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EFFECTS OF FISCAL SHOCKS IN A GLOBALIZED WORLD

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ABSTRACT

While theoretical models consistently predict that government spending shocks should lead to appreciation of the domestic currency, empirical studies have been stubbornly finding depreciation. Using daily data on U.S. defense spending (announced and actual payments), we document that the dollar immediately and strongly appreciates after announcements about future government spending. In contrast, actual payments lead to no discernible effect on the exchange rate. We examine responses of other variables at the daily frequency and explore how the response of the exchange rate to fiscal shocks varies over the business cycle as well as at the zero lower bound and in normal times.

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I. Introduction

What are the effects of fiscal policy on aggregate economic activity in a globalized world? This is a key question in current policy and academic debates. The central challenge in this debate is how to identify fiscal shocks in the data. Previous research has used narrative or structural time series (SVAR) methods to isolate unanticipated, exogenous innovations to government spending or revenue. While these approaches have many desirable properties, they typically have been applied at quarterly or even annual frequencies. These low frequencies can limit the plausibility of identifying assumptions (e.g., minimum delay restriction for government spending) and reduce statistical power (e.g., narrative shocks can account for only a few historical changes in fiscal variables). We address this challenge by using daily data on U.S. government spending.

Using daily variation does limit the scope of our investigation, for we are unable to measure the effects of shocks on slow moving aggregate variables, like real gross domestic product (GDP), for which comparable high-frequency data are unavailable. However, high-frequency analysis greatly enhances our ability to assess reactions of forward-looking variables such as exchange rates, asset prices, yields, spreads, commodity prices, etc. In previous research, analyses of how these variables react to government spending or revenue shocks were very limited because it was hard to rule out reverse causality using low-frequency data. In contrast, one can be fairly certain that, on a given day, shocks to actual or contracted payments of the U.S. government are not affected by economic news and hence causation is likely to flow from fiscal variables to forward-looking variables.

Since the U.S. economy is a dominant force in the world economy, domestic U.S. fiscal shocks are likely to have tangible effects on the rest of the world. However, the workings of these effects have been relatively understudied for several reasons. First, the magnitude of fiscal spillovers is likely to depend heavily on how exchange rates respond to fiscal shocks. However, as we discussed above, exchange rates are forward-looking variables and therefore it has been hard to establish causality. Second, typical time series analyses relied on relatively short time series and thus the scope of variables one could analyze was limited. In contrast, we have thousands of observations and consequently can examine how fiscal shocks propagate to the rest of the world through changes in exchange rates vis-à-vis changes in commodity prices or liquidity spreads. Third, asset prices are likely to move at the time when news about changes in government spending arrives rather than when the changes actually occur. With low frequency data, it is difficult to obtain precise timing of news and therefore one is likely to obtain attenuated responses to changes in government spending because low frequency analysis mixes the impact reaction to the news with the dynamics after the news. In contrast, using a daily frequency enables us to time shocks with high precision. Finally, at the daily frequency we can investigate cyclical variation of the response of exchange rates or other variables to various types of fiscal shocks. Previous research was greatly constrained in this context because we have only a handful of low frequency observations when economies are in recession or at the zero lower bound (ZLB).

We construct two daily series of government spending. The first series is payments to defense contractors reported in the daily statements of the U.S. Treasury. The second series is the announced volume of contracts awarded daily by the U.S. Department of Defense. Since one series measures actual outlays while the other provides a measure of future government spending, using these two series helps us to underscore the key role of fiscal foresight for timing shocks to government spending as well as responses to these shocks. While it is possible to construct more government spending variables at the daily frequency, we focus on military spending to minimize the possibility of reserve causality and other forms of endogeneity. We validate our daily military spending series by comparing them to standard government spending data available at lower frequencies and by relating them to major military developments.

While interpretation of spending shocks at this high frequency may be complex—we discuss that these shocks may include "level" (how much to spend), "timing" (when to spend), and "identity" (who receives government funding) components—we document that certain shocks to government spending have a non-negligible "level" component, which is the component typically studied with data at quarterly or annual frequencies. Specifically, we show that announcements about future military spending move the index of stock prices for firms in the defense industry.

To keep our analysis focused, we concentrate on how the exchange rate reacts to government spending shocks because these responses have crucial information for both policymakers and researchers. For example, these responses can inform policymakers about objects central for design of fiscal policies, such as the size of fiscal multiplier, the degree of fiscal spillovers, and the potential benefit of coordinating fiscal policies. These responses can also help researchers to discriminate among competing models of business cycles and to assess the relative importance of various frictions usually employed to match moments of the data.

Our key finding is that unanticipated shocks to announced military spending, rather than actual outlays on military programs, lead to an immediate and tangible appreciation of the U.S. dollar. This finding is broadly consistent with a variety of workhorse models in international economics and it suggests that fiscal shocks can have considerable spillovers into foreign economies. At the same time, this finding contrasts sharply with the results reported in previous studies. Specifically, the earlier work routinely documented that the domestic currency depreciates in response to government spending shocks, which is hard to square with the predictions of classic and modern open-economy models. We argue that this difference in results is likely to arise from the mis-timing of shocks in previous papers and their use of actual spending rather than news about spending. In short, we find that using daily series can resolve a long-standing puzzle in international economics.

To investigate the workings of fiscal spillovers further, we examine reactions of some key macroeconomic variables (commodity prices, stock market returns, liquidity and risk premia, etc.) available at the daily frequency. We find little support for military spending shocks influencing global markets via liquidity or uncertainty effects. Although our estimates have considerable sampling error, the picture painted by the responses is broadly consistent with the predictions of the mainstream models where government spending shocks operate through the demand channel.

This paper contributes to several strands of previous work. First, we build on the vast literature—started by Meese and Rogoff (1983)—trying, for the most part unsuccessfully, to relate exchange rate movements and domestic fundamentals such as the stance of fiscal and monetary policies, the state of the business cycle, and the current account deficit. We show that the relationship could be more apparent at high frequencies where identification and timing of shocks to fundamentals and responses to such shocks are more clear-cut. Second, we add to the body of work studying the effects of fiscal shocks on exchange rate movements (e.g., Monacelli and Perotti 2010, Ilzetzki et al. 2013, Ravn et al. 2012). This literature consistently has found the puzzling result that government spending shocks lead to depreciation of the domestic currency.

We argue that the puzzle can be resolved with enhanced identification of government spending shocks. Third, we contribute to the literature on microstructure determination of the exchange rate (see Lyons 2006 and Vitale 2007 for a survey). Specifically, we document that government spending shocks could be an additional determinant of exchange rate fluctuations at high frequencies. Fourth, we contribute to the rapidly growing strand of the literature focused on variation in the responses of macroeconomic variables to shocks in different states of the economy (recession vs. expansion, ZLB vs. non-ZLB). Specifically, we exploit high frequency variation in fiscal and outcome variables rather than using variation in quarterly or lower frequencies as in our previous work (e.g., Auerbach and Gorodnichenko 2012a, 2012b, 2013). Finally, we contribute to the ongoing debate about using actual vs. announced government spending to identify innovations to fiscal policy (e.g., Ramey 2011, Blanchard and Perotti 2002). Our results suggest that, in the context of studying responses of asset prices at high frequencies, one should use announcements about future government spending rather than actual outlays.

We structure the rest of the paper as follows. In the next section, we describe the sources of daily data on government spending on defense (announcements and actual outlays). In this section, we also relate the constructed series to alternative sources of information about government spending to validate our series. Section III presents our econometric framework to study effects of fiscal shocks. Section IV discusses interpretation of shocks. Section V documents responses of the exchange rate and other macroeconomic variables to spending shocks. We also investigate how these responses vary over time and across states of the economy (e.g., recession vs. expansion; binding zero lower bound on nominal interest rates vs. normal times). Section VI presents concluding remarks.

II. Data

We use two sources of daily data on U.S. government spending. The first source is the Daily Statements of the U.S. Treasury. The second source is the daily postings of the Department of Defense (hereafter DoD) about awarded contracts. In this section, we describe these sources and discuss pros and cons of each for measuring fiscal shocks.

A. Daily U.S. Treasury Statements

Since 1993, the U.S. Treasury has published daily reports on the federal government's actual receipts and spending. These statements include detailed information by types of receipts and spending. For example, we know how much money is transferred to defense contractors, to businesses and individuals as tax rebates, to the unemployed, and to banks (e.g., TARP).

While daily statements offer rich information about outlays of the government, we focus on payments to defense contractors for several reasons. First, as discussed in Ramey and Shapiro (1998) and elsewhere, defense spending is less likely than other types of spending to be determined by current economic conditions. Consistent with this logic, we do not observe any tangible cyclical variation in the payments on defense contracts. For example, there is barely any change in the payments over the course of the Great Recession.

Second, payments on defense contracts are much less predictable than other types of payments at high frequencies. For example, tax rebates have a large seasonal component and unemployment insurance payments appear to be timed to occur on certain days of the month. Because we are interested in unanticipated shocks to government spending, using payments on defense contracts provides a cleaner source of variation.

Third, the Daily Treasury Statements provide limited information on many components of spending in the early part of the sample, while payments on defense contracts have been consistently reported in the statements. Thus, we have a long time series for this spending component. This aspect of the data is important because it allows us to estimate state-dependent responses of macroeconomic variables to fiscal shocks.

Fourth, defense contracts tend to have a large domestic component. For example, Schwartz and Ginsberg (2013) estimate that the percentage of DoD contract obligations performed outside the United States ranged between 6 and 12 percent over the last 15 years or so. Such concentration on domestic spending helps us rule out large direct spillover (or "leakage") effects. That is, one is more likely to obtain a demand spending multiplier with military contract spending than with other components of government spending that are associated with a higher fraction of purchases of foreign goods and services.

Finally, defense spending is a major source of variation in government spending and there is enormous variation in daily payments on defense contracts (Panel A, Figure 1): they vary from \$11 million to \$4 billion. The payments aggregated to the monthly frequency are considerably smoother (Panel B, Figure 1), but even this aggregated series exhibits sizable volatility. The standard deviation of monthly changes in seasonally adjusted monthly payments is \$1.7 billion, with the range going from a reduction of \$4.0 billion to an increase of \$5.0 billion. Given that the mean monthly payment to defense contractors is about \$20.8 billion, these magnitudes translate into large percent changes.

To assess the quality of the payments data, we aggregate payments to the quarterly frequency and compare the resulting series with the corresponding data in the National Income and Product Accounts (NIPA). We construct the NIPA counterpart of the payments as purchases of intermediate goods and services (net of own-account investment[1] and sales to other sectors) plus gross investment, which is reported in the BEA's NIPA Table 3.11.5. Some of the discrepancy between the series can arise due to differences in timing of purchases (accrual vs. cash transactions) and the treatment of government enterprise expenditures. Although the definitions of variables are not aligned perfectly, the payment and NIPA spending series track each other closely and the levels of the variables are very similar, especially after 2000 (Panel C, Figure 1). Thus, one can interpret the payment series as a daily proxy for the conventional measures of military spending available at the quarterly frequency.

B. Department of Defense contracts

Since 1994, nearly every weekday at 5 pm, the DoD has announced (on http://www.defense.gov/contracts/) its new contract awards greater than \$6.5 million.[2] A typical announcement specifies the duration of the contract, awarded amount, the name of the winner, location of contract execution, and additional details about the nature of the contract (e.g., fixed price, "do not exceed", "cost plus", etc.). Each contract is assigned a unique code and is

[1] Own-account investment is measured in current dollars by compensation of general government employees and related expenditures for goods and services and is classified as investment in structures, software, and research and development.

[2] The threshold for contracts announced on the DoD website varied over time. For the most part of our sample, the threshold was five million dollars.

summarized by a paragraph in an announcement. The contracts tend to be of multi-year duration. This is an example of a contract awarded on July 28, 2014:

> SAIC, McLean, Virginia, was awarded an $89,526,485 cost-plus-incentive fee, incrementally- funded contract with options, for management and technical support for high performance computing services, capabilities, infrastructure, and technologies. Work will be performed at Wright-Patterson Air Force Base, Ohio; Aberdeen Proving Ground, Maryland; Stennis Space Center, Mississippi; Vicksburg, Mississippi; Kihei, Hawaii; Lorton, Virginia; and McLean, Virginia, with an estimated completion date of July 28, 2019. Bids were solicited via the Internet with four received. Research, development, testing and evaluation fiscal 2013 ($18,230,430) and fiscal 2014 ($5,770,000) funds are being obligated at the time of the award. U.S. Army Corps of Engineers, Huntsville, Alabama, is the contracting activity (W912DY-14-F-0103).

In addition to announcing new contracts, the DoD also makes announcements about modifications to existing contracts. The modifications can be linked to the initial DoD commitments using the unique contract code, and so one can construct a measure of the incremental changes in defense contracts. For example, on April 17, 2012, the DoD initially awarded $78 million to Electric Boat Corp., a Connecticut subsidiary of General Dynamics, for "long-lead-time material associated with the fiscal 2014 Virginia class submarine (SSN 792)." Using the unique contract code (N00024-12-C-2115), we can see that Electric Boat Corp. was later awarded an additional $307 million on December 28, 2012 for "… additional long-lead-time material associated with the fiscal 2014 Virginia-class submarine SSN 792 and the initiation of long-lead-time material for the fiscal 2015 Virginia-class submarines SSN 793 and SSN 794" and then another $520 million dollars on February 4, 2014 for "… additional long lead time material associated with the two fiscal 2015 Virginia-class submarines (SSN 794 and SSN 795) and the two fiscal 2016 Virginia-class submarines (SSN 796 and SSN 797)." On April 28, 2014, the DoD awarded Electric Boat Corp. with a $17.6 billion contract for construction of 10 Virginia-class submarines from fiscal 2014 to 2018. The evolution of modifications on this contract is fairly typical among contracts. In all likelihood, additional tranches are likely to be widely anticipated before the DoD announcements. To avoid mixing anticipated and unanticipated awards, we use only announcements of new contracts, that is, contracts that appear for the first time on the DoD website.

One drawback of using these data is that the DoD does not provide them in a format suitable for statistical analysis. To convert this information into usable form, we have downloaded web pages with announcements from the DoD archive (http://www.defense.gov/contracts/archive.aspx) and parsed data from the web pages. To verify the quality of the information, we use several algorithms of parsing information from the text of announcements, have at least two people check the consistency of collected data, and randomly check the validity of information extracted from a sample of web pages by independent research assistants. Overall, the quality of the data appears to be high.

While the announcements are not immediately translated into actual disbursements, using announcements offers one key potential advantage. Standard theory predicts that unconstrained, forward-looking agents should react at the time of the news rather than when actual spending occurs. The announcements can thus provide a better timing for spending shocks, as measured by the present value of contract awards.

Similar to daily spending on defense contracts reported by the U.S. Treasury, daily totals of announced contracts show huge variation (Panel A, Figure 2). The awarded amounts vary from $3 million to almost $25 billion with a standard deviation of $1.2 billion and a mean of $450 million. The daily totals of awarded contracts are weakly (0.08) correlated with daily spending on defense contracts.

In contrast to daily payments, daily contract awards do not appear much smoother when aggregated to monthly frequency (Panel B, Figure 2). The time series of monthly totals of awarded contracts is characterized by low serial correlation and spikes without any discernible seasonal pattern. Furthermore, these spikes in monthly totals can be related to major military developments. For example, we observe a surge in awarded contracts immediately after the 9/11 terrorist attack, the start of the second Iraq war in 2003, the Russo-Georgian war in 2008, and the start of Operation New Dawn (a major counter-insurgency operation in Iraq). In contrast, we observe no significant movements in actual payments on defense contracts.

C. Seasonal variation and other predictable components

While daily Treasury or DoD data provide considerable variation, their use presents a challenge. Specifically, economic theory predicts unanticipated movements in actual and promised spending should have stronger effects than anticipated ones. However, the daily data series can have predictable movements, for example because of institutional constraints such as budget cycles in military contract awards or spending disbursements. In particular, the daily data exhibit predictable movements on certain days of the week, days/weeks of the month, and months of the year, so one may observe systematic cycles at a variety of frequencies.

Unfortunately, there is no benchmark method for purging seasonal components from daily data. Popular approaches such as the X-12 algorithm are not available at a daily frequency. Using an extended set of dummy variables to capture seasonal effects could be unproductive because it would require many parameters to be estimated and run the risk of overfitting. To address this challenge, we use a novel framework developed in De Livera, Hyndman, and Snyder (2011). This framework allows for trends and multiple seasonal components modeled as a parsimonious series of trigonometric functions. After extensive specification searches, we include four cycles with periods that correspond to weekly, fortnightly, monthly, and yearly durations. In our analysis, we use military spending data deseasonalized and detrended using this approach. Appendix Table 1 presents descriptive statistics for the constructed government spending series.

III. Econometric framework

In our baseline specification, we follow our earlier work (Auerbach and Gorodnichenko 2012a, 2013) and estimate the effect of government spending using direct projections as in Jorda (2005). Specifically, we construct impulse responses by running a series of regressions:

$$X_{t+h} - X_{t-1} = \alpha_h G_t + \sum_{i=1}^{I} \beta_i \Delta G_{t-i} + \sum_{j=1}^{J} \gamma_j \Delta X_{t-j}$$

$$+constant + error, \qquad h = 0, \dots, H \tag{1}$$

where Δ is the first difference operator and the impulse response for an outcome variable X is given by $\{\alpha_h\}_{h=0}^{H}$. As we discuss in Auerbach and Gorodnichenko (2012a), this approach has a number of advantages. For example, in contrast to low-order vector autoregressions (VARs), it does not constrain the shape of the impulse response function (IRF).[3] This property of direct projection may be important in the context of volatile daily series with complex serial correlation structure. Furthermore, this approach allows straightforward estimation of state-dependent responses. Finally, note that when we construct the response of X to a change in G, the contemporaneous variation of G_t is purified from movements predictable by lags of G and X.[4]

This specification also corresponds to the standard VAR approach (e.g., Blanchard and Perotti 2002) where government spending is ordered first in the Cholesky decomposition. This ordering reflects the identifying assumption that a measure of government spending G_t does not respond contemporaneously to innovations in X_t. Given that we work with G_t at daily frequency, this assumption is likely to be satisfied.

