Foreign Exchange Responses to Macroeconomic Surprises: Playing “Peek-a-Boo” with Financial Markets

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*The Duke Community Standard was upheld in the completion of this thesis.*
Abstract
This paper explores the relationship between precisely timed macroeconomic “news” (or “surprises”) and the immediate currency price fluctuations that surround them. Using data from 2005-2011, I find significant movements in foreign exchange markets around a variety of announcements (unemployment, GDP, retail sales, inflation) for three different countries (United States, Australia, Canada). My results demonstrate that in the very short-run, as in the long run, the value of a country's currency is driven by its macroeconomic fundamentals. Upon further investigation, this paper also uncovers the following financial phenomena in these foreign exchange responses to macroeconomic surprises: asymmetric response, nonlinearity, financial stress, liquidity, and exchange rate specificity. These phenomena refer to the difference in responses between: positive and negative surprises, big versus small surprises, pre-crisis versus crisis surprises, ten- versus sixty-minute returns, and two distinct reference currencies, respectively.

Acknowledgements
I would have been unable to write this thesis without the assistance of many mentors, peers and friends. First and foremost, I owe my sincerest gratitude to my advisor, Professor Andrew Patton, who accomplished the impressive feat of remaining patient throughout my incessant, and sometimes repetitive, questions, while providing invaluable insight and encouraging me to push the boundaries of my research even further. In addition, I would like to thank the following faculty members for their constructive criticisms and comments throughout the process: Kent Kimbrough, Marjorie McElroy, Tim Bollerslev and George Tauchen.

My last two sources of gratitude are a bit more conceptual. First, I would like to thank Duke University for providing me with the tools to explore my academic curiosity. I am incredibly proud of this work, and know that its merit is due, in large part, to the education I received here in Durham, North Carolina.

Finally, I would like to thank my family and friends for always providing a sounding board to my relentless stream of thoughts. I understand that it might not always be fun to listen to me talk about economics, but I truly appreciate that you do anyways while rolling your eyes only once in a while.

Keywords: foreign-exchange, exchange rates, high-frequency data, liquidity, news, announcements, surprises, asymmetric response, nonlinearity, exchange-rate specificity

JEL Codes: E0, F0, F31, G0, G01, G13, G14, G15
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Section 1. Introduction

How are announcements of macroeconomic fundamentals reflected in the foreign exchange market? Traditional economic thinking dictates that the value of a country’s currency is derived from the strength of its underlying economy. This theory has become diluted in recent decades due to financial globalization and the introduction of foreign exchange trading. In a seminal work on the topic, Meese and Rogoff (1983) make the compelling case that exchange rate movements are random, and thus cannot be predicted by a domestic economy’s health.

Since then, a plethora of research has suggested otherwise. While the economics profession has always been certain that macroeconomic fundamentals drive exchange rates over the long run (e.g. Mark and Sul, 2001), only recently have their effect on short run exchange rates been documented. At the same time, the advent of high-frequency data recording has allowed researchers to redefine the “short run.” Instead of being limited by monthly, weekly or even daily data, researchers can now explore the minute-by-minute returns of many asset types, including currencies. Over the past three decades, researchers have taken advantage of this data availability to study whether fundamentals (namely, their announcements) affect exchange rates in the extreme short run—over windows of, say, 10 and 60 minutes. This study uses similar high frequency foreign exchange rate data to study near-instantaneous reactions of financial markets to macroeconomic news, allowing it to assume that all price movements during a narrow time interval are driven by the announcement itself. This assumption would be more questionable with the traditional use of daily or monthly data.

The true spirit of this paper investigates how markets incorporate information. When an announcement is made and differs from its expectation, new information regarding an asset’s fundamental value is provided. An efficient market should react so that the new asset price represents its new fundamental value. If the announcement does not differ from the expectation, no new information is provided and the market should have already incorporated the implications of the announcement into the asset’s price.

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1 This paper was the first to strongly argue that the “random walk hypothesis” applied to foreign exchange markets.
I utilize an empirical framework to examine the foreign exchange rate response to certain announcements of macroeconomic fundamentals that denote a nation’s economic health. Using datasets from Bloomberg, a large financial firm and the Duke University Department of Economics, I quantify the price jumps in the markets around macroeconomic announcements of three different countries. I find that “surprises” or “news” (defined as the difference between the announcement and market expectations) over these macroeconomic fundamentals produce significant movements in the values each country’s domestic currency. In this way, I corroborate and elaborate upon earlier research.

However, this paper distinguishes itself from previous work by expanding the scope of its research question. In addition to confirming the overall effect of news on high frequency fluctuations, as earlier studies have done, this paper uncovers patterns in how certain types of macroeconomic news affect foreign exchange markets. I utilize five different tests to expose whether these foreign exchange responses exhibit the following types of financial phenomena: asymmetric response, nonlinearity, financial stress, liquidity, and exchange-rate specificity. Let me discuss them briefly in turn.

Asymmetric response predicts that financial markets respond in an unbalanced manner to “good” and “bad” surprises. Conrad, Cornell and Landsman (2001) analyze the reaction of stock prices to 24,108 earnings announcements between 1988 and 1998 to find that stock markets react most strongly to “bad” news during “good” times. This paper studies whether a similar conclusion holds in currency markets.

Nonlinearity refers to the relationship between the magnitude of the immediate price fluctuation and the size of the surprise itself. If the market reacts linearly, each marginal unit of surprise should have an equal impact on asset’s immediate return. However, if this were not the case, we might find that the market reaction is a more complicated response.

Financial stress refers to the state of the financial system. During a typical business cycle, market participants behave differently throughout the various economic environments, such as a recessionary or expansionary period. It is therefore reasonable to expect investment and consumption patterns to change depending on the level of financial stress present. The time horizon of this paper—2005 to 2011—includes a deep global
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recession that began in January 2008, as defined by the International Monetary Fund (IMF). Using this date as a benchmark, this paper demonstrates that financial markets behaved much differently during the crisis than before.

In a perfectly liquid market, we would expect macroeconomic news to be immediately incorporated in the foreign exchange market. However, if this were not the case, it might take longer for the full effect of the surprise to take place. Thus, by observing the response over increasing intervals of time, we can determine the liquidity of the market itself.

“Exchange-rate specificity” refers to the hypothesis that macroeconomic surprises will manifest themselves differently in different exchange rates. Possible explanations include liquidity, varying domestic economic conditions, trading relationships, etc.; however, it follows that certain exchange rates will react more quickly and strongly than others. This paper will therefore compare the reactions of United States announcements in the markets for the USD using five different currency pairs: USDCAD (Canada), USDAUD (Australia), USDGBP (Great Britain), USDJPY (Japan), and USDEUR (Europe).

Another unique aspect of this study is the time frame it investigates. To my knowledge, my paper is the first to consider the most recent of financial data, between 2005 and 2011. Not only does this allow me to accomplish the financial stress test, but also makes the results more relevant to the future of economic research, as financial markets have evolved greatly over the past decade.

Finally, my paper also differentiates itself by considering macroeconomic announcements for multiple countries—Australia, Canada and United States. Such broad inclusion of nationalities allows us to draw more general conclusions than merely studying a single country.

In the most general sense, my results are similar to and consistent with those of earlier studies. I, too, find a significant relationship between exchange rate movements and macroeconomic surprises. Several studies have uncovered a similar correlation. My results

\begin{footnote}{Note that this may not be the traditional, widespread definition of “liquidity,” which often refers the ability to buy and sell an asset quickly without affecting its price. However, I will argue later that there is a strong relationship between this definition of an asset's liquidity and the amount of time required to incorporate information into its price.}
can be interpreted as confirming and expanding upon these prior papers using more recent data and various tests of financial phenomena.

This paper proceeds as follows. In Section 2, it provides an overview on the relevant economic and financial literature. In Section 3, it describes and defends the data used. In Section 4, it details the methodology utilized to provide the overall and test results. In Section 5, it provides the results along with a detailed interpretation. Finally, it concludes and offers suggestions for future research in Section 6.

Section 2. Literature Review

The economic literature of the importance of announcements is exceptionally comprehensive and contradictory. Though numerous studies have suggested a substantial power of announcements on market fluctuations, others claim perfectly otherwise, stating the effect of announcements is overstated and unimportant. Interestingly, throughout the past four decades, this same literature has exhibited a noticeable trend towards the conclusion that announcements are effective harbinger of immediately following price fluctuations. This pattern has coincided with the advent of high frequency data keeping. I will provide an overview of the major studies in reverse chronological order in order to highlight this pattern.

Clarida and Waldman (2007) look at the effects of a single independent variable— inflation surprises—on high frequency foreign exchange values in ten different countries. More specifically, they try to understand how the stated policy of a country’s central bank influences the transmission mechanism by which inflation surprises are reflected in the foreign exchange data. The countries included in their study reflect two different, relevant policies: inflation-targeting and non inflation-targeting. Inflation-targeters include countries whose central banks raise interest rates in response to higher-than-expected inflation. They find that, in such inflation-targeting countries, positive inflation surprises actually appreciate a currency, as investors expect the central bank to react by increasing interest rates, resulting in greater returns on the domestic currency. In addition, they find the effect of an inflation surprise to become more pronounced if the central bank has a reputation for more aggressive inflation targeting.
Evans and Lyons (2007) considered both direct and indirect effects via order flow of foreign exchange responses to macroeconomic surprises. The direct effect is the most obvious—that public news reveals incremental information that affects the fundamental drivers of an asset’s value, which is immediately reflected on the market. The indirect effect, central to the theory of order-flow, refers to the trading decisions once the direct effect has taken place and the market quote has been adjusted, thereby allowing traders to act on their personal opinions of the implications of the news. For example, if the market receives news of unexpectedly high inflation in the United States, dealers might immediately quote a higher yen/dollar rate. This is the direct transmission mechanism. However, market participants might view this risen exchange rate as too high or too low. Those that view the adjustment as too small will purchase dollars, while those that view the adjustment as too large will sell dollars. This is the indirect transmission mechanism. The authors found that two thirds of the effect of macroeconomic news on foreign exchange prices is transmitted via this indirect mechanism, the remainder being the direct effect of the news. These two effects combine to be responsible for 36% of the foreign exchange price variance within daily data. My study, however, focuses on this direct effect as it concerns immediate reactions, as opposed to reactions to those immediate reactions.

Faust, Rogers, Wang and Wright (2003) consider the joint effect of macroeconomic surprises on the exchange rates and interest rates in the United States over the time period between 1987 and 2002. More specifically, the authors analyzed the foreign exchange and zero-coupon bond markets in the context uncovered interest rate parity, which predicts how the two markets will react to one another. The authors utilized two dependent variables and included a longer span than is typically found in most other papers, but only focus on one country—the United States. The list of included macroeconomic surprise variables is vast: CPI, PPI, Fed Funds target, GDP, unemployment rate, initial unemployment claims, housing starts, nonfarm payrolls, retail sales, and trade balance. For many macroeconomic releases, the authors found that a positive surprise tends to appreciate the dollar immediately while lowering the risk premium to holding the foreign currency.

Fair (2003) completed a study that is also very pertinent to this investigation. He considers a 17-year time horizon, and identified incidences when S&P 500 futures values
changed by at least 0.75 percent over a five-minute interval. He proceeds to perform newswire searches to identify whether an important event occurred at that time. Surprisingly, he was able to identify market-implicating events in 32.4 percent of days where such extreme volatility occurred, and most often the event was a macroeconomic announcement dealing with monetary policy. This finding supports this study’s hypothesis that macroeconomic announcements are important determinants to foreign exchange rates in a narrow time window surrounding the release of an macroeconomic announcement. Whereas Fair only considered large events, this study looks at the average effects of all announcements on changes in exchange rates.

Anderson, Bollerslev, Diebold and Vega (2002) produced an important work on the subject in which they discover that announcement surprises produce conditional mean jumps in real-time exchange rate quotations. They analyze six years of data, between 1992 and 1998, to conclude that news about “fundamentals” are incorporated into high-frequency foreign exchange rates, contrary to the “random walk” theory popularized by Meese and Rogoff (1988) that states exchange rate fluctuations cannot be predicted by fundamentals or economic variables. Moreover, this study finds that these conditional jumps exhibit an asymmetric response pattern such that bad news (negative surprises) generates greater impacts than good news (positive surprises).

Note that all papers described above were written within the past decade. However, even earlier studies in previous decades confirmed similar conclusions. In particular, Goodhart, Hall, Henry, and Pesaran (1993) utilized one year of high-frequency Dollar/Pound exchange rates and two specific news events—a U.S. trade figure announcement and a U.K. interest rate change—to show that the news of both events caused exchange rate movements. Almeida, Goodhart and Payne (1998) produced examined three years of high-frequency DM/Dollar exchange rates and a more comprehensive list of news announcements to also uncover short-lived news effects. In addition, Dominguez (1999) makes a strong case that the ten seconds immediately following a macroeconomic news announcement are most vulnerable to extreme exchange rate changes.

However, naysayers are present in the economics literature. Notably, Cutler, Poterba and Summers (1989) challenged the widespread notion that financial asset prices
are wholly, or even significantly, impacted by the arrival of fundamental news. They used monthly stock returns between 1926 and 1985 and seven measures of monthly economic activity; however, because they did not have actual expectation data, they instead fit vector auto regressions on the seven variables, comparing their current values to their own lagged expectation value. They treated the resulting residuals as news and used them as explanatory variables for stock movements. The authors found difficulty of using publically available news regarding fundamentals to explain two-thirds of variance in stock prices. However, they did note that most of the macroeconomic news variables affect returns with statistically significant coefficients.

This view was shared by Roll (1984) who produced perhaps the most creative paper on the topic. He studied the market of orange juice futures, whose price is largely driven by temperature forecasts. Indeed, as Roll points out, it seems unlikely that supply and demand for orange juice futures is driven by anything other than temperature. Thus, using daily price data and weather values from the National Weather Service, Roll examined the effect of temperature surprises on OJ futures values. Indeed, even though weather has the most obvious impact on orange juice—and can be considered its strongest fundamental—Roll found that weather surprises constitute only a small fraction of variability in price of orange juice futures.

As explained earlier, this paper differentiates itself in a number of ways from this existing literature, particularly in the time period it considers, number of countries utilized, exchange rates used, and financial phenomena exhibited. Additionally, the focus of this thesis is slightly different from many of the works referenced earlier in this section. Rather than explaining asset variance by virtue of announcements, I hope to quantify the extent to which certain types of announcements increase or decrease asset values with a focus on particular subsets of surprises. This is the next logical step of research in this particular field of economics, once the profession accepts the insight that announcements matter. In this way, this paper will provide a valuable addition to existing research.

