Fiscal Stimulus in a Monetary Union:
Evidence from U.S. Regions

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March 27, 2011

Abstract

We use rich historical data on military procurement spending across U.S. regions to estimate the effects of government spending in a monetary union. Aggregate military build-ups and draw-downs have differential effects across regions. We use this variation to estimate an open economy government spending multiplier of approximately 1.5. Standard closed economy estimates of the government spending multiplier are highly sensitive to how strongly monetary policy “leans against the wind.” In contrast, our estimates “difference out” these effects because different regions in a monetary union share a common monetary policy. This allows us to better distinguish between alternative business cycle models. We show that our estimates are consistent with a New Keynesian model with GHH preferences. They are consistent with a small closed-economy multiplier when monetary policy is highly responsive (as in the Volcker-Greenspan era) and a substantially larger closed-economy multiplier when interest rates are less responsive (as at the zero lower bound).

Keywords: Fiscal stimulus, Government Spending, Multiplier, Monetary Union.

JEL Classification: E62, E32

*We thank Thuy Lan Nguyen for excellent research assistance. We thank Steve Davis, Gauti Eggertsson, Jordi Gali, Marcelo Moreira, James Stock, Michael Woodford, Pierre Yared, Motohiro Yogo and seminar participants at various institutions for helpful comments and conversations.
1 Introduction

The effect of government spending on output is often summarized by a fiscal multiplier—the percentage increase in output that results when government spending is increased by 1% of GDP. There is a wide range of views about this statistic in the literature. On the one hand, the recent American Recovery and Reinvestment Act (ARRA)—perhaps the largest fiscal stimulus plan in U.S. history—was motivated by a relatively high estimate of the multiplier of 1.6 (Romer and Bernstein, 2009). Other studies argue that the multiplier is substantially less than one and potentially close to zero. In particular, if the determination of output is dominated by supply-side factors, an increase in government purchases to a large extent “crowds out” private sector consumption and investment.

The wide range of views on the multiplier arises in part from the difficulty of measuring it. Changes in government spending are rarely exogenous, leading to a range of estimates depending on the estimation approach.\(^1\) Two main approaches have been used to estimate the multiplier in the academic literature. The first is to study the output effects of increases in military spending associated with wars, which are plausibly unrelated to prevailing macroeconomic conditions (Ramey and Shapiro, 1998; Edelberg, Eichenbaum and Fisher, 1999; Burnside, Eichenbaum and Fisher, 2004; Ramey, 2010; Barro and Redlick, 2011; Fisher and Peters, 2010). Most of the evidence from this approach derives from the U.S. experience during WWII and the Korean War, when changes in U.S. military spending were largest and most abrupt as a fraction of total output. However, confounding variation associated with wartime price controls, patriotism, tax increases, and other macroeconomic shocks remain sources of intense debate regarding the evidence from these episodes. Hall (2009) and Barro and Redlick (2011) emphasize that it is not possible to draw meaningful inference using aggregate data on military spending after 1955 because there is insufficient variation in military spending in this period. The second main approach used to identify fiscal multipliers in macroeconomics is the structural VAR approach (Blanchard and Perotti, 2002; Perotti, 2007; Mountford and Uhlig, 2008; Ilzetzki, Mendoza and Vegh, 2010). This approach relies on structural assumptions about output and fiscal policy dynamics to estimate the multiplier.

The lack of a clear prediction of theory for the size of the fiscal multiplier also contributes to the wide range of views. Neoclassical models generally imply a small multiplier, typically smaller than 0.5 (Baxter and King, 1993). In New Keynesian models with price or wage rigidities, the size of the multiplier depends critically on the extent to which monetary policy “leans against the

\(^1\) For surveys of the existing evidence, see for example Perotti (2007), Hall (2009), Alesina and Ardagna (2009) and Cogan et al. (2010).
Woodford (2010) shows that the multiplier is equal to one in a New Keynesian model if the monetary authority keeps the real interest rate constant in response to fiscal shocks. Most estimates of monetary policy over the past 30 years indicate that the Fed raises the real interest rate in response to inflationary shocks. This type of monetary policy can generate quite low fiscal multipliers. On the other hand, Eggertsson (2010) and Christiano, Eichenbaum, and Rebelo (2010) show that the multiplier may exceed two when the nominal interest rate is at its zero lower bound. Intuitively, at the zero lower bound, monetary policy is rendered impotent and a fiscal expansion is particularly effective since it lowers real interest rates by raising inflation. While both Neoclassical and New Keynesian models have the potential to generate multipliers substantially below one in “normal times,” the distinction between these classes of models may be critically important in times of crisis, such as the most recent world recession.

We analyze the effects of government spending in a monetary union. We show that a monetary union—with its fixed exchange rate policy across members—offers unique advantages in studying the fiscal multiplier. While the predictions of New Keynesian models for the closed economy multiplier range widely depending on the monetary policy stance, and overlap with those of neoclassical models for sufficiently responsive monetary policy, the predictions of such models for the “open economy multiplier” in a monetary union do not depend on monetary policy. We show that in a monetary union, it is possible to “difference out” the effects of the common monetary policy in a very precise way, avoiding dependence of the fiscal multiplier on the countercyclicality of monetary policy that plagues inference regarding the fiscal multiplier in closed economy settings.

We exploit the effects of military spending on different regions of the U.S. to empirically analyze the effects of government spending in a monetary union. The U.S. regions we analyze are roughly comparable in size and openness to mid-sized European countries such as Spain. Aggregate military procurement, our main source of variation in government spending, is among the largest and most variable forms of discretionary government purchases in the U.S., varying between 1% and 4.5% of U.S. GDP over the time period we consider. When national military procurement rises by 1 percentage point of GDP, it rises on average by more than 3 percentage points in defense-intensive states such as California and Connecticut, but by less than one-half of one percent in defense-insensitive states such as Illinois. We use this heterogeneity in sensitivity to aggregate military build-ups and draw-downs across regions to estimate the effects of government purchase shocks on output, employment and prices. Since we have data on many regions and regional variations in military procurement is much larger than aggregate variation, this approach allows us to overturn
the conclusion from the literature that focuses on aggregate data that little can be learned about fiscal multipliers from the post-1960 data.²

Our key identifying assumption is similar (but weaker than) the identifying assumption in the aggregate literature on military spending discussed above. We assume that aggregate military buildups—such as those associated with the Vietnam war and the Soviet invasion of Afghanistan—are unrelated to differences in macroeconomic conditions between defense-oriented states and non-defense-oriented states. We do not require that idiosyncratic variations in military procurement—such as the increase in procurement spending in Texas during the presidency of George W. Bush—are exogenous to local economic conditions.³ By including time fixed effects, we can also control for aggregate shocks that affect all states at a particular point in time—such as changes in distortionary taxes. We estimate large effects of government purchases on output. When relative per-capita government purchases in a region rises by 1% of regional output, relative per-capita output in that region rises by 1.5%. We estimate similar effects for employment.

Our setting differs in several important ways from the setting studied in much of the theoretical literature on the fiscal multiplier. First, the U.S. regions we study are open economies with substantial amounts of cross-border trade. Second, the regions we study belong to a fiscal union and increases in military spending in one region are paid for by the entire union. Third, (and most important) the regions we study belong to a monetary union. We develop an open economy dynamic stochastic general equilibrium model that incorporates these features and use this model to study the effects of fiscal shocks.

Since the U.S. regions we study belong to a fiscal union—in contrast to the member states of the Euro Area—the variation in spending we analyze does not cause the same negative wealth effect as does fiscal spending in a fiscally independent state. The wealth effect in our setting is likely to be positive but small.⁴ Both Neoclassical and New Keynesian business cycle models imply that negative wealth effects raise the fiscal multiplier (since leisure is a normal good). The absence of a negative wealth effect in our setting thus should lower the multipliers we estimate relative to a

²An advantage of studying the post-1960 period is that evidence on the effects of military spending from this period may be more informative about the size of the fiscal multiplier for “normal times” and “normal purchases.” Several authors suggest that the multiplier may be different for military versus non-military spending, but these findings rely heavily on the WWII and Korean War experiences when aggregate variation in military spending was largest (e.g., Perotti 2007; Auerbach and Gorodnichenko, 2010).

³The allocation of defense spending across U.S. regions is well-known to be influenced by political factors. See Mintz (1992) for a discussion of political issues related to the allocation of military procurement spending.

⁴Agents are getting paid for goods and services demanded by the federal government, but they must produce these goods and services. The goods and services are financed with tax revenue from the entire union and the benefits (national security) accrue to the entire union.
We show that our model has tight predictions for the multiplier we estimate that unlike in a closed economy setting, are not sensitive to how strongly monetary policy “leans against the wind.” To see why, consider two countries—A and B—that belong to a monetary union, and suppose government expenditure increases in country A relative to country B. The fact that countries A and B share the same monetary policy implies that no matter how monetary policy responds to variation in aggregate conditions, the response of the nominal interest rate in country A relative to country B is always equal to zero. We are thus able to measure the fiscal multiplier holding monetary policy fixed in the sense that the relative nominal interest rate does not respond to movements in relative output and inflation.

Since the nominal interest rate cannot offset any changes in relative output or inflation, one might infer that the setting we are using to measure the fiscal multiplier resembles a situation in a closed economy in which the nominal interest rate is at its zero lower bound and New Keynesian models generate large multipliers. We show, however, that this simple intuition ignores a crucial dynamic aspect of price responses in a monetary union. Since purchasing power parity holds in the long run and the exchange rate is fixed within the monetary union, any increase in prices in the short run in one region relative to the other must eventually be reversed in the long run. This implies that even though relative short-term real interest rates fall in response to government spending shocks in our model, relative long-term real interest rates don’t. Consumption is determined by the behavior of the long-term real interest rate via the Euler equation. Since long-term real interest rates don’t fall in our setting, consumption does not rise in the baseline version of our model and the open economy multiplier does not exceed one.

