the data used in this paper, while Section 4 outlines our estimation procedures and discusses the results. Section 5 concludes.

2. The model

In this section, we develop a model that relates expected returns on foreign exchange to observable variables, namely interest rate differentials and hedging demand. Our model is unique in that it bridges the gap between traditional asset pricing and microstructure models by using trading variables as proxies for risk premia derived in a standard risk-sharing environment. This feature is important in that previous work has interpreted the strong contemporaneous correlation between order flow and currency returns as evidence of the existence of private information in the foreign exchange market. Our model shows that the observed correlations are consistent with risk-sharing in a symmetric information environment. The model developed in Wang (1994) is similar in some respects to our model in that he also links the microstructure variables to expected returns by exploring the behaviour of trading volume in dynamic rational expectations economies.

The theoretical setting we consider is a simple economy populated by two types of risk-averse agents with utility functions that exhibit constant absolute risk aversion (CARA): hedgers and speculators. Agents can invest in either domestic or foreign risk-free bonds that yield r_{t-1}^D and r_{t-1}^F from period t - 1 to t, respectively. In order to purchase foreign bonds, agents must purchase foreign currency; P_t is the amount of domestic currency that can be exchanged for one unit of foreign currency. Hedgers are unique in that they also receive a non-tradable flow of stochastic income that yields r_t^N and is correlated with exchange rate returns. To close the model, we assume that all agents have symmetric information and that all assets are in zero net supply.[7]

Let W_t^h be the wealth of the hedger at time t

$$W_t^h = \left(1 + r_{t-1}^F\right)\left(1 + r_t^p\right)\lambda_t^h W_{t-1}^h + \left(1 + r_{t-1}^D\right)\left(1 - \lambda_t^h - \overline{\beta}\right)W_{t-1}^h + \left(1 + r_t^N\right)\overline{\beta}\, W_{t-1}^h \tag{1}$$

where λ_t^h is the hedger's portfolio holding of foreign assets chosen at time t - 1 and held through time t, $\overline{\beta}$ is the fixed proportion of wealth that the non-tradable income stream comprises, and r_t^p is the foreign currency return. In other words, if r_t^p is positive, then the foreign currency has appreciated relative to the domestic currency. Note that the domestic return on foreign bonds, $\left(1 + r_{t-1}^F\right)\left(1 + r_t^p\right)$, is

[7] The assumption that all assets are in zero net supply is purely for mathematical convenience; all of the results are essentially unchanged if there is a positive net supply of foreign and domestic bonds.

approximately equal to $1+r_{t-1}^{F}+r_{t}^{p}$.[8] Using this approximation, we can write down the wealth of the hedger as

$$W_t^h = W_{t-1}^h + \left(r_{t-1}^F + r_t^p\right)\lambda_t^h W_{t-1}^h + r_{t-1}^D\left(1-\lambda_t^h-\overline{\beta}\right)W_{t-1}^h + \left(r_t^N\right)\overline{\beta}\,W_{t-1}^h \quad (2)$$

Similarly, the wealth of the speculator at time t is W_t^s where

$$W_t^s = W_{t-1}^s + \left(r_{t-1}^F + r_t^p\right)\lambda_t^s W_{t-1}^s + r_{t-1}^D\left(1-\lambda_t^h\right)W_{t-1}^s \quad (3)$$

There are only two sources of uncertainty in this economy: exchange rate risk and the stochastic non-tradable income. We assume that both random variables are conditionally normally distributed:

$$r_t^p = E_{t-1}\left[r_t^p\right] + \varepsilon_t, \qquad \varepsilon_t \sim N\left(0,\sigma_\varepsilon^2\right)$$

$$r_t^N = \theta + \eta_t, \qquad \eta_t \sim N\left(0,\sigma_\eta^2\right)$$

$$E_{t-1}\left[\varepsilon_t\eta_t\right] \equiv \sigma_{t-1}^{\varepsilon\eta} \neq 0$$

where θ is a fixed scalar. For simplicity, we assume that both the hedger and speculator have CARA preferences and maximise utility over wealth next period. In this setting, agents effectively maximise the one-period return on wealth, r_t^{Wh} and r_t^{Ws}, for the hedger and speculator, respectively. Their preferences imply that their choices will only depend on the mean and variance of return on wealth.

$$E_{t-1}\left[r_t^{Wh}\right] = \left[\lambda_t^h\left(r_{t-1}^F + E_{t-1}\left[r_t^p\right]\right) + \left(1-\lambda_t^h\right)r_{t-1}^D + \theta\overline{\beta}\right] \quad (4)$$

$$Var_{t-1}\left[r_t^{Wh}\right] = \left(\lambda_t^h\right)^2\sigma_\varepsilon^2 + \overline{\beta}^2\sigma_\eta^2 + 2\lambda_t^h\overline{\beta}\sigma_{t-1}^{\varepsilon\eta} \quad (5)$$

The expressions for the mean and variance of the speculator are very similar and omitted for the sake of clarity. Thus, the hedger's investment problem is equivalent to

$$\max_{\lambda_t^h} E_{t-1}\left[r_t^{Wh}\right] - \frac{1}{2}\rho^h Var_{t-1}\left[r_t^{Wh}\right] \quad (6)$$

where ρ^h is the hedger's coefficient of constant absolute risk aversion. Taking the first-order conditions for (6) and solving for the hedging demand yields

$$\lambda_t^h = \frac{\left(r_{t-1}^F - r_{t-1}^D\right) + E_{t-1}\left[r_t^p\right] - \rho^h\overline{\beta}\sigma_{t-1}^{\varepsilon\eta}}{\rho^h\sigma_\varepsilon^2} \quad (7)$$

