

The response of multinationals' foreign exchange rate exposure to macroeconomic news^{*}

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Abstract

We describe two channels through which macroeconomic news affects the firm's exposure to the foreign exchange rate. A short-lived change in the exposure is caused by the revaluation effects of the macroeconomic news on the stock's price and foreign exchange rate. A permanent change in the exposure occurs when the news alters the expectations on how the foreign exchange rate changes affect the firm's value in the future. We identify these two effects by using intraday price data to obtain non-parametric estimates for the daily foreign exchange rate exposure of the firm value of US multinationals. We find that price index announcements have an immediate, though temporary impact on the foreign exchange rate exposure. Announcements on higher-than-expected nonfarm payroll and federal funds target interest rates lead to a permanent decrease of the foreign exchange rate exposure.

Keywords: Exchange rate exposure, high-frequency data, macroeconomic news.

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1 Introduction

Changes in the foreign exchange rate affect the cash flows and value of internationally active firms, these exposures are time-varying and therefore challenging to estimate (see, Jorion, 1990, Boudt et al., 2015). Can we benefit from the availability of intraday price data to obtain more timely estimates of the firm's foreign exchange rate coefficient? Is it possible to identify how macroeconomic news changes systematically the foreign exchange rate exposure? When are those macro effects on foreign exchange rate exposure likely to be persistent? We provide an empirical answer to those interesting questions based on analysis of the high-frequency price changes of US multinationals over the period 2008-2014.

This paper is the first to use high frequency data to estimate daily foreign exchange rate exposures. While in earlier empirical work one splits the sample (e.g., Jorion, 1990, Williamson, 2001), uses rolling windows (e.g., Glaum et al., 2000) or takes a parametric approach (e.g., Boudt et al., 2015), we use high frequency data which leads to more precise estimates of the time variation in the exposure. This allows us to contribute to the understanding of the foreign exchange rate exposure dynamics. The results can lead to improved hedging strategies and are therefore of interest to corporate risk managers and portfolio managers.

The paper also assesses the impact of macroeconomic news on the daily foreign exchange rate exposure of internationally active firms. We study how the news affects the investors' perception of the firm's exposure. We distinguish between a short-term learning effect and a permanent effect on the firm's exposure. The first is a short-lived effect of the news on the foreign exchange rates and stock's prices. The latter is permanent because the announcement contains information on the expected sensitivity of the firm's value to changes in the foreign exchange rates.

We study the exposure of a sample of 182 S&P 500 US multinationals over the period 2008–2014. We find that these firms, on average, benefit from a US dollar depreciation. However, we also document that this sensitivity is time-varying. Furthermore, the exposure of a multinational tends to respond to different types of macroeconomic announcements. GDP, nonfarm payroll, consumer price and interest rate announcements have a permanent impact on the foreign exchange rate exposure. In contrast, exchange rate exposures respond temporarily to inflation announcements, such as export price and producer price index surprises. Some differences are found across sectors, though most

conclusions hold quiet generally.

These results are related to the existing literature on the effects of macroeconomic and policy announcements on stock returns and foreign exchange rates (see, e.g., Bauer and Neely, 2014, Dewachter et al., 2014, Neely, 2015). Andersen et al. (2003, 2007) find that macroeconomic news adds information to the market and is therefore incorporated in both stock prices and foreign exchange rates. Lahaye et al. (2011) associate jumps in stock prices and foreign exchange rates with macroeconomic news releases on GDP, nonfarm payroll and federal funds target interest rates. Similar results are found by Mun (2012) who studies the joint response of foreign exchange rates and stock markets to macro announcements. Our paper differs from these studies in the focus on the direct impact of macro announcements on the firm's foreign exchange rate risk rather than the impact on aggregated stock markets and foreign exchange rates separately. In fact, those joint reactions, are the very reason for an immediate, short-lived change in the exposure. Suppose e.g., that the macroeconomic news leads to a depreciation of the currency and an increase in the firm's valuation, so that we expect an increase in the exposure as estimated over that short window, the day of the announcement.

Finally, our paper also fits in a strand of the literature examining the determinants of time variation in the foreign exchange rate exposures. Some attribute the variation to changes in industry and firm structure (see, e.g., Allayannis and Ihrig, 2001, Bodnar et al., 2002, Dominguez and Tesar, 2006, Doukas et al., 2003, Gao, 2000, Williamson, 2001). Jorion (1990) finds that the exchange rate exposure depends on the market development. He and Ng (1998) relate exposure to the relative importance of foreign activities and proxies of the firm's hedging behaviour. Francis et al. (2008) and Chaieb and Mazzotta (2013) find that firm and industry characteristics explain cross-sectional differences rather than the exposure dynamics. They find that the time-variation in the exposure in contrast is related to shifts in macroeconomic conditions. Chaieb and Mazzotta (2013) show that exposure of multinational firms increases in times of domestic recessions. This result is in line with Boudt et al. (2015), who show that the firm's exposure depends on the moneyness of the option to export. They argue that a firm's exposure should increase when exporting becomes more beneficial, because of the firm's real option to export. This argument is related to the finding that firms nowadays are often two-way traders, being both exporters and importers at the same time, and are therefore able to shift their activities depending on the economic regime (see, e.g., Muûls and Pisu, 2009). Our paper adds to this

literature by linking foreign exchange rate exposure dynamics to news on macroeconomic conditions.

The remainder of the paper is structured as follows. Section 2 provides an overview of the literature and develops the hypotheses. Section 3 discusses the data and methodology. Section 4 presents the estimated foreign exchange rate exposures. Section 5 analyzes the foreign exchange rate exposure dynamics. Section 6 further analyses the foreign exchange rate exposures of sectors, firms reporting high and low foreign sales, the incremental foreign exchange rate exposure and the impact of the choice of the estimator. Section 7 concludes.

2 Hypothesis development

In theoretical work, a firm's foreign exchange rate exposure is defined as the elasticity of that firm's value to changes in the exchange rate (Adler and Dumas, 1984). More precisely, let $V_{i,t}$ be the value of firm i at time t and S_t the spot exchange rate expressed in units of domestic currency per unit of foreign currency. The foreign exchange rate exposure of firm i at time t , $\delta_{i,t}$ is :

$$\delta_{i,t} = \frac{\partial \log V_{i,t}}{\partial \log S_t}. \quad (1)$$

In this paper, we study the day-by-day foreign exchange rate exposures of multinational firms. Even though we estimate the foreign exchange rate exposure on a day-to-day basis, we expect that these foreign exchange rate exposures are persistent. That is, we expect the estimates of the daily foreign exchange rate exposures to be autocorrelated. Adverse changes in the firms competitive position change the firm's production and selling strategy. Entering a foreign market or expanding the production capacity requires often time and irreversible investments. We therefore expect that these investments are delayed and thus short term persistency in a firm's foreign exchange rate exposure. This leads us to the following hypothesis:

Hypothesis 1: *The time-varying foreign exchange rate exposure of an internationally active firm is characterized by a positive serial correlation.*

The central question in this paper is how the release of macroeconomic news affects the foreign

exchange rate exposure. To understand these effects it is useful to combine the definition of the exposure in Equation 1, with the definition of the value of the firm as the discounted stream of expected cash flows:

$$V_{i,t} = \sum_{u=1}^{\infty} \frac{E_t(CF_{i,u})}{(1 + \rho_{i,t})^u}, \quad (2)$$

in which $CF_{i,u}$ is the cash flow at time u , ρ the required rate of return, and $E_t[\cdot]$ denotes the expectation, conditional on the publicly available information available up to time t . The foreign exchange rate exposure thus occurs through two channels: the cash flow channel and the discount rate channel (Bartram and Bodnar, 2012). For example, under the cash flow channel, a domestic currency depreciation is beneficial for exporting firms because it increases the value of their cash flows by increasing the domestic currency value of exports. At the same time, a local currency depreciation may increase the discount rate through its effect on the risk premium and expected inflation. Changes in the foreign exchange rate can thus change the exposure of a firm through both channels which might offset each other.