Our estimate of the open economy multiplier is larger than the value implied by baseline versions of both the New Keynesian model and the Neoclassical model. However, we show that our estimate lines up well with the multiplier implied by an open economy New Keynesian model with non-separable preferences over consumption and labor of the type considered by Greenwood, Hercowitz, and Huffman (1988). These GHH preferences have the characteristic that consumption and labor are complements. Such complementarities can amplify the response of output to government spending shocks in the New Keynesian model, as illustrated in a closed economy setting by Monacelli and Perotti (2008). As with the standard New Keynesian model, the closed economy fiscal

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5 Another potential approach to matching our multiplier estimate would be to consider a model with “hand-to-mouth” consumers as in Gali, Lopez-Salido, and Valles (2007).
multiplier in the New Keynesian model with GHH preferences is highly sensitive to the specification of monetary policy.

Studying a monetary union has the advantage that monetary policy is pinned down by the assumption of a fixed exchange rate within the union, as we describe above. This substantially sharpens the predictions of standard models for the government spending multiplier. In contrast, theoretical predictions in the closed economy setting are highly sensitive to the monetary policy response. U.S. monetary policy has varied greatly since the start of the 20th century. This variation is one likely culprit for the wide range of estimates of the multiplier in the closed economy literature. While we cannot comment on “the” closed economy multiplier predicted by our analysis—since this would depend on monetary policy—our estimates provide evidence for models in which government spending has the potential to have large effects on output, particularly at the zero lower bound.

Ilzetzki, Mendoza, and Vegh (2010) estimate fiscal multipliers for 44 countries using a structural VAR approach. They find a fiscal multiplier of 1.5 for countries that operate a fixed exchange rate regime, while it is zero in countries operating a flexible exchange rate regime. In our model, the open economy multiplier we estimate yields the same multiplier as a small open economy with a fixed exchange rate. Our results thus line up well with those of Ilzetzki, Mendoza, and Vegh (2010).

Our empirical approach builds on previous work by Davis, Loungani, and Mahidhara (1997), who study several drivers of regional economic fluctuations, including military procurement. Several other studies of the impact of defense spending on regional economic fluctuations are surveyed in Braddon (1995). The most important difference in our empirical methodology relative to these studies is our use of variation in aggregate military spending in creating instruments to account for potential endogeneity of local procurement spending. Our work is also related to Canova and Pappa (2007), who study the price effects of fiscal shocks in a monetary union. Our theoretical analysis is related to earlier work on monetary and fiscal policy in a monetary union by Benigno and Benigno (2003) and Gali and Monacelli (2008).

The theoretical framework we describe may be used to interpret recent and ongoing research on the effects of other forms of local government spending. Fishback and Kachanovskaya (2010) analyze the effects of government spending during the new deal. Cohen, Coval, and Mallow (2010) study the effects of congressional committee chairmanship on state-level federal expenditures. Several other recent papers study plausibly exogenous variation in federal and state government spend-

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ing (Clemens and Miran, 2010; Serrato and Wingender, 2010; Shoag, 2010; Wilson, 2011). There are some potentially important differences between our study and these. Some of these studies focus on windfall transfers rather than purchases. Also, military spending represents government purchases that are much less substitutable for private spending than most other sources of government purchases. Military spending is, furthermore, orders of magnitude larger than other forms of discretionary government spending. For example, Cohen, Coval, and Mallow (2010) report that earmarks are on average about $116 million per state per year, whereas the comparable figure for military spending is roughly $6 billion. With these caveats in mind, several of these papers also find large effects of regional government spending which can potentially be explained by similar factors to those we emphasize in our theoretical model.

The remainder of the paper is organized as follows. Section 2 described the data we use. Section 3 presents our empirical results. Section 4 presents the model we use to interpret these empirical results. Section 5 presents our theoretical results. Section 6 concludes.

2 Data

Our main source for military procurement data is the electronic database of DD-350 military procurement forms available from the US Department of Defense. These forms document military purchases of everything from repairs of military facilities to the purchase of aircraft carriers. They cover purchases greater than $10,000 up to 1983 and greater than $25,000 thereafter. Relative to other forms of federal government spending, the geographical distribution of military spending is remarkably well-documented, perhaps because of the intense political scrutiny surrounding these purchases. We have used the DD-350 database to compile data on total military procurement by state and year for 1966-2006. DD-350 forms provide detailed information on individual military procurement contracts, including the amount (and in some cases projected duration) of the contract, purchases reported on DD-350 forms account for 90% of military purchases. Furthermore, our analysis of census shipment data in section 3 suggests DD-350 purchases account for almost all of the time-series variation in total military procurement. DD-1057 forms are used to summarize smaller transactions but do not give the identity of individual sellers.

The electronic military prime contract data file was created in the mid-1960’s and records military prime contracts since 1966. This occurred around the time Robert McNamara was making sweeping changes to the procurement process of the U.S. Department of Defense. While aggregate statistics are available before this point, they appear not to be a reliable source of information on military purchases since large discrepancies arise between actual outlays and procurement for the earlier period, particularly at the time of the Korean war. See the Department of Defense Greenbook for aggregate historical series of procurement and outlays.
and the location where the majority of the work was performed.\textsuperscript{9}

We have also compiled data on shipments to the government from defense oriented industries. The source of these data are the *Annual Survey of Shipments by Defense-Oriented Industries* conducted by the US Census Bureau from 1963 through 1983. Since there is no electronic version of these data, we digitized the data from microfilm. This source provides direct evidence on the timing and location of production associated with military procurement. They allow us to assess the extent to which some fraction of the prime military contracts reported on DD-350 forms may have been subcontracted to manufacturers in other states. These data also provide information on value-added for these manufacturers that we use to calibrate our theoretical model.

Our primary measure of state output is the Gross State Product measure constructed by the U.S. Bureau of Economic Analysis (BEA). This measure is available at an aggregate level since 1963.\textsuperscript{10} We also make use of analogous data by major SIC/NAICS grouping.\textsuperscript{11} We use the BLS payroll survey from the Current Employment Statistics (CES) program to measure state-level employment. We also present results for the BEA measure of state employment which is available since 1969. We obtain state population data from the Census Bureau.\textsuperscript{12}

Finally, to analyze price effects, we construct state and regional inflation measures from several sources. Before 1995, we rely on state-level inflation series constructed by Marco Del Negro for the period 1969-1995 using a combination of BLS regional inflation data and cost of living estimates from the American Chamber of Commerce Realtors Association (ACCRA).\textsuperscript{13} After 1995, we construct state-level price indexes by multiplying a population-weighted average of cost of living indexes from the American Chamber of Commerce Realtors Association (ACCRA) for each region with the US aggregate Consumer Price Index. Reliable annual consumption data are unfortunately not available at the state level for most of the time period or regions we consider.\textsuperscript{14}

\textsuperscript{9}These data are for the federal government fiscal year. Since 1976, this has been from October 1st to September 30th. Prior to 1976, it was from July 1st to June 30th.

\textsuperscript{10}As an alternative measure of output, we have analyzed BEA State Personal Income data. These data yield similar results to our baseline measure.

\textsuperscript{11}The data are organized by SIC code before 1997 and NAICS code after 1997. BEA publishes the data for both systems in 1997, allowing the growth rate series to be smoothly pasted together.

\textsuperscript{12}Between census years, these data are estimated using a variety of administrative data sources. Since 1970, we are also able to obtain population by age group, which allows us to adjust our estimates for the working age population as opposed to the population as a whole.

\textsuperscript{13}See Appendix A of Del Negro (1998) for the details of this procedure.

\textsuperscript{14}Retail sales estimates from *Sales and Marketing Management Survey of Buying Power* have sometimes been used as a proxy for state-level annual consumption. However, these data are constructed by using employment data to impute retail sales between census years, rendering them inappropriate for our purposes. Fishback, Horrace, and Kantor (2004) study the longer run effects of New Deal spending on retail sales using Census data.
3 Government Spending Multiplier: Measurement

We use variation in military procurement spending across states and regions to identify the effects of government spending on output. There is a great deal of heterogeneity across states in the magnitude and variability of military procurement. As a fraction of output, military procurement ranges from less than 0.5% of state GDP in states such as Idaho or Oregon to over 5% of state GDP in Connecticut. Furthermore, military procurement spending in defense-oriented states tends to be more sensitive to changes in aggregate military procurement than military procurement in states with less military production.

Figure 1 illustrates these differences by plotting the evolution of military procurement in California and Illinois as well as the evolution of national military procurement. Over the period 1966-1971, military procurement in California fell by 2.5 percentage points (almost twice the national average), while military procurement in Illinois fell by only about 1 percentage point (about 2/3 the national average). We use this variation in the sensitivity of military spending across regions to national military build-ups and draw-downs to identify the open economy fiscal multiplier.

3.1 Empirical Specification and Identification

We estimate the output multiplier using the equation,

\[ \frac{Y_{it} - Y_{it-2}}{Y_{it-2}} = \alpha_i + \gamma_t + \beta \frac{G_{it} - G_{it-2}}{Y_{it-2}} + \epsilon_{it}, \]

(1)

where \( Y_{it} \) is per-capita output in region \( i \) in year \( t \), \( G_{it} \) is per-capita military procurement spending in region \( i \) in year \( t \), and \( \alpha_i \) and \( \gamma_t \) represent state and year fixed effects.\(^{15}\) The inclusion of state fixed effects implies that we are allowing for state specific time trends in output and military procurement spending. We using panel data on state and regional output and spending for 1966-2006. The regional data are constructed by aggregating state-level data within Census divisions. We make one adjustment to the Census divisions. This is to divide the “South Atlantic” division into two parts because of its large size.\(^{16}\) This yields ten regions made up of contiguous states.

