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Abstract

We use regional variation in the American Recovery and Reinvestment Act (2009-2012) to analyze the effect of government spending on consumer spending. Our consumption data come from household-level retail purchases in Nielsen and auto purchases from Equifax credit balances. We estimate that a $1 increase in county-level government spending increases consumer spending by $0.18. We translate the regional consumption responses to an aggregate fiscal multiplier using a multi-region, New Keynesian model with heterogeneous agents and incomplete markets. Our model successfully generates the estimated positive local multiplier, a result that distinguishes our incomplete markets model from models with complete markets. The aggregate consumption multiplier is 0.4, which implies an output multiplier higher than one. The aggregate consumption multiplier is almost twice the local estimate because trade linkages propagate government spending across regions.

Keywords: Consumer Spending, Fiscal Multiplier, Regional Variation, Heterogeneous Agents.

JEL Classification: E21, E62, H31, H71

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1 Introduction

If the government purchases $1 worth of goods, by how much does private consumption increase or decrease? 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 exogenous increases in defense spending decrease private consumption. On the other hand, Blanchard and Perotti (2002) and Gali, Lopez-Salido, and Valles (2007) find that exogenous fiscal expansions increase private consumption.[1] This disconnect is worrisome since consumer spending is the largest component of national income and its response is a key determinant of the fiscal multiplier.

In this paper, we estimate the response of consumer spending to fiscal stimulus. In particular, we use regional variation in the spending component of the American Recovery and Reinvestment Act (ARRA) to estimate the local effect of government spending on consumer spending. We then translate the local fiscal multiplier to an aggregate fiscal multiplier using a multi-region, New Keynesian model with heterogeneous agents and incomplete markets.[2] The model is disciplined based on the regional consumption variation we document in the data.

ARRA – commonly known as the stimulus package – was a very large program by historical standards. The spending component of the Act allocated roughly $228 billion. Around 95% of U.S. counties received funds. Our consumer spending data come from two separate sources. First, we collect household- and store-level information on retail purchases from the Nielsen Consumer Panel/Retail Scanner data. Second, we construct individual-level spending on vehicles by measuring changes in auto credit balances from FRB NY Consumer Credit Panel/Equifax (hereafter, CCP).

We estimate that a $1 increase in county-level government spending increases local retail spending by $0.11 and local auto spending by $0.07. Our estimation employs a narrative instrumental variable approach because the fiscal stimulus is likely to be endogenous to local economic conditions. Specifically, we identify components of ARRA funding allocated to localities based on criteria exogenous to the region's economic performance. This method requires a very detailed reading of the Act, federal codes, and regulations. The instrument is the sum of all spending allocated based on selection criteria that we view as exogenous to local economic conditions.[3]

[1] In a review of the literature and empirical methods, Hall (2009) finds a consumption multiplier from somewhat negative to 0.5. Other recent contributions include Ramey (2011), Auerbach and Gorodnichenko (2012), Ramey and Zubairy (2014), and Ramey (2016).

[2] It is well understood that estimates based on regional variation are not always representative of aggregate effects. Such estimates ignore general equilibrium effects that cannot be separately identified in the cross-regional regressions. For discussions of this point see Chodorow-Reich (2017) and Nakamura and Steinsson (2018).

[3] Other research on the ARRA using this narrative instrumental variable approach includes Dupor and

We translate the estimated local fiscal multiplier to an aggregate fiscal multiplier using a general equilibrium model. The model is a New Keynesian model with two regions. Each region produces a final good, which is purchased by the local consumers as well as the government. The final good is produced using both local and foreign intermediate inputs. Due to home bias, final goods are produced using a larger share of local inputs. Trade linkages – expressed in the degree of home bias – transfer some of the government spending across regions. The government finances spending using federal taxes (fiscal union). Finally, there is a monetary authority that sets the nominal interest rate for all regions (currency union).

Our model is novel in an important dimension: each region is populated by heterogeneous households who face idiosyncratic labor income risk and incomplete markets (Huggett, 1993; Aiyagari, 1994). Households self-insure using a risk-free bond, which is supplied by the government. Hence, our model combines a multi-region currency union model (Gali and Monacelli, 2008; Nakamura and Steinsson, 2014) with a New Keynesian model with heterogeneous agents (for example, McKay, Nakamura, and Steinsson, 2016; Kaplan, Moll, and Violante, 2017).

Our model successfully replicates the positive local consumption fiscal multiplier we document in the data. More importantly, we find an aggregate consumption fiscal multiplier around 0.4, more than twice as large as the local estimate. This finding suggests that a large part of the local government spending increases consumer spending in all regions simultaneously and thus cannot be picked up by the cross-regional regressions.

In the standard Neoclassical model without capital, the consumption multiplier is always negative which implies an output multiplier less than one. Government spending decreases consumption due to a negative wealth effect induced by higher taxes and also due to a higher real interest rate (Barro and King, 1984; Baxter and King, 1993; Woodford, 2011).

Our model deviates from the Neoclassical benchmark in three ways. First, in our New Keynesian model, higher government spending increases product and labor demand and pushes the real wage higher.[4] Higher labor income translates to higher consumer spending. Due to home bias, the region affected the most by government spending experiences a higher increase in the real wage and consumer spending, relative to the other region.

The key modeling assumption underlying this mechanism is idiosyncratic labor income risk coupled with incomplete markets. An increase in the real wage increases consumer spending especially by low wealth, high-marginal propensity to consume (MPC) households who are mostly labor-income dependent.[5] Absent heterogeneity, our model generates a local and an

Mehkari (2016) and Dupor and McCrory (2016).

[4]In the Neoclassical model, the real wage decreases due to the negative wealth effect, which increases labor supply. This is also true in our model but a stronger shift in labor demand leads to a higher equilibrium real wage.

[5]Gali, Lopez-Salido, and Valles (2007) introduce rule of thumb consumers to generate a positive consumption response to government spending. In contrast, we assume incomplete markets and borrowing constraints,

aggregate fiscal multiplier close to zero. More importantly, if asset markets were complete, both the local and the aggregate fiscal multiplier would be negative. With complete markets, any change in labor income is offset by transfers due to state-contingent claims. As a result, differences in consumption depend only on differences in regional prices (Backus and Smith, 1993).[6]

Second, in our model, higher inflation, due to the fiscal stimulus, decreases some of the government's debt service cost. As a result, the government can balance its budget with a relatively small increase in taxes. Moreover, this redistribution of resources hurts only net savers, namely wealthy, low MPC households.[7]

Third, in our model, the monetary authority does not adjust the nominal rate in response to inflationary pressures. This is consistent with our period of analysis, 2008-2012, in which the short-term nominal interest rate was close to zero. According to an extensive literature, government spending can generate high multipliers at the zero lower bound.[8] When the nominal interest rate is held constant, an increase in government spending triggers expected inflation which decreases the real interest rate and boosts consumer spending. When we relax the assumption of an unresponsive monetary authority, the local fiscal multiplier remains positive but the aggregate fiscal multiplier becomes negative.

An important difference with the above literature is that in a multi-region model local inflation should be followed by a deflationary period that is necessary to bring the real exchange rate to its steady state value (Nakamura and Steinsson, 2014). The anticipated deflation may depress consumer spending to such an extent that it might even render the effect on consumption negative. We show how trade linkages help mitigate this channel by linking local inflation rates and, therefore, minimizing the need for a deflationary period.

Trade linkages also explain why the aggregate fiscal multiplier is larger than the local fiscal multiplier. An increase in local government spending propagates – through trade in intermediate inputs – across all regions. As a result, local government spending increases real wages and consumer spending simultaneously in all regions.

Using cross-regional variation, we externally validate two key mechanisms in our model. First, we empirically show that counties that received more government aid experienced higher labor income growth. Second, we show that more credit-constrained counties (as measured by high balance-to-limit credit ratios in the CCP) increased their spending more in response to the ARRA spending.

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which allows us to calibrate the model to empirical evidence on net worth from the Survey of Consumer Finances.

[6]For a more detailed discussion of these results, see Farhi and Werning (2016) and Chodorow-Reich (2017).

[7]Auclert (2017) analyzes the redistribution channel from monetary policy to consumer spending.

[8]See for example the work by Eggertsson (2011) and Christiano, Eichenbaum, and Rebelo (2011).

Our paper contributes to three literatures. Foremost, our paper contributes to the extensive literature on the consumption multiplier. One strand of the literature empirically estimates the consumption multiplier using aggregate time-series VARs (for example, Ramey and Shapiro, 1998; Blanchard and Perotti, 2002; Perotti, 2005; Barro and Redlick, 2009). Another strand of the literature estimates multipliers using dynamic general equilibrium models (for example, Baxter and King, 1993; Christiano, Eichenbaum, and Rebelo, 2011; Drautzburg and Uhlig, 2015; to name a few).

Our paper differentiates from the literature on two points. First, we rely on cross-regional variation to identify the (local) effect of fiscal stimulus on consumer spending. Due to our disaggregated, geographical data we can use many more observations than what is typically used in the time-series studies. Moreover, we can identify exogenous variation in a much broader class of government spending than the defense spending variation in time-series studies. Second, we use the cross-regional variation to discipline a quantitative model. The model is then used to analyze the aggregate consumption response. Typical dynamic general equilibrium models do not rely on any cross-regional or cross-sectional evidence.

A paper that is methodologically closer to ours is Nakamura and Steinsson (2014). The authors use cross-state evidence to analyze the effect of fiscal stimulus on output. Our paper analyzes the cross-regional response of consumption using detailed micro-level evidence. At the same time, we show that heterogeneity and incomplete markets are crucial to generate a positive local consumption multiplier, consistent with the empirical evidence. Nakamura and Steinsson (2014) employ a model with complete markets and non-separable preferences between consumption and leisure to match the empirical evidence of a local output multiplier larger than one.

We also contribute to the increasingly popular literature that uses 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) and the effect of unemployment insurance across regions (Hagedorn, Karahan, Manovskii, and Mitman, 2016). Another strand explicitly analyzes the effect of fiscal stimulus and, in particular, the Recovery Act on employment and income: Romer (2012), Wilson (2012), Chodorow-Reich, Feiveson, Liscow, and Woolston (2012), Conley and Dupor (2013), Serrato and Wingender (2016), Leduc and Wilson (2017), to name a few. The above literature typically ignores general equilibrium effects, which may bias the empirical estimates. We show how local estimates can vary from the aggregate using a general equilibrium model. Our approach is close to Beraja, Hurst, and Ospina (2016) who use regional variation in wages to discipline key model parameters and then use a structural model to analyze the aggregate effect of shocks.

Finally, we contribute to the growing literature that combines heterogeneous agents and

a New Keynesian framework. Oh and Reis (2012) and McKay and Reis (2016) study the effects of government intervention on the U.S. business cycle. Hagedorn, Manovskii, and Mitman (2016), Auclert and Rognlie (2016), Bhandari, Evans, Golosov, and Sargent (2017), and Ferriere and Navarro (2017) study demand shocks and fiscal policy with heterogeneity and incomplete markets. McKay, Nakamura, and Steinsson (2016) and Kaplan, Moll, and Violante (2017) study the effects of monetary policy with heterogeneous agents. Our innovation is that we extend this setup to incorporate multiple regions that are linked through trade, fiscal, and monetary policy.

The rest of the paper is structured as follows. Section 2 describes our data. In Section 3 we describe our empirical specifications and document the basic empirical patterns regarding the response of consumer spending to government spending. Section 4 sets up the model. In Section 5 we describe our calibration and our main quantitative experiment. Section 6 analyzes our results under different model specifications. Finally, Section 7 concludes.

2 Data

Our empirical analysis employs regional variation in government spending and consumer spending. We collect data on government spending from the American Recovery and Reinvestment Act (ARRA). We use the Nielsen HomeScan and Retail Scanner datasets to collect information on household spending retail purchases.[9] Moreover, we use data on household auto financing from the FRB NY Consumer Credit Panel/Equifax (hereafter, CCP). We use auto finance as a proxy for auto purchases. We show that CCP auto finance aligns well with vehicle registrations. The Nielsen and CCP data are available at an individual/store level with 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.[10]

[9]All results are calculated (or derived) based on data from The Nielsen Company (US), LLC and marketing databases provided by the Kilts Center for Marketing Data Center at the University of Chicago Booth School of Business. The conclusion drawn from the Nielsen data are those of the researchers and do not reflect the views of Nielsen. Nielsen is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein. Information about the data and access are available at http://research.chicagobooth.edu/nielsen/.

[10]For example, Mian, Sufi, and Rao (2013) collect spending on groceries, furniture, and appliances purchased with a debit or credit card. Moreover, they collect information on auto vehicle registrations.

Table 1: Data Sources for Consumer Spending

Dependent variable	Source	# Observations	Time period
Retail spending	Nielsen HomeScan	60,000 households	2004-2014
	Nielsen Retail Scanner	40,000 stores	2006-2014
Auto spending	CCP/Equifax	10 million individuals	2001-2015

There are several advantages to using our datasets. First, in all datasets we have very detailed geographical information (zip code) for the household/store unit. Other commonly used datasets for consumption expenditures, such as the Consumption Expenditure Survey (CEX), provide information at a more aggregated regional level with only some U.S. states available. Second, our data are based on in-home or store scanners as well as credit records and thus are less suspect to measurement error. Finally, all our datasets can be relatively easily accessed by other researchers. Table 1 provides a summary of our sample of data.

2.1.1 Nielsen HomeScan/Retail Scanner

The Nielsen Homescan Consumer Panel Dataset is a longitudinal panel of approximately 60,000 U.S. households who continually provide information about their retail purchases.[11] The purchases are recorded by the panelists using in-home scanners. The data are available for the period 2004-2014.

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 HomeScan include a combination of non-durable and durable goods. The durable goods included in our data 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 of 3% of the annual retail spending in the dataset.

The Nielsen Retail Scanner data include data for roughly the same period (2006-2014).

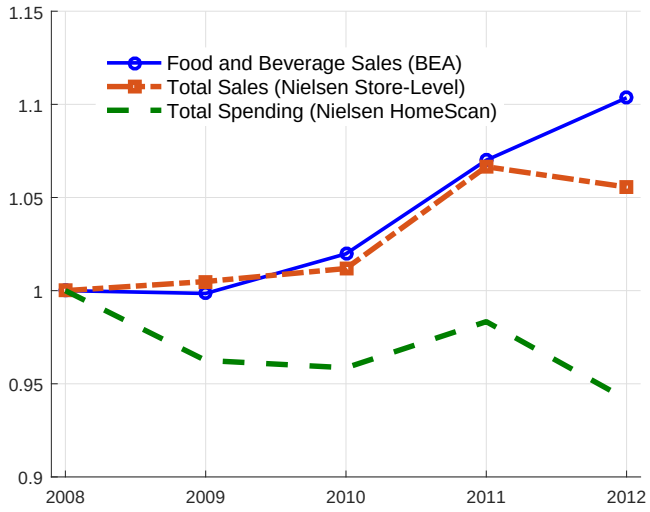
[11]Panelists are randomly recruited via mail or the Internet. Nielsen has ongoing communication with panelists to ensure cooperation, create enthusiasm, and monitor workload. Nielsen has also a number of systems to ensure quality data.

Table 2: Fraction of Spending by Store Type–Nielsen HomeScan

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

Notes: Spending in a store type as a fraction of total spending in all stores for year 2012. Store types follow the classification used by Nielsen.

Figure 1: Total Sales/Spending (Nielsen) vs. Food and Beverage Sales (BEA)



Notes: Total sales is computed using the Retail Scanner data while total spending using the HomeScan data. Total sales in food and beverages is calculated from BEA.

Approximately 40,000 stores of 90 retail chains provide weekly point-of-sale information on units sold, average price, UPC codes, and product characteristics. The dataset includes over 2.5 million UPCs. The store data provide information on the zip code where the store is located. In 2010 the total sales in Nielsen stores were 42% of total sales in grocery stores and approximately 7% of total retail sales (excluding vehicle purchases).

