The High-Frequency Response of Exchange Rates and Interest Rates to Macroeconomic Announcements

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Abstract: Many recent papers have studied movements in stock, bond, and currency prices over short windows of time around macro announcements. This paper adds to the announcement affect literature in two ways. First, we study the joint announcement effects across a broad range of assets--exchange rates and U.S. and foreign term structures. In order to evaluate whether the joint effects can be reconciled with conventional theory, we interpret the joint movements in light of uncovered interest rate parity or changes in risk premia. For several real macro announcements, we find that a stronger than expected release appreciates the dollar today, but that it must either (i) lower the relative risk premium for holding foreign currency rather than dollars, or (ii) imply considerable future expected dollar depreciation. The latter implies an overshooting behavior akin to that described by Dornbusch (1976). Second, we use a longer span of data (1987-2002), and more of the data are at high frequency that has been common in announcement work. A longer span of high frequency data contributes to the precision of our estimates and allows us to explore the possibility that the effects of macro surprises on asset prices have varied over time. We find evidence, for example, that PPI releases had a larger effect on U.S. interest rates before about 1992 than subsequently.

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1. Introduction

The study of high-frequency asset price movements has examined the relationships among the unexpected component of macroeconomic announcements and various asset returns.[1] This paper contributes to the literature in two ways. First, we consider the joint effects of U.S. macro announcements on exchange rates and U.S. and foreign interest rates of various maturities. Most prior work has considered announcement effects on a single asset or asset class. The interpretations these papers place on measured effects generally have implications about how other asset prices should have reacted to the announcement. For example, Anderson, Bollerslev, Diebold and Vega's (2003) (hereafter, ABDV) excellent study of the reaction of exchange rates to macro announcements finds that an announcement of U.S. retail sales that is greater than expected is associated with an appreciation of the dollar. This can be reconciled with conventional exchange rate theory, e.g., the monetary model, if the announcement portends higher-than-expected U.S. income, but this should also be reflected in a rise in U.S. interest rates. Studying the joint behavior of a broad range of asset returns allows us to shed additional light on the market reaction to news.

A second significant contribution of this paper is the use of a longer span of data and more high frequency data than used in most other papers. Our sample includes data from 1987 to 2002, a period including 2 NBER recessions. Earlier work covers a much smaller time period. For example, ABDV's sample is January 1992 to December 1998, a

[1] This includes Cutler, Poterba and Summers (1989), McQueen and Roley (1993), Ederington and Lee (1993), Fleming and Remolona (1997, 1999), Almeida, Goodhart and Payne (1998), Bollerslev, Cai and Song (2000), Kuttner (2001), Ehrmann and Fratzscher (2002), Anderson, Bollerslev, Diebold and Vega (2003), Gurkaynak, Sack and Swanson (2003) and Bernanke and Kuttner (2003). Some of these papers also document a systematic relationship between the announcements and the conditional variance of asset returns.

period in which the U.S. economy was always in an expansion phase. Fleming and Remolona (1997), in their study of bond returns, use a 1-year sample starting in mid-1993. A longer sample period including a broader range of states of the economy should contribute to sharper conclusions.

One reason for the short samples in earlier work is the limited availability of high frequency data. In estimating the effect of an announcement, it is desirable to measure the asset price changes in a narrow window around the time of the macro announcement. If we choose a window that is narrow enough, the information hitting the market during the window should be dominated by the macro announcement; thus, the events in the narrow window provide us an approximate natural experiment. Earlier work has shown that the average effect of announcements is completed very quickly, so that confining attention to a 20-minute window around the time of the announcement should be more than adequate. Especially for highly variable asset prices such as foreign exchange, using daily changes, which include the effect of announcements and all other information hitting the market that day, leads to very imprecise estimates of the announcement effects. Thus, there is often a tradeoff between using daily asset returns over a long sample period (e.g. Edison (1997)), or using high frequency data over a short sample period (e.g. Fleming and Remolona (1997) or Almeida, Goodhart and Payne (1998)).

Although we too face this tradeoff, we have made considerable progress on expanding the range of assets and sample period for which we have high frequency returns. As described in detail below, over most of the 1987-2002 period, we have high frequency data for exchange rates, and 3-month and 10-year rates in the U.S., UK, Japan and Germany. We also have high frequency data for the U.S. 5-year rate. We fill out the dataset with daily data on 1-year and 2-year interest rates for all four countries, and 5-year rates for the U.K., Japan and Germany.

Fair (2003) also considers high-frequency data on a range of asset prices over a long period (1982 to 1999). He identifies occasions on which the five-minute change in stock prices, bond prices or exchange rates exceeded 0.75 percentage points, and then conducts newswire searches to identify an important event that occurred at that time. An event can be identified in many (though not all) cases, and this event is often a U.S. macroeconomic announcement. Fair lists these events and studies the correlations of changes in stock prices, bond prices and exchange rates around these events. This supports the view that U.S. macro announcements are important determinants of asset prices in a narrow window around the time of the release. While Fair studies large events, we study the average effects of all announcements on changes in interest rates and exchange rates.

We follow most of the macro announcements literature in focusing on the "surprise" component of the announcements. We study 10 announcements of U.S. indicators: CPI, PPI, Fed Funds target, GDP, unemployment rate, initial unemployment claims, housing starts, nonfarm payrolls, retail sales, and trade balance. For most releases, we measure the surprise component as the difference between the actual release and the Money Market Services (MMS) survey expectation. For the FOMC announcement about the target Fed Funds rate, we follow Kuttner (2001) in taking the expected change from Fed Funds futures market. We discuss possible limitations of MMS surveys and Fed Funds futures data as sources of expectations data below.

We obtain significant and quite precisely estimated effects for several macroeconomic releases on exchange rates and the term structure of U.S. and foreign interest rates. Stronger than expected real releases (e.g. nonfarm payrolls, retail sales, GDP) tend to appreciate the dollar and raise short and long-term interest rates in the U.S. and, to a lesser extent, overseas. Higher than expected inflation (CPI or PPI) is estimated to have little effect on the exchange rate, but to raise U.S. interest rates significantly. Tighter than expected monetary policy (i.e. a higher than expected target Fed Funds rate) is estimated to appreciate the dollar and to raise the term structure of U.S. interest rates. Foreign interest rates rise as well, but not by as much at shorter maturities. The effect on the 10-year U.S. interest rate is more precisely estimated and smaller than Kuttner (2001) obtained with a very similar methodology, but using daily data.

For the most part our point estimates for individual asset returns are quite similar to those of earlier work including ABDV (exchange rates, intradaily data), Ederington and Lee (1993) (exchange rates and U.S. interest rates, intradaily data), Fleming and Remolona (1997, 1999) (U.S. interest rates, intradaily data), Kuttner (2001) (U.S. interest rates, daily data) and Gurkaynak, Sack and Swanson (2003) (forward U.S. interest rates, daily data).[2] Compared to work where only daily data has been used our inference is more precise and our results sometimes give a quite different picture.

Our main goal of characterizing the joint movements of exchange rates and interest rate term structures presents a bit of a presentational challenge. Uncovered interest rate parity (UIP) is a convenient starting point. We know that UIP does not hold unconditionally: there seems to be a highly variable risk premium reflected in the joint movements of interest differentials and exchange rates. However, as an interpretational device we can assume that the announcements do not change the risk premium, in which case our estimated effects imply a trajectory of the exchange rate response to the macro news. If the trajectory is difficult to reconcile as an expected path of the exchange rate, one can reason about what must have happened to the risk premium. We investigate the implied risk premium behavior under the assumption that exchange rate expectations are consistent with a random walk model.

For several real macro releases, such as nonfarm payrolls, we find that a stronger than expected release appreciates the dollar today, and that it either (i) lowers the risk premium for holding foreign rather than dollar-denominated assets, or (ii) implies future expected dollar depreciation in excess of the original jump. If one were to assert that a stronger-than-expected U.S. release *raises* the risk premium for holding foreign rather than dollar-denominated assets, our results imply that this could only be consistent with an even steeper path of expected dollar depreciation following the initial appreciation.

We find that higher-than-expected CPI and PPI releases also lower the foreign exchange risk premium and/or lead to significant long-run expected dollar depreciation. An unexpected tightening of U.S. monetary policy significantly lowers the foreign exchange risk premium (especially in the short run) and/or leads to a persistent significant expected appreciation of the dollar.

With our long sample, spanning two recessions, we can shed some light on questions such as time variation that we could not hope to answer with adequate precision using shorter samples. In principle, there is reason to expect that the effects of

[2] Gurkaynak, Sack and Swanson (2003) and Clare and Courtenay (2001) also consider the effect of UK

macroeconomic surprises might vary over time. The effect of macro surprises could vary across the business cycle or other economic conditions (see, for example, Boyd, Jagannathan and Hu (2001), Orphanides (1992), David (1997), Veronesi (1999), David and Veronesi (2001) and Ehrmann and Fratzscher (2002)). To take a case that may have been of relevance in the 1990s, if lower-than-expected inflation is perceived to be evidence of weak demand, then agents might expect monetary policy to be loosened, causing interest rates to fall and depreciating the dollar. But, if the unexpectedly low inflation is perceived to be evidence of productivity growth, then in some models U.S. interest rates rise and the dollar appreciates.[3]

We reject the null of parameter constancy for some announcements. Estimating models that allow for time varying parameters, we find that the effect of PPI surprises on interest rates has declined over our sample period and that the effect of trade balance surprises on exchange rates has also declined. There is also some evidence for time variation in the effects of surprises to nonfarm payrolls.

The plan for the remainder of this paper is as follows. Section 2 describes the data. Section 3 contains the basic regression results. Section 4 contains the analysis of the effects of surprises on expected future exchange rates and the UIP risk premium, that we can obtain only by studying the simultaneous responses of interest differentials and exchange rates to the data releases. Tests for parameter stability and models allowing for time-varying parameters are reported in section 5. Section 6 concludes.

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macro announcements on UK interest rates.

[3] See Glick and Rogoff (1995), and Erceg, Guerrieri and Gust (2002) for more discussion of the impact of productivity growth on real exchange rates and the trade balance. The latter paper argues that agents initially viewed the productivity acceleration in the U.S. in the 1990s as being transitory, but then came to believe that it represented a break in the trend growth rate of productivity. They back this up with survey

2. The Data

2.1 *The announcement surprises*

We consider the effects on exchange rates and interest rates of 10 macroeconomic announcements, including the FOMC day release of the decision about the target Federal Funds rate, as listed in Table 1. Nine of the announcements occur at 8:30am eastern time; the target Fed Funds rate is released at 2:15pm eastern time.[4] The timing of the 8:30am macroeconomic announcements is extremely precise, while the Fed's decision about the target Fed Funds rate has been announced on the FOMC day within a few minutes of 2:15pm since March 17, 1994.