Ramey (2011) shows that the timing of news about military spending relative to the date at which the spending actually occurs has important implications for the estimation of fiscal multipliers. Intuitively, the wealth effect that is associated with the fiscal spending occurs when the news

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\(^{15}\) We deflate both regional output and military procurement spending using the national CPI for the U.S.

\(^{16}\) We place Delaware, Maryland, Washington DC, Virginia and West Virginia in one region, and North Carolina, South Carolina, Georgia and Florida in the other.
arrives, while substitution effects occur at the time the spending occurs. Ramey’s analysis suggests that news about spending arrives with a lead of a few quarters. Our use of a biannual regression helps mitigate concerns about a lack of coincidence between news and actual spending. Also, our shocks have more limited wealth effects since military spending is financed at the federal level and because of risk sharing across states. The wealth shock in our setting is positive, while it is negative in the closed economy setting.\footnote{We have considered a specification with both current spending and future spending and find that the coefficient on current spending is unaffected, while the coefficient on future spending is positive. This suggests that we might possibly be underestimating the multiplier.}

Military procurement is notoriously political, suggesting that endogeneity in the timing of procurement spending is an important concern.\footnote{See Mintz (1992) for a discussion of political issues related to the allocation of military procurement spending.} We therefore estimate equation (1) using an instrumental variables approach. To account for endogeneity in state military procurement spending, the source of variation we exploit is variation in state military procurement spending associated with variation in national military procurement spending. During an aggregate military build-up, procurement spending systematically increases more in some states than others (see Figure 1).

Our estimate of \( \beta \) in the equation (1) reflects to what extent these relative movements in military procurement spending translate into relative movements in output.

Specifically, we instrument for state or region military procurement using total national procurement interacted with a state or region dummy. The “first stage” in the two-stage least squares interpretation of our procedure is therefore to regress regional procurement spending for each state on aggregate military procurement. This first-stage regression accounts for roughly one quarter of the total variation in state-level military spending. Our identifying assumption is similar to (but weaker than) the assumption used by Barro and Redlick (2011) to estimate fiscal multipliers using aggregate military spending. We assume that aggregate military build-ups and draw-downs are orthogonal to relative economic conditions in regions with high versus low exposure to variation in aggregate procurement spending.\footnote{Nekarda and Ramey (2010) use a similar approach to purge government purchases for particular industries of potentially endogenous responses to industry productivity. They use data at 5 year intervals to estimate the share of aggregate government spending from different industries, as opposed to the responsiveness of industry output to aggregate spending.}

We estimate the effects of military spending on employment and inflation using an analogous approach. For employment, the regression is analogous to equation (1) except that the left-hand side variable is the two year percentage change in the employment rate—\((L_{it} - L_{it-2})/L_{it-2}\)—where \( L_{it} \) is the employment rate (employment divided by population). For the inflation regression, the
left-hand side variable is the two-year inflation rate, \((P_{it} - P_{i,t-2})/P_{i,t-2}\), where \(P_{it}\) is the price level.

### 3.2 Effects of Government Spending Shocks

The results of these regressions are presented in the first row of table 1. For each specification, the table reports the open economy multiplier \(\beta\). Standard errors are in parentheses and are clustered by regions or states.\(^{20}\) In the second row of Table 1, we present an analogous set of results using a broader measure of military spending that combines military procurement spending with compensation of military employees for each state or region. We present results for output both deflated by national CPI and our measure of state CPI.

The point estimates of \(\beta\) for the output regression range from 1.4 to 1.9, while the point estimates of \(\beta\) for the employment regression range from 1.3 to 1.8. The estimates using regional data are, in general, slightly larger than those based on state data, though the differences are small and statistically insignificant. The point estimates of the effects of military spending on consumer prices are statistically insignificantly different from zero, ranging from small positive to small negative numbers.\(^{21}\)

The regressions above control for short-term movements in population associated with government spending by looking for relationships among variables in per-capita terms. The last column of Table 1 characterizes the nature of these population movements. The regression we estimate is again analogous to equation (1) except that the left-hand side variable is the two year percentage change in population—\((\text{Pop}_{it} - \text{Pop}_{i,t-2})/\text{Pop}_{i,t-2}\)—and the right-hand side government spending variable as well as the instruments are constructed using the level of government spending and output rather than per-capita versions of these variables. We find government spending shocks to have small and statistically insignificant effects on population over the time horizon we consider.\(^{22}\)

Figure 3 gives a visual representation of our main specification for output. The figure shows averages of changes in output and predicted military spending (based on our first-stage regression),

\(^{20}\)Our standard errors thus allow for arbitrary correlation over time in the error term for a given state. They also allow for heteroskedasticity. As we describe below, we have carried out an extensive Monte Carlo analysis of our estimator to judge the robustness of our results. The Monte Carlo analysis indicates that while the standard error for the state-level regressions is unbiased, the standard errors for the region regressions are slightly downward-biased: the standard 95% confidence interval based on the standard errors reported in table 1 is in fact a 90% confidence interval. This adjustment arises from the well-known small-sample bias in clustered standard errors in the presence of a small number of clusters.

\(^{21}\)The difficulty in obtaining a precise estimate of the effect of military spending on inflation no doubt arises in part from the paucity of the data involved—state and regional inflation data are likely to suffer from a large amount of measurement error. See section 2 for a discussion of the inflation data.

\(^{22}\)Blanchard and Katz (1992) show that population dynamics are important in determining the dynamics of unemployment over longer horizons.
grouped by 30 quantiles of the predicted military spending variable. Both variables are demeaned by year and state fixed effects. The vast majority of points in the figure are located in the NE and SW quadrants, leading to a positive coefficient in our IV regression. To assess the robustness of our result, we have experimented with dropping states and regions with especially large estimated sensitivity of spending to national spending and this slightly raises the estimated multiplier.  

Table 2 presents a number of alternative specifications for the effects of military procurement on output and employment. We report the output multiplier when per-capita output is constructed using a measure of the working age population as opposed to the total population. We add the price of oil interacted with state dummies as controls to our baseline regression. We add the real interest rate interacted with state dummies as controls to our baseline regression. We estimate the employment regression using the BEA’s employment series (available from 1969) instead of BLS payroll employment. This series includes estimated values of self-employment and other non-payroll employment. The table shows that these specifications all yield similar results to our baseline estimates.

An alternative way to construct instruments for state spending based on national spending is to scale national spending by the average level of spending in each state, an approach sometimes referred to as constructing “Bartik instruments” (Bartik, 1991; Blanchard and Katz, 1992). To construct these estimates, we use the average level of spending in the first five years of our sample, implying that the fraction of military spending is pre-determined relative to the majority of our sample period. Results for output and employment using this instrument instead of our baseline instruments are presented in Table 2. For output, this approach yields a multiplier of roughly 2.5 with a standard error of 0.9 for the states and 2.8 with a standard error of 0.7 for the regions. For employment, this approach also yields larger multipliers than our baseline specification.

Table 2 also presents OLS estimates of our baseline specification for output. The OLS estimates are substantially lower than our instrumental variables estimates. This suggests endogeneity is important in determining the timing of military procurement spending. In particular, it suggests that military procurement spending varies countercyclically in response to regional business conditions. There is a substantial literature in politics and political economy supporting this notion (see, e.g.

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23 MO and CT have substantially higher estimated sensitivity of spending to national spending than other states and ND has a substantially negative estimated sensitivity (alone among the states). Dropping any combination of these states from our baseline regression slightly raises the our multiplier estimate. Dropping all three yields 1.88 (0.57).

24 State-level measures of population by age-group are available from the Census Bureau starting in 1970. We define the working age population as the population between the ages of 19 and 64.
Table 3 presents the results for equation (1) estimated separately by major SIC/NAICS groupings. Statistically significant output responses occur in the construction, manufacturing, retail and services sectors. The largest output response is in the construction sector, where an increase in military procurement equal to 1% of state GDP is associated with a 5.4% increase in relative sectoral output. One might be concerned that our results on the effects of government spending shocks are driven in part by increases in output in the government sector itself, given the difficulties of measuring government output.\textsuperscript{25} Table 3 shows that this is not the case—increases in government sector output contribute negligibly to the overall effects we estimate. Table 3 also shows that increases in relative procurement spending are not associated with increases in non-procurement military output.

We have also extensively investigated the small-sample properties of our estimation approach using Monte Carlo simulations. Our analysis suggests no bias in the level of the region-level multiplier. However, it suggests that our estimates of the state regressions are likely to be slightly conservative in the sense of underestimating the fiscal multiplier for states by roughly 10% (implying that the true state-level multiplier is 1.65 rather than 1.43). Intuitively, this downward bias arises because instrumental variables does not fully correct for endogeneity in small samples, leading IV to be biased in the direction of OLS.\textsuperscript{26} The LIML estimator avoids this downward bias in the IV estimator but yields larger standard errors in both the data (see Table 2) and our Monte Carlo analysis.\textsuperscript{27}

\textsuperscript{25}The measurement difficulties imply that output in the government sector is typically measured using input costs.

