The Effect of the Recovery Act on Consumer Spending*

Bill Dupor  
Federal Reserve Bank of St. Louis

Marios Karabarbounis  
Federal Reserve Bank of Richmond

Marianna Kudlyak  
Federal Reserve Bank of San Francisco

M. Saif Mehkari  
University of Richmond

February 14, 2017

PLEASE DO NOT CIRCULATE

Abstract

We analyze the effect of the spending component of the Recovery Act (2009-2012) on consumer spending, namely retail and auto purchases. We find that a $1 increase in county-level government spending, increased county-level retail spending by $0.20, and auto spending by $0.05. We translate these regional estimates into aggregate effects using a novel quantitative model. We explicitly model several spillover channels through which government spending may spread across regions, such as trade in intermediate goods, a federal tax union, and a currency union. However, we also allow for heterogeneity and incomplete markets within each region. We simulate regional government spending shocks and analyze their effect on local consumer spending.

*Emails: Bill Dupor: billdupor@gmail.com; Marios Karabarbounis: marios.karabarbounis@rich.frb.org; Marianna Kudlyak: marianna.kudlyak@rich.frb.org; M. Saif Mehkari: smehkari@richmond.edu. We thank seminar participants at the 2015 CESifo Conference on Macroeconomics and Survey Data, UVA-Richmond Jamboree and the EEA-ESEM 2016 (Geneva). We acknowledge the Data Center at The University of Chicago Booth School of Business for providing Neilsen data and note that information on availability and access to the data is available at http://research.chicagobooth.edu/nielsen.
1 Introduction

During the Great Recession consumer spending declined dramatically, the largest decrease since World War II. In response, the government initiated a number of programs to support household spending and boost aggregate demand. The most notable is the Recovery Act. This was a very large—by historical standards—program which was initiated in 2009 and involved the allocation of about $840 billion. A significant part of the program (roughly one-third) was direct spending on local goods and services. Was the Recovery Act successful in boosting private consumer spending? Or did it crowd out household spending, as most macroeconomic models would predict?

Although the question of the consumption response to government spending is very old, the literature still lacks consensus. For example, Ramey and Shapiro (1998) find that during episodes of large exogenous increases in defense spending, private consumption falls whereas Blanchard and Perotti (2002) and Gali, Lopez-Salido, and Valles (2007) find a positive effect. This is worrisome since consumer spending is the largest component of national income and its response is a key determinant of the government spending multiplier.

The aforementioned literature relies on aggregate time series coupled with structural VAR to identify the consumption multiplier. What distinguishes our paper is that we use regional variation in the spending component of the Act and analyze its effect on consumer spending across localities. Almost 95% of U.S. counties benefited from the Act with some counties receiving much larger sums per resident than others. We construct regional-level spending using two separate datasets. We collect information on retail purchases from the Nielsen Consumer Panel Data and spending in auto vehicles by measuring changes in individual auto balances from Equifax. These spending categories are becoming common when analyzing regional-level consumer patterns (for example, Mian, Sufi, and Rao, 2013).

A common challenge in this type of analysis is to convincingly address the endogeneity between government aid and local economic conditions. For example, it is more likely that counties that received more money were hit the hardest by the recession. We address this endogeneity using a narrative approach. We find components of the Act that were allocated to localities based on criteria unrelated to the local business cycle. For example, the criteria for the dispersion of money from the Department of Education to children with disabilities was the relative population of children across regions not whether the local economy suffered through a recession.

We find strong, positive, and significant effects of fiscal spending on retail and auto spending. When government spending increases in a county by $1, households residing in the county increased their retail spending by around $0.20, and their auto spending by around $0.05, rel-
ative to other counties. These results are consistent with Berger and Vavra (2014) who claim that fiscal stimulus during recessions has a larger effect on nondurable consumption relative to durable purchases. We next analyze the consumer response to fiscal stimulus across income groups. Surprisingly, income groups respond the opposite way in their retail and auto vehicle purchases. In response to fiscal stimulus, counties in the bottom 25% of the income distribution spend relatively more than counties at the top 25% in retail but less than the top 25% in auto.

How should we interpret these coefficients? Our exercise summarizes the response of one region to a $1 injection of fiscal stimulus relative to another region that did not receive that extra dollar. However, these regional estimates are not always informative of aggregate effects (Nakamura and Steinsson, 2014; Beraja, Hurst, and Ospina, 2016). For example, fiscal spending may affect all regions proportionately by increasing federal taxes or by hiking the nominal interest rate. Our empirical framework cannot identify such aggregate changes to consumer spending, only changes in one region relative to another.\footnote{Nakamura and Steinsson (2014) give the name “open economy relative multiplier” to estimates of government spending using regional analysis within a currency union.}

To translate our local multiplier into a closed economy aggregate multiplier we use a dynamic multi-regional model. Our model is novel in two ways: First, we incorporate an Aiyagari economy within every region. In particular, each region is populated by heterogeneous households who face idiosyncratic income risk and incomplete markets. This means that household decisions aggregate to the regional level in a nonlinear manner. Hence, our model departs from recent models that aggregate trivially local behavior by considering complete markets (Nakamura and Steinsson, 2014; Beraja, Hurst, and Ospina, 2016). Second, our framework allows to consider more than two regions and hence to consistently map our model to cross-regional distributions.

Other than these two novel features, our model follows the New-Keynesian regional setup of Nakamura and Steinsson (2014). In particular, we incorporate several linkages through which government spending may spread across regions: (i) regional trade in intermediate goods, (ii) federal taxes, and (iii) a monetary authority that may adjust the nominal rate based on the weighted sum of local inflation rates (currency union).

Over the last years there has been a surge of papers using regional variation to estimate aggregate effects of shocks or policies. These include work on the regional effects of house prices shocks on consumer spending (Mian, Sufi, and Rao, 2013), the effect of unemployment insurance across regions (Hagedorn, Karahan, Manovskii, and Mitman, 2016), the effect of regional military spending on regional GPD (Nakamura and Steinsson, 2014), as well as many papers analyzing the effect of the Recovery Act on employment (Conley and Dupor, 2013 and
Chodorow-Reich, Feiveson, Liscow, and Woolston, 2013, to name a few).

What sets apart our paper is the following: one, our paper focuses on the effect of government spending on consumer spending, a question at the heart of the income multiplier debate. Most papers studying the effects of fiscal stimulus abstract from analyzing consumer spending since data are scarce especially at the regional level. Our paper brings forward evidence on regional consumer spending by combining two separate household-level datasets. Second, we translate our empirical findings using a dynamic multi-regional model. Most of the aforementioned papers only conduct an empirical analysis without using a model to isolate the effect of regional spillovers on their estimates.

As mentioned, our paper contributes to the very large literature on the consumption multiplier. One part of the literature empirically estimates the consumption multiplier using VAR models and aggregate time series (Ramey and Shapiro, 1998; Blanchard and Perotti, 2002). Another part of the literature estimates model-generated multipliers using dynamic general equilibrium models (for example, Christiano, Eichenbaum, and Rebelo, 2011). Our paper combines these approaches. We first empirically estimate a consumption multiplier using regional variation in consumer spending. Regional variation allows one to dispense common issues with the VAR/time series approach such as a short time sample and identification problems. We then build a model of government spending. The model uses the regional variation as information to give an estimate about the aggregate effects.

2 Data

Our paper combines multiple datasets. We use the Nielsen HomeScan dataset to get information on household retail purchases. We use Equifax to get information on household auto finance which we use as a proxy for auto purchases. We get data on government spending from the American Reinvestment and Reenactment Act (ARRA). This is a publicly available dataset and be found at the www.recovery.org site. All datasets provide a very detailed geographical information (zip code).

2.1 Consumer Spending

We collect information on two types of consumer expenditures: retail spending and auto spending. These consumption groups are becoming common when analyzing consumer patterns at a regional-micro level. For example, Mian, Sufi, and Rao (2013) collect spending on groceries, furniture, appliances purchased with a debit or credit card. Moreover, they collect information on auto vehicle registrations. We use Nielsen Homescan for retail spending and
Table 1: Data Sources for Consumer Spending

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Source</th>
<th>Original Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail Spending</td>
<td>Nielsen HomeScan</td>
<td>60,000 households</td>
</tr>
<tr>
<td>Auto spending</td>
<td>Equifax</td>
<td>10 million individuals</td>
</tr>
</tbody>
</table>

Note: The Table lists the micro-data we use to gather information on consumer spending. We use Nielsen Homescan for retail purchases. We use Equifax to collect information on auto financing we serves as a proxy for spending in auto vehicles.