We extend the direct-projections approach to allow the responses to vary by the state of the economy. For example for the case where regimes correspond to recessions and expansions, we estimate specifications of the following type:

$$\begin{aligned}X_{t+h} - X_{t-1} = {} & \alpha_h^E G_t \times I(expansion)_{t-1} + \alpha_h^R G_t \times I(recession)_{t-1} + \\ & + \sum_{i=1}^{I} \beta_i^E \Delta G_{t-i} \times I(expansion)_{t-1} + \sum_{i=1}^{I} \beta_i^R \Delta G_{t-i} \times I(recession)_{t-1} \\ & + \sum_{j=1}^{J} \gamma_j^E \Delta X_{t-j} \times I(expansion)_{t-1} + \sum_{j=1}^{J} \gamma_j^R \Delta X_{t-j} \times I(recession)_{t-1} \\ & + \chi_1 I(expansion)_{t-1} + constant + error, \qquad h = 0, \dots, H \qquad (2)\end{aligned}$$

where $I(expansion)_{t-1}$ and $I(recession)_{t-1}$ are indicator or probability variables measuring the state of the economy. The impulse responses for the recession and expansion regimes are given by $\{\alpha_h^R\}_{h=0}^H$ and $\{\alpha_h^E\}_{h=0}^H$ respectively. As we discuss in our earlier work, the direct-projections approach to estimating state-dependent effects has a number of advantages over estimating such effects in a standard VAR framework, which we did in Auerbach and Gorodnichenko (2012b). For example, it automatically incorporates the effect of government spending shocks on the state itself. Furthermore, the approach can be extended to estimation

[3] In contrast to vector autoregressions, the error term in specification (1) and other similar specifications is potentially serially correlated for $h > 1$ and therefore one has to use Newey-West or similar estimators to calculate standard errors correctly.

[4] In Auerbach and Gorodnichenko (2012a,b, 2013), we use professional forecasts to further purify government spending series of predictable movements. Such forecasts unfortunately are not available at a daily frequency. We use twenty lags in all specifications; that is, $I = J = 20$.

based on more sophisticated classifications of regimes, such as recession with a binding zero lower bound (ZLB) on short-term nominal interest rates:

$$
\begin{aligned}
X_{t+h} - X_{t-1} = {} & \alpha_h^{E,ZLB} G_t \times I(expansion)_{t-1} \times I(ZLB)_{t-1} \\
& + \alpha_h^{R,ZLB} G_t \times I(recession)_{t-1} \times I(ZLB)_{t-1} \\
& + \alpha_h^{E,noZLB} G_t \times I(expansion)_{t-1} \times (1 - I(ZLB)_{t-1}) \\
& + \alpha_h^{R,noZLB} G_t \times I(recession)_{t-1} \times (1 - I(ZLB)_{t-1}) \\
& + \sum_{i=1}^{I} \beta_i^{E,ZLB} \Delta G_{t-i} \times I(expansion)_{t-1} \times I(ZLB)_{t-1} \\
& + \sum_{i=1}^{I} \beta_i^{R,ZLB} \Delta G_{t-i} \times I(recession)_{t-1} \times I(ZLB)_{t-1} \\
& + \sum_{j=1}^{J} \gamma_j^{E,noZLB} \Delta X_{t-j} \times I(expansion)_{t-1} \times (1 - I(ZLB)_{t-1}) \\
& + \sum_{j=1}^{J} \gamma_j^{R,noZLB} \Delta X_{t-j} \times I(recession)_{t-1} \times (1 - I(ZLB)_{t-1}) \\
& + \chi_1 I(expansion)_{t-1} + \chi_2 I(ZLB)_{t-1} + \chi_3 I(expansion)_{t-1} \times I(ZLB)_{t-1} \\
& + constant + error, \qquad h = 0, \ldots, H
\end{aligned} \tag{3}
$$

where $I(ZLB)_{t-1}$ is a dummy variable equal to one when the economy is at the ZLB and zero otherwise. If one is interested in impulse responses of variable X to a shock in variable G in recession with a binding ZLB, the impulse response is given by $\{\alpha_h^{R,ZLB}\}_{h=0}^{H}$.

IV. Interpretation of innovations in government spending

Conventional macroeconomic analyses of how government spending affects the economy routinely use innovations to government spending as shocks. At relatively low frequencies (e.g., quarterly or annual), this treatment of innovations may be a reasonable approach as the frequency at which innovations are measured roughly corresponds to the frequency of government spending decisions. The interpretation of changes in government spending is more complex at higher frequencies.

For example, the day-to-day variation in amounts of government spending could have little bearing on total spending over a longer period such as a quarter or a year, perhaps capturing allocation of resources over time (i.e., news about timing of spending, or "timing news") rather than decisions about the level of resources committed for spending (i.e., news about levels of spending, or “level news”). Economic theory predicts that timing news should be considerably less powerful than level news. However, previous research (e.g., Parker et al. 2013) has found that even news about timing can affect economic activity. If variation in daily spending is dominated by timing news, one may expect that our estimates are likely to be a lower bound for the responses to news about levels.

In the context of DoD announcements, there could be additional uncertainty about the identity of firms that receive a contract but little or no uncertainty about the magnitude of the contract (i.e., “identity news”). For example, the public may know that the DoD plans to award a $10 billion contract to build a new fleet of bombers and the only uncertainty from the perspective of the public is the identity of the contract winner, e.g., Boeing or Lockheed. In this case, specific DoD contract awards may resolve no uncertainty at the aggregate level. If DoD announcements are dominated by such identity news, one may find weak, if any, reaction of macroeconomic variables to DoD announcements.

The plausibility that DoD announcement might provide “level news” is increased by the flexibility of the government spending process with respect to defense. Like other government spending programs, defense spending proceeds through a process beginning with the submission of the President’s budget and continuing through the Congressional appropriations process, which creates budget authority for committing the funds that are allocated by the contracts in our DoD announcement data. However, the funds allocated in any particular contract announcement do not necessarily come from current-year authorizations. First, through the procedure of “multiyear procurement,”[5] the DoD can award contracts for which future-year expenditures will be funded through future-year budget authority, rather than current-year authority. Such procurement requires Congressional approval and may involve penalties if subsequent funding is not provided, and so may provide news about the level of expected future appropriations. Second, as the July 28, 2014 announcement from our sample given above indicates, budget authority may be carried over from one fiscal year to the next. Unobligated budget authority can be carried over for one or more fiscal years if the appropriations measure specified a “no-year”

[5] For details, see the discussion in O’Rourke and Schwartz (2014).

or multi-year period of availability[6], which is common in DoD accounts. Thus, the present value of spending from a particular year's budget is affected by when funds in that budget are actually committed.

To assess the importance of level news in the daily payments and daily contract announcements data, we use specification (1) with the stock price index of firms in the defense industry as the dependent variable. If the only source of variation in DoD announcements is identity news, then stock prices of individual corporations may react to the news but one should not observe a reaction in the index since a win for Boeing is a loss for Lockheed. If the only source of variation in payments or contract announcements is timing news, then the index should not react to actual payments or announcements because that information should already be incorporated in the stock prices. If the index reacts to daily variation in payments or announcements, one can have more confidence that level news is an important source of variation in these series. Indeed, Fisher and Peters (2010) document that movements in the index of stock prices of major defense contractors have a significant predictive power for future military spending.

Panel A of Figure 3 plots impulse responses to daily DoD announcements for a stock price index for large defense and aerospace corporations.[7] The index rises in response to DoD announcements. Although stock prices are highly volatile, we can reject the null that the response is zero at least for several horizons. Furthermore, consistent with the efficient market hypothesis, stock prices of large defense and aerospace corporations jump at the time of the news and stay roughly constant for at least 30 days.

In contrast, daily U.S. Treasury payments to defense contractors generate no significant reaction of the defense index (Panel B, Figure 3). Furthermore, the point estimates are often negative so that overall effects are small not only statistically but also economically. These impulse responses are consistent with the view that timing shocks dominate level shocks in daily

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[6] See General Accounting Office, Office of the General Counsel (2004). Page 2-52.

[7] The index includes the following corporations: Boeing Co, General Dynamics, Honeywell Intl Inc, L-3 Communications Holdings, Lockheed Martin, Northrop Grumman Corp, Precision Castparts Corp, Raytheon Co, Rockwell Collins, Textron Inc, United Technologies Corp, AAR Corp, Aerovironment Inc, American Science & Engineering, Cubic Corp, Curtiss-Wright Corp, Engility Inc., GenCorp Inc, Moog Inc A, National Presto Industries, Orbital Sciences Corp, Taser International Inc, and Teledyne Technologies Inc. These corporations are included in the S&P 1500 index. We use equal weights to aggregate movements of stock prices across corporations.

payments. In this case, one may expect weaker reactions of macroeconomic variables to shocks in daily payments than to shocks in contract announcements.

V. Results

In an ideal setting, one would like to study responses of many macroeconomic variables at high frequencies to understand the effects and transmission mechanisms of government spending shocks. Unfortunately, most macroeconomic variables relevant for our analysis (e.g., imports and exports) are available only at a monthly or quarterly frequency, and even if available might react too slowly for one to observe an immediate response in daily data. As a result, our analysis focuses on asset prices available at a daily frequency. While we study the effects of government spending on various asset prices, we emphasize the dynamics of the exchange rate response because they represent a key channel for many proposed transmission mechanisms.

We use the trade-weighted exchange rate (for major trading partners) constructed by the Federal Reserve Board. A high value of the exchange rate corresponds to strong U.S. dollar. Figure 4 plots the time series of this exchange rate. The dollar appreciated in the late 1990s and early 2000s, reaching a peak in 2002, and depreciated steadily thereafter until the beginning of the Great Recession, after which its movement was quite volatile. Since 2012 the dollar has been appreciating.

A. Baseline model

Panel A of Figure 5 shows the impulse response of the nominal exchange rate to a unit shock in the DoD announcements (daily log volume of awarded contracts, deseasonalized and detrended). At the time of the shock, the dollar appreciates by 0.0001 (that is, 0.01%).[8] This contemporaneous response is statistically significant at the 95 percent level. Over time, the exchange rate appreciates further and reaches the maximum appreciation of 0.00052 after about

[8] DoD announcements are made at 5pm Eastern Time. Some markets are closed by this time and therefore some daily variables may be unable to respond to the announcement on the day it was made. In light of this discrepancy in timing, we use responses at $h = 1$ in specifications (1)-(3) as a measure of the contemporaneous response.

25 working days. Given the amount of volatility in both series (the exchange rate and the DoD announcements), statistical significance of the point estimates is remarkable.[9]

The direction of the response of the exchange rate is consistent with basic macroeconomic theory: in an economy with a flexible exchange rate, government spending shocks should lead to appreciation of the domestic currency. The dynamics of appreciation are broadly in line with economic theory as well. For example, the Dornbusch model predicts maximum reaction at the time of the shock. While the exchange rate peaks with a delay, the duration of the delay is fairly short relative to previous studies (e.g., Benetrix and Lane 2013) where the maximum reaction was delayed by many months. We cannot reject that the appreciation is zero at long horizons, but it certainly appears fairly persistent based on point estimates. Interestingly, when we aggregate data to the monthly frequency (Panel A, Figure 6) the delay becomes more pronounced: the response peaks after six months. Therefore, the delayed responses in the previous literature may be in part due to the use of low-frequency data.

To put the magnitude of the appreciation in a proper context, we also report the response of spending announcements to its own shocks (the figure on the right-hand side in Panel A). Clearly, the response is short-lived and for all practical purposes the shocks may be treated as daily innovations. These dynamics make interpretation easy because one does not have to adjust the response of the exchange rate or other macroeconomic series by the cumulative response of the shock series. A shock is measured as percent deviation from the daily average of awarded contracts. Given that there are roughly 250 business days in a year, a unit daily shock (100 percent; roughly double announced award on a given day) to awarded contracts corresponds approximately to a 100/250 percent ($\approx$ 0.4 percent) increase in the annual volume of awarded contracts. Thus, scaling the impact to a doubling of the annual budget of spending on defense contracts, which currently amounts to approximately two percent of GDP,[10] the implied dollar appreciation would be about 12 percent (250*0.00052), a significant amount.

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[9] The response is similar when it is estimated using the standard VAR approach; see Appendix Figure 1.

[10] According to the September 30, 2013 Daily Report of the U.S. Treasury, the total payment to defense contractors in the fiscal year of 2013 was 343 billion, which is equal approximately to 2% of the U.S. GDP. Note that this accounts for roughly half of the overall defense budget, which also includes labor expenses for soldiers and other employees, maintenance of military bases, military operations, etc.

To contrast the difference between announced and actual spending, we present the daily response of the exchange rate to actual spending (daily payments to defense contractors) in Panel B of Figure 5. We find no significant response at any horizon. The pattern is similar when we estimate the response using data at the monthly frequency, as shown in Panel B of Figure 6; if anything, the point estimates suggest that the dollar depreciates. This weak reaction is consistent with findings documented in earlier work. For example, Ilzetzki et al. (2013) report no reaction of exchange rates to government spending shocks in developed countries.[11] Furthermore, using VAR regressions, Kim and Roubini (2008), Monacelli and Perotti (2010), Enders et al. (2011) and Ravn et al. (2012) estimate that the exchange rate *depreciates* in response to government spending shocks identified as in Blanchard and Perotti (2002) or with sign restrictions. We reproduce this puzzling result in Appendix Figure 2.

At the same time, Corsetti, Meier, and Muller (2009) document that the dollar appreciates (with a delay) when one uses news about military spending shocks as in Ramey and Shapiro (1998). As argued in Ramey (2011), these shocks are likely to have better timing in the sense of being unanticipated innovations.[12] In a similar spirit, Born et al. (2013) find for a panel of OECD countries that domestic currency appreciates on impact after government spending shocks purified from predictable movements when one uses OECD forecasts for government spending as in Auerbach and Gorodnichenko (2012a).

This difference in responses to actual and announced government spending shocks can explain why previous studies using actual spending and data at low frequencies failed to find a robust link between exchange rate movements and fundamentals such as the fiscal deficit.

B. Transmission

The previous section documents that announcements about future U.S. government spending—rather than actual spending—lead to appreciation of the U.S. dollar. In this section, we examine

[11] Ilzetzki et al. (2013) do find that the exchange rate appreciates on impact for countries (developed and developing) with flexible exchange rates. However, this appreciation is temporary and the exchange rate depreciates shortly after the shock.

[12] However, even with the better timing of military spending announcements constructed in Ramey (2011), we find only a moderate improvement in the reaction of the exchange rate. Specifically, instead of depreciation, the dollar exhibits no reaction to the Ramey spending shocks. See Appendix Figure 2.

responses of additional macroeconomic variables to have a more complete picture of how spending shocks are transmitted.

We start this analysis with high-frequency variables that capture the state of liquidity, volatility and overall health of the U.S. economy (Figure 7). While these variables are "domestic", the U.S. economy is a key player in global markets and thus "local" effects of the U.S. government spending shocks may spill over into foreign markets. The TED spread,[13] which measures liquidity in the economy, does not exhibit any discernible reaction to spending shocks irrespective of whether these are announcements or actual payments. Therefore, there is little evidence that the exchange rate movements are determined via liquidity effects of government spending shocks. We also find little evidence that announced contract spending shocks result in greater uncertainty[14] (second row, left column in Figure 7). To the extent increased uncertainty stimulates a flight for quality (i.e., increased purchases of U.S. government debt), these shocks do not appreciate the dollar via this channel. At the same time, actual spending shocks are associated with increased uncertainty, for which we do not have a ready explanation. Finally, we examine if the overall stock market reacts to government spending shocks to assess the strength of the demand channel. While the response of the S&P 500 index is generally positive to announcement shocks and negative to actual payment shocks, the standard errors are too large to draw firm inferences.

Government spending shocks in the U.S. may influence other economies by affecting commodity prices. Figure 8 documents that in response to announcement shocks, oil prices tend to increase at the time of the shock but then gradually fall back. However, the confidence intervals are fairly wide and we cannot reject a zero response at the 95 percent confidence level. The response of gasoline prices to announcement shocks has a delayed peak (about 10 business days) but this increase is short-lived. For almost all horizons we cannot reject a zero response. While gold prices show no contemporaneous response to announcement shocks, they gradually

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[13] The TED spread is calculated as the difference between the 3-Month London Interbank Offer Rate (LIBOR) based on US dollars and the 3-Month Treasury bill rate.

[14] We measure uncertainty using the Chicago Board Options Exchange (CBOE) DJIA Volatility Index. This index shows the hypothetical performance of a portfolio that engages in a buy-write strategy on the Dow Jones Industrial Average (DJIA).

fall and this decline is statistically significant after about 20 business days. Responses to payment shocks are similar but the contemporaneous reactions to these shocks are attenuated.

Many theoretical models impose a tight link between movements in exchange rates and interest rates. Typically, appreciation of the U.S. dollar is associated with higher U.S. real interest rates. To preserve space, we report (Figure 9) only contemporaneous responses ($h = 1$ in specification (1)) of interest rates and inflation expectations at different maturities so that one can observe the behavior of the yield curve. Announcement shocks tend to raise short-term (less than a year) interest rates for U.S. government debt and for interbank loans (LIBOR). The response is not statistically significant which, apart from sampling uncertainty, may also signal the power of the Fed to control short-term interest rates. The point estimates for longer rates are close to zero. In contrast, announcement shocks appear to shift up the whole "yield curve" for inflation expectations measured from the prices of inflation swaps at different maturities. Unfortunately, we have measures of inflation expectations only for horizons greater than a year while the movements in the nominal interest rates are most discernible at much shorter horizons. Thus, we cannot establish if changes in inflation expectations at these short horizons are sufficiently large to offset changes in nominal rates. For longer horizons, the responses to announcement shocks are imprecisely estimated. While our results are statistically inconclusive about the importance of the real interest rate response, the point estimates of the responses are broadly in line with the predictions of workhorse models. In contrast, the picture is mixed for responses to payment shocks (in the right panel of Figure 9). Inflation expectations tend to decrease and nominal rates for U.S. government debt tend to fall while the nominal rates in the interbank market tend to rise. It's hard to reconcile these responses in a standard framework.

Finally, we examine how stock market indices for foreign markets react to U.S. government spending shocks. We focus on large exchanges with long time series. Specifically, we study responses of the NIKKEI 225 (Japan), the FTSE 100 (the U.K.) and the TSX (Canada). Announcement shocks tend to raise these indices although, again, the confidence bands are wide. We find a statistically significant, positive response only for the FTSE 100 and the TSX shortly after the shock. In contrast, payment shocks appear to lead to declines in foreign stock market indices.

