Fiscal Policy and Durable Goods*

Christoph E. Boehm
University of Michigan
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PRELIMINARY AND INCOMPLETE

Abstract

This paper shows that government purchases of nondurable goods stimulate aggregate demand more than purchases of durable or investment goods. Owing to the low intertemporal substitutability of nondurable goods, theory predicts that government purchases crowd out little private sector spending. As a result, the multiplier for nondurables is large. In contrast, the fiscal multiplier for durable goods with high intertemporal substitutability is small. When increased government demand temporarily drives up prices, private sector purchases are postponed until the fiscal expansion ends. I test these predictions using data on industry-level military spending. Consistent with the theory, spending in nondurables industries leads to greater sectoral expansions than spending on durables. I also find evidence for state-dependent multipliers in durable goods industries.

JEL Codes: E21, E32, E62, E63

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*University of Michigan, Department of Economics, 238 Lorch Hall, Ann Arbor, MI 48109-1220. Email: chrisboe@umich.edu. I would like to thank Chris House, Matthew Shapiro, Stefan Nagel, and Joshua Hausman for valuable comments, suggestions, and support. I also thank Aaron Flaaen, Miles Kimball, Nitya Pandalai Nayar, Richard Ryan, Dimitrije Ruzic and Isaac Sorkin for helpful conversations.
1 Introduction

In response to the severe economic downturn Congress passed the American Recovery and Reinvestment Act (ARRA) in February 2009 and President Obama signed it into law in the same month. This fiscal stimulus package included, among other things, provisions to raise spending on highways, railways, airports, and broadband. Total spending on infrastructure exceeded $70 billion. In this paper I ask whether spending on durable goods such as infrastructure is an effective way of raising aggregate demand.

I first show that basic theory predicts large crowding out of private sector spending when the government purchases durable goods. As a result the multiplier for durable goods is small. In contrast, theory predicts less crowding-out for nondurable goods so that the associated multipliers are relatively large. I then estimate multipliers separately for spending in durable and nondurable goods sectors. While, on average, a dollar of spending on durable goods raises sector gross output by less than 30 cents, the multiplier for spending on nondurable goods is around unity or above. Yet, as I explain below, these findings do not imply that spending on infrastructure in the Great Recession had little effect.

The economic mechanism behind the small durable goods multiplier is easily understood. Relative to nondurable goods durable goods have a very large intertemporal elasticity of substitution. Whereas nondurable goods and services are immediately consumed, durable goods such as cars, appliances or structures often have service lives of many years. If a durable good’s price is temporarily high, households can draw down the existing stock and postpone new purchases until prices revert to lower levels. Everything else equal, a longer service life leads to a greater intertemporal elasticity of substitution which, in turn, implies a greater demand elasticity.

This demand elasticity is a key determinant of the size of the fiscal multiplier. If supply curves are upward-sloping, greater government spending drives up prices. Higher prices, in turn, reduce private sector demand. The greater the elasticity of demand, the greater the quantity crowded out. It follows that multipliers for durable goods with high demand elasticities are smaller than multipliers for nondurable goods.

To test this hypothesis, I first assemble a new dataset from the NBER-CES Manufacturing In-

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1A detailed breakdown of allocation of the $840 billion covered by the bill can be found at http://www.recovery.gov/arra/Transparency/fundingoverview/Pages/fundingbreakdown.aspx.
dustry Database and two databases containing the universe of U.S. military prime contracts. The merged dataset contains industry-level outcomes such as gross output, value added, and employment together with military spending on goods in each industry. Second, I define an industry (or sectoral) multiplier as the change in a generic industry-level variable (e.g. gross output) divided by the change in industry-level spending, holding everything else equal. Unlike the economy-wide multiplier this industry multiplier is largely purged of general equilibrium effects. I provide a more formal definition of sectoral multipliers below.

I then estimate impulse response functions using Jordà’s (2005) local projection method and construct sectoral multipliers from the estimated impulse responses. As predicted by theory, I find that the sectoral multiplier is smaller in durable than in nondurable goods industries. Various tests indicate that this result is robust.

It is important to note that my findings do not suggest that the ARRA’s infrastructure spending had little effect. Durable goods sectors exhibit high volatility over the business cycle implying substantial underutilization of factors in recessions. As, for example, Auerbach and Gorodnichenko (2012, 2013), Bachmann and Sims (2012), and Michaillat (2014) show, multipliers can be larger in such environments. Indeed, when estimating state-dependent multipliers in durable goods sectors, I find that spending in recessions is quite effective — the sectoral gross output multiplier is around one. In contrast, multipliers for durable goods spending in expansions appear to be negative.²

This paper is related to a large literature on the effects of government spending. Hall (2009) shows in a simple static model with a single nondurable good that the fiscal multiplier is decreasing in the intertemporal elasticity of substitution. In his model the multiplier tends to zero as the intertemporal elasticity of substitution approaches infinity. I show below that the same result approximately holds for short-run multipliers of long-lived durable goods. In his discussion of Hall (2009), House (2009) showed that among the options that households face in response to greater government spending, reducing investment is more attractive than reducing consumption or raising the labor supply.³ On the empirical side, I follow Ramey and Shapiro (1998), among others, in assuming that military buildups are orthogonal to other shocks driving the U.S. business cycle. I

²The evidence on state dependence of fiscal multipliers is not uncontroversial. Owyang, Ramey, and Zubairy (2013) find that the multiplier in recessions is large in Canada, but not in the U.S.

³Additional recent theoretical contributions which emphasize the role of monetary policy for the size of the fiscal multiplier include Woodford (2011), Christiano, Eichenbaum, and Rebelo (2011), Farhi and Werning (2012), and Werning (2011).
construct instruments from national military spending in a manner similar to Nekarda and Ramey (2011) and Nakamura and Steinsson (2014).

Several papers study different types of government intervention. Finn (1998) shows in the context of an RBC model that government spending and government employment have markedly different effects on macroeconomic variables. Perotti (2004) and Pappa (2009a, 2009b) study the effects of government consumption and investment using structural VARs. Their findings are broadly consistent with the hypothesis that government consumption is associated with greater multipliers than government investment.\(^4\) Paying particular attention to anticipation effects and timing Leduc and Wilson (2013) study the effects of public infrastructure spending. They find a very large short-term multiplier in recessions and an insignificant short-term multiplier in expansions. Finally, it should be noted that this paper is exclusively interested in the demand stimulus of temporary spending increases on durable goods. Possible productivity effects as discussed in Baxter and King (1993) or questions regarding the returns to infrastructure spending as in Pereira (2000) are not the topic of this paper.

In the next section, I lay out a simple theory suggesting that the sectoral multiplier for durables is small relative to that of nondurable goods. I then turn to the empirical analysis and test this hypothesis in Section 3. In Section 4 I develop a general equilibrium model to analyze the mapping between industry-level multipliers and the aggregate multiplier. Section 5 concludes.

2 Durable goods and fiscal policy

In this section I first demonstrate that the intertemporal substitutability of durable goods is much larger than that of nondurable goods. I subsequently discuss the implications for fiscal policy. Finally, I argue that the state-dependence hypothesis for the fiscal multiplier is most relevant for durable goods.

2.1 The demand for durable and nondurable goods

Consider an infinitely-lived household deriving flow utility \(u(C_t, D_t)\) from the consumption of a nondurable good \(C_t\) and a durable good \(D_t\). Letting subscripts denote partial derivatives, I assume

\(^4\)See in particular table 4 to 6 in Perotti (2004), the “typical” state-level employment responses in figure 3 in Pappa (2009b) and table 1 in Pappa (2009a).
that \( u_C, u_D > 0 \) and \( u_{CC}, u_{DD} < 0 \) and that standard Inada-type conditions hold. The household receives income \( Y_t \), pays lump-sum taxes \( T_t \), and can purchase the nondurable good at price \( P_{C,t} \), the durable good at price \( P_{X,t} \) as well as a riskfree bond with nominal interest rate \( i_t \). Taking prices as given, the household chooses \( C_t \), new investments into the consumer durable \( X_t \), and the quantity of bonds \( B_t \) to maximize

\[
E_0 \sum_{t=0}^{\infty} \beta_t u(C_t, D_t)
\]

subject to the nominal budget constraint

\[
P_{C,t} C_t + P_{X,t} X_t + B_t = Y_t + B_{t-1} (1 + i_{t-1}) - T_t,
\]

the accumulation equation for the durable good

\[
D_t = X_t + (1 - \delta) D_{t-1},
\]

and a no-Ponzi game condition. Parameter \( \beta \) denotes the time discount factor and \( \delta \) is the depreciation rate of the durable good.