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3 Note that Roll was careful to only state that temperature was the driving fundamental of the market for orange juice futures, not orange juice itself. Indeed, the market for orange juice is likely driven by more traditional supply and demand factors, such as income, price of substitutes, input costs, etc.
Section 3. Data and Variables

Perhaps the biggest obstacle in accomplishing such a study is obtaining data that allows me to measure asset price changes in a narrow enough window around the macroeconomic announcement. If I choose a small enough window, then I can make one of two assumptions: (1) that the announcement is the only information hitting the market, or (2) the announcement dominates the immediate fluctuations in asset prices. Importantly, these assumptions allow me to treat these tight windows around such announcements as a natural experiment. This concept—that the announcement drives all exchange rate movements in such a narrow interval—remains the strongest assumption that underlies my interpretation of the results and also allows me to utilize an elegantly simple methodology, described later. To allow for comparability with earlier studies, I will confine the attention of this study to a 10-minute window around the time of the announcement.

Section 3.1 Foreign Exchange (FX) Data

First, I will clarify the exchange-rate conventions used in this paper to avoid future confusion. I use the market standard of quoting currencies. When describing any exchange rate for a particular country, I state the domestic currency (DOM) as the base and foreign currency (FOR) as the reference of the currency pair, such that DOMFOR denotes the amount of foreign units required to purchase one domestic unit. In this way, the value of any given currency pair can be considered the price of the domestic currency. For example, USDAUD denotes the number of Australian dollars required to purchase one United States dollar, and can thus be considered the price of the USD.

Section 3.1.a Canada, Australia

Among Canada and Australia, this study utilizes exchange rates that include the United States dollar as the reference currency. The explanation for this deliberate decision is twofold. The most prominent reason to use USD as the reference currency is because it is the most liquid currency in the world. In 2010, USD was the most traded currency by a sizeable margin, constituting 84.9 percent of all transactions on the foreign exchange
market—\(^4\) a key measure of an asset's liquidity. Thus, when market participants react to news about the Canadian or Australian economies, they likely first look to trade on the CADUSD and AUDUSD markets, respectively. In this way, if macroeconomic surprises of Canada and Australia are to be manifested in any exchange rate, it would very likely be paired against the USD. Because of its extreme liquidity, any exchange rates that include the USD will be the most accurate when studying the subtle fluctuations of the domestic currency over narrow time intervals surrounding macroeconomic announcements.

An additional reason to use the USD as the reference currency is that the United States represents a major trading partner for both Canada and Australia. This is especially true for Canada, as the United States accounts for 70.2 percent of exports and 61.7 percent of imports in 2009.\(^5\) For Australia, the United States represents its third biggest trading partner, behind China and Japan. Because America is so intricately involved in the economy of these countries, one might expect their exchange rates paired with the United States dollar to be of particular importance, as it forms a key aspect of the countries export-import business sector. Thus, any surprise that hints at a weakening or strengthening economy, and thus might affect a country's import/export business, will likely affect their exchange rate paired against the United States dollar.

Section 3.1.b United States

For the United States, we utilize five different exchange rates to test for exchange-rate specificity: USDAUD, USDCAD, USDEUR, USDGBP and USDYEN. The decision to examine these five currencies was deliberate: though they represent the five of the six most traded currencies behind the dollar in gross terms, there exists a significant variation in the liquidities of across them. Thus, if exchange-rate specificity holds and the response is contingent on the liquidity of the market, we would expect significantly different results in the markets for each currency pair.


\(^5\) These figures are provided by the Canadian Department of Foreign Affairs and International Trade, found online at: http://www.international.gc.ca/commerce/strategy-strategie/r1.aspx?view=d
Courtesy of Mr. John Caccavale, Executive Director of the Duke Financial Economics Center and faculty member of the Duke University Department of Economics, I was able to obtain certain exchange rate datasets from the BARX system of Barclays Capital, which kept an active record of the following historical spot market prices: USDAUD, USDCAD, and USDGBP. With the exception of USDGBP, all exchange rates included 5-minute prices. Only 10-minute prices were available for USDGBP. The time periods of all three exchange rates spanned between 2005 and 2011.

It is important to note that all times listed on these foreign exchange datasets is in Greenwich Mean Time (GMT), which differs significantly from the time zones in which many of the macroeconomic announcements are made.

The most pressing issue with this foreign exchange data, however, was that it was unbalanced. There were unequal observations per day, while certain days were missing altogether. In Appendix 1, please find the STATA code used to balance the dataset.

The other two exchange rates used, USDJPY and USDEUR, are obtained from proprietary datasets bought by the Duke University Department of Economics. Unfortunately, the details of these two exchange rates are slightly inconsistent with the others, as they provide the price of futures contracts traded on the market instead of spot market transactions. However, under certain reasonable assumptions, we can prove consistency between the spot and futures datasets by demonstrating the only difference between the two to be a negligible interest adjustment. Consider the following no arbitrage formula of the value of any futures contract, given by Hull (1997).\(^6\)

\[
F_t = S_t e^{rT} \text{ at time } t
\]

Where,

\(r\) is the risk free interest rate

\(T\) is the time of maturity

So that,

\[
\ln(F_t) = \ln(S_t) + rT
\]

\(^6\) Hull's original formula included a carry cost \(u\) and a convenience yield \(y\) in its exponent. However, these two variables only apply to commodities, not foreign exchange assets. For this reason, this paper ignores them completely.
When we calculate the returns of futures, we find:
\[
\ln(F_t) - \ln(F_{t-1}) = \ln(S_t) - \ln(S_{t-1}) + rT - r(T + 1)
\]
\[
= \ln(S_t) - \ln(S_{t-1}) - r
\]

Because we can assume that:
\[
\lim_{\Delta t \to 0} r = 0
\]

We conclude:
\[
\ln(F_t) - \ln(F_{t-1}) = \ln(S_t) - \ln(S_{t-1})
\]

However, even if \( r \) is not negligibly small, rather a constant \( \bar{r} \) we can instead conclude:
\[
\ln(F_t) - \ln(F_{t-1}) = \ln(s_t) - \ln(s_{t-1}) - \bar{r}
\]

Thus, when using the return on a futures contract as the dependent variable in any regression, even accounting for such an interest rate adjustment to the dependent variable would not affect the interpretation of the results, as it would merely change the \( \alpha \) of the regression and leave \( \beta \) untouched.\(^7\) In reality, though, the value of \( r \) likely exhibits elements of both characteristics—it is a negligibly small value that varies very slightly throughout the maturity of the futures contract. Thus, it is still reasonable to treat spot and futures returns similarly for the purposes of this paper.

As the USDEUR and USDJPY futures values were recorded from transactions on the Chicago Mercantile Exchange (CME), the time of each observation was recorded in Central Standard Time (CST).

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\(^7\) If we consider the regression:
\[
\ln(s_{t+1}) - \ln(s_{t-1}) = \alpha_0 + \beta_{\text{overal}i}S_t + \epsilon_t
\]
And substitute the futures return for the spot return:
\[
\ln(F_{t+1}) - \ln(F_{t-1}) - \bar{r} = \alpha_0 + \beta_{\text{overal}i}S_t + \epsilon_t
\]
Such that \( (\alpha_0 + \bar{r}) \) simply forms a new constant, \( \alpha_t \):
\[
\ln(F_{t+1}) - \ln(F_{t-1}) = \alpha_t + \beta_{\text{overal}i}S_t + \epsilon_t
\]
Table 1. Foreign Exchange Data Summary

<table>
<thead>
<tr>
<th>Exchange Rate</th>
<th>Type</th>
<th>Frequency (minutes)</th>
<th>Period</th>
<th>Time Zone</th>
<th># Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>USDEUR</td>
<td>Future</td>
<td>1</td>
<td>1/3/2005-12/31/2010</td>
<td>CST</td>
<td>614,036</td>
</tr>
<tr>
<td>USDJPY</td>
<td>Future</td>
<td>1</td>
<td>1/3/2005-12/31/2010</td>
<td>CST</td>
<td>614,036</td>
</tr>
</tbody>
</table>

Section 3.2 Expectation, Announcement and Surprise Data

For the 2005-2011 period, our expectation data is obtained from the Bloomberg News Service. Bloomberg regularly conducts surveys among economists, commercial and investment banks, and other financial institutions to gauge their expectations of an extensive array of macroeconomic announcements, including inflation, GDP, unemployment and retail sales. Bloomberg provides the median, average, highest, and lowest values of the survey results for each announcement. For the purposes of this study, I use the median survey value as the official market expectation of each announcement.8

This expectations data remains a notable upgrade from the proxy measures used in similar papers of the past. These dated studies, such as Cutler, Poterba and Summers (1989), tended to design models that utilized lagged values of macroeconomic variables to imply their expectations. The merit of such an approach is questionable. Though econometrically valid and certainly defendable, such models can never be proved to be accurate with certainty. Instead, economists can only speculate on their validity. This study bypasses the deficiencies of these complex models altogether by obtaining market expectations data right from their source—the market. In this way, using survey data is a

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8 This study follows the precedent of using the median expectation instead of the average in order to avoid potential bias from outliers. It is for this reason that the median is thought to be a better estimator of market expectations. Section 6 will discuss the implications of one potential cause of a significant difference between the median and average—survey dispersion.
tremendous improvement upon studies of the past, as is consistent with the most recent empirical literature on the topic (e.g. Anderson, Bollerslev, Diebold and Vega [2003]).

Of course, this data has its flaws. Namely, the use of this data relies on one key assumption, that the expectations data is perfectly up-to-date; that is, it provides the market’s expectation at the exact time of any announcement. This is the true spirit of a “surprise.” Unfortunately, it would be a herculean task to survey major financial institutions merely seconds before an announcement is scheduled to take place. Such a shortcoming in any survey expectation dataset is inevitable. The Bloomberg survey datasets also includes the date of when the expectation was recorded. Among the macroeconomic variables used in this paper, the expectations data trailed their respective announcements by merely 3 to 7 days. Thus, I make the assumption that the median expectation did not change significantly during this short, intervening period.

The announcement data is also derived from the Bloomberg News Services. Bloomberg maintains accurate records of the announced values of an extensive list of macroeconomic variables. Included in the dataset is also the precise time of the announcement, as well as the corresponding period and the revised value. This revised value refers to the corrected, updated figure that is calculated or measured months later, after considerations that arose after its initial release are taken into account. However, as I am only studying the immediate reaction of the foreign exchange market to the macroeconomic fundamental variable publicized at a specific time, I use the announced values.

All announcements share one important quality—they are measured in percentage terms. This allows for comparability and more similar interpretations of the results of each regression. This distinction was particularly important when deciding the announcement instrument to use for unemployment. While some market participants may argue for the merit of “number of employed persons,” as the most accurate proxy of an economy’s fundamental health, this study chose instead to utilize “unemployment rate,” to maintain the custom of only using independent variables that are measured in percentage terms. The same dilemma presented itself when deciding between GDP vs. GDP growth rate. In Appendices 3, 4 and 5, I have included descriptions of each announcement for each country.
Once I synchronized the time of the announcement data with the surrounding time intervals of the high-frequency foreign exchange data, I was left with considerably more manageable datasets. For each monthly announcement, I had between 59 and 70 usable observations, factoring in dataset limitations or missing values. For each quarterly announcement I was left with 22-23 usable observations.

With the exception of the inflation announcements, particular precaution was taken to prevent overlap between announcements of the same country, in order to ensure no redundancy among indicators. This is of critical importance as it validates the central assumption that the announcement dominates all price fluctuations during the surrounding 10-minute interval. While few pairs of announcements occurred concurrently, such incidences were certainly rare. The only scenario where this study could not ensure exclusivity of announcements was with inflation, where multiple figures (core vs. headline, monthly vs. yearly) are released at once.

Section 4. Methodology

Section 4.1 Overall

For any given time \( t \), I calculate the ten-minute returns as the percent change of the exchange rate between the five minutes following and preceding \( t \), given by:

\[
R_t = \ln(p_{t+5}) - \ln(p_{t-5})
\]

\( p_{t+5} \) is the foreign exchange rate (or price) five minutes after time \( t \)

\( p_{t-5} \) is the foreign exchange rate (or price) five minutes before time \( t \)

I then calculate the surprise variable as the difference between the announced value of the macroeconomic fundamental and its expectation given by the median value of the Bloomberg News Survey.\(^9\)

\[
S_t = Announcement_t - Expectation_t
\]

\(^9\)This aspect of the methodology may be criticized for treating any absolute surprise the same, regardless of its relative value. Instead, many economists might prefer the definition:

\[
S_t = \frac{Announcement_t - Expectation_t}{Expectation_t}
\]

However, I believe that the definition used in this study is superior as it follows a precedent (Clarida and Waldman, 2005) and allows for a convenient interpretation. My definition of surprise is in terms of a percent of the macroeconomic fundamental, whereas this definition is in terms of a percent of a percent. In addition, though the difference of the two definitions certainly makes sense theoretically, we observe no real difference in practice when comparing regression results empirically.
We then model this ten-minute return as a function of the individual macroeconomic surprises, such that:

\[ R_t = \alpha + \beta_{overall} S_t + \varepsilon_t \tag{1} \]

Thus,

\[ \frac{dR_t}{dS_t} = \beta_{overall} \]

Where \( \beta_{overall} \) captures the overall effect of the surprise on the 10-minute return of holding the currency. For the purpose of this paper, we will refer to \( \beta_{overall} \) as the “effect” of any given surprise, \( S_t \). Because the independent and dependent variables of this regression are given by decimal values of percentages, an announced value that is one percent above the expectation causes a \( \beta_{overall} \) percent change in the exchange rate relative to a zero surprise; if positive, an appreciation, if negative, a depreciation. For example, if \( \beta_{overall}=0.200 \) for a hypothetical announcement, then a one-percent surprise leads to a 0.200 percent appreciation of the hypothetical currency.