Overall, these results suggest spending shocks appear to increase the level of demand in the global economy. Oil/gasoline prices increase, while the price of gold—a commodity often used to hedge against recessions—decreases. Domestic interest rates and inflation expectations rise. Foreign stock markets boom. Alternative explanations based on liquidity and volatility risks seem to have no clear support. However, sampling uncertainty in the estimated responses is large and, obviously, such interpretation is tentative at best.

C. Robustness

Given that the period we study (1994-2014) is characterized by dramatic volatility in the economy and in asset prices (e.g., the Great Recession), we explore in this section whether our results are driven by particular events or subsamples. As a first pass, we estimate impulse responses for the pre-Great Recession period, ending in December, 2007. We find that the patterns estimated on the full sample are similar to those estimated on the pre-crisis period (Panel A, Figure 11). The response of the exchange rate to a DoD announcement is very similar for short horizons to those in Figure 5 although there is no upward trend as horizons lengthen. At the same time, the dollar depreciates (rather than stays at roughly zero) in response to increased payments to defense contractors.

A binding zero lower bound (ZLB) was a key aspect of the Great Recession; even now, more than five years since the recession trough, short-term interest rates are at ultra-low levels in the United States and many other developed countries. Wieland (2012) shows that the response of the exchange rate to a government spending shock at a binding ZLB can be different from the response in normal times (i.e., outside the ZLB). Specifically, a government spending shock can, in theory, lead to depreciation (rather than appreciation) of the exchange rate when the economy operates at the zero lower bound. Intuitively, in normal times when government spending shocks increase demand and hence generate inflation, the central bank raises the real interest rate to cool down the economy. This increase in the real interest rate yields appreciation of the domestic currency to keep asset markets cleared. In contrast, when the ZLB is binding, the central bank cannot raise nominal interest rates and therefore inflation generated by increased government spending translates into a fall in real interest rates. Such reaction of real interest rates at the ZLB leads to depreciation of the domestic currency. As a result, the fiscal multiplier in an open economy can be larger than in a closed economy when the ZLB is binding.

Panel B of Figure 11 plots impulse responses of the exchange rate to government spending shocks during the period with a binding ZLB. While we continue to find no significant response to payment shocks, the response to DoD announcements is now such that the contemporaneous response is weak and then the dollar greatly appreciates. Furthermore, the response at long horizons (25-30 days) is significant for these announcement shocks.

The behavior of the exchange rate at short horizons can be rationalized within the standard, micro-founded framework analyzed in Wieland (2012). In a frictionless economy, the exchange rate should appreciate in normal times and it should depreciate at the ZLB. If an economy has, for example, financial frictions, the response at the ZLB should be between these extremes. Depending on parameter values, one could obtain no reaction of the exchange rate. This prediction also squares with the traditional, Mundell-Fleming theoretical framework. In normal times, additional government spending crowds our private consumption and investment as well as net exports. However, such crowding-out is likely to be less pronounced in times of slack and liquidity trap (i.e., binding ZLB). In other words, one should observe weaker, if any, appreciation of the exchange rate in response to government spending shocks. On the other hand, the delayed, statistically significant appreciation of the dollar is inconsistent with the predictions of traditional and modern theoretical models.

One may conjecture that the estimated responses of the exchange rate during a binding ZLB period in the recent U.S. history could be affected by dramatic developments that are usually outside theoretical models. For example, the time series of the TED spread (Figure 12) suggests that liquidity was unusually scarce during the early part of the ZLB period. Perhaps responses to government spending shocks in such environments are atypical. To control for this potentially confounding factor, we introduce twenty lags of the TED spread as additional regressors in specification (1). Panel C of Figure 11 shows that these additional controls eliminate the "puzzle".

To further explore time variation in the strength of the exchange rate response to government spending shocks, we estimate specification (1) using rolling regression with a window of 24 months (approximately 500 daily observations). Figure 13 shows the time series of the contemporaneous response of the exchange rate, with periods of recession indicated. For DoD announcements, we observe that the response is generally low during recessions and the strength of the response appears to have declined over time. That is, the contemporaneous response is larger and statistically significant in the early part of the sample but becomes close to zero economically and statistically towards the end of our sample, which is consistent with results reported in Figure 12. Note that we estimate the strongest response in the mid- to late-1990s, which was the period of a strong expansion of the U.S. economy. Interestingly, the response to payment shocks (daily statements of the U.S. Treasury) shows the opposite cyclical variation: the response is larger in recessions than in expansions, although generally not significant statistically.

D. Microstructure effects

Previous studies of exchange rate movements at high frequencies emphasize that macroeconomic news could be powerful determinants of such movements.[15] One may be concerned that our findings are driven by a correlation between such news and innovations to government spending. To isolate the effect of government spending shocks from other macroeconomic news at high frequencies, we construct additional controls for macroeconomic news.

Specifically, we use two measures of innovations to monetary policy. The first measure is the difference between the fed funds rate target announced by the Fed and the expected value of the rate captured by the futures on the fed funds rate. As in Gorodnichenko and Weber (2013), we calculate this difference in a tight (30-minute) window around FOMC announcements. The second measure is the movement in the 5-year Treasury note at the time of the Fed's announcements about quantitative easing. Chorodow-Reich (2014, Table 1) reports these movements in tight windows around the announcements. We use two measures because the first one is not available at the ZLB while the second was not used by the Fed before the ZLB became binding.

For other macroeconomic news, we follow Andersen et al. (2003) and calculate the surprise component in macroeconomic releases as the difference between the released figures ("realization") and expectations of money market managers. We construct macroeconomic surprises for the following variables: GDP, capacity utilization, consumer confidence, CPI core inflation rate, employment cost index, initial unemployment claims, ISM manufacturing

[15] See Vitale (2007) for a survey.

composite index, index of leading indicators, new home sales, non-farm payrolls, PPI core inflation rate, retail sales, retail sales excluding motor vehicles, and unemployment.

We use these measures (current values and lags) as additional controls in specification (1). Figure 14 shows responses of the exchange rate to government spending shocks for different combinations of the additional controls. By and large, we observe little difference in the estimated impulse responses relative to what we obtain in the baseline specification, which does not control for other macroeconomic innovations. This negligible difference in the responses does not mean that the additional controls have no predictive power for the exchange rate movements. We find (Appendix Figure 3) that these sources of news do move the exchange rate significantly. As a result, one can interpret the stability of the responses to government spending shocks as suggesting little correlation between government spending shocks and the additional controls.

E. State-dependent responses

Results of Section V.C document variation in the responses of the exchange rate to government spending shocks. In this section, we examine if this variation can be related to the state of business cycle. We estimate specification (2) with two regimes: recession and expansion as identified by the National Bureau of Economic Research (NBER). Figure 15 plots the impulse responses of the nominal exchange rate to DoD announcements (Panel A) and U.S. Treasury payments to defense contractors (Panel B) for these two regimes. The figure also reports responses of government spending to its own shocks.

Similar to the previous results, we do not observe any persistence in our measures of government spending. The response of the exchange rate to announcement shocks in expansion is also similar to the response we estimate on the full sample in the linear model: the dollar appreciates on impact and stays appreciated. In contrast, the dollar *depreciates* to a payment shock (not statistically significant). Given large standard errors we cannot reject equality of these responses from the response we obtain in the linear model that pools data across regimes. The responses to spending shocks in recession, however, are radically different from those in expansion. The contemporaneous response is weak but, over time, the dollar strongly appreciates. This pattern applies to announcement and spending shocks.

As we discussed above, the gradual appreciation of the exchange rate is hard to reconcile in the standard theoretical framework. To assess whether these puzzling dynamics are driven by a binding ZLB, we estimate specification (3) which provides responses in four regimes: recession without a binding ZLB (March 2001—November 2001, December 2007—November 2008); recession with a binding ZLB (December 2008—June 2009); expansion with a binding ZLB (July 2009—present); expansion without a binding ZLB (October 1994—February 2001, December 2001—November 2007). We also highlighted before the importance of using the TED spread for understanding dynamics of the variables during the Great Recession. Hence, we report estimated responses when lags of the TED spread are excluded (Panel A in Figure 16 and Figure 17 for announcement and payment shocks respectively) and when they are included as controls (Panel B in the figures).

Consider responses to the announcement shocks (right-hand side of Figure 16) when the ZLB is not binding. We find that in expansion the dollar appreciates and stays strong. The contemporaneous response in recession is weaker than in expansion but then we observe a gradual appreciation. Although the magnitude of the appreciation is larger than the magnitude of the appreciation in expansion, the standard errors are large and we cannot reject equality of responses. In addition, we cannot reject the null of zero response in recession. Whether we control for the TED spread or not makes little difference for the estimates when the ZLB is not binding.

When the ZLB is binding (left-hand side of Figure 16), the response in expansion is small and not statistically different from zero. We observe this weak response with and without lags of the TED spread as controls in specification (3). In contrast, the dollar gradually and strongly appreciates in recession in the baseline specification. These puzzling dynamics vanish when we control for the lags of the TED spread. In this case, the response is volatile but it is much smaller in magnitude than in the case without lags of the TED spread. Furthermore, we cannot reject the null hypothesis that the response is zero once these controls are introduced. This finding is consistent with Wieland (2012) documenting that the reaction of the exchange rate to inflation surprises is close to zero.

When we compare “expansion” responses inside and outside the ZLB after controlling for the TED spread (Panel B, Appendix Figure 4), we observe that the point estimate of the response is lower when the ZLB binds than when it doesn't. The pattern is similar for the "recession" responses. While we cannot reject the null that the responses are the same across ZLB and non-ZLB periods, the weaker response of the exchange rate when ZLB is binding is qualitatively consistent with the modern theoretical models predicting a possibility of such depreciation (see Wieland 2012).

The responses to payment shocks (Figure 17) are puzzling. For example, the dollar depreciates (appreciates) when economy is in expansion (recession) and ZLB is not binding. Controlling for lags of the TED spread attenuates these puzzling dynamics, but even these additional controls cannot resolve the problem completely.

While we find only a weak statistical support for variation in the response of the exchange rate to fiscal shocks across regimes (recession vs. expansion; ZLB vs. non-ZLB), one should not infer that the responses are universally stable. Indeed, Woodford (2011) and others argue that the difference in the responses across regimes depends on the extent to which shocks spill from one regime into another. Our strongest results are for announcement shocks, but these shocks indicate spending over multiple years. Since a typical recession lasts for only a few quarters, it is possible that the differences across regimes are attenuated.

VI. Concluding remarks

How government spending shocks propagate in interconnected economies is a key question with a number of positive and normative implications. Yet, despite a great deal of attention to this question, understanding of the strength and channels of the propagation has been elusive. A main challenge has been the identification unanticipated shocks to government spending when fiscal foresight is potentially a dominant feature of the data and government spending can respond endogenously to the state of the economy. The challenge is particularly acute when investigations involve movements in asset prices, which respond to information very rapidly.

To address this challenge, we construct two *daily* series of an important component of U.S. government spending, actual defense outlays and announcements about future defense spending. At this high frequency, it is unlikely that spending reacts to developments in the economy and hence one can rule out reverse causality. Shocks to defense spending are much less cyclical than other components of government spending, which further reduces the possibility of endogeneity.

We show that, in contrast to actual outlays, announcements about future spending robustly lead to a significant and immediate appreciation of the U.S. dollar, which suggests potentially considerable fiscal spillovers. This finding differs sharply from the results reported in previous studies that find a depreciation of the currency in response to domestic government spending shocks, which may be interpreted as leading to "beggar-thy-neighbor" effects. We argue that this discrepancy is likely to arise for two reasons. First, using daily data rather than monthly, quarterly or annual data allows us to have a much finer precision in the timing of shocks and responses. Second, previous studies typically use actual outlays while forward-looking variables such as the exchange rate are likely to move at the time of the announcement.

In addition to documenting this central result, we also try to shed more light on the propagation mechanisms by studying responses of other variables. While sampling uncertainty in our estimates is quite high, the patterns of the responses are broadly consistent with the predictions of classic and modern open-economy models emphasizing the demand channel of government spending shocks. Finally, we examine how the response of the exchange rate to defense spending shocks varies with the state of the economy (recession vs. expansion, binding zero lower bound vs. normal times). Although we observe interesting variation in the responses, again sampling uncertainty is too large to reach firm conclusions.

Previous analyses documenting depreciation of the exchange rate after domestic government spending shocks stimulated development of new models to rationalize such depreciations, which were puzzling for the workhorse open-economy models. Our results suggest that, perhaps, further progress should be concentrated on improving identification of government spending shocks to establish solid foundations for subsequent theoretical work. We highlight potential benefits of using high-frequency data to study effects of fiscal shocks. We focus on defense spending but information for other types of spending is available for analyses. For example, daily statements of U.S. Treasury have information for dozens on spending components. While our results here suggest relatively weak responses to payments rather than announcements, previous research suggests that other components of government spending, such as tax rebates and transfer payments, might have a more noticeable impact. We hope that future work will exploit this wealth of information.

References

Andersen, Torben, Tim Bollerslev, Francis Diebold, and Clara Vega, 2003. “Micro Effects of Macro Announcements: Real-Time Price Discovery in Foreign Exchange,” *American Economic Review* 93, 38-62.

Auerbach, Alan J., and Yuriy Gorodnichenko, 2012a. "Fiscal Multipliers in Recession and Expansion," in *Fiscal Policy after the Financial Crisis*, pages 63-98, National Bureau of Economic Research, Inc.

Auerbach, Alan J., and Yuriy Gorodnichenko, 2012b. "Measuring the Output Responses to Fiscal Policy," *American Economic Journal: Economic Policy* 4(2), 1-27.

Auerbach, Alan J., and Yuriy Gorodnichenko, 2013. "Output Spillovers from Fiscal Policy," *American Economic Review*, 103(3), 141-46.

Benetrix, Agustin. S., and Philip R. Lane, 2013. "Fiscal Shocks and the Real Exchange Rate," *International Journal of Central Banking* 9(3), 6-37.

Blanchard, Olivier, and Roberto Perotti, 2002. “An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output,” *Quarterly Journal of Economics* 117(4), 1329-1368.

Born, Benjamin, Falko Juessen, and Gernot J. Müller, 2013. "Exchange rate regimes and fiscal multipliers," *Journal of Economic Dynamics and Control* 37(2), 446-465.

Chodorow-Reich, Gabriel, 2014. “Effects of Unconventional Monetary Policy on Financial Institutions,” forthcoming in *Brookings Papers on Economic Activity*.

Corsetti , Giancarlo, André Meier, and Gernot J. Müller, 2009. "Fiscal Stimulus with Spending Reversals," IMF Working Papers 09/106, International Monetary Fund.

De Livera, Alysha M., Rob J. Hyndman, and Ralph D. Snyder, 2011. “Forecasting Time Series With Complex Seasonal Patterns Using Exponential Smoothing,” *Journal of the American Statistical Association* 106(496), 1513-1527.

Enders, Zeno, Gernot J. Müller, and Almuth Scholl , 2011. "How do fiscal and technology shocks affect real exchange rates? New evidence for the United States," *Journal of International Economics* 83(1), 53-69.

Fisher, Jonas D.M., and Ryan Peters, 2010. “Using Stock Returns to Identify Government Spending Shocks,” *Economic Journal* 120(544), 414-436.

General Accounting Office, Office of the General Counsel, 2004. *Principles of Federal Appropriations Law*, 3rd Edition, Volume 1.

Gorodnichenko, Yuriy, and Michael Weber, 2013. “Are Sticky Prices Costly? Evidence From The Stock Market,” NBER Working Paper No. 18860.

Ilzetzki Ethan, Enrique G. Mendoza, and Carlos A. Vegh, 2013. “How Big (Small?) are Fiscal Multipliers?” *Journal of Monetary Economics* 60(2), 239-254.

Jorda, Oscar, 2005. “Estimation and Inference of Impulse Responses by Local Projections,” *American Economic Review* 95(1), 161-182.

Kim, Soyoung, and Nouriel Roubini, 2008. "Twin deficit or twin divergence? Fiscal policy, current account, and real exchange rate in the U.S," *Journal of International Economics* 74(2), 362-383.

Lyons, Richard, 2006. T*he Microstructure Approach to Exchange Rates*. MIT Press.

Meese, Richard, and Kenneth Rogoff, 1983. “Empirical Exchange Rate Models of the Seventies: Do They Fit Out of the Sample?” *Journal of International Economics* 13, 3-24.

Monacelli, Tommaso, and Roberto Perotti, 2010. "Fiscal Policy, the Real Exchange Rate and Traded Goods," *Economic Journal* 120(544), 437-461.

O’Rourke, Ronald, and Moshe Schwartz, 2014. *Multiyear Procurement (MYP) and Block Buy Contracting in Defense Acquisition: Background and Issues for Congress.* Congressional Research Service Report R41909, July 30.

Parker, Jonathan A., Nicholas S. Souleles, David S. Johnson, and Robert McClelland, 2013. "Consumer Spending and the Economic Stimulus Payments of 2008," *American Economic Review* 103(6), 2530-2553.

Ramey, Valerie, and Matthew D. Shapiro, 1998. “Costly Capital Reallocation and the Effects of Government Spending,” *Carnegie-Rochester Conference Series on Public Policy*.

Ramey, Valerie, 2011. “Identifying Government Spending Shocks: It's All In The Timing,” *Quarterly Journal of Economics* 126(1), 1-50.

Ravn, Morten O., Stephanie Schmitt-Grohé, and Martín Uribe, 2012. "Consumption, government spending, and the real exchange rate," *Journal of Monetary Economics* 59(3), 215-234.

Schwartz, Moshe, and Wendy Ginsberg, 2013. *Department of Defense Trends in Overseas Contract Obligations*. Congressional Research Service Report R41820, March 1.