Figure 1 compares aggregate time series of consumer spending in Nielsen and the Bureau of Economic Analysis (BEA) for the period 2008-2012. We use aggregate sales in food and beverages as this component is closer to Nielsen-type purchases. In Nielsen we plot separately (i) aggregate sales by all stores and (ii) aggregate spending by all households. We normalize each time series by its 2008 value. Based on our BEA time series, food and beverages experienced a slight decline in 2009 relative to 2008 and then experienced a strong increase up to 2012. For 2009-2011, aggregate store sales (Nielsen, Retail Scanner) follow the BEA time series closely. In 2012, Nielsen sales seem to decrease a bit relative to 2011, a pattern we do not see in the BEA data. Our aggregated time series in Nielsen HomeScan seems less able to track the BEA. Household spending – based on Nielsen – decreased in both 2009 and 2010 relative to 2008.

For the Nielsen HomeScan/Retail Scanner data, we impose the following criteria. (1) We keep stores/households for which we have information on their sales/spending for all years between 2008 and 2012. This way we do not have to worry about regions experiencing higher sales/spending just because there are more stores/individuals being sampled in our data. (2) Regarding HomeScan, we exclude households that moved between counties during 2008-2012. (3) We exclude stores/households in DC, South and North Dakota. The last two experienced an oil boom during our period of analysis. (4) For Retail Scanner/HomeScan we exclude counties with less than 20 stores/household s. Restrictions (1)-(3) leave us with 31,186 (23,834) stores (households) per year. Restriction (4) leaves us with 21,915 (15,031) stores (households) per year.

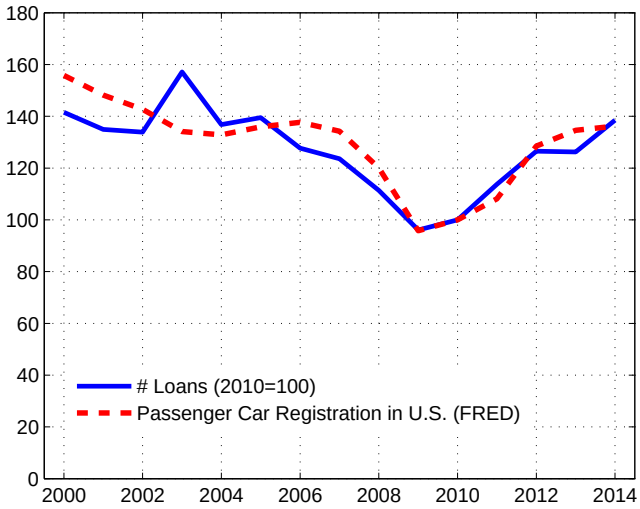
2.1.2 FRB NY Consumer Credit Panel

We measure regional spending 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 a 5% random sample of all U.S. consumers with credit record and social security number. This is called 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, CCP 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, Equifax's riskscore, and geographic identifiers to the zip code level.

We use auto finance as a proxy for spending on vehicles. We consider auto finance by both

Figure 2: Number of Auto Loans (CCP) vs. Number of Car Registrations (FRED)



Notes: Total number of loans is calculated from FRB NY Credit Consumer Panel while the number of newly (first-time) registered passenger cars is calculated from FRED. Both time series are normalized to 100 in period 2010.

banks and car dealerships.[12] 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. Figure 2 compares the total number of auto loans using our measure with the number of newly (first-time) registered passenger cars. Our measure of auto loans tracks pretty closely the number of registered auto vehicles.

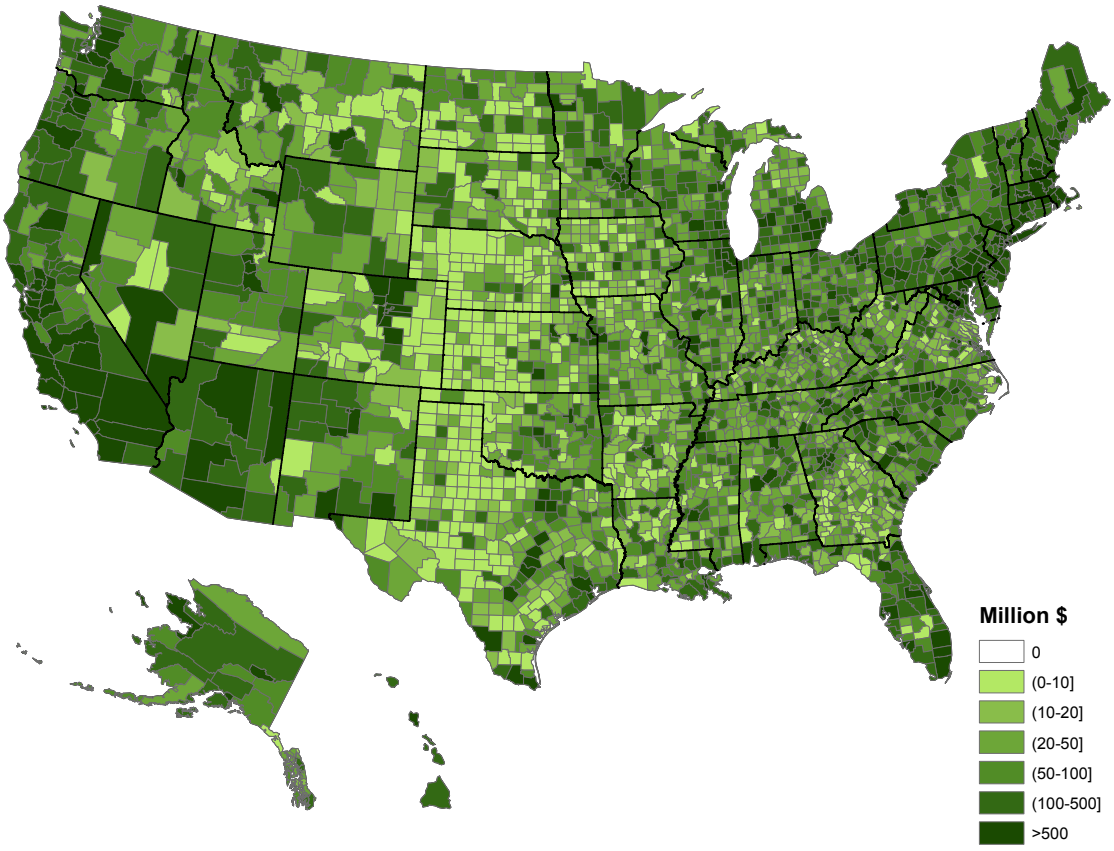
2.2 Government Spending

The American Recovery and Reinvestment Act of 2009 was enacted on February 17, 2009. The Act allocated roughly $840 billion with a primary goal of creating new jobs and providing temporary relief during the Great Recession.

The Act had three major components - tax benefits, entitlements, and federal contracts and grants - with roughly a third of the total spending going to each. In this paper, we focus on 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

[12] We use "Total Balance in Auto Finance (excludes bankruptcy)" (variable crtr_attr167) and "Total Balance in Auto Bank (excludes bankruptcy)" (variable crtr_attr168).

Figure 3: Government Spending by U.S. Counties



Notes: Total amount of government spending during the period 2009-2012 by U.S. counties (in million of dollars).

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 education awards went toward state fiscal stabilization funds, student aid, training and employment, and helping special education students, among other programs. The awards in the transportation sector went toward 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.

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 website 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. For every award, the website contained detailed information including the total 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.

The government spending data are available at a very fine geographical level (zip code). It includes information about vendors, subcontractors, and other entities that received government funding from a particular award. Instead of geocoding the funding by the primary agency, we exploit the available information to construct precise measures of government spending based on 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 we use the location and award information of the private entities.

Figure 3 shows the geographical variation in cumulative spending across U.S. counties during the period 2009-2012. Approximately 95% of U.S. counties received at least one award though 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.

2.2.1 Instrumental Variable

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

In particular, our data offer 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 guidance 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 economic conditions is the money given from the Department of Education to children with disabilities. The criterion for the 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 pro-

Table 3: Components of the Recovery Act used in the construction of the Instrument

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

Notes: Total amount awarded during the period 2009-2012 by Departments/Agencies. For each Agency we report the fraction of awards included in our instrument.

vided through the Federal Transit Administration for road improvement and maintenance. The criterion was the population density and passenger miles of the areas where these roads were located.

Another example relates to the water quality assistance grants. The EPA instructions for state agencies were to select projects where water quality needs were the greatest while priority was given to projects "ready to proceed to construction within 12 months" of the Act's passage. Moreover, 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. In Appendix A we provide a detail analysis of our methodology.

We construct our instrumental variable as the sum of the total value of funds allocated with our selected (exogenous) criteria. Table 3 summarizes the total amount of awards used in our instrument as a fraction of the total awards given. The total amount of money awarded in all of the U.S. during the period 2009-2012 was $228 billion. Out of this amount 20.2% was 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.

3 Estimates of the Local Fiscal Consumption Multiplier

3.1 Definitions and Basic Specification

This section describes our empirical specification. As mentioned, we use two categories of consumer spending: retail spending and auto finance loans, both available at the household/store level. Let c_{ijt} denote total spending of the household/store i located at region j at year t. N_{jt} is the number of households/stores in area j at year t.

We construct the average household/store spending by averaging across all households/stores that are located in an area. So $C_{j,t} = \frac{\sum_{i \in j} c_{ijt}}{N_{jt}}$ is the average spending at area j. Our level of aggregation is a county.

We summarize consumption responses by constructing cumulative changes in spending between the period 2008-2012:

$$\Delta C_j = \sum_{t=2008}^{2012} \{C_{j,t} - C_{j,2008}\} \tag{1}$$

Our left-hand side variable is the cumulative growth rate of consumer spending relative to 2008: $\frac{\Delta C_j}{C_{j,2008}}$. Our main explanatory variable is the total money awarded per household in county j during the period 2009-2012, denoted G_j. We estimate the number of households in each county by dividing county population by the average number of people per household. Our right-hand side variable is government spending normalized by the average consumer spending in year 2008: $\frac{G_j}{C_{j,2008}}$.

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

$$\frac{\Delta C_j}{C_{j,2008}} = a + \beta \times \frac{G_j}{C_{j,2008}} + X_j \ \Phi' + D_j + \varepsilon_j \tag{2}$$

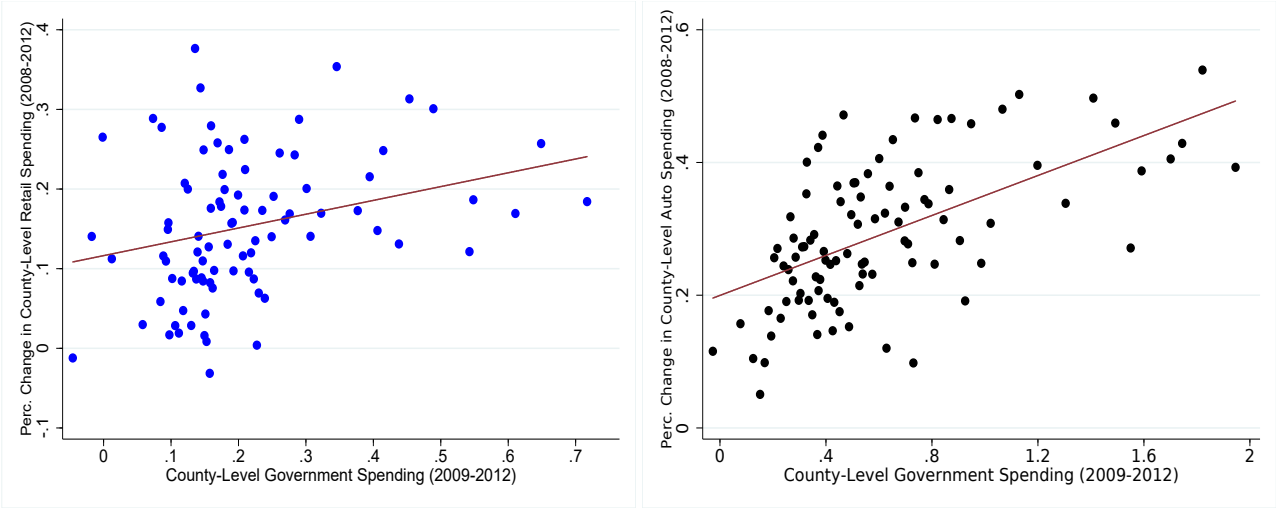
Note that using the same denominator on the left- and the right-hand side preserves the usual definition of the multiplier: β is the dollar change in consumer spending if government spending increases by \$1. We also use county-level control variables represented by the vector X_j. These are the county's population, per-capita county income, and the per-capita change in county income — as reported at IRS tax returns — between 2008-2012. Finally, we include a state dummy D_j. We run this regression using standard OLS and using our instrumental variable, which is the fraction of money allocated based on our selected exogenous criteria. In our regression, we weigh all counties by their population and we cluster standard errors

at the state level. We also winsorize the dependent and independent variable at the 1% level.[13]

3.2 The Effect of the Recovery Act on Consumer Spending

We start by plotting simple scatters of our data. Figure 4 plots county-level government spending (normalized by 2008 consumer spending) and county-level consumption growth rate over the period 2008-2012, in retail spending (left panel) and auto spending (right panel). In both plots higher government spending is associated with a higher consumption growth rate.

Figure 4: Government Spending and Percentage Change in Retail and Auto Spending (2008-2012), by Counties



Notes: Scatter plots between government spending (Recovery Act, 2009-2012) and percentage change in county-level consumer spending, between 2008-2012, by counties. The left panel shows changes in retail spending (Nielsen, Retail Scanner), and the right panel shows changes in auto spending (CCP/Equifax).

3.2.1 The Effect of the Recovery Act on Retail Spending (Nielsen)

In Table 4 we report estimates of our main regression (Equation 2) for retail consumer spending. We report results separately for Nielsen, HomeScan and Nielsen, Retail Scanner data. We also report separately OLS and IV estimates as well as estimates with and without county controls/state fixed effects.

The response of retail consumer spending to fiscal stimulus is positive. In HomeScan we estimate a multiplier between 0.08-0.12, while in Retail Scanner data between 0.11-0.23. When we do not include county controls/state fixed effects, the IV estimate is higher than the OLS.

[13]Our results are largely robust to these choices. In Appendix B we perform sensitivity analyses with respect to each of these specifications.

Table 4: Retail Spending Multipliers

Spending Category	Retail Consumer Spending (Nielsen, HomeScan)				Retail Consumer Spending (Nielsen, Retail Scanner)			
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Government Spending	0.10	0.12**	0.10	0.08	0.19***	0.23***	0.11***	0.11**
	(0.07)	(0.05)	(0.08)	(0.06)	(0.05)	(0.07)	(0.03)	(0.04)
Partial F stat.	—	127.0	—	104.4	—	139.7	—	116.2
County Controls/ State Fixed Effects	No	No	Yes	Yes	No	No	Yes	Yes
# Counties	272	272	272	272	365	365	365	365

Notes: The table shows the estimates of the regression of the growth rate in retail spending (HomeScan and Retail Scanner) on cumulative government spending at the county level during the period 2008-2012. We show results for our OLS and IV specification, with and without county controls/state fixed effects. The standard errors are given in parentheses. One, two, and three stars denote significance at the 10%, 5%, and 1% levels, respectively.

This is in line with the intuition that counties that experienced a deeper recession (and that also probably received more money) were more likely to have a lower growth rate (coefficient biased downward). Once we include county controls/state fixed effects, both the coefficient and the difference between OLS and IV become smaller.