Macroeconomic news releases provide information on the macroeconomic conditions and therefore on the expected domestic and foreign currency cash flows and discount rates. Upon receiving the macroeconomic news, investors revise their expectations on the intrinsic value of the firm, the foreign exchange rate and the sensitivity of the firm value to changes in the foreign exchange rate exposure. The revised firm valuation is expected to have an immediate but transitory effect on the realized exposure, as already argued. The change in the expected exchange rate sensitivity, in contrast, is expected to have a permanent impact on the exposure. Based on these arguments, we state following hypotheses:

Hypothesis 2a: *Investors learn about the value of the firm and foreign exchange rate with the release of macroeconomic news. This leads to an immediate, but transitory effect on the foreign exchange rate exposure.*

Hypothesis 2b: *Investors learn about the sensitivity of the firm's value to changes in the exchange rate with the release of macroeconomic news. This leads to a permanent effect on the foreign exchange rate exposure.*

We distinguish between different types of macroeconomic announcements which can affect the foreign exchange rate exposure of a firm, namely: real activity, inflation, trade and Federal Open Market Committee (FOMC) announcements on the federal funds target rate and 10-year yield shocks.

Real activity indicators include labor market indicators such as the number of employees on non-farm payrolls, unemployment rate and initial unemployment insurance claims. Surprises on labor market indicators are expected to have an asymmetric impact on both foreign exchange rates and stock returns. For example, Boyd et al. (2005) argue that higher-than-expected unemployment rates indicates lower expected growth and lower future interest rates. They find that the interest rate effect dominates in expansions and that higher-than-expected unemployment rates thus increases subsequent stock returns in expansions. For recessions, they find that the cash flow effect dominates and therefore higher-than-expected unemployment rates decreases subsequent stock returns in recessions. A higher-than-expected US unemployment rate is expected to depreciate the USD. The opposite holds for nonfarm payroll employment surprises. Nonfarm payroll surprises are found to be one of the most important macroeconomic indicators (Lahaye et al., 2011). In an expansion, when the economy is at almost full capacity, higher employment increases expected interest rates, which, in turn decreases subsequent stock returns. In recessions, the cash flow channel is expected to dominate the discount rate channel. Higher employment signals improving economic conditions which raises the value of the US dollar (Gavin and Kliesen, 2002).

Other real activity macroeconomic fundamentals that are expected to impact the foreign exchange rate exposure are GDP announcements. GDP is announced in three stages: (1) GDP Advance (initial estimate), (2) GDP Preliminary (revision of the initial estimate) and (3) GDP Final (final estimate). Lahaye et al. (2011) find that output surprises cause jumps in both the stock and foreign exchange market. The impact of an output surprise on the stock market depends on the impact on the discount rate. When the output surprise leads to an increase in capital expenditures, the stocks' prices rise. However, when the output surprise signals higher future inflation, expected interest rates raise and stock prices fall (Mun, 2012). The expected impact of output surprises on the foreign exchange rate exposures depends on one's view, as discussed in Mun (2012). Either an output surprise increases US income, rising import, increasing the supply of the domestic currency and depreciating the US dollar. Alternatively an increase in US income can increase the demand for the US dollar, increasing the

dollar's value. Vlaar (2007) finds that the impact of the output surprise on the foreign exchange rate depends on the origin of the output surprise. A decrease of the output gap depreciates the domestic currency, while an increase in potential output growth appreciates the domestic currency.

We expect inflationary announcements to affect the foreign exchange rate exposure of multinational firms. The impact of an unexpected increase in prices depends on the expected reaction of the Federal Reserve (Neely and Dey, 2010). If the increase in prices, raises the expected interest rates, the USD appreciates and stock prices fall. A positive surprise on the export price index similarly means that US exporters face a greater-than-expected demand, hereby appreciating the US dollar (Mun, 2012). Furthermore, an increase in export demand increases the exporter's cash flows and hence increases stock price.

Trade announcements include export, import and trade balance announcements. The US trade balance measures the difference between US exports and US imports. Trade balance announcements provide the market with information on the demand and supply of the domestic currency and the economic conditions in general (Aggarwal and Schirm, 1998). Lahaye et al. (2011) find that trade balance surprises have an impact on foreign exchange rates, their importance has, however, decreased over time (Faust et al., 2007).

Target and Wright interest rate announcements by the FOMC are forward looking announcements that provide news on the monetary policy implemented by the Federal Reserve Bank. These FOMC announcements strongly affect both stock prices and foreign exchange rates. Cieslak et al. (2015) find a close relationship between the equity risk premium and FOMC interest rate releases. A higher-than-expected interest rate implies a higher discount rate which in turn implies a decrease in stock prices. Simultaneously, the increase in the interest rate will attract additional capital, increasing the demand for the US dollar and hereby strengthening the domestic currency. An expected domestic currency appreciation in turn leads to a decrease in the expected foreign currency cash flows. Therefore, the firm's sensitivity to the foreign exchange rate is expected to decrease. A higher-than-expected interest rate is thus expected to have a positive short-term learning effect and a negative permanent effect.

3 Data and methodology

This section introduces the methodology used to estimate the daily foreign exchange rate exposure coefficient using high frequency data. We then describe the sample of firms included in the analysis, provide an overview of the stock and foreign exchange rate data, and the macroeconomic announcements. Third, we develop the test equation that relates the macroeconomic news announcements to the dynamics in the daily foreign exchange rate exposures.

3.1 Estimating the time-varying foreign exchange rate exposure

Previous studies allow for time variation in the foreign exchange rate exposure by splitting their sample or by using rolling windows (see, e.g., Jorion, 1990, Bartram and Bodnar, 2012). In this paper, we estimate the time-varying foreign exchange rate exposure using high-frequency data. We start from the benchmark estimation approach as proposed by Adler and Dumas (1984), which most empirical studies have used.¹

To obtain daily estimates of the foreign exchange rate exposure with intraday data, we use the K equally spaced intraday stock and foreign exchange rate returns. We assume that we have K equally spaced returns for firm i in the open to close time interval and denote $r_{i,t,k}$ as the log return of stock i during the k^{th} intraday period on day t . We denote the log return on the exchange rate or index of exchange rates over the same time interval as $s_{t,k}$. We further denote $r_{i,t} = \sum_{k=1}^K r_{i,t,k}$ as the open-to-close stock return. Figure 1 illustrates the operation of computing the high-frequency returns by zooming in on the intraday returns, for each day t .²

For each day, we then regress the intraday stock returns from firm i on the intraday exchange rate returns on day t :

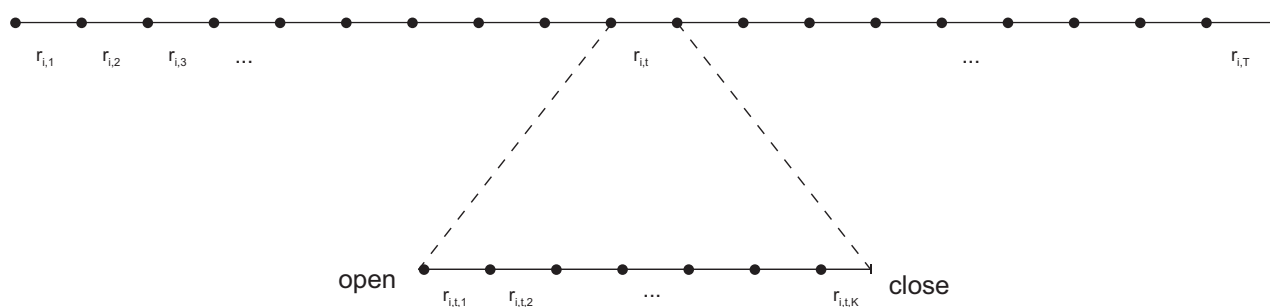
$$r_{i,t,k} = \alpha_{i,t} + \delta_{i,t} s_{t,k} + \varepsilon_{i,t,k}, \quad (3)$$

for intraday periods $k = 1, \dots, K$. Recall that we express the foreign exchange rate in units of domestic currency per unit of foreign currency. Therefore, net exporting firms should have a positive exposure

¹Often, the Adler-Dumas model is extended with a market index as proposed by Jorion (1990). Bodnar and Wong (2003) give a detailed discussion on the estimation issue. We discuss the foreign exchange rate exposures estimated using the Jorion model in Section 6.