Let \( \lambda_t \) denote the multiplier on budget constraint (1). Simple manipulations of the first order conditions yield the (inverse) demand function for the nondurable good

\[
P_{C,t} = \lambda_t^{-1} u_C (C_t, D_t)
\]

and that for the durable good

\[
P_{X,t} = \lambda_t^{-1} E_t \sum_{s=0}^{\infty} [\beta (1 - \delta)]^s u_D (C_{t+s}, D_{t+s}).
\]

The key difference between these demand functions is that the price of nondurable goods only depends on current marginal utility while the price of durable goods depends on a discounted sum of current and future marginal utilities.

Next define the intertemporal elasticity of substitution of nondurable goods as \( \sigma_C = -\frac{u_C}{u_{CC} C} \). The linear approximation of equation (2) then implies that, ceteris paribus, a one percent change in \( C_t \) lowers \( P_{C,t} \) by \( \sigma_C^{-1} \) percent. Estimates of elasticity \( \sigma_C \) vary and are somewhat controversial.
A recent study by Cashin and Unayama (2012) which explicitly distinguishes nondurable from storable and durable goods estimates a value 0.21, similar to Hall’s (1988) estimates. Such a low value suggests that the demand curve for nondurables is fairly steep.

Due to the dynamic nature of the model, an analogous elasticity for durable goods is difficult to obtain. Instead, I will argue on the basis of equation (3) that in a limiting case the shadow value of the durable good in units of utility, \( \lambda_t P_{X,t} \), is approximately constant. If \( \lambda_t P_{X,t} \) is approximately constant, the demand for \( X_t \) is perfectly elastic. The limiting approximation assumes that \( \beta \) approaches unity, \( \delta \) approaches zero and that all disturbances are short-lived — a reasonable assumption for temporary fiscal expansions. Of course, many durable goods do not have depreciation rates near zero. For instance, the Bureau of Economic Analysis (BEA) estimates the service live of household appliances at 11 years. Yet, the approximation provides the correct intuition that the demand elasticity rises with greater durability and it remains quite accurate for realistic calibrations of \( \delta \). I provide details on the numerical accuracy of this approximation below.

To see why \( \lambda_t P_{X,t} \) is approximately constant for long-lived durables, first notice that the consumer derives utility from the stock of the durable good \( D_t \), not current purchases \( X_t \). Because durables with long service lives have large stock to flow ratios (in steady state \( D/X = 1/\delta \)), even large changes in \( X_t \) cause only relatively small percentage changes in \( D_t \).

Second, if the household is sufficiently patient (\( \beta \) close to unity) and the durable long-lived (\( \delta \) close to zero), the shadow value \( \lambda_t P_{X,t} \) depends on utility flows far in the future. In stationary environments with short-lived shocks these future terms are barely affected since the economy quickly reverts back to its steady state. Any changes to the first few terms in the sum of equation (3) are dwarfed by the future terms which remain approximately unchanged. Hence, as \( \beta \) approaches unity and \( \delta \) approaches zero, the shadow value \( \lambda_t P_{X,t} \) becomes unresponsive to temporary shocks and the demand for \( X_t \) perfectly elastic.

Intuitively, the household smooths consumption of both the nondurable and the durable good. But since utility is derived from the stock \( D_t \) the consumer is willing to tolerate much larger variation in durables purchases \( X_t \) than in nondurables purchases \( C_t \). It is optimal to purchase durables only at favorable prices and to draw down the stock whenever prices are temporarily high. Adda and Cooper (2000), Mian and Sufi (2012) and Hausman (2015) all provide evidence for large

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5For the BEA’s estimates of service lives, see Bureau of Economic Analysis (undated).
intertemporal substitutability of automobile purchases.

Notice, finally, that not only the demand for consumer durables is highly elastic. The same economic mechanism applies to other long-lived goods, in particular investment goods such as machines, ships or structures.\(^6\) In this paper, I refer to all long-lived goods as durable goods, regardless of whether they are consumer durables or investment goods. Because services are immediately consumed, they are best understood as nondurable goods for the purposes of this paper.

### 2.2 Implications for fiscal policy

The elasticity of demand is crucial for the effectiveness of fiscal policy because it determines the degree of crowding out. To see this, suppose the government raises spending and shifts out the demand curve. If the supply curve is upward-sloping, the resulting price increase reduces private sector spending. Greater demand elasticities lead to greater crowding-out. In the limiting case with horizontal demand curve, all private sector spending is crowded out and the fiscal expansion has no effect. Figure 1 illustrates the effect of government spending in a sector with inelastic demand (Panel A) and elastic demand (Panel B). The supply curve and the fiscal expansion are the same in both sectors.

Durable goods sectors with highly elastic demand are therefore expected to experience greater crowding out and to have smaller multipliers than nondurables with inelastic demand. This is the first hypothesis that I will test below. An important assumption for this test, which I adopt in the baseline analysis, is that the supply curves are similarly elastic (or inelastic) in durables and nondurables sectors. While this assumption is a natural starting point, one concern arises which is closely connected to the state dependence hypothesis of fiscal multipliers.

### 2.3 Durable goods and state dependence

The state dependence hypothesis holds that the multiplier is greater in economic slumps than in booms. Since factors of production are underutilized in slumps, firms can raise inputs without substantially driving up marginal costs. Supply curves are therefore more elastic in slumps, mitigating crowding out of private sector spending. A version of this idea has recently been formalized by Michaillat (2014).

\(^6\)See, for instance, House and Shapiro 2008.
Applying the rationale of state dependence to an environment with multiple sectors suggests that those sectors with greater output variation over the business cycle should experience greater state dependence. As is well-known, the most cyclical sectors are those producing durable goods. Based on a sample from 1953 to 1996, Stock and Watson (1999) report standard deviations of 0.64 for service consumption, 1.11 for nondurables consumption, 4.66 for durables consumption, and 10.04 for residential investment.

Unfortunately, data limitations prevent me from testing whether the multiplier for durable goods experiences greater state dependence than the multiplier for nondurable goods. However, if multipliers do change over the business cycle, then the argument above suggests that his state dependence is most likely detected in data on durable goods industries.\(^7\) Hence, my second hypothesis is that the durable goods multiplier is greater in slumps than in booms.

In summary, two hypotheses emerge for sectoral multipliers which I define as the changes in sector-level outcomes (e.g. value added) in response a change in sector-level government spending. First, the sectoral multiplier of nondurable goods industries is greater than that in durable goods

\(^7\)The reason for the high cyclicity of durables is, of course, their large intertemporal substitutability. In a one sector RBC model, for example, investment falls more than consumption of the nondurable good in response to a negative TFP shock that temporarily raises prices. Barsky, House, and Kimball (2007) show that their high intertemporal substitutability make durables also much more responsive to monetary shocks than nondurable goods.
industries. Second, within durable goods sectors, the sectoral multiplier is greater in slumps than in booms.

3 Empirical evidence

3.1 Data

My empirical analysis is based primarily on two data sources, the NBER-CES Manufacturing Industry Database and the Military Prime Contract Files. The NBER-CES database contains annual data on, among other things, value added, value of shipments, cost of materials, expenditures on energy, the number production of workers, and production worker wages, along with various deflators. It ranges from 1958 to 2009 and covers all manufacturing industries. The database is constructed mainly from the Survey of Annual Manufactures and the Census of Manufactures, but complemented with additional information from the Bureau of Economic Analysis, the Bureau of Labor Statistics, and the Federal Reserve Board. A detailed description of this database is provided by Bartelsman and Gray (1996) and Becker, Gray, and Marvakov (2013).

The Military Prime Contract Files include information on all military prime contracts with values above the minimum threshold of $10,000 up to 1983 and $25,000 thereafter. They can be downloaded for the period from 1966 to 2003 from the U.S. National Archives. I complement the Prime Contract Files with data from USA Spending.gov, a government website dedicated to promoting transparency of federal spending. The data from USA Spending.gov is available from 2000 onwards. A comparison of the two data sources for the overlapping years from 2000 to 2003 reveals only negligible differences.

