How does an increase in government purchases affect the economy?

Martin Eichenbaum and Jonas D. M. Fisher

Introduction and summary

A classic question facing macroeconomists is: How does an increase in government purchases affect the economy? Our interest in this question is motivated by the desire to evaluate the properties of different rules and institutions for setting fiscal policy. For example, should government purchases vary systematically over the business cycle? What would the macroeconomic consequences of a balanced budget amendment be? What would the effect of a permanent decline in defense purchases be on aggregate employment and real wages? If we had observations on otherwise identical economies operating under the different fiscal policies that we are interested in evaluating, it would be easy to answer these types of questions. But we do not. So we have no choice but to attack them within the confines of economic models.

Which model should we use? We have at our disposal a plethora of competing business cycle models, each of which incorporates different views of the way the economy functions and makes different recommendations for macroeconomic policy. So one's views about the costs and benefits of different policy proposals depends critically on the model being used to assess the proposal. In this sense, research aimed at assessing the empirical plausibility of competing models is a crucial input to the policy process. One approach for choosing among competing models is to compare their predictions for the consequences of a shock for which we know how the actual economy responds.[1] To the extent that different models give rise to different predictions, some will be counterfactual and can be eliminated from the field of choice.

Shocks to government spending are likely to be useful in this regard. This is because many models give rise to different predictions for the effects of an increase in government purchases on real wages and average labor productivity (output per man hour). *Neoclassical models* of the sort discussed in Barro (1981), Aiyagari, Christiano, and Eichenbaum (1992) and Edelberg, Eichenbaum, and Fisher (1998) assume constant returns to scale and perfect competition. Models of this sort predict that real wages fall after an exogenous increase in government purchases, that is, after a change in government purchases that was not caused by other developments in the economy. For reasons discussed below, other models which deviate from the assumptions embedded in the neoclassical model generate different predictions. For example, models embodying increasing returns and imperfect competition of the sort considered by Devereaux, Head, and Lapham (1996) and Rotemberg and Woodford (1992) predict that real wages ought to rise. Which of the two predictions is correct?

Competing business cycle models also give rise to different predictions for how average labor productivity responds to an increase in government purchases. For example, some authors assume that average productivity of firms depends on the level of aggregate economic activity (for example, Baxter and King, 1992 and Farmer, 1993). Others assume that increasing returns to scale occur at the firm level (see Farmer, 1993). These models predict that average labor productivity should rise after an exogenous increase in government purchases. This prediction also emerges in models that allow for labor hoarding and variable capital utilization rates (Burnside, Eichenbaum, and Rebelo, 1993 and Burnside and Eichenbaum, 1996). Standard neoclassical models with constant returns to scale production functions (Aiyagari, Christiano, and Eichenbaum, 1992) predict that average labor

Martin Eichenbaum is a professor of economics at Northwestern University, a consultant to the Federal Reserve Bank of Chicago, and a research associate at the National Bureau of Economic Research. Jonas Fisher is a senior economist at the Federal Reserve Bank of Chicago. *The authors thank Judy Yoo for research assistance.*

productivity should fall. As with real wages, the key question is: Which prediction is correct?

The major difficulty in answering this question is identifying *exogenous* changes to government purchases. Simply observing what happens to real wages and average labor productivity after government purchases change does not reveal the effects of the changes in government purchases per se. This is because government purchases themselves are affected by developments in the private economy, say because of attempts to stabilize the business cycle. In these cases movements in real wages and average labor productivity confound the effect of government purchases and the factors that caused those purchases to change.

Various approaches for identifying exogenous changes in government purchases have been pursued in the literature.[2] Here, we build on the approach used by Rotemberg and Woodford (1992) and Ramey and Shapiro (1997) who focus on exogenous movements in defense spending as a proxy for exogenous movements in total government purchases. To isolate such movements, Ramey and Shapiro (1997) identify three political events that led to large military build ups which were arguably unrelated to developments in the domestic U.S. economy: the Korean War, the Vietnam War, and the Carter–Reagan military build up. We refer to these events as *Ramey–Shapiro episodes*. As in Edelberg, Eichenbaum, and Fisher (1998), our basic strategy is to document the behavior of various macro aggregates after the onset of the Ramey–Shapiro episodes, controlling for other developments in the U.S. economy.

Our main findings can be summarized as follows.[3] First, aggregate output and employment rise after an increase in government purchases. Second, real wages fall after an increase in government purchases. This is true across a broad range of real wage measures, including the measure used by Rotemberg and Woodford (1992) who argued that real wages rise after a positive shock to government purchases. Third, there is mixed evidence regarding the response of average labor productivity to a positive shock in government purchases: It falls in the manufacturing sector but rises in the private business sector as a whole.

Our first finding is consistent with the predictions of all the models discussed above. Our second finding casts doubt on the empirical plausibility of the class of business cycle models which predict that real wages rise after an increase in government purchases. Our third finding suggests that it is premature to eliminate any of the competing models based on the response of average productivity to a shock in government purchases.

In the next section, we summarize some competing models and their predictions for the response of real wages and average productivity to a shock in government purchases. Then we assess the empirical plausibility of these models by analyzing what actually happens after a shock to government purchases.

Shocks to product demand and the labor market

Two of the many dimensions along which competing business cycle models differ are their assumptions about the degree of competition in product markets and the degree to which households internalize increases in tax liabilities associated with changes in government purchases. These differences give rise to different predictions for the response of real wages and average productivity to an increase in government purchases.

Neoclassical models assume that, at least to a first approximation, 1) product and labor markets are perfectly competitive, 2) if a firm increased the input of all its factors of production by a given percentage, then its output would rise by the same percentage, that is, output is produced using a constant returns to scale technology, and 3) in the short run, due to some factors of production being in fixed supply, the increase in output that results from hiring an additional worker, that is, the marginal product of labor, declines in the amount of labor hired.[4]

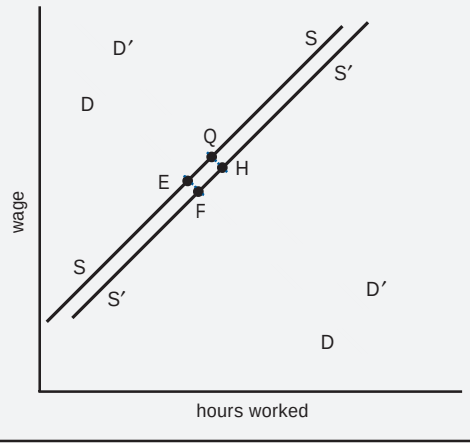
The first assumption implies that it is optimal for a firm to hire labor until the real wage equals the marginal product of labor. This rule gives rise to a demand curve for labor of the type labelled *DD* in figure 1. This curve specifies the amount of labor that the typical firm is willing to hire at any given real wage rate. Assumption 3 implies that the demand curve for labor is downward sloping: Other things equal, an increase in the real wage rate reduces the firm's demand for labor.

According to models embodying assumptions 1–3, the only factors that shift the market demand curve for labor are those which affect the marginal product of labor schedule. An example is a technological improvement that raises the entire marginal product of labor schedule. In contrast, an increase in government purchases or the demand for goods from overseas has no effect on the marginal product of labor schedule. So, these types of changes would not affect the demand curve for labor.

We now turn to the supply of labor. Many business cycle models assume perfectly competitive labor markets in which workers decide how much labor to supply, taking as given the real wage (see King and Rebelo, 1998, for a review). The representative labor

FIGURE 1

Equilibrium in the labor market



supplier behaves in a way that equates the marginal benefit and marginal cost of working. The marginal benefit equals the real wage rate times the marginal utility of wealth. The marginal cost equals the marginal utility of leisure. Under standard assumptions, this behavior implies that an individual's supply of labor will be an increasing function of the real wage rate. This relationship is summarized by the curve, labelled *SS*, depicted in figure 1.

Equilibrium in the labor market is depicted in figure 1 by the point E where the labor supply and demand curves intersect. Shocks to the economy affect employment and real wages by shifting one or both of these curves. We have already argued that, in the neoclassical model, an increase in government purchases does not affect the demand for labor. So to affect equilibrium real wages and hours worked, an increase in government purchases must affect the supply of labor. It does this by affecting the marginal utility of wealth.