\textsuperscript{26}See Stock, Wright, and Yogo (2002) for an overview of this issue. The concern is that the first-stage of the IV procedure may pick up some of the endogenous variation in the explanatory variable in the presence of a large number of instruments. In contrast to the canonical examples discussed in Stock, Wright, and Yogo (2002), this actually biases us away from finding a statistically significant result in small samples, since the OLS estimates in our case are close to zero. Our Monte Carlo analysis is roughly consistent with the asymptotic results reported in Stock and Yogo (2005). The partial R-squared of the excluded instruments, a statistic frequently used to gauge the “strength” of instruments is 12% for the state regressions and 18% for the region regressions. However, because we use a large number of instruments in our baseline case—one for each state or region—the Cragg-Donald (1993) statistic suggested by Stock and Yogo (2005) is roughly 5 for our baseline specification of the state-level regressions and 8 for the region-level regressions. (The Cragg-Donald statistic is, of course, much higher for the simpler Bartik specification discussed above, since it includes only a single instrument.) Our Monte Carlo analysis indicates that while the large number of instruments in the state-level specification leads to a slight downward-bias in the coefficient on government spending, the standard error on this coefficient is unbiased because of the high R-squared of our instruments taken as a whole. We thank Marcelo Moreira and Motohiro Yogo for generous advice on this issue.

\textsuperscript{27}See, e.g.,Stock and Yogo (2005) for a disucssion of the LIML estimator.
3.3 Subcontracting of Prime Military Contracts

An important question with regard to the use of military procurement data is to what extent the interpretation of these data might be affected by subcontracting of prime military contracts to surrounding states. To investigate this issue, we use Census Bureau data on shipments to the government from defense oriented industries. To our knowledge, these data have previously been used only infrequently in studying the geographical distribution of military spending. They were not previously available in digital form.\textsuperscript{28} The Census shipments data are available for the period 1963-1983. Figure 2 illustrates the close relationship between the state-level military procurement data and the shipments data for several states over this period. To summarize this relationship, we estimate the following relationship between shipments from a particular state and our measure of military procurement spending,

\[ MS_{it} = \alpha_i + \beta MPS_{it} + \epsilon_{it}, \]  

(2)

where \( MS_t \) is the value of shipments from the Census Bureau data and \( MPS_{it} \) is our measure of military procurement spending. Estimating this regression yields a point estimate of \( \beta = 0.96 \), suggesting that our measure of military procurement provides an accurate picture of state-level variation in military procurement.

3.4 Government Spending at High Versus Low Unemployment Rates

We next investigate whether the effects of government spending on the economy are larger in periods when the unemployment rate is already high. There are a variety of reasons why this could be the case. Most often cited is the idea that in an economy with greater slack, expansionary government spending is less likely to crowd out private consumption or investment.\textsuperscript{29} In a closed economy, a second potential source of such differences is the differential response of monetary policy—central bankers may have less incentive to “lean against the wind” to counteract the effects of government spending increases if unemployment is already high. This latter effect does not, however, influence the results we report below, since the open economy multipliers we consider difference out aggregate monetary and fiscal policy shocks.

\textsuperscript{28} We digitized these data from microfilm. See section 2 for a discussion of the shipments data.

\textsuperscript{29} This might arise, for example, if unemployment leads to a higher labor supply elasticity (Hall, 2009). Such effects might also occur in an economy with downwardly-rigid wages. During a recession, wages lie above their market-clearing level in such a model, making output more sensitive to variation in government spending. Finally, a fall in the share of durable goods consumption during recessions might lower the sensitivity of consumer expenditures to interest rates. These effects are beyond the scope of the model we present in section 4.
To investigate these issues, we estimate the following regression,

$$\frac{Y_{it} - Y_{it-2}}{Y_{it-2}} = \alpha_i + \gamma_t + \beta_h \frac{G_{it} - G_{it-2}}{Y_{it-2}} + (\beta_l - \beta_h) I_l \frac{G_{it} - G_{it-2}}{Y_{it-2}} + \epsilon_{it},$$

(3)

where $I_l$ is an indicator for a period of low economic slack, and the effects of government spending in high and low slack periods are given by $\beta_h$ and $\beta_l$ respectively. We define high and low slack periods in terms of the unemployment rate at the start of the interval over which the government spending occurs. Specifically, period $t$ is defined as a high slack period if $U_{t-2}$ is above its median value over our sample period.\(^{30}\) We allow for both state and time fixed effects, $\alpha_i$ and $\gamma_t$ respectively. As in our baseline specification, the presence of the time fixed effects $\gamma_t$ implies that our estimates rely on the differential effects of government spending shocks across regions, differencing out the effects of aggregate shocks and policies.

Table 4 presents our estimates of equation (3). The point estimates support the view that the effects of government spending are larger when unemployment is high: depending on the specification, the government spending multiplier lies between 2 and 3.5 in the high slackness periods, substantially above our estimates for the time period as a whole. Given the limited number of business cycles in our sample, we are not, however, able to estimate these effects with much statistical precision. The difference in the multiplier in the high and low spending periods is moderately statistically significant (with a P-value of 0.06) only in the case of the state-level output regression.

4 A New Keynesian Model of a Monetary Union

We consider a model economy that consists of two regions belonging to a monetary and fiscal union. Our model is a relatively standard New Keynesian model that builds on the framework developed in, e.g., Obstfeld and Rogoff (1995), Chari, Kehoe, and McGrattan (2002), Benigno and Benigno (2003), Woodford (2003), Benigno and Woodford (2005) and Gali and Monacelli (2008). We refer to the regions as “home” and “foreign”. The population of the entire economy is normalized to one. The population of the home region is denoted by $n$. Household preferences, market structure and firm behavior take the same form in both regions. Below, we describe the economy of the home region.

4.1 Households

The home region has a continuum of household types indexed by \( x \). A household’s type indicates the type of labor supplied by that household. Home households of type \( x \) seek to maximize their utility given by

\[
E_0 \sum_{t=0}^{\infty} \beta^t u(C_t, L_t(x)),
\]

where \( \beta \) denotes the household’s subjective discount factor, \( C_t \) denotes household consumption of a composite consumption good, \( L_t(x) \) denotes household supply of differentiated labor input \( x \). There are an equal (large) number of households of each type.

The composite consumption good in equation (4) is an index given by

\[
C_t = \left[ \frac{1}{\eta} C_{Ht}^{\eta-1} + \frac{1}{\eta} C_{Ft}^{\eta-1} \right]^{\frac{1}{\eta-1}},
\]

where \( C_{Ht} \) and \( C_{Ft} \) denote consumption of composites of home and foreign produced goods, respectively. The parameter \( \eta > 0 \) denotes the elasticity of substitution between home and foreign goods and \( \phi_H \) and \( \phi_F \) are preference parameters that determine the household’s relative preference for home and foreign goods. If \( \phi_H > \eta \), household preferences are biased toward home produced goods. It is analytically convenient to normalize \( \phi_H + \phi_F = 1 \).

The subindices—\( C_{Ht} \) and \( C_{Ft} \)— are given by

\[
C_{Ht} = \left[ \int_0^1 c_{ht}(z) \frac{\theta-1}{\theta} dz \right]^{\frac{\theta}{\theta-1}} \quad \text{and} \quad C_{Ft} = \left[ \int_0^1 c_{ft}(z) \frac{\theta-1}{\theta} dz \right]^{\frac{\theta}{\theta-1}}
\]

where \( c_{ht}(z) \) and \( c_{ft}(z) \) denote consumption of variety \( z \) of home and foreign produced goods, respectively. There is a continuum of measure one of varieties in each region. The parameter \( \theta > 1 \) denotes the elasticity of substitution between different varieties.

Goods markets are completely integrated across regions. Home and foreign households thus face the same prices for each of the differentiated goods produced in the economy. We denote these prices by \( p_{ht}(z) \) for home produced goods and \( p_{ft}(z) \) for foreign produced goods. All prices are denominated in a common currency called “dollars”.

Households have access to complete financial markets. There are no impediments to trade in financial securities across regions. Home households of type \( x \) face a flow budget constraint given by

\[
P_tC_t + E_t[M_{t,t+1}B_{t+1}(x)] \leq B_t(x) + W_t(x)L_t(x) + \int_0^1 \Phi_{ht}(z)dz - T_t,
\]

where \( P_t \) is a price index that gives the minimum price of a unit of the consumption good \( C_t \), \( B_{t+1}(x) \) is a random variable that denotes the state contingent payoff of the portfolio of financial
securities held by households of type \( x \) at the beginning of period \( t + 1 \), \( M_{t,t+1} \) is the stochastic discount factor that prices these payoffs in period \( t \), \( W_t(x) \) denotes the wage rate received by home households of type \( x \) in period \( t \), \( \Phi_{ht}(z) \) is the profit of home firm \( z \) in period \( t \) and \( T_t \) denotes lump sum taxes.\(^{31}\) To rule out Ponzi schemes, household debt cannot exceed the present value of future income in any state of the world.