Unfortunately, the data on defense spending is not easily matched to different industries. While the NBER-CES database is available for both SIC- and NAICS-based industry definitions, the Military Prime Contract Files contain SIC codes only for the relatively brief period from 1989 to 2000 and NAICS codes from 2000 onwards. Instead military purchases are classified according to the Federal Procurement Data System which assigns a unique Product Service Code (PSC) or Federal Supply Code (FSC) to each contract since 1966.

To obtain military spending at the industry level I construct a concordance from the FSC/PSC classification to 4-digit SIC codes. The concordance is based on the Military Prime Contract Files
from 1989 to 2000 which contain both, FSC/PSC and SIC codes. Details on the construction of this concordance as well as further information on the FSC/PSC classification system are available in Appendix A. Because the FSC/PSC system underwent a major revision in 1979, the concordance is only valid thereafter. This leaves me with a sample period from 1979 to 2009. The data are annual.\(^8\)

### 3.2 Empirical strategy

I first estimate impulse response functions using Jordà’s (2005) local projection method and then construct sectoral multipliers based on the estimated impulse response functions. The baseline specification is

\[
\frac{Y_{i,t+h} - Y_{i,t-1}^T}{VA_{i,t-1}^T} = \alpha_h \frac{G_{i,t} - G_{i,t-1}^T}{VA_{i,t-1}^T} + \beta_h \frac{Y_{i,t-1} - Y_{i,t-2}^T}{VA_{i,t-2}^T} + \gamma_h \frac{G_{i,t-1} - G_{i,t-2}^T}{VA_{i,t-2}^T} + \delta_{i,h} + \zeta_{t,h} + \varepsilon_{i,t+h}, \tag{4}
\]

for \(h = 0, 1, \ldots, 4\). In this equation \(Y_{i,t}\) is a generic variable of interest of sector \(i\) at time \(t\), \(G_{i,t}\) is defense spending in sector \(i\), and \(VA_{i,t}\) is value added. The superscript \(T\) denotes that the variable in question is an HP-filtered trend.

I estimate equation (4) separately for durable and nondurable goods sectors to obtain the objects of interest \(\{\alpha_h\}_{h=0}^4\). These parameters represent the impulse response coefficients for the impact year, \(h = 0\), and four subsequent years. The specification controls for the deviations of the dependent variable and defense spending from trend, lagged once, as well as time and industry fixed effects \(\delta_{i,h}\) and \(\zeta_{t,h}\).

The time fixed effect plays an important role in specification (4). It soaks up disturbances that affect all sectors symmetrically, notably monetary policy shocks and certain tax policies. Additionally, the time fixed effect controls for certain announcement effects that cause notorious problems in the estimation of aggregate multipliers: When the government increases spending, households understand that their (future) tax obligations rise and that their life-time wealth falls. Standard theory suggests that households respond by shifting their consumption trajectories downward and by increasing their labor supply. Both, lower demand and greater labor supply should affect all sectors symmetrically and are therefore controlled for through the time fixed effect. Notice that since I estimate equation (4) separately for durable and nondurable goods sectors the fixed effects

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\(^8\)For a detailed discussion of the military prime contract data see Nakamura and Steinsson (2014).
and all coefficients on control variables are allowed to differ for the two types of sectors.

One concern with specification (4) is that the impulse response coefficients \( \{\alpha_h\}_{h=0}^4 \) depend on the smoothness of the trends required for constructing the left and right-hand side variables. To err on the save side I extract very smooth trends with a smoothing parameter of 1600 for annual data. I also report results for alternative values of this parameter.

As Nekarda and Ramey (2011) discuss in detail, a cross-sector analysis of government spending may suffer from an endogeneity problem. Technological progress in a particular sector can lead both to greater private sector demand and to increased defense spending as the military upgrades its equipment. The resulting bias will inflate the impulse response coefficients above their true levels. To avoid this bias I follow a large literature and construct instruments from total defense spending (spending summed over all manufacturing industries).\(^9\) If total spending is determined by geopolitical events orthogonal to shocks driving the U.S. business cycle this instrument remedies the endogeneity problem.

More precisely, my instrumentation strategy is based on the fact that sectors experience different increases in demand when aggregate military spending expands. For example, when aggregate defense spending as a fraction of value added rises one percentage point above its trend, spending in SIC industry 3812 (Search, Detection, Navigation, Guidance, Aeronautical, and Nautical Systems and Instruments) rises, on average, by 2.98 percentage points. In contrast, spending in industry 3841 (Surgical and Medical Instruments and Apparatus) increases by only 0.29 percentage points. This is illustrated in Figure 2.

The observation that military buildups raise spending differentially across sectors suggests to construct instruments by interacting the change in aggregate spending with a dummy for each industry. In the two-stage least squares representation of the IV estimator, aggregate spending can then affect sectoral spending differentially in the first stage. The key advantage of this instrumentation strategy is that it preserves cross-sector variation in the predicted values of the first stage although all instruments are based on a single aggregate time series. Similar approaches have recently been employed by Nekarda and Ramey (2011) and Nakamura and Steinsson (2014).

Of course, both, \( \left( G_{i,t} - G_{i,t-1}^T \right) / V A_{i,t-1}^T \) and \( \left( G_{i,t-1} - G_{i,t-2}^T \right) / V A_{i,t-2}^T \) in equation (4) are potentially endogenous. Letting \( G_t \) and \( VA_t^T \) denote military spending and the trend of value

added summed over all manufacturing industries I therefore use \((G_t - G_{t-1}^T) / V A_{t-1}^T\) and its lag, both interacted with sector dummies, as instruments.

To illustrate the instruments’ predictive power, I run the regression

\[
\frac{G_{i,t} - G_{i,t-1}^T}{V A_{i,t-1}^T} = \alpha_i + \beta_i \frac{G_t - G_{t-1}^T}{V A_{t-1}^T} + u_{i,t},
\]

(5)

for each industry \(i\). Figure 3 plots the estimates of \(\beta_i\) and their t-statistics. Blue circles represent durable goods industries and red crosses represent nondurable goods industries. Panel A shows the full range of slope estimates and t-statistics. Panel B shows the same estimates and t-statistics but limits the range of the axes. In 296 out of 444 industries with strictly positive defense spending in all years, the t-statistic is greater than 2. Among these 296 industries are 200 durable goods industries and 96 nondurable goods industries. 91 out of the 148 industries with t-statistics smaller than 2 are are nondurable goods industries.
Figure 3 confirms the presence of substantial identifying variation for the impulse response coefficients in durable goods industries. Two sectors, Tanks and Tank Components (SIC 3795) and Ammunition, except for Small Arms (SIC 3483), have slope coefficients greater than 20. Additionally, 46 industries have t-statistics greater than 2 and slope coefficients greater than 1. On the other hand identifying variation is somewhat less plentiful for nondurable goods sectors. The largest slope coefficient is 6.21 (SIC 2385, Waterproof Outerwear). A total of 15 nondurable goods industries have t-statistics greater than 2 and slope coefficients greater than 1.

When constructing the baseline sample, I am confronted with a trade-off between strong instruments and a representative sample. When including all industries, the sample is representative for all of U.S. manufacturing. However, the instrumentation is weak for about one third of all industries. Alternatively, I can construct the baseline sample only from industries with t-statistics greater than, say, 2. This ensures strong instrumentation, but the sample is no longer representative for all of U.S. manufacturing. In the baseline analysis I choose to drop industries with t-statistics smaller than 2. I do so mostly to ensure equally strong instrumentation for durable and nondurable goods industries. To show that my findings do not depend on the exact value of this threshold, I
conduct a number of robustness tests. The results are reported in Appendix C.

I limit the sample further by excluding industries with little private sector demand. These industries are problematic for testing the hypotheses presented in Section 2 because with little private sector demand to begin with, there is little room for crowding out. In the complete absence of private sector demand, the theory discussed above does not apply and the sectoral multiplier should be unity regardless of whether the sector produces durable or nondurable goods. For the baseline sample, I therefore drop industries with average values of military purchases per industry gross output of greater than 0.35. Imposing this threshold leaves the number of nondurable goods industries unchanged at 96 but reduces the durable goods industries to 191. Appendix B lists all industries in the baseline sample. In the robustness exercises below I vary the minimum threshold for average military purchases per industry gross output as well.

3.3 Results

Figure 4 shows the estimated impulse response functions for the baseline sample. A unit increase in military spending leads to additional spending in subsequent years. As Panel A illustrates, spending increases slightly more in nondurable goods sectors. Panel B shows the dynamic responses of the value of shipments associated with these spending paths. Consistent with the hypothesis of greater crowding out in durable goods sectors, the value of shipments is barely affected and insignificantly different from zero. In contrast, nondurables sectors expand substantially in response to greater spending.