Similarly, the speculative demand is

$$\lambda_t^s = \frac{\left(r_{t-1}^F - r_{t-1}^D\right) + E_{t-1}\left[r_t^p\right]}{\rho^s\sigma_\varepsilon^2} \quad (8)$$

Since the bonds are in zero net supply, combining (6) and (7) and imposing market clearing, ie $\lambda_t^h + \lambda_t^s = 0$, yields

$$E_{t-1}\left[r_t^p\right] = \left(r_{t-1}^D - r_{t-1}^F\right) + \frac{\rho^h\rho^s}{\rho^h+\rho^s}\overline{\beta}\sigma_{t-1}^{\varepsilon\eta} \quad (9)$$

Equation (9) shows that the foreign exchange risk premium is driven by the covariance of the non-tradable income shocks and exchange rate returns. Unfortunately, these income shocks are unobservable to the econometrician. To find an observable proxy for the risk premium, we can substitute (9) into (7), which yields

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8 $\left(1+r_{t-1}^F\right)\left(1+r_t^p\right) = 1 + r_{t-1}^F + r_t^p + r_{t-1}^F r_t^p \approx 1 + r_{t-1}^F + r_t^p$. Note that, at the monthly level, bond and currency returns are likely to be less than 1% per month, implying that the term $r_{t-1}^F r_t^p$ will generally be less than 0.01%.

$$\lambda_t^h = -\frac{\rho^h}{(\rho^h + \rho^s)\sigma_\varepsilon^2}\overline{\beta}\sigma_{t-1}^{\varepsilon\eta} \quad (10)$$

Rearranging (10) and substituting back into (9) yields

$$E_{t-1}\left[r_t^p\right] = \left(r_{t-1}^D - r_{t-1}^F\right) - \left(\sigma_\varepsilon^2 \rho^s\right)\lambda_t^h \quad (11)$$

Equation (11) is now completely in terms of observables and can be estimated with the data.

The model developed above is very much in the spirit of the consumption-based CAPM developed by Rubinstein (1976) and Breeden (1979). Demand for foreign exchange is driven by the desire of hedgers to purchase assets that hedge their stochastic income stream; as their income becomes more correlated with currency returns, they demand less. Though we have assumed a single source of income uncertainty, multiple sources of uncertainty would increase or decrease hedging demands depending on their covariances. The model is also related to portfolio balance models of exchange rate determination described in Branson and Henderson (1985). In that class of models, currency risk premia arise from the imperfect substitutability of foreign and domestic bonds. In our model, foreign and domestic bonds are not perfect substitutes because the non-tradable income stream received by hedgers is correlated with currency fluctuations, making foreign bonds effective hedging instruments.

Though we do not explicitly model the random income shock, one can think of it as a domestic firm's income from a foreign subsidiary that repatriates profits quarterly or as receipts to a firm that exports goods overseas. Our non-marketable income stream is consistent with Obstfeld and Rogoff (2000) in that nominal price rigidities, pricing to market, and trading costs could induce non-tradable income shocks that cause firms to hedge in the futures market. From an asset pricing point of view, the non-marketability of the uncertain income stream violates the necessary conditions for a representative agent representation for this economy and forces us to identify an observable proxy for the risk premium.

3. The data

We use monthly observations on the aggregate positions of commercial traders in the currency futures markets to construct our hedging demand proxy; these data are collected and distributed by the Commodity Futures Trading Commission (CFTC). Our data set includes five currency futures contracts, the Canadian dollar (CAD), Swiss franc (CHF), Deutsche mark (DEM), pound sterling (GBP) and Japanese yen (JPY) over the period from January 1986 to December 2000.[9]

In each market, the CFTC classifies large traders as either commercial or non-commercial, where a trader is typically classified as a commercial trader if she is "engaged in business activities hedged by the use of the futures or option markets".[10] We follow Bessembinder (1992) and de Roon et al (2000) and treat commercial traders as hedgers and non-commercial traders as liquidity providers. These positions are reported to the public on a weekly basis in the Commitment of Traders Report; the reported positions typically account for 70-80% of the open interest in any given contract; summary statistics for each contract are reported in Table 1; note that these statistics are for the period January to December 2000.[11]

We form our measure of hedging demand in each currency as

$$h_t = \frac{\textit{number of long hedge contracts} - \textit{number of short hedge contracts}}{\textit{total number of hedge contracts}} \quad (12)$$

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9 We only study the Deutsche mark up to the introduction of the euro in January 1999.

10 From the Commitment of Traders Report Backgrounder, CFTC, October 2000, available at http://www.cftc.gov/opa/backgrounder/opacot596.htm.

11 The percentages reported for bank participation are for December 2000 only, but are fairly representative of average participation.

This definition was used in de Roon et al (2000) and is simply the *relative* net position of hedgers in the market. This is a natural measure of hedging activity because it captures the net portfolio weight the average hedger has in each currency. Summary statistics on the statistical properties of h_t are also reported in Table 1.

Figures 1 and 2 plot the historical path of the spot Japanese yen exchange rate and the hedging demand, h_t, for the yen, respectively. An alternative measure of hedging demand used in Bessembinder (1992) is the *absolute* net position of hedgers, or

$$h_t^a = \text{number of long hedge contracts} - \text{number of short hedge contracts}$$

We also construct speculative demand proxies analogously. We construct a relative net speculative demand series, x_t, and an absolute net speculative demand series, x_t^a

$$x_t = \frac{\text{number of long non-commercial contracts} - \text{number of short non-commercial contracts}}{\text{total number of non-commercial contracts}}$$

$$x_t^a = \text{number of long non-commercial contract} - \text{number of short non-commercial contracts}$$

We use the absolute net demand measures in Section 4.3 when we examine the causal relationship between hedging and speculative activity.