Equifax for auto finance data as a proxy for vehicle purchases. We show that Equifax auto finance aligns well with vehicle registrations. An advantage of our datasets is that they are easily accessible. Table 1 provides a summary of our datasets.

2.1.1 Nielsen HomeScan

We collect data on household retail spending from the Nielsen Homescan Consumer Panel Dataset. This is a longitudinal panel of approximately 60,000 U.S. households who continually provide information about their retail purchases. The purchases are recorded by the panelists using in-home scanners.

The dataset includes detailed information on all households’ shopping trips. It records the date of the trip, the UPC code, the total number of units purchased, and the total amount spent. Purchases in the Nielsen Home Scan include a combination of non-durable and durable goods. However, even the durable goods are fast-moving products and typically not very expensive. Examples of fast-moving durable goods available in Nielsen are cameras and office supplies. Table 2 reports the fraction of spending for each type of store in the Nielsen dataset. Around 53% of annual spending takes place in Grocery and Discount Stores. Hardware, Home Improvement, and Electronics Stores account for just 4% of annual spending. Nielsen also has information on Online Shopping which accounts for 3% of the annual retail spending in the dataset.

---

2The most commonly used dataset for consumption expenditures the Consumption Expenditure Survey (CEX). We consider this dataset not suitable for our analysis. On the one hand, it provides information at a relative aggregated regional level (U.S. States). Moreover, there are well known issues with measurement errors (Attanasio, Hurst, and Pistaferri, 2013).

3All our results are calculated (or Derived) based on data from The Nielsen Company (US), LL-C and marketing databases provided by the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business. Information about the data and access are available at http://research.chicagobooth.edu/nielsen/.

4Panelists are randomly recruited via mail or the Internet. Nielsen has ongoing communication with panelists to ensure cooperation, create enthusiasm and monitor workload. Nielsen has also a number of systems to ensure quality data.
Table 2: Fraction of Spending by Store Type–Nielsen HomeScan

<table>
<thead>
<tr>
<th>Store Type</th>
<th>Spending</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grocery</td>
<td>32.9%</td>
</tr>
<tr>
<td>Discount store</td>
<td>20.5%</td>
</tr>
<tr>
<td>Warehouse club</td>
<td>8.5%</td>
</tr>
<tr>
<td>Drug store</td>
<td>4.2%</td>
</tr>
<tr>
<td>Department store</td>
<td>3.9%</td>
</tr>
<tr>
<td>Online Shopping</td>
<td>3.0%</td>
</tr>
<tr>
<td>Hardware/Home Improv.</td>
<td>2.9%</td>
</tr>
<tr>
<td>Dollar Store</td>
<td>1.7%</td>
</tr>
<tr>
<td>Apparel Stores</td>
<td>1.6%</td>
</tr>
<tr>
<td>Convenience store</td>
<td>1.5%</td>
</tr>
<tr>
<td>Electronics store</td>
<td>1.1%</td>
</tr>
<tr>
<td>Gas mini mart</td>
<td>1.0%</td>
</tr>
<tr>
<td>Pet store</td>
<td>0.8%</td>
</tr>
<tr>
<td>Restaurant</td>
<td>0.7%</td>
</tr>
<tr>
<td>Office supplies store</td>
<td>0.7%</td>
</tr>
<tr>
<td>Quick serve restaurants</td>
<td>0.6%</td>
</tr>
<tr>
<td>Liquor store</td>
<td>0.6%</td>
</tr>
<tr>
<td>Home furnishings</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

Note: The Table reports the fraction of total spending in all Nielsen categories by Store type. Store types follow the classification used by Nielsen.

The data is available from 2004-2014. Alongside with retail spending panelists offer demographic information which is updated annually. These include the household size, age, employment, education, and occupation of its members, presence and age of children, and marital status. Panelists also report their annual income. The household income data are available in six intervals: (1) under $25,000, (2) $25,000-$35,000, (3) $35,000-$50,000 (4) $50,000-$70,000 (5) $70,000-$100,000, and (6) $100,000 and above. Finally, the dataset offers information on the household’s zip code, county and state.5

For the median household retail purchases are a sizable component of total expenditures. We collect information on total household expenditures using the Consumption Expenditure Survey (CEX) for the years 2000-2014. The median household spends annually $26,016 in all categories. We then identify spending categories that overlap with the categories shown in Table 2. We consider a narrow set of categories that include (1) food at home and (2) household supplies and a broader set that also include spending in (3) small appliances, (4) personal care and (5) miscellaneous equipment. Based on our narrow definition the median household spends 17% in Nielsen type spending while a household at the 90th percentile spends 32%. Based on our broader definition these numbers are 19% and 35%, respectively. Hence, available spending in Nielsen HomeScan represents a sizable component of total household spending.

5The panel composition is designed to be projectable to the total U.S. population. Since some households are more likely to be selected according to their characteristics Nielsen provides sample weights to correct for sample bias.
2.1.2 Equifax

We measure local purchases for vehicles using information on auto finance loans. We use the most detailed dataset on household debt, the New York Federal Reserve Bank Consumer Credit Panel/Equifax (CCP) data. The CCP is a quarterly panel of individuals with detailed information on consumer liabilities, some demographic information, credit scores, and geographic identifiers to the zip level. The core of the database constitutes of a 5% random sample of all U.S. consumers with credit record and social security number. This is called the primary sample. The dataset also includes information on anyone whose credit report is under the same address as the person in the primary sample. The total number of observations is approximately 10 million individuals.

The data cover all major categories of household debt including mortgages, home equity lines of credit, auto loans, credit cards, and student loans. For every type of liability Equifax provides information on the balance and the number of such accounts. We use information on auto balances. Other than consumer liabilities, the dataset provides information on individuals’ age, credit scores, and geographic identifiers to the zip level.

We use auto finance as a proxy for spending in vehicles. We consider auto finance by both banks and car dealerships. In particular, we consider individual $i$ to have purchased a vehicle at time $t$ if his/her auto balance increased between periods $t-1$ and $t$. The change in the auto balance is our proxy for spending in auto vehicles.

2.2 Government Spending

The American Recovery and Reinvestment Act of 2009 was enacted on February 17, 2009. The Act is commonly known as the “stimulus package”. The act allocated roughly $840 billion with a primary goal of creating new jobs and providing temporary relief during the great recession.

The Act can be thought of as having three major components: tax benefits, entitlements, and federal contracts with roughly a third of the total spending going to each. For this paper we are primarily interested in the last component of the Act. The government awarded roughly $228 billion in contracts, grants, and loans. This amount was spread across a number of different industries with Education being the largest and Transportation, Infrastructure, and Energy also receiving large amounts (see Table 3). The awards were dispersed through a number of different agencies such as the Federal Highway Administration, the Department of Energy, the Department of Housing and Urban Development, the Department of Education, etc.

These awards were used for a number of different purposes. For example, the educa-
tion awards went towards, among other programs, state fiscal stabilization funds, student aid, training and employment, and helping special education students. The awards in the transportation sector went towards building and maintaining highway infrastructure, railway infrastructure, and airports etc. The awards in the energy sector went to energy efficient and renewable energy programs, water and electricity infrastructure development, and other environmental programs. A full list of programs can be found on cached copies of the recovery.gov webpage.

To promote transparency the Act required recipients of ARRA funds to report how they used the money. All the data were posted on Recovery.gov so the public could track the Recovery funds. In particular, entities receiving ARRA awards (recipients) were required to report quarterly on the status of the award. May 1 2014 was the last time the website was updated. For every award the website contained detailed information including the total

Note: The Figure shows the cumulative amount of government spending in million dollars during the period 2009-2013 by U.S. counties.
amount awarded, the total amount spent to date, the award data, the name of the funding agency, and geographical information such as the zip code, city, and state.