²The US stock market opens at 9:00:00 a.m. EST and closes at 4:00:00 p.m. EST. Foreign exchange rate markets are open 24 hours. We use data over the stock market trading hours. More details on the data are provided in Section 3.

Figure 1: The calculation of intraday stock returns.



and thus benefits from a foreign currency appreciation. Following the same arguments, net importers are characterized by a negative exposure.

Bodnar and Wong (2003) define $\hat{\delta}$ in Equation 3 as the *total exposure* of a firm. The total exposure captures the sensitivity of the firm's value to changes in the foreign exchange rates and thus measures the direct impact of a change in the firm's value through all channels. It is therefore of interest to, for example, (corporate) risk managers who want to know the sensitivity of their firm's cash flow to changes in the foreign exchange rates. Also, investors looking to hedge their portfolio are interested in understanding the effects of changes in the foreign exchange rate on their portfolio's value.

3.2 Data

We start from a sample of 676 US firms that were included in the investment universe of the S&P 500 index between May 2008 and December 2014 (1,672 trading days). We exclude financial firms from the sample. We restrict our sample to multinational firms by requiring that the firms' international sales relative to total sales exceed 10% for each year over our sample period (see Jorion, 1990, Alayannis and Ofek, 2001, among others). After applying these criteria, we obtain a sample of 182 firms.

We use Thomson Reuters Datastream for the accounting data. Net sales, foreign sales, total assets and foreign assets are available on an annual basis. CRSP provides data on the stocks' market capitalizations. Table 1 reports descriptive statistics on the 182 firms included in the sample. At about 50%, the annual average foreign sales ratio substantially exceeds the required 10%. Between 2008 and 2014, the firms represent on average over 55% of the S&P 500.

The Traders and Quotes (TAQ) database provides high frequency stock price data. The exchange

Table 1: Firm specific characteristics for annual foreign-sales-to-total-sales ratio and market capitalization of the 182 US firms between 2008-2014. This table shows, for each year between 2008-2014, the average, first, second and third quartile of the annual foreign sales relative to total sales ratio and of the annual market capitalization, together with the average total weight the 182 firms represent in the S&P 500 index (in %).

	Foreign sales (%)				Market cap (in bio)				Weight in S&P 500
	Mean	Median	25%	75%	Mean	Median	25%	75%	Mean (%)
2008	47.08	46.59	31.01	60.88	31.93	34.34	26.27	35.77	57.20
2009	47.16	47.00	30.94	60.94	27.59	27.45	25.03	30.37	58.78
2010	48.57	47.00	30.78	63.43	32.88	32.85	31.50	34.26	57.33
2011	50.01	49.29	34.50	49.30	37.07	37.39	36.01	38.34	53.90
2012	50.33	49.49	34.48	49.49	39.43	39.52	38.65	40.24	55.89
2013	49.22	47.79	31.91	47.79	44.15	44.13	42.18	45.50	53.31
2014	49.17	48.29	32.48	48.29	49.05	49.15	48.25	49.97	52.92

rate return is the return on an trade-weighted index defined as units of USD per units of an index of foreign currencies, meaning that an increase (decrease) in the index refers to a depreciation (appreciation) of the USD relative to the set of foreign currencies. We obtain currency weights from the Federal Reserve. Table 9 in the Appendix A.1 reports the currency weights.

To overcome the problems coming from micro-structure noise or non-synchronous trading, we sample the stock price data and prices of the exchange rate index every ten minutes between 9:30 a.m. EST and 4:00 p.m. EST. One trading day thus consists of 39 ten-minute return observations.

Figure 2 plots the prices of the trade-weighted index over the sample period. The dollar appreciates up to the end of 2008. Over 2009-2011 the USD depreciated relative to the trade-weighted basket. The USD appreciated over the second period of our sample (2011-2015).

In Section 2, we argue that the exposure of a firm is persistent and impacted by macroeconomic announcements. We use the International Money Market Services (MMS) data on the expected (surveyed) and realized macroeconomic indicators. Table 2 provides an overview of the announcement data.³ The announcements included in the analysis are only an important subset of the US announcements available and are selected based on previous studies. These announcements are scheduled and released in a certain sequence (Andersen et al., 2003). In our sample, nonfarm payroll news is released first, followed by consumer price and producer price index announcements. The sequence of the latter is not fixed. These announcements are followed by export price index and trade balance announcements. GDP announcements are released one month after the end of the quarter. The FOMC meets every six weeks.

³Definitions of the macroeconomic indicators are included in the Appendix A.2.

Figure 2: Trade-weighted exchange rate index over period 2008 to 2014. The rates are expressed in US dollars per unit of foreign currencies.



Table 2: Macroeconomic announcements. The table provides an overview of the scheduled macroeconomic announcements included in the analysis over the period 2008-2014. Frequency: the frequency at which news on the fundamental is announced with Q: quarterly, M: monthly and 6 weeks: every 6 weeks. Time: announcement time in Eastern Standard Time (EST). First release: first release date of announcement in our sample. Observations: total number of observations. Mean: average surprise. # pos.: number of positive surprises. #neg: number of negative surprises.

Announcements	Variable name	Frequency	Time (EST)	First release	Observations	Mean	# pos.	# neg.
Real activity announcements								
Real GDP Advance	GDP Adv	Q	8 : 30	07-31-2008	26	0.08	11	12
Employees on nonfarm payrolls	NFP	M	8 : 30	06-06-2008	79	-0.14	34	44
Inflation announcements								
Consumer price index	CPI	M	8 : 30	05-14-2008	80	-0.10	21	34
Producer price index	PPI	M	8 : 30	05-20-2008	80	0.03	35	37
Export price index	EXPPI	M	8 : 30	05-13-2008	80	-0.08	41	35
Trade announcements								
Trade Balance	TRADE	M	8 : 30	05-09-2008	80	0.08	42	38
Federal Open Market Committee (FOMC)								
Federal funds target	FOMC TARGET	6W	14 : 15	06-25-2008	52	0.20	48	4
Federal funds Wright	FOMC WRIGHT	6W	14 : 15	06-25-2008	52	0.06	25	27

As in Balduzzi et al. (2001), we use the standardized surprise of an announcement. The surprise $Surp_{j,t}$ for fundamental j ($j = 1, \dots, J$) at day t is:

$$Surp_{j,t} = \frac{A_{j,t} - E_{j,t}}{\hat{\sigma}_j}, \quad (4)$$

where $A_{j,t}$ is the announced value of fundamental j at day t , $E_{j,t}$ is the survey expectation, and $\hat{\sigma}_j$ is the sample standard deviation of the surprise component for fundamental j . Standardization allows comparison across macroeconomic fundamentals.