For the 8:30 announcements, we measure the expected announcement using the median survey expectation from Money Market Services. The data come from the MMS survey of money managers taken the Friday before the release of the data. These survey data have been widely used and the properties have been much studied. They are generally found to possess reasonable properties as expectations series, as they are unbiased, pass simple forecast rationality tests, and outperform naive time series forecasts (see, for example, Balduzzi, Elton and Green (2001)). We measure the surprise component of the announcement as the actual data release less the MMS survey expectation. For some of the announcements, the MMS data do not go all the way back to the start of our sample: in these cases we just use the data as far back as possible. Data availability and the units in which the data are recorded are noted in Table 1.

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evidence. In a dynamic general equilibrium model, they show that this can account for much of the deterioration of the U.S. trade balance, and the real appreciation of the dollar.

[4] Many other countries, including Germany, do not release macroeconomic data at precise scheduled times.

We handle the target Federal Funds rate differently. Although MMS records survey expectations for the target Fed Funds rate, we instead measure the surprise component of the Fed's decision from intradaily changes in Federal Funds futures. We do this by the following algorithm, which is an adaptation of that proposed by Kuttner (2001) for daily data. If the FOMC meeting is on or before the 22nd of the month, take the change in the *current* month Fed Funds futures price from 2:10 to 2:30[5] and scale the change by the ratio of the total number of days in the month to the total number of days left in the month, to obtain the surprise change in the target Fed Funds rate. This scaling is necessary because the contract settles to the average interest rate in the month. If the FOMC meeting is on or after the 23rd of the month, we measure the surprise change in the target Fed Funds rate as the change in the *next* month Fed Funds futures price from 2:10 to 2:30.[6] The Fed Funds futures give a better measure of expectations of target Fed Funds rate changes than MMS survey expectations in the sense that in a regression of the actual realized target Fed Funds rate on the forecasts from the futures market and the MMS survey forecast, the coefficient on the futures rate is not significantly different from one, while the coefficient on the survey forecast is not significantly different from zero.

2.2 *Exchange Rate Data*

Our exchange rate data consist of the 5-minute exchange rate returns for dollar exchange rates versus the DM/euro, yen and pound, covering the entire calendar years 1987 to 2002

[5] More precisely, this is the change from the last price before 2:10 to the last price before 2:30, as long as it is after 2:15. If either of these are missing, which is unusual in recent years, we simply take the daily change in the closing current month Fed Funds futures price between the day of the FOMC meeting and the previous day instead.

[6] The reason for using the next month futures price change rather than the scaled change in the current month futures price change is because the data are recorded only to the nearest basis point (half basis point since 1995), so our measured surprise change has rounding error that would be exacerbated by the scaling.

inclusive, from Olsen and Associates.[7] To construct these data, Olsen and Associates record all Reuters quotes, average the bid and ask, and then linearly interpolate the resulting series to get prices at exactly the required times.

From these data, we construct exchange rate returns over 20-minute windows starting 5 minutes before the data release, and ending 15 minutes after the data release. For an 8:30 data release, we construct exchange rate returns from 8:25 to 8:45.[8] For an FOMC release, we construct exchange rate returns from 2:10 to 2:30.

Throughout this paper, we construct exchange rates as dollars per unit foreign currency, so that a positive exchange rate return represents an appreciation of the foreign currency against the dollar. The exchange rate returns are continuously compounded, and multiplied by 10,000, so they can be interpreted as (approximately) the exchange rate change in basis points.

2.3 *Interest Rate Data*

Our intradaily interest rate data consist of tick-by-tick transactions prices for Federal Funds futures, 5-year and 10-year Treasury bond futures, 90-day eurodollar futures contracts, 90-day euromark/euribor and sterling libor futures and 10-year UK, German and Japanese bond futures. The dates for which we have data on each of these instruments are shown in Table 2. We obtained foreign and U.S. futures data from the London International Financial Futures Exchange (LIFFE) and Genesis, respectively.

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[7] This consists of the HFDF2000 dataset covering the years 1987 to 1998, with an extension through the end of 2002, also purchased from Olsen.

[8] We could simply use exchange rate returns from the moment of the announcement until 5 minutes later, but do not for two reasons. First, although ABDV find that the response of exchange rates to macroeconomic announcements is fast, for some announcement-currency pairs they find that the full effect on the conditional mean takes a little more than 5 minutes. Second, since the data are based on linearly interpolated quotes, the exchange rate data for 8:30 may incorporate a quote that came after an 8:30 release. Taking exchange rate returns from 8:25 to 8:45 effectively circumvents this problem.

Federal funds futures trade at the Chicago Board of Trade (CBOT). There is a contract for every month. The settlement price for each contract is the average effective Fed Funds rate for that month. Contracts trade for each of about the next 8 months, but only the first few contracts are liquid. Eurodollar contracts trade at the Chicago Mercantile Exchange (CME). There is a contract for settlement in March, June, September and December of each year. The settlement price for each contract is simply the 90-day eurodollar deposit rate on the settlement day.

Treasury bond futures (5-year and 10-year) trade on CBOT. There is a contract for settlement in March, June, September and December of each year. The settlement price for each contract is the settlement day price of a cheapest to deliver bond with a particular coupon rate in a particular maturity range. Contracts trade for each of about the next 4 settlement days, but only the first one or two contracts are liquid.

Euromark/euribor and sterling libor contracts trade on LIFFE. They are similar to eurodollar contracts, except that they settle to mark/euro and sterling 90-day interest rates. The 10-year UK, German and Japanese bond futures also trade on LIFFE and are similar to 10-year Treasury bond futures.

We convert the prices of bond futures into implied approximate yields to maturity. The yield can be calculated from the futures price of the bond given that we know the coupon rate of each futures contract by assuming that 5-year and 10-year futures contracts require delivery of a bond with exactly 5 years and 10 years to maturity, respectively.

Trading in interest rate futures opens on CME and CBOT at 7:20am central time, so all of the futures are trading at 8:30am eastern time. All of the U.S. contracts are trading at 2:15pm eastern time, but LIFFE is closed at this time.

From these data, we construct interest rate changes in the first futures contract (the one with the closest settlement date) over 20-minute windows starting 5 minutes before the data release, and ending 15 minutes after the data release. For example, for an 8:30 data release, this is the change in the price of the first futures contract from 8:25 to 8:45.

We treat the high-frequency futures-based interest rate (with a near settlement date) as though it is the underlying spot interest rate. Trading in short-term interest rate and bond futures markets is extremely liquid: liquidity in the bond futures market is far greater than in the market for any one specific bond issue. The futures and spot instruments are very close substitutes.

We do not have intradaily data on 1-year, 2-year or 5-year interest rates (we have 5-year rates for the U.S. only), but we do have daily data on these rates for all currency denominations under consideration. We include these daily data in our dataset as well. For daily data, we take close quotes before and after the macro release, which requires us to keep careful track of the exact time of the daily quotes. Because LIFFE is closed at the time of the FOMC release, we never have high frequency data on foreign interest rates around the time of the FOMC release. For this release alone, we use only daily data for the foreign interest rates.

The daily 3-month and 1-year rates in all cases are British Bankers Association LIBOR fixings. The daily 2-year rates for the U.S. are zero coupon rates computed at the

Fed. The daily 2-year, 5-year and 10-year interest rates for the UK are zero coupon rates provided by the Bank of England. The 2-year, 5-year and 10-year rates for Germany and Japan are yields to maturity on benchmark government bonds, as constructed by Bloomberg.

Thus, using a mixture of intradaily data for some instruments and daily data for others, we have changes in 3-month, 1-year, 2-year, 5-year and 10-year interest rates bracketing each macroeconomic announcement for the years 1987 to 2002 for the U.S., the UK, Germany and Japan.[9] We multiplied each of these changes by 100, so that they are in basis points.

2.4 *A caveat about the interest rate data*

In all cases, we would like to have zero coupon interest rates. In several cases noted above, we instead have yields to maturity. Of course, all our data (daily and intradaily) on 1-year and 3-month interest rates are indeed zero coupon rates. The intradaily rates constructed from bond futures prices are yields to maturity and suffer from the additional complication that the bond futures contracts do not require delivery of a bond with an exact specified maturity -- rather there is a range of acceptable maturities. For example, the LIFFE 10-year UK government bond futures contract at present specifies that settlement shall be based on the cheapest-to-deliver UK government bond with a 6% coupon that has a maturity date falling between 8.75 and 13 years from settlement. The exact maturity of the bond on which settlement is actually based will depend on the level of interest rates and on the maturity dates of existing bonds with the required coupon.

[9] Except that the changes in 2 and 5-year rates for Germany and Japan even at the daily frequency do not go all the way back to 1987.

Thus, the futures market price is only approximately for bond with 10 years remaining maturity.

In the present paper, we treat all these interest rates as if they were zero coupon rates of exactly the nominal maturity. In future work we intend to attempt to calculate implied zero coupon rates allowing us to drop this assumption. For now we can simply note that much of the divergence between zero coupon rates of exactly the nominal maturity and our data on yields-to-maturity may be differenced out, given that we exclusively deal with changes in interest rates from before to after macroeconomic data releases. Unless the announcements affect the *slope* and *curvature* of the term structure much more than the *level* of the term structure, the change in zero coupon rates from before to after the data release should be well approximated by the change in yields to maturity.

3. Basic Regression Results

For each of the 10 macroeconomic releases, we run regressions of exchange rate returns and interest rate changes over 20-minute (or, in some cases, daily) windows around the time of the macroeconomic data release, r_t, on the surprise component of the data release, s_t. The regressions are estimated without a constant.[10] The regression equation is

$$r_t = \beta s_t + \varepsilon_t \tag{1}$$

While heteroskedasticity is not necessarily a first-order issue in these regressions, we use heteroskedasticity-robust White standard errors. We note that the regressor s_t could well be affected by measurement error, biasing the estimated coefficient towards zero. Indeed this concern motivates us to measure the surprise component of the target Fed Funds rate from intradaily futures rates rather than from MMS surveys, so as to avoid, or at least minimize, measurement error in this surprise.

3.1 *Results for Exchange Rate Returns*

In Table 3, we report the point estimates and the (uncentered) regression R-squared for the regression of each exchange rate return on each macroeconomic surprise. These regressions are run only over the 20-minute windows around the time of the macroeconomic announcement: for the announcements that are made monthly this means that there is one observation per month. The interpretation of the regression R-squared is the fraction of the variance of the exchange rate in that 20-minute window that is explained by the announcement, which is of course not at all the same thing as the fraction of the overall exchange rate variance that is explained by the announcement.