We use the data from recovery.gov to construct our measure of local government spending. This data is available at a very fine level and includes information about vendors, subcontractors, and other entities who received government funding from a particular award. Instead of geocoding the funding by the primary agency, we exploit these fine details to construct very precise measures of government spending by the ultimate recipient of the award. For example, say an award was given to a Federal Agency which in turn awarded it to a state-level agency which further awarded it to a number of private entities, then when constructing government spending measures we use the location and award information of the private entities.

Figure 1 shows the geographical variation in cumulative spending across U.S. counties during the period 2009-2013. Approximately 95% of U.S. counties received at least one award through the Act. The variation in awards is large: counties such as Los Angeles County, CA received roughly $6 billion while Piute County, UT received only $10,000. Even after accounting for population the variation is still quite large with Barbour County, WV with a population of 15,000 getting approximately $50,000 per person and Johnson County, AR with a population of 24,000 getting less than $30 per person. A large fraction of the federal dollars were channeled through state and local governments. The Act specified dollar amounts allocated for various categories; however, local and state governments had much latitude regarding when and on what projects ARRA dollars were spent.

2.2.1 Instrumental Variable

A common challenge to identify the effect of government programs on economic variables is that government programs usually take place during time of economic distress. Similar, in our case, it is possible that the money allocated to local communities was correlated with the local business cycle conditions. To overcome this endogeneity we find components of the Act that were allocated using criteria unrelated to the local labor’s market business cycle.

In particular, our data offers the opportunity to uncover exogenous movements in government spending. Each Agency responsible for dispersing Recovery Act dollars provided explicit criteria by which funds would be allocated. Identifying the different criteria requires a very detailed reading of the Act, federal codes and regulations as well as the implementation guidances written by the Agencies tasked with allocating the funds. We use these criteria to discern if the allocation process was exogenous or depended on the local economic conditions.

An example, of a program that was independent of local business conditions is the money given from the Department of Education to children with disabilities. The criterion for the
Table 3: Components of the Recovery Act used in the construction of the instrument

<table>
<thead>
<tr>
<th>Federal Department/Agency</th>
<th>Total Amount Authorized ($Billions)</th>
<th>Fraction included in IV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Protection Agency</td>
<td>6.7</td>
<td>87.5</td>
</tr>
<tr>
<td>General Services Administration</td>
<td>4.8</td>
<td>98.3</td>
</tr>
<tr>
<td>Department of Transportation</td>
<td>39.3</td>
<td>16.7</td>
</tr>
<tr>
<td>Department of Education</td>
<td>71.6</td>
<td>15.6</td>
</tr>
<tr>
<td>Department of Energy</td>
<td>33.3</td>
<td>43.5</td>
</tr>
<tr>
<td>Department of Justice</td>
<td>3.5</td>
<td>72.4</td>
</tr>
<tr>
<td>Department of Defense</td>
<td>4.3</td>
<td>87.1</td>
</tr>
<tr>
<td>All other Agencies</td>
<td>62.3</td>
<td>0.0</td>
</tr>
<tr>
<td>All Departments/Agencies</td>
<td>228.0</td>
<td>20.2</td>
</tr>
</tbody>
</table>

**Note:** The Table breaks down the total amount awarded during the period 2009-2012 by Departments/Agencies. For each Agency we report the fraction of awards included in our instrument.

dispersion of this money across localities was purely the relative population of children with disabilities, not whether these localities suffered a recession. Another example is money provided through the Federal Transit Administration for road improvement and maintenance. The criterion was the population density and passenger miles of the areas these roads were located.

Another example relates to the water quality assistance grants. The EPA instructions for state agencies was to select projects where water quality needs are the greatest while priority was given to projects “ready to proceed to construction within 12 months” of the Act’s passage. Moroever, 20% of funds were instructed to be allocated to green projects. Among these guidelines there is no mention of allocating water quality funds to counties with weakest economies.

We construct our instrumental variable as the sum of the total value of funds allocated with our selected (exogenous) criteria. In Table 3 we summarize the total amount of awards used in our instrument as a fraction of the total awards given in total. The total amount of money awarded in all the U.S. during the period 2009-2012 was $228 billions. Out of this amount 20.2% were allocated based on our selected criteria. Departments of Transportation, Education, and Energy were the main recipients of Recovery Act awards. We identify 16.7%, 15.6%, and 43.5%, respectively, of total money allocated to be awarded based on our selected criteria. For other Departments the fraction is much larger but the total money awarded was relatively small.
2.3 Other Variables

We use a number of other data sources for our analysis. We collect information on arealevel average income as well as wages and salaries from the IRS website. The information isavailable at the zip code level for the period 2001-2015. We collect information for inflationfrom the BEA. We have information on PCE price indexes for the period 2008-2014 for 382Metropolitan Statistical Areas (MSAs). House price growth is calculated based on Zillow.Information on area-level unemployment is taken by the BLS and is available at the statelevel. Finally, we collect information on area-level population from the Census.

3 Empirical Analysis

3.1 Definitions and Basic Specification

This section describes our empirical specification. As mentioned we use two categoriesof consumer spending: retail spending \((R)\) and auto finance loans \((A)\) both available at thehousehold level. Hence, \(c_{ijt} = \{R_{ijt}, A_{ijt}\}\) denotes total spending of the individual \(i\) locatedat region \(j\) at time \(t\).

We construct area-level spending by averaging across all individuals that reside in that area. So \(C_j = \frac{\sum_{i \in j} c_{ijt}}{N}\) is the area-level spending. In our specifications we will aggregate up to thecounty level. Our auto finance spending variable is truncated at zero since some householdswill not spend on auto vehicles in a particular year. Aggregating at the county-level allows toconstruct a non-truncated distribution and use ordinary least squares/instrumental variabletechniques. The independent variable is government spending allocated in region \(j\) at time \(t\): \(G_{jt}\).

Our data have both a time and an area dimension. So one could use a fixed effect specifi-cation along both dimensions. However we decide to use fixed effects only along the area dimension. We summarize the time effect by constructing cumulative changes in our vari-ables between the time 2009-2012. We do this for two reasons. One, we do not believe theRecovery.org data provide reliable information on the exact timing of the money awarded inlocalities. Second, as it often assumed, government spending affects consumption with some lag or lead. For example some areas might anticipate the money awarded and change their spending prior to the allocation. This makes the use of cumulative changes over the period 2009-2013 a more suitable and concise statistic.
Our left-hand side variable is the cumulative growth rate of spending relative to 2008.

\[ \Delta \log C_j = \sum_{t=2008}^{2012} \{ \log C_{j,t} - \log C_{j,2008} \} \]  

(1)

Since \( G_{j,2008} = 0 \) for all counties we cannot use a similar definition for the independent variable. Hence we will use \( \log G_j \) which denotes logged cumulative total money awarded to county \( j \) during the period 2009-2012, per-capita.

To estimate the effect of government spending on consumer spending we use the following specification at the county-level:

\[ \Delta \log C_j = a + \beta \times \log G_j + X_j \Phi' + D_j + \varepsilon_j \]  

(2)

where as mentioned \( \Delta \log C_j \) is the cumulative growth rate of (average) spending for county \( j \) between 2008-2012 and \( \log G_j \) is the per-capita cumulative change in money allocated in county \( j \) between 2008-2012 from the Recovery Act. Coefficient \( \beta \times 100 \) is the change in consumer spending growth rate if government spending increases by 1%.

We also use a wide set of county-level and state-level control variables. These are represented by the vector \( X_j \). The county-level controls are county population and the per-capita county income as reported at IRS tax returns between 2008-2012. The state controls are state population, per-capita state income, state income growth between 2007-2010, and 2010-2013, unemployment change during these two time intervals and house price growth between 2006-2008. We also include a state dummy \( D_j \). We will run this regression using standard OLS methods as well as using our instrumental variable—the fraction of money allocated based on our selected criteria.

### 3.2 The Effect of the Recovery Act on Consumer Spending

This section reports the estimates for the retail spending and the auto spending multiplier. Figure 2 plots simple scatters plot between per-capita money awarded in each county over the period 2009-2012 and the cumulative county-level growth rate in retail spending (Left Panel) and auto spending (Right Panel) over the same period. Recovery Act spending is expressed in log so the exponential gives the per-capita amount in dollars awarded to the county.