3.3 Modelling the macroeconomic effects on the foreign exchange rate exposure

To test the hypotheses on the effects of macroeconomic news on the foreign exchange rate exposure dynamics, we must define the dependent variable and the functional relationship linking the macroeconomic news to that variable. In our main analysis, we test our hypotheses using the cross-sectional average exposure coefficient as the dependent variable:

$$\bar{\delta}_t = \sum_{i=1}^N \hat{\delta}_{t,i},$$

with N the number of firms in our sample. In the robustness section, we consider several split samples based on industry and intensity of foreign sales.⁴

The model linking the surprises in the macroeconomic announcements ($Surp_{j,t}$) to the average foreign exchange rate exposure coefficient ($\bar{\delta}_t$) needs to be flexible enough to capture both the short-term effect of the news due to the revaluation of stock price and exchange rates, as well as the permanent change in the exposure coefficient. Importantly, it also needs to accommodate the possibility of a stationary autoregressive component in the exposure coefficient, that is adjusted for the time variation in the long term average exposure coefficient. The following model satisfies those objectives:

$$\bar{\delta}_t = c + c_t + \rho(\bar{\delta}_{t-1} - c - c_{t-1}) + \phi'X_t + \sum_{j=1}^J \theta_j Surp_{j,t} + \epsilon_t, \quad (5)$$

⁴We do not consider the individual exposure as the dependent variable, because of the pitfalls in terms of biased estimation when estimating by panel fixed effects estimation the parameters of an autoregressive panel regressions (see e.g. Nickell 1981).

$$\text{with } c_t = c_{t-1} + \sum_{j=1}^J \lambda_j \text{Surp}_{j,t} \text{ and } c_0 = 0,$$

The error term is assumed to be stationary with zero mean. Except for the auxiliary equation expressing the permanent changes of the macroeconomic news on the exposure coefficient, this is a standard regression specification, where X_t denotes a set of control variables. We consider two types of control variables. The first group of controls is related to the foreign exchange rate. We control for the sign of the change in the foreign exchange rate (see, e.g., Bartram, 2004, Bartram and Bodnar, 2012, Carter et al., 2003, Chaieb and Mazzotta, 2013, Koutmos and Martin, 2007), the magnitude of the change in the foreign exchange rate (see, e.g., Muller and Verschoor, 2006) and the moneyness of the option to export (Boudt et al., 2015). The second group of controls in X is related to one-off events. One-off events are news releases that could influence the foreign exchange rate exposure, but could coincide with a macroeconomic announcement. Including dummies for one-off events allows us to distinguish the systematic impact of surprises in macroeconomic announcements from the extraordinary impact of one-off events. For more details about the definition of the controls, we refer the reader to the Appendix A.3.

We estimate the model by non-linear least squares and account for the heteroscedasticity and autocorrelation in the residuals by using HAC standard errors (Andrews, 1991, Andrews and Monahan, 1992). Our sample amounts to 1,672 daily observations, 8 indicators, 486 announcements over 393 announcement days.

4 Estimated foreign exchange rate exposures

This section presents the results on the foreign exchange rate exposures. We focus on the results for an average US multinational, meaning that we take the daily cross-sectional average over the 182 firms in our sample.

First consider the estimated foreign exchange rate exposure coefficients reported in Panel A of Table 3. The exposure is on average positive and 44% of the estimated exposures are significant. If the foreign currency index appreciates by 1%, the firm's stock price tends to increase by 1.09%. This means that the firm has, on average, a net long economic position in the foreign exchange rate and therefore benefits from a strengthening foreign currency.

Table 3: Summary of the estimated foreign exchange rate exposures of an average multinational firm. The table reports the estimation results for the total (Panel A) and incremental (Panel B) foreign exchange rate exposures. Results are reported for all firms in the sample (All), firms reporting systematically a high foreign sales ratio (High FS) and a low foreign sales ratio (Low FS). The table shows the average exposure and the % of significantly positive and negative coefficients at the 5% and the 10% level.

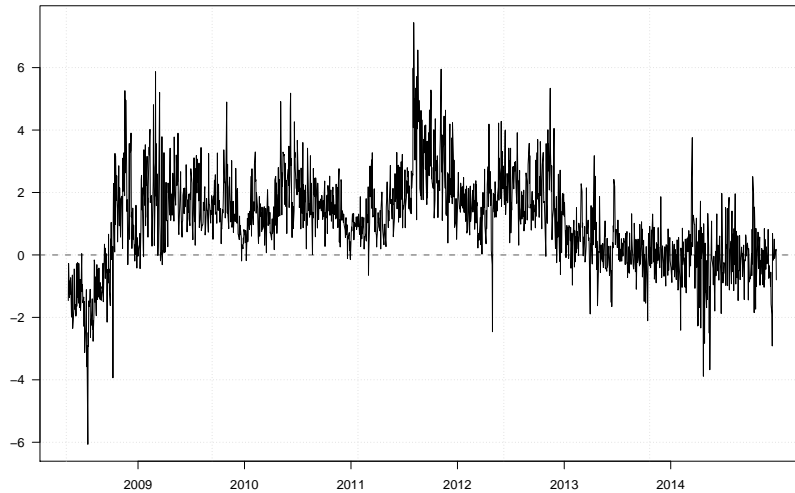
	Panel A: Total exposure			Panel B: Incremental exposure		
	All	High FS	Low FS	All	High FS	Low FS
Average	1.09	1.14	0.92	0.11	0.11	0.03
% + sign. at 5%	31.72	32.59	29.35	7.53	7.79	6.74
% + sign. at 10%	38.17	39.35	35.90	11.42	11.87	10.28
% - sign. at 5%	4.11	4.04	4.77	5.76	5.68	6.49
% - sign. at 10%	5.94	5.83	6.79	8.96	8.77	9.93

Figure 3 shows the substantial time variation in the estimated exposures of an average multinational firm. The beginning of the sample is actually characterized by negative exposure, while it increases from 2009 onwards up to 2011 to levels of two or more, after which it turns to about zero. Mid-2011 the exposure starts to decrease again and is on average negative at the end of the sample period. This pattern is similar to the pattern of depreciation and appreciation cycles shown in Figure 2. That is, the exposure falls, and even turns negative, when the USD is strong, in line with what one expects from the relative attractiveness of the export and import activities. Given that the firms are often two-way traders, meaning that firms typically have both exporting and importing activities, the firm can shift its activities depending on the movements of the exchange rate (Muûls and Pisu, 2009). Section 5 explores drivers of the foreign exchange rate exposure dynamics.

5 Foreign exchange rate exposure dynamics

In short, we find that a multinational firm has on average a positive but strongly time-varying exchange rate exposure. This section investigates the determinants of the exchange rate exposure dynamics. First, we consider the persistence in the exposure by regressing the cross-sectional average estimated daily exposure on its lagged value. Second, we analyze the impact of macro announcements on the foreign exchange rate exposure.

Figure 3: Time variation in the foreign exchange rate exposure of an average multinational firm. The plot shows the daily cross-sectional average of the estimated incremental foreign exchange rate exposure over the period May 2008–2014.



5.1 AR(1) dynamics

To investigate the persistence in the daily exchange rate exposure coefficients, we regress the cross-sectional average exposure on an AR(1) coefficient.

Column 1 of Table 4 reports the regression results. The AR(1) coefficient is positive significant. The foreign exchange rate exposure exhibits a strong dose of positive autocorrelation, which is in line with the first hypothesis.

5.2 Macroeconomic announcements

In this subsection, we analyse to what extent macroeconomic announcements impact the foreign exchange rate exposure of an average multinational firm. To summarize what follows, we find that real activity, inflationary and interest rate announcements have a significant impact on the foreign exchange rate exposures. Trade balance announcements have no significant impact, which is in line with Neely and Dey (2010), who find that the importance of the trade balance announcements has decreased over time.

We distinguish between an immediate, though short-lived learning effect and a permanent effect of the macro-economic announcements. Columns 2 and 4 of Table 4 investigate the transitory effects of macroeconomic surprises. The inflation announcements, namely consumer price, producer price and

export price index, have a significant impact on the foreign exchange rate exposure on the announcement day. A one standard deviation increase in the export price index tends to decrease the exposure by 0.25, if positive. Mun (2012) argues that inflation surprises have a negative impact on subsequent stock prices because these indicate lower expected future economic growth, more stringent monetary policy and an increase of interest rates. These arguments are in line with the findings of Andersen et al. (2007). On the other hand, higher-than-expected inflation could depreciate the dollar through purchasing power parity (Neely and Dey, 2010). Both lead to a decrease of the foreign exchange rate exposure.