Suppose that individuals are rational, forward looking, and understand that an increase in the present value of government purchases raises the present value of their tax obligations and lowers their after tax wealth. Other things equal, this raises individuals' marginal utility of wealth and shifts their labor supply curve to the right.[5] Put differently, the fact that individuals feel poorer because of the rise in their tax obligation causes them to offer more labor at any given real wage rate. In Figure 1 the new labor supply curve is labelled $D'D'$. The new equilibrium is depicted by the point F. It follows that in neoclassical models a rise in government purchases will lead to a rise in employment and output but a decline in real wages and the marginal product of labor.[6] For many specifications of technology, the decline in the marginal product of labor also implies that average labor productivity falls.

Based on empirical evidence discussed below, Rotemberg and Woodford (1992) argue that the predicted fall in real wages is counterfactual. To remedy this claimed defect, they abandon the assumption that firms are perfect competitors in the goods market. Instead they assume that firms have some market power and can set price above marginal cost. We refer to the ratio of price to marginal cost as the markup. With market power, firms will hire labor up to the point where the marginal product of labor is equal to the markup multiplied by the real wage rate.

Note that variations in the markup will affect the demand for labor just as technological improvements do. Suppose that a rise in the demand for goods drives firms' markups down, that is, markups behave in a countercyclical manner. Then the demand curve for labor will shift to the right, say to $D'D'$ in figure 1, that is, at a given real wage rate firms will now wish to hire more labor. Rotemberg and Woodford (1992) discuss a variety of models of imperfect competition in which markups fall when the demand for goods is high.

For simplicity, suppose that consumers do not internalize the rise in tax liabilities associated with a rise in government purchases. Then, only the labor demand curve will shift in response to an increase in government purchases. The new equilibrium is depicted in figure 1 by the point Q. So here an increase in government purchases leads to an increase in real wages as well as employment and output. As in neoclassical models, the marginal and average product of labor falls.[7] So the key difference between these models lies in their prediction for the response of real wages.

Of course one could allow for labor supply effects in models with imperfect competition, as Rotemberg and Woodford (1992) do. Under these circumstances, both the demand and the supply curve would shift to the right when government purchases rise. Real wages would rise or fall depending on whether the demand or the supply effect dominated. Given Rotemberg and Woodford's (1992) assumptions, the demand effect dominates and real wages rise. This situation is depicted in figure 1 by the point H which lies at the intersection of the curves labelled $D'D'$ and $S'S'$.

Other models exist in which the real wage could rise after an increase in government purchases. For example, Baxter and King (1992) and Farmer (1993) discuss models in which perfectly competitive firms produce output using a technology that exhibits constant returns to scale in firms' own factors of production. But, unlike all of the models discussed above, it

is assumed that each firm's output is an increasing function of aggregate output. Now suppose that an increase in government purchases leads to a shift in the supply of labor. Given the assumptions in Baxter and King (1992) and Farmer (1993), the increase in aggregate output leads to an upward shift in the marginal product of labor schedule. This in turn shifts the demand for labor to the right, that is, at every given real wage rate firms would like to hire more labor. After all adjustments have been made, the net result will be a rise in employment and output, and if the externalities are sufficiently large, a rise in the marginal product of labor, the average product of labor, and real wages.[8]

Finally, we note that neoclassical models and models embodying imperfect competition can be modified to reverse their prediction that average labor productivity falls after an increase in government purchases. For example, Burnside, Eichenbaum, and Rebelo (1993) and Burnside and Eichenbaum (1996) modify a neoclassical model by allowing for labor hoarding and variable capital utilization. In their models, labor effort and capacity utilization rise after an increase in government purchases. For example, firms could increase line speeds or add extra shifts. The result is that in response to an increase in government purchases, employment, output, and measured average labor productivity all rise, while real wages continue to fall. Presumably one could modify Rotemberg and Woodford's (1992) model in a similar way to overturn the prediction that measured average productivity falls after a positive shock to government purchases.

In sum, competing business cycle models generate different predictions for the effects of a shock to government purchases. Next we assess these models by analyzing what actually happens after a shock to government purchases.

Identifying exogenous movements in government purchases

As discussed above, government purchases, G_t, respond to many developments in the economy. Consequently we must make assumptions to isolate movements in G_t that were not caused by the response of the government to factors affecting the private economy. Various authors have argued that defense purchases, g_t, are less likely to respond to private sector developments.

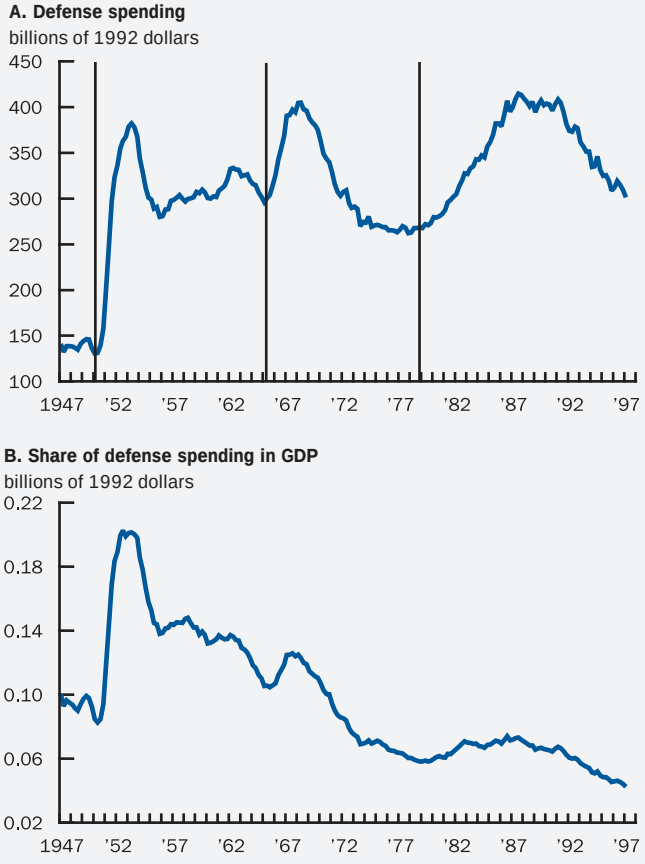
Based on their reading of history and contemporary news accounts, Ramey and Shapiro (1997) argue that they are able to isolate three arguably exogenous events that led to large military build ups: the Korean War, the Vietnam War, and the Carter–Reagan build up. They date these events at third quarter 1950, first quarter 1965, and first quarter 1980.[9]

As background to our analysis, panel A of figure 2 reports the log of real defense expenditures with vertical lines at the dates of the Ramey–Shapiro episodes. Panel B of figure 2 reports the share of defense spending in gross domestic product (GDP). Note that the time series on real defense expenditures is dominated by three events: the large increase in real defense expenditures associated with the Korean War, the Vietnam War, and the Carter–Reagan defense build up. The Ramey–Shapiro dates essentially mark the beginning of these episodes.

Various econometric procedures can be used to exploit the identifying assumption that the Ramey–Shapiro episodes corresponded to the onset of

FIGURE 2

Post World War II U.S. defense purchases



Note: The lines in panel A represent Ramey-Shapiro episodes.
Source: U.S. Department of Commerce, Bureau of Economic Analysis.

exogenous increases in government purchases. The procedure that we used is described in box 1. Our basic strategy is to summarize how the economy evolves over time using a statistical model which was estimated using quarterly U.S. data for the first quarter of 1948 through the fourth quarter of 1988. We chose this sample period to preserve comparability with Rotemberg and Woodford (1992). Edelberg, Eichenbaum, and Fisher (1998) present results obtained using data from the first quarter of 1948 through the first quarter of 1996.

Given our statistical model, we use a simulation procedure to estimate how the economy responded to the onset of a Ramey–Shapiro episode. The simulated response functions which we report below give the impact of an average increase in defense expenditures, where the average is taken across the three Ramey–Shapiro episodes. Under our assumptions, these correspond to an estimate of how the variable of interest would respond to a similar exogenous increase in government purchases. As a matter of terminology, we refer to the dynamic response of a variable to the onset of a Ramey–Shapiro episode as the response of that variable to a positive shock in government purchases.