A possible concern with using the Nielsen dataset is that it captures a narrow set of non-durable purchases. To translate our Nielsen estimates into a non-durable multiplier, we compare our Nielsen-type purchases from the CEX (food at home, alcohol and beverage, detergents, cleaning products and other household products, small appliances, and personal care products) to a more a general type of non-durable spending. Similar to Kaplan, Mitman, and Violante (2016) we construct a set of non-durable goods that includes other than our Nielsen-type bundle, spending on apparel, tobacco, and reading. This type of spending is on average 2.1 times larger than the Nielsen-type category. Also, we construct a broader spending group that includes the non-durable goods listed above as well as food away from home, spending on entertainment, telephone services, and transportation. This type of spending is on average 6.3 times larger than the Nielsen-type category.

The next step is to estimate the elasticity of non-durable spending to Nielsen-type spend-

ing. We estimate the following household-level regression:

$$\log C_{i,t}^{\text{non-durable}} = a + \beta \times \log C_{i,t}^{\text{Nielsen}} + X_{i,t}\ \Phi' + \varepsilon_{i,t} \tag{3}$$

for both groups of spending. We include a set of household controls such as a cubic on age and dummies on race, education, family type, and region and use the weights provided by the Survey. When we use our narrower definition, we find that a 1% increase in Nielsen-type categories increases non-durable consumer spending by 0.88%. When we use our broader category, we find that a 1% increase in Nielsen type categories increases non-durable consumer spending by 0.56%. Hence, to translate our Nielsen estimates into a non-durable multiplier, we should increase our coefficient somewhere between 88% $\times$ 2.1 and 56% $\times$ 6.3. This gives a non-durable consumption multiplier between 0.20 and 0.38.

3.2.2 The Effect of the Recovery Act on Auto Spending (CCP)

Table 5: Auto Spending Multipliers

Spending Category	Auto Spending (CCP/Equifax)			
	OLS	IV	OLS	IV
Government Spending	0.07*** (0.01)	0.11*** (0.01)	0.06*** (0.01)	0.07*** (0.02)
Partial F stat.	—	192.0	—	166.0
County Controls/ State Fixed Effects	No	No	Yes	Yes
# Counties	3000	3000	2936	2936

Notes: The table shows the estimates of the regression of the growth rate in auto spending on cumulative government spending at the county level during the period 2008-2012. We show results for our OLS and IV specification, with and without county controls/state fixed effects. The standard errors are given in parentheses. One, two, and three stars denote significance at the 10%, 5%, and 1% levels, respectively.

We estimate a positive response of fiscal stimulus to auto spending (Table 5).[14] Counties

[14]The response of auto vehicles spending to household tax rebates varies based on different studies. Johnson, Parker, and Souleles (2006) do not find a significant impact on auto spending based on the 2001 tax rebates while Parker, Souleles, Johnson, and McClelland (2013) find a significant effect on spending of durables – in particular of vehicles – to the tax rebates of 2008. With respect to non-durable goods, both studies find similar results: a significant increase in non-durable spending.

that received $1 more in government spending increased auto spending between $0.06-$0.11. Once more, the IV estimate is higher than the OLS and county controls/state fixed effects reduce the difference between OLS and IV estimates. The CCP provides a much richer geographical representation of the U.S. relative to Nielsen. This explains the differences in the number of counties.

3.3 Borrowing Constraints and the Consumption Response to Fiscal Stimulus

We presented evidence that the average response of consumer spending to the fiscal stimulus is positive. In this section we analyze how consumption responses differ based on households' ability to use unsecured credit. We focus only on retail spending based on Nielsen. To conduct our analysis we collect information on (i) total balances in unsecured credit and (ii) total unsecured credit limit, based on our household-level panel data from CCP/Equifax. The median credit card balance in 2008 is $4,113 while the median credit limit in 2008 is $17,171. The median credit card utilization (balance/limit) is 33%. Since households with a high credit balance relative to their credit limit have relatively more difficulty to smooth their consumption, we use the credit card utilization in 2008 as a measure of a borrowing constraint.[15]

We average our utilization measure across residents in counties to construct county-level measures of borrowing constraints. We generate dummy variables corresponding to the lower half and upper half of the utilization distribution. Counties at the lower half have a low balance-limit ratio so they are less borrowing constrained. Counties at the upper half have a high balance-limit ratio so they are closer to their borrowing constraint. We call these groups as "Low Balance/Limit" and "High Balance/Limit," respectively. Our regression follows exactly the benchmark specification (Equation 2). The only difference is that we interact the dummy variables with the total amount of money received from the Recovery Act.

Table 6 shows our results. Both the Nielsen HomeScan and Retail Scanner data produce qualitatively similar findings. Counties that were more borrowing constrained increased their spending more as a response to fiscal stimulus relative to less borrowing constrained counties. According to HomeScan data, the response was between 0.01 and 0.07 dollar higher while according to Retail Scanner data the response was between 0.01 and 0.04 dollar higher.

[15]When we consider the average utilization over a wider year window the results do not change.

Table 6: Borrowing Constraints and the Consumption Response to Fiscal Stimulus

Spending Category	Retail Consumer Spending			
	(Nielsen, HomeScan)		(Nielsen, Retail Scanner)	
	OLS	IV	OLS	IV
Rec. Act Spending	0.08	0.03	0.07	0.11
× [Low Balance/Limit]	(0.15)	(0.11)	(0.09)	(0.13)
Rec. Act Spending	0.09	0.10	0.13***	0.12***
× [High Balance/Limit]	(0.08)	(0.07)	(0.04)	(0.04)
County Controls/ State Fixed Effects	Yes	Yes	Yes	Yes
# Counties	272	272	365	365

Notes: The table shows the estimates of the regression of the growth rate in retail spending on county-level government spending interacted by county-level unsecured credit utilization. The utilization distribution is divided into the lower half and the upper half. We show results for OLS and IV specification with county controls/state fixed effects. The standard errors are given in parentheses. One, two, and three stars denote significance at the 10%, 5%, and 1% levels, respectively.

4 Model

In this section we present the quantitative model. Our framework combines a regional setup with trade in intermediate inputs with an incomplete markets, heterogeneous agents model.

4.1 Description of the Economy

The economy has $N = 2$ symmetric regions. Each region i has its own wage w_i and inflation rate π_i. Both regions have the same population μ_i and also face the same nominal interest rate R (currency union). 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 (1993) 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 local market. To finance expenditures it taxes households' labor income. Taxation occurs only at the federal level (fiscal union). 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 (denoted c) 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 represented by a time separable utility function of the form

$$U = \mathbf{E}_0 \left[\sum_{t=0}^{\infty} \beta^{t-1} \left\{ \frac{c_{i,t}^{1-\sigma}}{1-\sigma} + \psi \frac{(1-h_{i,t})^{1-\theta}}{1-\theta} \right\} \right] \tag{4}$$

where β is the discount factor, σ represents the degree of risk aversion, and θ affects the Frisch elasticity of labor supply.

Households consume only the final good produced in their region. They supply labor in the intermediate good sector of their region and receive real wage payments w_i. The effective wage rate is xw_i where x is an idiosyncratic shock that follows an AR(1) process in logs:

$$\log x_{t+1} = \rho \log x_t + \eta_{t+1}, \qquad \text{with} \quad \eta_{t+1} \sim \text{ iid } N(0, \sigma_\eta^2). \tag{5}$$

The transition matrix that describes the autoregressive process is given by $\Gamma_{xx'}$. Households also receive real dividends from the intermediate firms located in their region: D_i. We assume that real dividends are not uniformly distributed. In contrast, households get $\delta(x)$ fraction of total dividends. If dividends were uniformly distributed then low-productivity households would heavily rely on dividends as a source of income, which is in sharp contrast with the data. Finally, households pay labor income taxes based on the tax schedule $T(.)$ and also receive real lump-sum transfers F_i.

Households can insure against idiosyncratic shocks using a bond b. The bond costs \$1 and pays $(1+R)$ dollars where R is the nominal interest rate. The government supplies the asset. If households decide to borrow, they need to pay back $(1+R+\kappa)$ for every dollar borrowed. Households are not allowed to borrow more than $\underline{b}$. We denote the regional distribution of households across productivity and asset holdings as ϕ_i.

We write the decision problem of a household that resides in region i. For simplicity, we index only regional and not idiosyncratic variables by i.

$$V_t(x_t, b_t; \phi_t) = \max_{c_t, b_{t+1}, h_t} \left\{ \frac{c_t^{1-\sigma}}{1-\sigma} + \psi \frac{(1-h_t)^{1-\theta}}{1-\theta} + \beta \sum_{x_{t+1}} \Gamma_{x_t, x_{t+1}} V_{t+1}(x_{t+1}, b_{t+1}; \phi_{t+1}) \right\} \tag{6}$$

s.t. $c_t + (1 + \pi_{i,t+1})b_{t+1} = w_{i,t}x_t h_t - T(w_{i,t}x_t h_t) + (1 + R_{t-1} + \kappa \mathbf{I}_{[b_t<0]})b_t + \delta(x)D_{i,t} + F_{i,t}$ (7)

$$b_{t+1} \geq \underline{b} \tag{8}$$

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

$$\pi_{i,t+1} = \frac{P_{i,t+1}}{P_{i,t}} - 1 \tag{9}$$

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. Each final good is sold at P_i, which is the price aggregator in each region i. $Q_{i',i}$ is 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

$$Y_i = \left[\sum_{i'=1}^{N} \gamma_{ii'}^{\frac{1}{\epsilon}} \int_j x_{i,i',j}^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \tag{10}$$

$\gamma_{ii'}$ denotes the preference of firm i for inputs from region i'. We assume that $\sum_{i'} \gamma_{ii'} = 1$. The parameter ϵ captures the substitutability between intermediate inputs.[16] Demand of final good firm i for input j located at i' is:

$$x_{i,i',j} = \gamma_{ii'} \left[\frac{p_{i',j}}{P_i} \right]^{-\epsilon} Y_i \tag{11}$$

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

$$P_i = \left[\sum_{i'=1}^{N} \gamma_{ii'} \int_j p_{i',j}^{1-\epsilon} dj \right]^{\frac{1}{1-\epsilon}} \tag{12}$$

Intermediate good firms Each region i has a continuum of intermediate goods indexed

[16] Our production technology assumes the same degree of substitutability of inputs from within the region and from other regions. Since we think of regions as counties from the same state (see Section 5), our choice seems empirically plausible. Moreover, Imbs and Mejean (2015) relax the homogeneity assumption between sectors and find an elasticity of substitution between home and foreign goods as high as 6 or 7, which is in line with our parametrization.

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

$$y_{i,j} = L_{i,j} \tag{13}$$

where $L_{i,j}$ is labor demanded by firm j in region i. The intermediate good firm faces demand from both final good firms (local and foreign). 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

$$y_{i,j} = \sum_{i'} x_{i',i,j} \tag{14}$$

Due to monopolistic competition, the intermediate good firm takes 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 all profits to local households immediately. The manager discounts the future by β. Each firm can adjust its price with probability λ. We denote the reset price p^*. This is found by maximizing the value of firm:

$$\max_{p^*_{i,j,t}} \sum_{s=0}^{\infty} \left((1-\lambda)\beta\right)^s \left\{p^*_{i,j,t+s} y_{i,j,t+s} - W_{i,t+s} L_{i,j,t+s}\right\} \tag{15}$$

where W_i is the nominal wage. This leads to the optimal pricing equation

$$\frac{p^*_{i,j,t}}{P_{i,t}} = \frac{\epsilon}{\epsilon - 1} \frac{\sum_{i'=1}^{N} \gamma_{i'i} Q^{\epsilon}_{i',i,t} \left[w_{i,t} Y_{i',t} + (1-\lambda)\beta(1+\pi_{i',t+1})^{1+\epsilon} \mathcal{X}_{i',i,t+1}\right]}{\sum_{i'=1}^{N} \gamma_{i'i} Q^{\epsilon}_{i',i,t} \left[Y_{i',t} + (1-\lambda)\beta(1+\pi_{i',t+1})^{\epsilon} \mathcal{Z}_{i',t+1}\right]} \tag{16}$$

with

$$\mathcal{X}_{i',i,t} = w_{i,t} Y_{i',t} \;\; + \;\; (1-\lambda)\beta(1+\pi_{i',t+1})^{1+\epsilon} \mathcal{X}_{i',i,t+1} \tag{17}$$

$$\mathcal{Z}_{i',i,t} = Y_{i',t} \;\; + \;\; (1-\lambda)\beta(1+\pi_{i',t+1})^{\varepsilon} \mathcal{Z}_{i',i,t+1} \tag{18}$$

Equation (16) is the regional Phillips curve linking regional price setting with each of the final goods. An intermediate firm (i,j) sets its price based on a weighted average of each of the final good's demand for j's product. The weights are given by the preference of each final good firm over region's i inputs: $\gamma_{i'i}$. The larger the preference of i' for (i,j) the higher the pass through of demand changes to p^*_j. Regional inflation rates are also connected through the real exchange rate: $Q_{i',i} = \frac{P_{i'}}{P_i}$. If foreign input prices become more expensive (higher $P_{i'}$), the foreign final good firm switches some of its demand toward local intermediate inputs.

This will increase p_j^*. Finally the real profits for intermediate firm j in region i are

$$d_{i,j} = \frac{p_{i,j}}{P_i} * y_{i,j} - w_i * y_{i,j} \tag{19}$$

and the total real dividends distributed to region's i households are $D_i = \int_j d_{i,j}$.

4.4 Monetary Authority

Regions share a monetary union. We consider a simple Taylor rule where the monetary authority sets the nominal rate based on the aggregate inflation rate $\hat{\pi}$. In particular,

$$R_t = R_{ss} + \phi\hat{\pi}_t \tag{20}$$

The aggregate inflation rate $\hat{\pi} = \sum_i \mu_i \pi_{i,t}$ is a weighted average of the regional inflation rates.

4.5 Government

The government buys final goods from every region. Local government spending is denoted G_i. It finances spending using labor income taxes. We assume a simple linear tax function, $T(wxh) = \tau[wxh]$. Moreover, the government supplies government bonds $\bar{B}$. Every period it pays households back $(1+R_{t-1})b$ if $b > 0$ and charges $(1+R_{t-1}+\kappa)b$ if $b < 0$. The government budget constraint reads:

$$\sum_i \mu_i(1+\pi_{i,t+1}) \int_\phi b_{t+1} - \sum_i \mu_i[(1+R_{t-1}) \int_\phi b_t + \int_\phi \kappa b_t \mathcal{I}_{b_t<0}] = \sum_i \mu_i G_i - \sum_i \mu_i \int_\phi T(w_{i,t}x_t h_t) \tag{21}$$

4.6 Regional Accounts

We describe the regional income accounts. Regional income is the total value added by all intermediate inputs: $\mathcal{Y}_i = \int_j y_{i,j}dj = \int_j \sum_{i'} x_{i',i,j}dj$. Total income for every region i is equal to

$$\mathcal{Y}_i = w_i L_i + D_i$$

The final good produced in region i is Y_i and is equal to $\mathcal{Y}_i$ only if the region does not trade with the other region. 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

$$NX_i = \mathcal{Y}_i - Y_i = \mathcal{Y}_i - C_i - G_i$$

4.7 Characterizing the Model

We derive expressions that clarify some of our equilibrium conditions. As mentioned, the total demand for intermediate firm (i, j) in period t is

$$y_{i,j,t} = \sum_{i'} x_{i',i,j,t} = \sum_{i'} \gamma_{i'i} \left[\frac{p_{i,j,t}}{P_{i',t}}\right]^{-\epsilon} Y_{i',t}$$

Aggregating over j we can derive the total demand for intermediate inputs of region i in period t

$$\int_j y_{i,j,t} = \mathcal{Y}_{i,t} = \sum_{i'} \gamma_{i'i} \left[\frac{\int_j p_{i,j,t}}{P_{i',t}}\right]^{-\epsilon} Y_{i',t} \tag{22}$$

$$= \left[\lambda \left(\frac{p^*_{i,j,t}}{P_{i,t}}\right)^{-\epsilon} + (1-\lambda)(1+\pi_{i,t})^{\epsilon}\right] \cdot \sum_{i'} \gamma_{i'i} Q^{\epsilon}_{i',i,t} Y_{i',t} \tag{23}$$

The above expression is a key equation linking the trade flows between regions. It has a similar interpretation with Equation 16. Total demand for intermediate inputs of region i is a weighted sum of regional final goods $Y_{i',t}, \forall i'$. If the demand for final good $Y_{i',t}$ increases then $\mathcal{Y}_{i,t}$ increases depending on the preference of i' for i's inputs $\gamma_{i'i}$ and also on the relative price of final good $Q^{\epsilon}_{i',i,t}$. Higher preference implies a higher demand. Also a higher foreign final good price (in relative terms) $\left[\frac{P_{i',t}}{P_{i,t}}\right]^{\epsilon}$ implies a higher demand for the home intermediate input.