Identifying the major players in the currency futures markets is quite difficult. Using a similar data set, Kodres and Pritsker (1995) find that commercial banks, broker-dealers and hedge funds typically account for approximately 35% of the open interest in currency futures markets. Their study, however, did not include non-financial corporations. Anecdotal evidence suggests that the currency futures markets probably mirror activity in the interbank market. Major corporations typically do not transact in the futures market because they face very low transaction costs in spot and forward markets. Major currency dealers occasionally use futures markets to lay off inventory risk with hedge funds, commodity trading advisors (CTAs) or other “local” traders. Since commercial banks are classified as commercial traders by CFTC guidelines, it is likely that the dynamics in hedging activity are driven by changes in positioning by interbank dealers.

To compare the behaviour of trading currency futures to the spot market in foreign exchange, we also utilise a database of customer-dealer trades done by a major international bank.[12] This database contains over 800,000 transactions in all spot currency markets over the period from January 1998 to March 2000. While we have some data at the transaction level (ie customer locale, transaction size and rate), transactions are not time-stamped. We aggregate these trades to make them comparable to our futures data set. Anecdotal evidence suggests that the bank’s customer base was fairly diverse and included a significant proportion of hedge fund customers along with more traditional corporate customers.

We use spot exchange rate data released by the Federal Reserve Bank of New York. These rates are collected daily at 12 pm Eastern Standard Time. Our forward rate data consist of 30-day forward rates obtained from Datastream. In calculating our currency returns and expected depreciation, we restate all spot and forward exchange rates in terms of US dollars per unit of foreign currency to remain consistent with our modelling framework. Our data on bilateral trade flows come from the US Census Bureau.[13]

4. Estimation and empirical results

In this section, we test the model developed in Section 2 and perform some robustness checks against plausible alternative explanations for the results. The first set of results directly test (11) in Section 2. The next subsection explores the relation between hedging demand and future goods trade. The

[12] Estimates of this bank’s market share in the spot FX market range around 10%.

[13] Data on bilateral trade flows are available from the Census Bureau’s website at http://www.census.gov/foreign-trade/www/.

following subsections test the robustness of the results to two plausible alternatives: the private information hypothesis and the positive feedback trading hypothesis. This section concludes by comparing hedging demand and customer order flow to see if our results are generic to any type of order flow.

4.1 Hedging demand and exchange rate dynamics

Table 2 documents the results of standard uncovered interest parity (UIP) regressions on the five currencies we study, where p_t is the natural logarithm of the spot exchange rate quoted in terms of US dollars per unit of foreign currency at time t and f_t is the 30-day forward rate as of time t. The estimates in Tables 2 and 3 were calculated taking all five currencies as a system of equations using a generalised least squares (GLS) framework. GLS provides uniformly better estimates than OLS equation by equation in cases where the residuals are correlated across equations, as is likely to be the case here because all of the exchange rates we study are US dollar-based. The results in Table 2 mirror the findings of previous studies. The forward discount has extremely poor explanatory power over future changes in spot rates. The well documented forward discount bias is evident in the coefficients for the Swiss franc and the Japanese yen, ie that the β for these currencies is negative. These results are troubling because all but one of the coefficients are significantly less than one.

Table 3 reports the results of the regression which implements (11).[14] First, note how the coefficients on the forward discount term for the yen and franc have become more positive while the coefficient in the pound equation has basically remained unchanged. The β coefficients for the Canadian dollar and Deutsche mark have both become more negative, but these results may be confounded by current account flows in the case of the Canadian dollar and euro convergence trading for the Deutsche mark. Second, the coefficients on the hedging demand term are negative and significantly different from zero for all currencies; the sign of the coefficients is consistent with the theory. The sign of the coefficient indicates that when hedgers buy yen forward, for instance, the yen tends to depreciate relative to the US dollar, ie hedgers tend to lose money. Third, Table 3 also reports the implied price impact of trading 10,000 contracts for each market. Interestingly, the price impact of 10,000 contracts (roughly USD 1 billion for all contracts) is similar in magnitude to the price impact estimated in Evans and Lyons (2001). Finally, the adjusted R^2 for all of the equations has increased dramatically.

The impact of adding a hedging demand variable to the UIP regression is very similar to the effect observed in Evans and Lyons (2002), where they use signed inter-dealer order flow instead of hedging demand. An important difference between our results and the previous microstructure literature lies in the time period and horizon studied. By working at the monthly horizon over a 15-year sample, our results conclusively show that the effects we observe are economically meaningful and persistent. Another key difference between their work and this research is that we explicitly attribute the relationship between order flow and returns to a hedging motive. In the portfolio shifts model developed by Evans and Lyons (2002), the initial customer order flow which drives trading for the rest of the day is exogenous; it can be driven by either private information or hedging. Thus, their model cannot distinguish between informed speculation and risk-sharing as the driver of the relationship between order flow and exchange rate dynamics.

4.2 Hedging demand and the balance of payments

Table 2 documents the strong contemporaneous correlation between hedging demand and currency returns. These results beg the question, “What are these traders hedging?”. In this subsection, we study goods trade as a possible motivation for hedging activity. More specifically, we examine the forecasting power of hedging demand in the currency futures market over future realisations of bilateral trade balances.

Trade in goods and services is an intuitive place to begin the search for the non-tradable income streams discussed in Section 2. International trade induces currency exposures for firms because of

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[14] Though (11) relates currency returns to interest rate differentials and risk premia, the regression equation estimated is still equivalent to (11) by the covered interest parity condition, $f_t - p_{t-1} = r^F_{t-1} - r^D_{t-1}$.

the long lags between the time when a transaction is completed and the time when payment is physically made.[15] Firms uncomfortable with the uncertainty involved in receiving a fixed payment in foreign currency can easily hedge the transaction using either futures or forward contracts.