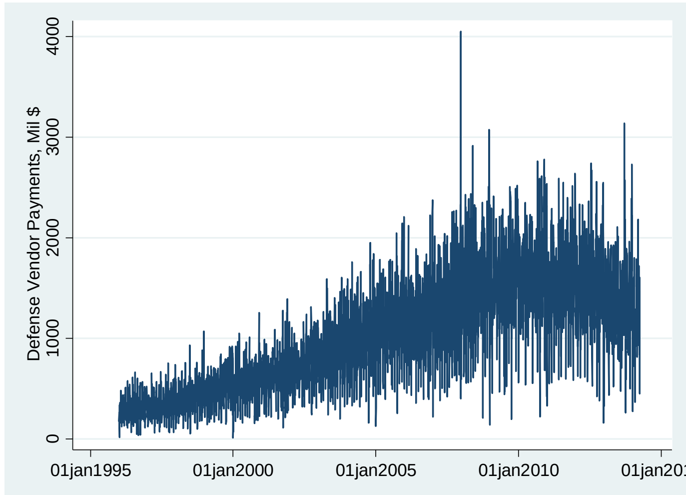
Vitale, Paolo, 2007. “A Guided Tour of The Market Microstructure Approach to Exchange Rate Determination,” *Journal of Economic Surveys* 21, 903-934.

Wieland, Johannes, 2012. Fiscal Multipliers at the Zero Lower Bound: International Theory and Evidence. UCSD manuscript.

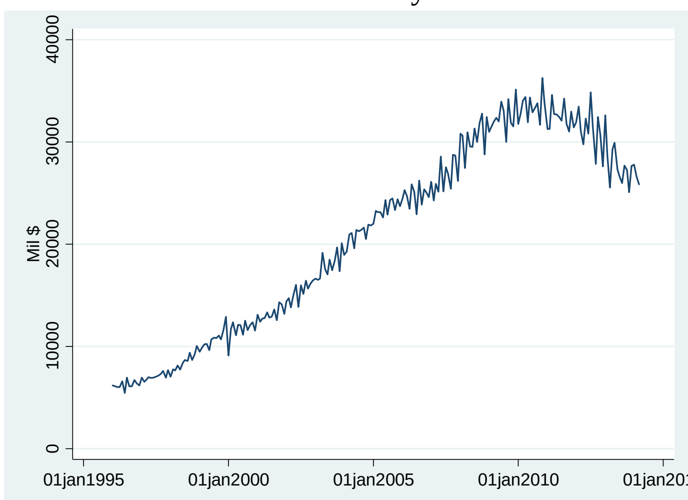
Woodford, Michael, 2011. "Simple Analytics of the Government Expenditure Multiplier," *American Economic Journal: Macroeconomics* vol. 3(1), 1-35.

Figure 1. Daily measures of government spending.

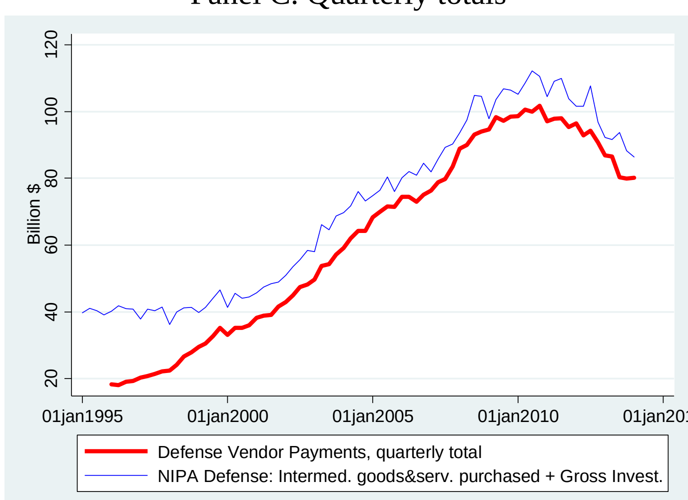
Panel A. Daily Cash Withdrawals from Fed. Res. Acct. for Defense Vendor Payments.



Panel B. Monthly totals

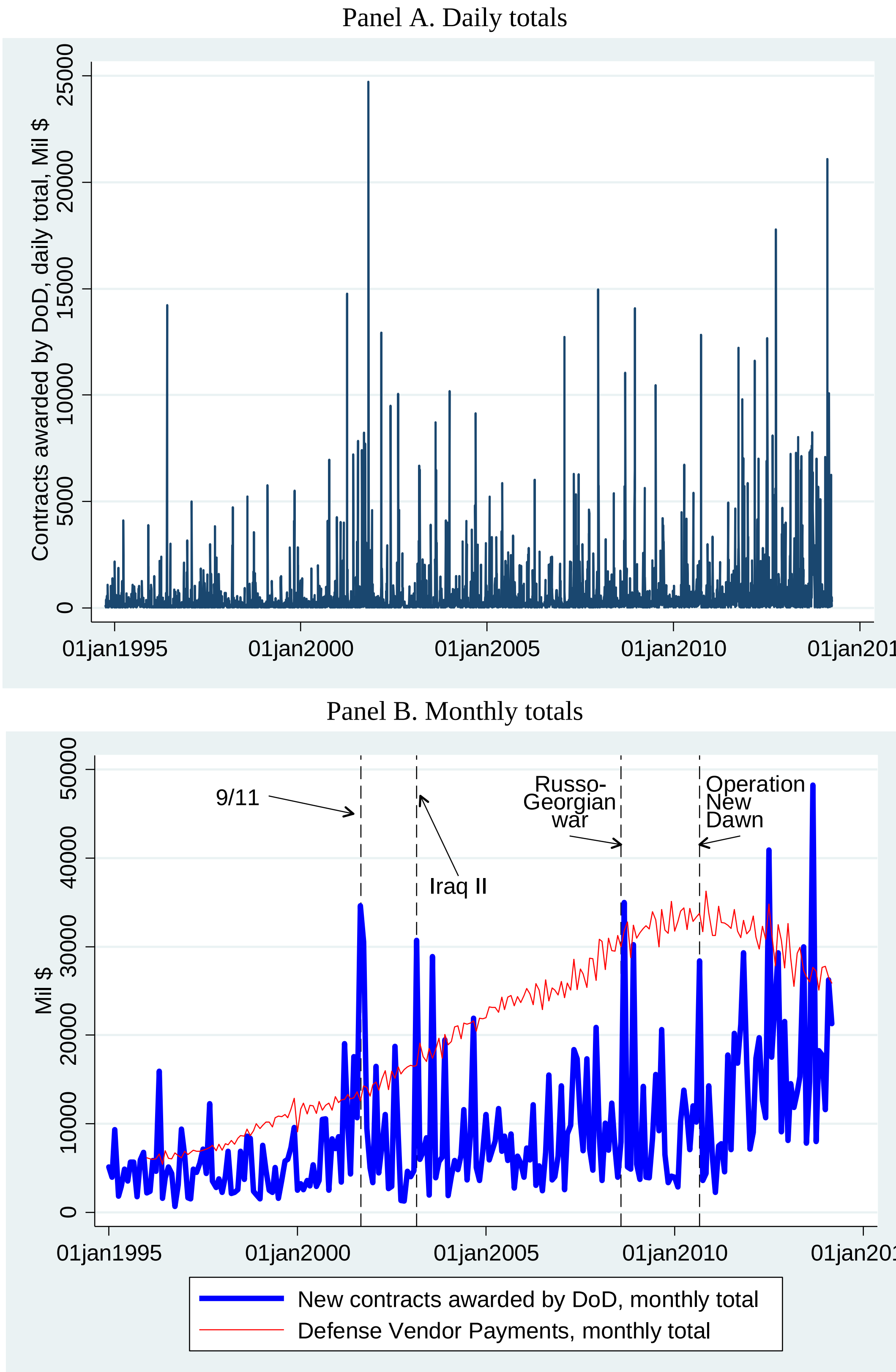


Panel C. Quarterly totals



Sources: Daily Statements of the U.S. Treasury; Department of Defense, http://www.defense.gov/contracts/archive.aspx. Monthly and quarterly totals are seasonally adjusted.

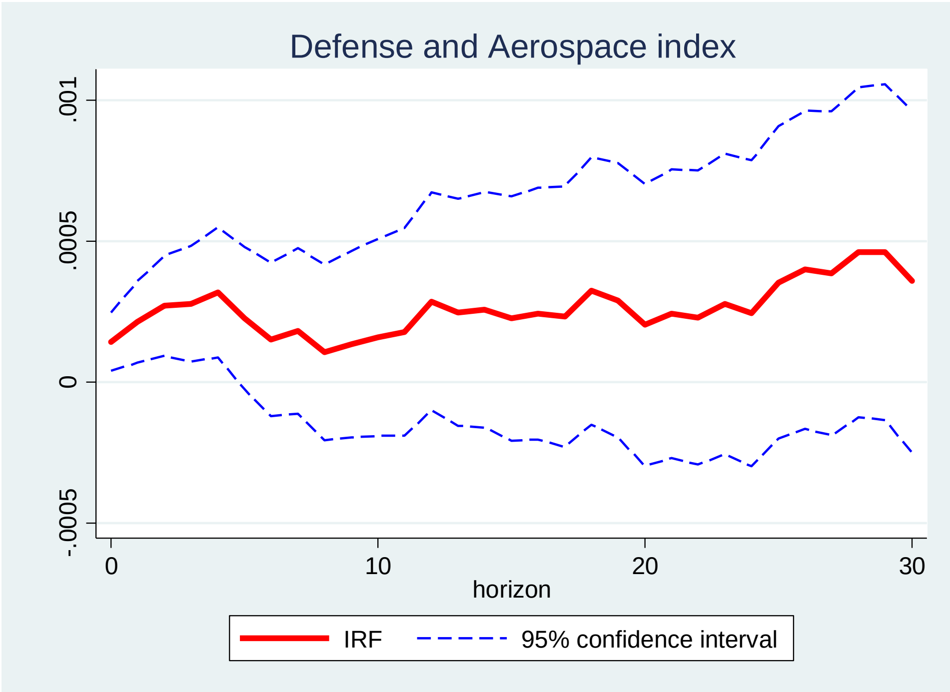
Figure 2. New contracts awarded by the Department of Defense, millions of dollars.



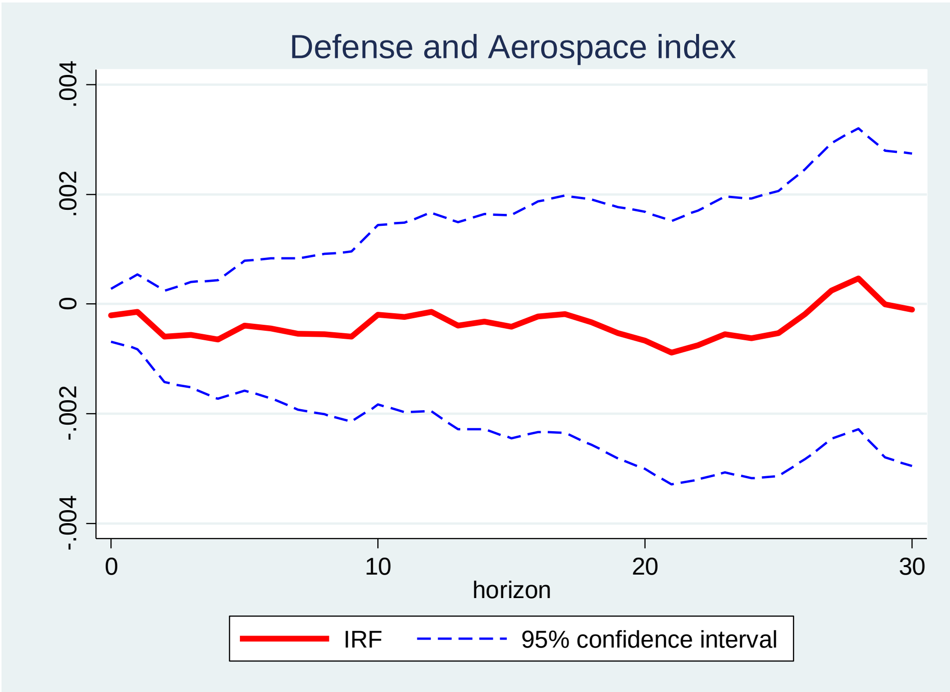
Source: Department of Defense, http://www.defense.gov/contracts/archive.aspx.

Figure 3. Response of index of stock prices of defense corporations to a government spending shock

Panel A. Responses to DoD announcements

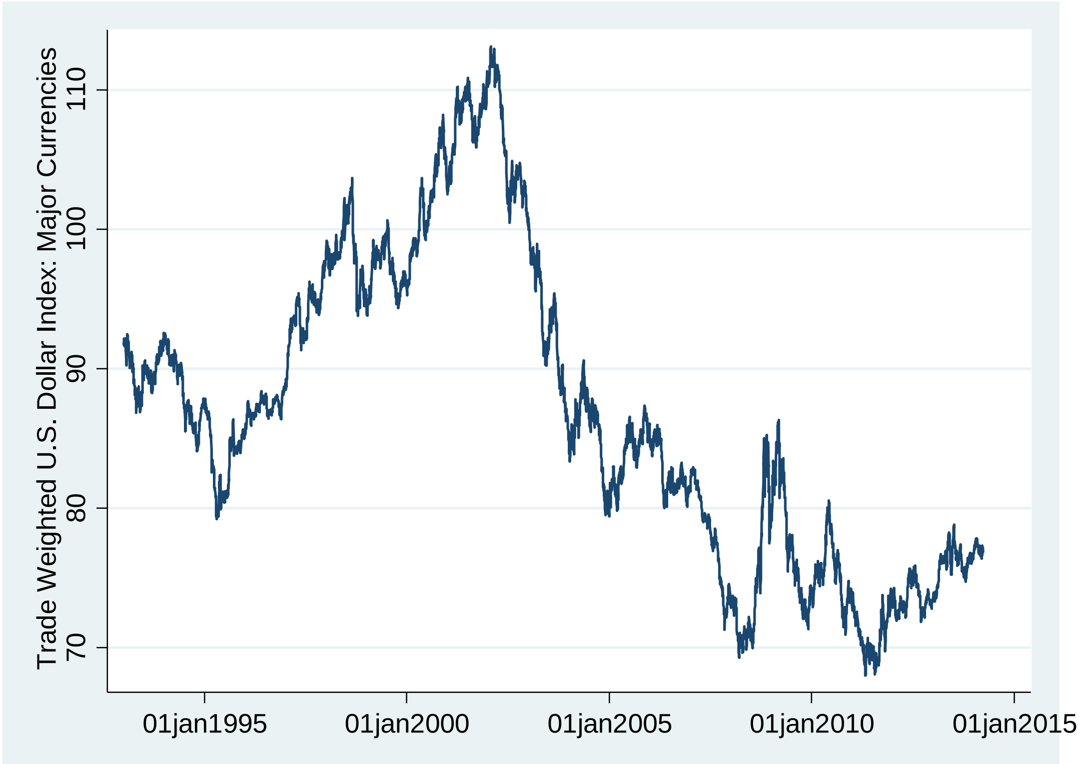


Panel B. Responses to a shock in daily payments to defense contractors (U.S. Treasury daily statements)



Notes: Each panel plots impulse responses estimated using specification (1). The dependent variable is the change in the value of price index for stock of defense corporations. The horizon (horizontal axis) is measured in days.

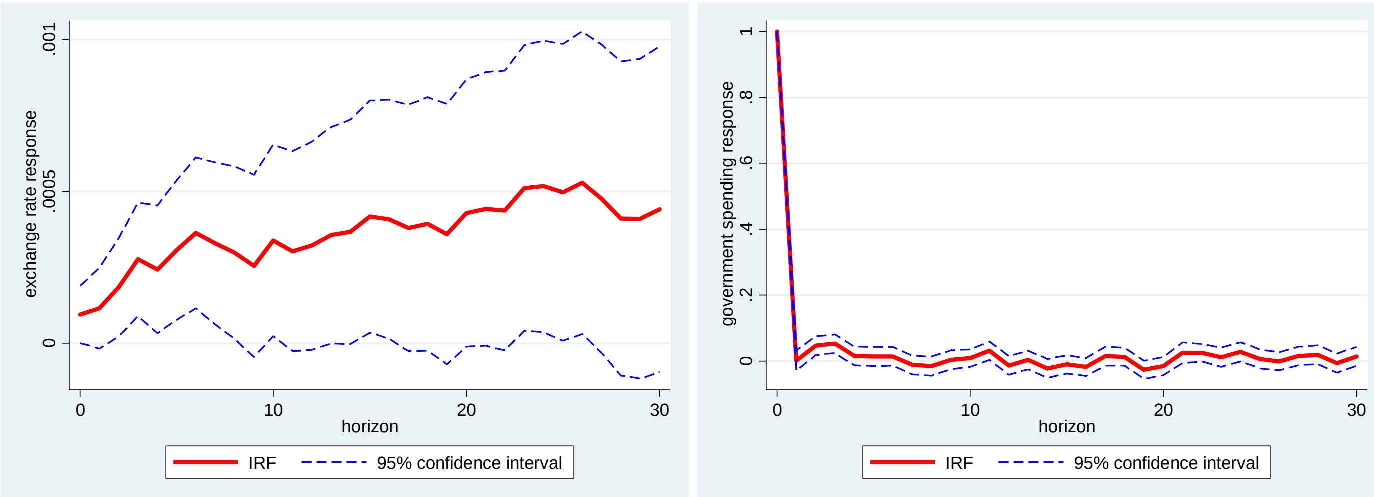
Figure 4. Trade Weighted U.S. Dollar Index: Major Currencies



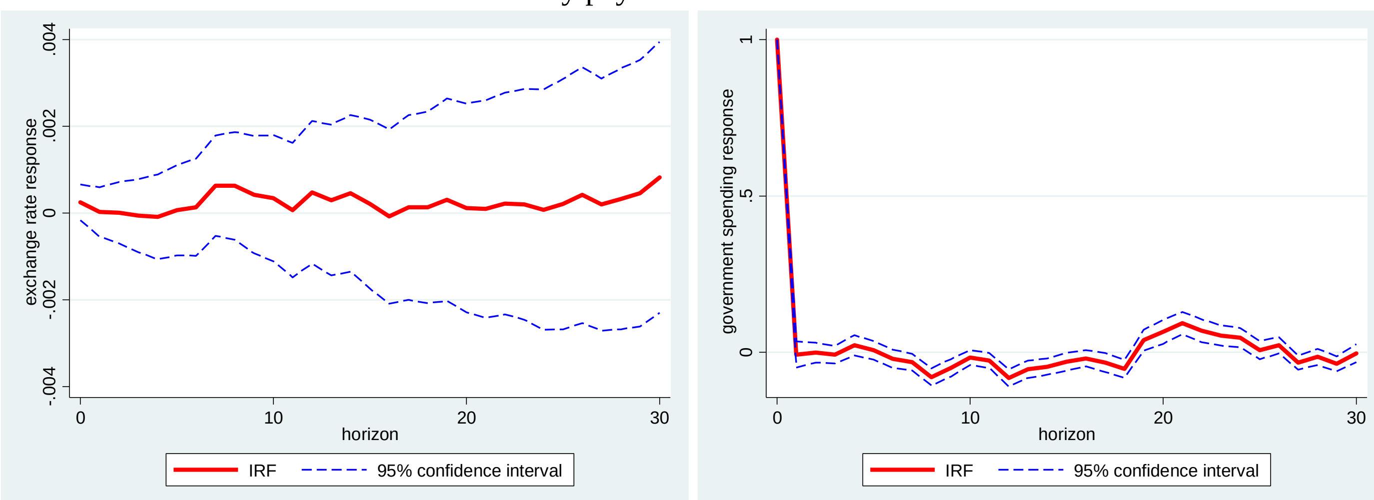
Source: Board of Governors of the Federal Reserve System, H.10 Foreign Exchange Rates.