We have very similar qualitative results to ABDV, although our sample period is substantially longer than theirs.[11] The announcements are such that positive surprises represent stronger-than-expected growth or higher-than-expected inflation. For the unemployment rate and initial jobless claims, which are both countercyclical indicators, we flip the sign of the surprise so that positive surprise reflect stronger-than-expected growth for these indicators as well. The point estimates in Table 3 generally indicate that stronger-than-expected announcements lead to negative exchange rate returns, i.e. dollar appreciation. The effect is statistically significant for some, though not all,

[10] Results including a constant are not substantially different, and are available from the authors on request.

announcement-currency pairs. The elements of Table 3 can be interpreted as the effect of a one unit surprise in the macroeconomic release on the exchange value of the dollar, in basis points. The point estimates are quite small -- for example if GDP[12] comes out one percentage point above expectations (quarter-over-quarter, at an annualized rate), the estimated effect is to appreciate the dollar against the other currencies by only about 10 basis points.

Some announcements are more systematically related to exchange rates than others. GDP, initial unemployment claims, nonfarm payrolls, retail sales, the trade balance and unemployment are all significantly different from zero at the 1% level for all three currencies. The FOMC decision on the target Fed Funds rate is significant at the 5% level for the yen, and at the 1% level for the other two currencies, with a surprise monetary policy easing being associated with dollar depreciation. The R-squared (over the 20 minutes around announcements) is over 20% for some announcement-currency pairs. Although such an association is weak, it is still a triumph by the dismal standards of modeling the relationship between exchange rates and macroeconomic fundamentals.

3.2 *Results for Interest Rate Changes*

We regress the changes in interest rates of different horizons on each macro surprise and plot the coefficients against the horizon of the interest rate in Figures 1 and 2. These figures represent the effects of a one unit surprise in the U.S. macro announcement on the term structure of U.S. and foreign interest rates.

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[11] Note however that ABDV define exchange rates as foreign currency per dollar, whereas we define exchange rates as dollars per foreign currency, so their coefficient estimates are mostly positive. Also note that ABDV normalize the macroeconomic surprises to have unit standard deviation, which we do not.

[12] In the United States, there are three releases of GDP during our sample period (aside from annual and benchmark revisions). The advance release comes out about 1 month after the end of the quarter to which

Stronger-than-expected releases tend to raise U.S. interest rates, including long-term interest rates, and the effects are in many cases statistically significant. Stronger-than-expected U.S. releases also tend to raise foreign interest rates, although by a smaller amount.

The effect of a shock to the Fed Funds rate on the term structure of interest rates is of special interest. A great many papers have considered estimation of the effect of a change in the Fed Funds rate on the term structure of interest rates including Cook and Hahn (1989), Radecki and Reinhart (1994), Roley and Sellon (1995) and Kuttner (2001). The conventional view of the monetary policy transmission mechanism is that a shock to the Fed Funds rate affects consumption and investment demand through its effect on long term interest rates. If long-term interest rates are insensitive to shocks to the Fed Funds rate then monetary policy is either ineffective, or must work through other channels (Barth and Ramey (1991) or Bernanke and Gertler (1995)).

Kuttner (2001) regresses one-day changes in the U.S. yield curve on the unexpected component of the change in the Federal Funds rate, as measured from daily closing prices in the Fed Funds futures market. Our regression of the U.S. term structure on the unexpected component of the change in the Federal Funds rate is similar to that of Kuttner, but we use intradaily data both to measure the monetary policy surprise, and to measure the effect of the surprise on other interest rates.

Our results are not inconsistent with those of Kuttner, but point to smaller and more precisely estimated effects of the monetary policy shock on long term interest rates. Kuttner estimated that a 100 basis point unexpected tightening of monetary policy raises

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it refers. The next two releases (called preliminary and final) are revisions that come out about 2 and 3

10-year yields by 31.5 basis points, with a standard error of 10.2 basis points. When Kuttner includes FOMC days on which no change in rates actually occurred, the estimate falls to 22.0 basis points, with a standard error of 9.2 basis points. Our estimate for the effect of a 100 basis point unexpected tightening in the Fed Funds rate on the 10-year U.S. interest rate is 4.6 basis points, with a standard error of 6.6 basis points. These very small estimates of the effects of monetary policy shocks on long-term interest rates are very close to those obtained by Roley and Sellon (1995) and Radecki and Reinhart (1994).

In comparing our results with those of Kuttner (2001), note that we run our regression only over FOMC days since 1994. It is only for these announcements that we have the precise time of the announcement and can use intradaily data. Demiralp and Jorda (2003), using daily data, report some evidence that the effect of monetary policy shocks on long-term interest rates was higher before 1994 than subsequently, and is higher for intermeeting moves than for target Fed Funds rate surprises on FOMC days.

We also note that the U.S. monetary policy shock has some tendency to raise foreign interest rates (both at the short and long end), but the effect on short-term interest rates is not surprisingly smaller abroad than in the U.S.

3.3 *Are Announcement Days Different?*

Our primary focus in this paper is on the effects of announcements on the conditional mean of asset prices, not their conditional variance. But for our method in this paper to be reasonable, it should be that asset price changes are more variable during the announcement window than in otherwise comparable windows. In Table 4, we report the

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months after the end of the quarter, respectively. In our data analysis we are using just the advance release.

standard deviation of intradaily exchange rate and interest rate changes over the 20 minutes bracketing each of the 10 macroeconomic announcements, relative to the intradaily exchange rate or interest rate change over the same 20 minutes on days when there is no macroeconomic announcement at all in that time interval. For example, the column of the table labeled CPI reports the standard deviation of exchange rate and interest rate changes between 8:25am and 8:45am on days when there is a CPI release divided by the standard deviation of the analogous changes between 8:25am and 8:45am on days when there is no 8:30am macro release at all. The Fed Funds column reports the standard deviation of exchange rate and interest rate changes between 2:10pm and 2:30pm on FOMC days divided by the standard deviation of the analogous change at that time on non-FOMC days.

Most of the elements of this table are greater than 1, indicating that exchange rates and interest rates are indeed more volatile around announcements than at the same time on non-announcement days. Releases of CPI, PPI, GDP, retail sales, the employment report and the target Fed Funds rate are all associated with substantially elevated volatility.

4. The Simultaneous Effect of Surprises on Exchange Rates and Interest Rates.

We next turn to studying the simultaneous effect of macroeconomic announcements on exchange rates and interest rates. Consider the UIP relationship

$$Ee_{t+k} - e_t = i_{t,k} - i^*_{t,k}$$

where $i_{t,k}$ ($i^*_{t,k}$) is the domestic (foreign) k-period interest rate, e_t is the log of the nominal exchange rate in home currency units per foreign, and E denotes the time-t expectation. Under rational expectations and risk-neutrality, a testable proposition is that in the regression

$$e_{t+k} - e_t = \alpha_k + \gamma_k (i_{t,k} - i^*_{t,k}) + \varepsilon_t$$

γ_k should be equal to unity (and α_k equal to zero). This is nearly uniformly rejected in the data, however, as γ_k is typically found to be negative, i.e., the currency with the higher interest rate typically *appreciates* (Engel, 1996). A familiar interpretation of the empirical failure of UIP posits the existence of a time-varying risk premium, $\rho_{t,k}$ such that

$$Ee_{t+k} - e_t = i_{t,k} - i^*_{t,k} + \rho_{t,k} \tag{2}$$

This risk premium is the expected excess return that agents require to hold foreign rather than dollar-denominated bonds. Equation (2) is simply a definition of the risk premium, which one may prefer to think of as the expected UIP deviation. Of course, UIP does not hold, and the deviations from UIP, $\rho_{t,k}$, are large and highly variable.

Consider the algebraic identity obtained from taking the difference in equation (2) from before to after the announcement

$$\hat{E}e_{t+k} = \hat{e}_t + \hat{i}_{t,k} - \hat{i}^*_{t,k} + \hat{\rho}_{t,k} \tag{3}$$

where the hat denotes the change in the variable from just before to just after the announcement. We can measure $\hat{e}_t$, $\hat{i}_{t,k}$ and $\hat{i}^*_{t,k}$ directly. From this we know $\hat{E}e_{t+k} - \hat{\rho}_{t,k}$, but not each component separately. If we make an assumption about either term, we can measure the other.

We first assume that the macro announcements do not affect the risk premium (i.e. $\hat{\rho}_{t,k} = 0$). In this case,

$$\hat{E}e_{t+k} = \hat{e}_t + \hat{i}_{t,k} - \hat{i}^*_{t,k}$$

and we can immediately compute the effect of the announcement on the expected future exchange rate as the effect of the announcement on $e_t + i_{t,k} - i^*_{t,k}$. We relate this in turn to the macro surprise by estimating the regression,

$$\hat{e}_t + \hat{i}_{t,k} - \hat{i}^*_{t,k} = \beta_k s_t + \varepsilon_t \tag{4}$$

Thus, under the assumption that the risk premium is unaffected by the macro announcement, the expected future exchange rate response to a one unit announcement surprise at horizon *k* is simply the coefficient β_k.

In Figures 3 and 4 we plot the coefficients β_k obtained from estimating equation (4) separately for *k* = 0, 3 months, 1 year, 2 years, 5 years and 10 years (at horizon 0, equation (4) reduces to equation (1) and the conditional UIP assumption is not required). These plots show the effect of a unit macro surprise on the expected future trajectory of exchange rates. Also shown are 90% confidence intervals, obtained from heteroskedasticity-robust standard errors in (4).

For the real announcements, the general pattern is that a stronger than expected announcement appreciates the dollar. But, assuming that the announcement does nothing to the UIP risk premium, this appreciation is not expected to last, and typically is expected to be more than reversed. For example, a release of higher-than-expected nonfarm payrolls data causes a significant appreciation of the dollar today, but causes an expected depreciation in 10 years time. This trajectory of exchange rates is akin to the overshooting described by Dornbusch (1976) for shocks to the money supply.

For the price indexes (CPI and PPI), data surprises do not have a significant effect on the current exchange value of the dollar. But, assuming that the announcement does nothing to the UIP risk premium, the projection coefficients imply that a higher than expected inflation number leads to significant expected future dollar depreciation.

The assumption that the risk premium is not affected by the data release is questionable. A second exercise that helps us to reason about the risk premium begins with assuming that exchange rate expectations are given by the random walk model at all points in time. Under this assumption, the effect of the announcement on $\rho_{t,k}$ is given by the change in the interest differential $\hat{i}^*_{t,k} - \hat{i}_{t,k}$. Thus, we can estimate the effect of announcements on the risk premium by regressing $\hat{i}^*_{t,k} - \hat{i}_{t,k}$ on s_t.