If firms actively use currency futures to hedge international transactions in goods and services, then one would expect currency hedging demand to have forecasting power over bilateral trade balances. The intuition here is that once a transaction is initiated, firms extending standard credit terms can expect payment within one to three months. If firms begin to hedge once they become aware of the currency exposure, then hedging demands should lead actual trade balance flows by one to three months. To explore this hypothesis, we test the in-sample forecasting power of currency hedging demand on bilateral trade balances. We do this by estimating autoregressive moving average with exogenous regressor (ARMAX) models for each currency pair in our study. Using the Box-Jenkins methodology, we estimate ARMAX(1,1,1) models of the form

$$\frac{tb_t - tb_{t-1}}{tb_{t-1}} = \alpha + \rho tb_{t-1} + \beta h_{t-1} + \varepsilon_t + \theta\varepsilon_{t-1} \qquad (13)$$

where ε_t is a white noise process and tb_t is the bilateral trade balance at time t with the United States taken as the home country. We report the results in Table 4.

The results are mixed, with the only significant results coming from the trade balances with Canada and Japan, the United States' first and third largest trading partners, respectively. The coefficient on the hedging demand term is of the correct sign in that purchases of Canadian dollars forward tend to lead increases in the trade balance. The coefficient on hedging demand for the Japanese trade balance does not have the expected sign. The lack of significance in the Swiss and UK regressions is not too surprising because of the relatively small bilateral trade between those countries and the United States.[16] The mixed results for both the Canadian and Japanese trading balances could be due to the use of natural or economic hedges by firms. Given the large volumes of trade between the United States and Canada and Japan, many firms may choose to locate their operations in foreign countries[17] to denominate their cost and revenue streams in a common currency to reduce their net exposure to currency fluctuations.

The weak relationship between hedging demand and trade flows is consistent with the types of agents that typically trade in currency futures. As described in Section 2, hedgers in the currency futures markets comprise large commercial banks and medium-sized corporations. Trading activity from banks is likely to reflect conditions in the interbank market while the corporate players in the futures markets probably account for a small portion of the total volume of bilateral goods trade.

4.3 Speculators: informed "insiders" or insurance providers

The previous subsection showed that hedging demand in currency futures markets does not appear to be driven by income shocks related to goods trade. While this result is not totally surprising given the relative magnitudes of trading volume in currencies versus the amount of bilateral trade between countries, it may imply that motives other than risk-sharing may be driving the results in Table 3.

An alternative hypothesis that is consistent with the results in Tables 3 and 4 is that hedgers are in fact noise traders who trade against much better informed speculators. Under this hypothesis, hedging demand should not be related to trade flows since hedgers trade in a random fashion and hedgers should, on average, lose money to informed speculators, leading to the negative coefficients on γ in Table 3. To explore the validity of this hypothesis, we regress exchange rate returns on speculative

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15 Currency exposures induced by trade are generally referred to as transaction exposures in the international corporate finance literature.

16 In 2000, the volume of trade between the United States and Switzerland was roughly USD 20 billion as compared to USD 80 billion traded between the United Kingdom and the United States or the USD 400 billion of trade between Canada and the United States.

17 Examples of these natural hedges include the construction of semiconductor fabrication plants in Ireland and Germany by Intel and AMD, both US firms, and the large manufacturing capacity that Japanese car manufacturer Toyota Motor Corporation has developed in North America, producing almost 20% of its output there.

and hedging demands to check that speculative demand is positively related to currency returns; these results are reported in Table 5.

These results indicate that when speculators buy a given currency, that currency appears to appreciate relative to the US dollar. This behaviour would be consistent with a Kyle (1985) setting where speculators have private information about future returns. The nature of trading in the futures pits implies that the speculators' gains come at the expense of the hedgers. The hypothesis that these results are due to an informational advantage held by speculators is somewhat suspect. First, the magnitude and stability of these returns imply that speculators have extremely good information about future returns. Second, the sustained losses by hedgers over the sample period seem too great to justify their continued existence.

The risk-sharing environment developed in Section 2, however, also predicts the observed relationship between speculators and hedgers. The intuition here is that hedgers "pay" speculators a premium for bearing risks that they do not wish to hold. Thus, under this interpretation one can view the losses of the hedgers as an insurance premium. The key difference between the information and risk-sharing scenarios is the causality between hedging and speculative demands. In the Kyle setting, speculators enter the market and induce hedgers to take the other side of their trades, while, in the risk-sharing model, hedgers are the initiators of trade.

To differentiate between these competing models, we run Granger causality tests to identify the causal relationship between innovations in hedging and speculative flows at the weekly level; the results are reported in Table 6.[18] The results are quite striking: in all currencies except the Canadian dollar, innovations in hedging demand Granger cause changes in speculative demand; even for the Canadian dollar, the results point towards hedging demand Granger causing speculative demand, but the results are not significant. Though Granger causality is at best a rough measure of causality, the results are fairly clear in that none of the tests indicates reverse causality. The consistency of the Granger causality tests lends strong support to the risk-sharing interpretation of the results. The findings make intuitive sense in that it is hard to believe that speculators could sustain an informational advantage over such a long period *while at the same time* hedgers continued to accumulate losses.

4.4 Hedging and feedback trading

The previous subsection showed that hedgers appear to be driving the trading dynamics in the futures market, lending support to the theory developed in Section 2. Another alternative model that could be driving the results is that hedgers are simply irrational feedback traders. The literature has typically focused on positive feedback, or momentum, trading as an irrational trading strategy. Many authors have shown the fragility of financial markets when positive feedback traders are present. Here, we study the nature of trading by hedgers that are following some type of positive feedback strategy.