Section 4.2 Tests

A key aspect of this paper is to determine any patterns or trends in how foreign exchange markets respond to macroeconomic surprises, given by the sign of its value, its magnitude, the current economic environment, the liquidity of the particular market, or the particular reference currency. In order to do so, I first rid the surprise datasets of zero surprises and then perform the following tests that divide the surprises into subsets that meet certain, mutually-exclusive criteria. I then run multivariate regressions on them separately. The basic premise of this test is the identification of two unique effects among the exclusive conditions whose difference is statistically significant. If so, the desired phenomenon does exist in that particular market. Please note that this section merely contains the methodology, while a more detailed explanation of each pattern, or phenomenon, is included in Section 5.
Table 2. Test Descriptions

<table>
<thead>
<tr>
<th></th>
<th>Condition #1</th>
<th>Condition #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymmetric Response</td>
<td>Positive ($S_t &gt; 0$)</td>
<td>Negative ($S_t &lt; 0$)</td>
</tr>
<tr>
<td>Nonlinearity(^{10})</td>
<td>Large $S_t &gt; \text{median}(</td>
<td>S_t</td>
</tr>
<tr>
<td>Financial Stress</td>
<td>Pre-Crisis ($t &lt; \text{January 2008}$)</td>
<td>Crisis ($t \geq \text{January 2008}$)</td>
</tr>
<tr>
<td>Liquidity</td>
<td>$R_t = \ln(p_t) - \ln(p_{t-5})$</td>
<td>$R_t = \ln(p_{t+30}) - \ln(p_{t-30})$</td>
</tr>
<tr>
<td>Exchange-Rate Specificity</td>
<td>Domestic Currency-Quote Currency(_1)</td>
<td>Domestic Currency-Quote Currency(_2)</td>
</tr>
</tbody>
</table>

Section 4.2.a Tests for Asymmetric Response, Nonlinearity, and Financial Stress

For each of these tests, I ran a multivariate regression with two independent variables. It is important to ensure exclusivity between the independent variables, such that when one variable registers a surprise, the other is zero\(^{11,12}\):

$$R_t = \alpha + \beta_1(S_t * D_{1t}) + \beta_2(S_t * D_{2t}) + \varepsilon_t \tag{2}$$

Where,

$$D_{1t} = \begin{cases} 1 & \text{if Condition 1 == True} \\ 0 & \text{else} \end{cases}$$
$$D_{2t} = \begin{cases} 1 & \text{if Condition 2 == True} \\ 0 & \text{else} \end{cases}$$

Such that,

$$\frac{dR_t}{d(S_t * D_{1t})} = \beta_1$$

\(^{10}\) When testing for nonlinearity, we are interested in the size of the surprise, not the direction or sign. Therefore, we median of the absolute value as the reference point to divide the data. If this precaution weren’t taken, then the nonlinearity would closely replicate the asymmetric response test, given a normal distribution of surprises.

\(^{11}\) A future study with more comprehensive data might look into the combination of any two or more tests (i.e. asymmetry and nonlinearity) such that the regression resembles:

$$R_t = \alpha + \beta_1S_t \begin{cases} 1 & \text{if positive, big} \\ 0 & \text{else} \end{cases} + \beta_2S_t \begin{cases} 1 & \text{if positive, small} \\ 0 & \text{else} \end{cases}$$
$$+ \beta_3S_t \begin{cases} 1 & \text{if negative, big} \\ 0 & \text{else} \end{cases} + \beta_4S_t \begin{cases} 1 & \text{if negative, small} \\ 0 & \text{else} \end{cases} + \varepsilon$$

However, the limitations of the data prevent this paper from doing so. There simply are not enough observations to provide valid estimates of the effects of such narrowly defined surprises.

\(^{12}\) In the discussion of Section 5, this paper replaces $\beta_1$ and $\beta_2$ with a more descriptive notation based on the condition it represents, i.e. $\beta_{\text{positive}}$ and $\beta_{\text{negative}}$. 
\[
\frac{dR_t}{d(S_t * D_{2t})} = \beta_2
\]

Where \( \beta_1 \) is the effect of surprises that meet Condition #1 and \( \beta_2 \) is the effect of surprises that meet Condition #2.

However, these tests are useless—no phenomenon is demonstrated—unless \( \beta_1 \) and \( \beta_2 \) can be proven to be different.\(^{13}\) Thus, this study utilizes the following two-sided hypothesis test:

\[
H_0: \beta_2 - \beta_1 = 0 \\
H_1: \beta_2 - \beta_1 \neq 0
\]

In order to approach this hypothesis test, I transform the regression into the following:

\[
R_t = \alpha + \beta_3(S_t * [D_{1t} + D_{2t}]) + \beta_4(S_t * D_{2t}) + \epsilon_t \tag{3}
\]

Where,

\[
\frac{dR_t}{d(S_t * [D_{1t} + D_{2t}])} = \beta_3 \\
\frac{dR_t}{d(S_t * D_{2t})} = \beta_4
\]

Such that \( \beta_3 \) captures the full effect of Condition #1 and a partial effect of Condition #2, and \( \beta_3 \) is the marginal effect of Condition #2.

Note that,

\[
\beta_1 = \beta_3 \\
\beta_2 = \beta_3 + \beta_4
\]

Thus, I can rearrange these variables to find,

\[
\beta_2 - \beta_1 = \beta_3 + \beta_4 - \beta_3 = \beta_4
\]

Such that,

\(^{13}\) As will be discussed later, note that none of the phenomena tested dictate any particular direction of \( \beta_1 \) with respect to \( \beta_2 \), such that the hypothesis test might resemble some variation of:

\[
H_0: \beta_1 - \beta_2 > 0 \\
H_1: \beta_1 - \beta_2 \leq 0
\]

Though these tests are certainly interesting and will be discussed qualitatively later in this paper, they do not represent the definition or spirit of any of these financial phenomena, which serve to point out mere differences in responses.
Therefore, I can simply use the t-statistic of $\hat{\beta}_4$ to determine whether $\beta_1$ and $\beta_2$ are significantly different and thus conclude whether the pattern does exist for any particular market around any particular announcement. This value is found in the Restriction section of the relevant tables.

Section 4.2.b Liquidity Tests

To test for liquidity, this study compares returns during two time intervals—the ten and sixty minutes surrounding the surprises. In order to do this, I utilized two different models.

**Model A: Condition #1**

$$R_{10 \text{minute}} = \alpha_1 + \beta_1 S_t + \varepsilon_{t1} \quad (4)$$

Where I calculated $R_{11}$ as follows:

$$R_{10 \text{minute}} = \ln(p_{t+5}) - \ln (p_{t-5})$$

**Model B: Condition #2**

$$R_{60 \text{minute}} = \alpha_2 + \beta_2 S_t + \varepsilon_{t2} \quad (5)$$

Where I calculated $R_{12}$ as follows:

$$R_{60 \text{minute}} = \ln(p_{t+30}) - \ln (p_{t-30})$$

As a market becomes more liquid, less time is required for any given piece of information to be manifested in asset prices. Thus, when testing for liquidity, we are really testing whether $\beta_1$ and $\beta_2$ are different. Thus, we can once again set up the following two-sided test.

$$H_0: \beta_2 - \beta_1 = 0$$

$$H_1: \beta_1 - \beta_2 \neq 0$$

Note that this hypothesis test merely reveals the significance of the difference between $\beta_1$ and $\beta_2$—the effects of the same announcements on returns over different periods of time. The existence of liquidity does not predict a particular direction or specific relationship between $\beta_1$ and $\beta_2$. Indeed, we can provide reasons why an illiquid market will

---

14 Note that this is the same regression as (1)
cause the magnitude $\beta_2$ to be greater (markets continue to appreciate/depreciate) or less (markets correcting an overreaction) than $\beta_1$.

In order to approach this hypothesis test, I transform the regression into the following:

\[
\text{Model C}
\]

\[
R_{60\text{minute}} - R_{10\text{minute}} = \alpha_2 + \beta_2 S_t + \varepsilon_2 - \alpha_1 - \beta_1 S_t - \varepsilon_1
\]

\[
= \alpha_2 - \alpha_1 + \beta_2 S_t - \beta_1 S_t + \varepsilon_2 - \varepsilon_1
\]

Resulting in the equation to be estimated by,

\[
R_3 = \alpha_3 + \beta_3 S_t + \varepsilon_{t3} \ (6)
\]

Where,

\[
\alpha_3 = \alpha_2 - \alpha_1
\]

\[
\varepsilon_3 = \varepsilon_2 - \varepsilon_1
\]

\[
\beta_3 = \beta_2 - \beta_1
\]

\[
R_3 = R_{60\text{minute}} - R_{10\text{minute}}
\]

So that,

\[
\frac{dR_3}{dS_t} = \beta_3
\]

Such that, $\beta_3$ captures the effect of the surprise over the two disjointed 25-minute intervals before and after the announcement occurs.

In addition, we find that:

\[
\frac{\bar{\beta}_3}{\sqrt{\sigma^2}} = \frac{\bar{\beta}_2 - \bar{\beta}_1}{\sqrt{\sigma^2_1 + \sigma^2_2 - 2\sigma_1\sigma_2\rho_{1,2}}}
\]

Therefore, we can simply use the t-statistic of $\hat{\beta}_3$ to determine whether $\hat{\beta}_1$ and $\hat{\beta}_2$ are significantly different and thus conclude the liquidity of that particular market around a certain announcement. This value is found in the Restriction section of the relevant tables.

There exists tremendous potential for confusion regarding Model C. One may interpret $R_3$ in one of two ways: (1) the return over the sixty-minute period surrounding an announcement minus the centered ten-minute period or (2) the return corresponding to the announcement in excess of the ten minutes surrounding it.
Section 4.2.3 Exchange-Rate Specificity Tests

Exchange-rate specificity dictates that the same news will affect different markets for the same product differently. In order to determine exchange-rate specificity, I utilize Regression (1), but alter the dependent variable to reflect the returns on different currency pairs. Consider any two models:

Model A: Foreign Currency$\_1$ (ABC)
\[
R_1 = \alpha_1 + \beta_1 S_t + \varepsilon_{t1} \tag{7}
\]
\[
R_1 = \ln(p_{t+5}) - \ln(p_{t-5})
\]

*Where $p$ is given by USDABC exchange rate*

Model B: Foreign Currency$\_2$ (DEF)
\[
R_2 = \alpha_2 + \beta_2 S_t + \varepsilon_{t2} \tag{8}
\]
\[
R_2 = \ln(p_{t+5}) - \ln(p_{t-5})
\]

*Where $p$ is given by the USDDEF exchange rate*

If exchange-rate specificity holds, we will expect $\beta_1$ and $\beta_2$ to be different. Once again, no direction of magnitude of this difference is assumed. Therefore, we use the same two-sided test:

\[
H_0: \beta_2 - \beta_1 = 0
\]
\[
H_1: \beta_2 - \beta_1 \neq 0
\]

The two events captured by $\beta_1$ and $\beta_2$ are by no means independent. In fact, one could argue that a certain positive correlation exists between $\beta_1$ and $\beta_2$, as they measure the effect of the same announcement on the same asset, simply priced against two reference currencies. However, as $p_{\beta_1, \beta_2}$ is difficult to control for, given two distinct dependent variables, I chose instead to treat the events as independent. Thus, in order to derive the significance of the difference between the effect of news on two different exchange rates, found in Appendices 8, 9, 10, 11, 12, 13 and 14, this paper calculates:

\[
\text{test statistic} = \frac{\hat{\beta}_1 - \hat{\beta}_2}{\sqrt{\sigma_1^2 + \sigma_2^2}} \tag{9}
\]

Though the calculation is not exactly accurate, it still provides a valid, even conservative interpretation of the results. If, instead, I chose to control for this correlation, such that:
test statistic = \frac{\hat{\beta}_1 - \hat{\beta}_2}{\sqrt{\sigma_1^2 + \sigma_2^2 - 2\rho_{\hat{\beta}_1, \hat{\beta}_2}}} \quad (10)

And assume,

\rho_{\hat{\beta}_1, \hat{\beta}_2} > 0

We would find that the denominator of (9) actually overestimates standard errors, thus reducing the magnitude of all test statistics towards zero in comparison to the correct test statistic denoted by (10). In this way, I can say with certainty that any significant result found in this section is unquestionably significant (even more so than stated), while those found just below the border are perchance significant.

In the Appendix, I provide calculations of (9) among each reference currency for each announcement. Please use the following template for guidance:

<table>
<thead>
<tr>
<th>Announcement XYZ</th>
<th>AUD</th>
<th>CAD</th>
<th>GBP</th>
<th>JPY</th>
<th>EUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAD</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GBP</td>
<td>B</td>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JPY</td>
<td>D</td>
<td>E</td>
<td>F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EUR</td>
<td>G</td>
<td>H</td>
<td>I</td>
<td>J</td>
<td></td>
</tr>
</tbody>
</table>

Where,

\begin{align*}
A &= \frac{\hat{\beta}_1 - \hat{\beta}_2}{\sqrt{\sigma_1^2 + \sigma_2^2}} \quad \text{using CAD in Model A and AUD in Model B} \\
B &= \frac{\hat{\beta}_1 - \hat{\beta}_2}{\sqrt{\sigma_1^2 + \sigma_2^2}} \quad \text{using GBP in Model A and AUD in Model B}
\end{align*}

Section 5. Empirical Results and their Interpretation
Section 5.1 Overall Results

Let me begin with a few guidelines of how to interpret the results. In its most basic explanation, \( \beta \) quantifies the changes in price that can be attributed to a macroeconomic surprise. A much more nuanced interpretation is that a \( \beta > 0 \) implies that the exchange rate moves in the same direction as the surprise, while a \( \beta < 0 \) implies that the exchange rate will move in the opposite direction, given \( \alpha = 0 \). Consequently, the interaction between \( \alpha \) and \( \beta \) is of crucial importance, as it may amplify or curtail the observed return around an announcement. For example, if \( \alpha < 0 \) and \( \beta > 0 \), then we might find a ten-minute return to be negative despite good news. Similarly, if \( \alpha > 0 \) and \( \beta > 0 \), then we
might find a ten-minute return to be positive despite bad news. Such non-zero values of $\alpha$ are rare in this study and can be attributed to the general appreciation or depreciation of the currency throughout the time period, 2005-2011. Due to this interaction between $\alpha$ and $\beta$, this paper implicitly interprets every value of $\beta$ as the effect of the given surprise relative to a zero surprise.

Note that the effects of all announcement types are positive with the exception of unemployment. This can be explained intuitively. Economic literature states that a currency’s value is directly related to the domestic economy’s performance. Good news should appreciate a currency in the same way that good news about a public company increases its share price. For all announcements with the exception of unemployment, positive surprises denote good news about an economy. In contrast, an unexpectedly high unemployment announcement is bad news about an economy. This manifests itself in the results. Consider Figure 1 below, where you can notice the contrast in regression results between unemployment and all other announcements. In particular, note the change in the direction of the slope of the best fit line, which this paper denotes as the “effect” of the announcement.