Panel C shows the responses of value added. In both sectors value added rises significantly above zero and, again, the dynamic response for durables sectors lies below that for nondurables sectors. Additionally, in nondurables sectors, the rise in valued added is accompanied by increased purchases of materials and energy (Panels D and E). In contrast, no significant changes in material and energy expenditures can be detected in durables sectors. Finally, Panel F shows the employment responses. Unfortunately, the estimates are too noisy to allow for a meaningful comparison of the two sectors.

For the interpretation of the impulse responses in the impact period it is important to note that

10 For example, Tanks and Tank Components (SIC 3795) and Ammunition, except for Small Arms (SIC 3483) have essentially no private sector demand.

11 Value added and cost of materials roughly sum to the value of shipments. The residual is small and likely due to survey error or other omitted components.
military spending by sector is constructed by aggregating the value of all contracts in a given year. I use the date on which the contract is signed for this aggregation. My dataset has no information on the date of actual payments. Panels B to F all suggest that there is little effect at the time the contract is signed, but only in subsequent years.

Taken together, nondurable goods sectors respond strongly to increased defense spending while
Table 1: Sectoral multipliers durable and nondurable goods industries

<table>
<thead>
<tr>
<th>Years after shock</th>
<th>Durable goods</th>
<th>Nondurable goods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Value of shipments</td>
<td>0.15</td>
<td>0.04</td>
</tr>
<tr>
<td>Value added</td>
<td>0.52</td>
<td>0.52</td>
</tr>
<tr>
<td>Cost of materials</td>
<td>-0.41</td>
<td>-0.56</td>
</tr>
<tr>
<td>Energy expenditures</td>
<td>0.004</td>
<td>0.001</td>
</tr>
<tr>
<td>Employment</td>
<td>5.07</td>
<td>6.07</td>
</tr>
<tr>
<td>(employees per year per $1m)</td>
<td>()</td>
<td>()</td>
</tr>
</tbody>
</table>

Notes: The table reports the cumulative multipliers for various outcome variables. Multipliers for value of shipments, value added, cost of materials, and energy expenditures have the usual interpretation of one additional dollar in the outcome variable per additional dollar of military spending. The multiplier for production employment is expressed as the number of employees per year per $1 million of military spending.

the reaction of durable goods sectors is quite moderate. These findings are consistent with the theory outlined above, suggesting that indeed there is little crowding out in nondurable goods sectors but substantial crowding out in durables sectors.

I next compute the sectoral multipliers as the cumulative change in the outcome variable divided by the cumulative change in spending. Table 1 summarizes these multipliers for time horizons of 1 to 3 years after the shock. The table confirms that multipliers for all five variables, the value of shipments, value added, cost of materials, energy expenditures, and employment are uniformly larger in nondurable goods sectors. Notice that the employment multiplier is expressed as additional employees per year per $1 million dollar of spending.

The finding that multipliers are larger in nondurable goods industries is consistent with the simple theory presented above. However, the theory also implies that sectoral multipliers should lie between zero to one. (This can, for instance, be seen in Figure 1.) In particular, the large multipliers
for the value of shipments in nondurables industries are inconsistent with this prediction. There are three possible explanations for this phenomenon: 1) Specification (4) leads to an upward bias of the impulse response coefficients. 2) The simple model in Section 2 is incorrect. And 3) sampling error leads to point estimates above unity although the true values are below unity.

I estimate various alternate specifications to see whether a bias explains the large multipliers. One possibility is that anticipation of future spending leads industries to expand prior to actual spending. To address this concern I add Ramey’s (2011) defense news variable interacted with industry indicators to specification (4). Ramey’s news variable is constructed from narrative records and measures the present value of new military spending at the time of announcement. Since the results are similar to those reported in Table 1, anticipation effects do not explain the large multipliers. A second concern is that the time fixed effects do not fully control for monetary policy. The reason is that the interest elasticity of demand increases with the length of the service lives of goods, and service lives vary across sectors. When controlling for the real interest rate interacted with industry indicators, however, the results barely change.\textsuperscript{12}

A third possibility is that input-output linkages of industries lead to a bias. If firms in a particular industry use inputs from other firms in the same industry, shipments and cost of materials will be counted multiple times. The Use Tables of various years suggest that 10 percent is a conservative estimate of the share of intra-industry shipments. Under this assumption, one dollar of final sales is counted $\frac{1}{(1 - 0.1)} \approx 1.11$ times. Although this bias is surely present, it is too small to explain multipliers of 2 and above.\textsuperscript{13} Furthermore, intra-industry shipments cannot explain the large multipliers for value added. Estimates of the above and additional robustness exercises are shown in Table X of Appendix E.

These considerations lead me to the conclusion that the large multipliers are either a result of intra-industry general equilibrium effects which are not captured by the simple models in this paper, or a result of sampling error.

I next turn to the impulse response functions of wages and prices. I estimate the specification

$$
\frac{P_{i,t+h} - P_{i,t-1}^T}{P_{i,t-1}^T} = \alpha_h \frac{G_{i,t} - G_{i,t-1}^T}{VA_{i,t-1}^T} + \beta_h \frac{P_{i,t-1} - P_{i,t-2}^T}{P_{i,t-2}^T} + \gamma_h \frac{G_{i,t-1} - G_{i,t-2}^T}{VA_{i,t-2}^T} + \delta_{i,h} + \zeta_{t,h} + \varepsilon_{i,t+h},
$$

(6)

\textsuperscript{12}In light of the findings of Judson and Owen (1997), the problems arising from dynamic panel estimation with fixed effects are also unlikely to give rise to a bias of this size.

\textsuperscript{13} An additional problem are intra-firm shipments...
where $P_{i,t}$ denotes the industry’s consumption wage, price, or product wage. The coefficients \( \{\alpha_h\}_{h=0}^4 \) are now akin to semi-elasticities and interpreted as follows. When the difference between government spending and its trend, normalized by the sector’s value added, rises by one, the government engages, on average, in further spending in subsequent periods as shown in Panel A of Figure 4. This spending path is associated with a price response, expressed as a percentage deviation from trend, given by \( \{\alpha_h\}_{h=0}^4 \). As before spending at the sector level is instrumented with interactions of aggregate spending and sector dummies. The control variables are similar to those of specification (4).

Figure 5 displays the results. As Panel A shows, consumption wages in durable goods sectors rise about 25 basis points above trend. While these estimates are significantly different from zero at time horizons from one to three years, the response for nondurables sectors only increases gradually and reaches statistical significance only three years after the shock.

Prices in durable goods sectors increase slightly and only insignificantly so (Panel B). In contrast, prices in nondurable goods sectors fall by about 50 basis points. The response of durable goods prices is roughly in line with the theory. Due to their high price sensitivity, fluctuations of durable goods prices should generally be small and hard to detect.\(^{14}\) However, the price decline in

\(^{14}\)See, for example, House and Shapiro (2008).
nondurable goods sectors is surprising and inconsistent with the theory. One possible explanation is a composition effect. The military likely purchases a different basket of goods from a particular sector than the private sector. If the basket purchased by the military has a lower price than that purchased by the private sector, then a price decline as that in Panel B would be observed. Another possible explanation is that the government purchases goods in bulk and receives greater discounts than the private sector. Given that many nondurable goods sectors in the sample produce food or clothing, this explanation seems plausible. Yet, the decline of prices in response to greater government spending remains puzzling. For completeness, Panel C displays the impulse response functions of product wages.

3.4 State dependence

I next test the state dependence hypothesis by estimating impulse response functions separately for recessions and expansions. Because insufficient variation of spending in nondurable goods sectors prohibits accurate inference, I estimate impulse response functions for durable goods industries only. The baseline sample consists of the same 191 durables industries that were used in the estimation above.