Households face a decision in each period about how much to spend on consumption, how many hours of labor to supply, how much to consume of each differentiated good produced in the economy and what portfolio of assets to purchase. Optimal choice regarding the trade-off between current consumption and consumption in different states in the future yields the following consumption Euler equation:

\[
\frac{u_c(C_{t+j},L_{t+j}(x))}{u_c(C_t,L_t(x))} = \frac{M_{t,t+j} P_{t+j}}{P_t} \tag{8}
\]
as well as a standard transversality condition. Subscripts on the function \( u \) denote partial derivatives. Equation (8) holds state-by-state for all \( j > 0 \). Optimal choice regarding the intratemporal trade-off between current consumption and current labor supply yields a labor supply equation:

\[
\frac{u_l(C_t,L_t(x))}{u_c(C_t,L_t(x))} = \frac{W_t(x)}{P_t}. \tag{9}
\]

Households optimally choose to minimize the cost of attaining the level of consumption \( C_t \). This implies the following demand curves for home and foreign goods and for each of the differentiated products produced in the economy:

\[
C_{H,t} = \phi_H C_t \left(\frac{P_{Ht}}{P_t}\right)^{-\eta} \quad \text{and} \quad C_{F,t} = \phi_F C_t \left(\frac{P_{Ft}}{P_t}\right)^{-\eta}, \tag{10}
\]

\[
c_{ht}(z) = C_{Ht} \left(\frac{p_t(z)}{P_{Ht}}\right)^{-\theta} \quad \text{and} \quad c_{ft}(z) = C_{Ft} \left(\frac{p_t(z)}{P_{Ft}}\right)^{-\theta}, \tag{11}
\]

where

\[
P_{Ht} = \left[\int_0^1 p_t(z)^{1-\theta} dz\right]^{\frac{1}{1-\eta}} \quad \text{and} \quad P_{Ft} = \left[\int_0^1 p_t^*(z)^{1-\theta} dz\right]^{\frac{1}{1-\eta}}, \tag{12}
\]

and

\[
P_t = \left[\phi_H P_{Ht}^{1-\eta} + \phi_F P_{Ft}^{1-\eta}\right]^{\frac{1}{1-\eta}}. \tag{13}
\]

As we noted above, the problem of the foreign household is analogous. We therefore refrain from describing it in detail here. It is, however, useful to note that combining the home and foreign

\(^{31}\)The stochastic discount factor \( M_{t,t+1} \) is a random variable over states in period \( t + 1 \). For each such state it equals the price of the Arrow-Debreu asset that pays off in that state divided by the conditional probability of that state. See Cochrane (2005) for a detailed discussion.
consumption Euler equations to eliminate the common stochastic discount factor yields

\[
\frac{u_c(C^*_t, L^*_t(x))}{u_c(C_t, L_t(x))} = Q_t,
\]  

(14)

where \(Q_t = \frac{P^*_t}{P_t}\) is the real exchange rate. This is the “Backus-Smith” condition that describes optimal risk-sharing between home and foreign households (Backus and Smith, 1993). For simplicity, we assume that all households—in both regions—initially have an equal amount of financial wealth.

### 4.2 The Government

The economy has a federal government that conducts fiscal and monetary policy. Total government spending in the home and foreign region follow an exogenous AR(1) process. Let \(G_{Ht}\) denote government spending per capita in the home region. Total government spending in the home region is then \(nG_{Ht}\). For simplicity, we assume that government demand for the differentiated products produced in each region takes the same CES form as private demand. In other words, we assume that

\[
g_{ht}(z) = G_{Ht} \left( \frac{p_{ht}(z)}{P_{Ht}} \right)^{-\theta} \quad \text{and} \quad g_{ft}(z) = G_{Ft} \left( \frac{p_{ft}(z)}{P_{Ft}} \right)^{-\theta}. 
\]

(15)

The government levies lump-sum taxes to pay for its purchases of goods.\(^{32}\) Our assumption of perfect financial markets implies that any risk associated with variation in taxes and transfers across the two regions is undone through risk-sharing. Ricardian equivalence holds in our model. Windfall government transfers from one region to the other and lump-sum taxes to finance government spending in one region, therefore, have no effect on equilibrium allocations in our model. Also, we need not specify the time-path or regional incidence of taxes.

The federal government operates a common monetary policy for the two regions. This policy consists of the following augmented Taylor-rule for the economy-wide nominal interest rate:

\[
\hat{\iota}_t = \rho_s\hat{\iota}_{t-1} + (1 - \rho_s)(\phi_n\hat{\pi}_{ag}^t + \phi_g\hat{y}_{ag}^t + \phi_{\pi}\hat{\pi}_{ag}^t),
\]

(16)

where hatted variables denote percentage deviations from steady state. The nominal interest rate is denoted \(\hat{\iota}_{t}\). It responds to variation in the weighted average of consumer price inflation in the two regions \(\hat{\pi}_{ag}^t = n\hat{\pi}_t + (1 - n)\hat{\pi}_t^*\), where \(\hat{\pi}_t\) is consumer price inflation in the home region and \(\hat{\pi}_t^*\) is consumer price inflation in the foreign region. It also responds to variation in the weighted

average of output in the two regions $\hat{y}_t^a = n\hat{y}_t + (1-n)\hat{y}_t^*$. Finally, it may respond directly to the weighted average of the government spending shock in the two regions $\hat{g}_t^a = n\hat{g}_t + (1-n)\hat{g}_t^*$.

4.3 Firms

There is a continuum of firms indexed by $z$ in the home region. Firm $z$ specializes in the production of differentiated good $z$, the output of which we denote $y_t(z)$. Labor is the only variable factor of production used by firms. Each firm is endowed with a fixed, non-depreciating stock of capital. Labor is immobile across regions.\footnote{Our results in section 3, suggest that this is a reasonable assumption over the horizons we focus on. An extension of our model that allows for an equal amount of labor and capital mobility yields virtually identical results for output as long as all variables (output, employment, government spending, etc.) are defined in per-capita terms. Blanchard and Katz (1992) emphasize that labor mobility plays an important role in the adjustment to regional shocks over longer horizons.} We follow Woodford (2003) in assuming that each firm belongs to an industry $x$ and that there are many firms in each industry. The goods in industry $x$ are produced using labor of type $x$ and all firms in industry $x$ change prices at the same time.

The production function of firm $z$ is

$$y_t(z) = f(L_t(z)).$$

(17)

The function $f$ is increasing and concave. It is concave because there are diminishing marginal returns to labor given the fixed amount of other inputs employed at the firm.

Firm $z$ acts to maximize its value,

$$E_t \sum_{j=0}^{\infty} M_{t,t+j}[p_{t+j}(z)y_{t+j}(z) - W_{t+j}(x)L_{t+j}(z)].$$

(18)

Firm $z$ must satisfy demand for its product. The demand for firm $z$’s product comes from three sources: home consumers, foreign consumers and the government. It is given by

$$y_t(z) = (nC_{Ht} + (1-n)C^*_H + nG_{Ht})\left(\frac{p_{ht}(z)}{P_{Ht}}\right)^{-\theta}.$$  

(19)

Firm $z$ is therefore subject to the following constraint:

$$(nC_{Ht} + (1-n)C^*_H + nG_{Ht})\left(\frac{p_{ht}(z)}{P_{Ht}}\right)^{-\theta} \leq f(L_t(z)).$$

(20)

Firm $z$ takes its industry wage $W_t(x)$ as given. Optimal choice of labor demand by the firm is given by

$$W_t(x) = f_t(L_t(z))S_t(z),$$

(21)
where $S_t(z)$ denotes the firm’s nominal marginal cost (the Lagrange multiplier on equation (20) in the firm’s constrained optimization problem).

Firm $z$ can reoptimize its price with probability $1 - \alpha$ as in Calvo (1983). With probability $\alpha$ it must keep its price unchanged. Optimal price setting by firm $z$ in periods when it can change its price implies

$$E_t \sum_{j=0}^{\infty} \alpha^j M_{t,t+j}(nC_{Ht+j} + (1 - n)C_{Ft+j} + nG_{Ht+j})P_{Ht+j}(1 - \theta)[pt(z) - \frac{\theta}{\theta - 1}S_{t+j}(z)] = 0. \quad (22)$$

### 4.4 Calibration

We analyze the behavior of the economy for several specific sets of assumptions about the utility function, production function, monetary policy and parameters of the model. We consider the following two forms for the utility function:

1. $u(C_t, L_t(z)) = C_t^{1-\sigma^{-1}} - \chi \frac{L_t(x)^{1+\nu^{-1}}}{1+\nu^{-1}}, \quad (23)$
2. $u(C_t, L_t(z)) = \frac{(C_t - \chi L_t(x)^{1-\nu^{-1}}/(1-\nu^{-1}))^{1-\sigma^{-1}}}{1-\sigma^{-1}}. \quad (24)$

In the first utility specification, consumption and labor enter separably. They are therefore neither complements nor substitutes. The second utility function is adopted from Greenwood, Hercowitz, and Huffman (1988). We refer to this utility function as GHH preferences. Consumption and labor are complements for households with GHH preferences. Recently, Monacelli and Perotti (2008), Bilbiie (2009), and Hall (2009) have emphasized the implications of consumption-labor complementarities for the government spending multiplier.

For both specifications for utility, we must specify values for $\sigma$ and $\nu$ ($\chi$ is irrelevant when utility is separable and determined by other parameters in the GHH case). In both cases, $\nu$ is the Frisch elasticity of labor supply. There is little agreement on the appropriate value for this parameter in the literature. We set $\nu = 2$. This value is somewhat higher than values estimated for employed workers. The higher value is meant to capture variation in labor on the extensive margin—such as variation in unemployment and retirement (Hall, 2009). We set $\sigma = 2$. For the separable utility specification, $\sigma$ denotes the intertemporal elasticity of substitution (IES). There is little agreement within the macroeconomics literature on the appropriate values for the IES. Hall (1988) estimates the IES to be close to zero, while Bansal and Yaron (2004), Gruber (2006) and Nakamura, et al. (2011) argue for values above 1.
We set the subjective discount factor equal to $\beta = 0.99$, the elasticity of substitution across varieties equal to $\theta = 5$ and the elasticity of substitution between home and foreign goods to $\eta = 1.5$. We assume the production function $f(L_t(z)) = L_t(z)^{\alpha}$ and we set $\alpha = 2/3$. We set $\alpha = 0.75$. This implies that firms reoptimize their prices on average once a year.