Empirical results

The response of output and employment

Figure 3 reports our estimates of the dynamic response of real defense spending, total government purchases, and aggregate output to the onset of a Ramey–Shapiro episode. The black lines display our point estimates. The colored lines correspond to 68 percent confidence interval bands. Consistent with results in Edelberg, Eichenbaum, and Fisher (1998), we find that the onset of a Ramey–Shapiro episode

BOX 1

Our econometric procedure

The statistical procedure that we used can be described as follows. Define the set of WAR dummy variables D_t, where $D_t = 1$ if $t = \{1950{:}Q3, 1965{:}Q1, 1980{:}Q1\}$ and zero otherwise. Denote by X_t the time t value of the set of macroeconomic variables that we are interested in studying. We assume that X_t consists of a group of k variables which evolves over time according to:

$$1) \quad X_t = \sum_{i=1}^{L} A_i X_{t-1} + \sum_{i=0}^{L} B_i D_{t-1} + u_t.$$

Here A_i and B_i, $i = 1, \ldots, L$ are sets of $k \times k$ matrices and u_t is a vector of identically and independently distributed random variables which are uncorrelated with X_{t-i}, $i > 0$, and D_{t-i}, $i \geq 0$. Equation 1, which is referred to as the vector autoregressive representation (VAR) of X_t, describes how the economy evolves over time as a function of past history and current shocks to the system. Given estimates of A_i and B_i, we can estimate the dynamic response of X_t to a shock in defense expenditures by simulating the system in equation 1 under the assumption that D_t takes on the value of one. Under our assumptions we can obtain consistent estimates of these matrices using equation-by-equation least squares.

Unless otherwise stated, in our analysis the vector X_t consisted of the log level of time t real *GDP*, the net three-month Treasury bill rate, the log of the producer price index of crude fuel, the log level of Ramey and Shapiro's measure of real defense purchases, g_t, and the log level of the variable whose response function we are interested in. In the case of inflation, we include the time t rate of inflation in X_t.

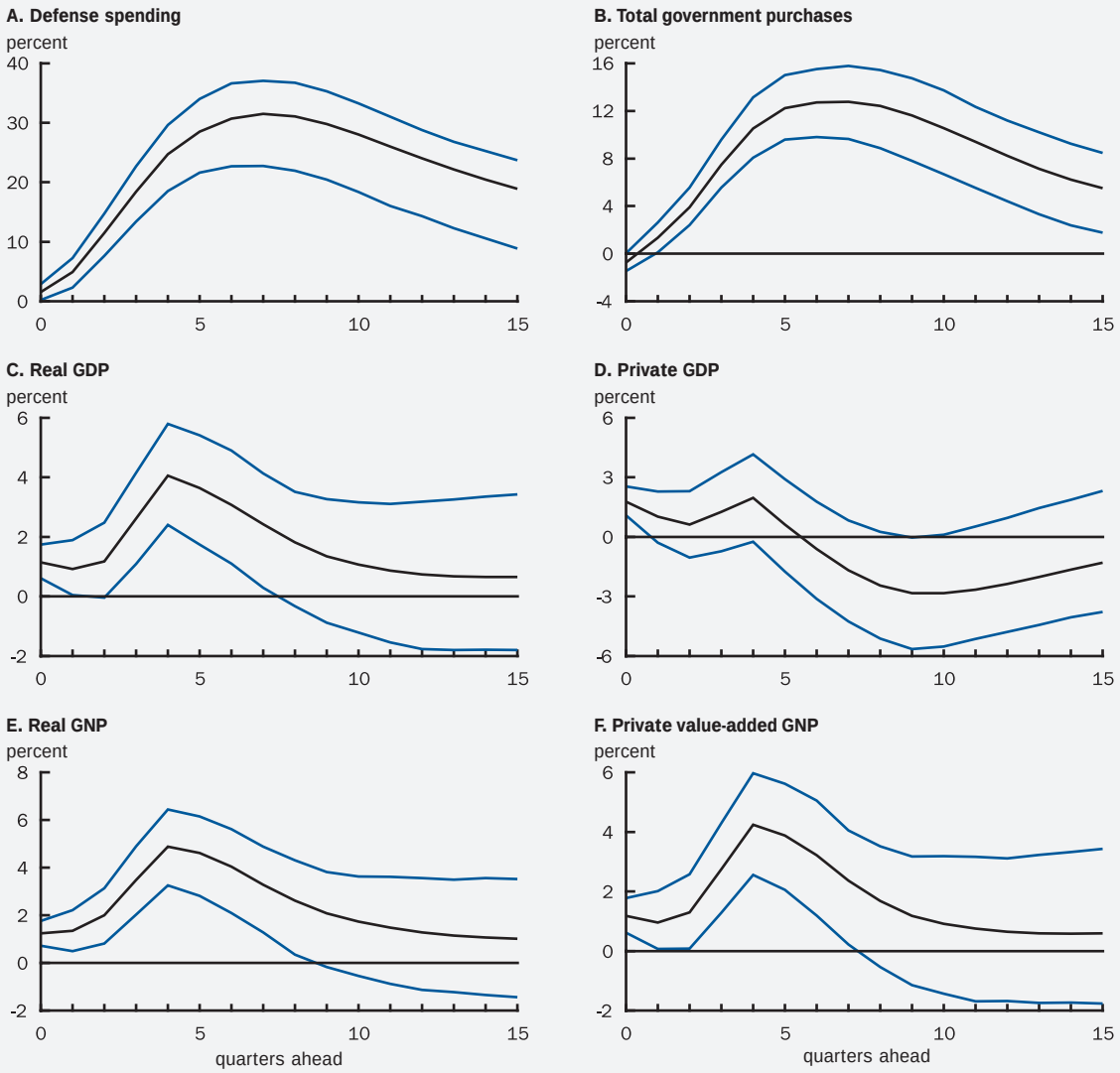
We computed standard errors for our estimated response functions using the following *bootstrap Monte Carlo procedure*. We constructed 500 time series on the vector X_t as follows. Let $\{\hat{u}_t\}_{t=1}^{T}$ denote the vector of residuals from the estimated VAR. We constructed 500 sets of new time series of residuals, $\{\hat{u}_t(j)\}_{t=1}^{T}$, $j = 1, \ldots, 500$. The tth element of $\{\hat{u}_t(j)\}_{t=1}^{T}$ was selected by drawing randomly, with replacement, from the set of fitted residual vectors, $\{\hat{u}_t(j)\}_{t=1}^{T}$. For each $\{\hat{u}_t(j)\}_{t=1}^{T}$ we constructed a synthetic time series of X_t, denoted $\{X_t(j)\}_{t=1}^{T}$, using the estimated VAR and the historical initial conditions on X_t. We then reestimated the VAR using $\{X_t(j)\}_{t=1}^{T}$ and the historical initial conditions, and calculated the implied impulse response functions for $j = 1, \ldots, 500$. For each fixed lag, we calculated the 80th lowest and 420th highest values of the corresponding impulse response coefficients across all 500 synthetic impulse response functions. The boundaries of the confidence intervals in the figures correspond to a graph of these coefficients.

leads to a large, persistent, hump-shaped rise in real defense expenditures. These initially rise by about 1 percent, with a peak response of 30 percent roughly six quarters after the shock. The response of total real government purchases is similar to that of defense purchases. While the response is smaller, it is still substantial: Total government purchases rise in a hump-shaped pattern with a peak response of 12 percent.

Next we consider the response of aggregate output to a shock in government purchases. Paralleling the rise in defense expenditures, there is a delayed, hump-shaped response in real GDP, with a peak response of about 3.5 percent four quarters after the shock. The increase in private real GDP, defined as GDP minus federal, state, and local government purchases, is much smaller, with a peak response of about 1.8 percent. In their analysis, Rotemberg and

FIGURE 3

Response of aggregate output to an increase in government purchases
(percentage response to WAR dummy)



Notes: Author estimations are described in the box. Each response is estimated using a five-variable system which includes the response variable, the three-month Treasury bill interest rate, defense purchases, real GDP, and the Producer Price Index of crude fuel in manufacturing industries. The black lines are point estimates of the response functions and the colored lines are the 68 percent confidence bands computed by the procedure in the box.