Columns 3 and 4 of Table 4 investigate the permanent impact of the macroeconomic surprises on the average exchange rate exposure. GDP, nonfarm payroll, consumer price index and FOMC announcements have a significant permanent effect. These macroeconomic indicators have been identified as the most important macroeconomic announcements as shown by e.g., Lahaye et al. (2011). Nonfarm payroll announcements are real activity macroeconomic fundamentals providing the market with information on both future expected growth and interest rates (Boyd et al., 2005). A positive surprise on the nonfarm payroll employees permanently reduces the foreign exchange rate exposure. As an indicator of future domestic growth, a higher-than-expected change in the number of nonfarm payroll employees might indicate an increase in US income and make the export business less attractive through an appreciation of the domestic currency, and therefore reduce the expected foreign currency cash flows and thus the foreign exchange rate exposure. Interestingly, higher-than-expected GDP tends to increase foreign exchange rate exposures. GDP measures the total value of goods and services produced by a country. It consists of private and public consumption, government investments and the net exports. Given that the GDP announcements precede trade balance announcements, a positive surprise might indicate an increase of the country's net exports, which in turn increases the foreign exchange rate exposure of exporting firms.

FOMC target and Wright announcements have a negative impact on the exposure. A higher-than-expected interest rate announced by the FOMC could lead to a dollar appreciation as discussed in Neely and Dey (2010). This in turn could decrease the expected foreign currency cash flows, hereby decreasing the sensitivity of the firm's value to changes in the foreign exchange rate.

Figure 4 shows two representative impulse-response functions for surprises on the export price

Table 4: The exposure dynamics for an average multinational firm. The dependent variable is the average daily exposure. The data set consist of 1,672 daily observations and 486 announcements. Details on the announcements included in the regression are provided in Table 2. Details on the control variables included are provided in Table 11. *, **, and *** denote significance at the 10%, 5%, and 1% level with HAC standard errors (between brackets).

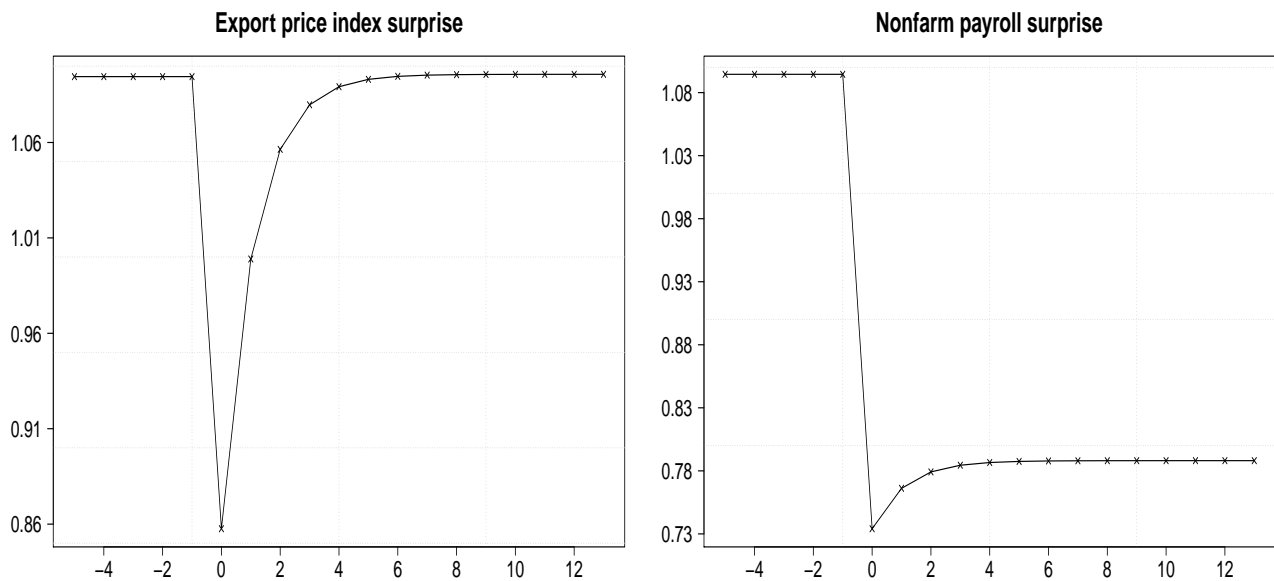
	(1). Transitory		(2). Permanent		(3). Trans. + Prem.	
	Est.	SE	Est.	SE	Est.	SE
(Intercept)	0.333***	(0.054)	-0.687***	(0.215)	-0.700***	(0.207)
AR(1)	0.686***	(0.021)	0.409	(0.029)	0.406***	(0.028)
GDP Adv Perm			0.165***	(0.043)	0.160***	(0.042)
GDP Adv Trans	-0.010	(0.179)			-0.035	(0.193)
NFP Perm			-0.307***	(0.029)	-0.308***	(0.028)
NFP Trans	-0.133	(0.151)			0.129	(0.132)
CPI Perm			0.099***	(0.026)	0.099***	(0.026)
CPI Trans	-0.075	(0.134)			-0.209*	(0.123)
PPI Perm			0.041	(0.044)	0.050	(0.043)
PPI Trans	-0.192	(0.170)			-0.291*	(0.176)
EXPPI Perm			0.004	(0.026)	0.010	(0.026)
EXPPI Trans	-0.213*	(0.113)			-0.248**	(0.101)
TRADE Perm			0.016	(0.033)	0.030	(0.033)
TRADE Trans	-0.077	(0.101)			-0.116	(0.081)
FOMCTARGET Perm			-0.163***	(0.022)	-0.169***	(0.022)
FOMCTARGET Trans	-0.081	(0.173)			0.070	(0.182)
FOMCWRIGHT Perm			-0.170***	(0.059)	-0.187***	(0.059)
FOMCWRIGHT Trans	0.101	(0.173)			0.195	(0.195)
Controls	Yes		Yes		Yes	
Adj. R^2 (%)	47.81		57.19		57.70	

index and nonfarm payroll employees. The figure is constructed as follows. We start from the estimated regression coefficients. To calculate the expected foreign exchange rate exposure, we set the responses equal to their mean, except the news, which we set to zero. To determine the impact of an announcement, we take a one standard deviation positive surprise. For the days after the announcement, we set the value of the news to zero, but use the new foreign exchange rate exposures as an input. An export price index announcement tends to decrease the foreign exchange rate exposure, though the impact is only transitory: the exposure decreases on the announcement day, but reverts to its previous level afterwards. On the other hand, a one standard deviation positive nonfarm payroll surprise decreases the foreign exchange rate exposure permanently.

6 Further analysis

In this section, we perform additional analyses of the foreign exchange rate exposure. First, while in the main analysis we aggregate all firms included in our sample, we now study the foreign exchange

Figure 4: The impact of a positive one standard deviation export price index (left) and nonfarm payroll (right) surprise on the average exchange rate exposure. Day 0 is the day of the announcement.



rate exposure aggregated at the sector level and categorized in groups based on the foreign sales ratio. Second, we control for the market exposure when estimating the firm’s foreign exchange rate exposure. Third, we redo the analysis with different estimators.

6.1 Sector exposures

In the main analysis, we aggregate the exposures over all firms in the sample. In this section, we refine our analysis by studying the exposures by sector. Differences in foreign exchange rate exposures across sectors are expected because of differences in the competitive structure (Marston, 2001). It is an empirical question whether the impact of macro announcements differ across the sectors. Table 5 reports the results for seven GICS sectors.⁵ The average exposures differ across the sectors. The Consumer Staples and Health Care sectors have an exposure which is on average below 0.70, while the average exposure of the Energy sector is above 1.70. The Health Care sector is characterized by import activities for the pharmaceutical industry and export for the medical equipment industry, which could partly offset each other, explaining the lower exposure (Chaieb and Mazzotta, 2013).

The main results also hold for the sector exposures. GDP advance, nonfarm payroll and FOMC interest rate announcements have a permanent impact on the foreign exchange rate exposure. An export

⁵The GICS sector classification consists of eleven sectors. We use seven of these sectors in our analysis. Sectors consisting of only a limited number of firms and the financial sectors are removed.