Table 7 documents the relationship between hedging demand and lagged currency returns. These results suggest that hedgers tend to act as negative feedback traders, ie hedgers tend to purchase a currency after it has depreciated. Negative feedback trading is much more difficult to justify using behavioural arguments, as it requires traders to buy after prices go down. This finding, coupled with the results from Table 8, sheds interesting new light on previous studies that documented positive feedback trading in futures markets; see Kodres (1994).

Our results suggest that destabilising speculation of the sort described in de Long et al (1990) is unlikely. In their model, rational speculators may bid up the price of a security, inducing noise traders who use positive feedback strategies to enter the market, subsequently selling out at a higher price. While some subset of traders classified as speculators may indeed fit the description of a positive feedback noise trader, the presence of hedgers who are on average negative feedback traders should drastically reduce the net susceptibility of the market to rational destabilisation.

[18] The results presented use two weekly lags; to measure changes in demand, we simply use the absolute net change in position for each class of trader. The results are essentially unchanged when one includes lags from one to four weeks.

4.5 Futures hedging and customer-dealer order flow

Recent research on the microstructure of the foreign exchange market indicates that aggregate foreign exchange order flow is significantly related to currency returns; see Rime (2000). In this subsection, we test to see how futures hedging demands are related to a data set containing customer-dealer order flow.

Table 8 documents the relationship between customer order flow normalised by USD 100 million, Δx_t^c, and currency returns at the weekly level. Note that we do not test the Deutsche mark here because it effectively stopped trading half way through our sample. The almost complete lack of explanatory power is surprising given prior research that has generally associated order flow with returns quite strongly. The large market share and diverse customer base of the bank we study go some way to explaining these results. Given that foreign exchange dealers are extremely reluctant to hold positions overnight, net daily customer order flow in the aggregate should fluctuate randomly around zero.

This set of results indicates that the effects we observe in previous tables are not due to a generic order flow effect. These results also have important implications for future research. It appears that researchers would be well served to study specific components of customer order flow to identify structural relationships in the market. Intuitively, the potential for informational gains from disaggregating order flows is similar to the benefits from studying cointegrating relationships versus simply differencing a non-stationary time series.

5. Conclusion

This paper developed a model of unobservable risk premia in a stylised foreign exchange market based on the need of some agents to hedge non-marketable income flows. Using data on hedging demand in the currency futures market, we tested the implications of the model and found broad support for it. We tested our results against the specific alternative that the observed results were due to information-based trading rather than risk-sharing. Consistent with our theory, we found that hedgers tended to lose money at the expense of speculators and changes in hedging demands Granger cause changes in speculative demand. We also ruled out the possibility that the influence of hedgers is driven by some type of naive positive feedback strategies. Lastly, we compared the explanatory power of futures hedging demand over currency returns to that of customer-dealer order flow from a major international bank. We found that our customer order flow data had little or no explanatory power over exchange rate returns over weekly horizons.

The consistency of the empirical findings with our theoretical predictions suggests that risk premia are present and identifiable in the foreign exchange market. Equivalently, the results suggest that -sharing can explain a significant proportion of the variation in exchange rates. Our findings intuitively show that the foreign exchange market is an efficient mechanism for allocating risk across the economy. The type of information which is privately held appears to be information related to risk premia and not future payoffs. This finding is consistent with previous evidence of asymmetric information in currency markets as well as the enormous depth and liquidity of the major currency markets. Traders are more willing to transact because they are less likely to be trading against someone with superior information.

While our theoretical model is straightforward, the result that hedging demand is closely related to risk premia is quite general. Unfortunately, this generality precludes a straightforward explanation of what drives the risk premium, but provides a fruitful area for future research. The composition of the large players in the futures markets and the lack of a relationship between hedging demand and trade balances suggest that the effects we observe reflect conditions in the interbank market. In future research, we plan to explore the process whereby risk-sharing among dealers and other speculative traders can drive short-term currency dynamics while macroeconomic forces enforce long-term cycles in exchange rates.

Our results also have practical implications. First, the observation that futures hedging demand is priced in the aggregate foreign exchange market implies that currency trading provides risk reduction benefits to a non-trivial group of agents. This suggests that the imposition of transaction costs to reduce speculation, at least in developed markets, could have significant welfare costs. Second, the lack of explanatory power of our aggregate customer order flow data set suggests that future research should focus on components of order flow which have an economic relation to variables of interest.

Tables

Table 1 shows some summary information on the specification of the currency futures contracts used in this study. The average daily volume and bank participation statistics reported below were calculated using data from January to December 2000 as this was the longest span over which these data were publicly available.

The next table provides summary statistics for our hedging demand proxy, h_t, by currency. ACF(i) corresponds to the *i*th term of the series' autocorrelation function and PACF(1) refers to the value of the first term of the series' partial autocorrelation function.