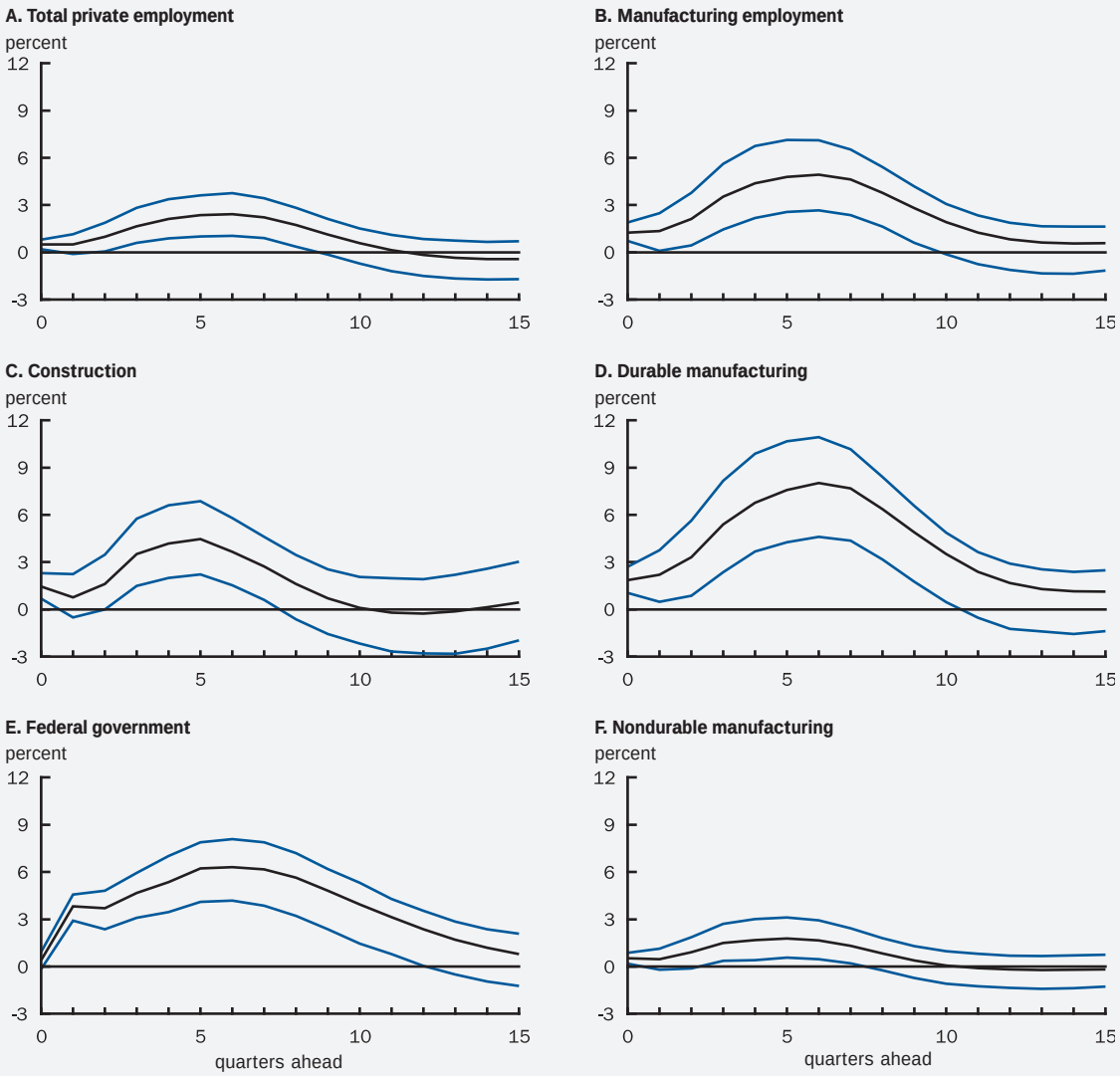
Sources: Author's calculations from data from U.S. Department of Commerce, Bureau of Economic Analysis—response variable, defense purchases, and real GDP; Board of Governors of the Federal Reserve System—Treasury bill interest rate; and U.S. Department of Labor, Bureau of Labor Statistics—Producer Price Index of crude fuel.

Woodford (1992) measure aggregate output using private sector value added, defined as real gross national product (GNP) minus real value added by federal, state, and local governments. From figure 3 we see that real GDP, real GNP, and private sector value added respond in similar ways to a shock in government purchases. However the peak increase in private sector value added is considerably larger than the peak increase in private GDP.

Figure 4 displays the response of employment to a positive shock in government purchases. Notice that total private employment rises in a hump-shaped pattern which parallels the hump-shaped increase in defense and total government purchases. The response of employment in the manufacturing sector is qualitatively similar to the response of total private employment but is larger with a peak increase of roughly 5 percent. Employment in both manufacturing durables

FIGURE 4

Response of employment to an increase in government purchases
(percentage response to WAR dummy)



Notes: Author estimations are described in the box. Each response is estimated using a five-variable system which includes the response variables, the three-month Treasury bill interest rate, defense purchases, real GDP, and the Producer Price Index of crude fuel in manufacturing industries. The black lines are point estimates of the response functions and the colored lines are the 68 percent confidence bands computed by the procedure in the box.

Sources: Author's calculations from data from U.S. Department of Commerce, Bureau of Economic Analysis—defense purchases and real GDP; Board of Governors of the Federal Reserve System—Treasury bill interest rate; and U.S. Department of Labor, Bureau of Labor Statistics—response variables, Producer Price Index of crude fuel.

and nondurables grows, with the increase in the first sector exceeding the increase in the second sector.[10] Consistent with Edelberg, Eichenbaum, and Fisher's (1998) finding that structural investment rises after a positive shock to government purchases, we see that employment in the construction sector rises. Finally, figure 4 indicates that employment by the federal government also increases.

We conclude, as do Rotemberg and Woodford (1992), Ramey and Shapiro (1997), Blanchard and Perotti (1998), and Edelberg, Eichenbaum, and Fisher (1998), that a positive shock to government purchases leads to a broad-based expansion in aggregate economic activity, with private output expanding by less than total output. Since this finding is consistent with all of the models discussed in the second section of this article, we cannot use it to discriminate between them. For that, we must turn to the responses of real wages and average productivity.

The response of inflation and real wages

All of our measures of the returns to work are constructed deflating some nominal measure of wages by a price index. Therefore it is useful to understand how the different price indexes we use respond to a shock in government purchases. Figure 5 summarizes the response functions of four price indexes and the corresponding inflation rates. These price indexes are the GDP deflator, the Consumer Price Index (CPI), the Producer Price Index (PPI), and Rotemberg and Woodford's (1992) private value added deflator.[11] The key result here is that all four price levels and inflation rates rise in response to the shock in government purchases.

With this as background, we now consider the way the return to work responds to an exogenous increase in government spending. Figure 6 displays the response patterns of eight measures of real compensation: compensation in the private business sector and in the manufacturing sector, each deflated by the four price indexes discussed above. Two key results emerge here. First, regardless of which measure we use, real compensation falls after a positive shock to government purchases. Second, compensation in the manufacturing sector falls more than compensation in the overall private business sector. Therefore compensation falls more in the sectors of the economy experiencing the largest growth in employment after the shock to government purchases.

Next we consider the response of real wages in the manufacturing sector. Figure 7 displays the response of eight different measures of real wages to a positive shock in government purchases: before- and after-tax real wage rates in the manufacturing sector, calculated using the CPI, the PPI, the GDP deflator, and the private value added deflator, respectively.[12] The key results here are 1) as in Edelberg, Eichenbaum, and Fisher (1998), *every* measure of real wages falls after a positive shock to government purchases, and 2) after-tax real wages fall by more than before-tax real wages.[13] This second result is noteworthy because it is the after-tax real wage rate that is relevant for assessing the response of labor supply to an increase in government purchases.