Most counties experienced a significant drop in retail spending in the period 2009-2012, relative to 2008 which is our base year. This explains why in the left panel of Figure 2 several counties are below the zero line. The plot hints toward a positive relationship between county-level Recovery Act spending and retail spending. Counties that were awarded larger amounts of money seem to have experienced, on average, a smaller cumulative decrease (relative to
Figure 2: Recovery Act spending (in log) and cumulative change in retail and auto spending (2008-2012), by counties

Note: The Figure plots the relation between per-capita Recovery Act spending and cumulative change in retail and auto spending, between 2008-2012, by counties. Recovery Act spending is in log.

2008) compared to other counties. Similarly, in the right panel of Figure 2 we plot a scatter plot between per capita money awarded in each county over the period 2009-2012 (in log) and cumulative change in the county-level growth rate in auto spending. In this case most counties are above the zero line meaning they experienced a (cumulative) increase relative to 2008. This happens because auto finance had started to decline well before the crisis so that 2008 was a relatively low point. Again, the plot hints toward a positive relationship between county-level Recovery Act spending and auto spending.

Table 4 gives the estimates of our main regression. We run our county-level regressions separately for retail sales and auto sales. We also report both the OLS and IV estimates. We use county controls and state fixed effects and refer to the Appendix for alternative specifications with no controls or with both county and state controls. Since the coefficients are not easy to interpret we write the dollar multiplier associated with each estimate. To do so we use the average county-level retail/auto and government spending. We cluster all standard errors by the county’s state code.

Our regressions point to a positive and statistically significant (at the 10%) response of retail spending to fiscal stimulus. Counties that received 1% more in government spending experienced an increase in retail spending growth between 0.031%-0.035%. The average county received $734 in government aid so that 1% increase translates in about $7. Moreover, the average county spent around $4,500 in retail purchases in our base year (2008). This means that $7 in government spending increased income between $1.8-$2.2. These translate into a retail spending multiplier between 0.25 and 0.31. Note that these are the cumulative
Table 4: Retail and Auto Spending Multipliers

<table>
<thead>
<tr>
<th>Spending Category</th>
<th>Retail Spending (Nielsen)</th>
<th>Auto Spending (Equifax)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td>IV</td>
</tr>
<tr>
<td>Recovery Act</td>
<td>0.035**</td>
<td>0.031*</td>
</tr>
<tr>
<td>Spending</td>
<td>(0.016)</td>
<td>(0.018)</td>
</tr>
<tr>
<td>$ Multiplier</td>
<td>$0.25</td>
<td>$0.31</td>
</tr>
<tr>
<td>Partial F stat.</td>
<td>—</td>
<td>169.8</td>
</tr>
<tr>
<td>State Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td># Counties</td>
<td>560</td>
<td>560</td>
</tr>
</tbody>
</table>

Note: The Table regresses the growth rate in retail and auto spending to cumulative government spending at the county level during the period 2008-2012. We show results for our OLS and IV specification and the standard errors in parenthesis. We include state fixed effects. We translate the empirical coefficient into a dollar multiplier using the average per capita retail/auto spending and government spending at the county level.

multipliers over the entire period. Equifax provides a much richer geographical representation of the U.S. relative to Nielsen. This explains the differences in our samples (600 vs. 2900 counties). For Equifax the average county-level loan is around 620$. Similar calculations lead to a dollar multiplier around 0.05$.

Table 5 breaks down these regressions by county-level income. In particular, we regress county-level cumulative growth rate in retail/auto spending to county-level Recovery Act spending interacted by county-level Adjusted Gross Income. We include three dummy variables corresponding to the bottom 25%, between 25% and 75% and the top 25% of the AGI distribution. There is substantially heterogeneity in the consumer response across income groups. Counties in the bottom 25% of the AGI distribution spent relative more in retail than counties at the middle and the top of the distribution. In particular, the bottom 25% experienced a larger increase in retail spending growth relative to the middle-income counties by around 0.002%. Similarly, the middle-income counties experienced a larger increase in growth relative to the top 25% counties by around 0.005%.

Like we did with retail, we regress county-level cumulative auto spending to county-level Recovery Act spending interacted by county-level Adjusted Gross Income. In sharp contrast with retail spending, counties in the bottom 25% of the AGI distribution spent relative less in auto than counties at the top. The bottom 25% experienced a smaller increase in auto spending growth relative to the middle-income counties by around 0.007%. Similarly the middle-income counties experienced a smaller increase in auto spending growth relative to the
Table 5: Heterogeneity in Retail/Auto Spending by Income

<table>
<thead>
<tr>
<th>Spending Category</th>
<th>Retail Spending (Nielsen)</th>
<th>Auto Spending (Equifax)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td>IV</td>
</tr>
<tr>
<td>Recovery Act</td>
<td>0.042**</td>
<td>0.038*</td>
</tr>
<tr>
<td>Spending</td>
<td>(0.02)</td>
<td>(0.02)</td>
</tr>
<tr>
<td>Rec. Act Spending</td>
<td>-0.010*</td>
<td>-0.011*</td>
</tr>
<tr>
<td>× Low Income</td>
<td>(0.007)</td>
<td>(0.007)</td>
</tr>
<tr>
<td>Rec. Act Spending</td>
<td>-0.012*</td>
<td>-0.012*</td>
</tr>
<tr>
<td>× Medium Income</td>
<td>(0.007)</td>
<td>(0.005)</td>
</tr>
<tr>
<td>Rec. Act Spending</td>
<td>-0.018**</td>
<td>-0.015*</td>
</tr>
<tr>
<td>× High Income</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td># Counties</td>
<td>560</td>
<td>560</td>
</tr>
</tbody>
</table>

Note: The Table regresses the growth rate in retail and auto spending to cumulative government spending at the county level during the period 2008-2012. We show results for our OLS and IV specification and the standard errors in paranthesis. We include state fixed effects. We translate the empirical coefficient into a dollar multiplier using the average per capita retail/auto spending and government spending at the county level.

top 25% counties by around 0.004%

3.3 Income and Inflation

It is informative to analyze the effect of the fiscal stimulus on two variables that affect consumer spending: income and inflation. As mentioned, we collect information on area-level average income from the IRS website. The information is available at the zip code level for the period 2001-2015. We collect information for inflation from the BEA. We have information on PCE price indeces for the period 2008-2014 for 382 Metropolitan Statistical Areas (MSAs). For both variables we follow the exact specification as we did for consumer spending.

We find the Recovery Act to have a significiant effects on county-level income. If government spending increases by 1% then average gross income increases between 0.016%-0.028%. If the average county received $734 in government aid then 1% increase translates in about $7. The average county had an income of $45,696 in our base year (2008). This means that $7 in government spending increased income between $7.3-$12.7. These translate into an income multiplier between 1.0 and 1.8. In contrast, there does not seem to be an effect of government spending on inflation.
Figure 3: Recovery Act spending (in log) and cumulative percentage change in income and inflation (2008-2012), by counties

![Graph showing recovery act spending and percentage change in income and inflation](image)

**Note:** The Figure plots the relation between per-capita Recovery Act spending and cumulative change in auto spending, between 2008-2012, by counties. Recovery Act spending is in log.

Table 6: Income and Inflation Multipliers

<table>
<thead>
<tr>
<th>Category</th>
<th>Adjusted Gross Income (IRS)</th>
<th>Inflation (BLS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td>IV</td>
</tr>
<tr>
<td>Recovery Act Spending</td>
<td>0.028***</td>
<td>0.016*</td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>$ Multiplier</td>
<td>$1.81</td>
<td>$1.06</td>
</tr>
<tr>
<td>Partial F stat.</td>
<td>—</td>
<td>154.2</td>
</tr>
<tr>
<td>State Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td># Counties</td>
<td>2873</td>
<td>2873</td>
</tr>
</tbody>
</table>

Note: The Table regresses the income growth rate and inflation rate to cumulative government spending at the county level during the period 2008-2012. We show results for our OLS and IV specification and the standard errors in parentheses. We include state fixed effects. We translate the empirical coefficient into a dollar multiplier using the average county-level income as well as the average government spending.