In analogy to Auerbach and Gorodnichenko (2013), the baseline specification is

\[
\frac{Y_{i,t+h} - Y^T_{i,t-1}}{V_{i,t-1}} = \alpha^R F_{i,t-1} \frac{G_{i,t} - G^T_{i,t-1}}{V_{i,t-1}} + \alpha^E (1 - F_{i,t-1}) \frac{G_{i,t} - G^T_{i,t-1}}{V_{i,t-1}} + \beta^R F_{i,t-1} \frac{Y_{i,t-1} - Y^T_{i,t-2}}{V_{i,t-2}} + \beta^E (1 - F_{i,t-1}) \frac{Y_{i,t-1} - Y^T_{i,t-2}}{V_{i,t-2}} + \gamma^E (1 - F_{i,t-1}) \frac{G_{i,t-1} - G^T_{i,t-2}}{V_{i,t-2}} + \eta F_{i,t-1} + \delta_{i,h} + \zeta_{t,h} + \varepsilon_{i,t+h}.
\]

(7)

In this equation

\[ F_{i,t} = \frac{\exp(-\kappa \cdot V_{i,t}^C)}{1 + \exp(-\kappa \cdot V_{i,t}^C)}, \kappa > 0, \]

and \( V_{i,t}^C \) denotes the demeaned and standardized cycle component of HP-filtered value added in sector \( i \).\(^{15}\) \( F_{i,t} \) measures the “degree” to which industry \( i \)’s value added is below trend (in recession). It varies between zero and one and takes greater values whenever the industry’s value added is low. Hence, the empirical model (7) permits estimation of impulse response functions

\(^{15}\)I use a smoothing parameter of 1600.
separately for recessions ($F_{i,t} = 1$) and expansions ($F_{i,t} = 0$). These impulse response functions are given by $\{\alpha_{R}^h\}_{h=0}^{4}$ and $\{\alpha_{E}^h\}_{h=0}^{4}$. Parameter $\kappa$ is set to 1.5 which implies that the economy spends about 20 percent of the time in recessions — a value consistent with U.S. business cycle facts. For more details see Auerbach and Gorodnichenko (2012, 2013). Notice finally, that I include $F_{i,t-1}$ as a control variable. By doing so, I allow the left-hand side variable to directly depend on the state of the economy.

Figure 6 shows the impulse response functions starting with military spending in Panel A. Evidently, a spending shock in recessions was followed by somewhat lower subsequent spending than a spending shock in expansions. Although standard errors are fairly large, there is strong evidence for greater multipliers in recessions. The impulse response functions for the value of shipments (Panel B), value added (Panel C), cost of materials (Panel D), and employment (Panel F) display much greater rises in recessions than expansions. Energy expenditures (Panel E) are the only exception to this regularity. As I show in Appendix X, this exception is not robust. Interestingly, it appears that the dynamic responses in recessions and expansions diverge only 2 years after the shock. This delay is likely due to the long latency period between signing of the contract and its implementation.

Table 2 shows the associated multipliers. It confirms large differences in the effectiveness of fiscal policy in recessions and expansions. The estimates of value added and value of shipment multipliers both exceed unity in recessions two years after the shock. In contrast, their estimates in expansions becomes negative. Although imprecisely estimated, the employment multipliers also indicate greater effectiveness of fiscal policy in recessions. Taken together, there is quite strong evidence for the state dependence hypothesis of government spending in durable goods sectors.

4 Fiscal policy in general equilibrium

In this section of the paper I present a model to study the effects of fiscal policy in general equilibrium. The main objective is to shed light on the economic mechanisms at work and on the relationship between sectoral and aggregate multipliers.
Notes: The figure plots impulse response functions for the durable goods industries of the baseline sample estimated using specification (7). See text for a description of the baseline sample. The shock is a unit increase of government spending above trend, normalized by the sector’s value added. For employment the impulse is a $1 million increase in military spending and the response is expressed as the number of additional employees. Shaded regions mark 90 percent confidence bands based on standard errors which are clustered at the sector level.

4.1 Model description

The model economy is a New Keynesian framework with two sectors, a large sector $Z$, and a small sector $X$. The small sector represents a typical manufacturing industry studied above. It produces either durable or nondurable goods for final consumption, depending on the choice of the depreciation rate $\delta_D$. The large sector $Z$ represents the aggregate of all remaining sectors. It
Table 2: Sectoral multipliers in recessions and expansions

<table>
<thead>
<tr>
<th>Years after shock</th>
<th>Recessions</th>
<th>Expansions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Value of shipments</td>
<td>0.85</td>
<td>1.18</td>
</tr>
<tr>
<td>Value added</td>
<td>0.40</td>
<td>1.11</td>
</tr>
<tr>
<td>Cost of materials</td>
<td>-0.17</td>
<td>0.10</td>
</tr>
<tr>
<td>Energy expenditures</td>
<td>-0.004</td>
<td>-0.008</td>
</tr>
<tr>
<td>Employment</td>
<td>6.76</td>
<td>11.07</td>
</tr>
</tbody>
</table>

Notes: The table reports the cumulative multipliers for various outcome variables. Multipliers for value of shipments, value added, cost of materials, and energy expenditures have the usual interpretation of one additional dollar in the outcome variable per additional dollar of military spending. The multiplier for production employment is expressed as the number of employees per year per $1 million of military spending.

produces goods which can alternately be used for final nondurable consumption $C$, for investment into capital of the two sectors, $I_Z$ and $I_X$, or for intermediate goods $M_X$ used in the production of good $X$. Notice that sector $Z$ is a hybrid sector, producing both nondurable goods ($C$ and $M_X$) and durable investment goods ($I_Z$ and $I_X$).

### 4.1.1 Households

The representative household maximizes life-time utility

$$E_0\sum_{t=0}^{\infty} \beta^t \left[ \left( 1 - \frac{1}{\sigma} \right)^{-1} \left[ \left( \omega (C_t)^{\frac{\rho-1}{\rho}} + (1 - \omega) (D_{H,t})^{\frac{\rho-1}{\rho}} \right)^{\frac{\sigma}{\rho-1}} \right] ^{\frac{1}{\rho-1}} + \Gamma (D_{G,t}) - \frac{(N_t)^{1+\frac{1}{\eta}}}{1+\frac{1}{\eta}} \right]$$
subject to the nominal budget constraint

\[ \begin{align*}
P_{X,t}X_{H,t} + P_{Z,t}(C_t + I_{X,t} + I_{Z,t}) + B_t &= \nabla X_{H,t} + P_{Z,t} \left( C_t + \delta D H_{t-1} \right) + R_{X,t}K_{X,t-1} + R_{Z,t}K_{Z,t-1} + B_{t-1} (1 + \delta_i + \Pi_t - T_t), \end{align*} \]

(8)

the accumulation equations

\[ \begin{align*}
D_{H,t} &= X_{H,t} + (1 - \delta_D) D_{H,t-1}, \quad K_{j,t} = I_{j,t} + (1 - \delta_K) K_{j,t-1}, \quad j \in \{Z, X\},
\end{align*} \]

(9)

the labor aggregator

\[ \begin{align*}
N_t = \left[ \phi \left( N_{Z,t} \right)^{\eta + \mu} + (1 - \phi) \left( N_{X,t} \right)^{\eta + \mu} \right]^{\eta / (\eta + \mu)},
\end{align*} \]

(10)

and a no-Ponzi game condition.

Utility is derived from three components. The first component is a CES aggregate of the nondurable good \(C_t\) and the good \(D_{H,t}\). When \(\delta_D = 1\), \(D_{H,t} = X_{H,t}\) is a nondurable good. For \(\delta_D < 1\), \(D_{H,t}\) is the household’s durable good stock, while \(X_{H,t}\) are new purchases (see first equation in 9). \(\sigma\) is the intertemporal elasticity of substitution and \(\rho\) governs the substitutability between \(C_t\) and \(D_{H,t}\). The second component, \(\Gamma (D_{G,t})\), represents the household’s utility derived from government purchases \(X_{G,t}\) which accumulate into the stock \(D_{G,t}\). Since I assume that \(\Gamma\) enters additively separable, government spending does not directly influence the household’s behavior through complementarities (or possibly substitution). Finally, the third term is the household’s disutility of labor. The labor aggregate \(N_t\), specified in equation (10), is composed of hours \(N_{Z,t}\) supplied to the large hybrid sector and hours \(N_{X,t}\) supplied to the small sector.\(^{16}\) \(\eta\) is the Frisch labor supply elasticity and \(\mu\) parameterizes labor mobility across sectors. If \(\mu = 0\), labor is perfectly mobile across sectors. If \(\mu = 1\), labor is completely immobile. Intermediate values imply partial labor mobility.

