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Regional Consumption Responses and the Aggregate Fiscal Multiplier*

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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 $0.29. 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 0.64, which implies an output multiplier higher than one. The aggregate consumption multiplier is larger than 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]

ARRA – commonly known as the stimulus package – took place between 2009-2012 and was a very large program by historical standards. The spending component of the Act allocated roughly $228 billion. Our consumer spending data come from two separate sources. First, we collect store-level information on retail purchases from the Nielsen 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.

We estimate that a $1 increase in county-level government spending increases local retail spending by $0.20 and local auto spending by $0.09. We show that ARRA funding did not significantly target low-income areas. Nonetheless, we address potential endogeneity using a narrative instrumental variable approach. In particular, we identify components of ARRA funding that did not explicitly target local economic recovery.[3]

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 gov-

[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 (2016), and Ramey and Zubairy (2018).

[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 (2018) and Nakamura and Steinsson (2018).

[3] Our method requires a very detailed reading of the Act, federal codes, and regulations. Other research on the ARRA using this narrative instrumental variable approach includes Dupor and Mehkari (2016) and Dupor and McCrory (2017).

ernment. 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 multi-region 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, 2018).

Our model successfully replicates the positive local consumption fiscal multiplier we document in the data. More importantly, we find an aggregate consumption fiscal multiplier equal to 0.64. The aggregate consumption multiplier is larger than the local estimate because trade linkages propagate government spending across regions. We estimate the strength of trade linkages based on commodity shipments between regions from the Commodity Flow Survey.

Our framework generates positive consumption responses at the local and the aggregate level, which is generally difficult to deliver in more standard models.[4] The key necessary element to generate a positive *local* consumption multiplier is incomplete markets. With complete markets, any change in regional 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 regions with larger fiscal stimulus injections also experience higher inflation, the local consumption multiplier is negative (see for example, Nakamura and Steinsson, 2014; Farhi and Werning, 2016; Chodorow-Reich, 2018).

Heterogeneity is not a necessary ingredient to generate a positive local or aggregate consumption response but it is crucial to generate substantial consumption responses consistent with the data. We show that an incomplete markets, representative agent, New Keynesian model can also generate positive local and aggregate multipliers, albeit much smaller than our benchmark model. The main mechanism underlying the larger consumption responses in the model with heterogeneous agents is the substantial response of high-marginal propensity to consume (MPC), labor-income-dependent households who experience increase in their labor earnings.

[4]In the standard Neoclassical model without capital, the aggregate 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).

The necessary element for a positive *aggregate* consumption multiplier is the weak response of monetary policy to fiscal stimulus. 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. The decrease in the real interest rate induces consumers to save less. Moreover, it decreases the government's debt service cost. As a result, the government can balance its budget with a relatively small increase in taxes.[5]

Our multi-region, heterogeneous agents, New Keynesian model brings new insights on the transmission mechanism of fiscal policy on consumption that are absent in heterogeneous agents, New Keynesian models with a single region. When fiscal stimulus is injected into an open economy, local inflation is followed by a deflationary period necessary to bring the real exchange rate to its steady-state value (Nakamura and Steinsson, 2014). The anticipated deflation increases the (long-run) real interest rate and induces households to consume less. We show that the strength of this channel depends on the degree of home bias as well as the relative size of the regions. Models with a single region naturally miss the importance of trade linkages and relative price adjustments between regions for the aggregate consumption multiplier.

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 aggregate consumption multiplier using aggregate time-series VARs (for example, Ramey and Shapiro, 1998; Blanchard and Perotti, 2002; Perotti, 2005; Barro and Redlick, 2011). 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 use 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 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 translate the cross-regional variation into an aggregate consumption response using a quantitative model. 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

[5]The decrease in the government's debt service cost is a redistribution of resources from the private to the public sector, which hurts net savers, namely wealthy, low-MPC households. In contrast, the small adjustment in taxes affects a broader group of consumers including low-income, high-MPC households. Auclert (2018) analyzes the redistribution channel from monetary policy to consumer spending.