### 3.4 Placebo Diagnostics

We perform a diagnostic to evaluate whether our results are driven by different income groups receiving different amounts of fiscal stimulus. The diagnostic is performed by randomly assigning government spending across income groups. We first partition counties based on their per-capital Adjusted Gross Income for the year 2008. Then we re-assign the government
Table 7: Placebo Diagnostics

<table>
<thead>
<tr>
<th>Spending Category</th>
<th>Retail Spending</th>
<th>Auto Spending</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Nielsen)</td>
<td>(Equifax)</td>
</tr>
<tr>
<td>OLS</td>
<td>0.001</td>
<td>-0.000</td>
</tr>
<tr>
<td>IV</td>
<td>0.000</td>
<td>-0.000</td>
</tr>
<tr>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>(0.003)</td>
<td></td>
<td></td>
</tr>
<tr>
<td># Counties</td>
<td>560</td>
<td>2990</td>
</tr>
</tbody>
</table>

Note: The Table regresses the growth rate in retail and auto spending to cumulative government spending if we re-assign the government spending of a particular county to another county within the same income group. The reassignment occurs only within states.

spending of a particular county to another county within the same income group. The reassignment occurs only within states. The distribution of government spending accross income groups is the same as before. What changes here is the allocation of government funds within each income group. If we expected income to drive our results then our estimates would remain largely intact by this re-assignment. Table 7 shows the results of our benchmark specification when we perform the kind of reshuffling described above. For both spending categories (retail and auto) the positive effects vanish and become insignificant.

4 Model

4.1 Description of the Economy

The economy is divided in $i = \{1, \ldots, N\}$ regions. Each region has its own wage $w_i$ and inflation rate $\pi_i$. But faces the same nominal interest rate $R$. Each region produces a final good $Y_i$ using intermediate inputs produced by monopolistically competitive firms. There is a continuum of intermediate good firms indexed by $(i, j)$. The intermediate good firm $j$ located in region $i$ produces $y_{i,j}$ at price $p_{i,j}$. Regions trade with each other in intermediate inputs.

Each region is an open Huggett economy. In particular, there is a continuum of households making consumption, working and saving decisions. Finally, there is a government buying final goods from each of the $N$ local markets. To finance expenditures it taxes households at the federal level based on a progressive tax schedule. The government also supplies the nominal bond used by households as a savings instrument.
4.2 Households

Each region is populated by a measure one continuum of households. Households derive utility from consumption and leisure. A household is endowed with one unit of productive time, which it splits between work $h$ and leisure. Households’ decisions depend on preferences representable by a time separable utility function of the form

$$U = E_0 \left[ \sum_{t=0}^{\infty} \beta^t \left\{ \frac{c_{1,t}^{1-\sigma}}{1-\sigma} + \psi \frac{(1-h_{i,t})^{1-\theta}}{1-\theta} \right\} \right]$$

(3)

where $\beta$ is the discount factor and $\theta$ affects the Frisch elasticity of labor supply. Households only consume the final good produced in their region. They also receive the real dividends from the intermediate firms located in their region: $D_i$.

Households supply labor in the intermediate good sector and receive real wage payments $w_i$. The effective wage rate is $s_ixw_i$ where $s_i$ is a region-specific constant productivity effect (fixed effect) and $x$ is an idiosyncratic shock. This regional productivity is distributed as $s_i \sim N(0, \sigma_s^2)$ while idiosyncratic shock that follows an AR(1) process in logs:

$$\log x' = \rho \log x + \eta', \quad \text{with} \quad \eta' \sim \text{iid } N(0, \sigma_{\eta}^2).$$

(4)

The transition matrix, which describes the autoregressive process, is given by $\Gamma_{xx'}$. Household pay labor income taxes based on a progressive schedule $T(.)$ and also receive some real lump-sum transfers $F$. Households can insure using a bond $b$ and face a tight borrowing constraint. The bond costs 1 dollar and pays $(1 + R)$ dollars where $R$ is the nominal interest rate. The government will supply the asset. We denote the regional distribution of households across productivity and asset holdings as $\phi_i$.

We write the household’s problem in a recursive way.

$$V_i(x, b, \phi) = \max_{c, b', h} \left\{ \frac{c^{1-\sigma}}{1-\sigma} + \psi \frac{(1-h)^{1-\theta}}{1-\theta} + \beta \sum_{x'} \Gamma_{xx'} V_i(x', b', \phi') \right\}$$

(5)

s.t. $c + (1 + \pi_{i,t+1})b' = ws_i xh - T(ws_i zh) + (1 + R_{t-1})b + D_i + F$

$$b' \geq 0$$

(6)

(7)

Note that $\pi_{i,t+1}$ is the region-specific inflation rate defined as

$$\pi_{i,t+1} = \frac{P_{i,t+1}}{P_{i,t}} - 1$$

(8)
where $P_i$ is the price of the final good in region $i$ (defined below).

### 4.3 Firms

#### Final good firms

There is one final good firm in every region $i$ that produces $Y_i$. So there are $\{Y_1, Y_2, ..., Y_N\}$ final goods in the economy. Each final good is sold at $P_i$ which is the price aggregator at each region $i$. We will use the notation $Q_{i' i}$ to denote the relative price (real exchange rate) between final goods $i'$ and $i$: $Q_{i' i} = \frac{P_{i'}}{P_i}$. Each final good uses a variety of intermediate inputs. Inputs are purchased not only locally but from other regions as well. We call the demand from region $i$ of input $j$ that is produced in region $i'$ as $x_{i'i'j}$. It is purchased at price $p_{i'j}$. The production technology is

$$\gamma_{i'i'} = \sum_{i' = 1}^{N} \frac{1}{\epsilon} \int_{j} x_{i'i'j}^{\frac{1-\epsilon}{\epsilon}}$$

(9)

$\gamma_{i'i'}$ denotes the preference of firm $i$ for inputs from region $i'$. The parameter $\epsilon$ captures the substitutability between intermediate goods within a region. Final good firm $i'$'s demand for input $j$ located at $i'$ is:

$$x_{i'i'j} = \gamma_{i'i'} \left[ \frac{p_{i'j}}{P_{i'}} \right]^{-\epsilon} Y_i$$

(10)

The final good firm is making zero profits (perfect competition) which allows to write the price aggregate as

$$P_i = \left[ \sum_{i' = 1}^{N} \frac{1}{\epsilon} \int_{j} \frac{1}{p_{i'j}^{1-\epsilon}} \right]^{\frac{1}{1-\epsilon}}$$

(11)

#### Intermediate good firms

Each region $i$ has a continuum of intermediate goods indexed by $j$. The intermediate good $y_{i,j}$ is produced using only labor. We assume that labor cannot move across regions. Firms use a linear technology

$$y_{ij} = L_{ij}$$

(12)

where $L_{ij}$ is the labor demanded by firm $j$ in region $i$. Firms sell their product to final good firms at price $p_{i,j}$. The intermediate good firm faces demand from all $N$ final good firms. As mentioned, a firm $j$ located in region $i'$ faces demand by final good firm $i$ equal to $x_{i'i'j}$. The aggregate demand for region $i$ intermediate good firm $j$ will be

$$y_{ij} = \sum_{i' = 1}^{N} x_{i'i'j}$$

(13)
Due to monopolistic competition, the intermediate good firm will take the demand into account when setting its price \( p_{i,j} \). The regional intermediate good firms are controlled by a risk-neutral manager who distributes to local households all profits immediately. The manager discounts future by \( \beta \). Each firm can adjust its price with probability \( \lambda \). We denote the reset price \( p^* \). This is found by maximizing the real value of firm:

\[
\max_{p_{i,j,t}} \sum_{s=0}^{\infty} \left( (1 - \lambda)\beta \right)^s \left\{ p^*_{i,j,t+s} y_{i,j,t+s} - W_{i,t+s} L_{i,j,t+s} \right\}
\]

where \( W_i \) here is the nominal wage. This leads to the optimal pricing equation

\[
\frac{p^*_{ij,t}}{P_{it}} = \frac{\epsilon}{\epsilon - 1} \sum_{i'=1}^{N} \gamma_{i' i} Q_{i' t} \left[ w_{i' t} Y_{i' t} + (1 - \lambda)\beta (1 + \pi_{i' t+1})^{1 + \epsilon} \Gamma_{i' t+1} \right] \]

with

\[
\Gamma_{i',i,t} = w_{i',i} Y_{i',t} + (1 - \lambda)\beta (1 + \pi_{i',t+1})^{1 + \epsilon} \Gamma_{i',i,t+1}
\]

\[
\Delta_{i',i,t} = Y_{i',t} + (1 - \lambda)\beta (1 + \pi_{i',t+1})^{1 + \epsilon} \Delta_{i',i,t+1}
\]