Table 1

Summary statistics for currency futures contracts

Currency futures contract specifications and summary information

	Canadian dollar	**Swiss franc**	**Deutsche mark**	**Pound sterling**	**Japanese yen**
Contract size	CAD 100,000	CHF 125,000	DEM 125,000	GBP 62,500	JPY 12.5 m
Delivery months	3, 6, 9, 12	3, 6, 9, 12	3, 6, 9, 12	3, 6, 9, 12	3, 6, 9, 12
Avg open interest	42,248	45,412	79,109	39,849	74,736
Avg daily volume	9,672	12,862	649	8,054	15,736
Bank participation	29.7%	40.4%	NR	16.0%	32.7%

Statistical properties of hedging demand proxy, h_t, by currency

	Canadian dollar	**Swiss franc**	**Deutsche mark**	**Pound sterling**	**Japanese yen**
Mean	– 0.14	0.06	0.01	– 0.01	0.09
Std deviation	0.41	0.45	0.31	0.43	0.39
Median	– 0.15	0.10	0.02	0.02	0.12
Minimum	– 1.00	– 0.84	– 0.65	– 0.89	– 0.92
Maximum	0.73	0.88	0.82	0.90	0.72
ACF(1)	0.56	0.44	0.45	0.34	0.56
ACF(2)	0.33	0.16	0.25	0.10	0.33
PACF(2)	0.02	– 0.04	0.07	– 0.01	0.02

Table 2 shows the relationship between currency returns and the expected returns in the currency forward market, commonly referred to as the uncovered interest parity relation. The statistics below are from the regression

$$p_t - p_{t-1} = \alpha + \beta(f_{t-1} - p_{t-1}) + \varepsilon_t$$

where p_t is the natural logarithm of the US dollar price of one unit of foreign currency at time t and f_t is the natural logarithm of the one-month forward price in US dollars of one unit of foreign currency. We use monthly data from January 1986 to December 2000 and estimate the system of equations together using generalised least squares (GLS). Standard errors are reported in parenthesis.

Table 2

Uncovered interest parity without hedging demand

Currency	**α**	**β**	**Adj R^2**	**D-W**
Canadian dollar	– 0.0003 (0.0010)	0.1167 (0.4274)	0.00	2.10
Swiss franc	0.0003 (0.0025)	– 0.5746 (0.4482)	0.01	1.77
Deutsche mark	– 0.0004 (0.0024)	– 0.0020 (0.3646)	0.01	1.91
Pound sterling	– 0.0002 (0.0023)	0.5602 (0.5287)	0.00	1.81
Japanese yen	0.0031 (0.0032)	– 0.5013 (0.6577)	0.00	1.76

Table 3 shows the impact of adding the hedging demand proxy, h_t, to the regression of currency returns on the expected return in the currency forward market. Formally, we run the regression

$$p_t - p_{t-1} = \alpha + \beta(f_{t-1} - p_{t-1}) + \gamma h_t + \varepsilon_t$$

where p_t is the natural logarithm of the US dollar price of one unit of foreign currency at time t, f_t is the natural logarithm of the one-month forward price in US dollars of one unit of foreign currency at time t, and h_t is the relative net hedging demand proxy for that currency. We use monthly data from January 1986 to December 2000 and estimate the system of equations together using generalised least squares (GLS). Standard errors are reported in parenthesis.

Table 3

Uncovered interest parity with hedging demand

Currency	**α**	**β**	**γ**	**Price impact for 10,000 contracts**	**Adj R^2**	**D-W**
Canadian dollar	– 0.0032 (0.0009)	0.0482 (0.3328)	– 0.0208 (0.0019)	– 34 bp	0.39	2.33
Swiss franc	0.0045 (0.0019)	– 0.1414 (0.3583)	– 0.0406 (0.0028)	– 54 bp	0.47	2.02
Deutsche mark	0.0035 (0.0018)	– 0.2215 (0.2934)	– 0.0537 (0.0046)	– 32 bp	0.47	2.17
Pound sterling	0.0008 (0.5718)	0.5718 (0.4085)	– 0.0389 (0.0029)	– 44 bp	0.48	1.98
Japanese yen	0.0070 (0.0025)	0.3273 (0.5356)	– 0.0533 (0.0045)	– 34 bp	0.38	1.88

Table 4 shows the effectiveness of the hedging demand proxy, h_t, in forecasting the bilateral trade balance between the United States and each country in our study. The results below are from the ARMAX(1,1,1) model

$$\frac{tb_t - tb_{t-1}}{tb_{t-1}} = \alpha + \rho tb_{t-1} + \beta h_{t-1} + \varepsilon_t + \theta\varepsilon_{t-1}$$

where tb_t is the bilateral trade balance between the United States and the foreign country reported in US dollars. The model is fitted on monthly data from January 1986 to December 2000. Standard errors are reported in parenthesis.

Table 4

Bilateral trade balances and hedging demand

Currency	**α**	**ρ**	**β**	**θ**	**Adj R^2**	**D-W**
Canadian dollar	0.1079 (0.0195)	0.6401 (0.1561)	0.1727 (0.0801)	– 0.8216 (0.1183)	0.04	2.09
Swiss franc	– 2.7528 (2.2908)	0.7900 (1.2612)	3.8625 (4.5578)	– 0.7783 (1.2916)	– 0.02	2.02
Deutsche mark	– 0.1113 (0.2104)	– 0.2740 (1.6258)	– 0.5116 (0.6763)	0.3143 (1.6049)	– 0.01	2.01
Pound sterling	– 1.1399 (1.5193)	– 0.5394 (1.2986)	– 3.3372 (3.5313)	0.5316 (1.3310)	– 0.01	1.97
Japanese yen	0.0205 (0.0042)	0.1204 (0.1229)	– 0.0327 (0.0154)	– 0.7236 (0.0852)	0.26	1.97

Table 5 shows the relationship between currency returns and relative net hedging and speculative demands, $h_{i,t}$ and $x_{i,t}$, respectively. The table contains the results from the following regressions:

$$p_t - p_{t-1} = \alpha_h + \gamma_h h_t + \varepsilon_t$$

$$p_t - p_{t-1} = \alpha_s + \gamma_s x_t + \varepsilon_t$$

where $p_{i,t}$ is the natural logarithm of the US dollar price of one unit of foreign currency i at time t. Note that a positive γ_s coefficient implies that as speculators increase their net positions in the currency futures contract, the currency *appreciates* versus the US dollar. The regressions are run on monthly data from January 1986 to December 2000. Standard errors are reported in parenthesis.