We set the size of the home region to $n = 0.1$. This roughly corresponds to the size of the average region in our regional regressions (where we divide the U.S. into 10 regions). We use data from the U.S. Commodity Flow Survey (CFS) and the U.S. National Income and Product Accounts (NIPA) to set the home-bias parameter $\phi_H$. The CFS reports data on shipments of goods within and between states in the U.S. It covers shipments between establishments in the mining, manufacturing, wholesale and retail sectors. For the average state in 2002, 38% of shipments were within state and 50% of shipments were within region. However, roughly 40% of all shipments in the CFS are from wholesalers to retailers and the results of Hillberry and Hummels (2003) suggest that a large majority of these are likely to be within region. Since the relevant shipments for our model are those from manufacturers to wholesalers, we assume that 83% of these are from another region (50 of the remaining 60 percent of shipments).

NIPA data indicate that goods represent roughly 30% of U.S. GDP. If all inter-region trade were in goods—i.e., all services were local—imports from other regions would amount to 25% of total consumption ($30 \times 0.38 = 25$). However, for the U.S. as a whole, services represent roughly 20% of international trade. Assuming that services represent the same fraction of cross-border trade for regions, total inter-region trade is 31% of region GDP ($25 / 0.8 = 31$). We therefore set $\phi_H = 0.69$. This makes our regions slightly more open than Spain and slightly less open than Portugal. We set $\phi_H^*$ so that overall demand for home products as a fraction of overall demand for all products is equal to the size of the home population relative to the total population of the economy. This implies that $\phi_H^* = (n/(1 - n)) \phi_F$.

We consider three specifications of monetary policy. First, we consider a specification that is meant to mimic the policy of the U.S. Federal Reserve during the Volcker-Greenspan period. Many recent papers have estimated monetary rules similar to the one we adopt for the Volcker-Greenspan period (see, e.g., Taylor, 1993 and 1999; Clarida, Gali and Gertler, 2000). Guided by this literature we refer to $\rho = 0.8$, $\phi_\pi = 1.5$, $\phi_y = 0.5$ and $\phi_g = 0$ as the Volcker-Greenspan policy. Notice that the Volcker-Greenspan policy is one in which the monetary authority “leans against the wind” in the sense that it raises the real interest rate in response to inflationary shocks.

The second monetary policy we consider is one that responds directly to the fiscal policy shock
in such a way as to neutralize the effect that such shocks have on the real interest rate. In other words, this policy maintains a constant real interest rate when fiscal policy shocks occur. We refer to this policy as the constant real interest rate policy. This policy does not lean against the wind in response to government spending shocks. To guarantee price level determinacy, we must rule out self-fulfilling variation in inflation that is not driven by fundamental shocks (i.e., sunspot equilibria). We do this by setting $\phi_\pi = 1.5$. This implies that the real interest rate will react to any variation in inflation that is not caused by government spending shocks. Along the equilibrium path, no such variation occurs in our model.

The third policy specification we consider is one that maintains a constant nominal interest rate when fiscal policy shocks occur. We refer to this policy as the constant nominal interest rate policy. This policy is meant to mimic monetary policy at the zero lower bound. Again, to guarantee price level determinacy, the constant nominal interest rate policy has $\phi_\pi = 1.5$.

We set the steady state value of government purchases as a fraction of output to 0.2. We set the AR(1) coefficient on the government spending shock such that the half-life of the government spending shock is 2 years (i.e. an AR(1) coefficient of $0.5^{1/5} \approx 0.917$) to roughly match the persistence of aggregate military procurement spending in the data. We log-linearize the equilibrium conditions of the model and use the methods of Sims (2001) to find the unique bounded equilibrium.

### 5 Government Spending in a New Keynesian Model

In this section, we analyze the effects of fiscal policy shocks in the model presented in section 4.

#### 5.1 The Closed Economy Multiplier

Consider first the standard closed economy multiplier, calculated as the response of total output (combining home and foreign production) to total government spending. To estimate the closed economy multiplier, we simulate data from the model described in section 4 and estimate a closed economy version of equation (1). Specifically, we use aggregate output and aggregate government spending to construct the dependent and independent variables and we no longer include fixed effects in the regression. To compute the same objects in the data and model, we time-aggregate quarterly data from the model to an annual frequency to estimate equation (1).

The first panel of table 5 reports results for the model in section 4 for the standard case of household preferences that are additively separable between consumption and labor. The first
column reports results on the closed economy multiplier. We present results for three different
monetary policies that differ in the degree to which movements in the interest rate are used to “lean
against the wind” in response to the government spending shock—a Volcker-Greenspan monetary
policy in which real interest rates are assumed to rise in response to increasing output or inflation, a
fixed real interest rate rule, and a fixed nominal interest rate rule meant to mimic monetary policy
at the zero lower bound.

The monetary policy with the greatest amount of “leaning against the wind” is the Volcker-
Greenspan monetary policy, which prescribes that the Federal Reserve raise real interest rates
in response to an increase in output or inflation caused by a government spending shock. This
monetary policy implies a low closed economy output multiplier of 0.14. With the constant real
interest rate monetary policy, real interest rates remain unchanged (as opposed to rising) in response
to a fiscal-policy induced expansion in output. For this monetary policy, the closed economy
multiplier is one. Woodford (2010) shows that for a constant real interest rate monetary policy,
the closed economy multiplier is one for a broad set of parameter values in models without capital.
Intuitively, consumption doesn’t change since the real interest rate is constant. Output must
therefore rise one-for-one with government spending.

Finally, we report results for constant nominal interest rate monetary policy. This is a close
cousin of monetary policy at the zero-lower bound, a scenario analyzed in detail by Eggertsson
(2010), Christiano, Eichenbaum, and Rebelo (2010), and Mertens and Ravn (2010). This policy
has the potential to generate extremely large multipliers since expansionary fiscal policy, by raising
inflationary expectations, drives down real interest rates, leading to further increases in consumption
and output. In our framework, the closed economy multiplier is 2.44 if the nominal interest rate
is fixed and the government spending shock has a half-life of one year (i.e., $\rho_g = 0.85$). This
result is, however, sensitive to the persistence of the government spending shock. For our baseline
parameters, where government spending is slightly more persistent ($\rho_g = 0.917$), the closed economy
multiplier falls to 0.13.\textsuperscript{34}

Needless to say, the rise in GDP that arises if the government buys more output is highly
sensitive to the stance of monetary policy in the closed economy setting. This sensitivity carries

\textsuperscript{34}The sensitivity of the fixed nominal interest rate multiplier to the persistence of government spending is closely
related to issues discussed in Mertens and Ravn (2010). Intuitively, the government spending shock has both deflationary effects (for a given level of output, it increases labor supply and thus reduces marginal costs by reducing consumption) and inflationary effects (it increases demand at a given interest rate since households would like to smooth consumption). Which effect is bigger depends on the persistence of the government spending shock. With highly persistent government spending shocks, the deflationary effect dominates (demand does not increase by much because the shock has a large effect on permanent income).
over to other variables. Much recent work on the effects of fiscal policy has focused on consumption, real wages and markups (Ramey, 2010; Perotti, 2007). Our closed economy new Keynesian model with Volcker-Greenspan monetary policy generates a fall in all three of these variables in response to positive government spending shocks, while the same exercise with the constant real interest rate monetary policy yields an increase in real wages and markups, and leaves consumption unchanged.

This sensitivity of the multiplier to the stance of monetary policy may help to explain some of the wide range of estimates of the multiplier in the empirical literature. Most economists agree that the extent to which the Federal Reserve has “leaned against the wind” has varied substantially over the last century. Many economists believe, for example, that monetary policy was far more expansionary during the 2007-2009 financial crisis than in earlier financial crises such as the Great Depression.

The sensitivity of the closed economy multiplier to the stance of monetary policy makes it difficult to distinguish between alternative models of the economy. The last row in Panel A Table 5 presents results for a version of our model with flexible prices. The closed economy multiplier in this case is 0.34, which lies well within the range of multipliers for the New Keynesian model for alternative monetary policies. While the Neoclassical and New Keynesian models may yield similar government spending multipliers under responsive monetary policies such as the Volcker-Greenspan policy, their implications can differ greatly when nominal interest rates are fixed—such as when interest rates hit the zero lower bound. The Neoclassical model continues to yield a small multiplier in this case, whereas the New Keynesian multiplier is potentially very large. Thus, while the predictions of New Keynesian and Neoclassical models for the effects of government spending may be difficult to tell apart in normal times, the distinction may be crucially important in times of crisis.

5.2 The Open Economy Multiplier

Contrast the wide range of different “closed economy multipliers” produced by our model for different monetary policies with the complete stability of the “open economy multiplier” reported in the second data column of Table 5. This open economy multiplier is calculated by estimating equation (1) using the region data from the model. For all three specifications of monetary policy we consider, this open economy output multiplier is 0.82. In other words, the open economy multiplier
The intuition for this result rests on the fact that in estimating the open economy multiplier we control for aggregate shocks affecting the different regions in the monetary union. Since the different regions share the same monetary policy, this procedure “differences out” the effects of monetary policy on the government spending multiplier in a very precise way. We measure the differential effect of government spending on output across regions holding fixed the difference in monetary policy across regions.

The open economy multiplier we estimate turns out the be equal to the multiplier in a small open economy with a fixed exchange rate. We have verified this by letting the size of the home country go to zero and calculating the home multiplier for that country in the limit. Intuitively, if the home country is sufficiently small, it has a negligible effect on the currency union as a whole. As a consequence, the "relative" effect of government spending will be the same as the absolute effect on the home region—i.e., the time dummies will be zero in equation (1)—and the open economy multiplier becomes equivalent to the multiplier for the small open economy with a fixed exchange rate.