Figure 5. Impulse responses to a government spending shock, daily data.

Panel A. Department of Defense announcements



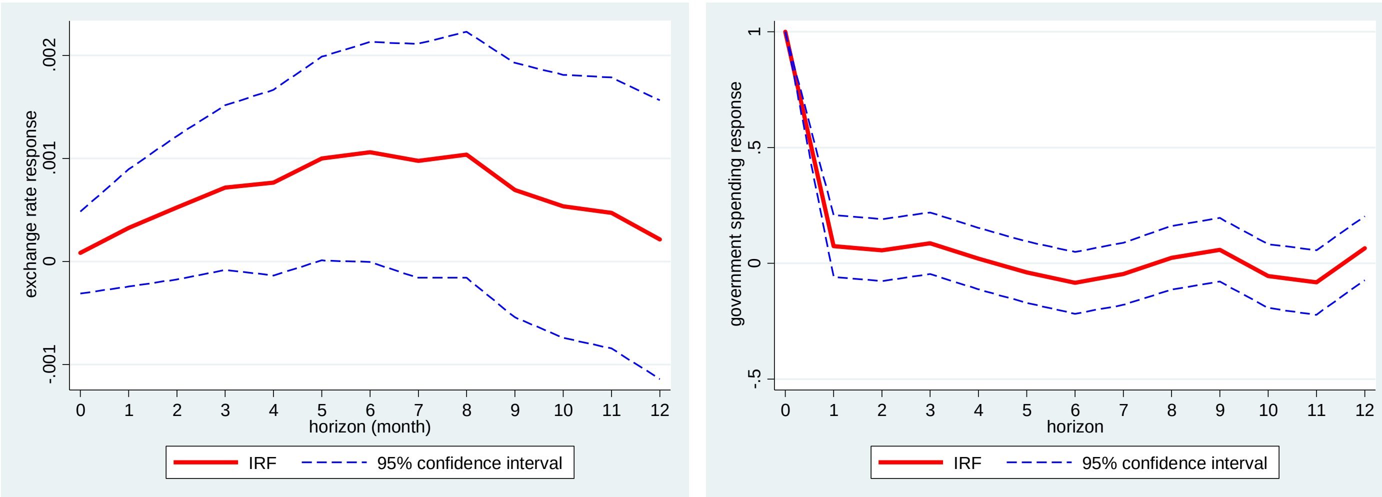
Panel B. Daily payments to defense contractors



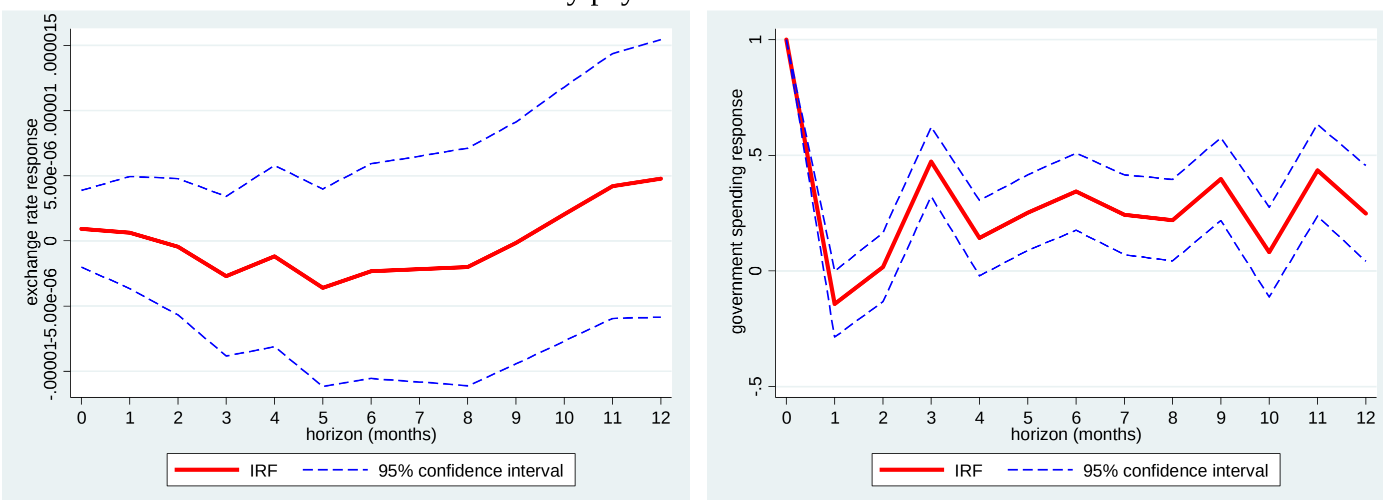
Notes: Figures show impulse response functions for the Trade Weighted U.S. Dollar Index (Major Currencies) and government spending to a unit shock to government spending. Impulse responses are estimated using specification (1). The horizon (horizontal axis) is measured in days.

Figure 6. Impulse response to a government spending shock, monthly data.

Panel A. Department of Defense announcements

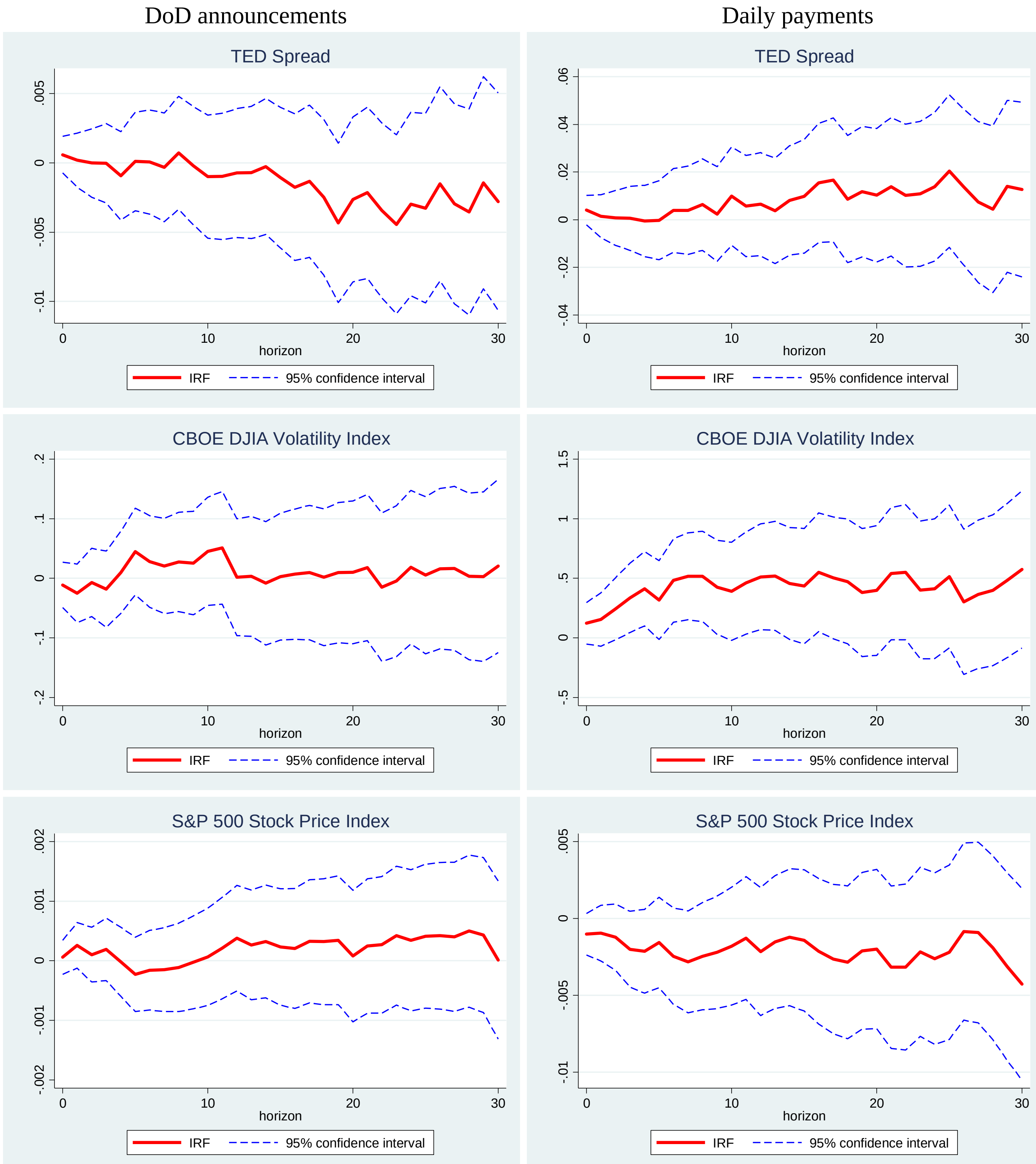


Panel B. Daily payments to defense contractors



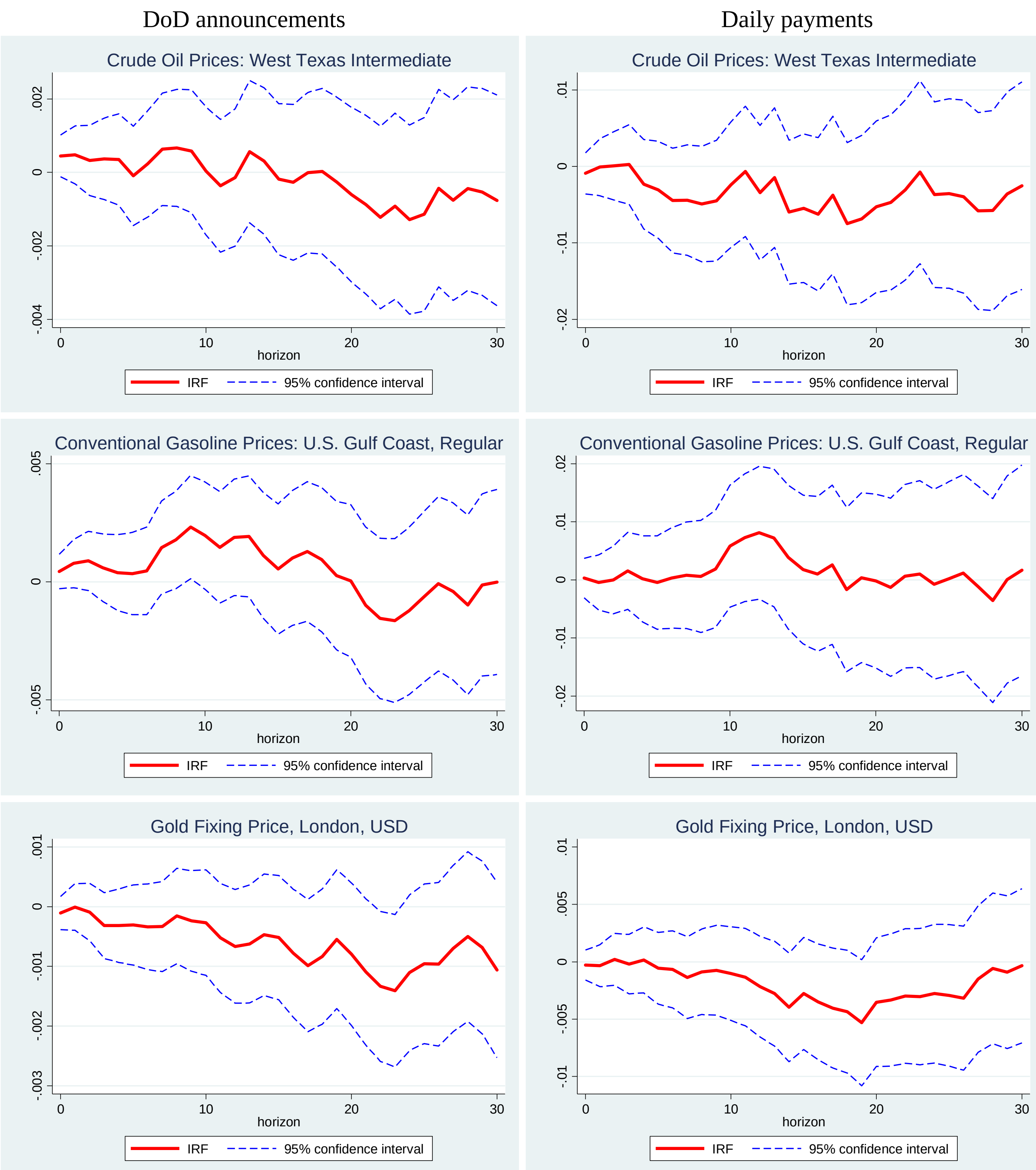
Notes: Figures show impulse response functions for the Trade Weighted U.S. Dollar Index (Major Currencies) and government spending to a unit shock to government spending. Impulse responses are estimated using specification (1). Daily data are aggregate to monthly frequency. The horizon (horizontal axis) is measured in months.

Figure 7. Responses of additional macroeconomic variables to a government spending shock.



Notes: Impulse responses are estimated using specification (1). All series are taken from FRED© database. FRED codes are reported in parentheses: TED spread (TEDRATE), CBOE DJIA Volatility Index (VXDCLS), S&P500 Stock Price Index (SP500). The horizon (horizontal axis) is measured in days.

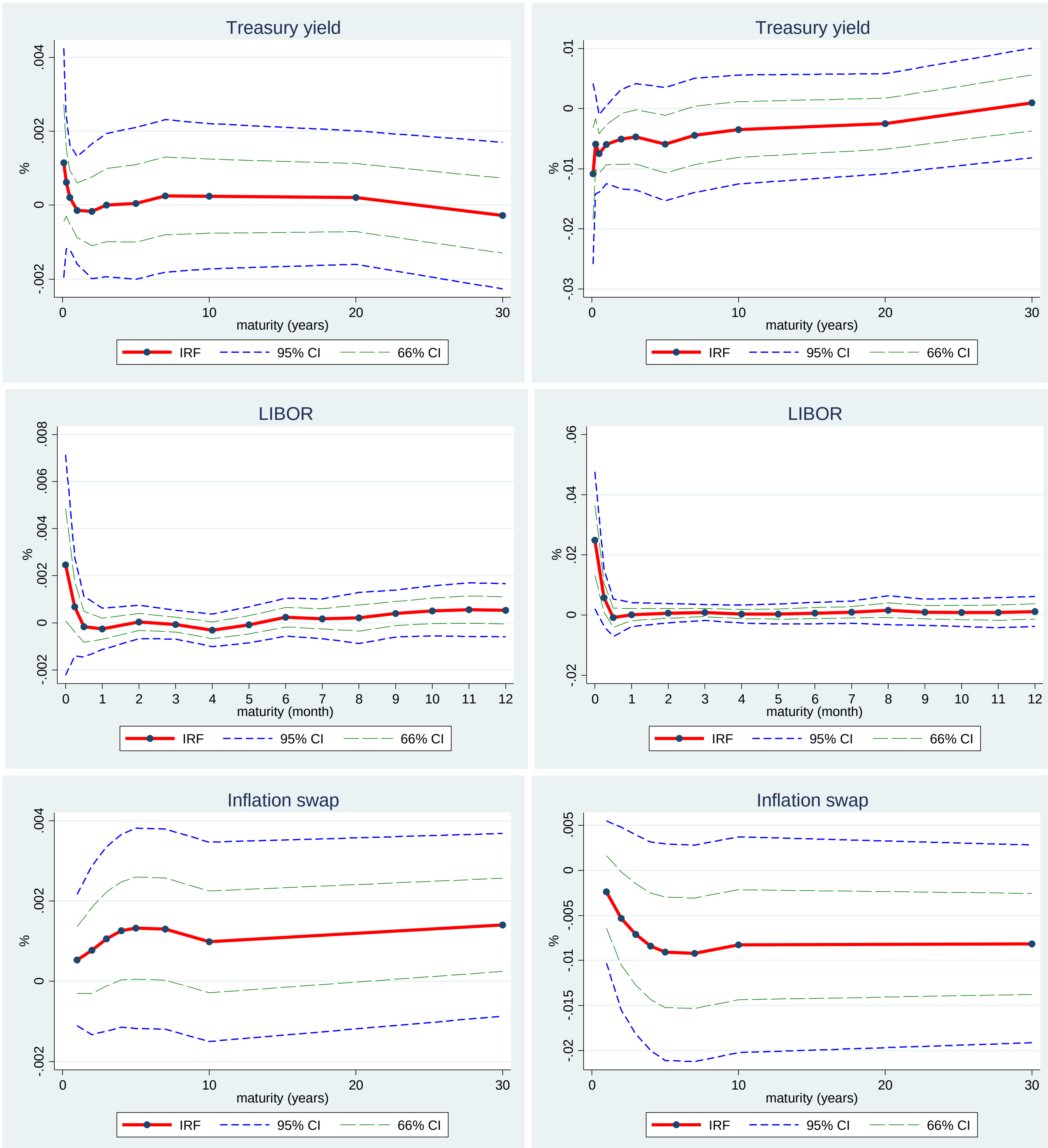
Figure 8. Responses of commodity prices to a government spending shock.



Notes: Impulse responses are estimated using specification (1). All series are taken from FRED© database. FRED codes are reported in parentheses: Crude Oil Prices (DCOILWTICO), Conventional Gasoline Prices (DGASUSGULF), Gold Fixing Price (GOLDPMGBD228N). All variables are measured in U.S. dollars. The horizon (horizontal axis) is measured in days.