Equation (15) is the regional Phillips curve linking regional price setting with each of the \( N \) final goods. An intermediate firm \((i, j)\) sets its price based on a weighted average of the \( N \) final goods. The weights are given by the effective preference of each of final good firm over region’s \( i \) inputs: \( \gamma_{i' i} Q_{i' i} \). The larger the preference of \( i' \) for \((i, j)\) (expressed in \( \gamma_{i' i} \)) and the larger the increase in final good price \( P_{i'} \) (relative to \( P_{i} \)) the higher the pass through in \( p^* \). Finally the real profits for intermediate firm \( j \) in region \( i \) is

\[
d_{ij} = \frac{p_{ij}}{P_{i}} \times y_{ij} - w_i \times y_{ij}
\]

### 4.4 Monetary Authority

Regions share a monetary union. There is a monetary authority which sets the nominal interest rate

\[
R_t = R_{ss} + \phi \hat{\pi}_t
\]

We consider a simple Taylor rule where the monetary authority sets the nominal rate based on the aggregate inflation rate \( \hat{\pi} \). This is given by

\[
\hat{\pi}_t = \sum_{i=1}^{N} w_i \pi_{i,t}
\]
where \(w_i\) are regional weights. We assume that a region is weighted based on its size relative to the economy. The relative economic size of every region is \(w_i = \frac{GDP_{i,ss}}{\sum_i GDP_{i,ss}}\). The weights remain constant and are invariant to policy. Finally, \(R_{ss}\) is the steady state nominal interest rate.

4.5 Government

The government buys final goods from every region \(G_i = \{G_1, G_2, ..., G_N\}\). They finance this expenditure using labor income taxes. Moreover the government supplies government bonds \(\bar{B}\). Every period they pay back \(R\sum_i \int \phi b_i = RB\). The government budget constraint reads (taking into account that each region \(i\) has population \(\mu_i\)):

\[
\sum_i \mu_i(1 + \pi_{i,t+1}) \int \phi b_i' - (1 + R)\left(\sum_i \mu_i \int \phi b_i\right) = \sum_i \mu_i G_i - \sum_i \mu_i \int \phi T(w_i; s_i, x_i) \tag{20}
\]

4.6 Regional accounts

In this section we define the regional accounts. Regional GDP is the total value added on all intermediate inputs \(y_i\). Total income for every region \(i\) will be equal to

\[y_i = w_iL_i + D_i\]

The final good produced in region \(i\) is \(Y_i\) and will be equal to \(y_i\) only if the region does not trade with other regions. Final good \(Y_i\) is consumed by local households or purchased by the government.

\[Y_i = C_i + G_i\]

Hence we can define the net exports of region \(i\) as

\[NX_i = y_i - C_i - G_i\]

Total lump-sum transfers across regions and total net exports, all sum to zero:

\[
\sum_i \mu_i F_i = 0
\]

\[
\sum_i \mu_i NX_i = 0
\]
4.7 Characterizing the model

In this section we derive some equations that clarify how some variables will be pinned down. By combining the households’ FOC between regions $i, i'$ we derive an expression for the real exchange rate (Backus-Smith condition):

$$\frac{Q_{i't}}{Q_{i'i(t+1)}} = \left[\frac{C_{it}}{C_{i't}}\right]^\sigma \cdot \left[\frac{C_{i't+1}}{C_{it+1}}\right]^\sigma$$

(21)

If region $i$ experiences higher consumption growth between $t$ and $t + 1$ relative to region $i'$ then the real exchange rate must appreciate ($Q_{i't}$ decreases). Using the price aggregator (Equation 11) we can derive an equation linking the regional inflation rate $\pi_{it}$ to the regional reset prices $p_{ij}^*$ for all $i$:

$$1 = \sum_{i'=1}^{N} \gamma_{i'i} Q_{i'i}^{1-\epsilon} \left[ \lambda \left( \frac{p_{i'j}^*}{P_{i'}^*} \right)^{1-\epsilon} + (1 - \lambda)(1 + \pi_{i't})^{\epsilon-1} \right]$$

(22)

As mentioned the total demand for intermediate firm $(i, j)$ is

$$y_{ij} = \sum_{i'} x_{i'i} = \sum_{i'} \gamma_{i'i} \left[ \frac{p_{ij}}{P_{i'}^*} \right]^{-\epsilon} Y_{i'}$$

Aggregating over $j$ we can derive the total demand for intermediate inputs of region $i$

$$\int_{j} y_{ij} = y_i = \sum_{i'} \gamma_{i'i} \left[ \int_{j} \frac{p_{ij}}{P_{i'}^*} \right]^{-\epsilon} Y_{i'}$$

(23)

$$= \left[ \lambda \left( \frac{p_{i'j}^*}{P_{i'}^*} \right)^{-\epsilon} + (1 - \lambda)(1 + \pi_{it})^\epsilon \right] \cdot \sum_{i'} \gamma_{i'i} Q_{i'i}^{1-\epsilon} Y_{i'}$$

(24)

The above expression is a key equation linking the trade flows between regions. It has a similar interpretation with the Equation 15. Total demand for intermediate inputs of region $i$ is a weighted sum of final goods $Y$ of all regions. If the demand for final good $Y_{i'}$ increases then $y_i$ will increase depending on the preference of $i'$ for $i$'s inputs $\gamma_{i'i}$ and also on the relative price of final good $Q_{i'i}$. Higher preference implies a higher demand. Also a higher relative final good price $\left[ \frac{p_{i'j}^*}{P_{i'}^*} \right]^{-\epsilon}$ implies a higher demand. Note that for $y_i$ constant the immediate effect of an increase in $Y_{i'}$ will be a decrease in the local final good $Y_{i}$ to accommodate the flow of inputs toward $Y_{i'}$. This will increase local inflation $\pi_i$ and the reset price. However an increase in $\frac{p_{i'j}^*}{P_{i'}^*}$ will also increase the local wage and labor supply $L_i$ increasing $Y_i$. Hence even though a higher $Y_{i'}$ will definitely increase local GDP $y_i$, the effect of $Y_{i'}$ on the final good produced
locally $Y_i$, is not certain.

Since in region $i$ there is a continuum of intermediate firms each producing a total of $y_i$ and a continuum of households supplying a total of $L_i$ we will have $y_i = L_i$. Finally we can derive an expression for the real dividends paid by firms.

$$ d_i = \left[ \lambda \left( \frac{P^d_{ij}}{P_i} \right)^{1-\epsilon} + (1 - \lambda)(1 + \pi_{it})^{\epsilon - 1} \right] \sum_{i'} \gamma_{ij} \gamma_{i'j} Y_{i'} - w_i L_i $$ (25)

5 Equilibrium

We describe the steady state equilibrium and the transition separately. A household-level variable is denoted with a small letter while a regional variable with a capital letter. For example, $c_i$ is household consumption in region $i$ while $C_i$ is region’s total consumption. We denote the measure of households over bonds and productivity in region $i$ as $\phi_i$. Hence, $C_i = \int_{\phi_i} c$.

5.1 Steady State Equilibrium

At the steady state we assume that $\lambda = 1$ (flexible prices) and price symmetry within and across regions: $\frac{p_{ij}}{P_i} = 1 \quad \forall i$ and $Q_{ii'} = 1 \quad \forall i, i'$. For an exogenous level of regional government spending $\{G_i\}$ a stationary equilibrium is a cross-section of regional variables: $\{C_i\}_1^N$, $\{L_i\}_1^N$, $\{B_i\}_1^N$, $\{F_i\}_1^N$, $\{Y_i\}_1^N$, $\{y^d_i\}_1^N$, $\{w_i\}_1^N$, $\{D_i\}_1^N$, $\{\phi_i\}_1^N$ and two aggregate variables the nominal rate $R$ (which equals the real rate) and the federal tax rate $\tau$. We are thus looking for a total of $9 \times N + 2$ equations. These are:

1-3) For every region $\{C_i, L_i^s, B_i^r\}$ satisfy households’ optimization problem.