The effect of the U.S. macro announcement on the risk premium under the random walk assumption is plotted against the horizon in Figures 5 and 6; the risk premium is expressed at annualized rate. Generally stronger-than-expected U.S. releases lead to significant and large declines in the risk premium.

Jointly, the two exercises lay out two possibilities. Either stronger-than-expected real macro news leads to expectations of dollar depreciation in the long-run, or lead to declines in the required risk compensation for holding foreign rather than dollar denominated assets. While we do not have good models for explaining empirically observed risk premia, one might have supposed that good macro news in the U.S. would raise the relative risk in owning foreign assets.[13] If this were the case, even steeper dollar depreciation would be implied in the long-run.

The idea that a stronger-than-expected real U.S. data release that leads initially to dollar appreciation would then lead to long-term depreciation can be reconciled with theory. The macro news could indicate higher relative real rates in the short-term (say, due to a policy response) but higher inflation and nominal rates in the long-term. This is the story laid out by Gurkaynak, Sack and Swanson (2003) to account for their results regarding the effect of news on the U.S. term structure.

5. Time Variation in Parameters

With our dataset covering the years 1987 to 2002, which spans two NBER recessions, we can address questions that we could not hope to answer with adequate precision using shorter samples. In particular, we can study time variation in the effect of macroeconomic releases on exchange rates and interest rates. We have intradaily data on exchange rate changes and UK 3-month and 10-year interest rates covering the whole sample 1987 to 2002. We have daily data on German, U.S. and Japanese 3-month and 10-year interest rates covering the whole sample, but have the corresponding intradaily data on these series for some of these years only. Since we want to study the effects of macro announcements on a range of asset prices over the whole sample period, we consider the stability of equation (1) using (i) intradaily data on exchange rates and UK

[13] Note however that Alvarez, Atkeson and Kehoe (1999, 2003) propose a general equilibrium model in which agents have to pay a fixed cost to exchange money for assets. In this model, a positive shock to U.S. money growth raises the U.S. inflation rate, induces more agents to pay the fixed cost and participate in asset markets, and thereby lowers the foreign exchange risk premium.

3-month and 10-year interest rates, and (ii) daily data on German, U.S. and Japanese interest rates.[14] Tests of the null of parameter constancy, using the structural stability test statistic proposed by Nyblom (1989), and using the sup-F statistic (the maximum value of the Chow statistic over all possible break dates) are reported in Tables 5 and 6, respectively.[15]

For most asset-exchange rate pairs, the hypothesis of parameter constancy is not rejected. Time-variation in the effect of announcements on exchange rates and interest rates does not generally seem to be a first order issue. There are however some notable exceptions. The hypothesis of parameter constancy is rejected in the regression of exchange rate returns on trade balance surprises, and also in the regression of 10-year U.S. interest rate changes on trade balance surprises. The hypothesis of parameter constancy is rejected in the regression of U.S. interest rates on PPI surprises. It is also rejected in the regression of the 3-month U.S. interest rate on nonfarm payrolls surprises.

Given that the effects of certain pieces of macroeconomic news seem to vary over time, we next turn to modeling the relationship between macroeconomic surprises and exchange rates in models that allow for parameter instability.

5.1 *The Random Coefficient Regression Model*

A widely used statistical model that allows for time-variation in regression parameters is the random coefficient model of Rosenberg (1972), Cooley and Prescott (1973), and

[14] Results for examining the stability of equation (1) using intradaily changes in 3-month German and U.S. interest rates, 5-year U.S. interest rates and 10-year German, U.S. and Japanese interest rates over the shorter subsamples for which we have these higher frequency data are also available from the authors on request. We do not use these as our baseline results because we want to examine stability over the same long sample period for all assets.

[15] The null limiting distribution of this statistic was provided by Andrews (1993). We exclude break dates in the first and last 15% of the sample (see Andrews (1993)).

Watson and Engle (1983). In the context of the regression of a change in interest rates or exchange rate returns on announcement surprises, the model can be written as

$$\begin{aligned} r_t &= \beta_t s_t + \varepsilon_t \\ \beta_t &= \beta_{t-1} + v_t \end{aligned} \tag{5}$$

Under an assumption of normality in the errors, the parameters of the model in equation (5) can be estimated by maximum-likelihood.[16] Taking the maximum likelihood estimates as given, we can do inference on the unobserved state variable β_t conditional on the entire sample, using the Kalman smoother, which also provides associated standard errors. The smoothed coefficient estimates reflect our beliefs at the end of the sample period about what the responsiveness of the asset price to macroeconomic surprises was, at each point in time.

We applied this model to the effect of nonfarm payroll, PPI and trade balance surprises on exchange rates and interest rates. We picked these three announcements, because there was some evidence of parameter instability in each of their effects. The smoothed estimates of the effects of a surprise in nonfarm payrolls, PPI and the trade balance are shown in Figures 7, 8 and 9, respectively.

In Figure 7, we see that the sensitivity of 3-month U.S. interest rates to nonfarm payrolls releases peaked in the early 1990s and has since fallen. Interestingly, the sensitivity of the exchange rate response to nonfarm payrolls surprises exhibits a mirror image pattern. It was exactly when short term interest rates were most sensitive to nonfarm payrolls surprises that these surprises led to the most dollar appreciation. The

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[16] Procedures for inference in this model are reviewed in Harvey (1991). We initialize the Kalman filter with a diffuse prior.

results on the significance of the time variation in the exchange rate effect of nonfarm payrolls news are however mixed (Tables 3 and 4).

In Figure 8, we see that the sensitivity of interest rates to PPI announcements was high in the early years of the sample, but then declined and is no longer significantly different from zero, for interest rates of any maturity. This could reflect the interpretation of PPI news as conveying news about stronger-than-expected productivity growth, rather than demand strength, later in the sample.

The strongest evidence of time variation is for the effects of trade balance releases. In Figure 9, we see that the sensitivity of the exchange rate to news about the trade balance was very high in the early years of the sample, but it has subsequently waned and is no longer significantly different from zero. Trade balance releases never had much effect on short term U.S. interest rates. However, a lower than expected trade deficit was estimated to lead to a reduction in 10-year U.S. interest rates in the early part of the sample, but this effect has since waned too. Indeed, the decline in the effect of trade balance surprises on 10-year yields mirrors the decline in its effect on the exchange value of the dollar.

An interpretation of this time variation in the effect of trade balance data is that in the 1980s and early 1990s, investors worried about the sustainability of the current acoount. Higher than expected trade deficits would be interpreted as a sign that the current account deficit is unsustainable, leading to dollar depreciation. It could also lead to an increase in yields on 10-year government bonds as the U.S. would have to offer more attractive yields to continue to get foreigners to finance the deficit for a bit longer.

But, perhaps, beginning in the mid 1990s, investors started to think of the trade deficit as reflecting a positive country-specific productivity shock, as U.S. residents seek to smooth their consumption by borrowing from abroad in anticipation of higher future income. Arguably, investors paid little attention to the possibility of a break in the trend growth rate of productivity until the mid-1990s. At that point, however, they may well have begun to take seriously the idea of a break, and hence became more prone to interpret macroeconomic data surprises as conveying news about productivity. If so, higher than expected trade deficits would be interpreted as positive productivity shocks that would, if anything, lead to dollar appreciation, by the Balassa-Samuelson effect.

6. Conclusion

Existing work on high-frequency movements in asset prices has documented the relationship between macroeconomic announcements and asset returns around those announcements. The literature has typically focused on a single asset or asset class, in isolation of other markets which theory predicts should move simultaneously. Much of this work has used a relatively short sample period and/or calculated asset returns over fairly wide windows such as a day.

In this paper we contribute to this literature by studying the joint behavior of a broad range of asset returns using a longer span of data--and more high frequency data--than found in most other papers. We interpret the joint behavior of exchange rates and interest rates in the context of uncovered interest rate parity, thereby obtaining evidence on the interaction between UIP risk premia and expected exchange rate dynamics, conditional on (U.S.) macro announcements. Our work is not a test of UIP; rather, it characterizes combinations of risk premium and expected exchange rate dynamics in response to macro news that are consistent with the data.

We find that for several real U.S. macro announcements better than expected news appreciates the dollar today, consistent with existing evidence. From the responses of U.S. and foreign interest rate term structures, we are also able to infer that such releases either lower the risk premium for holding foreign currency or imply future expected dollar depreciation that exceeds the original appreciation. While we do not have good models for explaining empirically observed risk premia, one might have supposed that good macro news in the U.S. would raise the relative risk in foreign assets. If it is implausible that stronger than expected U.S. news lowers the risk premium on foreign assets, then this could only be consistent with an even steeper path of expected dollar depreciation following the initial appreciation. This would of course be inconsistent with a random walk formulation of expected exchange rate movements.

Finally, there is some evidence of parameter instability for some announcements. Estimating models that allow for time varying parameters, we find that the effect of PPI surprises on interest rates has declined over our sample period and that the effect of trade balance surprises on exchange rates has also declined. We also find some evidence for time variation in the effects of surprises to nonfarm payrolls.

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Table 1
U.S. Macroeconomic Announcements

Data Release	Source[1]	Frequency	First Release Date	Last Release Date	Units	Release Time
CPI	BLS	Monthly	1/21/1987	12/17/2002	% change mom	8:30
Fed Funds Rate (Target)	Fed	8 per year	3/17/1994	12/10/2002	Change in pct pts	14:15
GDP (Advance Release)	BEA	Quarterly	4/23/1987	10/31/2002	% change qoq[2]	8:30
Housing Starts	Census	Monthly	2/18/1987	12/17/2002	millions	8:30
Initial Unemployment Claims	ETA	Weekly	7/18/1991	12/26/2002	thousands	8:30
Nonfarm Payrolls	BLS	Monthly	1/9/1987	12/6/2002	Change in thousands	8:30
PPI	BLS	Monthly	1/9/1987	12/13/2002	% change mom	8:30
Retail Sales	Census	Monthly	2/12/1987	12/12/2002	% change mom	8:30
Trade Balance	BEA	Monthly	2/27/1987	12/18/2002	$ billion	8:30
Unemployment	BLS	Monthly	1/9/1987	12/6/2002	% rate	8:30

[1]: Acronyms for the sources are as follows: BEA (Bureau of Economic Analysis), BLS (Bureau of Labor Statistics), Census (Bureau of the Census), ETA (Employment and Training Administration), Fed (Federal Reserve Board of Governors).
[2]: Expressed at an annualized rate.