Since the relative nominal interest rate is constant in response to a government spending shock in one region—i.e., the monetary authority cannot respond to the shock by making monetary policy tighter in that region alone—one might at first have thought that this situation would be analogous to the response of a closed economy to a government spending shock at the zero lower bound. An increase in government spending in the home region leads to a rise in expected inflation, lowering real interest rates—just as in the closed economy case at the zero lower bound.

This logic turns out to ignore crucial aspects of the open economy setting. The crucial difference versus the closed economy zero lower bound setting is that in our setting, the long-term real interest rate does not fall in response to the fiscal shock, even though the short-term real interest rate does. The fiscal shock leads to an immediate rise in prices and expectations of further rises in prices in the short term. This lowers the short term real interest rate. However, since purchasing power parity must hold in the long run, any short term increase in prices in one region relative to the other region must be undone by a fall in prices in that region later on. This means that the long term real interest rate does not fall in our open economy setting. In fact, the initial jump up in prices implies that going forward prices are anticipated to fall more in the long run than they are.

The open economy multiplier is, of course, not completely insensitive to other parameters of the model, such as the persistence of the government spending shock, as can be seen from the fourth row of the table.
anticipated to rise further in the short run. This implies that the relative long-term real interest rate actually rises slightly in the home region in response to an increase in government spending.

Since the relevant interest rate—the long-term real interest rate—actually rises slightly in response to an increase in government spending irrespective of the persistence of the shock and other parameters, the fixed relative nominal interest rate policy in a monetary union is fundamentally different from a fixed nominal interest rate policy in a closed economy setting. The response of long-term real interest rates in the open economy setting is closest to the fixed real interest rate case in the closed economy setting, where the output multiplier equals 1.0. The open economy case is slightly more contractionary (since long-term real interest rates actually rise a slight bit). Table 5 shows that the open economy multiplier is, in fact, 0.85 for our baseline parameter values—far below the fixed nominal rate multipliers emphasized by Eggertsson (2010) and Christiano, Eichenbaum, and Rebelo (2010) and just slightly lower than the closed economy fixed real rate multiplier.

To more clearly see the intuition for this result, Figure 4 presents the impulse response of the price level and the real interest rate in the home region relative to the foreign region after a government spending shock in our model. The home price level rises for several periods, but then falls back to its original level of purchasing power parity. This movement in prices implies that the real interest rate in the home region initially falls, but then rises above its steady state level for a prolonged period. Figure 4 shows what happens to consumption in the home region relative to the foreign region after a government spending shock in our model. Despite the short-run fall in the real interest rate, consumption falls. This is because households anticipate high real rates in the future—equivalently, they face a high current long-term real interest rate—and therefore cut their consumption.

5.3 GHH Preferences

Empirical evidence suggests there may be important complementarities between consumption and work (see, e.g., Aguiar and Hurst, 2005). This can potentially raise the response of output to increases in government spending, as emphasized in recent work by Monacelli and Perotti (2008), Bilbiie (2009), and Hall (2009). Panel B of Table 5 reports results for a model with consumption-labor complementarities in the form of GHH preferences.

With GHH preferences, the closed economy multipliers are even more sensitive to monetary

\footnote{Schmitt-Grohe and Uribe (2009) estimate a rich business cycle model with Jaimovich and Rebelo (2009) preferences—which nests GHH and King and Rebelo (1988) preferences as special cases. Their estimates show that the data strongly prefers parameters that give GHH preferences.}
policy: ranging from -1 to almost 6. The table makes clear, furthermore, that GHH preferences can either raise or lower the closed economy output multiplier in comparison to the model with separable preferences. If monetary policy is relatively unresponsive to increases in output (e.g., the constant real rate case), we find that incorporating GHH preferences raises the closed economy output multiplier. However, if monetary policy is highly responsive to output as in the Volcker-Greenspan policy, GHH preferences lead to lower multipliers. The Neoclassical (flexible price) model yields a multiplier of essentially zero. This is well within the range of multipliers implied by the New Keynesian model for alternative monetary policies as in the separable utility case.

The second data column of Panel B of Table 5 reports results for the open economy multiplier. It is 1.46 for all three specifications of our benchmark model ($\rho_g = 0.917$) and 1.92 for the case of more transitory government spending shocks ($\rho_g = 0.5$). Incorporating GHH preferences unambiguously raises our open economy multiplier. This arises because, as we describe above, real interest rates rise only slightly to offset higher output in a particular region/country in the monetary union. Since the monetary policy is effectively quite unresponsive to local shocks, the complementarity between consumption and work embodied in GHH preferences raises the output multiplier. Intuitively, since households are working more and consumption is complementary to labor, their demand for consumption is larger than in the model with separable preferences. This shifts the trade-off between more work and less consumption further towards more work and thus increases the output multiplier—so long as real interest rates do not rise too much in response to the increase in output.

Figure 6 plots relative output and consumption in our open economy model with GHH preferences after a positive shock to home government spending. Both output and consumption rise on impact by a little more than twice the amount of the shock. They then both fall more rapidly than the shock. The fact that the initial rise in consumption is as large as the rise in output implies that the home region responds to the shock by running a trade deficit in the short run. Consumption eventually falls below its steady state level for a period of time. During this time the home region is running a trade surplus. Intuitively, the complementarity between consumption and labor implies that home households want to shift their consumption towards periods of high work effort associated with positive government spending shocks.

5.4 Discussion

Let us now compare the results of these models to the empirical results from section 3. Our estimates of equation (1) based on the military procurement data suggest that the open economy multiplier
is roughly 1.5. This lies far above the open economy multipliers for the Neoclassical model—which are roughly 0.5 for both separable preferences and GHH preferences. Our empirical estimate of 1.5 is also substantially higher than the open economy multiplier of 0.82 implied by the New Keynesian model with separable preferences. Since the open economy multiplier reflects a monetary policy slightly more responsive than a fixed real rate, it cannot rise above one. Even if we assume that prices change on average only every 2 years, the open economy output multiplier in the New Keynesian model rises only to 0.94. The model with complementarities between consumption and leisure embodied in GHH preferences comes much closer to replicating the multiplier we estimate in the data. The New Keynesian model with GHH preferences yields an output multiplier of 1.46, in line with our empirical estimates.\footnote{Models with hand-to-mouth consumers of the type studied by Gali, Lopez-Salido, and Valles (2007) may also have the potential to generate large open economy multipliers.}

In contrast to the closed economy case, our estimates of the “open economy multiplier” provide a stark way of distinguishing among alternative models. Our empirical estimates are most consistent with a New Keynesian model with GHH preferences in which the effects of government spending shocks are potentially large, and are highly sensitive to monetary policy. For this specification, government spending shocks yield a small multiplier under a highly responsive monetary policy such as the Volcker-Greenspan monetary policy, but an extremely large multiplier if the monetary authority chooses to accommodate expansionary government spending, or if nominal interest rates are fixed, as in the case of monetary policy at the zero lower bound.

6 Conclusion

We study the effects of government spending on output in a monetary union. Our empirical analysis makes use of historical data on military procurement spending across U.S. regions. We measure the consequences of a differential increase in government spending in a particular region on output, employment, and prices in that region. Since regional procurement spending potentially responds to underlying economic conditions in the region, we focus only on the effects of relative changes in government spending that arise from aggregate military build-ups or draw-downs, controlling for aggregate shocks that affect all regions. Our estimates imply an open economy output multiplier of approximately 1.5.

We show that standard models have tight predictions for this statistic because different regions in a monetary union share a common monetary policy. In the closed economy setting, the fiscal
multiplier is highly sensitive to monetary policy, ranging from zero or negative in New Keynesian models with highly responsive monetary policy (such as the policy that prevailed during the Volcker-Greenspan era) to over two if the nominal interest rate is fixed—such as at the zero lower bound. The Neoclassical model yields similar multipliers to the New Keynesian model given standard (responsive) monetary policy but very different implications if monetary policy accommodates the fiscal policy expansion.

In contrast, we show that the “open economy multiplier” we estimate is not sensitive to how strongly monetary policy “leans against the wind.” This difference arises because of the special features of a monetary union. Regions in a monetary union share a fixed exchange rate and a common nominal interest rate. We show that an increase in government spending in a particular region affects the short-run real interest rate, but leaves the long-run real interest rate—the relevant interest rate for household consumption decisions—roughly unchanged. The “open economy multiplier” therefore closely resembles the closed economy multiplier under a fixed real interest rate policy. We show that our empirical results support a New Keynesian model with GHH preferences in which the effects of government spending on output are potentially large.
References


## TABLE I
The Effects of Military Spending

<table>
<thead>
<tr>
<th>Output</th>
<th>States</th>
<th>Regions</th>
<th>Output defl. State CPI</th>
<th>States</th>
<th>Regions</th>
<th>Employment</th>
<th>States</th>
<th>Regions</th>
<th>CPI</th>
<th>States</th>
<th>Regions</th>
<th>Population</th>
<th>States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prime Military Contracts</td>
<td>1.43</td>
<td>1.85</td>
<td>1.35</td>
<td>1.91</td>
<td>1.28</td>
<td>0.03</td>
<td>-0.26</td>
<td>-0.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.36)</td>
<td>(0.58)</td>
<td>(0.36)</td>
<td>(0.65)</td>
<td>(0.29)</td>
<td>(0.18)</td>
<td>(0.45)</td>
<td>(0.17)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prime Contracts plus Military Compensation</td>
<td>1.61</td>
<td>1.62</td>
<td>1.36</td>
<td>1.45</td>
<td>1.39</td>
<td>0.19</td>
<td>0.06</td>
<td>0.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.40)</td>
<td>(0.84)</td>
<td>(0.39)</td>
<td>(0.88)</td>
<td>(0.32)</td>
<td>(0.16)</td>
<td>(0.41)</td>
<td>(0.22)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The dependent variable is stated at top of each column. Each cell in the table reports results for a different regression with the main regressor of interest listed in the far left column. Standard errors are in parentheses. Military spending variables are per capita except in Population regression. All regressions include region and time fixed effects, and are estimated by two stage least squares. The sample period is 1966-2006 for output, employment and population, and 1969-2006 for the CPI. Output is state GDP, first deflated by the national CPI and then by our state CPI measures. Employment is from the BLS payroll survey. The CPI measure is described in the text. Standard errors are clustered by state or region.
### TABLE II
Alternative Specifications for Effects of Military Spending