Table 5: The exposure dynamics of GICS sectors. The dependent variable is the sector's average daily exposure. The data set consist of 1,672 daily observations and 486 announcements. Details on the announcements included in the regression are provided in Table 2. Details on the control variables included are provided in Table 11. *, **, and *** denote significance at the 10%, 5%, and 1% level with HAC standard errors (between brackets).

	Energy		Materials		Industrials		Cons. goods		Cons. staples		Health care		IT	
	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE
(Intercept)	1.34***	(0.31)	-0.47**	(0.21)	-0.91***	(0.24)	-1.39***	(0.30)	-0.54***	(0.15)	-0.55***	(0.16)	-1.18***	(0.24)
AR(1)	0.28***	(0.03)	0.32***	(0.03)	0.39***	(0.03)	0.42***	(0.03)	0.36***	(0.03)	0.32***	(0.03)	0.34***	(0.03)
GDP Adv Perm	0.17**	(0.07)	0.19***	(0.04)	0.20***	(0.05)	0.20***	(0.05)	0.07**	(0.03)	0.07*	(0.04)	0.17***	(0.04)
GDP Adv Trans	0.24	(0.30)	-0.04	(0.18)	-0.15	(0.19)	-0.21	(0.23)	0.06	(0.12)	0.07	(0.22)	0.05	(0.22)
NFP Perm	-0.21***	(0.04)	-0.31***	(0.03)	-0.36***	(0.03)	-0.39***	(0.04)	-0.20***	(0.02)	-0.22***	(0.02)	-0.34***	(0.03)
NFP Trans	-0.03	(0.17)	0.11	(0.13)	0.15	(0.16)	0.16	(0.16)	0.08	(0.10)	0.06	(0.13)	0.17	(0.14)
CPI Perm	0.19***	(0.04)	0.14***	(0.03)	0.12***	(0.03)	0.10***	(0.03)	0.03*	(0.02)	0.03	(0.02)	0.10***	(0.03)
CPI Trans	-0.07	(0.21)	-0.34**	(0.12)	-0.24**	(0.14)	-0.28	(0.17)	-0.18**	(0.09)	-0.22*	(0.12)	-0.20	(0.17)
PPI Perm	0.01	(0.05)	0.01	(0.04)	0.04	(0.05)	0.04	(0.05)	0.02	(0.03)	0.08**	(0.04)	0.10**	(0.05)
PPI Trans	-0.35	(0.26)	-0.32	(0.19)	-0.27	(0.19)	-0.30	(0.18)	-0.16	(0.13)	-0.30*	(0.17)	-0.36*	(0.20)
EXPPI Perm	0.09**	(0.04)	0.04*	(0.03)	0.00	(0.03)	-0.02	(0.03)	0.00	(0.02)	0.02	(0.02)	0.00	(0.03)
EXPPI Trans	-0.24	(0.17)	-0.24**	(0.12)	-0.26**	(0.11)	-0.27**	(0.12)	-0.14*	(0.07)	-0.26**	(0.10)	-0.27**	(0.12)
TRADE Perm	-0.05	(0.04)	0.07*	(0.03)	0.03	(0.04)	0.05	(0.04)	0.03	(0.02)	-0.01	(0.03)	0.05	(0.04)
TRADE Trans	-0.09	(0.15)	-0.16	(0.11)	-0.11	(0.09)	-0.11	(0.09)	-0.13*	(0.07)	-0.08	(0.07)	-0.14	(0.10)
FOMC TARGET Perm	-0.10**	(0.04)	-0.15***	(0.02)	-0.19***	(0.03)	-0.21***	(0.03)	-0.11***	(0.02)	-0.15***	(0.02)	-0.20***	(0.02)
FOMC TARGET Trans	-0.15	(0.29)	-0.02	(0.21)	0.04	(0.19)	-0.01	(0.20)	0.22	(0.18)	0.12	(0.21)	0.12	(0.20)
FOMC WRIGHT Perm	-0.16**	(0.07)	-0.20***	(0.06)	-0.21***	(0.07)	-0.23***	(0.07)	-0.17***	(0.04)	-0.11**	(0.05)	-0.17***	(0.06)
FOMC WRIGHT Trans	0.28	(0.25)	0.23	(0.19)	0.25	(0.21)	0.29	(0.24)	0.19	(0.16)	0.19	(0.19)	-0.03	(0.22)
Controls	Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Adj. R^2 (%)	38.54		51.05		55.16		56.77		44.86		44.23		54.17	
# of firms	17		16		34		31		21		21		39	
Average exp	1.77		1.28		1.20		1.10		0.54		0.69		1.13	

price index surprise has a significant permanent impact on the Energy and Materials sector's exposures. A higher-than-expected export price index temporarily decreases the exposure of all sectors except for the Energy sector. All sectors, except for the Health care sector, are exposed to consumer price index surprises. A higher-than-expected consumer price index could depreciate the US dollar through purchasing power parity, which increases the profitability of the foreign currency activities and hereby increasing the foreign exchange rate exposure.

6.2 Exposures based on foreign sales

Previous research shows that the firm's foreign exchange rate exposure is positively related to its foreign sales (see, e.g., Williamson, 2001). In this section, we analyse whether the foreign exchange rate exposure of firms with a high foreign sales ratio exhibits different dynamics compared with firms with a lower foreign sales ratio. Therefore, we categorize the multinational firms into two groups. For each year in our sample, we sort the firms based on their reported foreign sales ratio and take the firms reporting the 25% lowest and 25% highest foreign sales. The group of low foreign sales firms consists of the firms systematically reporting the lowest number of foreign sales (i.e., for each year included in the sample). Similarly, the group of high foreign sales firms consists of the firms systematically reporting the highest number of foreign sales.

Table 6: The exposure dynamics for an average multinational firm categorized by foreign sales. The low (high) foreign sales category consists of the 25% firms systematically reporting the lowest (largest) percentage of foreign sales over the sample (2008-2014). The dependent variable is the average daily exposure. The data set consist of 1,672 daily observations and 486 announcements. Details on the announcements included in the regression are provided in Table 2. Details on the control variables included are provided in Table 11. *, **, and *** denote significance at the 10%, 5%, and 1% level with HAC standard errors (between brackets).

	(1). Low Foreign Sales		(2). High Foreign Sales	
	Est.	SE	Est.	SE
(Intercept)	-0.907***	(0.217)	-0.852***	(0.213)
AR(1)	0.417***	(0.028)	0.3760***	(0.028)
GDP Adv Perm	0.152***	(0.043)	0.176***	(0.043)
GDP Adv Tran	-0.120	(0.161)	0.031	(0.184)
NFP Perm	-0.301***	(0.029)	-0.310***	(0.028)
NFP Trans	0.135	(0.136)	0.144	(0.131)
CPI Perm	0.085***	(0.025)	0.095***	(0.026)
CPI Trans	-0.301**	(0.117)	-0.178	(0.141)
PPI Perm	0.037	(0.042)	0.063	(0.044)
PPI Trans	-0.273*	(0.162)	-0.326	(0.200)
EXPPI Perm	-0.009	(0.026)	0.013	(0.026)
EXPPI Trans	-0.213**	(0.092)	-0.269**	(0.112)
TRADE Perm	0.032	(0.032)	0.041	(0.034)
TRADE Trans	-0.125*	(0.068)	-0.050	(0.088)
FOMC TARGET Perm	-0.167***	(0.022)	-0.177***	(0.022)
FOMC TARGET Trans	0.072	(0.178)	0.133	(0.180)
FOMC WRIGHT Perm	-0.172***	(0.058)	-0.173***	(0.058)
FOMC WRIGHT Trans	0.217	(0.193)	0.135	(0.189)
Controls	Yes		Yes	
Adj. R^2 (%)	54.85		56.65	
# of firms	31		31	
Average foreign sales ratio	22.13		77.29	

As reported in Panel A of Table 3, the average exposure of a high foreign sales firm is 1.14 while the average exposure of a low foreign sales firms is 0.91. Overall, low and high foreign sales firms behave very similarly. Despite the similarities across both groups, the low foreign sales firms respond to three different announcements: the consumer price, producer price and trade balance surprises have a transitory impact.