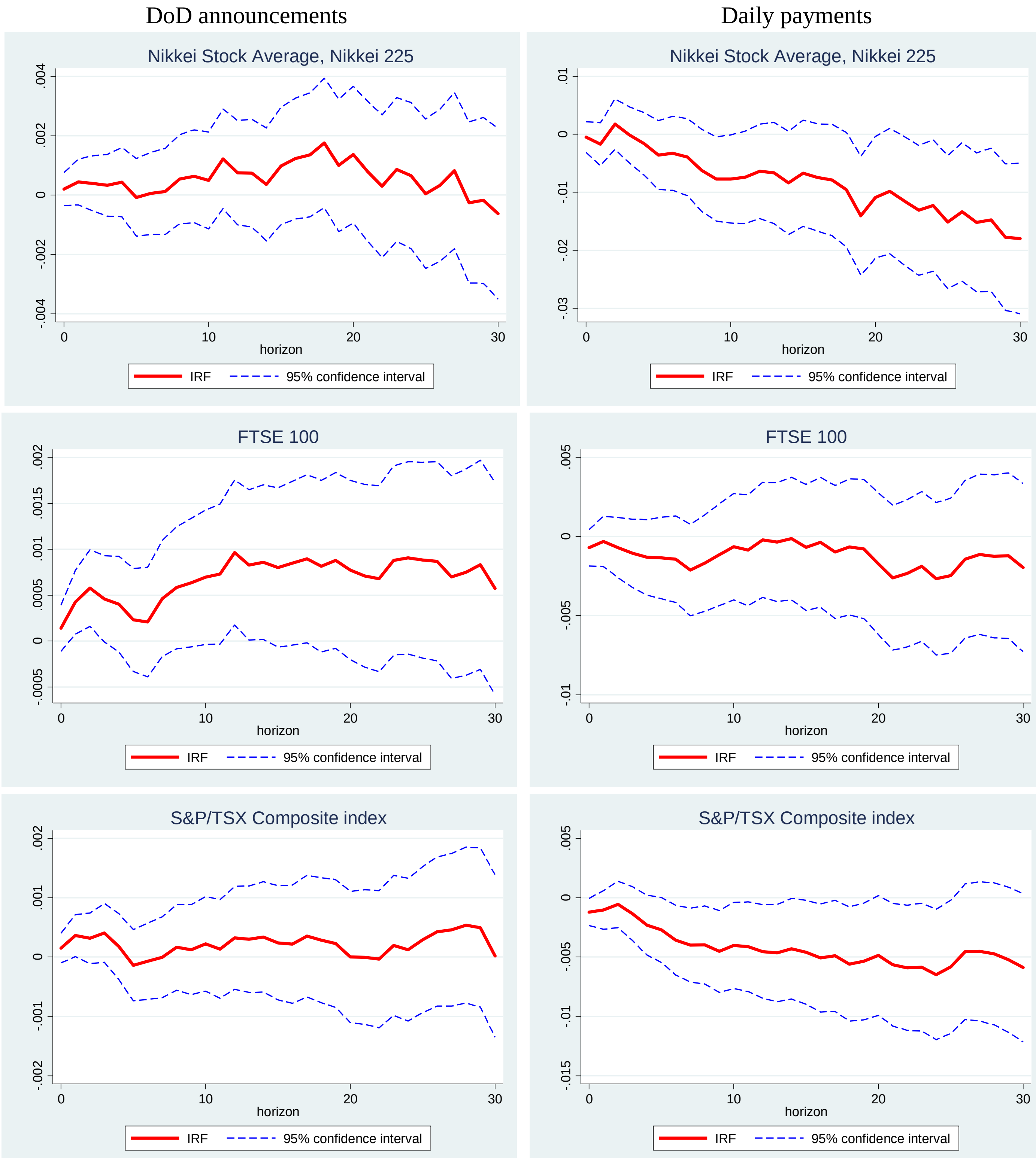
Figure 9. Contemporaneous responses of yield curves to a government spending shock.

DoD announcements   Daily payments



Notes: Impulse responses are estimated using specification (1) with $h = 1$. All series are taken from FRED© database. FRED codes are reported in parentheses: Treasury (DGS*), LIBOR (USD*D156N), Inflation Swap (DSWP*), where * denotes the maturity.

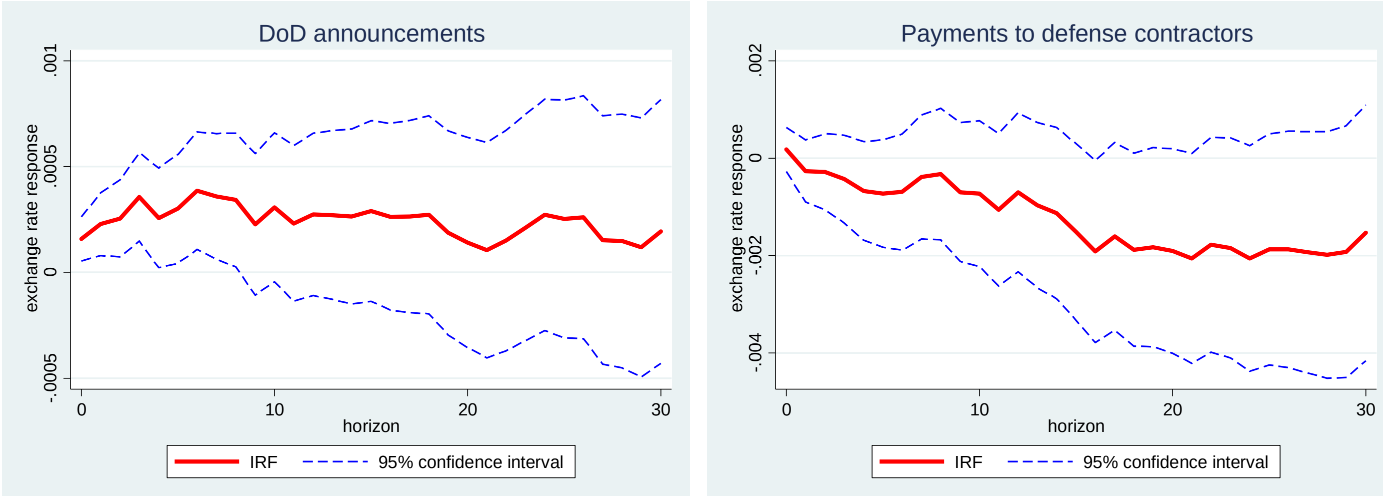
Figure 10. Response of foreign stock market indices to a government spending shock.



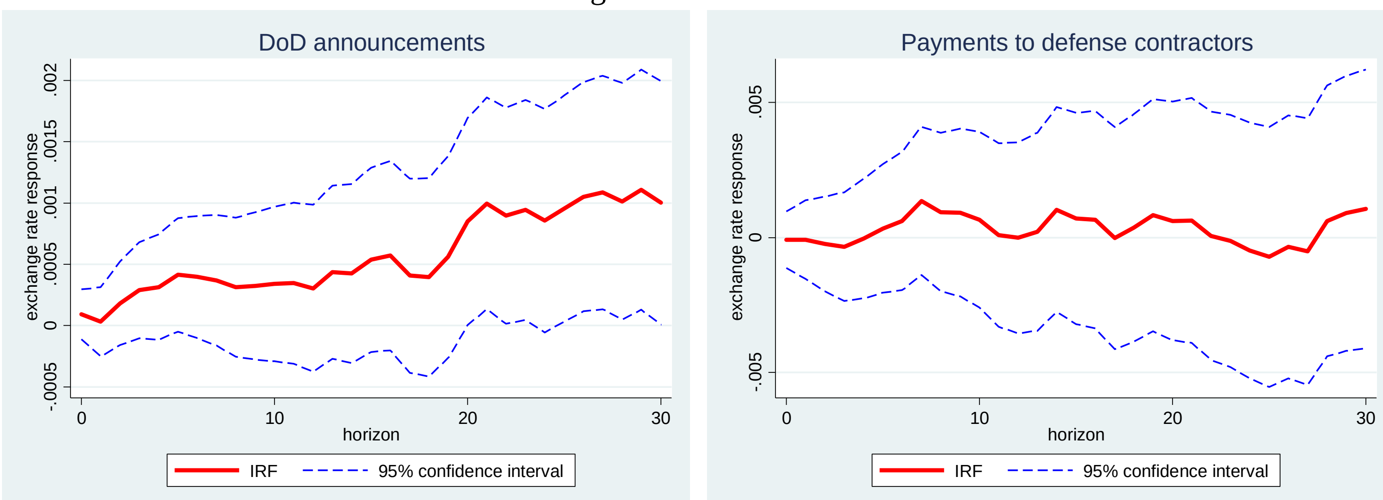
Notes: Impulse responses are estimated using specification (1). NIKKEI, FTSE 100 and TSX are stock market indexes for exchanges in Tokyo (Japan), London (the U.K.) and Toronto (Canada). The horizon (horizontal axis) is measured in days.

Figure 11. Stability of the responses to a government spending shock.

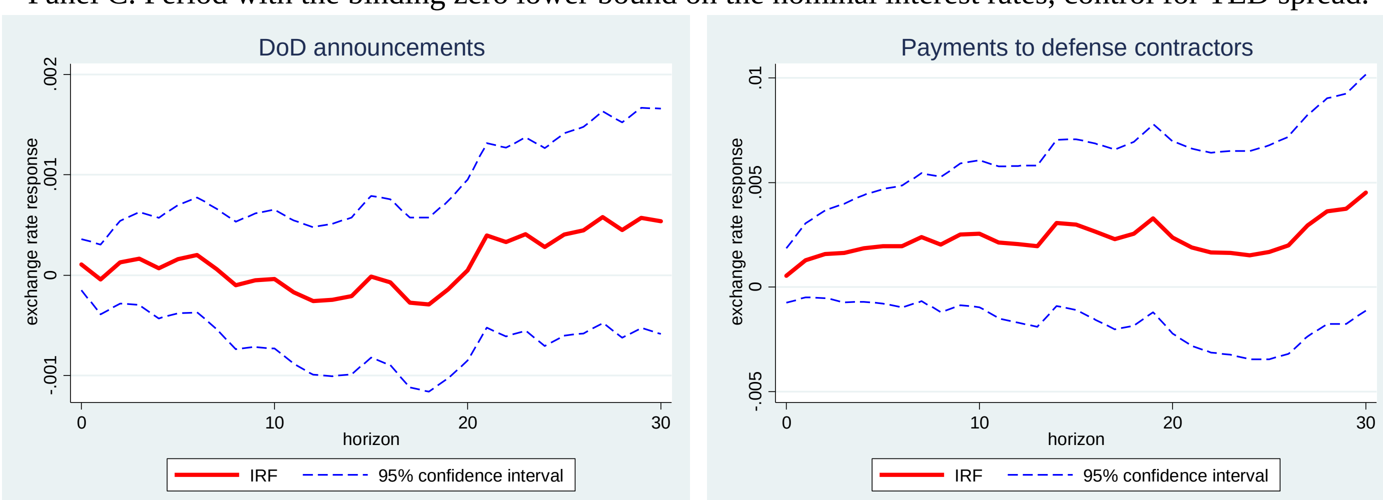
Panel A. Pre-Great Recession period



Panel B. Period with the binding zero lower bound on the nominal interest rates

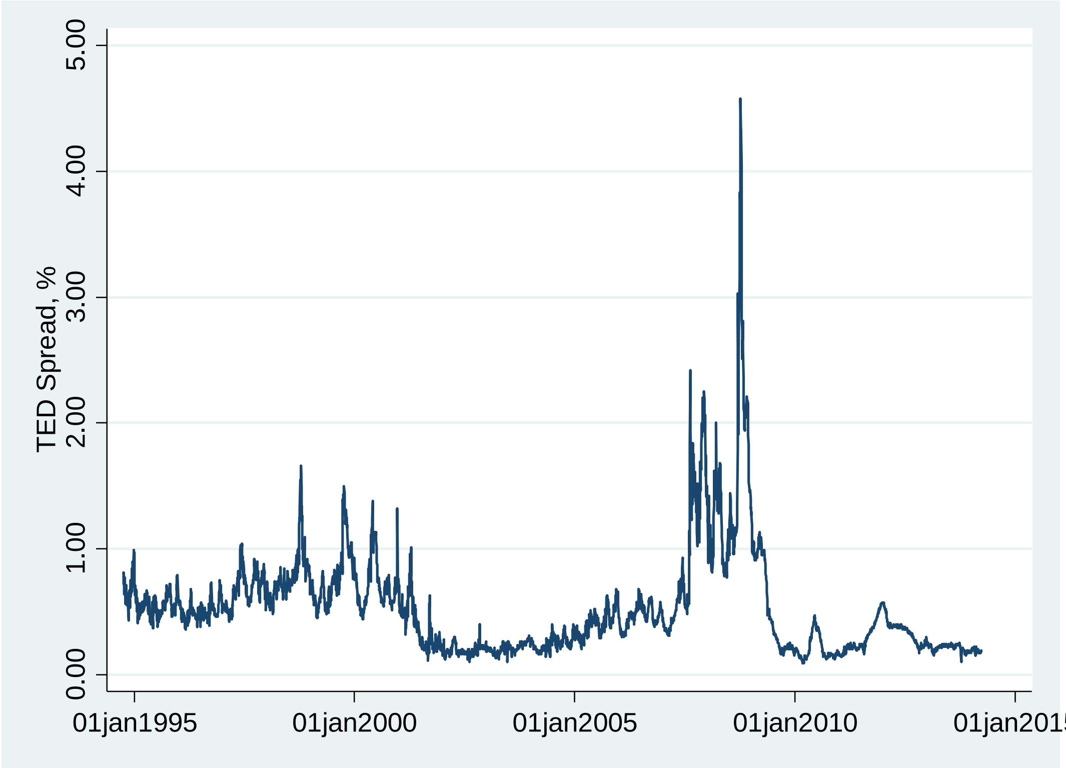


Panel C. Period with the binding zero lower bound on the nominal interest rates, control for TED spread.



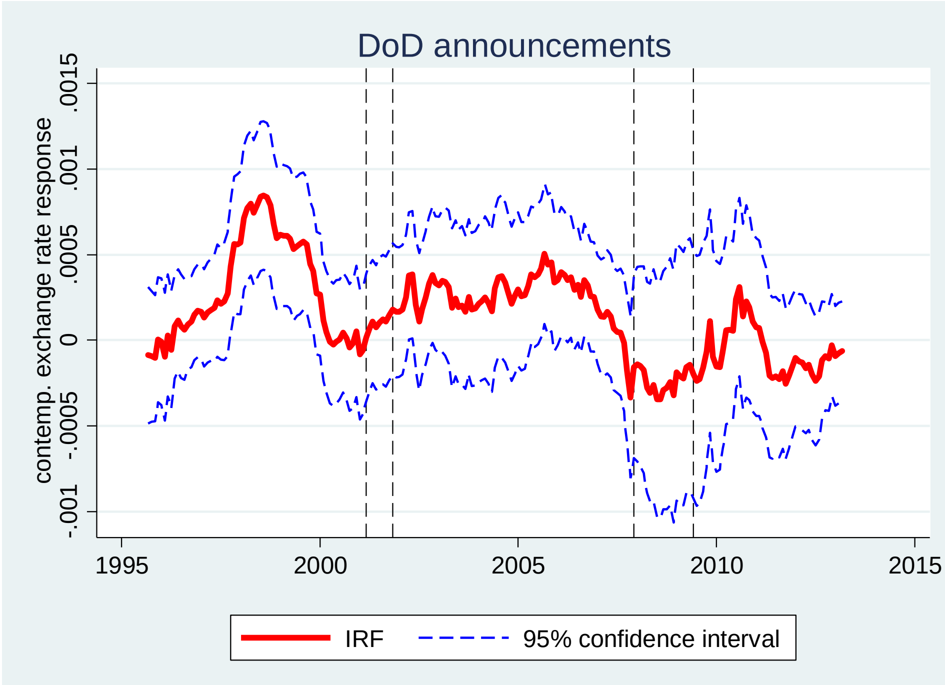
Notes: Impulse responses are estimated using specification (1). Specification in Panel C also include 20 lags of the TED spread. The horizon (horizontal axis) is measured in days.

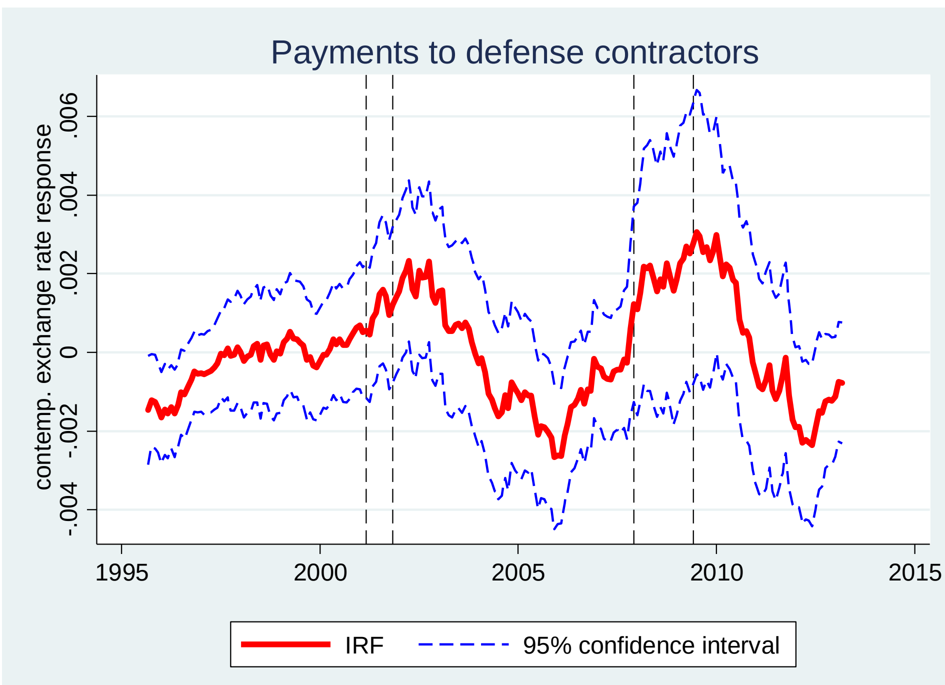
Figure 12. TED Spread.