\textit{Figure 1.}
\textit{Difference between Unemployment and other Fundamental Announcements$^{15}$}

(a) Unemployment

(b) Others

---

$^{15}$ These are estimates of Equation (1).
Though the results seem to imply that positive inflation surprises are good news, such a conclusion may be misleading. The sign of an inflation surprise is unbalanced in how it represents the health of the underlying economy. While a negative surprise is certainly bad news, a positive surprise exists as a more ambiguous indicator of a domestic economy. It could certainly be interpreted as good news if driven by increased consumer spending and accelerated economic growth. On the other hand, a positive surprise could be considered bad news if it lowers the real return on assets and increases production costs.

First, let us examine the overall results corresponding to the United States, using the USD-AUD exchange rate.

### Table 3.
Estimate of Equation (1) for United States Announcements using USD-AUD exchange rate

<table>
<thead>
<tr>
<th></th>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>MoM, Core</th>
<th>MoM, Headline</th>
<th>YoY, Core</th>
<th>YoY, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha \times 1000 )</td>
<td>-0.049</td>
<td>-0.267</td>
<td>0.099</td>
<td>-0.084</td>
<td>-0.189</td>
<td>-0.100</td>
<td>-0.192</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-0.13)</td>
<td>(-1.29)</td>
<td>(0.45)</td>
<td>(-0.37)</td>
<td>(-0.77)</td>
<td>(-0.41)</td>
<td>(-0.78)</td>
</tr>
<tr>
<td>( \beta_{\text{overall}} )</td>
<td>-0.228</td>
<td>0.079*</td>
<td>-0.064</td>
<td>0.866***</td>
<td>0.193</td>
<td>0.555***</td>
<td>0.082</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-0.93)</td>
<td>(1.70)</td>
<td>(-1.39)</td>
<td>(3.61)</td>
<td>(1.11)</td>
<td>(3.04)</td>
<td>(0.66)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.0151</td>
<td>0.0443</td>
<td>0.0454</td>
<td>0.1661</td>
<td>0.0203</td>
<td>0.0662</td>
<td>0.0060</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>69</td>
<td>69</td>
<td>68</td>
<td>69</td>
<td>69</td>
<td>69</td>
<td>69</td>
</tr>
</tbody>
</table>

* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.

Interestingly, only three United States announcements are statistically significant. Among the four inflation variables, only core inflation measures demonstrated significance. Core inflation excludes commodities with relatively inelastic demand curves that are prone to volatile price fluctuations. It is a more stable figure, and is widely considered to paint a more realistic picture of an economy’s growth prospects, as well as act as a better forecaster of overall inflation. Recently, this claim has been under attack (Thornton 2011).

However, given the results in Table 3, it is safe to state that financial institutions believed in the merit of core inflation measures over headline inflation measures during the time period of this study. Not only were core inflation surprises more statistically significant than their headline counterparts, but were also apparently more powerful with effects at least four times larger.

One interesting observation is that insignificant results for the overall regression does not necessary denote insignificance among all types of surprises of the same
announcement. When I perform other tests and divide the data into subsets to calculate their individual effects separately, certain significances emerge among the announcements whose overall effects were insignificant. For example, consider United States Retail Sales announcements. Their overall effect of all announcements ($\beta_{overall} = -0.064$) is insignificant, with a t-statistic of 1.39. However, consider Table 6, which shows that the effect of negative surprise ($\beta_{negative} = -0.240$) is, in fact, significant with a t-statistic of 3.62. Such observations extend beyond the division of surprises into positive and negative, also including the big and small, as well as pre- and during-crisis surprises tested later in this paper.

There exists an econometric reason for such subset significance. Consider again the example of United States Retail Sales announcements. If we divide the surprise into positive and negative subsets, we find their effects to be vastly different—$\beta_{positive} = 0.121$ and $\beta_{negative} = -0.240$, respectively. When combining these into an overall regression, as Regression (1) does, the resulting effect ($\beta_{overall} = -0.064$) averages the individual effects of the subsets. However, because the effects of positive and negative surprises differ so tremendously, the resulting $\beta_{overall}$ becomes a terrible estimator for all surprises, thus increasing standard errors and resulting in insignificant values. Thus, even if the effect of a subset is significant, it may be hidden in the overall results. It is only revealed upon the dissembling of the surprise variable based on the tests described later in this paper.

On the other hand, there are certain overall surprises that lose their significance once we divide them into subsets. For example, consider the overall effect of United States MoM, Core Inflation announcements, where $\beta_{overall} = 0.866$ is significant with a t-statistic of 3.61. However, in Table 6, where this study divides these surprises into positive and negative, we find that neither subset has a significant effect individually, with t-statistics of 1.04 and 1.00, respectively. There too exists an econometric reason for this. The effects of positive and negative surprises are relatively similar—$\beta_{positive} = 1.016$ and $\beta_{negative} = 0.673$, respectively—and both insignificant. However, when we combine these into an overall regression, the resulting $\beta_{overall} = 0.866$, which averages these individual effects, becomes a reasonable estimator for all surprises while effectively doubling the number of observations that are sensibly estimated by this overall regression, lowering standard errors even further.
Next, I perform the overall regressions for the two other countries, Canada and Australia.

**Table 4.**

*Estimate of Regression (1) for Canada Announcements using CADUSD exchange rate*

<table>
<thead>
<tr>
<th></th>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>MoM, Core</th>
<th>MoM, Headline</th>
<th>YoY, Core</th>
<th>YoY, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$ (x1000)</td>
<td>0.373</td>
<td>0.130</td>
<td>-0.088</td>
<td>-0.200</td>
<td>-0.095</td>
<td>-0.179</td>
<td>-0.104</td>
</tr>
<tr>
<td>t-stat</td>
<td>(0.91)</td>
<td>(0.62)</td>
<td>(-0.44)</td>
<td>(-0.83)</td>
<td>(-0.38)</td>
<td>(-0.73)</td>
<td>(-0.41)</td>
</tr>
<tr>
<td>$\beta_{\text{overall}}$</td>
<td>-1.019***</td>
<td>0.418***</td>
<td>0.194***</td>
<td>0.452**</td>
<td>0.454***</td>
<td>0.440**</td>
<td>0.420***</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-4.09)</td>
<td>(2.66)</td>
<td>(5.34)</td>
<td>(2.18)</td>
<td>(3.20)</td>
<td>(2.26)</td>
<td>(2.81)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.1697</td>
<td>0.1402</td>
<td>0.4700</td>
<td>0.1529</td>
<td>0.1623</td>
<td>0.1548</td>
<td>0.1362</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>70</td>
<td>69</td>
<td>68</td>
<td>69</td>
<td>69</td>
<td>69</td>
<td>69</td>
</tr>
</tbody>
</table>

* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.

**Table 5.**

*Estimate of Regression (1) for Australia Announcement using AUDUSD exchange rate*

<table>
<thead>
<tr>
<th></th>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>YoY, Headline</th>
<th>QoQ, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$ (x1000)</td>
<td>1.204***</td>
<td>-0.293</td>
<td>-0.427</td>
<td>-0.026</td>
<td>0.078</td>
</tr>
<tr>
<td>t-stat</td>
<td>(3.28)</td>
<td>(-0.60)</td>
<td>(-1.02)</td>
<td>(-0.05)</td>
<td>(0.16)</td>
</tr>
<tr>
<td>$\beta_{\text{overall}}$</td>
<td>-1.239***</td>
<td>0.946***</td>
<td>0.217***</td>
<td>0.872***</td>
<td>0.845***</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-5.19)</td>
<td>(5.46)</td>
<td>(2.67)</td>
<td>(5.24)</td>
<td>(4.89)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.3032</td>
<td>0.6580</td>
<td>0.1178</td>
<td>0.4658</td>
<td>0.4533</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>69</td>
<td>23</td>
<td>22</td>
<td>23</td>
<td>23</td>
</tr>
</tbody>
</table>

* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.

The results from Canada and Australia are quite shocking in how dramatically they differ from those of the United States. Across the board, all surprises were undeniably significant. This represents a dramatic departure from the results of the United States, where only few surprises were significant, and none with such high t-statistics that we see among Canada and Australia.

A closer inspection of the data shows that all $\beta_{\text{overall}}$ values tend to be much greater among Australia and Canada than among the United States. A possible explanation of this observation deals with liquidity. As mentioned earlier, the United States dollar (USD) is the most liquid currency on the currency market, contributing the vast majority of foreign exchange trades. Thus, if we consider the individual markets of these three currencies, we would expect there to be many more factors affecting the price of the United States dollar as opposed to the Canadian or Australian dollars. For this reason, we would expect the...
same surprise variable to have a inhibited effect in the United States compared to other, less complicated countries.

Notably, unemployment announcements were particularly strong in Australia and Canada, where one percent positive surprises lead to 1.019 and 1.234 percent depreciation in their respective currencies—much larger than the effects of all other significant announcements. Australian GDP surprises are similarly powerful.

In addition, among inflation announcements results in Canada, we notice that there is no substantial difference between headline and core measures that we noticed in the United States. Both measures seemed to be equally telling of immediate price fluctuations around their announcement. Of course, one possible explanation is that core and headline inflation surprises are more correlated in Canada than in the United States. In Australia, only two inflation measures were available and released by the appropriate governing body: YoY and QoQ Headline Inflation. However, even these headline measures were vastly more statistically significant and powerful than those in the United States, but that could be explained by virtue of core numbers being unavailable or unmeasured.

Because of the overwhelming significance of the Canadian and Australian surprises, I was mainly only able to observe instances where effects of surprise subsets became insignificant. For example, consider Retail Sales announcements in Australia. Though their overall effect ($\beta_{\text{overall}}=0.217$) is significant with a t-statistic of 2.67, the division of the surprises into positive and negative subsets in Table 8 leads to the insignificant effects $\beta_{\text{positive}}=0.263$ and $\beta_{\text{negative}}=0.154$, with t-statistics of 0.94 and 0.43, respectively.

Section 5.2 Asymmetric Response Results

As mentioned earlier, asymmetric response refers to the differences in price movements that result from good and bad news. If asymmetric response is present in a market, then we would notice a different reaction, or effect, between positive and negative surprises when regressed against the immediate ten-minute return. I have provided a hypothetical graphic representation of asymmetric response in Appendix 6.

The data did not seem to demonstrate the prevalence of asymmetric response in foreign exchange markets with respect to macroeconomic surprises. In the restriction row
of the following three tables—which measures the t-statistic of the difference between $\beta_{positive}$ and $\beta_{negative}$—I regularly find insignificant disparity between the effects of positive and negative surprises.

Table 6.

Estimate of Regression (2) for United States Announcements using USD-AUD exchange rate
Asymmetric Response Test

<table>
<thead>
<tr>
<th></th>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>MoM, Core</th>
<th>MoM, Headline</th>
<th>YoY, Core</th>
<th>YoY, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$ (x1000)</td>
<td>0.420</td>
<td>-0.193</td>
<td>-0.772**</td>
<td>-0.521</td>
<td>0.647</td>
<td>-0.398</td>
<td>-0.077</td>
</tr>
<tr>
<td>t-stat</td>
<td>(0.46)</td>
<td>(-0.74)</td>
<td>(-2.10)</td>
<td>(-0.52)</td>
<td>(1.05)</td>
<td>(-0.57)</td>
<td>(-0.13)</td>
</tr>
<tr>
<td>$\beta_{positive}$</td>
<td>-0.396</td>
<td>0.079</td>
<td>0.121</td>
<td>1.016</td>
<td>-0.358</td>
<td>0.750</td>
<td>-0.059</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-0.59)</td>
<td>(1.12)</td>
<td>(1.27)</td>
<td>(1.04)</td>
<td>(-0.90)</td>
<td>(1.36)</td>
<td>(-0.21)</td>
</tr>
<tr>
<td>$\beta_{negative}$</td>
<td>-0.045</td>
<td>0.082</td>
<td>-0.240***</td>
<td>0.673</td>
<td>0.713**</td>
<td>0.359</td>
<td>0.251</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-0.10)</td>
<td>(1.02)</td>
<td>(-3.62)</td>
<td>(1.00)</td>
<td>(2.47)</td>
<td>(0.72)</td>
<td>(0.91)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.0245</td>
<td>0.0663</td>
<td>0.1721</td>
<td>0.2041</td>
<td>0.0724</td>
<td>0.1535</td>
<td>0.0132</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>47</td>
<td>55</td>
<td>64</td>
<td>42</td>
<td>48</td>
<td>41</td>
<td>53</td>
</tr>
<tr>
<td>Restriction</td>
<td>0.34</td>
<td>0.03</td>
<td>-2.56**</td>
<td>-0.22</td>
<td>1.72*</td>
<td>-0.40</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Restriction values given by t-statistic of $\beta_{positive}$ in Regression (3).
* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.

Table 7.