The remaining notation is chosen as follows. \(P_{X,t}\) and \(P_{Z,t}\) denote the prices in the small sector \(X\) and the large sector \(Z\). Wages are analogously denoted by \(W_{X,t}\) and \(W_{Z,t}\). Each sector has its own capital stock \(K_{X,t}\) and \(K_{Z,t}\) earning rental rates \(R_{X,t}\) and \(R_{Z,t}\). Household can hold a risk-free nominal bond with interest rate \(i_t\) whose quantity is denoted by \(B_t\). \(\Pi_t\) are profits and \(T_t\) is a lump-sum tax.

\(^{16}\)This specification is taken from Barsky, House, and Kimball (2003).
4.1.2 Firms

Both sectors consist of a representative aggregating firm and a unit continuum of differentiated firms. The aggregating firms assemble the differentiated varieties into CES bundles

\[
X_t = \left[ \int_0^1 x_t(s) \frac{\varepsilon - 1}{\varepsilon} ds \right]^{\frac{1}{\varepsilon - 1}}, \quad Z_t = \left[ \int_0^1 z_t(s) \frac{\varepsilon - 1}{\varepsilon} ds \right]^{\frac{1}{\varepsilon - 1}}. \tag{11}
\]

Optimal behavior in competitive markets implies the demand functions

\[
x_t(s) = X_t \left( \frac{p_{x,t}(s)}{P_{X,t}} \right)^{-\varepsilon}, \quad z_t(s) = Z_t \left( \frac{p_{z,t}(s)}{P_{Z,t}} \right)^{-\varepsilon} \tag{12}
\]

where \(p_{x,t}(s)\) and \(p_{z,t}(s)\) denote the prices of a generic variety \(s\) in each sector and \(P_{X,t}\) and \(P_{Z,t}\) are given by

\[
P_{X,t} = \left( \int_0^1 (p_{x,t}(s))^{1-\varepsilon} ds \right)^{\frac{1}{1-\varepsilon}}, \quad P_{Z,t} = \left( \int_0^1 (p_{z,t}(s))^{1-\varepsilon} ds \right)^{\frac{1}{1-\varepsilon}}. \tag{13}
\]

A differentiated firm in sector \(X\) produces variety \(s\) using production function

\[
x_t(s) = \left[ (k_{x,t}(s))^\alpha (n_{x,t}(s))^{1-\alpha} \right]^\chi [m_{x,t}(s)]^{1-\chi}. \tag{14}
\]

The firm rents capital \(k_{x,t}(s)\) at rate \(R_{X,t}\) and employs labor \(n_{x,t}(s)\) at wage \(W_{X,t}\). Additionally, the firm purchases an intermediate \(m_{x,t}(s)\) from the large sector. Parameter \(\chi\) is the cost share of capital and labor and \((1 - \chi)\) is that of intermediates. Cost minimization in competitive factor markets yields the firm’s conditional factor demand functions and an expression for its marginal costs \(MC_{X,t}\).

Firms set prices as in Calvo (1983). Let \(\theta_X\) denote the probability that a firm in sector \(X\) proceeds to the next period without adjusting its price. Then the monopolistically competitive firm chooses the reset price \(p^*_{X,t}\) to maximize objective

\[
E_t \sum_{j=0}^{\infty} (\theta_X \beta)^j \frac{\lambda_{t+j} \lambda_t}{\lambda_t} \left[ p^*_{X,t}x_{t+j} - MC_{X,t+j}x_{t+j} \right]
\]

subject to the sequence of demand functions (the first equation in 12) and its marginal costs
$MC_{X,t+j}$. In this expression $\lambda_t$ is the multiplier on the budget constraint (8). The optimal reset price is

$$p^*_X = \frac{\varepsilon}{\varepsilon - 1} \frac{E_t \sum_{j=0}^{\infty} (\theta X \beta)^j \lambda_{t+j} X_{t+j} (P_{X,t+j})^\varepsilon MC_{X,t+j}}{E_t \sum_{j=0}^{\infty} (\theta X \beta)^j \lambda_{t+j} X_{t+j} (P_{X,t+j})^\varepsilon}.$$ 

Monopolistic competitors in the large sector behave similarly. The only difference is that they do not require an intermediate input. Their production function is simply

$$z_t(s) = (k_{z,t}(s))^\alpha (n_{z,t}(s))^{1-\alpha}$$

and capital and labor are paid the rental rate $R_Z$ and the wage $W_Z$. Price rigidity in sector $Z$ is parameterized by $\theta_Z$. Notice that I assume that productivity in both sectors is not affected by government spending.

**4.1.3 Market clearing, government, accounting, and monetary policy**

Market clearing in sectors $Z$ and $X$ requires

$$Z_t = C_t + I_{X,t} + I_{Z,t} + M_{X,t} \quad \text{and} \quad X_t = X_{H,t} + X_{G,t},$$

and labor and capital market clearing is given by

$$L_{X,t} = \int_0^1 l_{x,t}(s) \, ds, \quad L_{Z,t} = \int_0^1 l_{z,t}(s) \, ds$$

and

$$K_{X,t-1} = \int_0^1 k_{x,t}(s) \, ds, \quad K_{Z,t-1} = \int_0^1 k_{z,t}(s) \, ds.$$

Since the economy is closed and the government always balances its budget ($T_t = P_{X,t} X_{G,t}$), bonds are in zero net supply, $B_t = 0$. I assume that government purchases in sector $X$ follow the AR(1) process

$$X_{G,t} = (1 - \varrho X) X_G + \varrho X X_{G,t-1} + \varepsilon_{G,t}. \quad \text{(15)}$$

Variables without time subscripts, such as $X_G$, denote steady state values.
I define GDP at constant prices as

\[ Y_t = P_X X_t - P_Z M_{X,t} + P_Z Z_t. \]

The GDP deflator is then

\[ P_t = \frac{P_{X,t} X_t + P_{Z,t} Z_t - P_{Z,t} M_{X,t}}{P_X X_t + P_Z Z_t - P_Z M_{X,t}}, \]

and inflation is

\[ \pi_t = \frac{P_t - P_{t-1}}{P_{t-1}}. \]

I initially assume that the monetary authority follows a fairly general rule of the form

\[ i_t = \iota \left( \{i_{t-s-1}, P_{t-s}, P_{X,t-s}, P_{Z,t-s}, Y_{t-s}, X_{t-s}, Z_{t-s}\}_{s=0}^{\infty} \right). \]  

In this specification, \( \iota \) is any function of the given arguments. I summarize all model equations in Appendix X.

### 4.2 Approximation results

I next turn to two analytical approximations which illustrate the difference between durable and nondurable sectoral multipliers and the relationship to their aggregate counterparts. Although the approximations capture well the short-term dynamics of the equilibrium it should be noted that they provide little, if any, information about the medium and long run. I address questions regarding the medium and long run below.

The approximations require similar assumptions as those made in Section 2. In particular, I assume that \( \beta \) approaches unity and that the depreciation rate of capital \( \delta_K \) tends to zero. The economy is then shocked by a short-lived increase in government purchases, \( X_G \), in the small sector. To preserve space I limit myself to the discussion of these results and provide details on the derivations in Appendix X.

#### 4.2.1 Spending on durable goods

I first consider the case in which the small sector produces highly durable goods. For concreteness, I introduce the following notation. Gross output at constant prices in sector \( X \) is \( GO_{X,t} = P_X X_t \)
and value added is $VA_{X,t} = P_X X_t - P_Z M_{X,t}$. Also denote government purchases of good $X$ at constant prices by $G_{X,t} = P_X X_{G,t}$.

**Approximation result 1.** Suppose that $\beta \to 1$, $\delta_K \to 0$, and $\delta_D \to 0$. Then, for a short-lived increase in spending, it is approximately true that (1) $X_{H,t} \approx -X_{G,t}$, (2) the price $P_{X,t}$ remains unchanged, (3) the sectoral multipliers for gross output and value added are zero, $\frac{dGO_{X,t}}{dG_{X,t}} \approx \frac{dVA_{X,t}}{dG_{X,t}} \approx 0$, and (4) the aggregate multiplier is zero, $\frac{dY_t}{dG_{X,t}} \approx 0$.

Notice first that this result only requires the stated parametric assumptions. In particular, the result holds regardless of the degree of labor mobility across sectors and regardless of whether or not the small sector requires intermediates for production. The result is also independent of the degree of price stickiness (as long as prices are not perfectly sticky) and the precise specification of the monetary policy rule (equation 16).