6.3 Incremental foreign exchange rate exposure

Section 3.1 describes the foreign exchange rate exposure estimation approach. Previous studies often add, as proposed by Jorion (1990), a market return to this regression to control for effects which are common to all firms in the market. The Jorion regression is:

$$r_{i,t,k} = \alpha_{i,t} + \beta_{i,t} r_{t,k}^m + \gamma_{i,t} s_{t,k} + \epsilon_{i,t,k}, \quad (6)$$

in which $r_{i,t,k}$ is the log return of stock i during the k^{th} intraday period of day t , $r_{t,k}^m$ is the corresponding market return over the k^{th} intraday interval and $s_{t,k}$ is the domestic currency log return on the trade-weighted exchange rate index over the k^{th} intraday period. The market return included in the analysis is the return on the S&P 500 index. We use the highly liquid SPY exchange traded fund, tracking the S&P 500 index, to calculate the high-frequency market returns (see Patton and Verardo, 2012, among others).

The foreign exchange rate exposure $\hat{\gamma}$ is referred to as the *incremental exposure*, while the foreign exchange rate exposure $\hat{\delta}$ estimated in Equation 3 is the firm's *total exposure* (Bodnar and Wong, 2003). A firm's incremental exposure measures the difference between the firm's total exposure and the market's exposure weighted by the firm's market beta.

Panel B of Table 3 describes the incremental exposures of an average multinational firm. The incremental exposure is on average positive (0.11) and 20% (13%) of the estimates are significant at the 10% (5%) level. The incremental exposures are substantially lower compared with the total exposure in Table 3, but follow a similar pattern over time, albeit much weaker. Figure 5 plots the daily incremental exposure. The average incremental exposure is low in 2008, increases up to 2012, and drops afterwards. The average incremental exposure exhibits some spikes, e.g., on the day of the Flash Crash in May 2010 the average incremental exposure jumps to 3.54.

In Table 7, we analyse the dynamics of the incremental exposure. The incremental exposure exhibits no significant autocorrelation. Compared with the total exposure, a greater number of macroeconomic announcements tend to have a permanent impact on the foreign exchange rate exposure. All announcements, except for the trade balance announcement, have a permanent impact on the incremental exposure. A higher-than-expected nonfarm payroll announcement, decreases the incremental exposure. The FOMC Wright surprises are the only surprises with a transitory impact. A positive FOMC Wright surprise has a negative impact on the incremental exposure.

6.4 Robustness

In this Section we test whether our results are affected by the choice of the estimator. First, we estimate the results using outlier robust estimators as in Yohai (1987) to control for possible jumps induced by macroeconomic announcements (Lahaye et al., 2011). Second, we estimate the foreign

Figure 5: Time variation in the incremental foreign exchange rate exposure of an average multinational firm. The plot shows the daily cross-sectional average of the estimated incremental foreign exchange rate exposure over the period May 2008–2014.

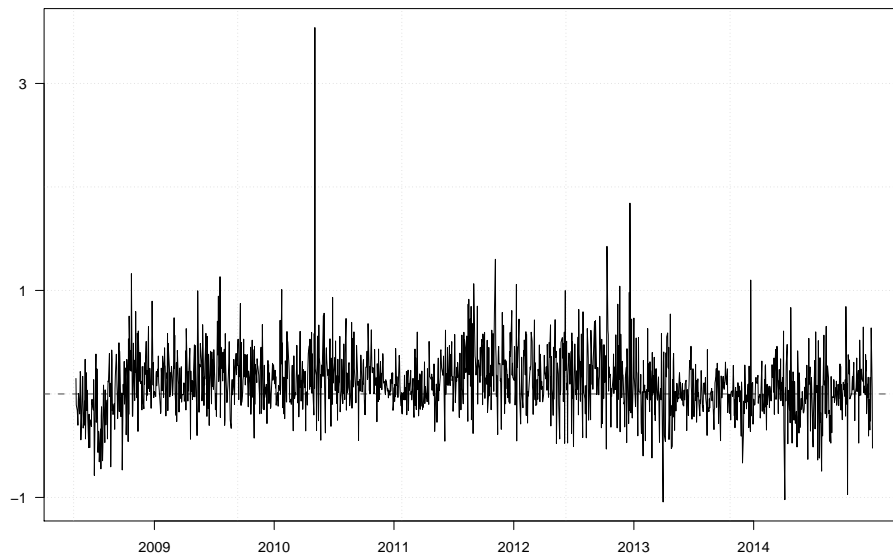


Table 7: The incremental exposure dynamics for an average exporting firm. The dependent variable is the average daily incremental exposure. The data set consist of 1,672 daily observations and 486 announcements. Details on the announcements included in the regression are provided in Table 2. Details on the control variables included are provided in Table 11. *, **, and *** denote significance at the 10%, 5%, and 1% level with HAC standard errors (between brackets).

	(1). Transitory		(2). Permanent		(3). Perm. + Transitory		(1). Transitory		(2). Permanent		(3). Perm. + Transitory	
	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE
(Intercept)	0.063***	(0.014)	-0.130***	(0.033)	-0.129***	(0.033)	-0.688***	(0.167)				
AR(1)	0.079***	(0.029)	-0.011	(0.025)	-0.011	(0.025)	0.407***	(0.022)				
GDP Adv Perm			0.018**	(0.007)	0.017**	(0.007)	0.146***	(0.043)				
GDP Adv Trans	0.072	(0.058)			0.064	(0.066)	-0.106	(0.179)				
NFP Perm			-0.026***	(0.004)	-0.025***	(0.004)	-0.279***	(0.022)				
NFP Trans	-0.037	(0.028)			-0.017	(0.028)	0.116	(0.105)				
CPI Perm			0.010**	(0.004)	0.010**	(0.004)	0.080**	(0.024)				
CPI Trans	-0.001	(0.036)			-0.001	(0.033)	-0.212**	(0.107)				
PPI Perm			0.016**	(0.008)	0.018**	(0.008)	0.051	(0.040)				
PPI Trans	-0.028	(0.033)			-0.032	(0.033)	-0.274***	(0.103)				
EXPPI Perm			-0.007*	(0.004)	-0.007*	(0.004)	0.008	(0.022)				
EXPPI Trans	-0.013	(0.027)			-0.011	(0.029)	-0.229**	(0.102)				
TRADE Perm			0.006	(0.005)	0.006	(0.005)	0.042	(0.029)				
TRADE Trans	-0.008	(0.029)			-0.013	(0.024)	-0.149	(0.101)				
FOMCTARGET Perm			-0.014***	(0.004)	-0.015***	(0.004)	-0.159***	(0.021)				
FOMCTARGET Trans	-0.010	(0.051)			0.010	(0.058)	0.044	(0.218)				
FOMCWRIGHT Perm			-0.017**	(0.008)	-0.015**	(0.008)	-0.193***	(0.043)				
FOMCWRIGHT Trans	-0.082*	(0.042)			-0.092**	(0.046)	0.258	(0.212)				
Controls		Yes		Yes		Yes						
Adj. R^2 (%)		1.03		10.33		10.58						

Table 8: The exposure dynamics for an average exporting firm. The dependent variable is the average daily exposure. The data set consist of 1,672 daily observations and 486 announcements. Details on the announcements included in the regression are provided in Table 2. Details on the control variables included are provided in Table 11. *, **, and *** denote significance at the 10%, 5%, and 1% level with HAC standard errors (between brackets).