4.8 Steady-State Equilibrium

For the steady-state equilibrium we abstract from time variable t. 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 total consumption in region i. Since the measure of households over bonds and productivity in region i is denoted ϕ_i, we have $C_i = \int_{\phi_i} c_i$.

At the steady state, we assume inflation is zero and prices are symmetric within and across regions: $\frac{p_{i,j}}{P_i} = 1 \, \forall i$ and $Q_{ii'} = 1 \, \forall i, i'$. For an exogenous (and symmetric over the two regions) level of regional government spending $\{G_i\}_{i=1}^2$, a stationary equilibrium is a cross-section of re-

gional variables: $\{C_i\}_{i=1}^2$, $\{L_i\}_{i=1}^2$, $\{B_i'\}_{i=1}^2$, $\{F_i\}_{i=1}^2$, $\{Y_i\}_{i=1}^2$, $\{\mathcal{Y}_i\}_{i=1}^2$, $\{w_i\}_{i=1}^2$,$\{D_i\}_{i=1}^2$,$\{\phi_i\}_{i=1}^2$, and two aggregate variables, the nominal interest rate R (which equals the real interest rate) and the federal tax rate τ. We are thus looking for a total of $9 \times 2 + 2$ equations. These are:

1-3) For every region $\{C_i, L_i, B_i'\}$ satisfy households' optimization problem.
4) Final good i equals local consumption by households and the government: $Y_i = C_i + G_i$ $\forall i = 1, 2$
5) Final goods $\{Y_1, Y_2\}$ satisfy $\mathcal{Y}_i = \sum_{i'} \gamma_{i'i} Y_{i'}$ $\forall i = 1, 2$
6) Regional income equals regional labor demand $\mathcal{Y}_i = L_i$ $\forall i = 1, 2$
7) Real wage is given by $w_i = \frac{\epsilon - 1}{\epsilon}$ $\forall i = 1, 2$
8) Dividends are given by $D_i = \mathcal{Y}_i - w_i L_i$ $\forall i = 1, 2$
9) The stationary regional measures ϕ_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 budget.

4.9 Transition

The transition is a time sequence of equilibrium variables. We take as a given the steady-state level of interest rate R_{ss}, and the steady state transfers $\{F_{i,ss}\}_{i=1}^2$. We are looking to solve for $\{C_{i,t}\}_{i=1}^2$, $\{L_{i,t}\}_{i=1}^2$, $\{B_{i,t}'\}_{i=1}^2$, $\{Y_{i,t}\}_{i=1}^2$, $\{\mathcal{Y}_{i,t}\}_{i=1}^2$, $\{w_{i,t}\}_{i=1}^2$, $\{\frac{p_{i,j,t}^*}{P_{i,t}}\}_{i=1}^2$, $\{\pi_{i,t}\}_{i=1}^2$, $Q_{12,t}$, $\{D_{i,t}\}_{i=1}^2$, $\{\phi_{i,t}\}_{i=1}^2$, R_t, $\hat{\pi}_t$, and τ_t for $t = \{T, \infty\}$ where T is the time of the policy change. A total of $11 \times 2 + 3$ equations. These are:

1-3) $\{C_{i,t}, L_{i,t}, B_{i,t}'\}$ satisfy the households' problem.
4) Final good equals local consumption by households and the government: $Y_{i,t} = C_{i,t} + G_{i,t}$ $\forall i = 1, 2$
5) Regional income $\mathcal{Y}_{i,t}$ is given by

$$\mathcal{Y}_{i,t} = \left[\lambda \left(\frac{p_{i,j,t}^*}{P_{i,t}} \right)^{-\epsilon} + (1 - \lambda)(1 + \pi_{i,t})^{\epsilon} \right] \cdot \sum_{i'} \gamma_{i'i} Q_{i',i,t}^{\epsilon} Y_{i',t} \quad \forall i = 1, 2$$

6) The real wage is set to equalize labor demand and supply $\mathcal{Y}_{i,t} = L_{i,t}$ $\forall i = 1, 2$
7) The reset price $\frac{p_{ijt}^*}{P_{i,t}}$ satisfies

$$\frac{p_{i,j,t}^*}{P_{i,t}} = \frac{\epsilon}{\epsilon - 1} \frac{\sum_{i'=1}^N \gamma_{i'i} Q_{i',i,t}^{\epsilon} \left[w_{i,t} Y_{i',t} + (1 - \lambda)\beta(1 + \pi_{i',t+1})^{1+\epsilon} \mathcal{X}_{i',i,t+1} \right]}{\sum_{i'=1}^N \gamma_{i'i} Q_{i',i,t}^{\epsilon} \left[Y_{i',t} + (1 - \lambda)\beta(1 + \pi_{i',t+1})^{\epsilon} \mathcal{Z}_{i',t+1} \right]}$$

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

$$1 = \sum_{i'} \gamma_{ii'} Q_{i',i,t}^{1-\epsilon} \left[\lambda \left(\frac{p_{i',j,t}^*}{P_{i',t}} \right)^{1-\epsilon} + (1-\lambda)(1+\pi_{i',t})^{\epsilon-1} \right] \quad \forall i = 1, 2$$

9) Real exchange rate $Q_{1,2,t} = \frac{P_{1,t}}{P_{2,t}}$ satisfies the following equation

$$\frac{(1+\pi_{1,t})}{(1+\pi_{2,t})} = \frac{P_{2,t-1}}{P_{1,t-1}} \frac{P_{1,t}}{P_{2,t}} = Q_{2,1,t-1} Q_{1,2,t}$$

10) Dividends are given by

$$D_{i,t} = \left[\lambda \left(\frac{p_{i,j,t}^*}{P_{i,t}} \right)^{1-\epsilon} + (1-\lambda)(1+\pi_{i,t})^{\epsilon-1} \right] \cdot \sum_{i'} [\gamma_{i'i} Q_{i',i,t}^{\epsilon} Y_{i',t} - w_{i,t} L_{i,t}] \quad \forall i = 1, 2$$

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

12) The government balances its budget.

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

14) National inflation rate is given by: $\hat{\pi}_t = \sum_{i=1}^{N} \mu_i \pi_{i,t}$.

5 Quantitative Analysis

We use the model to translate the local fiscal multiplier to an aggregate fiscal multiplier. First, we describe our calibration and steady-state results. Then we consider the main quantitative experiment: a temporary regional government spending shock.

5.1 Calibration

Table 7 summarizes our parameter choices. The model period is a quarter. The discount factor β is set to match an annual nominal interest rate equal to 2%. The Frisch elasticity of labor supply is set to 0.5 based on Chetty (2012). The disutility of labor ψ is set so that on average households work 40% of their time endowment. Finally, we set $\sigma = 1$. The productivity process is calibrated based on the estimates of Floden and Linde (2001). Using our model we simulate labor income paths and then annualize the simulated data to match a persistence of $\rho = 0.92$ and $\sigma_\eta^2 = 0.04$. We set τ to match a government spending to income ratio equal to 20%. Parameter $\epsilon = 6$ and the probability of changing price at $\lambda = 0.15$ are

Table 7: Benchmark Parameters

Parameter	Notation	Value	Target / Source
Risk aversion	σ	1	–
Discount factor	β	0.987	Annual nominal rate=2%
Labor supply elasticity	$1/\theta$	0.5	Chetty (2012)
Disutility of labor	ψ	0.3	Hours worked=40%
Persistence of x	ρ	0.955	Floden and Linde (2001)
Variance of innovation to x	σ_η^2	1.5%	Floden and Linde (2001)
Tax parameter	τ	0.29	G/Y=20%
Dividend allocation	$\delta(x)$	See text	c_{75}/c_{25} and c_{90}/c_{10}
Elasticity of substitution	ϵ	6	McKay, Nakamura, and Steinsson (2016)
Price reset probability	λ	0.15	McKay, Nakamura, and Steinsson (2016)
Taylor rule coefficient	ϕ	0.0	–
Stock of liquid assets	$\bar{B}$	1.21× Annual income	SCF
Credit spread	κ	0.03	%Households with $b < 0$
Borrowing limit	$\underline{b}$	0.25× Quarterly labor income	Kaplan, Moll, and Violante (2017)
Home bias	γ_{ii}	0.89	Local consumption multilpier=0.18

both based on McKay, Nakamura, and Steinsson (2016).

Since after 2008 the short-term nominal rates were nearly zero, we set $\phi = 0$. This case captures the effect of government spending in an environment where the monetary authority is unresponsive.[17] We also perform robustness exercises where the monetary authority responds to inflation based on a standard Taylor rule $\phi = 1.5$.

As Kaplan and Violante (2014) have shown, households use primarily liquid assets to adjust their consumption. Moreover, Carroll, Slacalek, Tokuoka, and White (2017) have shown that a model that matches the degree of inequality in liquid financial assets generates marginal propensities to consume closer to the empirical estimates. Hence, we calibrate the debt-to-income ratio to match the empirical ratio of liquid assets to income. We use data from the Survey of Consumer Finances (SCF) for periods 1998-2007. We define liquid assets following Kaplan and Violante (2014). In particular, liquid financial assets are cash, checking accounts, savings accounts, money market accounts, and stocks net of credit card debt. There is no data in the SCF on households' cash holdings. As a result, we increase liquid asset holdings by a factor of 1.04 (see the Appendix in Kaplan and Violante, 2014). In 2009 prices, the average (median) household owns \$94,443 (\$3,149) in liquid assets. Average (median) household income is \$78,500 (\$46,564). As a result, we target an annual debt-to-income ratio of 1.20. Finally, we calibrate the credit spread κ to match the fraction of households with

[17] Hagedorn, Manovskii, and Mitman (2016) and Hagedorn (2017) show that incomplete markets models can address many of the stability issues surrounding models at the zero lower bound.

negative net worth, and we follow Kaplan, Moll, and Violante (2017) and set the borrowing limit to 0.25× average quarterly labor income.

We approximate the dividend allocation function as $\delta(x) = a_1 x + a_2 x^2$. The parameters are calibrated based on the cross-sectional dispersion in consumer spending. A very unequal allocation of dividends implies a more dispersed cross-sectional consumer spending and vice versa. In particular, we use the ratio of the average consumption at the top to the average consumption at the bottom quartile to discipline a_0. Similarly, we use the ratio of the average consumption at the top to the average consumption at the bottom decile to discipline a_2.

We use information on consumer spending from the Consumption Expenditure Survey. For non-durable consumer spending, we keep the same definition as in Section 3.2. We find that $c_{75}/c_{25} = 3.81$ and $c_{90}/c_{10} = 6.57$. We then normalize $\delta(x)$ so that $\sum_x \int_a \phi(b, x)\delta(x) = 1$. Our parametrization implies that households with the highest productivity acquire seven times more dividends than the average household.[18]

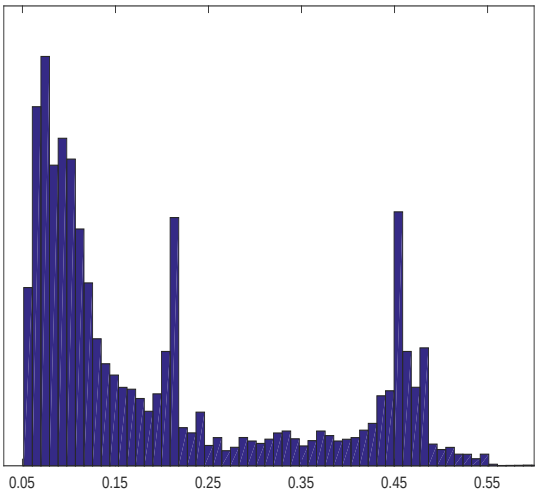
We interpret the two regions in our model as two symmetric U.S. counties within the same U.S. state. This resembles closely our empirical exercise that compared consumer spending between counties with high and low government spending and that belong to the same U.S. state. Our empirical analysis also controls for per-capita income (level and growth) and population, which is consistent with our narrative of two symmetric areas. The reason we emphasize on our estimates with state fixed effects is the larger degree of spillovers between counties of the same state versus counties of different states.

The last parameter to calibrate is the preference of the home final good firm for home versus foreign inputs. Using direct evidence from shipments of goods to calibrate home bias is not ideal. The Commodity Flow Survey, the only dataset suitable for such an analysis, provides information on trade flows between MSAs and non-MSAs. This division does not fit our definition of trade flows between symmetric counties of the same state.

Since this is a hard parameter to pin down directly from the data, we let the model inform us of what its value should be. In particular, the degree of home bias is disciplined using local variation in consumer spending. A high degree of home bias affects the spillover of fiscal stimulus across regions and consequently, regional differences in consumption. We explain this link in detail in Section 6. The value of home bias so that the model-generated local consumption multiplier matches the empirical local consumption multiplier is 0.89.

Table 8: Statistics over Liquid Assets and MPC Heterogeneity

Statistic	SCF (1998-2007)	Model
Households with $b < 0$	19.2%	20.7%
Liquid Assets/Income		
Mean	1.20	1.21
25^{th} percent.	0.01%	0.98%
50^{th} percent.	0.04	0.17
75^{th} percent.	0.32	1.20
90^{th} percent.	1.68	3.72
99^{th} percent.	18.8	12.2
Liquid Assets Gini	0.93	0.77
Median MPC		0.13
Average MPC		0.22



Notes: Summary statistics regarding wealth concentration and the marginal propensity to consume. All statistics are reported at an annual frequency. We transform the quarterly into an annual MPC using the formula $1-(1-\text{quartrely MPC})^4$.

5.2 Steady-State Results

In Table 8 we compare the model to data regarding the liquid asset distribution. We also report the median and the average marginal propensity to consume.[19] Our model is calibrated to capture the average liquid assets-to-income ratio as well as the fraction of households with negative net worth. Looking across wealth percentiles we see that the model cannot capture the very high concentration of wealth at the top of the distribution - a standard feature of this class of models. However, the model manages to produce a reasonable amount of wealth concentration. The wealth Gini is 0.77 in our model, lower than the empirical value of 0.93 but considerably higher than typical Aiyagari models that find a Gini around 0.60. The reason we are able to do so is that we include an unequal distribution of dividends that is correlated with productivity. This distribution was calibrated to match the distribution of cross-sectional consumption.

Table 8 also reports the median and the average marginal propensity to consume. The figure on the right panel plots the entire distribution. There has been ample recent evidence on the magnitude of consumption responses to unexpected income transfers. Most studies find estimates of MPC between 0.2-0.6 (Carroll, Slacalek, Tokuoka, and White (2017)). For

[18] In particular, we get the following function $\delta(x) = [0.05, 0.12, 0.26, 0.60, 1.36, 3.08, 7.00]$.

[19] Although the model is calibrated at a quarterly frequency we report our results at an annual rate. Similar to Carroll, Slacalek, Tokuoka, and White (2017) we report MPCs at an annual rate to facilitate comparison with most studies that estimate MPCs over approximately a year after the transfer payment was made.

example, Sahm, Shapiro, and Slemrod (2010) analyze survey responses and find that roughly one-third of the 2008 economic stimulus rebate income was spent and that the spending was concentrated in the few months after the receipt. Also analyzing the tax rebates of the 2008 economic stimulus, Parker, Souleles, Johnson, and McClelland (2013) find that households spend between 12-30 cents of every dollar received, during the first three months. Jappelli and Pistaferri (2014) use a survey that asks how much people would consume or save were they unexpectedly to receive a transfer equal to their monthly income. They find substantial heterogeneity with the average MPC being around 48 percent.