Part (1) of the result states that every dollar spent by the government crowds out one dollar of private sector spending. If prices are not perfectly sticky, the small sector’s supply curve is upward-sloping. Hence, an increase in demand would lead to a greater equilibrium price. In this limiting approximation, however, the private sector’s demand for durable goods is perfectly elastic and any price increase would result in a complete withdrawal of the private sector from the market. Clearly, this cannot be an equilibrium outcome. Instead, the equilibrium quantity and price in the small sector both remain unchanged. This requires that private sector demand contracts dollar for dollar with greater government spending. The mechanism is easily illustrated in a demand and supply diagram similar to Figure 1 Panel B except that the demand curve is now perfectly elastic.

Since the equilibrium quantity in the small sector is unaffected by the fiscal expansion, the sectoral multiplier must be zero. It turns out that in this limiting case the aggregate multiplier is zero as well. The explanation of this result has three components. First, as noted above, the fiscal expansion has no effect on the small sector’s output and therefore leaves factor demands unchanged. It follows that the household’s factor income remains the same and that there are no spillovers to the large sector through the demand for intermediate inputs. The second effect concerns the government’s financing of the rise in spending. Because the expansion is by assumption brief, its effect on life-time income through taxation is very small. In fact, the approximation procedure treats the change in life-time income as negligible. It then follows that households neither change their labor supply nor their overall consumption demand. Finally, notice that both prices $P_X$ and
remain unchanged. Hence greater government spending does not raise inflation or output and no adjustment is required for the nominal interest rate.

An important corollary of this approximation result is that fiscal multipliers need not be large at the zero lower bound. As, among others, Christiano, Eichenbaum, and Rebelo (2011) and Woodford (2011) show, the multiplier is large whenever the fiscal expansion leads to inflation, and these inflationary forces are not offset by a higher policy rate. At the zero lower bound, higher inflation reduces the real rate stimulating private consumption and therefore resulting in a large fiscal multiplier. However, when the government purchases highly durable goods, private spending is crowded out and inflation barely rises. Hence, the mechanism of greater demand leading to greater inflation and greater inflation leading to even greater demand is interrupted from the start. If the model’s predictions are correct, the difference between nondurables and durables multipliers at the zero lower bound are particularly pronounced.

4.2.2 Spending on nondurable goods

I next turn to the case in which the small sector produces a nondurable good.

**Approximation result 2.** Suppose that $\beta \to 1$, $\delta_K \to 0$, and $\delta_D = 1$. Suppose further that $\rho = \sigma$, $\mu = 1$, and $\theta_X = \theta_Z = 0$. Lastly, assume that the government subsidizes monopolistic firms such that their steady state mark-up over marginal costs is zero. Then a short-lived increase in spending yields a gross output sectoral multiplier equal to

$$\frac{dGO_{X,t}}{dG_{X,t}} \approx \frac{\left(1 + \eta^{-1}\right) \chi^{-1} - (\alpha + \eta^{-1})}{\sigma (\alpha + \eta^{-1}) \frac{\chi\mu}{\chi} + (1 + \eta^{-1}) \chi^{-1} - (\alpha + \eta^{-1})}$$

(17)

and approximately equal sectoral value added and aggregate multipliers

$$\frac{dVA_{X,t}}{dG_{X,t}} \approx \frac{dY_t}{dG_{X,t}} \approx \frac{1 - \alpha}{\sigma (\alpha + \eta^{-1}) \frac{\chi\mu}{\chi} + (1 + \eta^{-1}) \chi^{-1} - (\alpha + \eta^{-1})}.$$  

(18)

The price $P_{X,t}$ rises in response to greater spending.

Notice first that this result requires more assumptions than the previous one. These include complete labor immobility ($\mu = 1$), and that prices in both sectors are fully flexible.

When the small sector produces a nondurable good, all three multipliers are positive. More precisely, they are bounded between zero and one — a feature common to neoclassical environ-
ments. Additionally, the sectoral value added multiplier and the aggregate multiplier are again approximately equal. This implies that sectoral multipliers are of direct policy interest.

I next discuss how various parameters affect the multipliers. A key property that this paper emphasizes is the multipliers’ dependence on the intertemporal elasticity of substitution $\sigma$. The greater $\sigma$ the smaller the multipliers. As $\sigma$ approaches infinity all three multipliers tend to zero — the same value that multipliers of highly durable goods take.

To understand the role of the remaining parameters, I consider two polar cases. Suppose first that no intermediates are required for production ($\chi = 1$). Then it is easy to show that all three multipliers equal

$$\frac{1 - \alpha}{1 - \alpha + \sigma (\alpha + \eta^{-1}) \frac{X'}{X}}.$$

This formula is identical to that in Hall (2009, p. 199), although one should keep in mind that it holds here only approximately. It illustrates clearly that the multiplier is increasing in the labor supply elasticity, $\eta$, and decreasing in the capital share, $\alpha$, reflecting the fact that capital is a fixed factor in the short run.

I next turn to the opposite case in which $\chi \to 0$ so that the small sector uses almost entirely intermediates in production. It then follows that the sectoral multiplier for gross output, $\frac{dG_{OX,t}}{dG_{X,t}}$, approaches unity while the sectoral multiplier for value added and the aggregate multiplier tend to zero. What is the intuition behind these results?

A gross output multiplier of unity implies that the small sector expands one-for-one with greater government demand. Since additional output is almost exclusively produced from intermediates, it is clear that value added in the small sector remains approximately unchanged.\(^{17}\) It can also be shown that

$$M_{X,t} \approx -(I_{X,t} + I_{Z,t}),$$

so that purchases of intermediates crowd out investment in the large hybrid sector dollar for dollar. Hence, while the small sector expands one-for-one, this expansion has no effect on the large sector and total value added (GDP) remains unchanged. We therefore encounter a second instance in which the crowding out of durable goods with large intertemporal elasticity of substitution — in this case investment goods — implies a low multiplier.

\(^{17}\)Of course, in the limit, sector X has no value added to begin with.
Although this finding is certainly extreme and crucially relies on the assumption that the large sector’s output can be used for investment, the approximation clearly illustrates how sectoral linkages affect fiscal multipliers: If government purchases either directly or indirectly through intermediate input linkages raise the demand for durable goods, they largely crowd out private sector demand. If, in contrast, government purchases are targeted at nondurable goods, there is less crowding out and the multipliers are larger.

4.3 Numerical results

I next turn to an exact (linear) numerical analysis of the model. Before proceeding, however, I modify the model slightly. In order to avoid the extreme crowding out effects that greater intermediate purchases cause in the large hybrid sector, I introduce capital adjustment costs. These adjustment costs reflect the fact that some intermediates are nondurable in nature (e.g. consulting services) and therefore have a less elastic demand function than those intermediates that are durable.

4.3.1 Calibration

The length of a period is a quarter and households discount the future with discount factor $\beta = 0.99$. I set the labor supply elasticity $\eta$ to unity. This value is slightly larger than that recommended by Chetty et al. (2011) and reflects the labor market slack present in recessions when countercyclical fiscal policy becomes necessary (Hall, 2009). In line with the estimates in Cashin and Unayama (2012), I select an intertemporal elasticity of substitution of 0.25. Next, I assume that the goods of the small sector are gross complements for those of the large hybrid sector and set the elasticity of substitution $\rho$ equal to 0.5.

Recall that $\mu$ parameterizes the degree of labor mobility across sectors. A value of unity implies complete immobility and a value of 0 implies perfect mobility. To permit a small degree of mobility, I set $\mu$ to 0.9. Turning to the production side of the model, I choose $\alpha = 1/3$ as is standard in the literature. Consistent with an intermediate input share of roughly 55 percent in the 2007 Make and Use Tables, I calibrate $\chi$ to 0.45. Further, I set $\varepsilon$ to 6, implying a steady state mark-up of 20 percent. In my choice of the the price stickiness parameters $\theta_X$ and $\theta_Z$, I follow Gali (2008) and assume that both are equal to 2/3. The depreciation rates of both types of capital are set to 0.025, approximately implying a 10 percent annual depreciation rate. I show results for various alternative
values of $\delta_D$, including $\delta_D = 0.025$ and $\delta_D = 1$ so that the small sector produces a nondurable good. The preference weight $\omega$ is chosen so that value added in the small sector is one hundredth of total value added. Once $\omega$ is fixed, the value of $\phi$ does not affect equilibrium dynamics.