Table 2
Interest Rate Data

	Source	Data Starts	Data Ends	Time Observed
Intradaily Futures Tick Data				
10 year US Bond	CBOT	10/1992	12/2002	Tick data
5 year US Bond	CBOT	10/1992	12/2002	Tick data
Eurodollars	CME	4/1992	12/2002	Tick data
10 year UK Bond	LIFFE	full sample		Tick data
10 year Bund	LIFFE	10/1998	12/2002	Tick data
10 year JGB	LIFFE	4/1991	12/1998	Tick data
Euromark	LIFFE	4/1989	12/1998	Tick data
Sterling Libor	LIFFE	full sample		Tick data
Fed Funds	CBOT	8/1992	12/2002	Tick data
Daily Interest Rate Data				
10 year US	Fed (zero coupon)	full sample		3pm Eastern time
5 year US	Fed (zero coupon)	full sample		3pm Eastern time
2 year US	Fed (zero coupon)	full sample		3pm Eastern time
1 year US	British Bankers Association	full sample		11am London time
3 month US	British Bankers Association	full sample		11am London time
10 year UK	Bank of England (zero coupon)	full sample		4:30pm London time
5 year UK	Bank of England (zero coupon)	full sample		4:30pm London time
2 year UK	Bank of England (zero coupon)	full sample		4:30pm London time
1 year UK	British Bankers Association	full sample		11am London time
3 month UK	British Bankers Association	full sample		11am London time
10 year Germany	Bloomberg (yield to maturity)	full sample		noon Eastern time
5 year Germany	Bloomberg (yield to maturity)	2/1991	12/2002	noon Eastern time
2 year Germany	Bloomberg (yield to maturity)	9/1990	12/2002	noon Eastern time
1 year Germany	British Bankers Association	full sample		11am London time
3 month Germany	British Bankers Association	full sample		11am London time
10 year Japan	Bloomberg (yield to maturity)	full sample		6am Eastern time
5 year Japan	Bloomberg (yield to maturity)	4/1988	12/2002	6am Eastern time
2 year Japan	Bloomberg (yield to maturity)	9/1990	12/2002	6am Eastern time
1 year Japan	British Bankers Association	full sample		11am London time
3 month Japan	British Bankers Association	full sample		11am London time

Notes: Full sample means calendar years 1987 to 2002, inclusive.

Table 3
Estimated Coefficients in Regression of 20-minute Exchange Rate Returns on Announcement Surprise

Data Release	DM/Euro		Pound		Yen	
	β	R^2	β	R^2	β	R^2
CPI	3.92	0.00	-5.16	0.00	8.94	0.00
Fed Funds Rate	-1.25***	0.22	-0.72***	0.21	-0.65**	0.09
GDP	-13.80***	0.18	-8.15***	0.10	-7.98***	0.08
Housing Starts	-25.26*	0.02	-15.21	0.01	-13.67	0.01
Initial Unemployment Claims †	-0.16***	0.04	-0.09***	0.02	-0.11***	0.02
Nonfarm Payrolls	-0.13***	0.21	-0.10***	0.21	-0.07***	0.16
PPI	-1.23	0.00	-8.37*	0.02	-0.11	0.00
Retail Sales	-14.16***	0.15	-12.12***	0.19	-5.59***	0.05
Trade Balance	-10.09***	0.24	-7.13***	0.20	-7.54***	0.16
Unemployment †	-57.51***	0.07	-48.69***	0.09	-29.43***	0.05

Notes: This table reports the coefficient in a regression of the returns from 5 minutes before the data release to 15 minutes after the release on the surprise component of that data release (equation (1)). One, two and three asterisks denote significance at the 10%, 5% and 1% levels, respectively, using White standard errors. No constant is included in the regression. The (uncentered) R-squared from each regression is also reported. A positive exchange rate return denotes dollar depreciation. Exchange rate returns are continuously compounded, multiplied by 10,000. So the elements of the table can be interpreted as the effect of a one unit surprise on the exchange rate, in basis points. The signs of the announcement surprises in the countercyclical indicators denoted with the † symbol have been flipped.

Table 4
Relative Standard Deviation of Intradaily Asset Price Changes Over Announcement and Non-Announcement Windows

	Initial Claims	CPI	GDP	Starts	Nonfarm Payrolls	PPI	Retail Sales	Trade Balance	Fed Funds
DM/Euro	1.31	1.48	2.23	1.33	2.98	2.39	1.53	3.04	2.08
Pound	1.26	1.44	2.04	1.42	2.62	1.78	1.34	2.72	1.52
Yen	1.17	1.53	2.01	1.16	1.98	2.12	1.12	2.90	1.73
US 10 year	1.56	2.54	2.95	1.33	5.17	2.69	2.78	1.04	3.10
US 5 year	1.61	2.48	3.12	1.31	5.78	2.64	2.89	1.07	3.79
US 3 month	1.84	2.15	2.7	1.48	5.48	2.11	2.45	1.1	5.08
GE 10 year	1.24	1.59	1.62	1.05	2.93	2.2	1.69	1.19	
UK 10 year	0.9	1.3	1.55	0.96	1.85	1.52	1.28	0.91	
JP 10 year	1.11	1.55	1.23	1.07	2.88	1.54	1.47	1.26	
UK 3 month	1.18	1.21	1.64	1.89	1.47	1.36	0.94	1.49	
GE 3 month	1.02	1.14	1.06	1.07	2.61	1.72	1.29	1.41	

Notes: This table reports the standard deviation of intradaily interest rate changes over the 20 minutes window around each macro announcement, divided by the standard deviation of interest rate changes over the same window on days when there is no macro announcement. The results for the unemployment release are identical to those for nonfarm payrolls (and hence not shown separately) because the unemployment and nonfarm payrolls releases are always simultaneous.

Table 5
Nyblom Stability Test in Regressions on Macroeconomic Surprises

	Initial Claims	CPI	GDP	Starts	Nonfarm Payrolls	PPI	Retail Sales	Trade Balance	Unemp	Fed Funds
DM/Euro	0.23	0.31	0.11	0.07	0.42*	0.11	0.16	7.00***	0.15	0.16
Pound	0.44*	0.18	0.06	0.11	0.66**	0.16	0.13	6.98***	0.09	0.16
Yen	0.18	0.44*	0.09	0.05	0.38*	0.07	0.06	6.76***	0.11	0.15
US 3m	0.59**	0.48**	0.06	0.15	2.03***	0.58**	0.06	0.21	0.15	0.62**
US 1y	0.20	0.63**	0.10	0.15	0.72**	0.82***	0.15	0.11	0.04	0.25
US 2y	0.65**	0.14	0.16	0.43*	0.37*	0.86***	0.23	0.16	0.07	0.24
US 5y	0.39*	0.16	0.14	0.36*	0.27	0.67**	0.14	0.23	0.07	0.13
US 10y	0.34	0.32	0.14	0.32	0.16	0.72**	0.21	0.31	0.12	0.15
Ge 3m	0.28	0.20	0.07	0.03	0.83***	0.12	0.05	0.23	0.67**	0.22
Ge 1y	0.12	0.19	0.34	0.29	0.35*	0.38*	0.03	0.28	0.29	0.06
Ge 10y	0.18	0.08	0.12	0.21	0.04	0.22	0.63**	0.09	0.23	0.14
UK 3m	0.02	0.51**	0.15	0.10	0.46**	0.31	0.13	0.80***	0.34	0.22
UK 1y	0.67**	0.43*	0.37*	0.30	0.15	0.33	0.13	0.14	0.03	0.10
UK 10y	0.76***	0.70**	0.16	0.10	0.25	0.17	0.08	0.12	0.20	0.15
JP 3m	0.42*	0.07	0.13	0.18	0.72**	0.04	0.28	0.39*	0.07	0.32
JP 1y	0.03	0.12	0.04	0.09	1.47***	0.07	0.04	0.28	0.33	0.10
JP 10y	0.10	0.29	0.27	0.31	0.08	0.56**	0.16	0.18	0.04	0.21

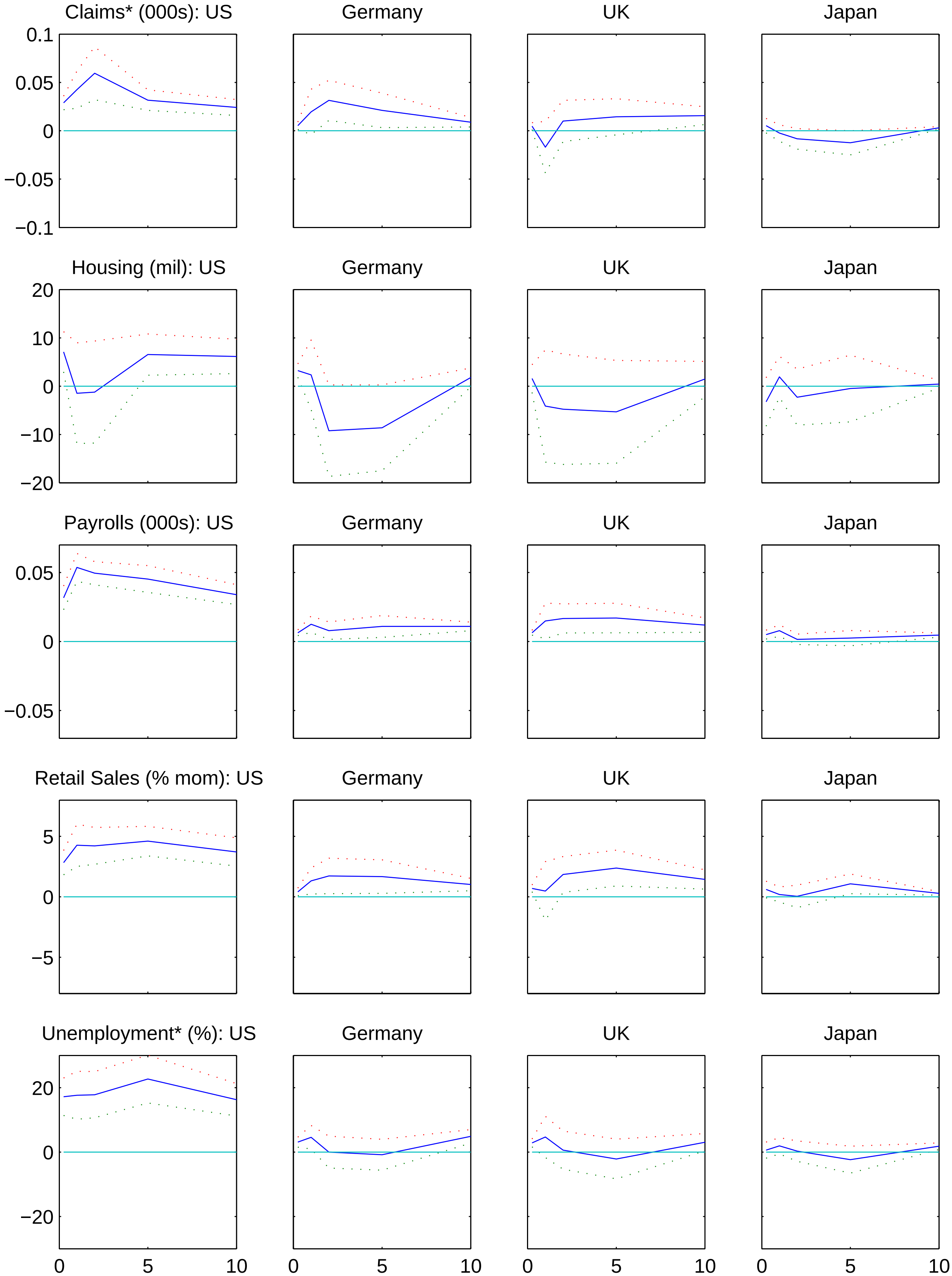
Notes: This table reports the Nyblom test for parameter constancy in equation (1). One, two and three asterisks denote significance at the 10%, 5% and 1% levels, respectively.