The average marginal propensity to consume in our model is 0.22. This is at the lower bound but within the range of the empirical evidence. Our model also features substantial heterogeneity in MPCs: some households can spend as high as 55 cents out of every new dollar earned. Similar to the evidence provided by Jappelli and Pistaferri (2014), it is the households with low asset holdings or negative net worth that feature these high MPCs.

5.3 Government Spending Shock and Transition

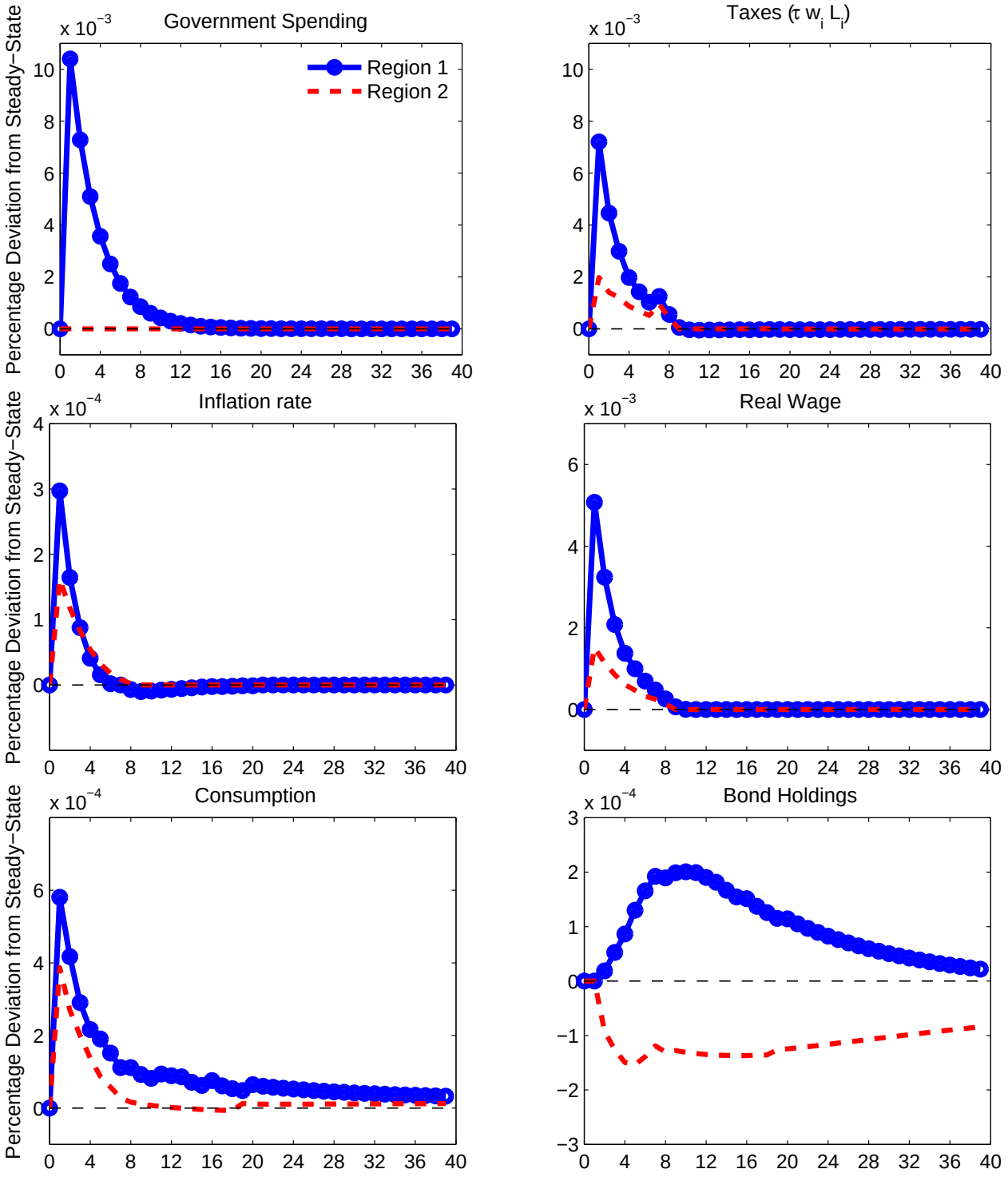
We analyze the effect of a government spending shock on consumer spending. Specifically, we simulate a 1% increase in government spending only in Region 1. The shock is assumed to be a one-time unexpected innovation and households can perfectly foresee the future evolution of prices and quantities. The government spending shock decays slowly based on a persistence parameter $\rho_g = 0.70$. This corresponds roughly to the four-year horizon of the Recovery Act. We plot the impulse response functions for macroeconomic aggregates in Figure 5.

The increase in government spending G_1 increases the demand for final good Y_1. As a result, local inflation π_1 increases (middle left panel). To accommodate the extra demand, intermediate good firms in Region 1 demand more labor, which increases the local real wage w_1 (middle right panel). The percentage increase in labor income turns out to be higher than the percentage increase in total income so that dividends decrease.

Region 2 does not receive any additional fiscal stimulus relative to the steady state. However, the region responds to the fiscal stimulus injected in Region 1. Due to trade linkages, a fraction of the stimulus spreads to Region 2 in the form of higher demand for intermediate inputs. As a result, inflation and wages π_2, w_2 increase as well, albeit less than Region 1.

Higher inflation in Region 1 relative to Region 2 implies an initial appreciation of the real exchange rate $Q_{i'i} = \frac{P_i'}{P_i}$. The appreciation induces an expenditure switching effect. The final good firm in Region 1 substitutes local with now cheaper foreign intermediate inputs. Once the fiscal stimulus is over, Region 1 enters a deflationary period. This ensures that the real exchange rate $Q_{i',i}$ must return to one once the economy converges to the symmetric steady state.

Figure 5: Impulse Responses to a Government Spending Shock



Notes: Impulse response functions for a temporary government spending shock that occurs only in Region 1. All units are expressed as percentage deviations from their steady state. For the inflation rate we report the deviation from the steady state in levels.

To keep the budget balanced, taxes increase in both regions (upper right panel). However, due to higher inflation, which decreases some of the government's debt service cost, the increase in taxes is relatively small.

Both regions increase consumer spending as a response to fiscal stimulus (lower left panel). Region 1 consumes more than Region 2 not only on impact but throughout the transition. This happens because Region 1 saves some of its higher income during the fiscal stimulus while Region 2 deaccumulates bond holdings (lower right panel). We provide a more detailed analysis of the effect of wages, inflation, dividends, and taxes on consumer spending in the next section.

We compute local and aggregate consumption multipliers using the model-generated impulse responses. The local consumption multiplier is computed from the model-generated regional data using the exact same specification as in our empirical analysis (see Equation 2). The aggregate multiplier is computed as $\frac{\sum_i \Delta C_{i,t}}{\sum_i \Delta G_{i,t}}$, where ΔC and ΔG denote the cumulative change of consumption and government spending, respectively, relative to the steady state.

Table 9: Consumption Multipliers: Data vs. Model

Horizon	$t = 8$	$t = 16$	$t = 32$
Data			
Local	–	0.18	–
Model			
Local	0.09	0.15	0.22
Aggregate	0.35	0.40	0.50

Notes: Data estimates use our combined findings from Table 4 and Table 5. We derive our target by adding the Nielsen multiplier plus the auto spending multiplier.

Table 9 presents our main two findings. First, the model successfully generates a positive local multiplier very close to our empirical findings. Second, we find an aggregate fiscal multiplier between 0.35 and 0.50.

In a standard Neoclassical model without capital, the consumption multiplier is always negative which implies an output multiplier less than one. Government spending decreases consumption due to a negative wealth effect induced by higher taxes and also due to a higher real interest rate (Barro and King, 1984; Baxter and King, 1993; Woodford, 2011).

Our model deviates from the Neoclassical benchmark for three reasons. First, in our New Keynesian model, the real wage increases as a response to government spending.[20] Higher labor income translates to higher consumer spending. Due to home bias, Region 1 experiences a higher increase in the real wage and consumer spending, relative to Region 2.

The key modeling assumption underlying this mechanism is idiosyncratic labor income risk coupled with incomplete markets. An increase in the real wage increases consumer spending especially by low wealth, high-marginal propensity to consume (MPC) households who are mostly labor-income dependent. In Section 6 we show that absent heterogeneity, our model generates a local and an aggregate fiscal multiplier close to zero. More importantly, if asset markets were complete, both the local and the aggregate fiscal multiplier would be negative (Nakamura and Steinsson, 2014; Farhi and Werning, 2016; Chodorow-Reich, 2017). With complete markets, any change in labor income is offset by transfers due to state-contingent claims. As a result, differences in regional consumer spending are pinned down only by differences in regional prices. And since Region 1 experiences higher inflation, both relative and aggregate consumer spending decrease.

Second, in our model, higher inflation, due to the fiscal stimulus, decreases some of the government's debt service cost. As a result, the government can balance its budget with a relatively small change in the tax rate (τ). Moreover, this redistribution of resources hurts only net savers, namely wealthy, low MPC households.

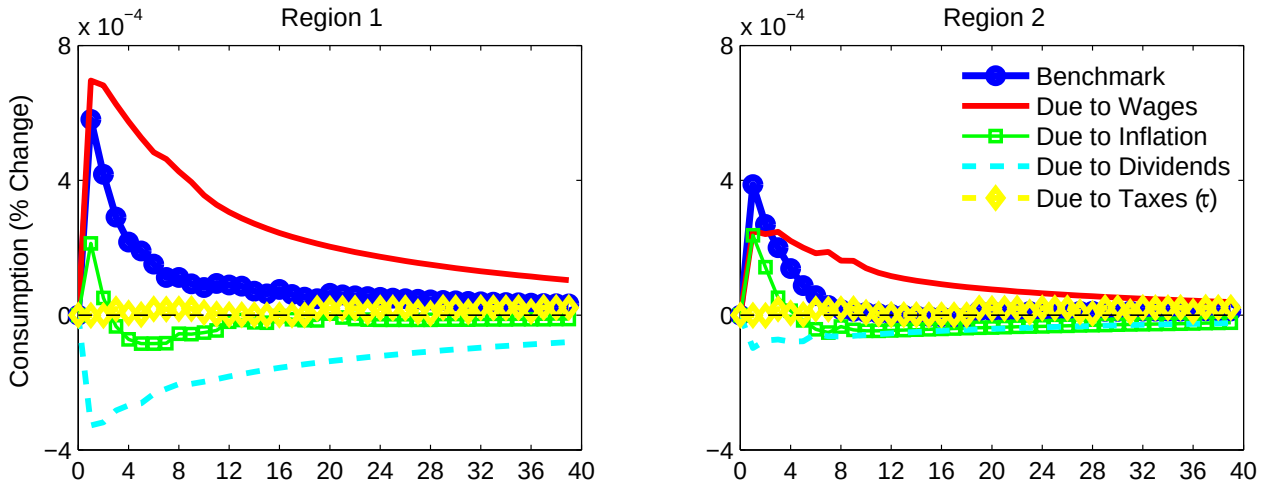
Third, in our model, the monetary authority does not adjust the nominal rate in response to inflationary pressures. When the nominal interest rate is held constant, an increase in expected inflation decreases the real interest rate and boosts consumer spending. In Section 6, we relax the assumption of an unresponsive monetary authority. We find a smaller but still positive local fiscal multiplier but a negative aggregate fiscal multiplier.

Once the fiscal stimulus is over, inflation in Region 1 is followed by a deflationary period which tends to depress consumer spending. Trade linkages help mitigate this channel by linking local inflation rates: inflation rate in Region 2 responds as strongly and quickly becomes higher than inflation in Region 1. As a result, Region 1 experiences a relatively small deflationary period. In our quantitative exercise, we exploit this mechanism to calibrate trade linkages (home bias) and match the regional consumption responses. Although the degree of home bias helps us match the data precisely, it cannot match the consumption moment by itself. As mentioned, our results depend mostly on the key assumptions of heterogeneity in labor-income risk and incomplete markets.

Trade linkages also explain why the aggregate fiscal multiplier is larger than the local

[20] In the neoclassical model, the real wage decreases due to the negative wealth effect, which increases labor supply. This is also true in our model but a stronger shift in labor demand leads to a higher equilibrium real wage.

Figure 6: Change in Consumption: Decomposition



Notes: Percentage change in consumption with one at a time macro aggregate changed. Each path sets one variable according to its equilibrium path and all others to their steady state.

fiscal multiplier. An increase in local government spending propagates – through trade in intermediate inputs – across all regions. As a result, local government spending increases real wages and consumer spending simultaneously in all regions.

5.3.1 Decomposing Consumption Changes

We decompose the change in consumer spending by each variable: wages, dividends, inflation, and taxes. In particular, we feed the model with the equilibrium path of a variable and assume the other variables remain constant at their steady-state value. This generates the marginal effect of a variable to total consumer spending. Figure 6 plots the consumer spending path for every case as well as when all effects are considered (Benchmark).

In both regions wages increase along the transition path as a response to higher demand for labor. On the other hand, dividends decrease for both regions. Higher labor income affects mainly high MPC households who increase substantially their spending, while lower dividends mainly hurt low MPC households who are less responsive. As a result, the combined effect of wages and dividends on consumer spending is positive. The positive effect is more pronounced for Region 1, the fiscal stimulus recipient. If only wages had changed, the local multiplier would be 0.44 (for an eight-year horizon) while the aggregate would be 0.98. If only dividends had changed, the local multiplier would be –0.26 while the aggregate would be –0.47. The combined effect of the two yields an aggregate multiplier of 0.51 very close to our benchmark aggregate, eight-year multiplier of 0.50.

A higher expected inflation decreases the real interest rate and thus, increases consumer spending. In Region 1, inflation dynamics have only a temporary positive effect since the region soon enters a deflationary period. In Region 2, the positive effect is more pronounced. If only inflation had changed, the local multiplier would be –0.03 and the aggregate multiplier would be –0.04. The contribution of inflation to consumer spending is quantitatively small relative to the contribution of wages.[21]

If only tax rates had changed, the local multiplier would be zero since taxes occur at the federal level. In such a case, the aggregate multiplier is 0.02. In the first years of the fiscal stimulus tax rates actually decrease slightly. The reason is that higher inflation decreases the debt service cost of the government. This is a redistribution from savers (households) to borrowers (government).

5.3.2 Empirical Evidence on Labor Income and Inflation

The model predicts a strong positive local effect of government spending on labor income and a positive but moderate effect on inflation. It is informative to evaluate empirically the effect of the fiscal stimulus on these two variables. We collect information on county-level wages from the Quarterly Census of Employment and Wages (QCEW). We collect information for inflation from the Bureau of Labor Statistics (BLS). We have information on PCE price indices for the period 2008-2014 for 382 Metropolitan Statistical Areas (MSAs).