Table 5

Profitability of hedgers versus speculators

Currency	**α_h**	**α_s**	**γ_h**	**γ_s**
Canadian dollar	– 0.0033 (0.0008)	– 0.0020 (0.0008)	– 0.0210 (0.0019)	0.0134 (0.0014)
Swiss franc	0.0052 (0.0019)	0.0061 (0.0021)	– 0.0578 (0.0042)	0.0371 (0.0034)
Deutsche mark	0.0035 (0.0018)	0.0047 (0.0020)	– 0.0872 (0.0062)	0.0500 (0.0043)
Pound sterling	0.0005 (0.0017)	0.0001 (0.0018)	– 0.0503 (0.0034)	0.0286 (0.0026)
Japanese yen	0.0082 (0.0021)	0.0100 (0.0023)	– 0.0575 (0.0055)	0.0372 (0.0039)

Table 6 outlines the results of Granger causality tests on the relationship between the absolute net hedging and speculative demand measures, h_t^a and x_t^a, respectively. The test is done on weekly data from 13 October 1992 to 26 December 2000 using two weekly lags. The test consists of running the bivariate regressions

$$h_t^a = \alpha_1 + \beta_1 h_{t-1}^a + \beta_2 h_{t-2}^a + \gamma_1 x_{t-1}^a + \gamma_2 x_{t-2}^a + \varepsilon_t$$

$$x_t^a = \alpha_2 + \theta_1 x_{t-1}^a + \theta_2 x_{t-2}^a + \lambda_1 h_{t-1}^a + \lambda_2 h_{t-2}^a + \eta_t$$

The hypothesis that "h_t^a does not Granger cause x_t^a" corresponds to a test of the hypothesis $\lambda_1 = \lambda_2 = 0$. If we cannot reject the hypothesis that x_t^a does not Granger cause h_t^a but do reject the hypothesis that h_t^a does not Granger cause x_t^a in the second regression, then we say that Granger causality runs one way from hedging demand to speculative demand.

Table 6

Granger causality test of weekly hedging versus speculative flows

Currency	Hypothesis	F-statistic	p-value
Canadian dollar	h_t^a does not Granger cause x_t^a	1.879	0.154
	x_t^a does not Granger cause h_t^a	0.641	0.527
Swiss franc	h_t^a does not Granger cause x_t^a	8.070	0.000
	x_t^a does not Granger cause h_t^a	2.526	0.081
Deutsche mark	h_t^a does not Granger cause x_t^a	4.480	0.012
	x_t^a does not Granger cause h_t^a	1.954	0.144
Pound sterling	h_t^a does not Granger cause x_t^a	3.088	0.047
	x_t^a does not Granger cause h_t^a	2.028	0.133
Japanese yen	h_t^a does not Granger cause x_t^a	5.927	0.003
	x_t^a does not Granger cause h_t^a	0.676	0.509

Table 7 shows the dependence of the hedging demand proxy, h_t, on past currency returns. Specifically, the results below are from the regression

$$h_t = \alpha + \beta(p_{t-1} - p_{t-2}) + \varepsilon_t$$

using monthly data from January 1986 to December 2000. p_t is the US dollar price of a unit of foreign currency at time *t*. Standard errors are reported in parenthesis.

Table 7

Hedging demand and past currency returns

Currency	α	β	Adj R^2	D-W
Canadian dollar	– 0.1470 (0.0279)	– 11.3914 (2.0545)	0.15	1.43
Swiss franc	0.0939 (0.0289)	– 5.9398 (0.7173)	0.14	1.82
Deutsche mark	0.0451 (0.0206)	– 3.5058 (0.5644)	0.07	1.96
Pound sterling	– 0.0032 (0.0302)	– 5.5366 (0.8990)	0.11	1.91
Japanese yen	0.1192 (0.0258)	– 4.7413 (0.6685)	0.13	1.32

The table below shows the results of the regression

$$p_t - p_{t-1} = \alpha + \beta x_t^c + \varepsilon_t$$

using weekly data over the period from January 1998 to March 2000. p_t is the natural logarithm of the US dollar price of a unit of foreign currency for currency *i* at the end of week *t* and $x_{i,t}^c$ is the net customer order flow in a particular currency over week *t*. Standard errors are reported in parenthesis.

Table 8

Customer order flow and currency returns

Currency	α	β	Adj R^2	D-W
Canadian dollar	– 0.0002 (0.0008)	– 0.0003 (0.0009)	0.00	2.38
Swiss franc	– 0.0017 (0.0014)	– 0.0012 (0.0010)	0.01	2.12
Pound sterling	0.0002 (0.0009)	0.0004 (0.0004)	0.01	2.20
Japanese yen	0.0011 (0.0020)	0.0005 (0.0004)	0.02	1.81