Table 6
Sup F Stability Test in Regressions on Macroeconomic Surprises

	Initial Claims	CPI	GDP	Starts	Nonfarm Payrolls	PPI	Retail Sales	Trade Balance	Unemp	Fed Funds
DM/Euro	3.59	5.22	2.59	1.84	8.16*	2.60	4.44	86.45***	2.96	3.00
Pound	4.54	7.62*	2.22	3.88	12.49**	3.80	2.77	85.87***	1.57	2.61
Yen	2.78	7.39*	1.98	0.73	6.52	1.09	1.57	88.49***	1.75	2.60
US 3m	5.55	5.19	1.88	2.42	24.66***	35.39***	1.11	3.50	2.31	8.70*
US 1y	4.12	7.27*	2.56	2.51	10.25**	36.13***	3.72	1.54	0.70	3.14
US 2y	8.40*	5.57	3.84	7.26*	6.64	18.69***	3.39	6.63	1.09	1.66
US 5y	6.24	5.06	2.99	6.10	5.32	17.82***	2.34	7.27*	1.80	0.52
US 10y	5.51	8.10*	2.86	4.40	5.23	20.19***	3.13	6.36	2.75	1.32
Ge 3m	3.70	2.45	2.33	0.46	8.49	4.16	3.58	4.69	9.52**	7.42*
Ge 1y	4.40	2.70	4.39	4.40	5.86	7.35	1.18	3.48	6.12	3.07
Ge 10y	2.87	2.64	3.59	3.77	1.30	3.36	7.37*	2.05	4.53	1.84
UK 3m	0.26	7.24*	3.81	1.89	10.23**	4.86	1.99	13.81***	8.60*	3.89
UK 1y	14.60***	6.20	6.32	16.66***	6.23	4.20	4.41	3.52	0.68	1.42
UK 10y	8.52*	13.51***	2.87	1.72	4.77	7.23*	1.59	1.59	3.39	1.83
JP 3m	8.46*	1.98	3.58	6.39	12.19**	2.73	3.38	4.89	2.09	4.98
JP 1y	1.72	2.68	1.26	1.53	21.75***	1.78	0.94	4.29	6.00	2.75
JP 10y	1.47	3.59	6.68	4.57	1.37	5.94	2.36	3.08	0.94	3.87

Notes: This table reports the sup F test for parameter constancy in equation (1). One, two and three asterisks denote significance at the 10%, 5% and 1% levels, respectively.

Fig. 1: Effect of Macro Surprises on Interest Rates of Different Maturities (years)



*: The Sign of Surprises in these Countercyclical Indicators Has Been Flipped

Fig. 2: Effect of Macro Surprises on Interest Rates of Different Maturities (years)

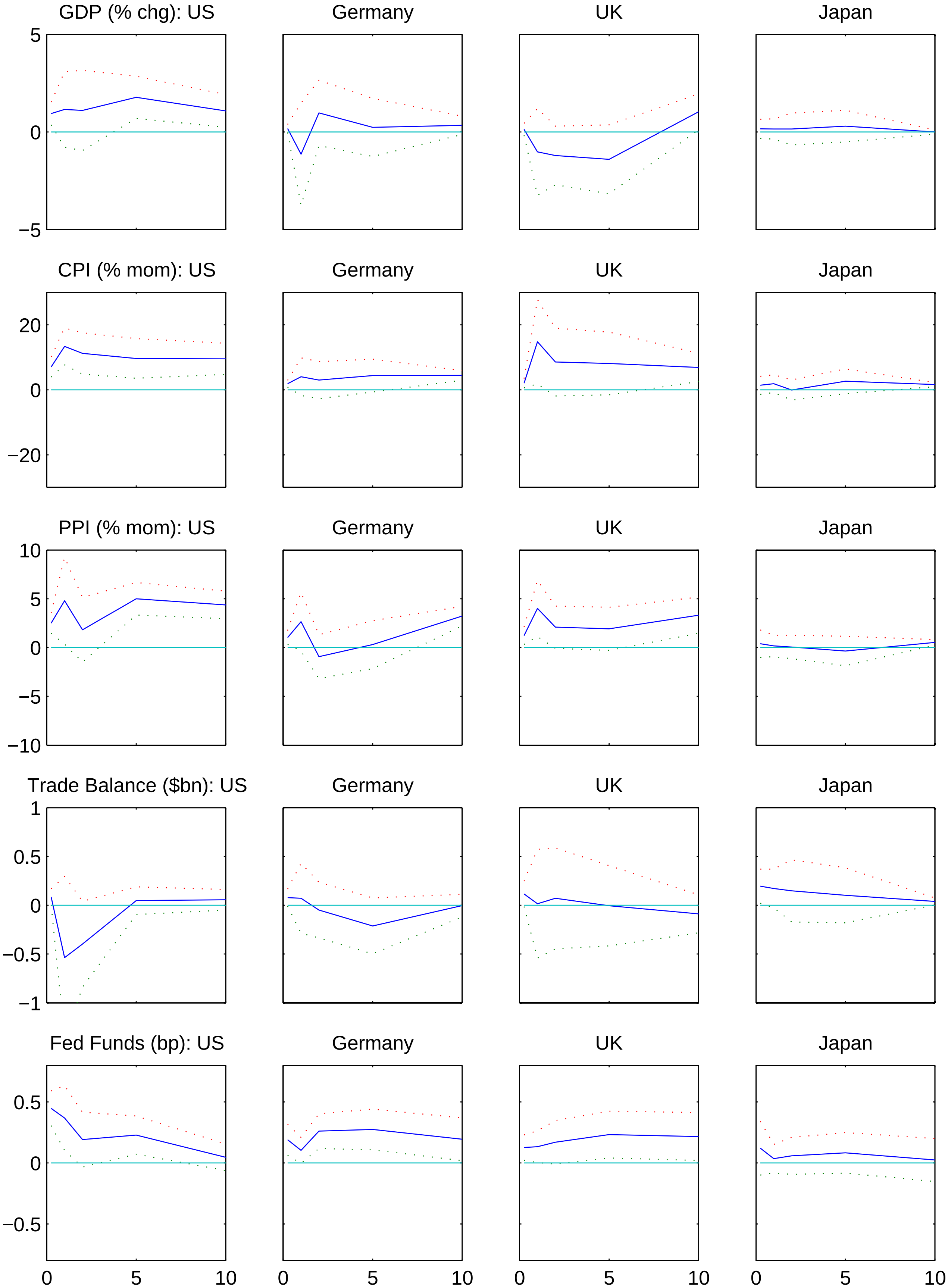
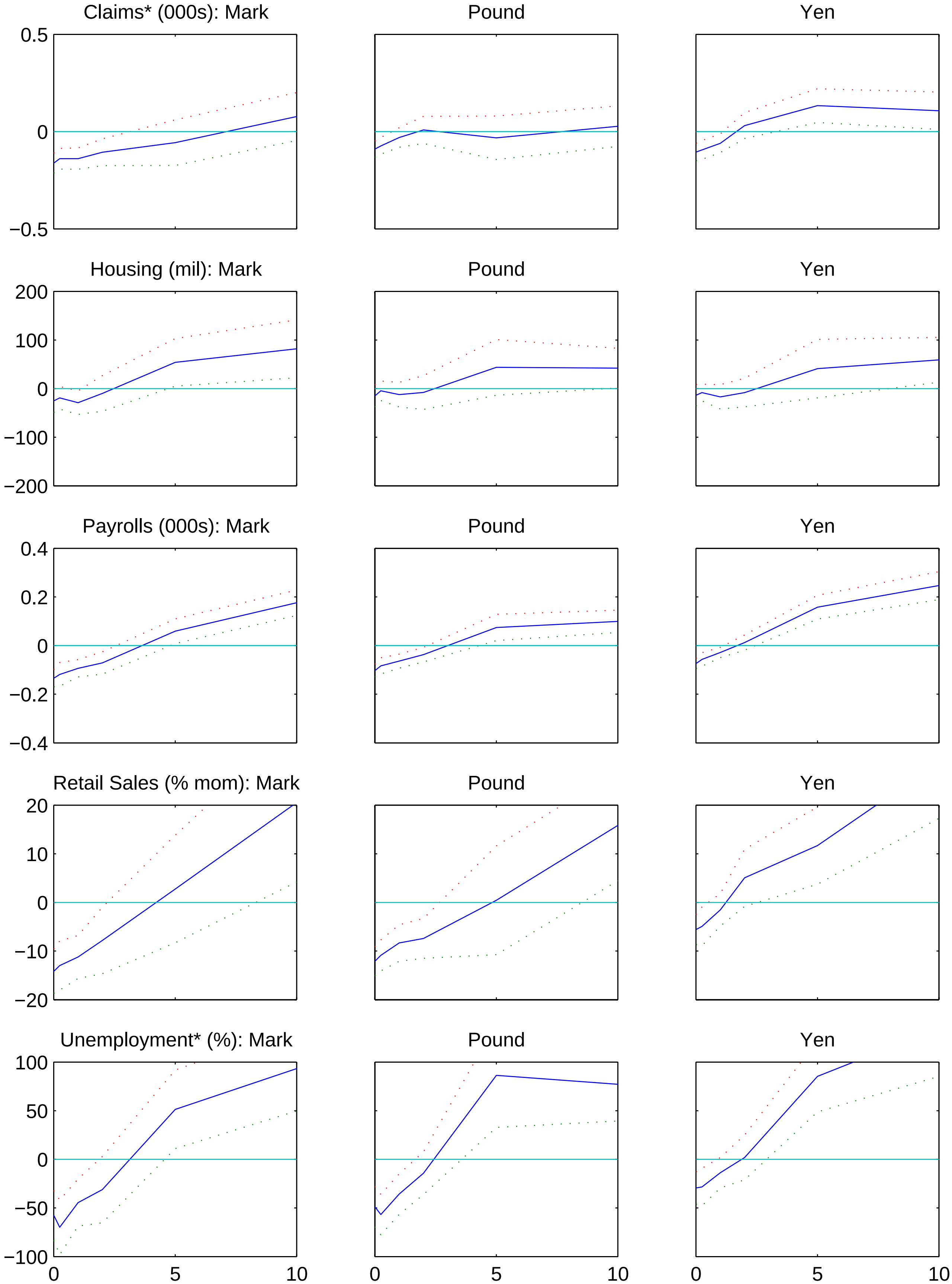