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. In addition, we show that incomplete markets can generate a positive local consumption multiplier, consistent with the empirical evidence. Nakamura and Steinsson (2014) employ a model with complete markets and rely on 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 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: 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. In contrast, 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 (2017), Bhandari, Evans, Golosov, and Sargent (2018), and Auclert, Rognlie, and Straub (2018) study demand shocks and fiscal policy with heterogeneity and incomplete markets. McKay, Nakamura, and Steinsson (2016) and Kaplan, Moll, and Violante (2018) 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. We show that in a model with multiple regions, the transmission mechanism of fiscal policy depends on relative price adjustments between regions and the strength of trade linkages, a point missed by models with a single region.

The rest of the paper is structured as follows. Section 2 describes our data. Section 3 describes our empirical specifications and documents the basic empirical patterns regarding the response of consumer spending to government spending. Section 4 sets up the model. Section 5 describes 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 retail purchases.[6] Moreover, we use data on household auto financing from the FRB NY Consumer Credit Panel/Equifax (hereafter, CCP). The Nielsen and CCP data are available at an individual/store level with detailed geographical information (zip code).

2.1 Consumer Spending

Our data from the Nielsen Retail Scanner are available for the period 2006-2014. 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 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).

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. 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.

In our main analysis, we only use data from the Nielsen Retail Scanner. In Appendix A, we show that Retail Scanner data correlate more closely with aggregate time series from the Bureau of Economic Analysis relative to HomeScan data.

Purchases in the Nielsen dataset 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. We find that around 53% of annual spending takes place in Grocery and Discount Stores. Hardware, Home Improvement, and Electronics Stores account for just 4% of annual

[6] 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/.

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

spending.

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-code level. 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.

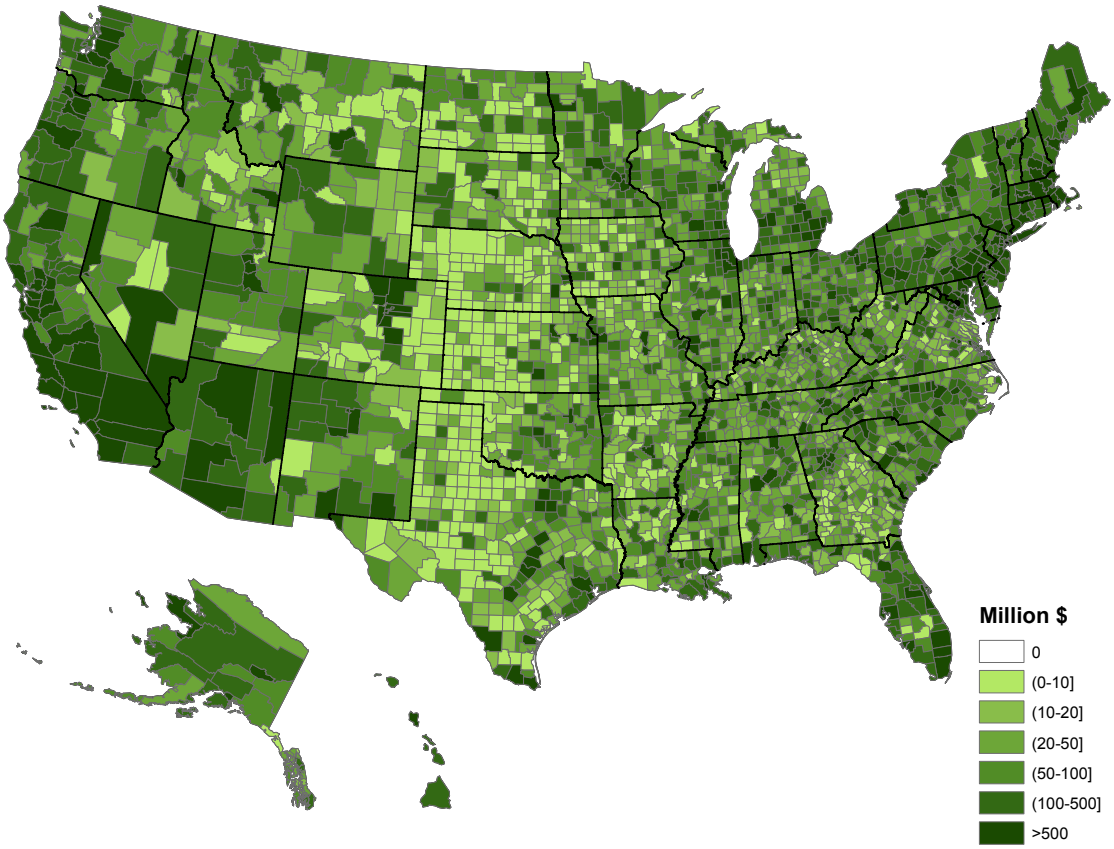
We use auto finance as a proxy for spending on vehicles. We consider auto finance by both banks and car dealerships. In particular, we consider individual i to have purchased a vehicle at time t if his/her auto balance increased between periods $t-1$ and t. The change in the auto balance is our proxy for spending in auto vehicles. We find that the total number of auto loans based on our measure closely track with the number of newly (first-time) registered passenger cars (see Appendix A). Table 1 provides a summary of our consumer spending data.