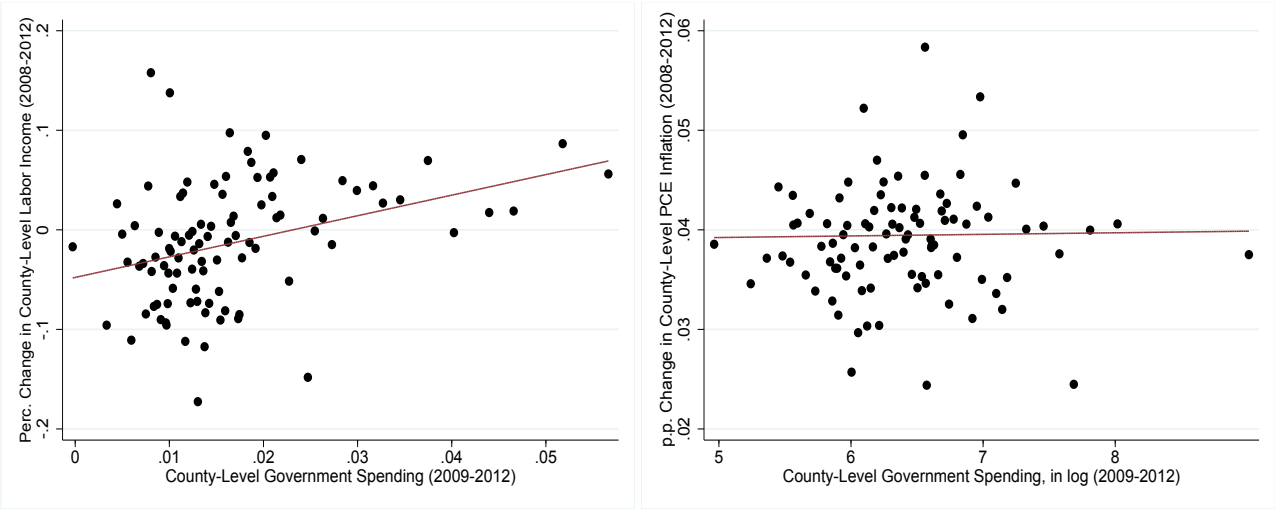
Consistent with our model, the Recovery Act has a positive effect on county-level labor income (left panel, Figure 7 and Table 10). Regarding inflation, there does not seem to be an effect of government spending on inflation (Right Panel, Figure 7 and Table 10). Our model predicts a positive yet small effect on inflation mostly due to our relatively high degree of price stickiness.

6 Sensitivity Analysis

We perform various sensitivity analyses to see how our main results change with respect to different specifications. In particular, we compute the local and aggregate multiplier under the following specifications. First, we consider an economy with no trade flows $\gamma_{12} = 0$. Second, we analyze an economy where taxation occurs at the local and not the federal level. Next we combine both model elements which shuts down all sources of spillovers between regions. Third, we examine the case where the monetary authority can respond to inflation.

[21] We are not the first to stress the relative stronger effect of wages and the relative weaker effect of inflation on consumer spending. See for example, the analysis in Kaplan, Moll, and Violante (2017).

Figure 7: Government Spending (2009-2012) and Percentage Change in Labor Income and Inflation (2008-2012), by Counties



Notes: Scatter plots between government spending (Recovery Act, 2009-2012) and percentage change in county-level labor income (left panel) and inflation (right panel), between 2008-2012, by counties. Information on labor income and inflation is collected from the QCEW and the BLS, respectively.

Table 10: Responses of Labor Income and Inflation to Government Spending (2008-2012)

Variable	Labor Income		Inflation	
Data Source	QCEW		BLS	
	OLS	IV	OLS	IV
Government Spending	1.339***	0.814*	-0.000	-0.0002
	(0.344)	(0.419)	(0.001)	(0.002)
Partial F stat.	—	272.7	—	166.5
County Controls/ State Fixed Effects	Yes	Yes	Yes	Yes
# Counties	2916	2852	1116	1111

Notes: First two columns show estimates of a regression of percentage change in labor income on cumulative government spending at the county level during the period 2008-2012. Last two columns show estimates of a regression of percentage point change in inflation on log-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. One, two, and three stars denote significance at the 10%, 5%, and 1% levels, respectively. In our specifications we include county controls/state fixed effects.

In particular, we use a standard Taylor rule coefficient $\phi = 1.5$. Fourth, we consider an economy with no within-region heterogeneity. This is equivalent to a representative-agent New

Table 11: Sensitivity Analysis

Model	Local multiplier		Aggregate multiplier	
	t=8	t=16	t=8	t=16
Benchmark	0.09	0.15	0.35	0.40
No Spillovers	-0.24	-0.49	-0.24	-0.49
No Trade Linkages	-0.13	-0.30	-0.25	-0.58
Local Taxes	0.08	0.14	0.46	0.53
Responsive Monetary Policy	0.08	0.13	-0.22	-0.19
RA-NK	0.01	0.05	0.06	0.05
One-Region Model	–	–	0.69	0.82

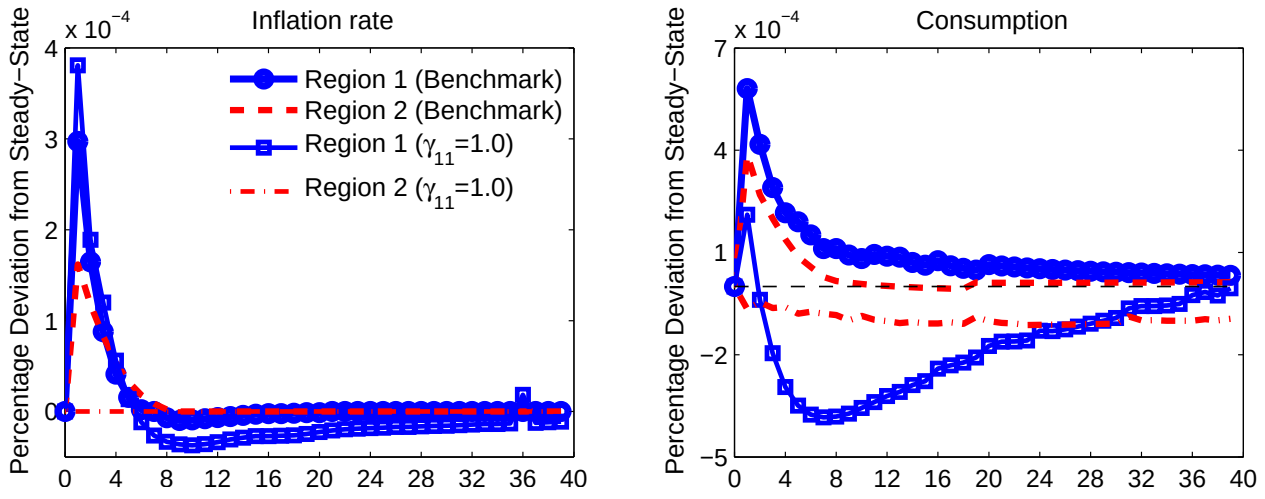
Notes: The Benchmark features: trade linkages ($\gamma_{11} = 0.89$), federal taxes, unresponsive monetary policy ($\phi = 0.0$), heterogeneity within a region ($\sigma_\eta > 0$), and two regions (N=2). We report the multiplier two and four years after the government spending shock.

Keynesian model (RA-NK) with two counties. Finally, we compute the aggregate multiplier in a one-region economy with heterogeneity. In each sensitivity analysis, we keep all other parameters of the model the same as those in our benchmark specification. Table 11 reports the results of the sensitivity analysis.

No trade linkages In this case we assume that final good firms buy only local inputs ($\gamma_{12} = 0, \gamma_{21} = 0$). Figure 8 shows the impulse response functions for inflation and consumer spending in our Benchmark ($\gamma_{11} = 0.89$) and in the case with no trade linkages ($\gamma_{11} = 1.00$). Since government spending does not spill over, inflation in Region 1 is initially higher than in the Benchmark. In contrast, inflation in Region 2 is zero since there is no change compared to the steady state.

As a result, relative inflation $\frac{1+\pi_i}{1+\pi_{i'}}$ increases initially more relative to the Benchmark. When the spending stops, Region 1 experiences a period of significant deflation so that the real exchange rate converges back to its steady-state value. This increases the real interest rate for Region 1 and depresses consumption. Consumer spending falls below steady-state after only two periods since households expect the higher future real interest rate and start saving early on. Consumer spending in Region 2 also decreases throughout the transition. This occurs because the prolonged period of deflation increases the nominal value of debt and

Figure 8: Impulse Responses to a Government Spending Shock with no Trade Linkages



Notes: Impulse response functions for our benchmark case ($\gamma_{11} = 0.89$) and if there are no trade linkages ($\gamma_{11} = 1.0$). All units are expressed in percentage deviations from their steady state.

increases tax rates.

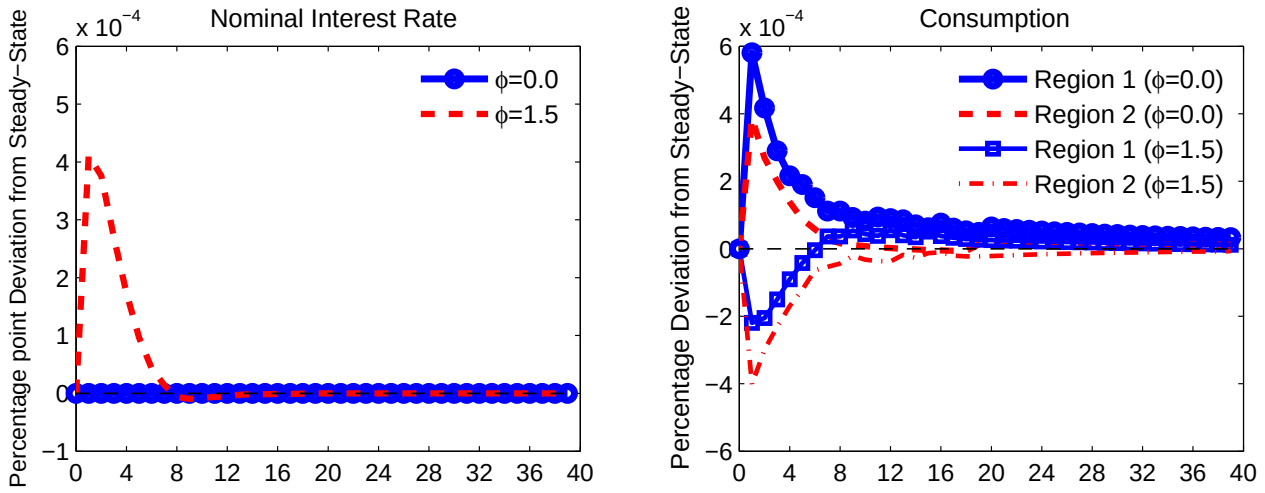
Table 11 reports the local multiplier in the case of no trade linkages. The local multiplier is negative since consumer spending in Region 1 quickly falls below consumer spending in Region 2. We conclude that if government spending shocks are too localized, the recipient-region experiences too much subsequent deflation so that consumption declines. In contrast, if spending spreads through the economy, local inflation rates are correlated to a larger degree and the recipient-region does not have to experience significant deflation. Hence, consumption rises.

This link explains how we pin down the home bias parameter. If home bias is too high, then the local consumption multiplier will be low or even negative. As home bias decreases, the local consumption multiplier increases.

Finally, the aggregate four-year multiplier is -0.58. This means that weak trade linkages affect negatively both the local and the aggregate consumption multiplier.

Local Taxes In the benchmark model, taxation occurs at the federal level. In this case, we assume that the recipient-region pays a higher fraction of taxes. Since Region 1 receives all the government aid, it pays a tax rate higher than the steady state: $\tau^1 > \tau_{ss}$. Region 2 does not receive any aid, so it pays $\tau^2 = \tau_{ss}$. Since Region 2 is not burdened with additional taxes the local multiplier is a little lower than our Benchmark. However, the aggregate multiplier increases, which means the gains for Region 2 are higher than the losses for Region 1.

Figure 9: Impulse Responses to a Government Spending Shock when Monetary Policy is Responsive



Notes: Impulse response functions for our benchmark case ($\phi = 0.0$) and when the monetary policy is responsive to inflation ($\phi = 1.5$). Left panel is expressed in percentage point changes from steady state while right panel in percentage deviations from steady state.

No Spillovers In this case, we shut down both channels that generate spillovers. We set $(\gamma_{12} = 0, \gamma_{21} = 0)$ and assume that tax rates are region-specific. The local and the aggregate multiplier are by definition the same and equal to -0.49.

Responsive Monetary Policy For our Benchmark we have assumed a monetary policy that is unresponsive to inflation pressures, a case resembling the zero lower bound. We now consider a monetary policy that is responsive to the national inflation rate. As before the nominal interest rate is given by a standard Taylor rule: $R_t = R_{ss} + \phi\hat{\pi}_t$, however we assume here that $\phi = 1.5$, a value standard in the literature.

A wealth of recent papers has studied the government spending multiplier at the zero lower bound. The basic mechanism that makes the multiplier large is a decrease in the real interest rate during government spending due to an increase in expected inflation (see for example, Christiano, Eichenbaum, and Rebelo, 2011). As a result, when we allow the monetary policy to respond to inflation, the (more than one-to-one) increase in the nominal rate increases the real interest rate, depressing consumer spending. This is true for both regions as there is a currency union.

The above can be seen in Figure 9. Consumer spending drops for both regions since the real interest rate decreases. In this case the local consumption multiplier is not affected much

given that the shock is aggregate. However, the four-year aggregate multiplier falls from 0.40 to -0.19. This exercise confirms the intuition of the literature claiming that estimates at the zero lower bound (i) do not affect the local multiplier, only the aggregate, and (ii) are an upper bound for the multiplier during times of conventional monetary policy (see for example, Chodorow-Reich, 2017).

Representative Agent New Keynesian Model (RA-NK) Our benchmark model combines a regional framework with a heterogeneous-agents model. A natural question is what exactly do we gain by introducing heterogeneity within a region? To address this question, we shut down idiosyncratic shocks. We assume that all agents receive the average productivity shock (normalized to one) and that this shock persists in all time periods. Hence, in this model, the within-region distribution of labor income and assets $\phi_i(x_t, a_t)$ is degenerate. However, regions are still different across the transition because only one receives government spending.

For a steady-state equilibrium with positive bond holdings to exist we have to assume that $\beta(1+R)=1$. We write the problem of the *representative* household in region i:

$$V_{i,t}(b_t) = \max_{c_t, b_{t+1}, h_t} \left\{ \frac{c_t^{1-\sigma}}{1-\sigma} + \psi \frac{(1-h_t)^{1-\theta}}{1-\theta} + \beta V_{i,t+1}(b_{t+1}) \right\} \tag{24}$$

$$\textbf{s.t.} \quad c_t + (1+\pi_{i,t+1})b' = w_{i,t}h_t - T(w_{i,t}h_t) + (1+R_{t-1}+\chi)b_t + D_{i,t} + F_{i,t} \tag{25}$$

$$b_{t+1} \geq \underline{b} \tag{26}$$

The main difference in the budget constraint is that we have replaced the borrowing wedge κ with the following function

$$\chi = \Delta(b_{t+1} - b_{ss}).$$

Similar types of debt rules are common in small open economy models and help induce stationarity (Schmitt-Grohe and Uribe, 2003). We set $\Delta = -0.01\%$, which means that the savings interest rate is lower when agents save more than the steady-state bond holdings and vice versa. Moreover, the assumption of a borrowing constraint is irrelevant as the representative household never holds a negative net worth. Table 12 compares the steady state between our Benchmark and the RA-NK economy. The RA-NK model features a lower MPC compared to our Benchmark. The average MPC is 0.12 while in our benchmark economy it is 0.22.