4) Final good $i$ equals local consumption by households and the government: $Y_i = C_i + G_i \quad \forall i = 1, N$

5) Final goods $\{Y_1, \ldots Y_N\}$ satisfy

$$ y^d_i = \left[ \lambda \left( \frac{P^d_{ij}}{P_i} \right)^{-\epsilon} + (1 - \lambda)(1 + \pi_{it})^{\epsilon} \right] \cdot \sum_{i'} \gamma_{ij} \gamma_{i'j} Y_{i'} \quad \forall i = 1, N $$

6) Regional GDP (regional labor demand) equals regional labor supply $y^d_i = L_i^s \quad \forall i = 1, N$

7) Real wage is given by $w_i = \frac{\pi_{it} + 1}{\epsilon} \quad \forall i = 1, N$

8) Dividends are given by $D_i = y^d_i - w_i L_i^s \quad \forall i = 1, N$

9) The stationary regional measures $\phi_i$ evolve based on the policy functions and the transition matrices described in the model.
10) Bond market clears: \( \bar{B} = \sum \mu_i B'_i \)

11) The government balances its constraint: \( R(\sum \mu_i \bar{B}) = \sum \mu_i G_i - \sum \mu_i T_i - \sum \mu_i F_i \)

Note that if the above conditions are satisfied the aggregate resource constraint \( \sum_i NX_i = 0 \) is automatically satisfied.

5.2 Transition

The transition is a time sequence of equilibrium variables. We take as a given the steady-state level of interest rate \( R_{ss} \), the steady state income \( \{Y_{i,ss}\}_1^N \), and the steady state transfers \( \{F_{i,ss}\}_1^N \). We are looking to solve for \( \{C_{i,t}\}_1^N \), \( \{L_{i,t}\}_1^N \), \( \{B'_{i,t}\}_1^N \), \( \{Y_{i,t}\}_1^N \), \( \{y^d_{i,t}\}_1^N \), \( \{w_{i,t}\}_1^N \), \( \{\pi_{i,t}\}_1^N \), \( \{Q_{ijt}\ \forall i, i'\} \) pairs, \( \{D_{i,t}\}_1^N \), \( \{\phi_{i,t}\}_1^N \), \( R_t \), \( \hat{\pi}_t \), and \( \tau_t \) for \( t = \{T, \infty\} \) where \( T \) is the time of the policy change. A total of \( 11 \times N + 3 \) equations. These are:

1-3) \( \{C_i, L^*_i, B'_i\} \) all satisfy the households’ problem.

4) Final good \( i \) equals local consumption by households and the government: \( Y_i = C_i + G_i \) \( \forall i = 1, N \)

5) Regional GDP \( \{y^d_1, ..y^d_N\} \) is given by

6) The real wage is set to equalize labor demand and supply \( y^d_i = L^*_i \) \( \forall i = 1, N \)

7) The reset price \( \frac{P^*_j}{P^*_i} \) satisfies

8) The inflation rates \( \pi_{i,t} \) satisfy

9) Relative final good price pairs \( Q_{ijt} \) satisfy

\[
\frac{Q_{ijt}}{Q_{ij(t+1)}} = \left[ \frac{C_{it}}{C_{it}^{t+1}} \right]^{\sigma} \cdot \left[ \frac{C_{i(t+1)}^{t+1}}{C_{it}^{t+1}} \right]^{\sigma}
\]

23
10) Dividends are given by
\[ D_i = \left[ \lambda \left( \frac{p^*_{ij}}{P_i} \right)^{1-\epsilon} + (1 - \lambda)(1 + \pi_{it})^{\epsilon-1} \right] \cdot \sum_{i'} \left[ \gamma_{i'i} Q_{i'i} Y_{i'i} - w_i L_i \right] \forall i = 1, N \]

11) The stationary regional measures \( \phi_{i,t} \) evolve based on the policy functions and the transition matrices described in the model.

12) Government budget clears
\[ \sum_i \mu_i (1 + \pi_{i,t+1}) B_i' - (1 + R)(\sum_i \mu B_i) = \sum_i \mu_i G_i - \sum_i \mu_i T_i - \sum_i \mu_i F_{i,ss} \]

13) Interest rate is given by a standard Taylor rule: \( R_t = R_{ss} + \phi \tilde{\pi}_t \)

14) National inflation rate is given by: \( \tilde{\pi}_t = \sum_{i=1}^{N} w_i \pi_{i,t} \), where the weights are the calculated based on the relative economic size of each region \( Y_{i,ss} \).

6 Quantitative Analysis

We use our model to translate the regional into an aggregate consumption multiplier. First, we describe our calibration. We then consider a simple setup with two regions one of which receives a temporary government spending shock. We use this setup to evaluate the role of (i) spillovers through trade (ii) a federal tax union (iii) a fixed vs. a flexible nominal rate. We then proceed to the full model with multiple regions.

6.1 Calibration and Steady State Results

The model period is a year. We have three set of parameters: Household parameters, firm parameters (both within a region) and regional parameters.

The discount factor \( \beta \) is set to match a nominal interest rate equal to 2%. The Frisch elasticity of labor supply is set to 0.5 based on Erosa, Fuster, and Kambourov (2013). The disutility of labor \( \psi \) is set so that on average households work 40% of their time endowment. Finally, \( \sigma \) is set to 1 and we analyze other parameter values for \( \sigma \) as robustness exercises.

The productivity process parameters are calibrated based on PSID. We set \( \rho = 0.92 \) and \( \sigma^2_\eta = 0.04 \). For the tax function we use the following form: \( T(wszh) = wszh - (1 - \tau_0)[wszh]^{1-\tau_1} \). We follow Guner, Kaygusuz, and Ventura (2013) and set \( \tau_1 = 0.07 \). We set \( \tau_0 \) to match a government spending to income ratio equal to 20%. Parameter \( \epsilon \) is set to 6 based on Nakamura and Steinsson (2014). The probability of changing price is set at \( \lambda = 0.3 \) based
Table 8: Benchmark Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Notation</th>
<th>Value</th>
<th>Target / Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Aversion</td>
<td>$\sigma$</td>
<td>1</td>
<td>–</td>
</tr>
<tr>
<td>Discount Factor</td>
<td>$\beta$</td>
<td>0.96</td>
<td>Nominal rate=2%</td>
</tr>
<tr>
<td>Labor supply elasticity</td>
<td>$1/\theta$</td>
<td>0.5</td>
<td>Erosa, Fuster, and Kambourov (2013)</td>
</tr>
<tr>
<td>Disutility of labor</td>
<td>$\psi$</td>
<td>0.3</td>
<td>Hours worked=40%</td>
</tr>
<tr>
<td>Persistence of $x$</td>
<td>$\rho$</td>
<td>0.92</td>
<td>PSID</td>
</tr>
<tr>
<td>Variance of innovation to $x$</td>
<td>$\sigma_x^2$</td>
<td>4.0%</td>
<td>PSID</td>
</tr>
<tr>
<td>Variance of innovation to $s$</td>
<td>$\sigma_s^2$</td>
<td>2.5%</td>
<td>IRS</td>
</tr>
<tr>
<td>Tax parameter</td>
<td>$\tau_0$</td>
<td>0.18</td>
<td>G/Y=20%</td>
</tr>
<tr>
<td>Tax parameter</td>
<td>$\tau_1$</td>
<td>0.07</td>
<td>Guner, Kaygusuz, and Ventura (2013)</td>
</tr>
<tr>
<td>Elasticity of substitution</td>
<td>$\epsilon$</td>
<td>6</td>
<td>Nakamura and Steinsson (2014)</td>
</tr>
<tr>
<td>Price reset probability</td>
<td>$\lambda$</td>
<td>0.3</td>
<td>Christiano, Eichenbaum, and Rebelo (2011)</td>
</tr>
<tr>
<td>Preference parameters</td>
<td>$\gamma_{ii'}$ (see matrix)</td>
<td></td>
<td>CFS</td>
</tr>
<tr>
<td>Stock of liquid assets</td>
<td>$\bar{B}$</td>
<td>1.29$\times$ Income</td>
<td>SCF</td>
</tr>
<tr>
<td>Borrowing limit</td>
<td>$b$</td>
<td>0.25$\times$ Labor Income</td>
<td>Kaplan, Moll, and Violante (2016)</td>
</tr>
<tr>
<td>Taylor rule coefficient</td>
<td>$\phi$</td>
<td>1.5</td>
<td>–</td>
</tr>
</tbody>
</table>

on Christiano, Eichenbaum, and Rebelo (2011). We set the Taylor rule coefficient $\phi = 1.5$ a value standard in the literature.