Estimate of Regression (2) for Canada Announcements using CADUSD exchange rate
Asymmetric Response Test

<table>
<thead>
<tr>
<th></th>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>MoM, Core</th>
<th>MoM, Headline</th>
<th>YoY, Core</th>
<th>YoY, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$ (x1000)</td>
<td>0.946</td>
<td>0.041</td>
<td>-0.354</td>
<td>0.594</td>
<td>0.122</td>
<td>0.532</td>
<td>0.460</td>
</tr>
<tr>
<td>t-stat</td>
<td>(1.19)</td>
<td>(0.09)</td>
<td>(-1.03)</td>
<td>(0.99)</td>
<td>(0.22)</td>
<td>(0.88)</td>
<td>(0.79)</td>
</tr>
<tr>
<td>$\beta_{positive}$</td>
<td>-1.457**</td>
<td>0.484</td>
<td>0.231***</td>
<td>0.103</td>
<td>0.365</td>
<td>0.135</td>
<td>0.191</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-2.78)</td>
<td>(1.14)</td>
<td>(3.77)</td>
<td>(0.30)</td>
<td>(1.13)</td>
<td>(0.42)</td>
<td>(0.60)</td>
</tr>
<tr>
<td>$\beta_{negative}$</td>
<td>-0.613</td>
<td>0.376</td>
<td>0.157**</td>
<td>0.984***</td>
<td>0.559</td>
<td>0.947**</td>
<td>0.674</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-1.23)</td>
<td>(1.29)</td>
<td>(2.39)</td>
<td>(2.65)</td>
<td>(1.84)</td>
<td>(2.54)</td>
<td>(1.90)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.2479</td>
<td>0.1633</td>
<td>0.4840</td>
<td>0.2124</td>
<td>0.1942</td>
<td>0.2168</td>
<td>0.1971</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>56</td>
<td>51</td>
<td>63</td>
<td>55</td>
<td>56</td>
<td>53</td>
<td>51</td>
</tr>
<tr>
<td>Restriction</td>
<td>0.93</td>
<td>-0.17</td>
<td>-0.68</td>
<td>1.36</td>
<td>0.35</td>
<td>1.30</td>
<td>0.81</td>
</tr>
</tbody>
</table>

Restriction values given by t-statistic of $\beta_{positive}$ in Regression (3).
* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.
Table 8.
Estimate of Regression (2) for Australia Announcements using AUDUSD exchange rate
Asymmetric Response Test

<table>
<thead>
<tr>
<th></th>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>YoY, Headline</th>
<th>QoQ, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$ (x1000)</td>
<td>0.967</td>
<td>1.394</td>
<td>-0.523</td>
<td>0.134</td>
<td>0.460</td>
</tr>
<tr>
<td>$t$-stat</td>
<td>(1.15)</td>
<td>(1.59)</td>
<td>(-0.41)</td>
<td>(0.14)</td>
<td>(0.45)</td>
</tr>
<tr>
<td>$\beta_{positive}$</td>
<td>-1.378**</td>
<td>0.444***</td>
<td>0.263</td>
<td>0.763**</td>
<td>0.654*</td>
</tr>
<tr>
<td>$t$-stat</td>
<td>(-2.26)</td>
<td>(2.07)</td>
<td>(0.94)</td>
<td>(2.07)</td>
<td>(1.84)</td>
</tr>
<tr>
<td>$\beta_{negative}$</td>
<td>-1.244**</td>
<td>1.540***</td>
<td>0.154</td>
<td>0.961***</td>
<td>1.009***</td>
</tr>
<tr>
<td>$t$-stat</td>
<td>(-2.26)</td>
<td>(5.36)</td>
<td>(0.43)</td>
<td>(3.36)</td>
<td>(2.80)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.3803</td>
<td>0.7625</td>
<td>0.1220</td>
<td>0.4678</td>
<td>0.4584</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>50</td>
<td>19</td>
<td>20</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>Restriction</td>
<td>0.14</td>
<td>2.50**</td>
<td>-0.18</td>
<td>0.35</td>
<td>0.55</td>
</tr>
</tbody>
</table>

Restriction values given by $t$-statistic of $\beta$ in Regression (3).
* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.

However, the data did support three announcements that registered asymmetric response—Australian GDP and United States Retail Sales and MoM, Headline Inflation announcements. Let me discuss them in turn.

The results for the effect of Australian GDP announcements in the AUDUSD market provide the simplest interpretation of asymmetric response. The results meet three key conditions: (1) a significant restriction value, (2) significance among both subsets and (3) the effects of both subsets exhibiting the same sign. Because these three conditions are met, we can say that the demonstrated asymmetric response is driven by $\beta_{negative}$ being truly more powerful than $\beta_{positive}$. Put differently, good news causes a smaller appreciation in the currency than the depreciation caused by bad news of the same exact magnitude. In this way, Australian GDP announcements provide an example of a special type of asymmetric response, and the one most associated with the name, that suggests that one type of response is truly more powerful than the other.

Unfortunately, when one of the second two conditions of Australian GDP announcements is not met, the interpretation of the results becomes necessarily more difficult. Though asymmetric response is still present, we must refrain from making any conclusive statement regarding its absolute direction. Consider an announcement whose results to the asymmetric response test meets the following three, slightly different conditions: (1) a significant restriction value, (2) significance among subsets, and (3) the
effect of both subsets exhibiting opposite signs. We would be able to derive two comfortable conclusions from these observations: that asymmetric response is present and both positive and negative surprises cause appreciations (depreciations) of the asset price. While supporting the asymmetric response hypothesis, such a conclusion is, nonetheless, counterintuitive.

Let’s go even further and look at what happens if both of the second two conditions of Australian GDP announcements are not met, such that the interpretation of the results becomes even more liberal. Consider an announcement that meets the following three, even looser conditions: (1) a significant restriction value, (2) insignificance among at least one subset and (3) the effect of both subsets exhibiting opposite signs. Then, the underlying explanation of asymmetric response is even weaker. I can only state that asymmetric response is present without speculating on the direction of one surprise relative to the other. This was the case among the remaining two instances of asymmetric response found in this paper—United States Retail Sales and MoM Headline Inflation announcements.

Section 5.3 Nonlinearity Results

We may also expect the ten minute returns around macroeconomic announcements to exhibit traits of nonlinearity, such that the market may respond more dramatically to either “small” or “big” surprises. As described earlier, I define small surprises as those equal to or less than the median of the absolute value of all surprises. I have provided a hypothetical graphic representation of nonlinearity in Appendix 7.

The data did not seem to demonstrate a prevalence of nonlinearity in foreign exchange markets with respect to macroeconomic surprises. In the restriction row of the following three tables—which measures the t-statistic of the difference between $β_{small}$ and $β_{big}$—I regularly find insignificant disparity between the effects of big and small surprises.
Restriction values given by t-statistic of $\hat{\beta}_i$ in Regression (3); * denotes significance at a 10 percent level; ** denotes significance at a 5 percent level; *** denotes significance at a 1 percent level.

### Table 9.

**Estimate of Regression (2) for United States Announcements using USD/USD exchange rate Nonlinearity Test**

<table>
<thead>
<tr>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>MoM, Core</th>
<th>MoM, Headline</th>
<th>YoY, Core</th>
<th>YoY, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$ ($x1000$)</td>
<td>0.167</td>
<td>-0.189</td>
<td>0.157</td>
<td>-0.339</td>
<td>-0.329</td>
<td>-0.177</td>
</tr>
<tr>
<td>t-stat</td>
<td>(0.40)</td>
<td>(-0.87)</td>
<td>(0.68)</td>
<td>(-1.03)</td>
<td>(-0.91)</td>
<td>(-0.70)</td>
</tr>
<tr>
<td>$\hat{\beta}_{big}$</td>
<td>-0.263</td>
<td>0.076</td>
<td>-0.079*</td>
<td>0.651**</td>
<td>0.037</td>
<td>0.387**</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-0.98)</td>
<td>(1.58)</td>
<td>(-1.67)</td>
<td>(2.12)</td>
<td>(0.20)</td>
<td>(2.01)</td>
</tr>
<tr>
<td>$\hat{\beta}_{small}$</td>
<td>0.064</td>
<td>0.176</td>
<td>0.216*</td>
<td>0.972***</td>
<td>0.818**</td>
<td>0.667**</td>
</tr>
<tr>
<td>t-stat</td>
<td>(0.12)</td>
<td>(1.22)</td>
<td>(1.69)</td>
<td>(2.70)</td>
<td>(1.84)</td>
<td>(2.30)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.0266</td>
<td>0.0705</td>
<td>0.0903</td>
<td>0.2110</td>
<td>0.0886</td>
<td>0.1623</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>47</td>
<td>55</td>
<td>64</td>
<td>42</td>
<td>48</td>
<td>41</td>
</tr>
<tr>
<td>Restriction</td>
<td>0.54</td>
<td>0.65</td>
<td>2.14**</td>
<td>0.68</td>
<td>1.53</td>
<td>0.81</td>
</tr>
</tbody>
</table>

### Table 10.

**Estimate of Regression (2) for Canada Announcements using CAD/USD exchange rate Nonlinearity Test**

<table>
<thead>
<tr>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>MoM, Core</th>
<th>MoM, Headline</th>
<th>YoY, Core</th>
<th>YoY, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$ ($x1000$)</td>
<td>0.316</td>
<td>0.135</td>
<td>-0.133</td>
<td>-0.200</td>
<td>-0.059</td>
<td>0.219</td>
</tr>
<tr>
<td>t-stat</td>
<td>(0.74)</td>
<td>(0.52)</td>
<td>(-0.62)</td>
<td>(-0.68)</td>
<td>(-0.21)</td>
<td>(-0.74)</td>
</tr>
<tr>
<td>$\hat{\beta}_{big}$</td>
<td>-1.0277***</td>
<td>0.431**</td>
<td>0.197***</td>
<td>0.432*</td>
<td>0.451***</td>
<td>0.435*</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-3.57)</td>
<td>(2.39)</td>
<td>(4.94)</td>
<td>(1.89)</td>
<td>(2.92)</td>
<td>(2.04)</td>
</tr>
<tr>
<td>$\hat{\beta}_{small}$</td>
<td>-1.025**</td>
<td>0.321</td>
<td>0.172**</td>
<td>0.614*</td>
<td>0.484</td>
<td>0.498</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-2.06)</td>
<td>(1.58)</td>
<td>(2.23)</td>
<td>(1.65)</td>
<td>(1.31)</td>
<td>(1.36)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.2385</td>
<td>0.1639</td>
<td>0.4773</td>
<td>0.1722</td>
<td>0.1920</td>
<td>0.1789</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>56</td>
<td>51</td>
<td>63</td>
<td>55</td>
<td>56</td>
<td>53</td>
</tr>
<tr>
<td>Restriction</td>
<td>0.01</td>
<td>-0.40</td>
<td>-0.28</td>
<td>0.41</td>
<td>0.08</td>
<td>0.15</td>
</tr>
</tbody>
</table>

### Table 11.

**Estimate of Regression (2) for Australia Announcements using AUD/USD exchange rate Nonlinearity Test**

<table>
<thead>
<tr>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>YoY, Headline</th>
<th>QoQ, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$ ($x1000$)</td>
<td>0.934*</td>
<td>-0.223</td>
<td>-0.367</td>
<td>-0.082</td>
</tr>
<tr>
<td>t-stat</td>
<td>(1.95)</td>
<td>(-0.30)</td>
<td>(-0.72)</td>
<td>(-0.15)</td>
</tr>
<tr>
<td>$\hat{\beta}_{big}$</td>
<td>-1.389***</td>
<td>0.939***</td>
<td>0.215**</td>
<td>0.868***</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-5.75)</td>
<td>(4.20)</td>
<td>(2.58)</td>
<td>(5.02)</td>
</tr>
<tr>
<td>$\hat{\beta}_{small}$</td>
<td>-0.830</td>
<td>0.994*</td>
<td>0.206</td>
<td>0.895</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-1.33)</td>
<td>(1.69)</td>
<td>(0.42)</td>
<td>(0.94)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.3912</td>
<td>0.7087</td>
<td>0.1202</td>
<td>0.4661</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>50</td>
<td>19</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>Restriction</td>
<td>0.88</td>
<td>0.08</td>
<td>-0.02</td>
<td>0.03</td>
</tr>
</tbody>
</table>
Empirically, only one announcement demonstrated nonlinearity—United States Retail Announcements. Interestingly, this was the same announcement that also exhibited asymmetric response.

When considering nonlinearity, one might assume that $\beta_{\text{big}}$ and $\beta_{\text{small}}$ must exhibit the same sign. After all, it seems unintuitive to say that a large, positive surprise should appreciate a currency while a small, positive surprise causes a depreciation. However, nonlinearity makes no such assumptions of the direction of the responses; rather, it only states that small surprises affect markets differently from large surprises. Therefore, it is very much possible for nonlinearity to be demonstrated if the significant restriction is driven by the fact that small surprises appreciate (depreciate) a currency while large surprises depreciate (appreciate) the currency.

This was the case among United States Retail Sales announcements, whose results to the nonlinearity test exhibited three conditions: (1) a significant restriction value, (2) significance among subsets, and (3) the effect of both subsets exhibiting opposite signs. Thus, the USD AUD market around United States Retail Sales announcements demonstrates nonlinearity such that small surprises appreciate (depreciate) a currency while large surprises caused the currency to depreciate (appreciate), albeit very slightly. Again, though counterintuitive, this conclusion is empirically proven.

Section 5.4 Financial Stress

During times of stress or chaos—such as crises—financial actors and institutions behave differently. They change their investment strategies and process information differently than they would during a period of prosperity and economic growth. On an aggregate level, this behavioral difference might manifest itself in how markets respond to surprises. Stated differently, we may notice interesting patterns in foreign exchange responses if we control for underlying macroeconomic health. Indeed, it has been well documented that bad news in “good times” have unusually large effects (e.g. Anderson, Bollerslev, Diebold and Vega 2005). The time period of our sample, 2005-2011, contains both “good” and “bad” times, as it includes the most potent economic recession since the Great Depression, nicknamed the “Great Recession.” The International Monetary Fund
(IMF) defines a “global recession” as having started in 2008. Therefore, this study uses this benchmark to define “good times” or “pre-crisis” as any observation occurring before January 2008, and “bad times” or “crisis” as any observation occurring since then.

Typically, economic studies utilize official declarations of recessionary periods given by professional governing bodies such as the National Bureau of Economics Research (NBER). This paper bypasses such this precedent altogether for the following reasons. When looking at foreign exchange markets, it is insufficient to simply consider domestic business cycle fluctuations. The paper would at least need to consider the economic conditions of both countries involved in any given currency pair. Even then, the entire purpose of testing for financial stress is undermined if one economy was expanding while the other was receding. Therefore, it makes sense to use a measure of global economic fluctuations in a study like this, where multiple countries and exchange rates are utilized.

The data demonstrates an overwhelming prevalence of different foreign exchange reactions to macroeconomic surprises before and during the crisis. In the restriction row of the following three tables—which measures the t-statistic of the difference between $\beta_{\text{crisis}}$ and $\beta_{\text{pre-crisis}}$—I regularly find significant disparity between the effects of surprises before and after January 2008.

<table>
<thead>
<tr>
<th>Table 12.</th>
<th>Estimate of Regression (2) for United States Announcements using USAUD exchange rate Financial Stress Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unemployment</td>
</tr>
<tr>
<td>$\alpha$ (x1000)</td>
<td>-0.115</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-0.31)</td>
</tr>
<tr>
<td>$\beta_{\text{pre-crisis}}$</td>
<td>-0.712*</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-1.92)</td>
</tr>
<tr>
<td>$\beta_{\text{crisis}}$</td>
<td>-0.138</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-0.50)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.0275</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>69</td>
</tr>
<tr>
<td>Restriction</td>
<td>1.26</td>
</tr>
</tbody>
</table>

Restriction values given by t-statistic of $\beta_x$ in Regression (3)
* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.
Restriction values given by t-statistic of $\hat{\beta}_i$ in Regression (3)
* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.