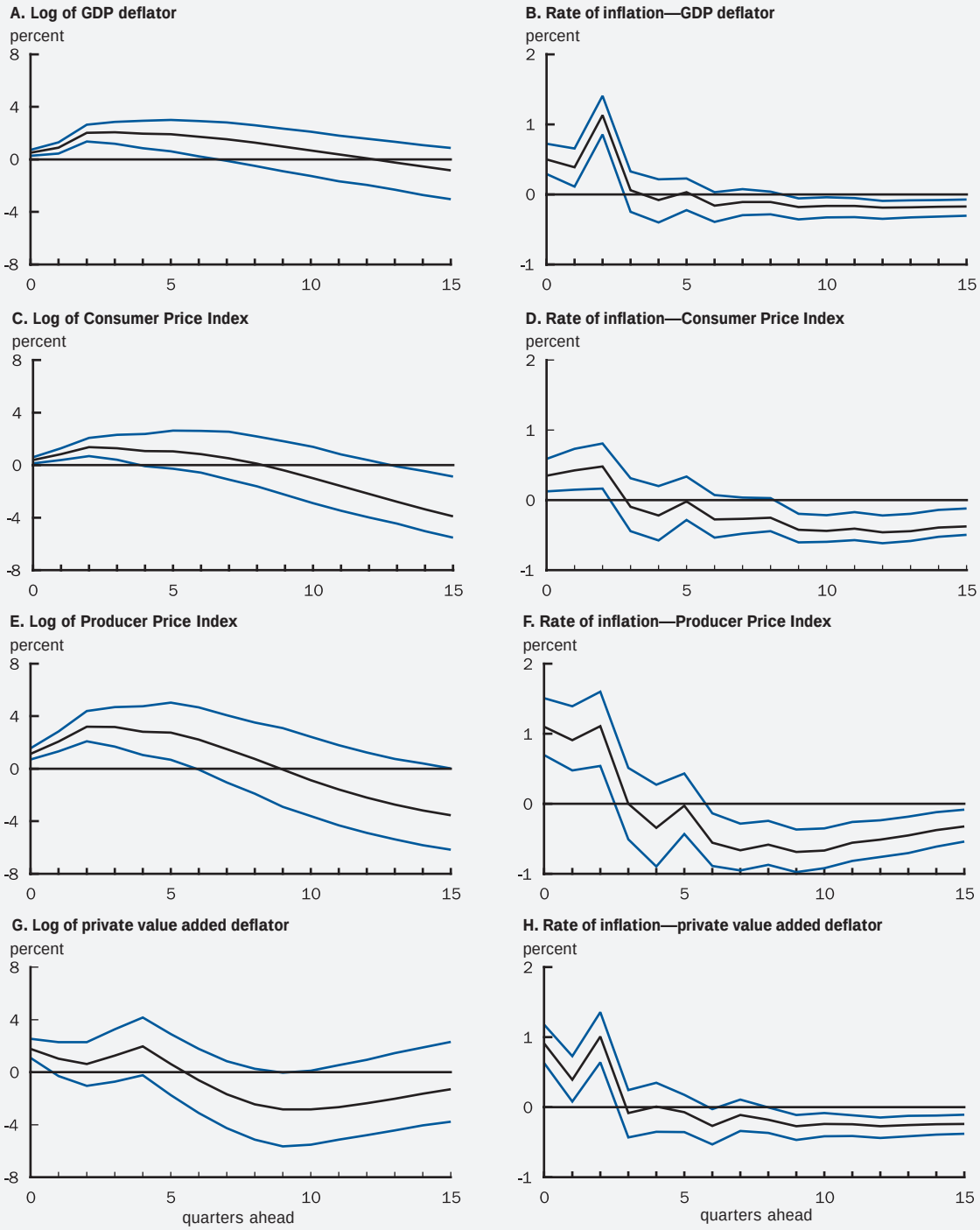
It is worth emphasizing that the real wage measure, denoted Manufacturing Wages/Private Value Added, is the same as the one used by Rotemberg and Woodford (1992). These authors argue that real wages increase after an increase in government purchases. The only difference between our analysis and theirs is the way exogenous increases in government purchases are identified. Like us, Rotemberg and Woodford (1992) seek to identify exogenous movements in government purchases with movements in defense purchases. But their procedure for isolating exogenous movements in defense purchases is different from ours. Specifically, they identify such movements with the error term in a regression of military purchases on lagged values of itself and the number of people employed by the military. Edelberg, Eichenbaum, and Fisher (1998) argue that there are at least three reasons for being skeptical of regression-based measures of exogenous shocks to government purchases. First, the estimated innovations may reflect shocks to the private sector that cause defense contractors to optimally rearrange delivery schedules, say because of strikes or other developments in the private sector. Second, private agents and the government may know about a planned increase in defense purchases well before it is recorded in the data. For example, suppose that the government receives information at a particular date that causes it to commit to a stream of defense purchases in the future. The variables used in the regression for military purchases may not contain this information. If this is the case, then the regression-based procedure would generate, at best, a polluted measure of exogenous shocks to government purchases. Finally, inference using regression-based measures of shocks to government purchases appears to be quite fragile to perturbations in the sample period used as well as the list of variables used (see Christiano, 1990).

To see what impact adopting the regression-based procedure would have on our results, we adopted as our measure of a shock to defense purchases the error term obtained by regressing g_t on four lags of the log level of real *GDP,* the net three-month Treasury bill rate, the log of the Producer Price

FIGURE 5

Response of prices and inflation to an increase in government purchases

(percentage response to WAR dummy)