Notes: TED spread is calculated as the spread between 3-Month LIBOR based on US dollars and 3-Month Treasury bill.

Figure 13. Rolling regressions, 24-month window



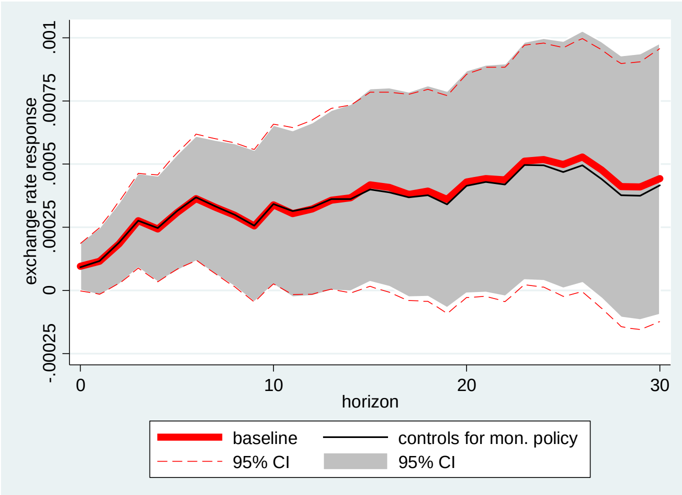


Notes: Impulse responses are estimated using specification (1).Vertical lines identify recessions as identified by the NBER. The horizontal axis shows calendar time.

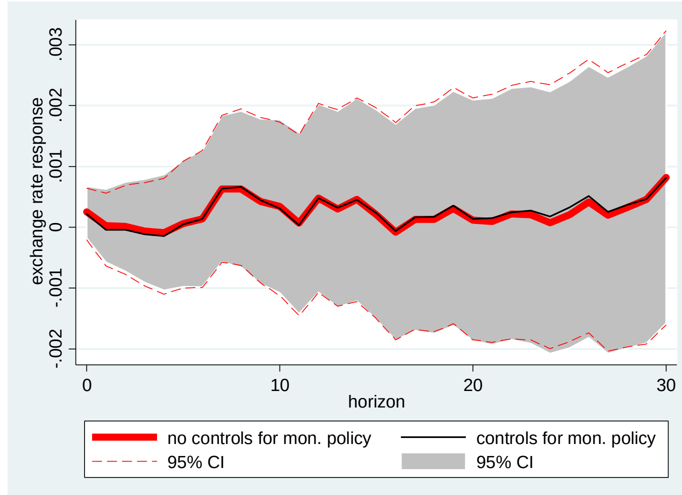
Figure 14. Controls for macroeconomic news

Panel A. Control for monetary policy shocks

DoD announcements

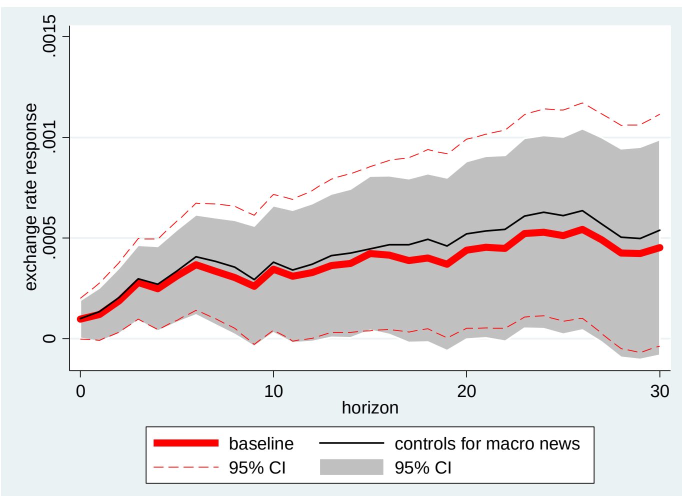


Daily payments

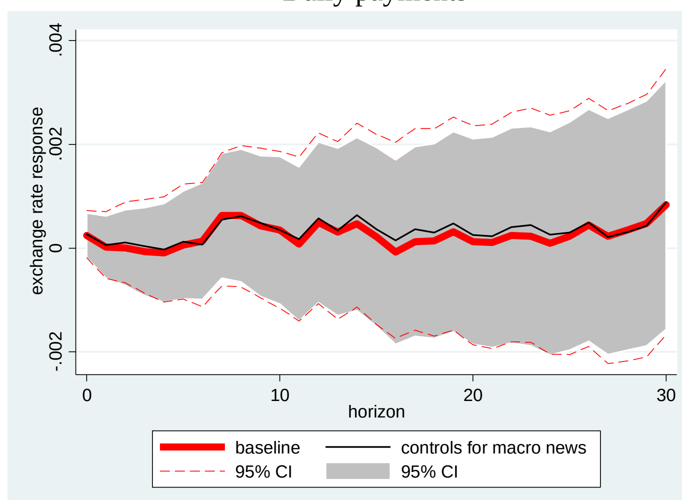


Panel B. Control for macroeconomic surprises

DoD announcements

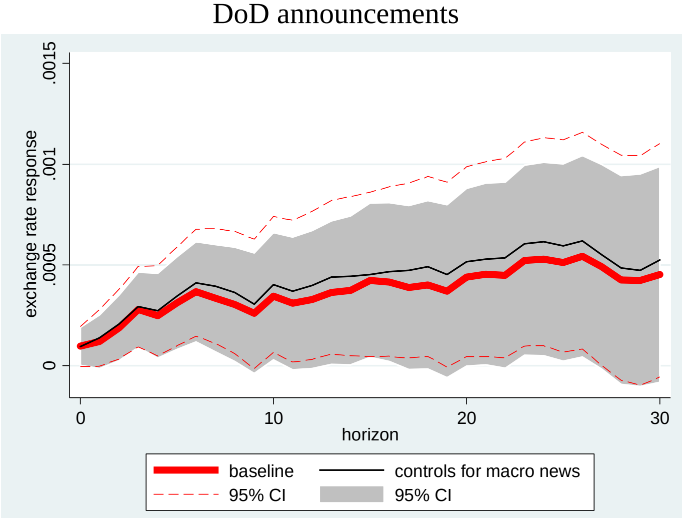


Daily payments

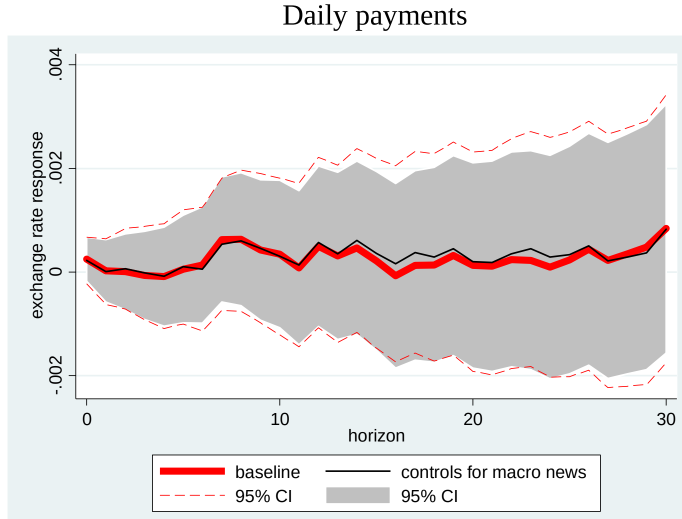


Panel C. Control for monetary policy shocks and macroeconomic surprises

DoD announcements



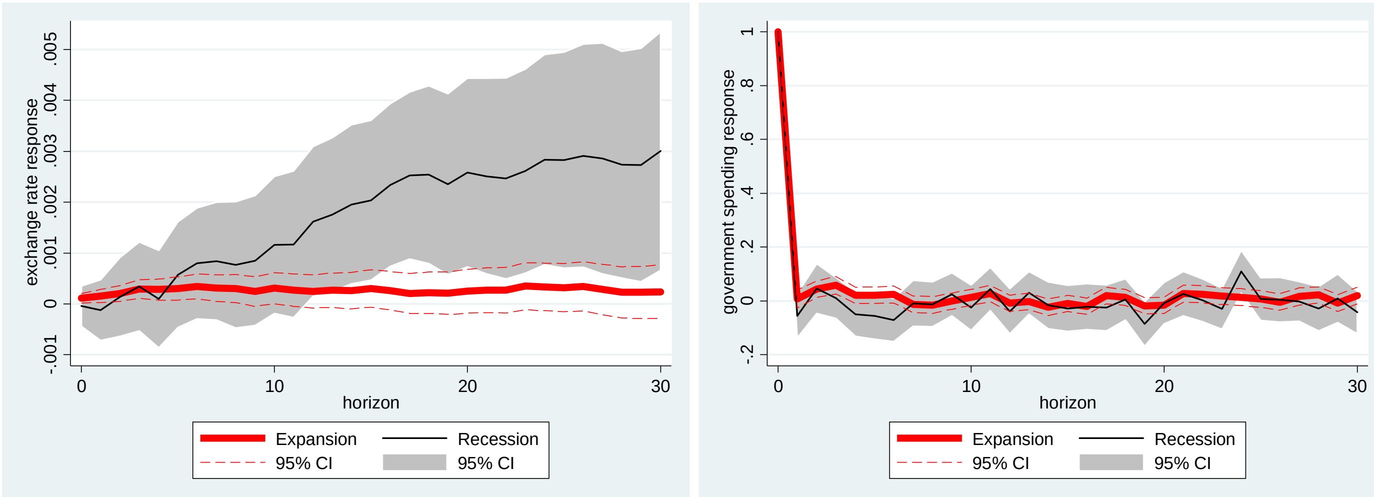
Daily payments



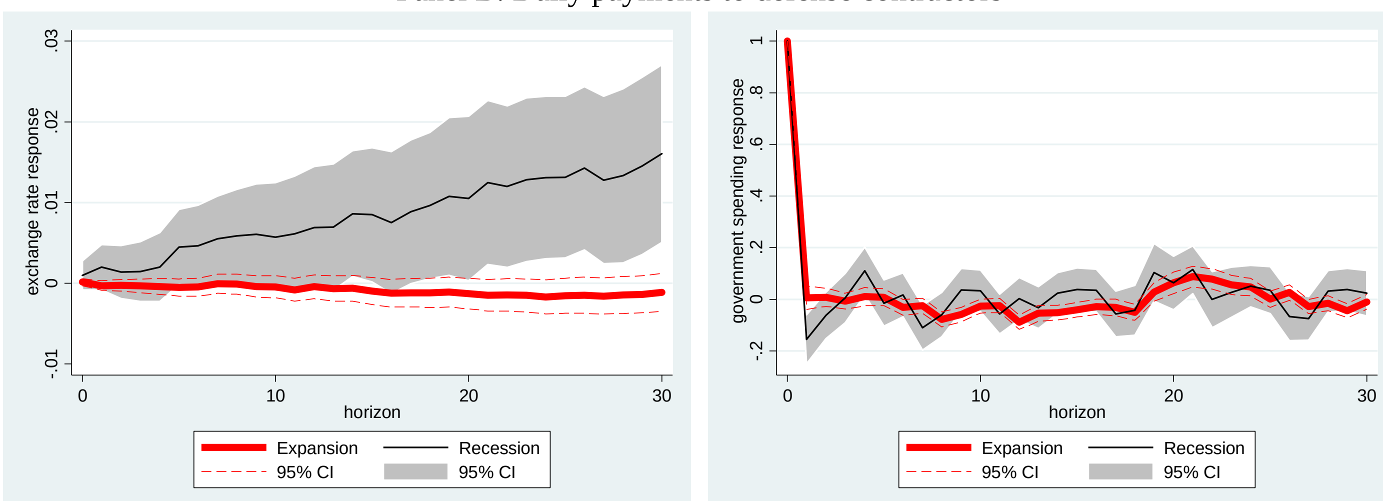
Notes: Impulse responses are estimated using specification (1) augmented with controls indicated in the panel title and described in Section 5.C. The horizon (horizontal axis) is measured in days.

Figure 15. State-dependent responses to a government spending shock, business cycle.

Panel A. Department of Defense announcements



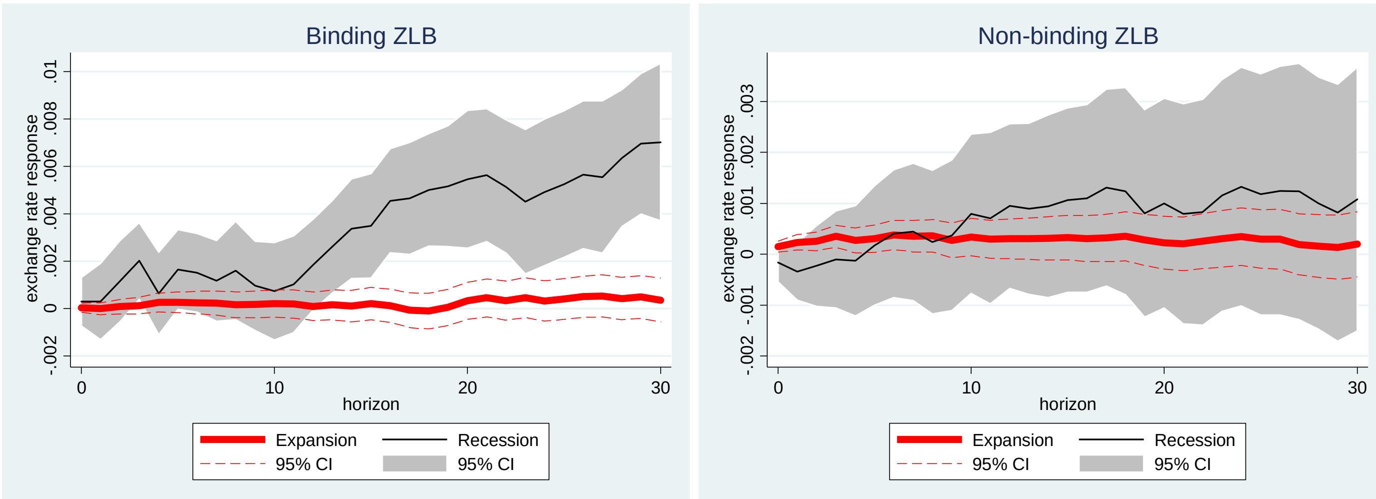
Panel B. Daily payments to defense contractors



Notes: Impulse responses are estimated using specification (2). The horizon (horizontal axis) is measured in days.

Figure 16. State-dependent responses of the exchange rate to a government spending shock, business cycle and ZLB. Department of Defense announcements.

Panel A. Baseline

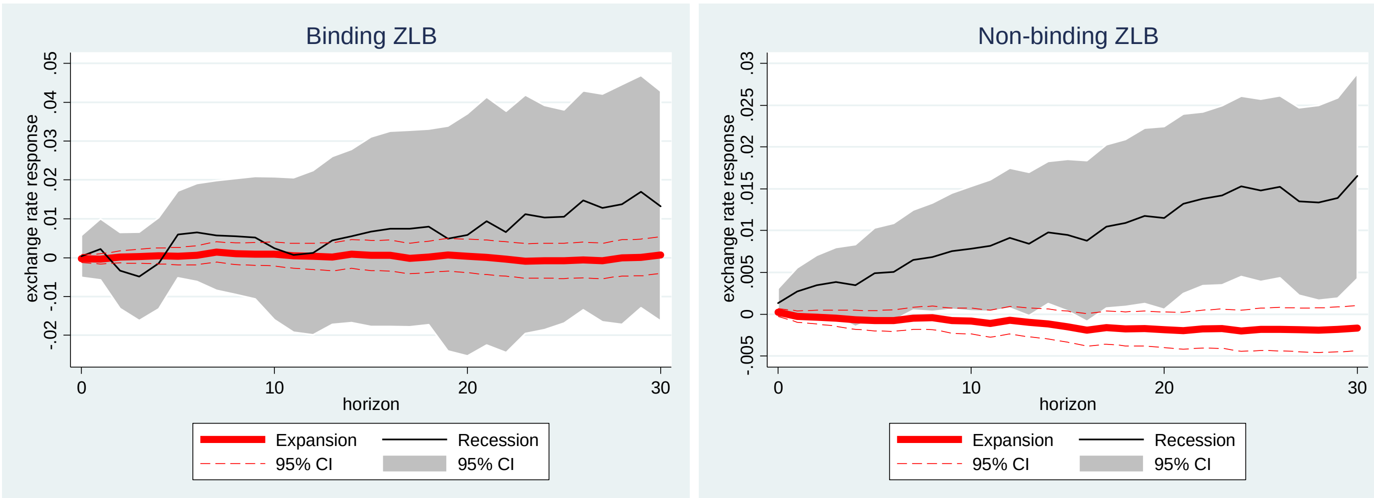


Panel B. Control for TED rate

Notes: Impulse responses are estimated using specification (3). The horizon (horizontal axis) is measured in days.

Figure 17. State-dependent responses of the exchange rate to a government spending shock, business cycle and ZLB. Daily payments to defense contractors

Panel A. Baseline



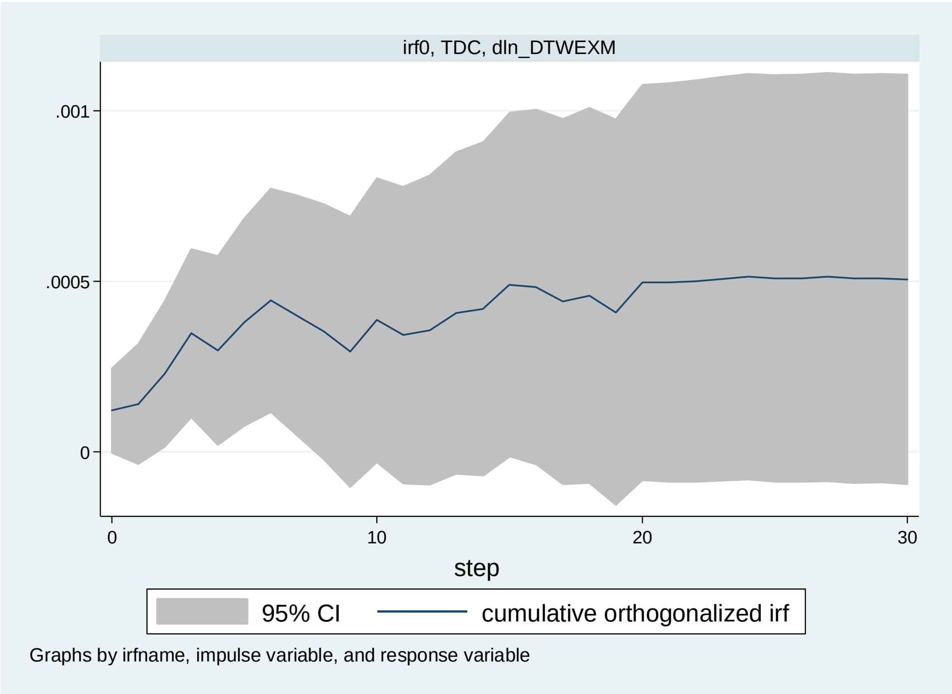
Panel B. Control for TED rate

Notes: Impulse responses are estimated using specification (3). The horizon (horizontal axis) is measured in days.