Both the local and the aggregate fiscal multiplier decrease compared to our Benchmark. In the RA-NK model both multipliers are equal to 0.05. Figure 10 shows that in both regions consumer spending increases less relative to the Benchmark. Moreover, consumer spending

Table 12: Steady State: Benchmark vs. RA-NK

	Benchmark	RA-NK
Liquid Assets/Income	1.21	1.23
Liquid Assets Gini	0.77	0.00
Median MPC	0.13	0.12
Average MPC	0.22	0.12

Notes: Selected steady-state statistics in two economies. The benchmark model and an economy with a representative agent in each region (RA-NK).

in the two regions increases by almost the same amount. There are two reasons for the differences in the responses. First, in the RA-NK model, consumer spending responds less to government spending as there are no borrowing constrained agents. The second reason relates to precautionary savings. In the RA-NK model, the Euler equation of a representative household with bond holdings b reads:

$$\frac{1}{c_t(b_t)} = \frac{\beta(1+R)}{(1+\pi_{i,t+1})} \frac{1}{c_{t+1}(b_{t+1})}$$

Rewriting the same equation for $c_{t+1}, c_{t+2}, ..$ and using repeated substitution, we derive

$$\frac{1}{c_t(b_t)} = \frac{1}{\sum_{s=1}^{T}(1+\pi_{i,t+s})} \frac{1}{c_T(b_T)}$$

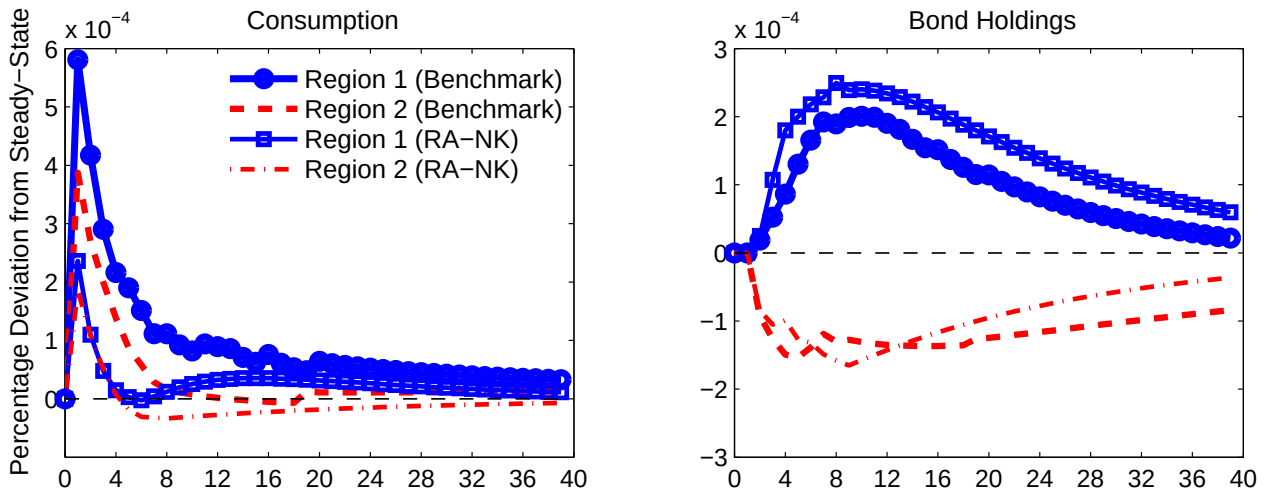
where T is the period when the economy has converged back to the steady-state and we have also used for simplicity that $\beta(1+R) = 1$. Term $\frac{1}{\sum_{s=1}^{T}(1+\pi_{i,t+s})}$ captures the long-run real interest rate households face at time t. Hence, absent of uncertainty, consumer spending is affected *on impact* by the long-run and not the short-run interest rate.

In the benchmark model, the Euler equation of an unconstrained household with type (x, b) reads:

$$\frac{1}{c_t(x_t, b_t)} = \frac{\beta(1+R)}{(1+\pi_{i,t+1})} \sum_{x_{t+1}} \Gamma_{x_t, x_{t+1}} \frac{1}{c_{t+1}(x_{t+1}, b_{t+1})}$$

In this case households save not only for intertemporal reasons, which are associated with the real interest rate $\frac{(1+R)}{(1+\pi_{i,t+1})}$, but also precautionary reasons, which are associated with the expectation operator. As a result, long-term interest rates have a smaller impact on current consumption as a large fraction of households' saving occurs for precautionary reasons. This

Figure 10: Impulse Responses to a Government Spending Shock with no Within-Region Heterogeneity (RA-NK)



Notes: Impulse response functions for benchmark case (heterogeneity within regions, $\sigma_\eta > 0$) and RA-NK model (representative agent, $\sigma_\eta = 0$). All units are expressed in percentage deviations from their steady state.

intuition has been outlined in both Nakamura and Steinsson (2014) for a regional RA-NK economy and McKay, Nakamura, and Steinsson (2016) for the response of a heterogeneous agents New Keynesian economy with one region to a monetary shock. Our exercise combines these ideas into a regional, heterogeneous agents, New Keynesian model that responds to a government spending shock.

One-Region Model We estimate the aggregate consumption multiplier if there is only one region in the economy. This is equivalent to both regions receiving the same amount of government spending. The multiplier is around twice as large as in our Benchmark.

What distinguishes a local government shock from an aggregate government shock is that the former affects relative prices while the latter does not. In the Benchmark, higher local inflation is followed by local deflation in order for the real exchange rate to return to its steady-state value. We showed how strong trade linkages — which link local inflation rates — tend to mitigate this effect. If the shock is aggregate, then the inflation rates are perfectly correlated (constant real exchange rate) so there is no period of deflation. Hence, in all periods the real interest rate is below or the same as its steady-state value. This boosts consumer spending and explains the differences in the multiplier. We conclude that government spending at the zero lower bound yields different predictions in a multi-region model relative to a one-region model such as the one in Christiano, Eichenbaum, and Rebelo (2011).

7 Conclusion

The response of private consumer spending to a fiscal stimulus injection is at the heart of the income multiplier debate. We estimate a positive response of consumer spending to the Recovery Act (2009-2012) using regional variation. Localities that received $1 more in government spending spent around 0.18 combined in retail and auto purchases.

We estimate the aggregate response of consumer spending to fiscal stimulus using a structural model. Our model is novel in that it embeds a regional framework into a heterogeneous agents, New Keynesian setup. The model reproduces successfully the positive local consumption multiplier we document in the data. This is a new finding and distinguishes our incomplete markets model from previous literature that employed regional models with complete markets. The structural model predicts an aggregate consumption multiplier around 0.4. This falls in the upper bound of estimates found in the literature (Hall, 2009).

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Appendix

A American Recovery and Reinvestment Act

In this section, we provide our reasons for including the various components of Recovery Act spending in our construction of the instrument.[22]

Environmental Protection Agency (EPA) State and Tribal Assistance Grants. The Recovery Act included $7.22 billion for EPA projects. The largest programs were the State Revolving Fund Capitalization Grants to supplement the federal Clean Water State Revolving Fund and the Drinking Water State Revolving Fund, for which the act allocated $4 billion and $2 billion, respectively. Since the capitalization grants were the lion's share of the EPA's entire stake in the Recovery Act, our discussion of the EPA's funding guidelines will be restricted to this program.

States prepared annual Intended Use Plans to describe how funds would be used. An administrative guidance, Environmental Protection Agency (2009) describes several of the criteria that states were to use in their own project selection. These include giving priority to projects that will be "ready to proceed to construction within 12 months of enactment of the Act," and having "not less than 20% of funds go to green projects." There were also "Buy American" requirements for iron, steel, and manufactured goods incorporated into projects and Davis-Bacon wage rate restrictions. Nowhere in the guidances that we read or the legislation itself is there mention of states being directed to apply funding to areas hardest hit by the recession.[23] Given the federal guidances, we argue that program administrators – at the state level – would put much greater concern toward putting money where water quality needs were greatest as opposed to attempting to use funds to combat low employment in particular counties within a state.

Department of Justice Office of Justice Programs (OJP). These grants were administered to state and local governments to support activities "to prevent and control crime and to improve the criminal justice system."[24] The program was authorized $2.7 billion. Of this amount, $1.98 billion was issue via formulary Justice Assistance Grants (JAG). Sixty percent of the JAG allocation was awarded to states with the remainder set aside for local governments. Formula-dictating allocations are based on population and violent crime statistics. The formula also includes minimum allocation rules to prevent states and localities from receiving disproportionately low funds. The next three largest components of the OJP were for

[22] The information in this section of the appendix also appears as an appendix in Dupor and McCrory (2016).

[23] These documents include Environmental Protection Agency (2009) and Environmental Protection Agency (2011).

[24] See Justice, Department of (2009a).

correctional facilities on tribal lands ($225 million), grants to improve the functioning of the criminal justice system ($125.3 million), and rural law enforcement grants to combat crime and drugs ($123.8 million). All three were discretionary grants.

Nowhere in the program's documentation that we examined do we find instructions from the Department of Justice to have localities or states direct grant aid to those areas harder hit by the recession. For example, with respect to the correctional facilities on tribal lands grants, there are a number of restrictions (see Justice, Department of (2009b)). A few of these are "Buy American" provisions, Bacon-Davis wage requirements, and preference for quick start activities. Serving areas hardest hit by the recession as an instruction to recipients or a criterion for receiving the grant is not among the restrictions. We conclude that the allocations of this component of the act were largely uncorrelated with the degree of economic weakness in the local labor markets that received this aid.

Department of Energy (DOE). The Recovery Act authorized $16.51 billion for 10 distinct Energy Efficiency and Renewable Energy (EERE) programs. According to U.S. Dept. of Energy (2009), EERE projects "will stimulate economic development, provide opportunities for new jobs in growing industries, and lay the foundation for a clean energy future." Moreover, "Over $11 billion of EERE's Recovery Act funds will be used to weatherize homes of low-income Americans through the Weatherization Assistance Program (WAP) and will go to states and local communities through the State Energy Program (SEP) and Energy Efficiency and Conservation Block Grant Program (EECBG) to implement high priority energy efficiency projects."

The Recovery Act weatherization component, the largest of the EERE Recovery Act programs, totaled $4.98 billion and was an add-on to the regular annual federal WAP. The Weatherization program state-by-state allocation formula is based on several factors: the low income population, climatic conditions, and residential energy expenditures by low-income households.

The Department of Energy EERE guidances concerning the Recovery Act do not discuss how states and localities should spend dollars in order to maximize support for areas hardest hit by the recession.[25]

U.S. Army Corps of Engineers. First, the act provided $4.6 billion allocated to the U.S. Army Corp of Engineers (USACE) Civil Financing Only program. It consisted primarily of two parts: Construction ($2 billion) and Operations and Maintenance ($2.075 billion). The spending was applied to improve categories such as inland and coastal navigation, environmental and flood risk management, hydropower, and recreation. Besides general provisions applied to all components of Recovery Act funding, the Corp applied the following five additional criteria for project selection: (1) be obligated quickly; (2) result in high, immediate

[25]See U.S. Dept. of Energy (2009) and U.S. Dept. of Energy (2010).

employment; (3) have little schedule risk; (4) be executed by contract or direct hire of temporary labor; and (5) complete a project phase, a project, an element, or will provide a useful service that does not require additional funding (see U.S. Army Corp of Engineers (2010a)).

In two key agency Recovery Act plans, U.S. Army Corp of Engineers (2010a) and U.S. Army Corp of Engineers (2010b), there was little discussion of the USACE aiming funds toward areas that faced greater economic stress during the past recession. The only exception is that these planning documents mentioned in several places the USACE's desire to "support the overall purpose of ARRA to preserve and create jobs and promote economic recovery; to assist those impacted by the recession; and to provide investments needed to increase economic efficiency." Otherwise, there was no discussion of the USACE aiming targeting project funds to the worst hit areas. Also, there was no specific discussion of how the desire to assist those most impacted by the recession was operationalized in the USACE's plans. Finally, all USACE project decisions were made at the federal level; therefore, there was no potential endogeneity introduced by state-government-level allocation decisions.

U.S. Department of Education Special Education Fund. The act authorized the Office of Special Education and Rehabilitation Services to allocate $12.2 billion to states to assist local education agencies in providing free and appropriate public education (FAPE) to students with special needs.[26]

The lion's share of these grant monies came in the form of add-ons to the regular Individuals with Disabilities Education Act (IDEA) Part B funding. The Recovery Act funding formula follows the IDEA Part B formula.[27] The national FFY2009 regular grant amount was $11.5 billion. The first $3.1 billion (both from regular funding and the Recovery Act add-on) was divided amongst states so that they were guaranteed to receive their FFY1999 awards. The remaining part of the national award was allocated among the states according to the following rule: "85% are allocated to States on the basis of their relative populations of children aged 3 through 21 who are the same age as children with disabilities for whom the State ensures the availability of an FAPE) and 15% on the relative populations of children of those ages who are living in poverty."[28] The Recovery Act add-on totaled $11.3 billion. Since, at the margin, the FY1999 requirements had already been met by the regular awards, every Recovery Act dollar was in effect assigned according to the 85/15 percent rule.

Next and importantly, we address how funds were assigned from state education agencies to local education agencies (LEA). These initial allocations too were made at the federal level.

[26]Our discussion of the instrument here follows Dupor and Mehkari (2016), which uses the special education funding component of the act as an instrument to assess the effect on school districts' spending of the Recovery Act grants.

[27]See U.S. Dept. of Education (2009b) and New America Foundation (2014).

[28]Enclosure B of U.S. Dept. of Education (2009b) contains the precise description of how Recovery Act funds were allocated across states.

Each LEA was first allocated a minimum of its FFY1999 award.[29] Beyond these minimums, which were already met by the regular annual award amounts, a slightly different 85/15 rule was used. Within each state, 85% of dollars were allocated to according to the share of school age children in the LEA and 15% were allocated according the LEA's childhood poverty rate. After this, states were allowed to do reallocations as explained below. Before we explain how reallocations worked, we ask whether the observed spending data at the within-state level are explained by the simple formulary rules.

Let $P_{j,s}$ and $\tilde{P}_{j,s}$ be the enrollment of students and students in poverty, respectively, in district j and state s. Let $IDEA_{j,s}$ denote the total Recovery Act special needs funding in district j in state s. Based on the above formula, the distribution of Recovery Act IDEA dollars would be

$$IDEA_{j,s} = \left(0.85 \times \frac{P_{j,s}}{\sum_{i=1}^{N_s} P_{i,s}} + 0.15 \times \frac{\tilde{P}_{j,s}}{\sum_{i=1}^{N_s} \tilde{P}_{i,s}} \right) IDEA_s$$

Letting P_s and $\tilde{P}_s$ denote the sum within state s of the two district-level enrollment variables, we can rewrite the above equation as:

$$\frac{IDEA_{j,s}}{P_{j,s}} = \left[0.85 \times \frac{1}{P_s} + 0.15 \times \frac{1}{\tilde{P}_s} \left(\frac{\tilde{P}_{j,s}}{P_{j,s}} \right) \right] IDEA_s$$

Thus, within each state, the district-level per-pupil IDEA amount would be perfectly predicted by the ratio of the low-income enrollment to the overall enrollment in the district. By running state-level regressions (available on request) we show that this variable has very little predictive power for the IDEA per-pupil amount. This tells us that other factors besides poverty rate in each district are influencing the allocation of IDEA funds.

This brings us to the rules for redistribution of dollars within state across LEAs, given by Code of Federal Regulation 300.707(c)(1). It states:

> If an SEA determines that an LEA is adequately providing FAPE to all children with disabilities residing in the area served by that agency with State and local funds, the SEA may reallocate any portion of the funds under this part ... to other LEAs in the State that not adequately providing special education and related services to all children with disabilities residing in the area served by those LEAs.

We conclude that the primary reason that IDEA money was allocated differently from the formulary rule is that, within individual states, some localities were able to meet their funding requirements of special needs students without using any or all of the Recovery Act IDEA

[29] Federal code also describes how minimum awards are determined for LEAs created after 1999.

funds. Those funds were then reallocated to districts with additional funding for special needs students. Differences in funding requirements across districts were likely due to various factors, such as the number of special needs students, the types of disabilities and their associated costs, and the districts' own funding contributions for providing the services to these special needs students. Our exogeneity assumption is that this set of factors driving redistributions of IDEA funds is orthogonal to the error term in second-stage equation.

B Robustness Analysis

In this section, we analyze the sensitivity of our empirical estimates (Table 4 and Table 5). We examine the implications of the following specification choices: (1) population weights, (2) winsorization of the independent variable, (3) clustering of standard errors, and (4) excluding counties with too few households/stores.