	Robust		20 min.	
	Est.	SE	Est.	SE
(Intercept)	-0.650	(0.408)	-0.800***	(0.224)
AR(1)	0.363***	(0.076)	0.295***	(0.0231)
GDP Adv	0.170***	(0.070)	0.163***	(0.045)
GDP Adv Trans	-0.074	(0.182)	0.075	(0.236)
NFP Perm	-0.319***	(0.057)	-0.345***	(0.029)
NFP Trans	0.174	(0.112)	0.156	(0.140)
CPI Perm	0.112**	(0.053)	0.096***	(0.027)
CPI Trans	-0.202	(0.124)	-0.229	(0.145)
PPI Perm	0.038	(0.074)	0.043	(0.047)
PPI Trans	-0.305*	(0.187)	-0.141	(0.167)
EXPPPI Perm	0.011	(0.047)	0.015	(0.028)
EXPPPI Trans	-0.249**	(0.101)	-0.426***	(0.142)
TRADE Perm	0.013	(0.061)	0.054	(0.035)
TRADE Trans	-0.098	(0.088)	-0.130	(0.107)
FOMC Target Perm	-0.159***	(0.041)	-0.189***	(0.023)
FOMC Target Trans	0.109	(0.168)	0.318*	(0.186)
FOMC Wright Perm	-0.188**	(0.101)	-0.235***	(0.064)
FOMC Wright Trans	0.206	(0.196)	0.369	(0.229)
Adj. R^2 (%)	53.47		48.17	

exchange rate exposures using 20-minute return observations. Table 8 summarizes the regression results of these two robustness checks. The robust foreign exchange rate exposures in Column 1 exhibit similar coefficients as in the main analysis, except for the consumer price index which are found to have a permanent impact. Similar announcements have an effect on the 20-min exposures reported in Column 2, except for the consumer and producer price index announcements which have no longer a transitory impact.

7 Conclusion

The value of exporting firms is sensitive to changes in the foreign exchange rate. This paper investigates the foreign exchange rate dynamics of US exporting firms over the period 2008-2014. We start by quantifying the daily foreign exchange rate exposure using high frequency stock and foreign exchange rate data. The foreign exchange rate exposure is estimated for each firm by regressing the intraday stock returns on a trade-weighted index of foreign currencies. Using intraday data allows us

to obtain more precise estimates of the time variation in.

We find that a multinational firm benefits, on average, from a local currency depreciation. Yet, this sensitivity appears to be time-varying. We relate this time variation to macroeconomic announcements. These scheduled macroeconomic announcements provide information on the macroeconomic conditions of the domestic market and the profitability of the foreign business. We distinguish between a short-term learning effect on the foreign exchange rate and stock prices, and a permanent effect on the firm's sensitivity to changes in the foreign exchange rate. GDP, nonfarm payroll, consumer price index and federal funds target rate and 10-year yield announcements are found to have a permanent effect on the foreign exchange rate exposure. A higher-than-expected number of employees on the nonfarm payroll, decreases the foreign exchange rate exposure. Export price, consumer price and producer price index surprises have a transitory effect on the foreign exchange rate exposures. A positive price index tends to decrease the foreign exchange rate exposure, though the effect is only transitory.

In a further analysis, we analyze the dynamics for different sectors and firms reporting a low and high number of foreign sales. Additionally, we re-estimate the foreign exchange rate exposures with an additional market return in the regression, as proposed by Jorion (1990). These so-called incremental exposures control for the market's exposure. Overall, the main results are confirmed for the different sensitivity analyses.

The paper provides insight in the drivers of the exposures. This is of importance for both (corporate) risk managers and investors with an international portfolio, who could incorporate our results to improve their hedging strategies.

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A Appendix

A.1 Currency weights in the trade-weighted index

Table 9: Currency weights (%) in trade-weighted index based on Federal Reserve Total Trade Weights.

	2008	2009	2010	2011	2012	2013	2014
Australia	1.9	2.1	2.1	2.3	2.2	2.0	2.0
Brazil	3.2	2.9	3.2	3.5	3.5	3.4	3.4
Canada	22.1	20.4	20.6	20.2	19.8	20.0	20.0
Euro area	27.0	27.1	25.2	25.8	25.5	25.9	25.9
Hong Kong	2.0	2.0	2.0	2.0	2.0	2.1	2.1
Japan	12.6	11.5	12.1	11.4	11.9	10.9	10.9
Korea	5.4	5.7	6.0	6.1	6.0	6.1	6.1
Mexico	14.5	15.9	17.3	17.6	18.3	18.8	18.8
Singapore	2.9	3.2	3.2	3.1	3.0	2.8	2.8
Switzerland	2.3	2.8	2.6	2.6	2.6	2.7	2.7
United Kingdom	6.2	6.4	5.6	5.5	5.3	5.3	5.3

A.2 Definition of the macroeconomic announcements

Table 10: Macroeconomic announcements. The table provides definitions of the scheduled macroeconomic announcements based on Neely and Dey (2010).

Announcements	Definition
Real activity announcements	
Real GDP Advance	Initial estimate of GDP, the value of the goods and services produced by the US, 1-month lag
Real GDP Preliminary	Adjusted estimate of GDP Advance, 2-month lag
Real GDP Final	Final estimate of GDP, 3-month lag
Employees on nonfarm payrolls	Change in number of employed people during previous months, excluding farming industry, trends in hiring payments and sectors
Inflation announcements	
Consumer price index	The normalized price paid by urban for a representative basket of goods and services
Producer price index	Price level of output from domestic producers
Export price index	Change in prices of goods sold to foreign buyers by US exporters
Trade announcements	
Exports	Exports disaggregated by country of final destination and type of good
Imports	Imports disaggregated by country of origin and type of good
Trade balance	Difference in value of exports and imports
FOMC	
Federal funds target	Target interest rate set at FOMC meeting
Federal funds Wright	10-year yield shocks to measure unconventional monetary policy

A.3 Control variables

Table 11: Control variables. This table provides details on the control variables included in the analysis. Panel A shows the controls related to the foreign exchange rate. Panel B reports the one-off events included in the analysis. The one-off dummy $D_{q,t}$ ($q = 1 \dots Q$) equals to one on days that news is released which could influence the foreign exchange rate exposure, but could coincide with a macroeconomic announcement. Including dummies for one-off events allows us to distinguish the systematic impact of surprises in macroeconomic announcements from the extraordinary impact of one-off events. Details on the Fed LSAP program can be found in Bauer and Neely (2014)

Panel A: Controls based on the foreign exchange rate		
Variable	Description	
M_{t-1}	Moneyness: The moneyness is defined as the distance between the exchange rate level at time t , S_t , and the level of the exchange rate at which the value of the option becomes zero, \bar{S}_t . We set \bar{S}_t as the average value of the rolling window of 100 exchange rate values (Boudt et al., 2015)	
$\Delta S_t * I(\Delta S_t > 0)$ ($\Delta S_t * I(\Delta S_t < 0)$)	Positive (negative) change in the exchange rate value (see ,e.g., Chaieb and Mazzotta, 2013)	
ΔS_t^2	The magnitude of the change in the foreign exchange rate (see , e.g., Muller and Verschoor, 2006)	
Panel B: One-off events		
Event	Date	Description
Coordinated interest rate cut	10-08-2008	Coordinated interest rate cut between the European Central Bank, Bank of England, Federal Reserve Bank, Bank of Canada, Swedish Riksbank and Swiss National Bank.
Joint currency intervention	03-17-2011	G-7 joint currency intervention to weaken in the wake of the Thoku earthquake in Japan
OMT announcement	07-26-2012	ECB announcement of the Outright Monetary Transactions program by Mario Draghi: "Whitin our mandate the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough"
Fed LSAP program	11-25-2008	Initial LSAP announcement
	12-01-2008	Chairman's speech on LSAP
	12-16-2008	FOMC states that it considers to expand purchases of agency securities and initiating purchases of Treasury securities
	03-18-2009	FOMC announces purchases up to an additional \$750 billion
	08-10-2010	Balance Sheet Maintained: Fed will reinvest principal payments from LSAP purchases in Treasuries
	09-21-2010	Statement projects that inflation is likely to remain subdued for some time before rising to levels the Committee considers consistent with its mandate.
	11-03-2010	Statement announces purchases of \$600 billion in Treasury securities
	08-22-2012	FOMC members "judged that additional monetary accomodation would likely be warranted fairly soon."
	09-13-2012	Fed will purchase \$40 billion of MBS per month as long as "the outlook for the labor market does not improve substantially ... in the context of price stability."