Fig. 3: Effect of Macro Surprises on Exchange Rate at Different Horizons (years) Assuming Conditional UIP



*: The Sign of Surprises in these Countercyclical Indicators Has Been Flipped

Fig. 4: Effect of Macro Surprises on Exchange Rate at Different Horizons (years) Assuming Conditional UIP

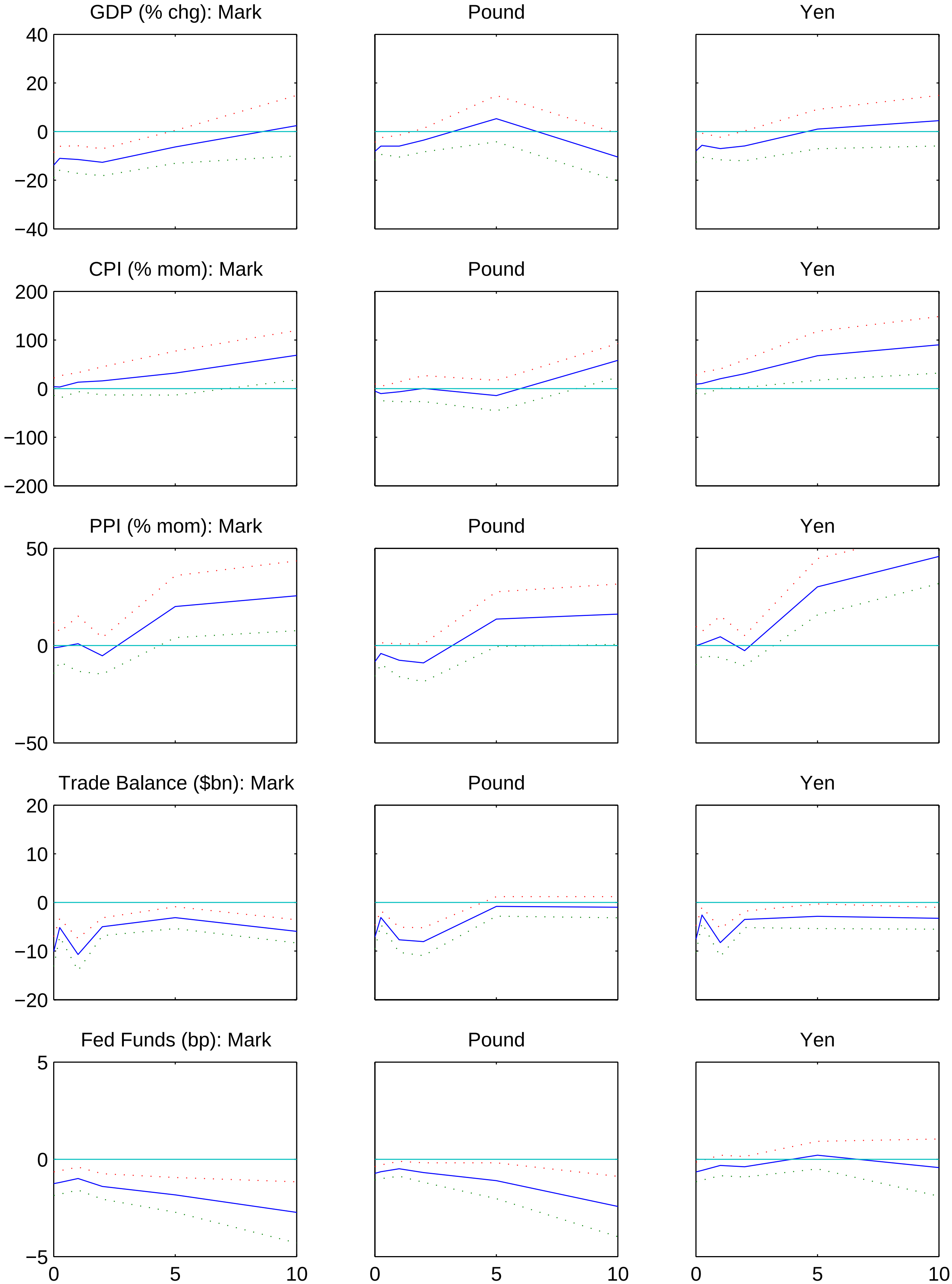
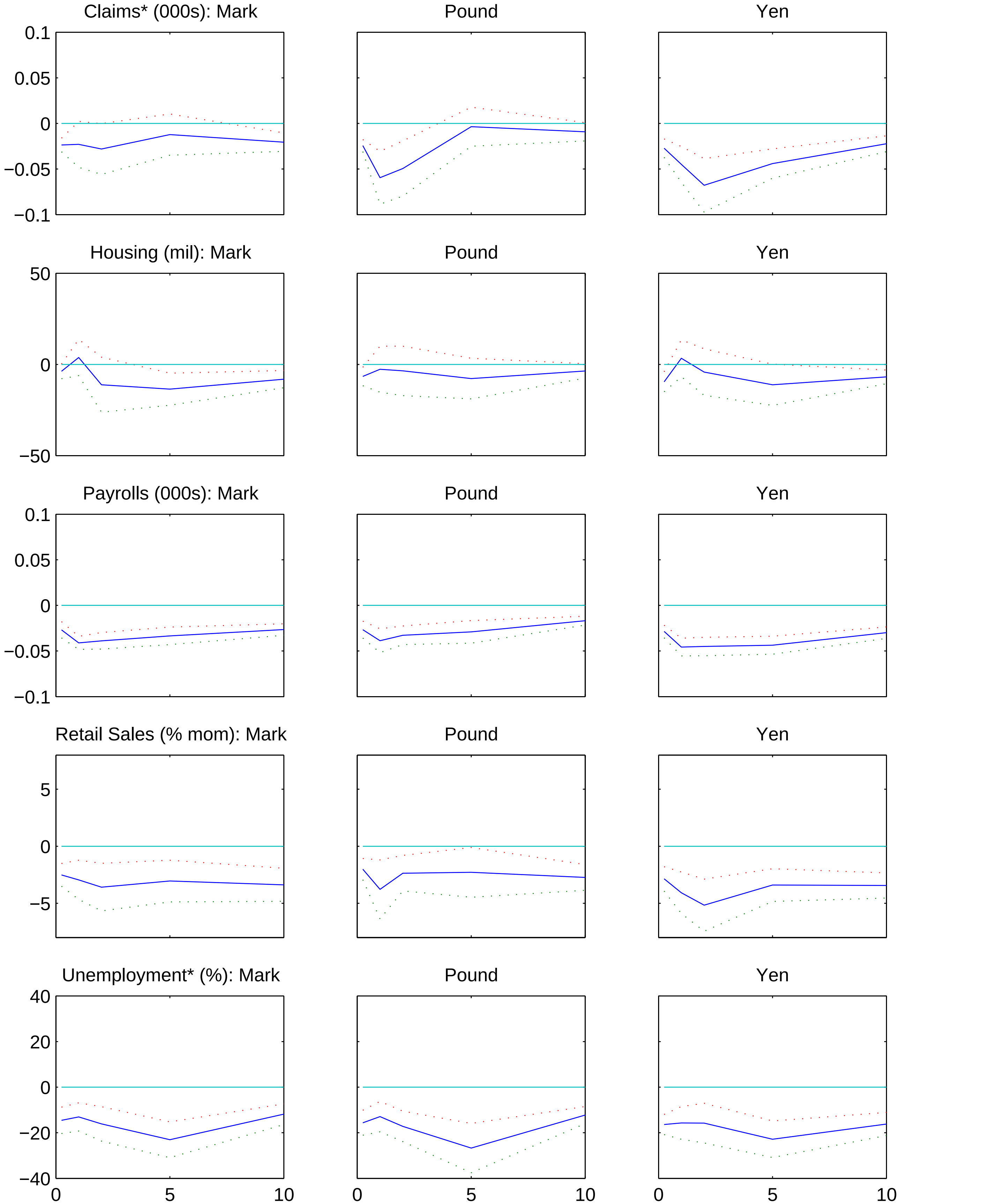


Fig. 5: Effect of Macro Surprises on Risk Premia at Different Horizons (years) Assuming RW Exchange Forecasts



*: The Sign of Surprises in these Countercyclical Indicators Has Been Flipped

Fig. 6: Effect of Macro Surprises on Risk Premia at Different Horizons (years) Assuming RW Exchange Forecasts