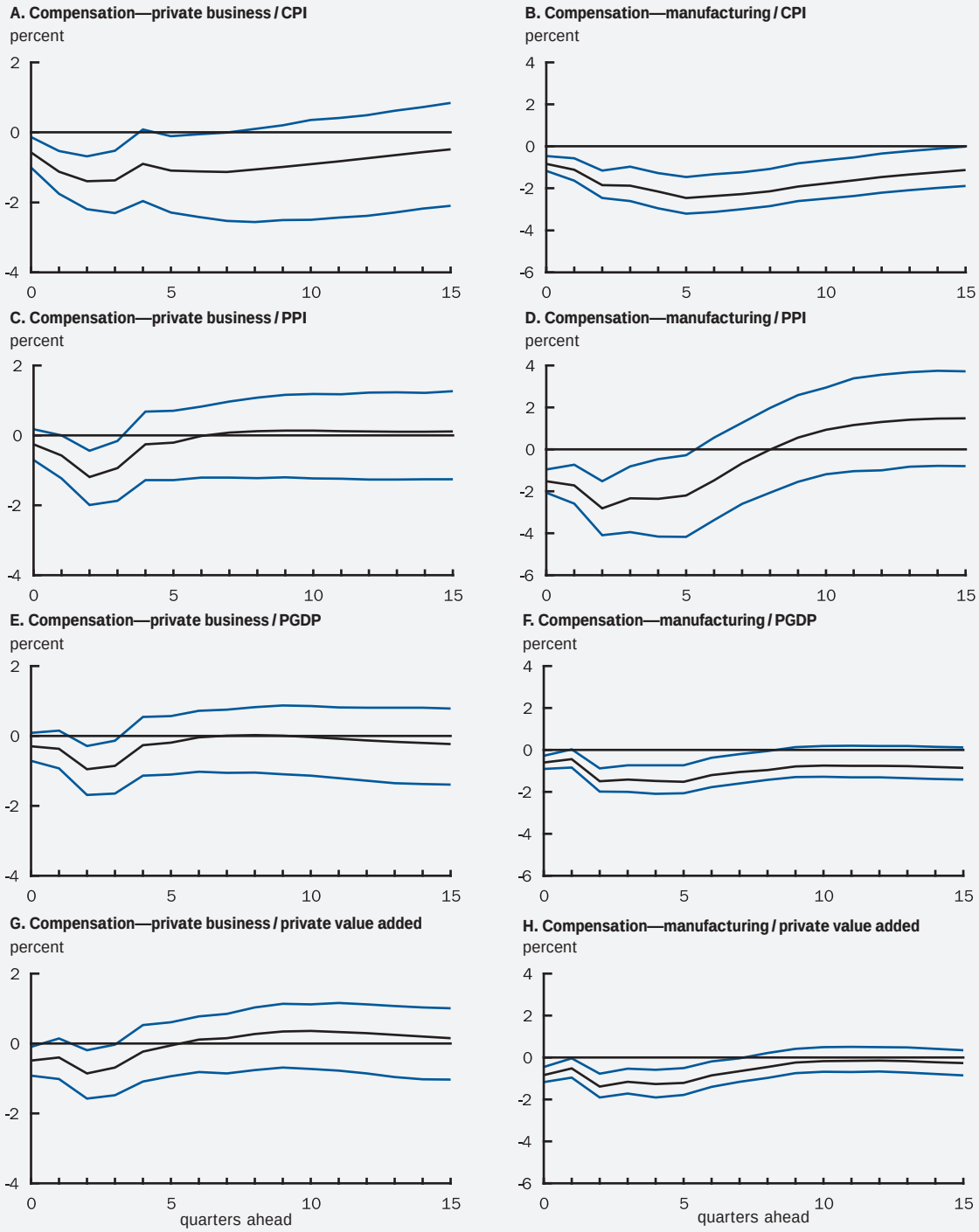


Notes: Author estimations are described in the box. Each response is estimated using a five-variable system which includes the response variable, the three-month Treasury bill interest rate, defense purchases, real GDP, and the Producer Price Index of crude fuel in manufacturing industries. The black lines are point estimates of the response functions and the colored lines are the 68 percent confidence bands computed by the procedure in the box.

Sources: Author's calculations from data from U.S. Department of Commerce, Bureau of Economic Analysis—response variables for the GDP deflator and real private value added, defense purchases and real GDP; Board of Governors of the Federal Reserve System—Treasury bill interest rate; and U.S. Department of Labor, Bureau of Labor Statistics—response variables for the Producer Price Index, Consumer Price Index, and the Producer Price Index of crude fuel.

FIGURE 6

Response of compensation to an increase in government purchases
(percentage response to WAR Dummy)



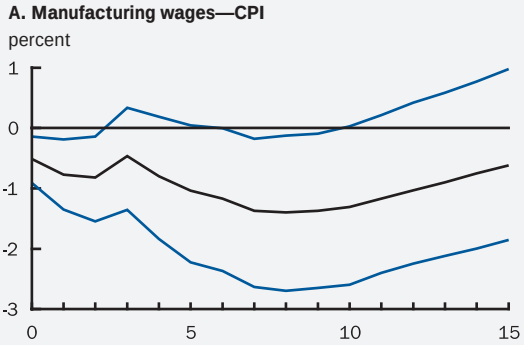
Notes: Author estimations are described in the box. Each response is estimated using a five-variable system which includes the response variable, the three-month Treasury bill interest rate, defense purchases, real GDP, and the Producer Price Index of crude fuel in manufacturing industries. The black lines are point estimates of the response functions and the colored lines are the 68 percent confidence bands computed by the procedure in the box.

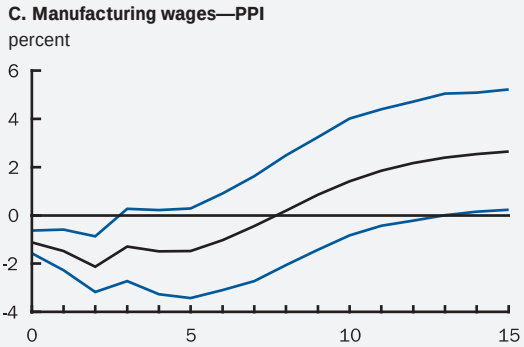
Sources: Author's calculations from data from U.S. Department of Commerce, Bureau of Economic Analysis—response variable, deflators for PGDP and private value added, defense purchases, and real GDP; Board of Governors of the Federal Reserve System—Treasury bill interest rate; and U.S. Department of Labor, Bureau of Labor Statistics—deflators for the Producer Price Index and Consumer Price Index, compensation, and the Producer Price Index of crude fuel.

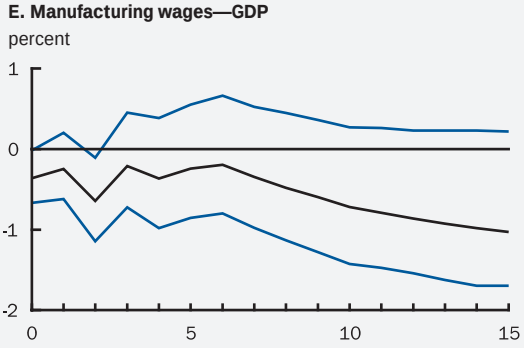
FIGURE 7

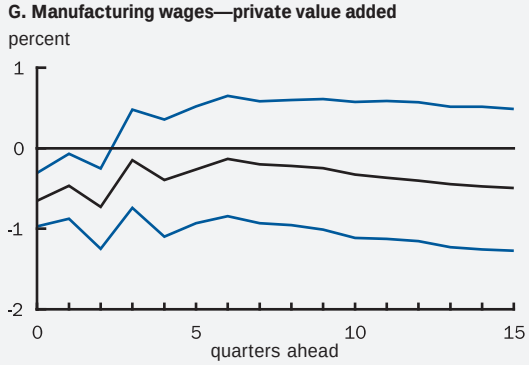
Response of real wages to an increase in government purchases

Before tax

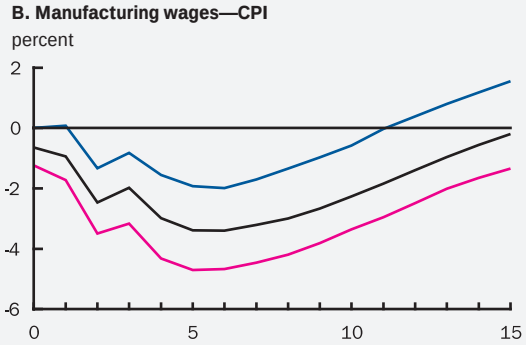


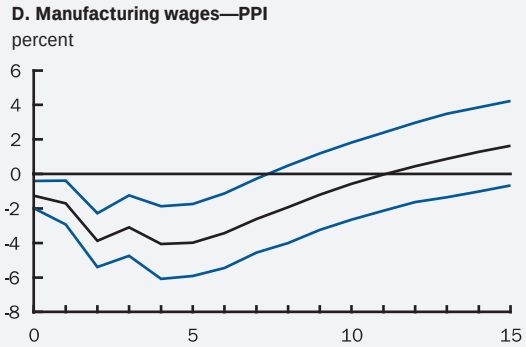


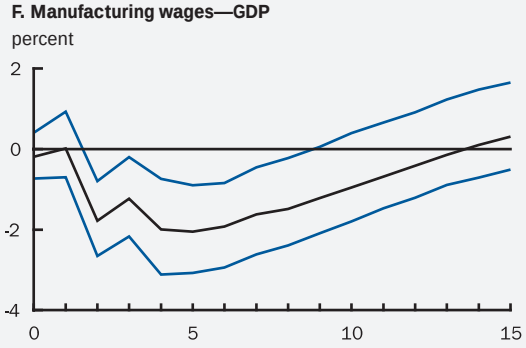


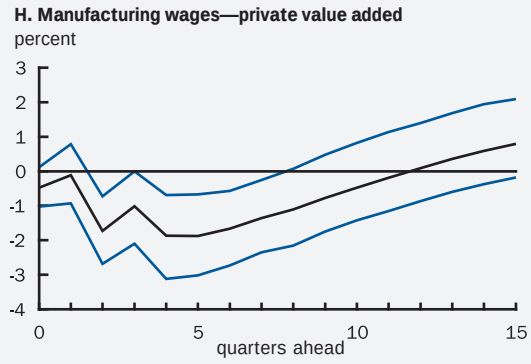


After tax









Notes: Author estimations are described in the box. Each response is estimated using a five-variable system which includes the response variable, the three-month Treasury bill interest rate, defense purchases, real GDP, and the Producer Price Index of crude fuel in manufacturing industries. The black lines are point estimates of the response functions and the colored lines are the 68 percent confidence bands computed by the procedure in the box.