In steady state, the government purchases one fifth of all output in the small sector $X$. I calibrate the persistence $g_X$ of the spending process (15) to 0.6. This value implies that the fiscal expansion largely dissipates after six quarters. The monetary authority follows a simple Taylor rule, that is, I replace the general rule (16) by $\iota_t = \beta^{-1} - 1 + \phi_\pi \pi_t + \phi_Y Y_t$. As, among others, Nakamura and Steinsson (2014) discuss in detail, a sufficiently accommodative monetary authority can essentially generate any aggregate multiplier. I therefore limit myself to a simple case in which the central bank responds stronger than at the zero lower bound, but less than in the hawkish Volcker era. More concretely, I set $\phi_\pi = 1.1$ and $\phi_Y = 0$. Notice that this policy rule satisfies the Taylor principle ensuring equilibrium determinacy as shown in Bullard and Mitra (2002).

Finally, I assume that capital investment at time $t$ is subject to adjustment costs of the form

$$K_{j,t-1} \frac{\zeta_K}{2} \left( \frac{I_{j,t}}{K_{j,t-1}} - \delta_K \right)^2, \quad j \in \{X, Z\}.$$ 

I present results for several values of $\zeta_K$ below. In the baseline calibration $\zeta_K$ is set to 10.

### 4.3.2 Simulation results

Figure 7 shows the impulse response functions of a 100 basis point increase in government spending in the small sector. I consider four different depreciation rates. First, I set $\delta_D = 1$ so that the small sector produces nondurables. Second, I set $\delta_D = 0.025$ — a realistic value for many consumer durables. Third, I select a value of $\delta_D = 0.005$ and label this case “highly durable”. Such a low depreciation rate is only realistic for infrastructure and housing. Finally, I consider a depreciation rate of $\delta_D = 0.001$. This value is clearly lower than justifiable in realistic model calibrations, but I include it in the Figure to illustrate the accuracy of the above approximation results.

Panel A displays the fiscal expansion in the public sector and Panel B shows the private sector response. If the small sector produces a nondurable good, private sector spending barely changes. Since there is very little crowding out, the small sector expands almost one-for-one with public spending. This is shown in Panel C. The gross multiplier in the small sector is close to unity (Panel D) and the aggregate multiplier is near 0.8 (Panel E). If, in contrast, the small sector produces
Figure 7: Model impulse response functions

Notes: The figure plots impulse response functions for the baseline calibration. The impulse is a 100 basis point shock in the small X sector.

durable goods, the multipliers are much smaller.

For lower depreciation rates, there is more crowding out. When $\delta_D = 0.025$, about half of the public sector expansion is undone by a contraction of the private sector (recall that in steady state
the government purchases one fifth of the output in the small sector). All multipliers — gross output, value added, and aggregate — also fall by about half relative to the case in which the small sector produces a nondurable good. As the depreciation rate approaches zero, crowding out becomes nearly perfect and the multipliers tend to zero. Though unrealistically low, the case in which $\delta_D = 0.001$ illustrates that the approximation results above become arbitrarily accurate as $\delta_D$ approaches zero.

These impulse response functions largely confirm the results presented earlier: In the short run the demand for durable goods is very similar to the demand of an extremely interest (or price) elastic nondurable good. However, they yield one additional insight. Because all real variables of the model are stationary, they return to their steady state values in the long run. This model feature implies that any demand for durable goods that was temporarily crowded out has to be made up in the long run as households replenish their stock of durables. In fact, Panel B shows that households’ purchases of the durable goods rise above zero roughly 8 quarters after the shock.

An implication of this delayed demand effect is that all multipliers of durable goods sectors begin to rise about 4 quarters after the shock. From the viewpoint of stabilization policy, it is an unfortunate fact that demand picks up only after the fiscal expansion ends and the pressure on prices recedes. The economy will never enjoy the increased government and private sector demand at the same time.

I finally turn to the question of what sectoral multipliers teach us about aggregate multipliers. In the limiting approximations above, crowding out of capital investment was perfect and, as a result, the aggregate multipliers were equal to the sectoral value-added multipliers. However, when the depreciation rate of capital is 0.025 and capital investment is subject to adjustment costs, as in the baseline calibration, crowding out is imperfect. The aggregate multiplier is therefore greater than the sectoral value added multiplier. In fact, for all four calibrations shown in Figure 7, the aggregate multiplier lies above the sectoral value added multiplier and slightly below the gross output multiplier.

I compute sectoral and aggregate multipliers for various alternative calibrations to see how robust their magnitudes are. The first three rows in table 3 illustrate the role of capital adjustment costs. Whereas neither gross output nor value added sectoral multipliers change substantially with adjustment costs, aggregate multipliers do. Higher adjustment costs imply less crowding out
Table 3: Multipliers for alternative calibrations

<table>
<thead>
<tr>
<th>Calibration</th>
<th>Durable $\delta_D = 0.025$</th>
<th>Nondurable $\delta_D = 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sectoral multiplier</td>
<td>Aggregate multiplier</td>
</tr>
<tr>
<td></td>
<td>Gross output</td>
<td>Value added</td>
</tr>
<tr>
<td>Baseline (baseline calibration)</td>
<td>0.37</td>
<td>0.13</td>
</tr>
<tr>
<td>High adjustment costs $\zeta_K = 100$</td>
<td>0.37</td>
<td>0.13</td>
</tr>
<tr>
<td>Low adjustment costs $\zeta_K = 1$</td>
<td>0.36</td>
<td>0.13</td>
</tr>
<tr>
<td>High labor mobility $\mu = 0.5$</td>
<td>0.40</td>
<td>0.16</td>
</tr>
<tr>
<td>High labor supply elasticity $\eta = 2$</td>
<td>0.41</td>
<td>0.16</td>
</tr>
<tr>
<td>Flexible prices $\theta_X = \theta_Z = 0$</td>
<td>0.18</td>
<td>0.07</td>
</tr>
<tr>
<td>More aggressive Taylor rule $\phi_x = 1.5, \phi_Y = 0.5/4$</td>
<td>0.36</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Notes: The table reports the multipliers at a time horizon of one year after the shock as generated by the model.

of investment through purchases of intermediates. When adjustment costs are high, aggregate multipliers are quite close to the gross output multipliers.

I next compute multipliers, assuming a greater degree of labor mobility across sectors. Since greater labor mobility raises the elasticity of both sectors’ supply curves, the sectoral multipliers increase slightly. Of course more workers in one sector imply fewer in the other so greater labor mobility has an even smaller effect on aggregate multipliers. In order to mimic severe slack in labor markets in recessions, I also compute multipliers for a calibration with greater labor supply elasticity ($\eta = 2$). This parameterization also implies more elastic sectoral supply curves but now additional hires in one sector do not draw labor away from the other. As a result all multipliers increase.

An additional determinant of the short-run elasticity of supply curves are sticky prices. If prices
in a sticky, as in the baseline calibration, a fraction of firms must serve increased demand at fixed
prices. When I assume that prices are flexible, the case $\theta_X = \theta_Z = 0$, it is therefore unsurprising
that multipliers fall. Naturally, this decline in multipliers relative to the baseline calibration is
larger in the more price sensitive durable goods sectors.

Finally, I consider an alternative Taylor rule in which the monetary authority responds stronger
to both inflation and deviations of output from trend ($\phi_\pi = 1.5, \phi_Y = 0.5/4$). As the open economy
relative multiplier in Nakamura and Steinsson (2014), sectoral multipliers appear less sensitive to
alternative monetary policy rules than aggregate multipliers. Of course, aggregate multipliers fall
when the monetary authority “leans against the wind” with increasing strength.

Across all calibrations, a good rule of thumb is that the aggregate multipliers lie between sectoral
value added and gross output multipliers. In the simple model presented here, this rule suggests
that the aggregate multiplier is between 0.1 and 0.4 for durable goods and between 0.5 and 0.9 for
nondurables goods. Of course many studies, including this one, have estimated multipliers outside
this range, many of them greater than one. It is worth noting that while greater aggregate multipli-
ers can easily be generated in models when the monetary authority is sufficiently accommodative,
it is not clear how to obtain sectoral multipliers outside the range from zero to one.

5 Conclusion

Cite Taylor (1982)

As far as fiscal policy at the ZLB is concerned, the goal should be to generate inflation. This
is best done by purchasing nondurable goods, or more generally, goods with an extremely low
intertemporal elasticity of substitution
References


Hausman, Joshua. 2015. “What was Bad for GM was Bad for America: The Auto Industry and the 1937–38 Recession.” Working paper, University of Michigan.