Table 13.
Estimate of Regression (2) for Canada Announcements using CADUSD exchange rate
Financial Stress Test

<table>
<thead>
<tr>
<th></th>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>MoM, Core</th>
<th>MoM, Headline</th>
<th>YoY, Core</th>
<th>YoY, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$ (x1000)</td>
<td>0.368</td>
<td>0.148</td>
<td>-0.161</td>
<td>-0.150</td>
<td>-0.060</td>
<td>-0.066</td>
<td>-0.066</td>
</tr>
<tr>
<td>t-stat</td>
<td>(0.88)</td>
<td>(0.71)</td>
<td>(-0.80)</td>
<td>(-0.68)</td>
<td>(-0.24)</td>
<td>(-0.29)</td>
<td>(-0.26)</td>
</tr>
<tr>
<td>$\beta_{\text{pre-crisis}}$</td>
<td>-1.072***</td>
<td>0.586***</td>
<td>0.247***</td>
<td>1.193***</td>
<td>0.747***</td>
<td>1.106***</td>
<td>0.624***</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-3.99)</td>
<td>(2.91)</td>
<td>(9.02)</td>
<td>(8.25)</td>
<td>(4.76)</td>
<td>(7.24)</td>
<td>(3.92)</td>
</tr>
<tr>
<td>$\beta_{\text{crisis}}$</td>
<td>-0.994***</td>
<td>0.344*</td>
<td>0.156***</td>
<td>0.138</td>
<td>0.262</td>
<td>0.171</td>
<td>0.263</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-2.85)</td>
<td>(1.70)</td>
<td>(3.33)</td>
<td>(0.69)</td>
<td>(1.41)</td>
<td>(0.85)</td>
<td>(1.25)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.1699</td>
<td>0.1514</td>
<td>0.4949</td>
<td>0.3264</td>
<td>0.2065</td>
<td>0.2950</td>
<td>0.1606</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>70</td>
<td>69</td>
<td>68</td>
<td>69</td>
<td>69</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td>Restriction</td>
<td>0.18</td>
<td>-0.84</td>
<td>-1.66*</td>
<td>-4.23***</td>
<td>-2.00**</td>
<td>-3.70***</td>
<td>-1.36</td>
</tr>
</tbody>
</table>

Table 14.
Estimate of Regression (2) for Australia Announcements using AUDUSD exchange rate
Financial Stress Test

<table>
<thead>
<tr>
<th></th>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>YoY, Headline</th>
<th>QoQ, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$ (x1000)</td>
<td>1.292***</td>
<td>-0.254</td>
<td>-0.429</td>
<td>-0.047</td>
<td>0.086</td>
</tr>
<tr>
<td>t-stat</td>
<td>(3.62)</td>
<td>(-0.60)</td>
<td>(-0.94)</td>
<td>(-0.10)</td>
<td>(0.18)</td>
</tr>
<tr>
<td>$\beta_{\text{pre-crisis}}$</td>
<td>-0.521</td>
<td>0.611***</td>
<td>0.221</td>
<td>0.690***</td>
<td>0.711***</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-1.54)</td>
<td>(3.97)</td>
<td>(1.26)</td>
<td>(4.12)</td>
<td>(3.58)</td>
</tr>
<tr>
<td>$\beta_{\text{crisis}}$</td>
<td>-1.515***</td>
<td>1.206***</td>
<td>0.214**</td>
<td>1.295***</td>
<td>1.061***</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-5.78)</td>
<td>(5.15)</td>
<td>(2.27)</td>
<td>(3.68)</td>
<td>(3.17)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.3472</td>
<td>0.7228</td>
<td>0.1179</td>
<td>0.5132</td>
<td>0.4721</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>69</td>
<td>23</td>
<td>22</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Restriction</td>
<td>-2.43***</td>
<td>2.10**</td>
<td>-0.03</td>
<td>1.51</td>
<td>0.87</td>
</tr>
</tbody>
</table>

Restriction values given by t-statistic of $\hat{\beta}_i$ in Regression (3)
* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.

In the United States, four of seven announcements, including two of three non-inflation measures, registered considerably different reactions before and after January 2008. In Canada, the difference was equally prevalent. Again four announcements of seven announcements, including three of four inflation measures, registered significant restriction values. In Australia, however, only a minority of announcements (two) registered significantly different foreign exchange responses before and during this global financial crisis.
Interestingly, among all countries, the sign of the effect rarely changed between the subsets of surprises, unlike the results of the asymmetric response and nonlinearity tests. This means that the same announcements that cause an appreciation (deprecation) before the crisis likely caused an appreciation (deprecation) during the crisis. However, between these three countries, the results demonstrated different patterns regarding whether the effect of a surprise became more or less pronounced once the crisis began.

In this way, the Australian results actually provide us with an interesting contrast from Canada and the United States. Notice that in Australia, the significance of the restriction value is driven by foreign exchange markets becoming more responsive to announcements after January 2008. The absolute value of $\beta_{\text{crisis}}$ is consistently larger than the absolute value of $\beta_{\text{pre-crisis}}$. On the other hand, consider the United States and Canada, where the significance of the restriction values was instead driven by foreign exchange markets becoming less responsive to announcements after January 2008. The absolute value of $\beta_{\text{pre-crisis}}$ is consistently larger than the absolute value of $\beta_{\text{crisis}}$.

To my knowledge, this is the first paper to observe such a critical distinction in how news of different countries’ macroeconomic fundamentals affects their respective domestic currencies during times of financial stress. Therefore, we can only speculate upon the reason or this disparity.

One possible explanation may lie in the existence of another phenomena tested in this paper. Perhaps the statistically significant difference of $(\beta_{\text{crisis}} - \beta_{\text{pre-crisis}})$ can be explained by the relatively prevalent existence of certain surprise subsets that were included in earlier tests and found to be statistically different. Only one announcement fits this description, such that it registered significant restriction values for both asymmetric response and financial stress tests—United States Retail Sales announcements. Let’s take a closer look. Interestingly, this is the one announcement for which the sign of the effect switched before and after January 2008. In Table 12, we found that the post-January 2008 effect $(\beta_{\text{crisis}} = -0.144)$ to significantly different than the pre-January 2008 effect $(\beta_{\text{pre-crisis}}=0.094)$. In addition, Table 6 reveals that asymmetric response also exists for this particular surprise in the USD/AUD market, such that negative surprises $(\beta_{\text{negative}}=-0.240)$ have a much larger effect than positive surprise $(\beta_{\text{positive}}=0.121)$. 


Perhaps the difference between $\beta_{\text{pre-crisis}}$ and $\beta_{\text{crisis}}$ found in this section is derived from a larger concentration of negative surprises after January 2008.

This is not the case. In Figure 2, I provide the distribution of surprises before and after January 2008. One can easily notice that there exists no noteworthy difference in the distributions, as both are seemingly normal and centered around zero. Such a finding makes sense. It seems unlikely that market expectations of macroeconomic announcements became consistently more positive (negative) or big (small) upon the onset of the global financial crisis. Even if that were true, this explanation would still be lacking, as the vast majority of announcements that demonstrated significant restrictions to the financial stress test did not report significant restrictions to any other test.

*Figure 2.*

*Distribution of United States Retail Sales Surprises*

The financial stress test also provides key insight into market volatility before and during the crisis. Consider Canada, where the test statistics found among pre-crisis surprises are much greater than those found among crisis surprises. We can attribute this to greater volatility or uncertainty in foreign exchange markets after January 2008, causing high standard errors when trying to measure the impact of any surprise. The same trend was partially exhibited among the United States and Australia results, but not with the same universality of announcements in Canada.
Section 5.5 Liquidity

The most popular definition of liquidity refers to an asset’s ability to be converted quickly into cash, or bought and sold in the market without affecting its price. It, therefore, may not be immediately obvious how this paper’s test demonstrates this same characterization of liquidity. Recall that the liquidity test investigates whether there is a significant difference between the effects of a surprise on the ten- and sixty-minute returns around the announcement. In this way, the test is designed to measure how quickly the market incorporates the information conveyed by the announcement into the asset’s price.

This paper argues in favor of using the duration of the response as a proxy of liquidity. I assume that the most liquid assets tend to be those characterized by high levels of trading activity, and that the most active markets will incorporate information fastest.¹⁶ In this way, liquid markets require much less time to react to news.

Consider Figure 3, which displays two different paths that a hypothetical asset may follow in the hour around any given announcement, $S_t$ at $t=0$, that causes the asset to appreciate. In Panel (A), I demonstrate a liquid market in which the appreciation is fully captured in the 10-minute window around the announcement, between $t+5$ and $t-5$. On the other hand, in Panel (B), I demonstrate a relatively illiquid market in which the 10-minute window fails to capture the entirety of the appreciation. Instead, a significant portion of the appreciation occurs in the window between $t+5$ and $t+30$. It is the price movement during this time interval that drives the statistical significance of the liquidity test.

¹⁶ An interesting contrast might look at the housing market, which is often considered illiquid. Houses sometimes stay on the market for years before being sold. However, housing prices are known to incorporate information quickly and are incredibly responsive to announcements, such as those of central bank interest rate policies. Consequently, the main distinction between an illiquid market like housing and a liquid market like foreign exchange is how we define “quickly” between the two. We are looking at price fluctuations around a very narrow time interval—10 minutes. Due to high transactions costs in the housing market (internalizing information, dealing with brokers and real estate agents, changing prices on online registries), it often requires more time for the market to incorporate information into the price—perhaps hours, days or even weeks.
The announcement occurs at time $t=0$.

The liquidity test is different from previous tests in the paper. Whereas earlier tests required a change in the independent variable, this section modifies the dependent variable to reflect ten and sixty minute returns surrounding the announcements. The data demonstrates few instances where the foreign exchange response requires more than ten minutes. The restriction row of the following three tables—which measures the t-statistic of the difference between $\beta_{\text{overall}}$ and $\beta_{60\text{minute}}$—displays only a couple significant differences between the effect of an announcement on the surrounding ten and sixty minutes.

**Table 15.**

*Estimate of Regression (5) for United States Announcements using USDAUD exchange rate Liquidity Test*

<table>
<thead>
<tr>
<th></th>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>MoM, Core</th>
<th>MoM, Headline</th>
<th>YoY, Core</th>
<th>YoY, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$ (x1000)</td>
<td>-0.504</td>
<td>-0.690*</td>
<td>0.301</td>
<td>-0.448</td>
<td>-0.565*</td>
<td>-0.428</td>
<td>-0.562*</td>
</tr>
<tr>
<td>$t$-stat</td>
<td>(-1.12)</td>
<td>(-1.77)</td>
<td>(0.92)</td>
<td>(-1.46)</td>
<td>(-1.78)</td>
<td>(-1.35)</td>
<td>(-1.78)</td>
</tr>
<tr>
<td>$\beta_{60\text{minute}}$</td>
<td>0.035</td>
<td>0.093*</td>
<td>-0.120*</td>
<td>1.034***</td>
<td>0.409**</td>
<td>0.888***</td>
<td>0.362**</td>
</tr>
<tr>
<td>$t$-stat</td>
<td>(0.14)</td>
<td>(1.84)</td>
<td>(-1.84)</td>
<td>(2.99)</td>
<td>(2.13)</td>
<td>(3.38)</td>
<td>(2.51)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.0002</td>
<td>0.0182</td>
<td>0.0679</td>
<td>0.1347</td>
<td>0.0522</td>
<td>0.0962</td>
<td>0.0663</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>69</td>
<td>69</td>
<td>68</td>
<td>69</td>
<td>69</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td>Restriction</td>
<td>1.02</td>
<td>0.33</td>
<td>-1.15</td>
<td>0.69</td>
<td>1.29</td>
<td>1.50</td>
<td>2.22***</td>
</tr>
</tbody>
</table>

Restriction values given by $t$-statistic of $\beta_{\text{1}}$ in Regression (6)

* denotes significance at a 10 percent level.

** denotes significance at a 5 percent level.

*** denotes significance at a 1 percent level.
**Table 16.**

*Estimate of Regression (5) for Canada Announcements using CADUSD exchange rate*

<table>
<thead>
<tr>
<th>Liquidty Test</th>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>MoM, Core</th>
<th>MoM, Headline</th>
<th>YoY, Core</th>
<th>YoY, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>α (x1000)</td>
<td>0.133</td>
<td>-0.375</td>
<td>-0.277</td>
<td>-0.077</td>
<td>0.099</td>
<td>-0.041</td>
<td>0.081</td>
</tr>
<tr>
<td>t-stat</td>
<td>(0.28)</td>
<td>(-0.94)</td>
<td>(-0.66)</td>
<td>(-0.23)</td>
<td>(0.29)</td>
<td>(-0.12)</td>
<td>(0.24)</td>
</tr>
<tr>
<td>β_{60 minute}</td>
<td>-1.47***</td>
<td>0.358</td>
<td>0.234***</td>
<td>0.729***</td>
<td>0.650***</td>
<td>0.698***</td>
<td>0.668***</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-5.01)</td>
<td>(1.45)</td>
<td>(3.60)</td>
<td>(4.22)</td>
<td>(3.80)</td>
<td>(4.49)</td>
<td>(4.07)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.2468</td>
<td>0.0391</td>
<td>0.2123</td>
<td>0.2176</td>
<td>0.1809</td>
<td>0.2131</td>
<td>0.1888</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>69</td>
<td>69</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>68</td>
</tr>
<tr>
<td>Restriction</td>
<td>-3.02***</td>
<td>-0.38</td>
<td>1.04</td>
<td>2.07**</td>
<td>1.39</td>
<td>2.08**</td>
<td>1.93*</td>
</tr>
</tbody>
</table>

Restriction values given by t-statistic of β₃ in Regression (6)
* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.

**Table 17.**

*Estimate of Regression (5) for Australia Announcements using AUDUSD exchange rate*

<table>
<thead>
<tr>
<th>Liquidty Test</th>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>YoY, Headline</th>
<th>QoQ, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>α (x1000)</td>
<td>1.304**</td>
<td>-0.362</td>
<td>-0.050</td>
<td>-0.344</td>
<td>-0.217</td>
</tr>
<tr>
<td>t-stat</td>
<td>(2.71)</td>
<td>(-0.76)</td>
<td>(-0.10)</td>
<td>(-0.50)</td>
<td>(-0.31)</td>
</tr>
<tr>
<td>β_{60 minute}</td>
<td>-1.173***</td>
<td>0.920***</td>
<td>0.083</td>
<td>1.126***</td>
<td>1.076***</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-4.45)</td>
<td>(5.17)</td>
<td>(0.55)</td>
<td>(4.12)</td>
<td>(3.66)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.1772</td>
<td>0.6491</td>
<td>0.0121</td>
<td>0.4277</td>
<td>0.4042</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>69</td>
<td>23</td>
<td>22</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Restriction</td>
<td>0.24</td>
<td>-0.34</td>
<td>-1.47</td>
<td>1.67*</td>
<td>1.47</td>
</tr>
</tbody>
</table>

Restriction values given by t-statistic of β₃ in Regression (6)
* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.