In Table B-1 we report the empirical estimates for each of the alternative specifications as well as the benchmark specification. For simplicity, we only report the IV estimates that employ state fixed effects (results would apply similarly to the OLS coefficients). First, population weights do not affect the Nielsen estimates but affect greatly the Equifax estimates. Equifax provides a much wider geographical representation compared to Nielsen. As a result, estimates are more susceptible to low-population counties with large changes in consumer spending. When we use population weights the auto spending multiplier decreases from 0.26 to 0.07.

Second, we analyze the implications of winzorizing the independent variable. We make this choice since many low-population counties received very large per-capita funding. When we do not winzorize the independent variable coefficients remain intact but statistical significance increase especially for Nielsen HomeScan. When we winzorize at 2% and 5%, respectively, coefficients decrease for Nielsen HomeScan and lose their statistical significance, similar to our Benchmark. In Nielsen Retail Scanner the estimates increase substantially (0.14 and 0.18, respectively) while significance remains intact. The same pattern is true for Equifax. The multiplier increases to 0.10 and 0.14, respectively, and estimates remain statistically significant at the 1%.

Third, in our Benchmark we clustered standard errors by state level. We analyze what happens if we do not cluster standard errors and if we cluster at a higher regional level, namely the nine Census Divisions. The coefficients by definition remain the same in such an exercise. What may change is the strength of statistical significance. Table B-1 shows that the standard errors change only slightly by these changes.

Finally, we analyze the implications of excluding from the analysis counties with too few households or stores. In some counties, Nielsen samples only a few households or stores. As

Table B-1: Robustness Analysis

Specification	Nielsen HomeScan	Nielsen Retail Scanner	Equifax
Benchmark	0.08	0.11**	0.07***
	(0.06)	(0.04)	(0.02)
W/o pop. weights	0.09	0.09**	0.26***
	(0.08)	(0.04)	(0.05)
Winsorizing G			
at 0%	0.09***	0.08**	0.07***
	(0.03)	(0.03)	(0.02)
at 2%	0.08	0.14**	0.10***
	(0.07)	(0.05)	(0.02)
at 5%	0.06	0.18**	0.14***
	(0.10)	(0.07)	(0.03)
Cluster S.E.			
No Cluster	0.08	0.11**	0.07***
	(0.07)	(0.04)	(0.01)
by Census Division	0.08	0.11***	0.07***
	(0.06)	(0.03)	(0.02)
Excluding counties			
with #HH/Stores < 3	0.13**	0.12***	–
	(0.06)	(0.03)	
with #HH/Stores < 6	0.11**	0.10***	–
	(0.05)	(0.03)	
with #HH/Stores < 9	0.07	0.10**	–
	(0.05)	(0.04)	
with #HH/Stores < 12	0.08	0.08**	–
	(0.06)	(0.03)	
with #HH/Stores < 15	0.11**	0.10**	–
	(0.05)	(0.04)	
with #HH/Stores < 30	0.17**	0.07*	–
	(0.08)	(0.04)	

Note: The table shows the estimates of the regression of the growth rate in retail spending (HomeScan and Retail Scanner) to cumulative government spending at the county level during the period 2008-2012. Our benchmark specification uses population weights, winsorizes at the 1%, clusters standard errors by state and excludes counties with less than 20 households/stores. We show results for IV specification with county controls/state fixed effects. The standard errors are given in parentheses. One, two, and three stars denote significance at the 10%, 5%, and 1% levels, respectively.

a result, it is possible that county-level estimates are driven by a few observations. Note that there is no similar issue with Equifax which has a much higher number of observations per county (dataset totals 10 million individuals). In the benchmark we excluded counties with households/stores less than 20. Table B-1 shows the results when we vary the minimum number of households/stores per county. In HomeScan the multiplier exhibits a U-shape as we increase the minimum number of households. The lowest value of the multiplier is 0.07 close to our benchmark specification. In Retail Scanner data the multiplier decreases as we increase the minimum number of households. The lowest value of the multiplier is 0.07, around 4 cents lower than our Benchmark.

B.1 Alternative Specification

In our benchmark specification we estimate the dollar change to consumer spending if government spending increases by \$1. In this section, we use the logarithm of government spending and estimate a semi-elasticity. As in the benchmark specification, our left-hand side variable is the cumulative growth rate of spending relative to 2008.

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

For our independent variable, we use the per-capita total money awarded to county j during the period 2009-2012, in logs. This is denoted as $\log G_j$. To estimate the effect of government spending on consumer spending we use the following specification at the county-level:

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

Coefficient $\beta/100$ is the change in the consumer spending growth rate if government spending increases by 1%. Table B-2 shows the retail spending estimates based on our specification. The coefficients remain positive in this case as well. We find that a 1% increase in government spending increases county-level retail spending growth around 0.023/100 for Nielsen HomeScan, and around 0.033/100 for Nielsen Retail Scanner data, respectively. Table B-3 shows the auto spending estimates based on our specification. Once more, the coefficients remain positive. We find that a 1% increase in government spending increases county-level auto spending growth around 0.06/100.

Table B-2: Retail Spending Multipliers

Spending Category	Retail Consumer Spending (Nielsen, HomeScan)				Retail Consumer Spending (Nielsen, Retail Scanner)			
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Government Spending	0.022*	0.029*	0.032*	0.023	0.016	0.0.37*	0.029*	0.033
	(0.013)	(0.014)	(0.017)	(0.019)	(0.020)	(0.022)	(0.017)	(0.017)
Partial F stat.	—	166.9	—	220.4	—	132.4	—	213.4
County Controls/ State Fixed Effects	No	No	Yes	Yes	No	No	Yes	Yes
# Counties	272	272	272	272	365	365	365	365

Note: The table shows the estimates of the regression of the growth rate in retail spending (HomeScan and Retail Scanner) on cumulative government spending, in logs. We show results for our OLS and IV specification, with and without county controls/state fixed effects. The standard errors are given in parentheses. One, two, and three stars denote significance at the 10%, 5%, and 1% levels, respectively.

Table B-3: Auto Spending Multipliers

Spending Category	Auto Spending (CCP/Equifax)			
	OLS	IV	OLS	IV
Government Spending	0.015	0.061***	0.045***	0.060***
	(0.024)	(0.023)	(0.014)	(0.015)
Partial F stat.	—	192.0	—	166.0
County Controls/ State Fixed Effects	No	No	Yes	Yes
# Counties	3000	3000	2936	2936

Note: The table shows the estimates of the regression of the growth rate in auto spending on cumulative government spending at the county level, in logs. We show results for our OLS and IV specification, with and without county controls/state fixed effects. The standard errors are given in parentheses. One, two, and three stars denote significance at the 10%, 5%, and 1% levels, respectively.

C Derivation of Equations

In this section we derive the main equations in the text. The production technology of final good firm in region i is

$$Y_i = \left[\sum_{i'=1}^{N} \gamma_{ii'}^{\frac{1}{\epsilon}} \int_j x_{ii'j}^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}}$$

The maximization problem for the firm i reads:

$$\max_{x_{ii'j}} \quad P_i Y_i - \sum_{i'} \int_j p_{i'j} x_{ii'j}$$

$$\implies x_{ii'j}^{-\frac{1}{\epsilon}} = \frac{1}{\gamma_{ii'}^{\frac{1}{\epsilon}}} \frac{p_{i'j}}{P_i} \left[\sum \gamma_{ii'}^{\frac{1}{\epsilon}} \int_j x_{ii'j}^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{1}{1-\epsilon}}$$

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

The zero profit condition leads to the price aggregator:

$$P_i Y_i = \sum_{i'=1}^{N} \int_j p_{i'j} x_{ii'j} = \sum_{i'} \int_j p_{i'j} \gamma_{ii'} \left[\frac{p_{i'j}}{P_i}\right]^{-\epsilon} Y_i$$

$$\implies P_i = \sum_{i'} \gamma_{ii'} P_i^{\epsilon} \int_j p_{i'j}^{1-\epsilon} \implies P_i^{1-\epsilon} = \sum_{i'} \gamma_{ii'} \int_j p_{i'j}^{1-\epsilon}$$

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

Let λ firms get to change their price every period. If they change their price, they set it at p_{ij}^*. The inflation rate at region i is $\pi_t = \frac{P_{i,t}}{P_{i,t-1}} - 1$. We can write the price aggregator as

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

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

where $Q_{i'i} = \frac{P_i'}{P_i}$. Total demand for intermediate firm (i, j) is

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

Total demand for intermediate inputs of region i is

$$\begin{aligned}
\int_j y_{ij} = \mathcal{Y}_i &= \sum_{i'} \gamma_{i'i} \left[\frac{\int_j p_{ij}}{P_{i'}} \right]^{-\epsilon} Y_{i'} \\
&= \sum_{i'} \gamma_{i'i} \left[\lambda \left(\frac{p^*_{ij}}{P_{i'}} \right)^{-\epsilon} Y_{i'} + (1-\lambda) \left(\frac{P_{it-1}}{P_{i't}} \right)^{-\epsilon} Y_{i'} \right] \\
&= \sum_{i'} \gamma_{i'i} Y_{i'} \left[\lambda \left(\frac{p^*_{ij}}{P_{i'}} \right)^{-\epsilon} \left(\frac{P_i}{P_i} \right)^{-\epsilon} + (1-\lambda) \left(\frac{P_{it-1}}{P_{i't}} \frac{P_{it}}{P_{it}} \right)^{-\epsilon} \right] \\
&= \sum_{i'} \gamma_{i'i} Y_{i'} \left[\lambda \left(\frac{p^*_{ij}}{P_i} \right)^{-\epsilon} Q^{\epsilon}_{i'it} + (1-\lambda)(1+\pi_{it})^{\epsilon} Q^{\epsilon}_{i'it} \right] \\
\implies \mathcal{Y}_i &= \left[\lambda \left(\frac{p^*_{ij}}{P_i} \right)^{-\epsilon} + (1-\lambda)(1+\pi_{it})^{\epsilon} \right] \cdot \sum_{i'} \gamma_{i'i} Q^{\epsilon}_{i'it} Y_{i'}
\end{aligned}$$

The firm chooses its price p_{ij} to maximize its long-run profits. As mentioned, we call the reset price p^*. If firm gets to reset price at time t:

$$\max_{p^*_{ijt}} \quad p^*_{ijt} y_{ijt} - W_{it} y_{ijt} + (1-\lambda)\beta [p^*_{ijt} y_{ijt+1} - W_{it+1} y_{ijt+1}] + ((1-\lambda)\beta)^2 [p^*_{ijt} y_{ijt+2} - W_{it+2} y_{ijt+2}] + \dots$$

$$\max_{p^*_{ijt}} \quad p^*_{ijt} \sum_{i'} \gamma_{i'i} p^{*-\epsilon}_{ijt} \frac{Y_{i't}}{P^{-\epsilon}_{i't}} - W_{it} \sum_{i'} \gamma_{i'i} p^{*-\epsilon}_{ijt} \frac{Y_{i't}}{P^{-\epsilon}_{i't}} + (1-\lambda)\beta \left[p^*_{ijt} \sum_{i'} \gamma_{i'i} p^{*\epsilon}_{ijt} \frac{Y_{i't+1}}{P^{-\epsilon}_{i't+1}} - W_{it+1} \sum_{i'} \gamma_{i'i} p^{*\epsilon}_{ijt} \frac{Y_{i't+1}}{P_{i't+1}} \right] + \dots$$

$$p^*_{ijt} = \frac{\epsilon}{\epsilon - 1} \frac{\sum_{i'=1}^N \gamma_{i'i} \left[W_{it} \frac{Y_{i't}}{P^{-\epsilon}_{i't}} + (1-\lambda)\beta W_{it+1} \frac{Y_{i't+1}}{P^{-\epsilon}_{i't+1}} + ((1-\lambda)\beta)^2 W_{it+2} \frac{Y_{i't+2}}{P^{-\epsilon}_{i't+2}} + \dots \right]}{\sum_{i'=1}^N \gamma_{i'i} \left[\frac{Y_{i't}}{P^{-\epsilon}_{i't}} + (1-\lambda)\beta \frac{Y_{i't+1}}{P^{-\epsilon}_{i't+1}} + ((1-\lambda)\beta)^2 \frac{Y_{i't+2}}{P^{-\epsilon}_{i't+2}} + \dots \right]}$$

$$p^*_{ijt} = \frac{\epsilon}{\epsilon - 1} \frac{P^{-\epsilon}_{it}}{P^{-\epsilon}_{it}} \frac{\sum_{i'=1}^N \gamma_{i'i} \left[W_{it} \frac{Y_{i't}}{P^{-\epsilon}_{i't}} + (1-\lambda)\beta W_{it+1} \frac{Y_{i't+1}}{P^{-\epsilon}_{i't+1}} + ((1-\lambda)\beta)^2 W_{it+2} \frac{Y_{i't+2}}{P^{-\epsilon}_{i't+2}} + \dots \right]}{\sum_{i'=1}^N \gamma_{i'i} \left[\frac{Y_{i't}}{P^{-\epsilon}_{i't}} + (1-\lambda)\beta \frac{Y_{i't+1}}{P^{-\epsilon}_{i't+1}} + ((1-\lambda)\beta)^2 \frac{Y_{i't+2}}{P^{-\epsilon}_{i't+2}} + \dots \right]}$$

$$\frac{p^*_{ijt}}{P_{it}} = \frac{\epsilon}{\epsilon - 1} \frac{\sum_{i'=1}^N \gamma_{i'i} Q^{\epsilon}_{i'it} \left[w_{it} Y_{i't} + (1-\lambda)\beta (1+\pi_{i't+1})^{1+\epsilon} \mathcal{X}_{i'it+1} \right]}{\sum_{i'=1}^N \gamma_{i'i} Q^{\epsilon}_{i'it} \left[Y_{i't} + (1-\lambda)\beta (1+\pi_{i't+1})^{\epsilon} \mathcal{Z}_{i't+1} \right]}$$

with

$$\mathcal{X}_{i'it} = w_{it} Y_{i't} \quad + \quad (1-\lambda)\beta (1+\pi_{i't+1})^{1+\epsilon} \mathcal{X}_{i'it+1}$$

$$\mathcal{Z}_{i'it} = Y_{i't} \quad + \quad (1-\lambda)\beta (1+\pi_{i't+1})^{\varepsilon} \mathcal{Z}_{i'it+1}$$

Finally, the profits of firm (i,j) at time t is given by $p_{ij} * y_{ij} - W_i * y_{ij}$ so that the real

profits for intermediate firm j in region i is $d_{ij} = \frac{p_{ij}}{P_i} * y_{ij} - w_i * y_{ij}$. As a result, profits in region i can be written as

$$D_i = \int_j \frac{p_{ij}}{P_i} * y_{ij} - w_i * L_i \rightarrow$$

$$D_i = \int_j \frac{p_{ij}}{P_i} * \sum_{i'} \gamma_{i'i} \left[\frac{p_{ij}}{P_{i'}}\right]^{-\epsilon} Y_{i'} - w_i * L_i \rightarrow$$

$$D_i = \int_j \sum_{i'} \gamma_{i'i} \frac{p_{ij}}{P_i} * \left[\frac{p_{ij}}{P_{i'}}\right]^{-\epsilon} Y_{i'} - w_i * L_i \rightarrow$$

$$D_i = \sum_{i'} \gamma_{i'i} \int_j (\frac{p_{ij}}{P_i})^{1-\epsilon} \left[\frac{P_i'}{P_i}\right]^{\epsilon} Y_{i'} - w_i * L_i \rightarrow$$

$$D_i = \sum_{i'} \gamma_{i'i} Q_{i'i}^{\epsilon} Y_{i'} \int_j (\frac{p_{ij}}{P_i})^{1-\epsilon} - w_i * L_i \rightarrow$$

$$D_i = \left[\lambda \left(\frac{p_{ij}^*}{P_i}\right)^{1-\epsilon} + (1-\lambda)(1+\pi_{it})^{\epsilon-1}\right] * \sum_{i'} \gamma_{i'i} Q_{i'i}^{\epsilon} Y_{i'} - w_i * L_i$$

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