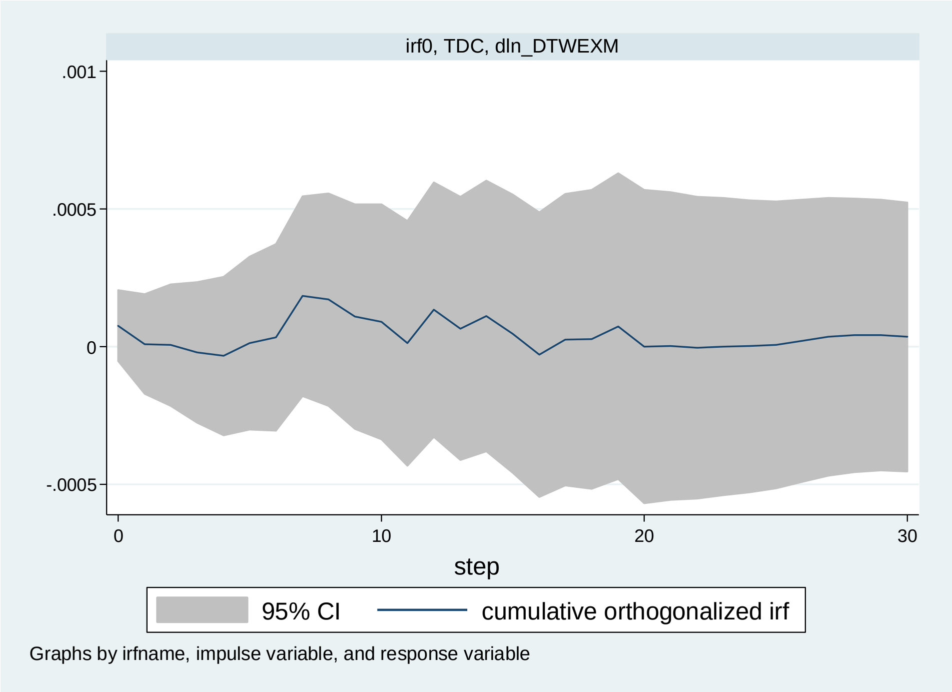
APPENDIX

Appendix Figure 1. Impulse response of the exchange rate to a government spending shock, daily data, VAR.

Panel A. Department of Defense announcements.

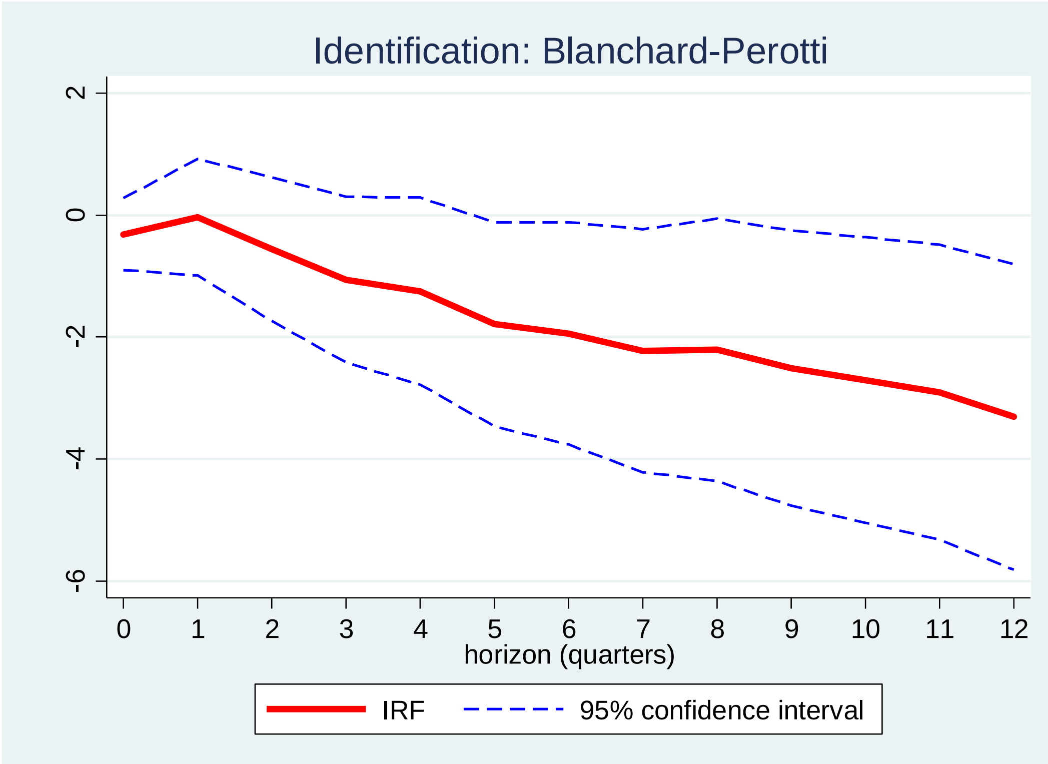


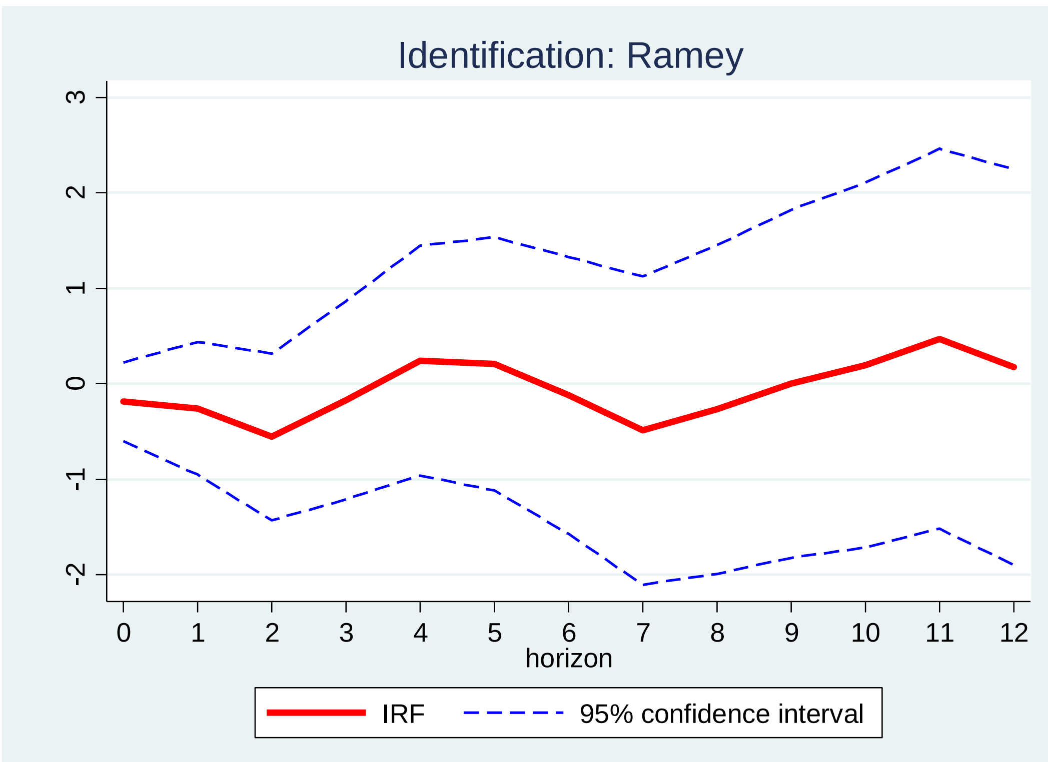
Panel B. Daily payments to defense contractors, U.S. Treasury.



Notes: The step (horizontal axis) is measured in days.

Appendix Figure 2. Response of the exchange rate to a government spending shock

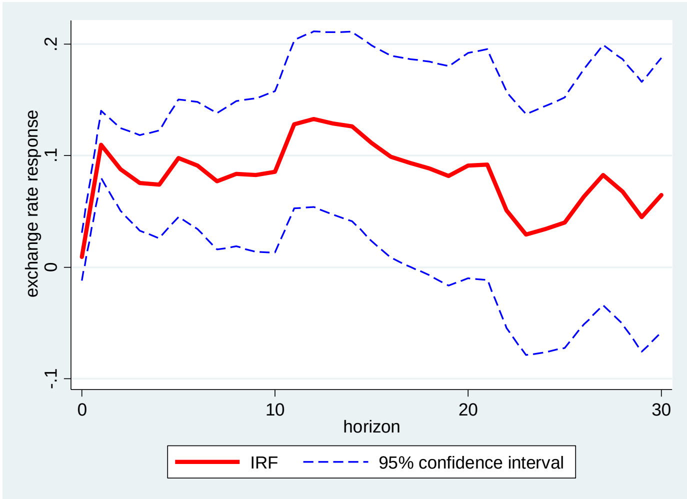




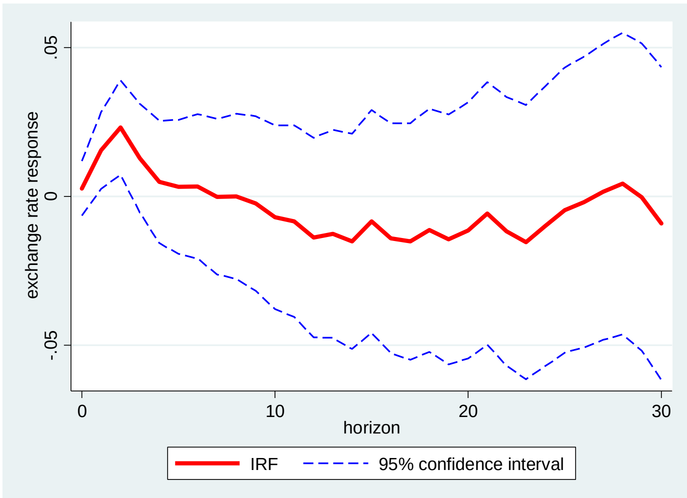
Notes: Blanchard-Perotti identification amounts to putting government spending first in the Cholesky ordering. Ramey identification is based on the narrative approach applied to military spending. Ramey shocks are measured in percent of GDP. Impulse responses in both panels are calculated using direct projections. The list of controls include four lags of growth rate of real GDP, inflation rate (GDP deflator), government spending (corresponding series), and the exchange rate (see note to Figure 4). The horizon (horizontal axis) is measured in quarters.

Appendix Figure 3. Response of the exchange rate to macroeconomic news and monetary policy shocks

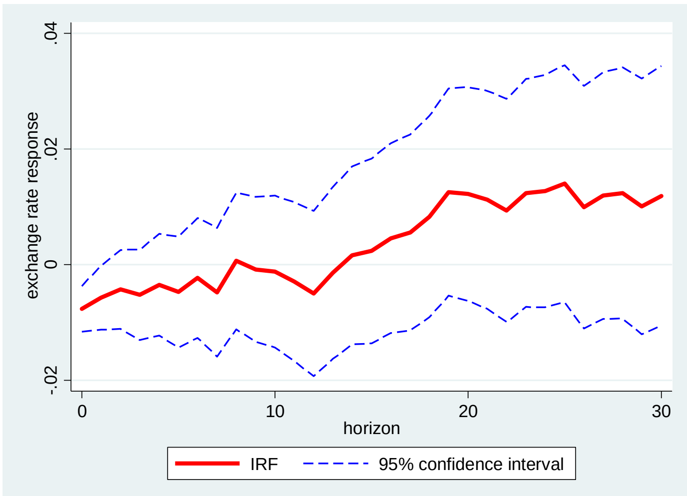
Panel A. Exchange rate response to innovations in monetary policy: Quantitative easing, Chodorow-Reich (2014).



Panel A. Exchange rate response to innovations in monetary policy: Innovations to fed fund rate target, Gorodnichenko and Weber (2013).



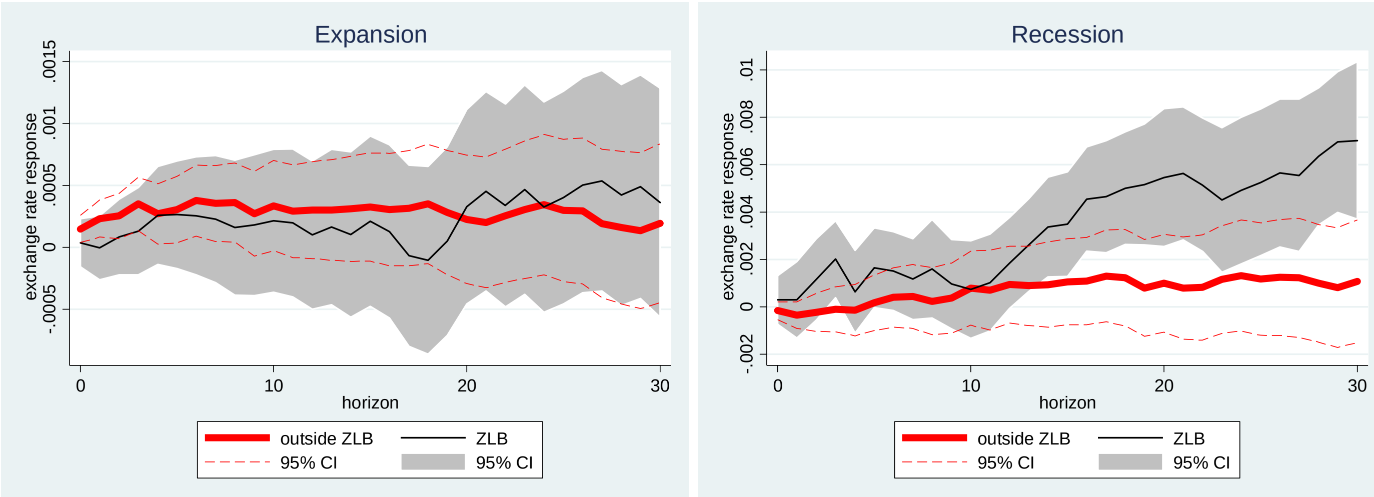
Panel C. Exchange rate response to news about unemployment rate (constructed as in Andersen et al., 2003).



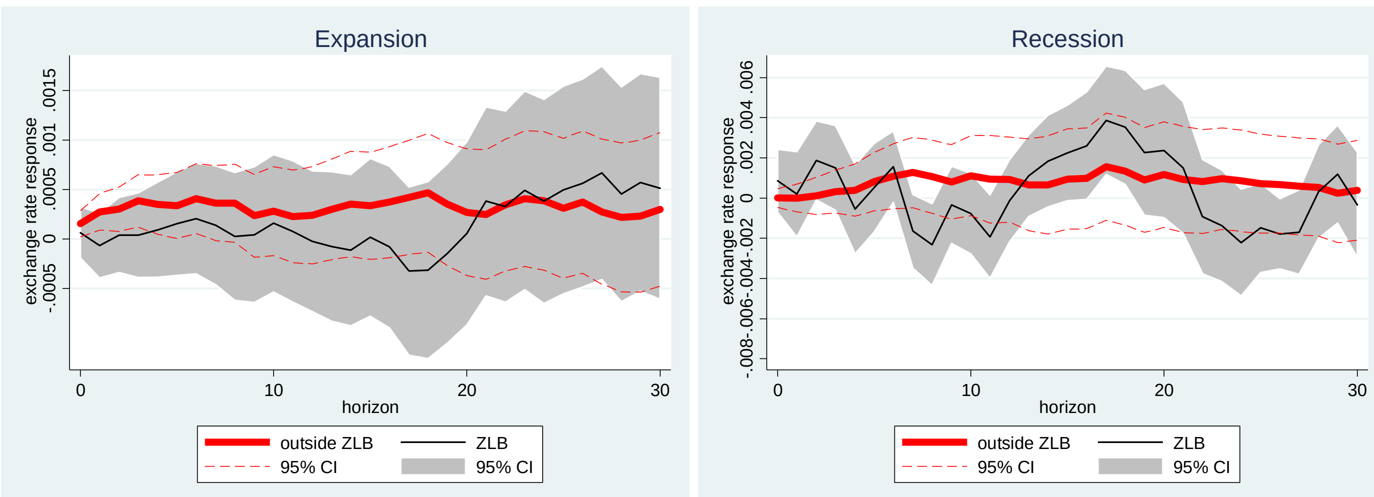
Notes: Panels A and B show that when interest rates increase in response to a change in monetary policy, the U.S. dollar appreciates. Panel C shows that when the released figures for the U.S. unemployment rate is greater than anticipated, the U.S. dollar depreciates. The horizon (horizontal axis) is measured in days.

Appendix Figure 4. State-dependent responses of the exchange rate to a government spending shock, business cycle and ZLB. Department of Defense announcements.

Panel A. Baseline



Panel B. Control for TED rate



Notes: Impulse responses are estimated using specification (3). The horizon (horizontal axis) is measured in days.

Appendix Table 1. Descriptive statistics

	Announcements about contract award, U.S. Defense of Defense (1)	Payments to defense vendors, U.S. Treasury (2)
Number of observations	4,895	4,587
Mean	0.016	-0.004
Standard deviation	1.337	0.315
Interquartile range	1.677	0.326
Percentiles		
1	-3.031	-1.073
5	-2.165	-0.572
10	-1.637	-0.331
25	-0.841	-0.143
50 (median)	-0.033	0.024
75	0.837	0.184
90	1.687	0.336
99	3.564	0.619

Notes: series are seasonally adjusted and measured in log deviations from the trend. The frequency is daily.