Notice that even in the market for the same currency, we find that certain announcements signify greater and less liquidity. Consider Table 16, which measures the CADUSD market, where four of seven announcements denoted illiquidity. Therefore, throughout this section, I will begin the convention of saying that a certain market is liquid “around” a certain announcement.

If relatively liquid assets experience high trading volume and incorporate information more quickly, one might reasonably expect very few United States announcements to register significant restriction values in the USDAUD market. The United States dollar certainly fits the description of liquidity, constituting the vast majority of foreign exchange trades. Empirically, I have confirmed this hypothesis. Only one United
States announcement required more than ten minutes to be fully incorporated into the price of the USD—YoY Headline Inflation announcements. However, this exception becomes somewhat irrelevant once we consider the earlier finding in Table 3 that the overall effect YoY Headline Inflation announcements is insignificant. The results of the liquidity test among United States announcements corroborate the purported positive correlation between liquidity and required reaction time.

The market for the Australian dollar also experiences widespread liquidity around macroeconomic announcements. Only one announcement denotes illiquidity of the Australian dollar—YoY Headline Inflation Announcements, but barely so, with a restriction value of 1.67.

Meanwhile, Canada provides a convenient juxtaposition to Australia and the United States. The CADUSD market experienced illiquidity around four of seven macroeconomic announcements, including unemployment and three inflation measures—Core MoM, Core YoY and Headline YoY Inflation. All of these announcements also demonstrated significant overall effects in Table 4.

It is not clear why Canada differs from the United States and Australia in required response time to surprises. While one might make the case that the USD is more liquid than the CAD, the same argument would not explain the difference between Canadian and Australian results. Indeed, while AUD is involved in more foreign exchange trades than CAD, the difference is marginal and cannot fully explain why the CAD market responds much more slowly to surprises.

Section 5.6. Exchange-Rate Specificity

So far, this study has focused on the effects of the same announcements in different countries. This section takes a slightly different turn. Here, we study on the effects of the same announcements in the same country, using different reference currencies when calculating responses. Like the liquidity test, this section modifies the dependent variable. This section attempts to demonstrate the same news about a country can generate different returns on the domestic currency when priced against different reference currencies.
The data strongly demonstrates that exchange-rate specificity exists, such that the same United States announcement can incite significantly different responses in different markets for the USD. Consider Tables 18, 19, 20, 21 and 22 that shows the overall effect of the same United States announcements on the price of the USD, using different currency pairs.

Table 18.
Estimate of Equation (1) for United States Announcements using USDAUD exchange rate
Exchange-Rate Specificity Test

<table>
<thead>
<tr>
<th></th>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>MoM, Core</th>
<th>MoM, Headline</th>
<th>YoY, Core</th>
<th>YoY, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>α (x1000)</td>
<td>-0.049</td>
<td>-0.267</td>
<td>0.099</td>
<td>-0.084</td>
<td>-0.189</td>
<td>-0.100</td>
<td>-0.192</td>
</tr>
<tr>
<td>t-stat</td>
<td>-0.13</td>
<td>-1.29</td>
<td>0.45</td>
<td>-0.37</td>
<td>-0.77</td>
<td>-0.41</td>
<td>-0.78</td>
</tr>
<tr>
<td>βoverall</td>
<td>-0.228</td>
<td>0.079*</td>
<td>-0.065</td>
<td>0.866***</td>
<td>0.193</td>
<td>0.555***</td>
<td>0.082</td>
</tr>
<tr>
<td>t-stat</td>
<td>-0.93</td>
<td>1.70</td>
<td>-1.39</td>
<td>3.61</td>
<td>1.11</td>
<td>3.04</td>
<td>0.66</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.0151</td>
<td>0.0443</td>
<td>0.0454</td>
<td>0.1661</td>
<td>0.0203</td>
<td>0.0662</td>
<td>0.0060</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>69</td>
<td>69</td>
<td>68</td>
<td>69</td>
<td>69</td>
<td>69</td>
<td>69</td>
</tr>
</tbody>
</table>

* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.

Table 19.
Estimate of Equation (1) for United States Announcements using USDCAD exchange rate
Exchange-Rate Specificity Test

<table>
<thead>
<tr>
<th></th>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>MoM, Core</th>
<th>MoM, Headline</th>
<th>YoY, Core</th>
<th>YoY, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>α (x1000)</td>
<td>0.262</td>
<td>0.312</td>
<td>-0.155</td>
<td>0.273*</td>
<td>0.297**</td>
<td>0.281*</td>
<td>0.298**</td>
</tr>
<tr>
<td>t-stat</td>
<td>(0.91)</td>
<td>(1.52)</td>
<td>(-0.96)</td>
<td>(1.78)</td>
<td>(2.01)</td>
<td>(1.82)</td>
<td>(2.03)</td>
</tr>
<tr>
<td>βoverall</td>
<td>0.052</td>
<td>0.007</td>
<td>0.041</td>
<td>-0.170</td>
<td>0.024</td>
<td>-0.084</td>
<td>0.036</td>
</tr>
<tr>
<td>t-stat</td>
<td>(0.31)</td>
<td>(0.18)</td>
<td>(1.23)</td>
<td>(-1.17)</td>
<td>(0.35)</td>
<td>(-0.67)</td>
<td>(0.75)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.0012</td>
<td>0.0004</td>
<td>0.0352</td>
<td>0.0178</td>
<td>0.0008</td>
<td>0.0042</td>
<td>0.0032</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>69</td>
<td>69</td>
<td>68</td>
<td>69</td>
<td>69</td>
<td>69</td>
<td>69</td>
</tr>
</tbody>
</table>

* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.

Table 20.
Estimate of Equation (1) for United States Announcements using USDEUR exchange rate
Exchange-Rate Specificity Test

<table>
<thead>
<tr>
<th></th>
<th>Unemployment</th>
<th>GDP</th>
<th>Retail Sales</th>
<th>MoM, Core</th>
<th>MoM, Headline</th>
<th>YoY, Core</th>
<th>YoY, Headline</th>
</tr>
</thead>
<tbody>
<tr>
<td>α (x1000)</td>
<td>-0.369</td>
<td>-0.219</td>
<td>0.061</td>
<td>0.058</td>
<td>-0.019</td>
<td>0.056</td>
<td>-0.022</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-1.03)</td>
<td>(-1.56)</td>
<td>(0.36)</td>
<td>(0.37)</td>
<td>(-0.11)</td>
<td>(0.34)</td>
<td>(-0.13)</td>
</tr>
<tr>
<td>βoverall</td>
<td>-0.316</td>
<td>0.102**</td>
<td>0.036</td>
<td>0.621***</td>
<td>0.111</td>
<td>0.475***</td>
<td>0.016</td>
</tr>
<tr>
<td>t-stat</td>
<td>(-1.19)</td>
<td>(2.46)</td>
<td>(1.00)</td>
<td>(3.17)</td>
<td>(0.93)</td>
<td>(2.77)</td>
<td>(0.17)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.0238</td>
<td>0.1308</td>
<td>0.0219</td>
<td>0.1746</td>
<td>0.0140</td>
<td>0.0996</td>
<td>0.0004</td>
</tr>
<tr>
<td>No. Obs.</td>
<td>72</td>
<td>72</td>
<td>72</td>
<td>71</td>
<td>72</td>
<td>72</td>
<td>72</td>
</tr>
</tbody>
</table>

* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.
There exists a substantial disparity in the results between reference currencies. On the surface, it would seem as though the USDJPY market responds 23 times more strongly to GDP surprises than the USDCAD market. This is consistent with the general trend of $\beta_{\text{overall}}$ values being much larger in the USDJPY market than in the USDCAD market. Even more interesting is the clear and consistent paradigm in relative $\beta_{\text{overall}}$ values across these five different markets. In order from largest to smallest, and across most announcements, $\beta_{\text{overall}}$ adheres to the following magnitude-based order: USDJPY, USDGBP, USDEUR, USDAUD and USDCAD. It must not be a coincidence this corresponds very closely to the list of these very same reference currencies ranked by their relative liquidities.

Such an observation is consistent with an assumption made earlier in this paper—information contained in surprises is more likely to be incorporated in liquid markets than illiquid markets over a 10 minute period. Because financial institutions are trading news of
the United States of the American economy on the USDJPY market with much greater frequency and in much higher volumes than other markets, the Japanese Yen is vulnerable to much greater price changes around United States surprises.

There is one particularly strange anomaly. The Euro is twice as liquid as the Yen, but exhibits half as powerful responses to macroeconomic surprises. Consequently, we can use another explanation from earlier in the paper to illuminate this behavior. The Euro exists as the official currency of a majority of the Eurozone. Recall that in Section 5.1, I compared the effects of American announcements to those in Australia and Canada and noticed a much more depressed effect among United States Announcements. I concluded that, because the United States dollar is influenced by many more factors than other currencies, the relative importance of any single macroeconomic announcement is much lower than that of a parallel announcement in a country with a less complicated economy, with respect to their domestic currency. This same logic explains the difference of $\beta_{overall}$ between USDEUR and USDJPY. The Euro is the official currency of 17 different countries, and is thus affected by the macroeconomic health of 17 different countries. Though no individual country may be as complicated as Japan, their combination creates a significantly more complex entity, such that the Euro is naturally affected by many more factors than the Yen. For this reason, we would expect the response to a given surprise to be more pronounced in the USDJPY market than in the USDEUR market. This serves as an example where liquidity of a country’s currency and the sheer magnitude of its economy have opposing effects in the scale of their currency’s response to macroeconomic surprises.

There also exists a gross disparity in results between USDJPY and all other currencies, with respect to statistical significance and magnitude of $\beta_{overall}$. The only announcements with significant effects on the USDEUR, USDGBP, USDAUD and USDCAD markets seem to be GDP, MoM Core and YoY Core inflation measures, consistent with the discussion in Section 5.1. In contrast, all announcements with the exception of headline inflation measures seem to have statistically significant and more powerful effects in the USDJPY market.17

17 Considering this, a natural question may be why this study does not utilize the USDJPY exchange rate when examining the effects of United States announcements throughout the entire paper, for all tests. After all, it is a more liquid currency pair, and the effects of announcements are much more significant and (continued ...)

45
As mentioned earlier, the tables found in Appendix 8, 9, 10, 11, 12, 13 and 14 provide conservative measures of the test-statistics of the difference between the effects of each announcement on two different currency pairs.

Of the fourteen instances where the difference of an announcement’s effect was significant, eleven included either the Euro or Yen, or both. This is consistent with our earlier discussion on the effects of liquidity on announcement effects. Interestingly, there were no instances of significant differences between the effects of MoM and YoY Headline surprises on different currency pairs. Upon closer inspection, we notice that the low t-statistic values for these two announcements are driven by very large individual standard errors, as opposed to similar $\beta_{overall}$ values. This is consistent with our earlier finding from Section 5.1 that headline inflation are subpar indicators of macroeconomic health in the United States, and are thereby rarely used among financial institutions to determine investment strategies.

All of our results point to the strong relationship between a currency pair’s liquidity and the extent to which it incorporates information.

Section 6. Conclusion and Suggestions for Future Research

The original question that inspired this paper was, “do announcements affect asset prices over the very short run?” In order to approach an answer, I utilize an empirical framework and best available data to empirically determine the almost-instantaneous reaction of currency markets to macroeconomic news. I find an overwhelming “yes” to this original research question among three different countries and five different currency pairs. Macroeconomic surprises in Australia, Canada and the United States tend to trigger notable movements in the value of their respective currencies.

While such a conclusion is certainly interesting, this paper dives even further into the data to uncover more nuanced behaviors of currency markets around announcements by testing for various financial phenomena. Certainly, some tests yielded weak or no powerful on the USDJPY exchange rate. The use of the USDAUD rate throughout the paper was done deliberately in order to maintain consistency among the dependent variable across all tests performed in this paper. Due to limitations of the data—namely, USDJPY futures values are only available starting at 8:21 AM EST—this paper would have been unable to complete the liquidity test with the USDJPY exchange rate.
evidence. This held true for the asymmetric response, nonlinearity and liquidity tests. Though we were able to uncover a few markets where the significance of the tests indicated the presence of these phenomena, such rare results did not compensate for the vast majority of announcements whose market responses could not be proven to behave as the phenomena would predict.

On the other hand, the financial stress and exchange-rate specificity tests were largely successful, and provide the basis for potential forthcoming research. More specifically, the financial stress test demonstrated that in certain countries (namely, Australia), the effect of announcements became more prominent during the financial crisis, while in other countries (i.e. Canada and the United States) more repressed. As no explanation is immediately obvious, future studies might examine why the presence of financial stress adds a premium to the announcements of certain countries, and a discount to others. Meanwhile, the exchange-rate specificity test demonstrated that even a single country's announcements could generate different movements of its domestic currency priced against different reference currencies. We can interpret these findings as the result of differing liquidities across currency pairs.

An interesting direction for future research might consider the variance of the survey data. This paper does not consider the role of widespread consensus—or lack thereof—on market responses to surprises. Instead, we only use the survey data for its median value, and disregard everything else. Doing so might be detrimental to studying the impact of news, as it ignores a significant influence of the market’s response—the variance or “dispersion” of the survey itself. Consider two hypothetical survey results for the same announcement, both with the same median value. The first, however, experiences a much lower dispersion such that most individual expectations are concentrated closely to the median, denoting that market has reached a consensus regarding the announcement. The second experiences greater dispersion with a much wider distribution, denoting that the market has not reached a consensus regarding the announcement value. Suppose the announcement arrives, and it is different from the median expectation. Logically, because the market represented by the first survey was more certain, it might respond more strongly to the news than the market represented by the second survey, which was more uncertain, and is therefore not as “surprised” by the announcement. In sum, simply casting
the median value of the survey as the “market expectation” might disregard an important influence of the market response to announcements. As such, I recommend that other related research projects add dispersion to their analyses.

With regards to exchange-rate specificity, future studies might look into whether relatively illiquid currency pairs *eventually* respond to the same announcement to the same degree. In fact, one could make a compelling argument defending this notion. A defining aspect of this test is that it considers a single asset (in this case, USD), and how its value changes upon receipt of same information regarding its fundamentals, using two different pricing standards, or reference currencies.\(^\text{18}\) For this reason, it is completely possible—and reasonable to expect—that the markets for all currency pairs will respond to the same degree, eventually. The only difference is the amount of time required to realize this price change. That being said, the elongated response time found among relatively illiquid pairs allows for other announcements and new information to affect its price before the concerned announcement has taken its full effect. Such might be an interesting direction for future research.