Sources: Author's calculations from data from U.S. Department of Commerce, Bureau of Economic Analysis—response variable, deflators for PGDP and private value added, defense purchases, and real GDP; Board of Governors of the Federal Reserve System—Treasury bill interest rate; U.S. Department of Labor, Bureau of Labor Statistics—deflators for the Producer Price Index and Consumer Price Index, wages, and the Producer Price Index of crude fuel; and Fairlie and Meyer (1996)—taxes.

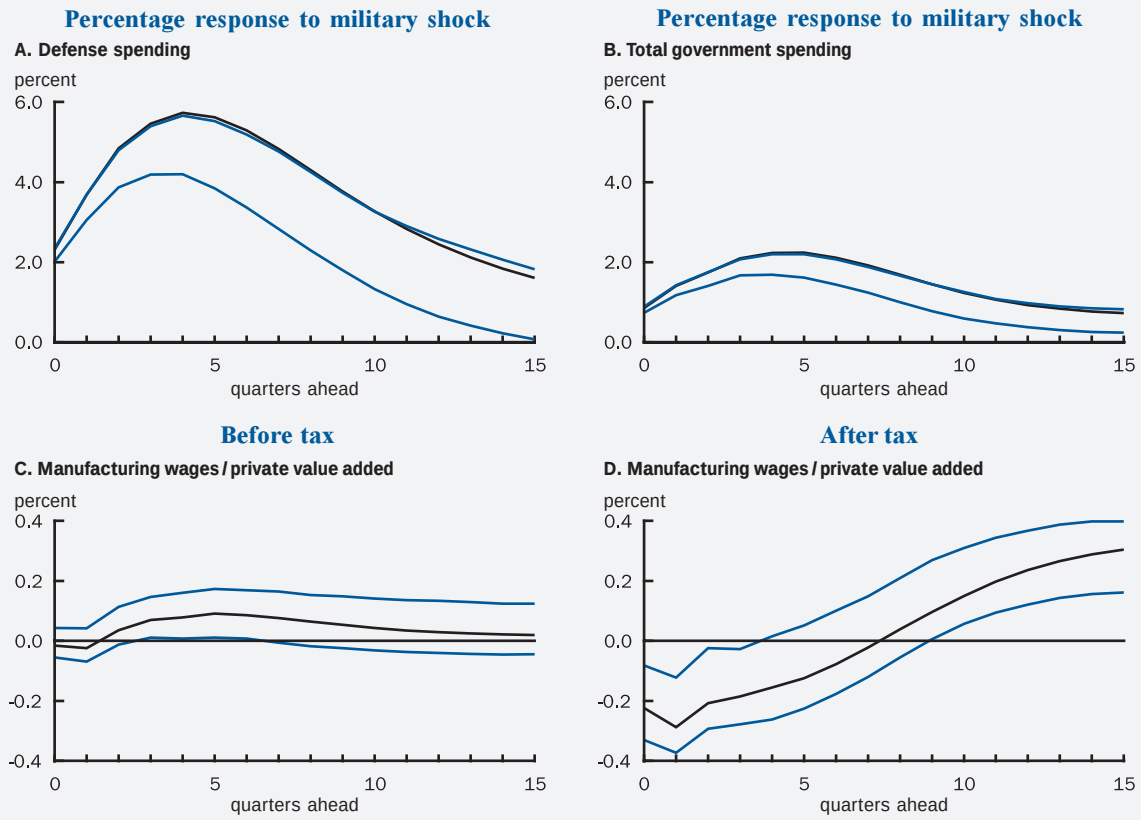
Index of crude fuel, and g_t.[14] Figure 8 displays the corresponding estimated response functions of defense spending, total government purchases, and Rotemberg and Woodford's (1992) real wage measure. Three key results emerge. First, the new shock measure continues to generate a hump-shaped increase in defense spending and total government purchases. Second, after an increase in the new shock measure, the before-tax version of Rotemberg and Woodford's (1992) real wage measure briefly falls, but then rises. We conclude that the reason for the difference between our results and those of Rotemberg and Woodford (1992) is that we identify an exogenous increase in government purchases in different ways. Third, even with the new shock measure, the after-tax version of Rotemberg and Woodford's (1992) wage measure falls in response to a rise in government purchases. Viewed overall, we believe that the preponderance of the evidence is clear: Real wages fall, rather than rise, after an exogenous increase in government purchases.

The response of average productivity

Figure 9 presents our estimates of the response of average productivity to a positive shock in government purchases. As can be seen, average productivity falls in the manufacturing sector. Interestingly, it falls by more in the sector where output and employment rise the most: durables manufacturing. This is consistent with models which assume that output is produced using a constant return to scale technology and which abstract from varying labor effort and capacity utilization. However, average productivity in the business and nonfarm sectors appears to rise. This offers support to alternative theories which allow

FIGURE 8

Response of aggregates to a positive shock in government purchases: Alternative identification scheme



Notes: Author's estimations are described in text and includes the response variables, the three-month Treasury bill interest rate, defense purchases, real GDP, and the Producer Price Index of crude fuel in manufacturing industries. The black lines are point estimates of the response functions and the colored lines are the 68 percent confidence bands computed by the procedure in the text.

Sources: Author's calculations from data from U.S. Department of Commerce, Bureau of Economic Analysis—response variable for defense spending and total government purchases, deflator for private value added, defense purchases, and real GDP; Board of Governors of the Federal Reserve System—Treasury bill interest rate; and U.S. Department of Labor, Bureau of Labor Statistics—wages and Producer Price Index of crude fuel.

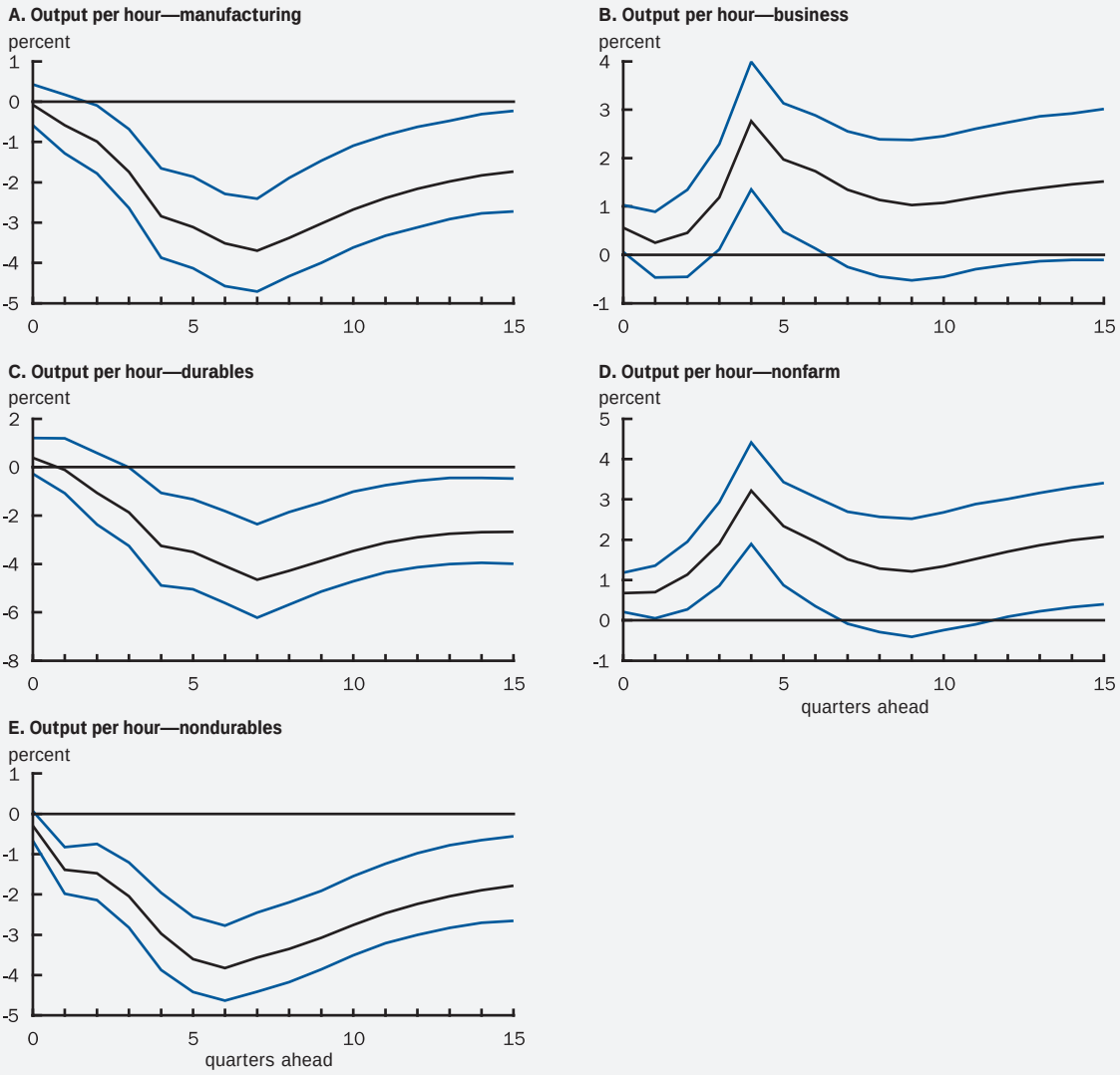
for increasing returns to scale, labor hoarding, and/or variable capacity utilization. It would clearly be of interest to track down the reasons for the difference in the response of average productivity in the manufacturing, business, and nonfarm sectors. Unfortunately, the data to do this are, to the best of our knowledge, unavailable. Absent a resolution of this puzzle, we are unwilling to say which of the competing theories is favored by the average productivity evidence.