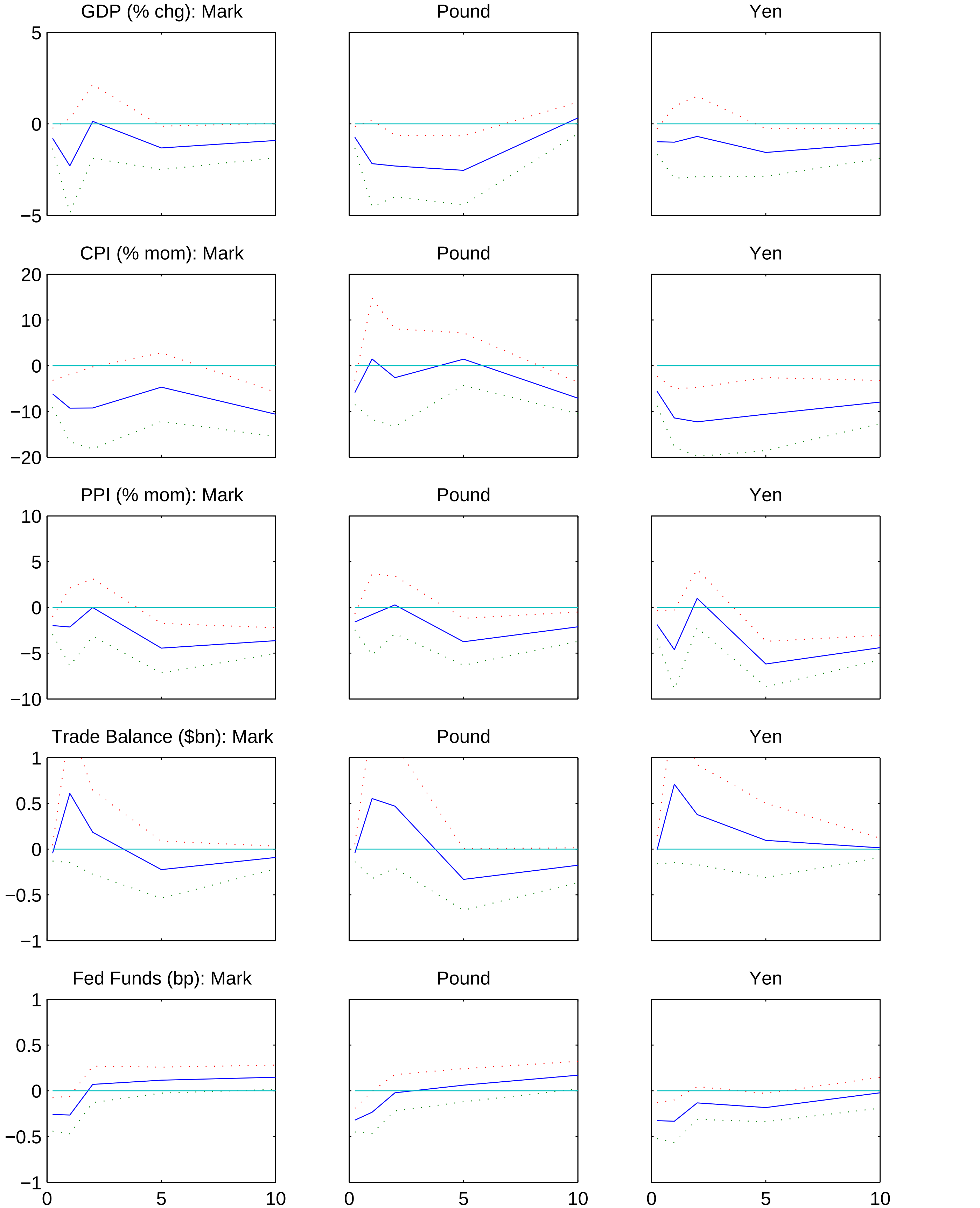


Figure 7: Smoothed Estimates of the Effect of Nonfarm Payrolls Surprise

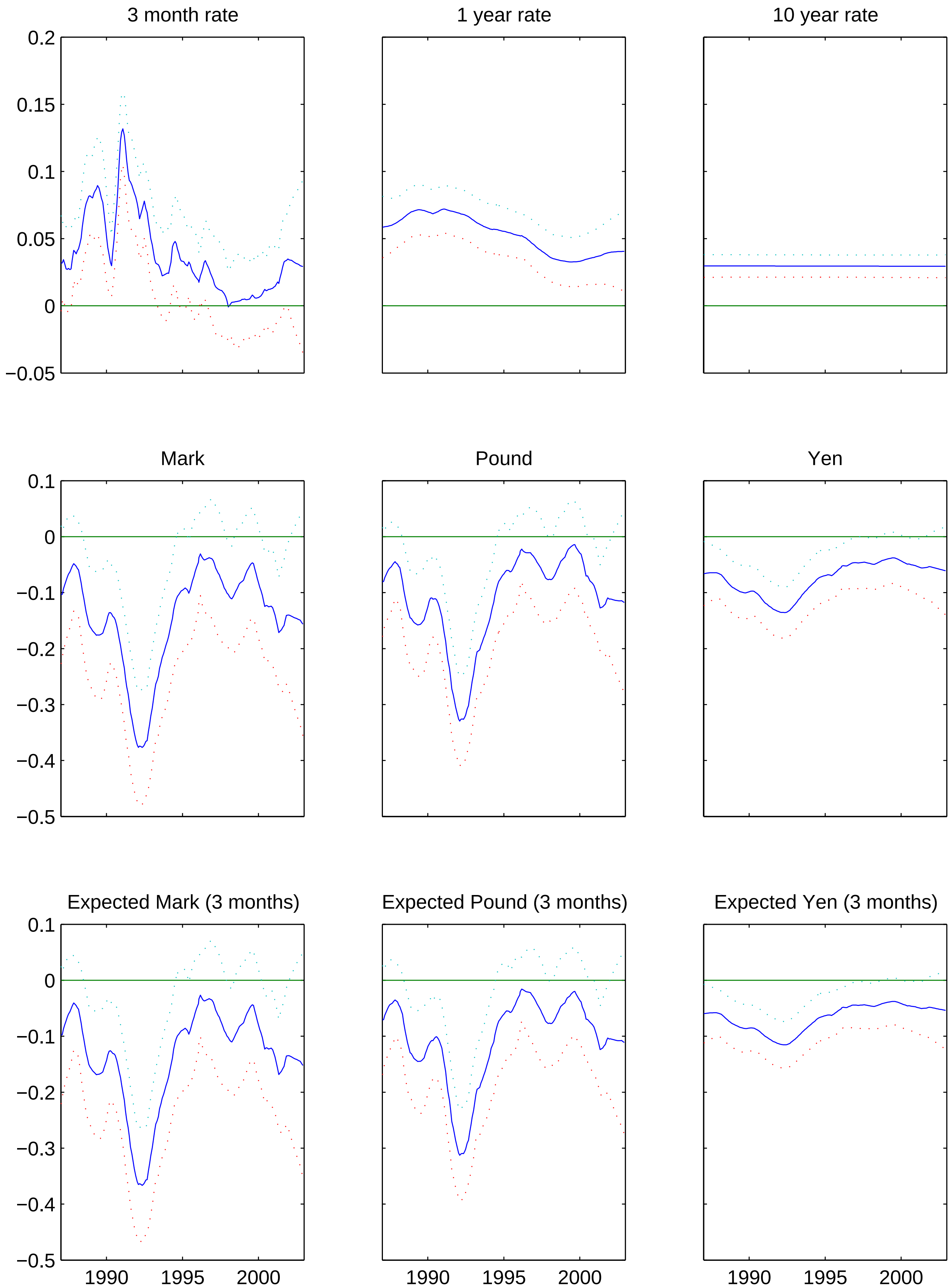


Figure 8: Smoothed Estimates of the Effect of PPP Surprise

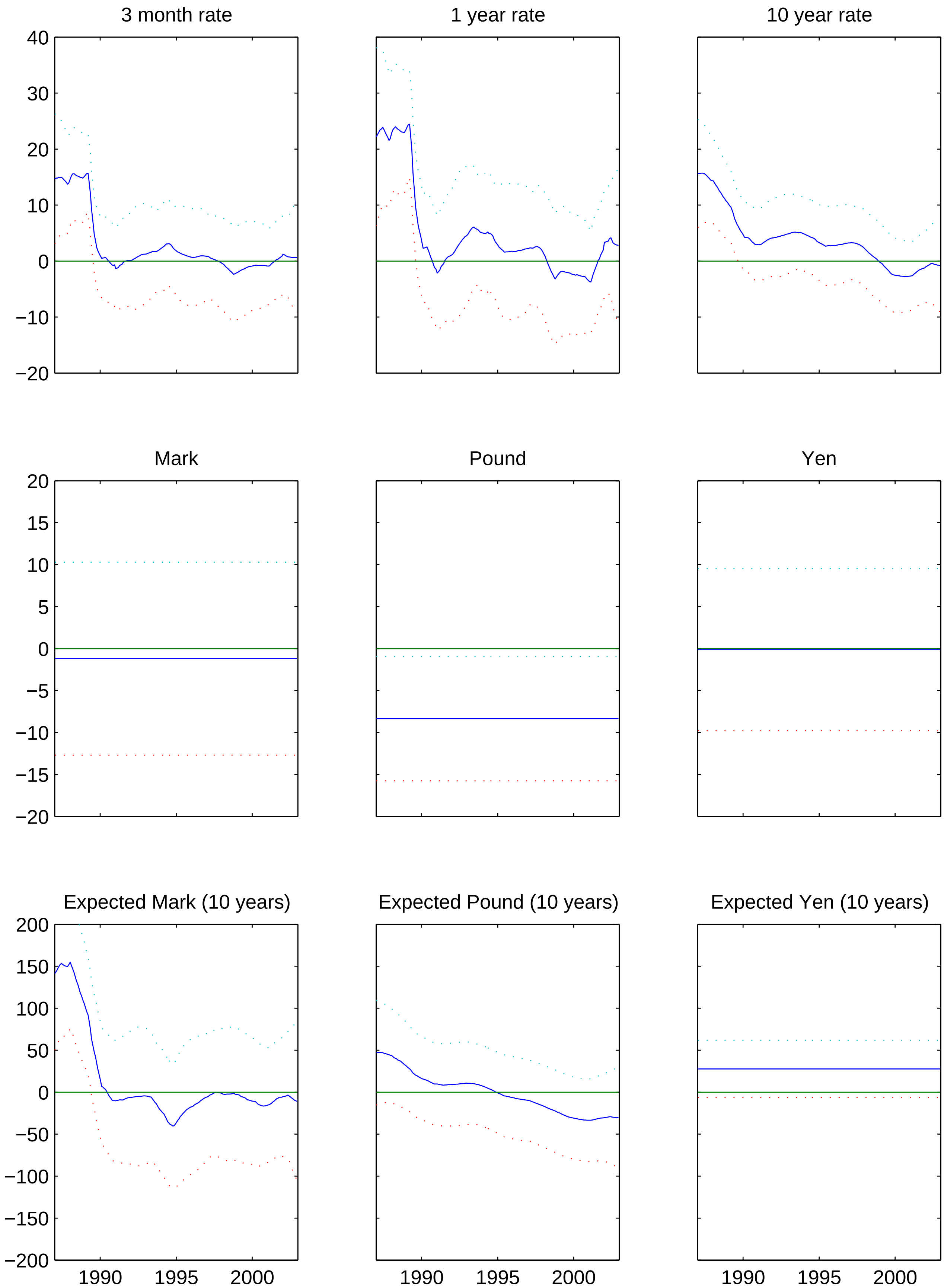


Figure 9: Smoothed Estimates of the Effect of Trade Balance Surprise