We estimate the dispersion in the region-specific productivity based on state-level information on wages and salaries from the IRS website. We find set $\sigma_s^2 = 2.5\%$. Parameters $\gamma_{ii'}$ are important for our analysis as they capture the magnitude of linkages between regions. We use the Commodity Flow Survey to measure the trade flows in intermediate inputs between regions.

To calibrate the total stock of debt we use data from the Survey of Consumer Finances for periods 1998-2007. Since we do not explicitly model housing we only focus on liquid assets in the household portfolios. We define liquid assets following the Kaplan and Violante (2014). In particular, the financial assets considered liquid are cash, checking accounts, savings accounts, money market accounts, directly held savings bonds and stocks net of credit card debt. The ratio of the value of liquid assets to the total household income is 1.29. Finally, we set the borrowing limit to target the fraction of households with negative liquid assets.

In Table 9 we compare the model to data regarding the liquid asset distribution. Our model is calibrated to capture the average liquid assets to income ratio. Looking across wealth percentiles we see that the model cannot capture the high concentration of wealth at the top of the distribution—a standard feature of this class of models. In the figure we plot the model generated wealth distribution as well as the average marginal propensity to consume across wealth groups. Wealth-poor individuals have a higher marginal propensity to consume than the wealth-rich. The average marginal propensity to consume in our model is close to
Table 9: Statistics over liquid assets (Table) and MPC-Liquid assets distribution (Figure)

<table>
<thead>
<tr>
<th>Statistic</th>
<th>SCF (1998-2007)</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households with $b &lt; 0$</td>
<td>19.2</td>
<td>10.2</td>
</tr>
<tr>
<td>Liquid Assets/Income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.29</td>
<td>1.25</td>
</tr>
<tr>
<td>25&lt;sup&gt;th&lt;/sup&gt; percent.</td>
<td>0.06%</td>
<td>1.98%</td>
</tr>
<tr>
<td>50&lt;sup&gt;th&lt;/sup&gt; percent.</td>
<td>0.09</td>
<td>0.28</td>
</tr>
<tr>
<td>75&lt;sup&gt;th&lt;/sup&gt; percent.</td>
<td>0.78</td>
<td>1.39</td>
</tr>
<tr>
<td>90&lt;sup&gt;th&lt;/sup&gt; percent.</td>
<td>3.99</td>
<td>5.33</td>
</tr>
<tr>
<td>99&lt;sup&gt;th&lt;/sup&gt; percent.</td>
<td>44.28</td>
<td>16.71</td>
</tr>
</tbody>
</table>

Liquid Assets Gini         | 0.78             | 0.61  |

0.10.

6.2 A simple two region framework

Before turning to our multiregion model we first analyze the effects of government spending in a model with only two regions. We will assume that the monetary authority keeps the nominal interest rate pegged at its steady-state value. Our full quantitative analysis will incorporate trade flows between regions. Here, since we analyze two regions, we follow Nakamura and Steinsson (2014) and interpret the home region as a U.S. state and the foreign region as the rest of the U.S. Using their calibration, we set the trade flow matrix equal to

$$
\gamma_{i,i'} = \begin{bmatrix} 0.8 & 0.2 \\ 0.2 & 0.8 \end{bmatrix}.
$$

We simulate a 2% increase in government spending only in region 1. The shock declines with some persistence and is artificially set to zero after 10 years. We plot the impulse response functions (Figure 4) for key macro aggregates: regional consumption, income, wage, inflation and bond holdings. All units are expressed in percentage deviations from their steady-state.

An increase in government spending in region 1 increases demand for final output $Y_1$ and hence the total demand for intermediate inputs $y_1$ (region’s 1 GDP). This will increases local inflation $\pi_1$. Region’s 1 firms will demand more labor to accomodate the extra demand which will raise local real wages $w_1$. Region 2 does not receive any government spending. However, a fraction of government spending at region 1 will spread to region 2 in the form of higher demand for region’s 2 intermediate inputs. This explains the increase in output in region 2.
Note: The Figure plots the IRFs for a government spending shock in Region 1. All units are expressed in percentage deviations from their steady-state.

Higher demand for inputs will subsequently be translated to higher inflation and wages $\pi_2, w_2$. All macro variables increase less than region 1’s since only a part of government spending spreads to region 2. Since region 2 is transferring inputs to region 1 it will increase its bond holdings relative to the steady state.

Consumer spending increases in both regions. There are two channels through which government spending affects consumer spending. The first is by altering the income mix between labor income and dividends. Wages increase in both regions so households have higher labor earnings. At the same time, firms have to pay out higher wages. Given our relative low value of labor supply elasticity, firms have to increase wages substantially to increase the labor input. This makes profits decrease. Hence, whether income (and consumption) will increase or decrease depends on how much individuals rely on labor income versus dividends. Note that since the nominal interest rate is fixed and bond holdings adjust slowly capital income will be less important.

In Figure 5 we plot the percentage change in total income relative to the steady-state across productivity groups. Low productivity groups rely heavily on dividends since labor
Note: The Figure plots the
earnings are small. Hence, these groups experience a decrease in their income. In contrast, as we move up the productivity ladder income growth becomes positive. Consumption follows a similar pattern. It will be negative for low productivity groups while positive for high productivity groups. Since the low productivity workers have a high MPC consumption will decrease sharply for these individuals. In contrast, the highly productive will have a low MPC and will tend to increase their consumption by a smaller amount. At the aggregate consumer spending increases. This is because most workers are around the median in terms of productivity, a group that experiences a rise in consumption. In region 2 all groups experience a rise in consumption.

The second channel is the expected inflation channel which is present in any model that features a fixed nominal rate (such as a zero lower bound case). Since the nominal rate is fixed, future inflation will decrease the real interest rate and increase current consumption. This will be true for all income categories.

We next evaluate the effects of several model elements such as an endogenous nominal interest rate and taxes paid proportionately to government aid. In the first model called “Endogenous R” the monetary authority responds to aggregate inflation based on a Taylor rule. As expected consumer spending decreases in both regions since a higher nominal rate induces households to save more. In addition the wage rate in region 2 will decrease since a higher interest rate will increase labor supply more than labor demand. Region 1 experiences
a large increase in labor demand so that the wage increases overall (but less than in our benchmark). The second model we evaluate is called “Local taxes”. Here, we assume that each region pays taxes proportionally to the level of local government aid. In our case region 1 pays all the extra taxes. As a result, consumption decreases relative to the steady state.

7 Full quantitative Model with N Regions (In progress)

8 Conclusion

The response of private consumer spending to a fiscal stimulus injection is at the heart of the income multiplier debate. We analyze the response of household spending to the Recovery Act (2009-2012) using regional variation. We construct local-level household spending on retail and auto vehicles using two household-level dataset: the Nielsen HomeScan dataset and the
We find a sizable and significant effect of county-level fiscal stimulus on county-level household spending. When government spending increases in a county by 1%, households residing in the county increase their retail spending by around $0.20, and their auto spending by around $0.05, relative to other counties. We decompose this response across income groups. In response to fiscal stimulus, counties in the bottom 25% of the income distribution spend relatively more than counties at the top 25% in retail but less than the top 25% in auto.

To translate these regional findings into an aggregate effect we build a New Keynesian multi-regional model with incomplete markets. Our framework features several linkages between regions which manifest through i) regional trade in intermediate goods, ii) a federal tax union, and iii) a currency union. Moreover, we introduce labor income risk and incomplete markets within regions. This allows to analyze the heterogeneity in consumer responses to local government spending shocks.
References