Figure 1

Plot of spot Japanese yen/US dollar exchange rate
January 1986 to December 2000

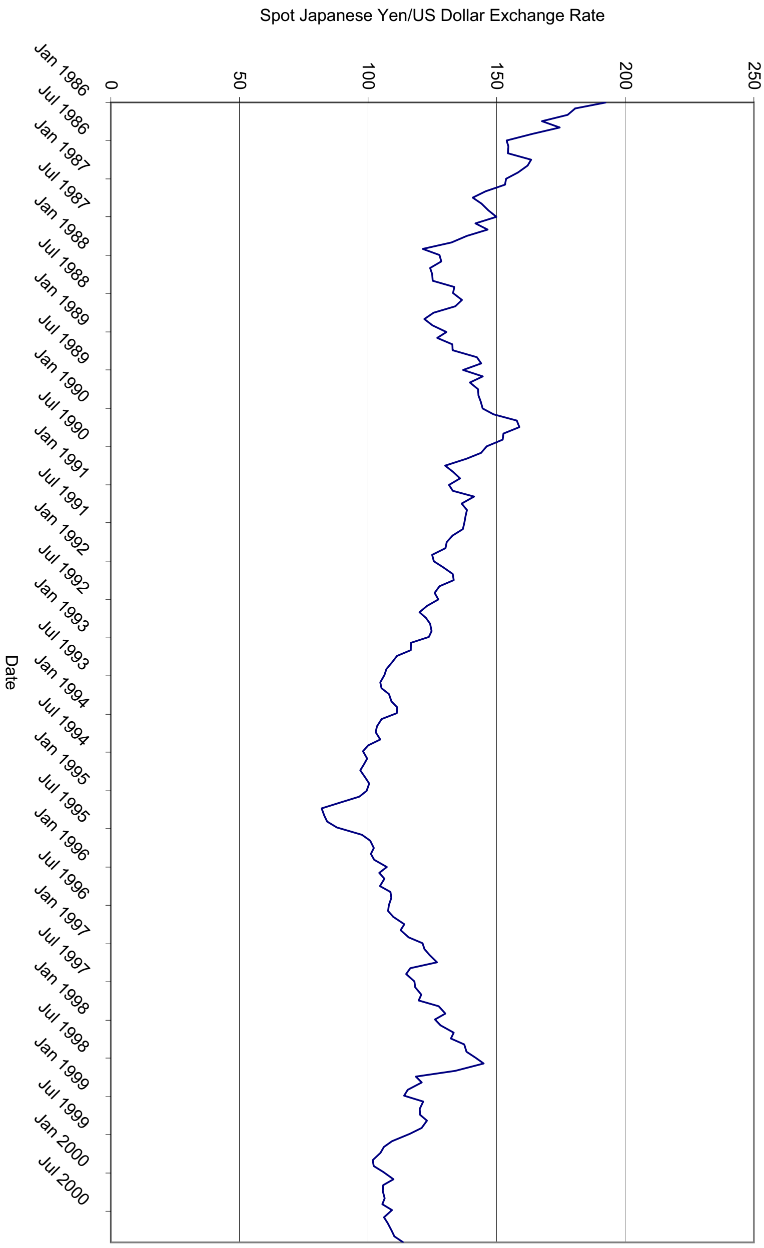
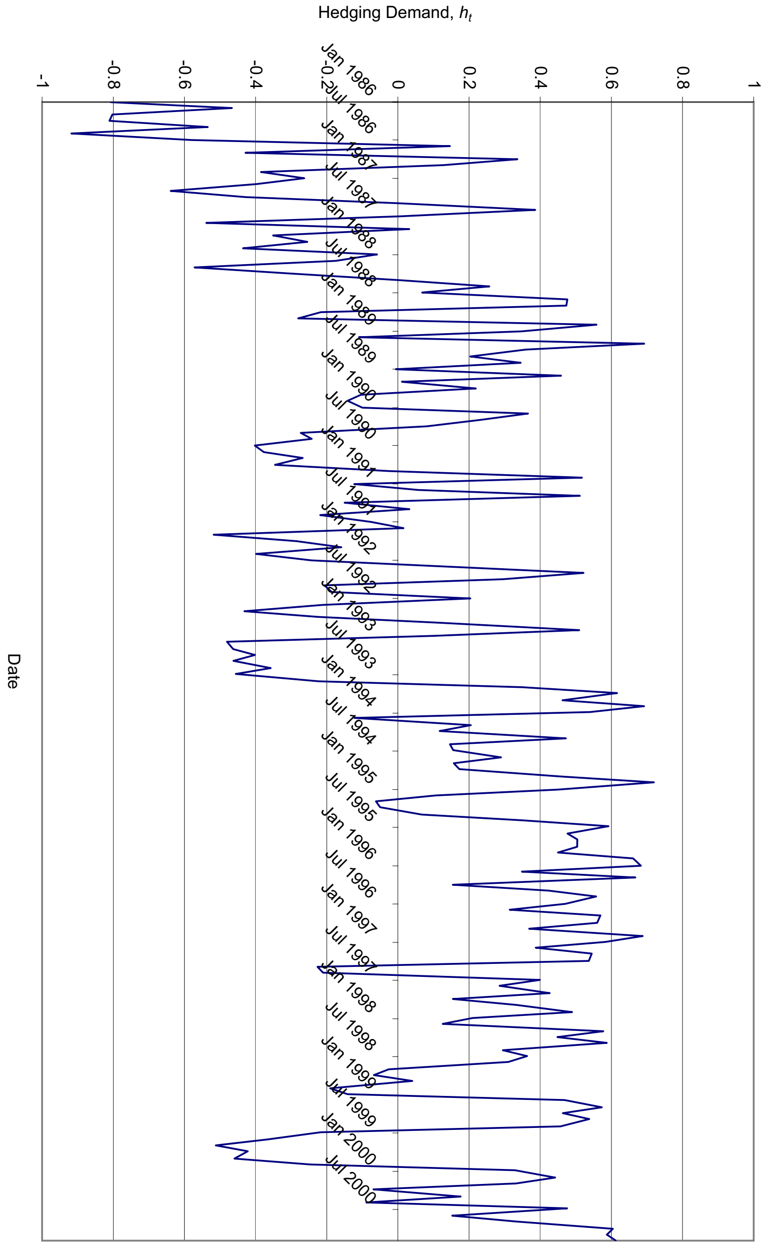


Figure 2

Plot of hedging demand, h_t , in Japanese yen
January 1986 to December 2000



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