Conclusion

This article builds on results in Edelberg, Eichenbaum, and Fisher (1998) to characterize the effect of an exogenous increase in government purchases on output, employment, real wages, and average labor productivity. Our results shed light on the empirical plausibility of alternative business cycle models. Our main finding is that after a positive shock to

FIGURE 9

Response of average productivity to an increase in government purchases
(percentage response to WAR dummy)



Notes: Author estimations are described in the box. Each response is estimated using a five-variable system which includes the response variable, the three-month Treasury bill interest rate, defense purchases, real GDP, the Producer Price Index, and crude fuel in manufacturing industries. The black lines are point estimates of the response functions and the colored lines are the 68 percent confidence bands computed by the procedure in the box.

Sources: Author's calculations from data from U.S. Department of Commerce, Bureau of Economic Analysis—defense purchases and real GDP; Board of Governors of the Federal Reserve System—Treasury bill interest rate; and U.S. Department of Labor, Bureau of Labor Statistics—response variable and Producer Price Index of crude fuel.

government purchases, employment rises but real wages fall. This is consistent with models that stress the effect of higher tax obligations associated with a rise in government purchases. It is inconsistent with models that stress the importance of increasing returns to scale in production and/or countercyclical markups. Our results presume that exogenous changes in defense purchases are a reasonable proxy for exogenous changes in total government purchases. This is an important maintained assumption in much of the literature. It is certainly open to challenge. It would be interesting to obtain other measures of exogenous increases in government purchases and aggregate demand to see if they too lead to a rise in employment and a fall in real wages.

NOTES

[1]See Christiano, Eichenbaum, and Evans (1998) for a review of the literature that uses this strategy to distinguish between competing models of the monetary transmission mechanism.

[2]See Edelberg, Eichenbaum, and Fisher (1998) for a discussion.

[3]Many of the results reported in this paper appear in Edelberg, Eichenbaum, and Fisher (1998).

[4]For a recent review of this class of models, see King and Rebelo (1998).

[5]To simplify the discussion we have implicitly assumed that taxes are lump sum in nature.

[6]See Aiyagari, Christiano, and Eichenbaum (1992) for a formal discussion of this point.

[7]This follows from the assumed properties of the technology for producing goods.

[8]See Farmer (1993) for models of imperfect competition and increasing returns to scale at the firm level that generate the same set of predictions as the models just discussed.

[9]See Ramey and Shapiro (1997) for a detailed discussion of how these dates were chosen. Also see Edelberg, Eichenbaum, and Fisher (1998) for a discussion of robustness of results to perturbations in these dates.

[10]This is consistent with results of Eichenbaum, Edelberg, and Fisher (1998) who show that output in the durables manufacturing sector expands by more than output in the nondurables manufacturing sector.

[11]The private value added deflator is constructed by dividing nominal value added produced in the private sector by constant-dollar value added in the private sector.

[12]After-tax wages are constructed using the annual average marginal tax rates reported in Fairlie and Meyer (1996).

[13]Edelberg, Eichenbaum, and Fisher (1998) show that before- and after-tax real wage rates in the durable goods, nondurable goods, wholesale trade, and construction sectors also fall.

[14]Estimated impulse response functions were obtained using a vector autoregression assuming military spending does not respond within the quarter to the other variables in the system.

REFERENCES

Aiyagari, R., L. J. Christiano, and M. Eichenbaum, 1992, "The output, employment and interest rate effects of government consumption," *Journal of Monetary Economics*, Vol. 30, pp. 73–86.

Barro, R. J., 1981, "Output effects of government purchases," *Journal of Political Economy*, Vol. 9, pp. 1086–1121.

Baxter, M., and R. G. King, 1993, "Fiscal policy in general equilibrium," *American Economic Review*, Vol. 83, pp. 315–334.

_____, 1992, "Productive externalities and business cycles," University of Virginia, manuscript, and forthcoming *European Economic Review*.

Blanchard, O., and R. Perotti, 1998, "An empirical characterization of the dynamic effects of changes in government spending and taxes on output," Massachusetts Institute of Technology, manuscript.

Burnside, C., and M. Eichenbaum, 1996, "Factor hoarding and the propagation of business cycle shocks," *American Economic Review*, Vol. 86, pp. 1154–1174.

Burnside, C., M. Eichenbaum, and S. Rebelo, 1993, "Labor hoarding and the business cycle," *Journal of Political Economy*, Vol. 101, pp. 245–273.

Christiano, L. J., 1990, Handout for comment on "Oligopolistic pricing and the effects of aggregate demand on economic activity," by Rotemberg and Woodford, Economic Fluctuations Meeting, National Bureau of Economic Research, Palo Alto, CA, February.

Christiano, L., and M. Eichenbaum, 1992, "Current real business cycle theories and aggregate labor market fluctuations," *American Economic Review*, Vol. 82, pp. 430–450.

Christiano, L., M. Eichenbaum, and C. Evans, 1998a, "Monetary policy shocks: What have we learned and to what end?," in *Handbook of Monetary Economics*, Michael Woodford and John Taylor (eds.), forthcoming.

_____, 1998b, "Modelling money," National Bureau of Economic Research, working paper, No. 6371.

Devereaux, M. B., A. C. Head, and M. Lapham, 1996, "Monopolistic competition, increasing returns, and the effects of government spending," *Journal of Money, Credit and Banking*, Vol. 28, pp. 233–254.

Edelberg, W., M. Eichenbaum, and J. Fisher, 1998, "Understanding the effects of a shock to government purchases," Northwestern University, manuscript.

Fairlie, R. W., and B. D. Meyer, 1996, "Trends in self-employment among white and black men: 1910–1990," Northwestern University, manuscript.

Farmer, R., 1993, *The Macroeconomics of Self-Fulfilling Prophecies*, Cambridge, MA: The MIT Press.

King, R. G., and S. Rebelo, 1998, "Resuscitating real business cycle models," Northwestern University, manuscript.

Ramey, V., and M. Shapiro, 1997, "Costly capital reallocation and the effects of government spending," *Carnegie Rochester Conference on Public Policy*, forthcoming.

Rotemberg, J., and M. Woodford, 1992, "Oligopolistic pricing and the effects of aggregate demand on economic activity," *Journal of Political Economy*, Vol. 100, pp. 1153–1297.