In addition, we suggest that future academics use an expanded dataset to combine the tests used in this paper in order to explore how such financial phenomena interact with one another. As described earlier in the paper, it might be interesting to observe the difference in market responses to big, negative surprises versus big, positive surprises. Or, one could go even further and compare big, negative surprises before the crisis to big, positive surprises during the crisis. Doing so would require substantially more comprehensive datasets over a longer time horizon than those used in this study, as incorporating more specifically defined surprise subsets lowers the number of observations in each and reduces the viability of the results.

This paper’s final suggestion for future research is simple—add more countries, currencies and announcements. Note that the most interesting conclusions drawn from this paper were not the simple regression results of any one announcement, country or currency pair, but rather *how they compared with each other*. In this way, this paper is able

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\(^\text{18}\) In this way, the relevance of liquidity to exchange-rate specificity is different than to the liquidity test in Section 5.4. With exchange-rate specificity, this paper is concerned with identical products and identical announcements. The liquidity test, on the other hand, compares two different assets and announcements altogether.
to notice patterns in responses, in addition to individual effects. Certain trends applied to some countries, while the opposite trends applied to others. Though it may be tempting to speculate, the best way to understand the underlying cause of these differences is to include more depth to the analysis, and then use the results to draw even more expansive conclusions.
References


Appendix

Appendix 1.

STATA Code to Balance Foreign Exchange Datasets

use H:\AUDUSD.DTA //Or any foreign exchange dataset//
gen x=minute if mod(minute,5)==4 //Revealed time values that demonstrated problematic characteristics, i.e. 8:49:59 instead of 8:50:00//
replace minute=minute+1 if mod(minute,5)==4 //Corrected these problematic observations by adding one second to their value//
drop x

gen midquote=(bid+ask)/2 //Midquote used for all return calculations//
gen timediff=minute[_n+1]-minute[_n-1] //Revealed unbalanced observations by calculating the time difference between all adjacent observations. Only 10-minute and, later, 60-minute differences are usable.//
tab timediff
replace timediff=600000 if (timediff==85800000 & date[_n+1]-date[_n-1]==1) //Corrects for balanced data at the end of the day, surrounding midnight//
gen ten=ln(midquote[_n+1])-ln(midquote[_n-1]) if timediff==600000 //Calculates ten minute returns only when interval is ten minutes.//
gen timediff1=minute[_n+6]-minute[_n-6]
replace timediff1=3600000 if (timediff==82800000 & date[_n+1]-date[_n-1]==1) //Corrects for balanced data at the end of the day, surrounding midnight//
gen sixty=ln(midquote[_n+6])-ln(midquote[_n-6]) if timediff==3600000 //Calculates sixty minute returns only when interval is sixty minutes.//
log close

Appendix 1.

STATA Code to Merge FX & Announcement Data, Regressions

use "H:\New Australia\10 minute\Unemployment\Unemployment Rate.dta" //Or any announcement type data//
rename Date date
rename Time minute
//To add consistency between FX and Announcement Data for merge.//
drop Period Srv_Avg Srv_High Srv_Low Srv_Num Prior Revised

gen xsurprise= Actual- Srv_Med

gen surprise=0
//Due to rounding errors, I had to use a proxy surprise variable that I would then convert in Excel, then paste back into the STATA data browser//
edit
browse
merge 1:1 date minute using "H:\AUDUSD.DTA" //Or any foreign exchange data//
drop if _merge!=3 //To ensure only FX observations around announcements were used.//
tab timediff
drop if timediff!=600000

tab timediff2

drop if timediff1!=3600000
//To ensure that all dependent variable data is balanced.//
drop _merge
generate ten surprise, robust //Overall results//
generate ten surprise if surprise!=0, robust //Nonzero results//
drop sym
generate precrisis=0
generate crisis=0
replace precrisis=surprise if date<date[33]
replace crisis=surprise if date>=date[33] //Please note that the reference point used to divide surprises between precrisis and crisis varied announcement from announcement, typically dependent on the availability of Bloomberg's data//
generate ten precrisis, robust //Financial stress results//
generate ten surprise crisis, robust //Financial stress test statistics//
generate weird=0
replace weird=sixty-ten //"weird" is simply the return in the fifty minutes surrounding the announcement, excluding the immediate ten minute interval.//
generate sixty surprise, robust //Liquidity results//
generate weird surprise, robust //Liquidity test statistics//
drop if surprise==0
generate pos=0
generate neg=0
replace pos=surprise if surprise>0
replace neg=0 if surprise<0
generate ten pos neg, robust //Asymmetric Response results//
generate ten surprise neg, robust //Asymmetric response test statistics//
generate big=0
generate small=0
generate absolutevalue=abs(surprise) //To divide between big and small, we are interested in the absolute value of surprises.//
table absolutevalue //Provides the distribution of absolute values of all surprises//
replace big=surprise if absolutevalue>=0.002 //Please note that the reference point used to divide surprises between big and small varied announcement from announcement//
replace small=surprise if big==0
generate ten big small, robust //Nonlinearity results//
generate ten surprise small, robust //Nonlinearity test statistics//
log close
### Appendix 3.
**United States Announcement Summaries**

<table>
<thead>
<tr>
<th>Type</th>
<th>Official Title</th>
<th>Releasing Agency</th>
<th>Time (GMT)</th>
<th>Frequency</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unemployment</td>
<td>US Unemployment Rate Total in Labor Force Seasonally Adjusted</td>
<td>Bureau of Labor Statistics</td>
<td>12:30</td>
<td>Monthly</td>
<td>Rate / %</td>
</tr>
<tr>
<td>GDP</td>
<td>GDP US Chained 2005 Dollars QoQ SAAR</td>
<td>Bureau of Economic Analysis</td>
<td>12:30</td>
<td>Monthly</td>
<td>Rate / %</td>
</tr>
<tr>
<td>Retail Sales</td>
<td>Adjusted Retail &amp; Food Services Sales SA Total Monthly % Change</td>
<td>U.S. Census Bureau</td>
<td>12:30</td>
<td>Monthly</td>
<td>Rate / %</td>
</tr>
<tr>
<td>YoY, Core</td>
<td>US CPI Urban Consumers Less Food &amp; Energy YoY NSA</td>
<td>Bureau of Labor Statistics</td>
<td>12:30</td>
<td>Monthly</td>
<td>Rate / %</td>
</tr>
<tr>
<td>YoY, Headline</td>
<td>US CPI Urban Consumers YoY NSA</td>
<td>Bureau of Labor Statistics</td>
<td>12:30</td>
<td>Monthly</td>
<td>Rate / %</td>
</tr>
</tbody>
</table>

### Appendix 4.
**Canada Announcement Summaries**

<table>
<thead>
<tr>
<th>Type</th>
<th>Official Title</th>
<th>Releasing Agency</th>
<th>Time (GMT)</th>
<th>Frequency</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unemployment</td>
<td>STCA Canada Labor Force Unemployment Rate SA</td>
<td>STCA - Statistics Canada</td>
<td>11:00/12:00</td>
<td>Monthly</td>
<td>Rate / %</td>
</tr>
<tr>
<td>GDP</td>
<td>STCA Canada GDP All Industries Chained 2002 Prices SA MoM</td>
<td>STCA - Statistics Canada</td>
<td>12:30/13:30</td>
<td>Monthly</td>
<td>Rate / %</td>
</tr>
<tr>
<td>Retail Sales</td>
<td>STCA Canada Retail Sales MoM SA</td>
<td>STCA - Statistics Canada</td>
<td>12:30/13:30</td>
<td>Monthly</td>
<td>Rate / %</td>
</tr>
<tr>
<td>MoM, Core</td>
<td>STCA Canada CPI Ex the 8 Most Volatile Components and Indirect Taxes MoM NSA</td>
<td>STCA - Statistics Canada</td>
<td>11:00/12:00</td>
<td>Monthly</td>
<td>Rate / %</td>
</tr>
<tr>
<td>MoM, Headline</td>
<td>STCA Canada CPI MoM NSA 2002=100</td>
<td>STCA - Statistics Canada</td>
<td>11:00/12:00</td>
<td>Monthly</td>
<td>Rate / %</td>
</tr>
<tr>
<td>YoY, Core</td>
<td>STCA Canada CPI Ex the 8 Most Volatile Components and Indirect Taxes YoY</td>
<td>STCA - Statistics Canada</td>
<td>12:30/13:30</td>
<td>Monthly</td>
<td>Rate / %</td>
</tr>
<tr>
<td>YoY, Headline</td>
<td>STCA Canada CPI YoY NSA 2002=100</td>
<td>STCA - Statistics Canada</td>
<td>12:30/13:30</td>
<td>Monthly</td>
<td>Rate / %</td>
</tr>
</tbody>
</table>
## Appendix 5.
**Australia Announcement Summaries**

<table>
<thead>
<tr>
<th>Type</th>
<th>Official Title</th>
<th>Releasing Agency</th>
<th>Time (GMT)</th>
<th>Frequency</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unemployment</td>
<td>Australia Labor Force Unemployment Rate SA</td>
<td>Australian Bureau of Statistics</td>
<td>00:30/1:30</td>
<td>Monthly</td>
<td>Rate / %</td>
</tr>
<tr>
<td>GDP</td>
<td>Australia GDP QoQ SA</td>
<td>Australian Bureau of Statistics</td>
<td>00:30/1:30</td>
<td>Quarterly</td>
<td>Rate / %</td>
</tr>
<tr>
<td>Retail Sales</td>
<td>Australia Qtrly Retail Turnover QoQ SA</td>
<td>Australian Bureau of Statistics</td>
<td>00:30/1:30</td>
<td>Quarterly</td>
<td>Rate / %</td>
</tr>
<tr>
<td>QoQ, Headline</td>
<td>Australia CPI All Groups Goods Component QoQ</td>
<td>Australian Bureau of Statistics</td>
<td>00:30/1:30</td>
<td>Quarterly</td>
<td>Rate / %</td>
</tr>
<tr>
<td>YoY, Headline</td>
<td>Australia CPI All Groups Goods Component YoY</td>
<td>Australian Bureau of Statistics</td>
<td>00:30/1:30</td>
<td>Quarterly</td>
<td>Rate / %</td>
</tr>
</tbody>
</table>

## Appendix 6.
**Hypothetical Graphical Representation of Asymmetric Response**

(A) Symmetric Response

(B) Asymmetric Response
Appendix 7.
Hypothetical Graphical Representation of Nonlinearity

(A) Linear Response
(B) Nonlinear Response

Appendix 8.
Exchange-Rate Specificity t-statistics: Unemployment Announcements

<table>
<thead>
<tr>
<th></th>
<th>AUD</th>
<th>CAD</th>
<th>GBP</th>
<th>JPY</th>
<th>EUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUD</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>CAD</td>
<td>0.94</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>GBP</td>
<td>0.38</td>
<td>1.40</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>JPY</td>
<td>1.22</td>
<td>2.13**</td>
<td>0.90</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>EUR</td>
<td>0.25</td>
<td>1.17</td>
<td>0.12</td>
<td>0.97</td>
<td>X</td>
</tr>
</tbody>
</table>

* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.

Appendix 9.
Exchange-Rate Specificity t-statistics: GDP Announcements

<table>
<thead>
<tr>
<th></th>
<th>AUD</th>
<th>CAD</th>
<th>GBP</th>
<th>JPY</th>
<th>EUR</th>
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</thead>
<tbody>
<tr>
<td>AUD</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>CAD</td>
<td>1.15</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>GBP</td>
<td>0.03</td>
<td>0.10</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>JPY</td>
<td>1.51</td>
<td>2.80***</td>
<td>0.06</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>EUR</td>
<td>0.38</td>
<td>1.61</td>
<td>0.01</td>
<td>1.21</td>
<td>X</td>
</tr>
</tbody>
</table>

* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.
### Appendix 10.
**Exchange-Rate Specificity t-statistics: Retail Sales Announcements**

<table>
<thead>
<tr>
<th></th>
<th>AUD</th>
<th>CAD</th>
<th>GBP</th>
<th>JPY</th>
<th>EUR</th>
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<tbody>
<tr>
<td>AUD</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>CAD</td>
<td>1.85*</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>GBP</td>
<td>1.16</td>
<td>0.51</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>JPY</td>
<td>4.41***</td>
<td>3.09***</td>
<td>3.06***</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>EUR</td>
<td>1.71*</td>
<td>0.12</td>
<td>0.40</td>
<td>3.13***</td>
<td>X</td>
</tr>
</tbody>
</table>

* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.

---

### Appendix 11.
**Exchange-Rate Specificity t-statistics: MoM, Core Inflation Announcements**

<table>
<thead>
<tr>
<th></th>
<th>AUD</th>
<th>CAD</th>
<th>GBP</th>
<th>JPY</th>
<th>EUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUD</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>CAD</td>
<td>3.70***</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>GBP</td>
<td>1.56</td>
<td>1.86*</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>JPY</td>
<td>0.80</td>
<td>3.28***</td>
<td>0.92</td>
<td>X</td>
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</tr>
<tr>
<td>EUR</td>
<td>0.79</td>
<td>3.24***</td>
<td>0.91</td>
<td>0.00</td>
<td>X</td>
</tr>
</tbody>
</table>

* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.

---

### Appendix 12.
**Exchange-Rate Specificity t-statistics: MoM, Headline Inflation Announcements**

<table>
<thead>
<tr>
<th></th>
<th>AUD</th>
<th>CAD</th>
<th>GBP</th>
<th>JPY</th>
<th>EUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUD</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>CAD</td>
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<tr>
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<td>0.64</td>
<td>0.29</td>
<td>0.09</td>
<td>X</td>
</tr>
</tbody>
</table>

* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.

---

### Appendix 13.
**Exchange-Rate Specificity t-statistics: YoY, Core Inflation Announcements**

<table>
<thead>
<tr>
<th></th>
<th>AUD</th>
<th>CAD</th>
<th>GBP</th>
<th>JPY</th>
<th>EUR</th>
</tr>
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<td>3.60***</td>
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<td>2.63***</td>
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</tr>
</tbody>
</table>

* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.
## Appendix 14.

*Exchange-Rate Specificity t-statistics: YoY, Headline Inflation Announcements*

<table>
<thead>
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<th>EUR</th>
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</tr>
</tbody>
</table>

* denotes significance at a 10 percent level.
** denotes significance at a 5 percent level.
*** denotes significance at a 1 percent level.