<table>
<thead>
<tr>
<th>Prime Military Contracts</th>
<th>Prime Contracts plus Military Comp.</th>
<th>Num Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>States</strong></td>
<td><strong>Regions</strong></td>
<td><strong>States</strong></td>
</tr>
<tr>
<td>1.46</td>
<td>1.94</td>
<td>1.32</td>
</tr>
<tr>
<td><strong>(0.58)</strong></td>
<td><strong>(1.21)</strong></td>
<td><strong>(0.36)</strong></td>
</tr>
<tr>
<td>1.79</td>
<td>1.74</td>
<td>1.43</td>
</tr>
<tr>
<td><strong>(0.60)</strong></td>
<td><strong>(1.00)</strong></td>
<td><strong>(0.39)</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Num Obs.</th>
<th>1785</th>
<th>350</th>
<th>1785</th>
<th>350</th>
<th>1938</th>
<th>380</th>
<th>1989</th>
<th>390</th>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Output Level Instr.</th>
<th>Employment Level Instr.</th>
<th>Output LIML</th>
<th>BEA Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>States</strong></td>
<td><strong>Regions</strong></td>
<td><strong>States</strong></td>
<td><strong>Regions</strong></td>
</tr>
<tr>
<td>Prime Military Contracts</td>
<td>2.48</td>
<td>2.75</td>
<td>1.81</td>
</tr>
<tr>
<td><strong>(0.94)</strong></td>
<td><strong>(0.69)</strong></td>
<td><strong>(0.41)</strong></td>
<td><strong>(0.31)</strong></td>
</tr>
<tr>
<td>Prime Contracts plus Military Comp.</td>
<td>4.79</td>
<td>2.60</td>
<td>2.07</td>
</tr>
<tr>
<td><strong>(2.65)</strong></td>
<td><strong>(1.18)</strong></td>
<td><strong>(0.67)</strong></td>
<td><strong>(0.98)</strong></td>
</tr>
</tbody>
</table>

The dependent variable is stated at top of each column. Each cell in the table reports results for a different regression with the main regressor of interest listed in the far left column. Standard errors are in parentheses. Specifications: 1) Constructs per-capita output using the working age population, which is available starting in 1970; 2) Adds the price of oil interacted with state dummies as controls; 3) Adds the real interest rate interacted with state dummies as controls; 4) OLS estimates of the benchmark specification; 5) and 6) Use national military spending scaled by fraction of military spending in the state in 1966-1971 relative to the average fraction as the instrument for state spending; 7) LIML estimate of baseline specification; 8) Estimates the employment regression using the BEA employment series, which starts in 1969. All specifications include time and regions fixed effects in addition to the main regressor of interest. Standard errors are clustered by state or region depending on the specification.
<table>
<thead>
<tr>
<th>Sector</th>
<th>Weight</th>
<th>States</th>
<th>Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>0.05</td>
<td>5.43*</td>
<td>5.51*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.24)</td>
<td>(1.33)</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0.20</td>
<td>2.83*</td>
<td>3.45*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.95)</td>
<td>(1.50)</td>
</tr>
<tr>
<td>Retail</td>
<td>0.09</td>
<td>1.36*</td>
<td>1.78*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.28)</td>
<td>(0.51)</td>
</tr>
<tr>
<td>Services</td>
<td>0.18</td>
<td>0.99*</td>
<td>0.84*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.39)</td>
<td>(0.41)</td>
</tr>
<tr>
<td>Wholesale</td>
<td>0.07</td>
<td>0.44</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.35)</td>
<td>(0.63)</td>
</tr>
<tr>
<td>Mining</td>
<td>0.02</td>
<td>-0.48</td>
<td>12.88</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.03)</td>
<td>(6.89)</td>
</tr>
<tr>
<td>Agriculture</td>
<td>0.02</td>
<td>1.85</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.13)</td>
<td>(3.81)</td>
</tr>
<tr>
<td>Transportation and Utilities</td>
<td>0.08</td>
<td>-0.05</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.41)</td>
<td>(0.67)</td>
</tr>
<tr>
<td>Finance, insurance, rental, estate</td>
<td>0.17</td>
<td>0.22</td>
<td>1.93</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.71)</td>
<td>(1.39)</td>
</tr>
<tr>
<td>Government</td>
<td>0.13</td>
<td>0.15</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.34)</td>
<td>(0.64)</td>
</tr>
<tr>
<td>Federal Military</td>
<td>0.01</td>
<td>0.23</td>
<td>-1.37</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.82)</td>
<td>(1.87)</td>
</tr>
</tbody>
</table>

The table reports results of regressions of the change in sectoral state output on the change in state military spending. All regressions include region and time fixed effects, and are estimated by two stage least squares. The sample period is 1966-2006. The first data column reports the weight of each sector in total output over our sample period. All variables are in per capita terms. A star indicates statistical significance at the 5% level.
TABLE IV
Effects of Military Spending in High Versus Low Unemployment Periods

<table>
<thead>
<tr>
<th></th>
<th>Output</th>
<th>Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>States</td>
<td>Regions</td>
</tr>
<tr>
<td>$\beta_h$</td>
<td>3.54</td>
<td>3.27</td>
</tr>
<tr>
<td></td>
<td>(1.51)</td>
<td>(1.60)</td>
</tr>
<tr>
<td>$\beta_l - \beta_h$</td>
<td>-2.80</td>
<td>-1.85</td>
</tr>
<tr>
<td></td>
<td>(1.49)</td>
<td>(1.91)</td>
</tr>
</tbody>
</table>

The dependent variable is stated at top of each column. Standard errors are in parentheses. The two regressors are 1) change in military spending and 2) change in military spending interacted with a dummy indicating whether the national unemployment rate is below its median value over the sample period. This yields the effect of spending during high unemployment periods ($\beta_h$) and the difference between the effect of spending during low and high unemployment periods ($\beta_l - \beta_h$). All regressions include region and time fixed effects, and are estimated by two stage least squares. The sample period is 1966-2006. Output is state GDP. Employment is from the BLS payroll survey. All variables are per capita.
### TABLE V
Government Spending Multiplier in Business Cycle Models

<table>
<thead>
<tr>
<th>Panel A: Separable Preferences</th>
<th>Closed Economy</th>
<th>Open Economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volcker-Greenspan Monetary Policy</td>
<td>0.14</td>
<td>0.82</td>
</tr>
<tr>
<td>Constant Real Rate</td>
<td>1.00</td>
<td>0.82</td>
</tr>
<tr>
<td>Constant Nominal Rate</td>
<td>0.13</td>
<td>0.82</td>
</tr>
<tr>
<td>Constant Nominal Rate ($\rho_g=0.80$)</td>
<td>2.44</td>
<td>0.89</td>
</tr>
<tr>
<td>Flexible Prices</td>
<td>0.34</td>
<td>0.48</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B: GHH Preferences</th>
<th>Closed Economy</th>
<th>Open Economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volcker-Greenspan Monetary Policy</td>
<td>0.25</td>
<td>1.46</td>
</tr>
<tr>
<td>Constant Real Rate</td>
<td>5.00</td>
<td>1.46</td>
</tr>
<tr>
<td>Constant Nominal Rate</td>
<td>-0.93</td>
<td>1.46</td>
</tr>
<tr>
<td>Constant Nominal Rate ($\rho_g=0.50$)</td>
<td>5.59</td>
<td>1.92</td>
</tr>
<tr>
<td>Flexible Prices</td>
<td>0.00</td>
<td>0.47</td>
</tr>
</tbody>
</table>

The table reports the government spending multiplier for output deflated by the regional CPI for different specifications of the business cycle model presented in the text. Panel A presents results for the model with separable preferences, while panel B presents results for the model with GHH preferences. The first three rows in each panel differ only in the monetary policy being assumed. The fourth row in each panel varies the persistence of the government spending shock relative to the baseline parameter values. The fifth row presents results for a version of the model with flexible prices.
Figure I
Prime Military Contract Spending as a Fraction of State GDP
Figure II
Prime Military Contracts and Military Shipments
The figure shows averages of changes in output and predicted military spending (based on our first-stage regression), grouped by 30 quantiles of the predicted military spending variable. Both variables are demeaned by year and state fixed effects.
Figure IV
Prices and Real Interest Rates after a Government Spending Shock
The figure plots the relative price level and the relative real interest rate in the two regions for the model with separable preferences after a positive government spending shock to the home region.

Figure V
Consumption and Real Interest Rate after a Government Spending Shock
The figure plots the relative consumption and the relative real interest rate in the two regions for the model with separable preferences after a positive government spending shock to the home region.
Figure VI
Output and Consumption after a Government Spending Shock in GHH Model

The figure plots the relative output and consumption in the two regions for the model with GHH preferences after a positive government spending shock to the home region.