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, which awarded roughly $228 billion. This amount was spread across a number of different industries, with education being the largest and transportation, infrastructure, and energy also receiving large amounts.

Figure 1: Government Spending by U.S. Counties



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

To promote transparency, the Act provided detailed information about the awards, recipients, and selection criteria through the Recovery.gov website. First, for every award, the website contained detailed information including the total amount awarded, the total amount spent to date, the award date, and the name of the funding agency. Second, the website provided detailed geographical information (zip code) not only for the primary recipient but for all vendors, subcontractors, and other entities that received government funding from a particular award. Therefore, we assign money to localities 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 1 shows the geographical variation in cumulative spending across U.S. counties during the period 2009-2012.

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. Similarly, in our case, it is possible that the money allocated to local communities explicitly targeted areas that were hit the hardest by the recession. To address this endogeneity, we identify components of the Act that were allocated using criteria not strongly correlated with the local business cycle.

Each agency responsible for dispersing Recovery Act dollars provided explicit criteria by which funds would be allocated. We use these criteria to distinguish between awards that explicitly targeted local economic recovery and awards that did not. An example of a program that did not explicitly target local economic recovery is the money given through the Department of Education to children with disabilities. The criterion for the dispersion of this money across localities was the relative population of children with disabilities. Another example is money provided through the Federal Transit Administration for road improvement and maintenance. The criterion was the population density and passenger miles of the areas where these roads were located. Many awards that did not explicitly target local economic recovery relate to 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.

We construct our instrumental variable as the sum of all funds allocated based on criteria that we view as exogenous to the local business cycle.[7] 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.

Although the language used for the dispersion of funds included in our instrument did not explicitly target local economic recovery, it is possible that these awards were inadvertently allocated toward areas most affected by the recession. For example, even if water quality assistance grants were allocated based on environmental and not economic needs, they might have been implicitly directed toward low-income areas. To analyze if the Recovery Act spending correlates with local economic conditions we use the following county-level regression:

$$G_j = a + \beta \times X_j + D_j + \varepsilon_j \tag{1}$$

where G_j is the total money awarded per household in county j during the period 2009-2012. X_j denotes pre-Recovery Act, county-level economic characteristics. These include per-capita income in 2007 and 2008, unemployment rate in 2007 and 2008, change in per-capita income between 2007-2009, and change in unemployment between 2007-2009. D_j is a state fixed

[7] In Appendix B, we provide a detailed analysis of our methodology.

Table 2: Recovery Act Spending and Local Economic Characteristics

	Recovery Act Spending (2009-2012)			
	Total	Instrument	Total	Instrument
Per-capita county income 2007 (/100)	0.73***	0.13	0.66*	0.12
	(0.26)	(0.08)	(0.35)	(0.11)
Per-capita county income 2008 (/100)	0.82**	0.15	0.72	0.14
	(0.31)	(0.10)	(0.43)	(0.13)
Change in per-capita county income 2007-2009 (/100)	-1.52	-0.28	-1.82	-0.36
	(1.28)	(0.30)	(1.33)	(0.34)
County unemployment rate 2007 (p.p)	-48.8	-11.1	-62.6	1.3
	(31.4)	(10.4)	(39.2)	(10.8)
County unemployment rate 2008 (p.p.)	-68.4	-3.4	-97.8***	-7.6
	(35.1)	(8.3)	(33.1)	(8.7)
Change in county unemployment rate 2007-2009 (p.p.)	-151.2***	-25.9**	-279.2***	-41.8***
	(42.6)	(9.9)	(48.3)	(9.3)
State F.E.	No	No	Yes	Yes

Notes: Table shows results from the regression in Equation (1). "Total" is the total amount of government spending while "instrument" is the fraction of spending allocated based on our selected criteria. We weigh by county population and cluster standard errors at the state level. The standard errors are given in parentheses. One, two, and three stars denote significance at the 10%, 5%, and 1% levels, respectively.

effect. We run the regression separately for each local economic characteristic. We distinguish between total money authorized (denoted "Total") and the subset of money allocated using our exogenous selected criteria (denoted "Instrument"). Table 2 reports our estimates.

When we regress county-level government spending on county-level per-capita income in 2007 and 2008 we find a positive correlation and not a negative correlation as economic targeting would imply. There is some evidence of targeting when we look at the change in per-capita income between 2007-2009. In particular, counties with a $1 increase in per-capita income between 2007-2009 received between 1.5 to 1.8 cents less from the Recovery Act, depending on the specification. However, these estimates are not statistically significant.

Similarly, we find no evidence of economic targeting when we regress county-level government spending on county-level unemployment rate. Counties with higher unemployment in 2007 and 2008 received less funds. The same holds for changes in unemployment rate between 2007-2009. Counties with 1 percentage point higher unemployment rate between 2007-2009 received between $151 to $279 *less* from the Recovery Act, depending on the specification.

The group of spending included in our instrument is less correlated with per-capita income

and unemployment relative to total Recovery Act spending. Therefore, overall, our instrument helps us mitigate the correlation between the Recovery Act and local economic conditions. But the added value of the instrument is relatively small (especially with state fixed effects), which reflects the lack of correlation between the overall spending and local economic conditions. Our results are consistent with the analysis of Boone, Dube, and Kaplan (2014) who also find that there was not particular economic targeting in the Recovery Act.

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

We summarize consumption responses by constructing cumulative changes in spending between the period 2008-2012, which coincides with the Recovery Act period:

$$\Delta C_j = \sum_{t=2008}^{2012} \{C_{j,t} - C_{j,2008}\} \tag{2}$$

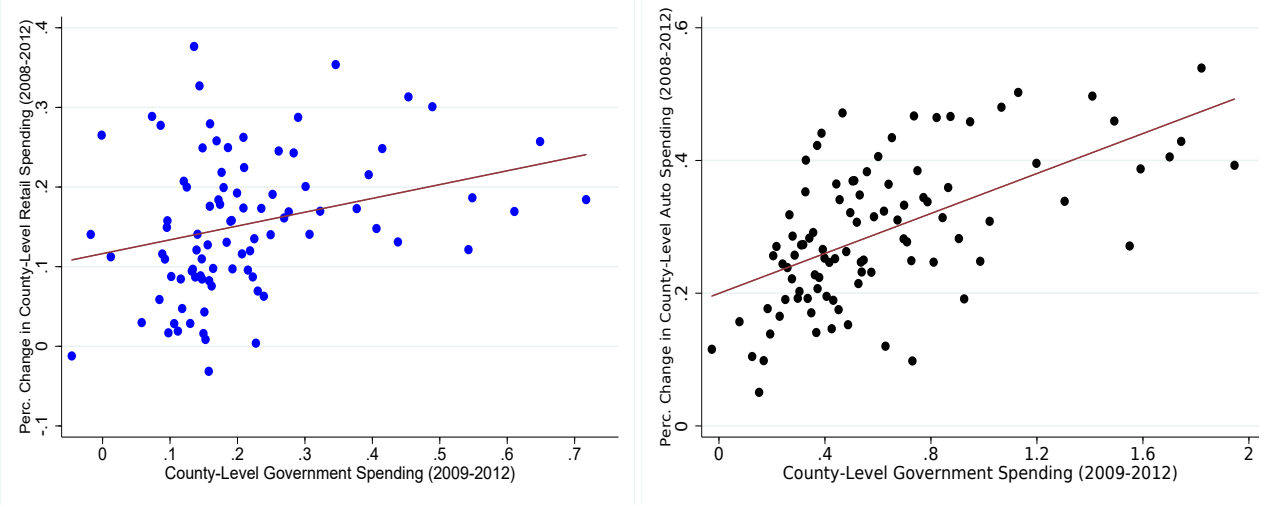
The left-hand side variable in our regression is the cumulative growth rate of consumer spending relative to 2008: $\frac{\Delta C_j}{C_{j,2008}}$. Our main explanatory variable is the total money awarded per household in county j during the period 2009-2012, denoted G_j. We estimate the number of households 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:

$$\frac{\Delta C_j}{C_{j,2008}} = a + \beta \times \frac{G_j}{C_{j,2008}} + X_j \;\; \Phi' + D_j + \varepsilon_j \tag{3}$$

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

Figure 2: 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).

X_j. These are the county's population, per-capita county income in 2007 and 2008, and county-level unemployment rate in 2007 and 2008. 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. Ramey (2018) highlights the importance of using population weights when using cross-regional variation.[8] We also cluster standard errors at the state level and winsorize the dependent and independent variable at the 1% level.

3.2 The Effect of the Recovery Act on Consumer Spending

We start by plotting simple scatters of our data. Figure 2 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.

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

In Table 3, we report estimates of our main regression (Equation 3) for retail consumer spending. We show results only for Retail Scanner data and include the estimates for Home-

[8]Unweighted auto spending estimates increase substantially relative to our weighted estimates since Equifax/CCP provides a wide geographical representation of the U.S. including many small counties. On the other hand, the unweighted retail spending estimates are similar to the weighted estimates (see Appendix C).

Table 3: Retail Spending Multipliers

Spending Category	Retail Consumer Spending (Nielsen, Retail Scanner)			
	OLS	IV	OLS	IV
Government Spending	0.19***	0.23***	0.11***	0.11**
	(0.05)	(0.07)	(0.03)	(0.04)
Partial F stat.	—	139.7	—	116.2
County Controls/State F.E.	No	No	Yes	Yes
# Counties	365	365	365	365

Notes: The table shows the estimates of the regression of the growth rate in retail 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.

Scan data in Appendix C. We 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. Using the specification that includes county controls/state fixed effects and the IV, we estimate a retail spending multiplier equal to 0.11. It is possible that other government programs or federal grants were positively correlated with ARRA spending at the state level. As a result, when we do not include county controls/state fixed effects, the OLS and IV estimates are higher. Therefore, the specification that includes county controls/state fixed effects and also uses the IV is our preferred specification.

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 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. Table 4 shows a summary of goods included in the bundles.

Table 4: Nielsen and CEX

Bundle	Spending	×Nielsen	Elasticity	Multiplier
Nielsen	food at home, alcohol and beverage, detergents, cleaning/hh products, small appliances, and personal care products	1.0	–	0.11
CEX narrow	Nielsen + apparel, tobacco, and reading	2.1	0.88	0.20
CEX broad	CEX narrow + food away from home, spending on entertainment, telephone services, transportation	6.3	0.56	0.38

Notes: Bundles of goods are constructed from the Consumption Expenditure Survey (CEX) for the period 2000-2015. We report the size of each bundle compared to Nielsen-type spending as well as the elasticity estimated from regression (4). The Nielsen multiplier is translated into a non-durable multiplier by multiplying the coefficient times the share times the elasticity.

The next step is to estimate the elasticity of non-durable spending to Nielsen-type spending. We estimate the following household-level regression using CEX data between 2000-2015:

$$\log C_{i,t}^{\text{non-durable}} = a + \psi \times \log C_{i,t}^{\text{Nielsen}} + X_{i,t} \;\; \Phi' + \varepsilon_{i,t} \tag{4}$$

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 is associated with a 0.88% increase in non-durable consumer spending. When we use our broader category, we find that a 1% increase in Nielsen-type categories is associated with a 0.56% increase in non-durable consumer spending. Hence, to translate our Nielsen estimates into a non-durable multiplier, we should increase our coefficient somewhere between 88% × 2.1 and 56% × 6.3. Combined with our preferred estimate from Table 3 gives a local non-durable consumption multiplier between 0.20 and 0.38.

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

We estimate a positive response of fiscal stimulus to auto spending (Table 5).[9] In our preferred specification, which includes county controls/state fixed effects and uses the IV, we

[9]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.

estimate a multiplier equal to 0.09. Once more, the IV estimate is slightly 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.

Table 5: Auto Spending Multipliers

Spending Category	Auto Spending (CCP/Equifax)			
	OLS	IV	OLS	IV
Government Spending	0.07***	0.11***	0.06***	0.09***
	(0.01)	(0.01)	(0.01)	(0.01)
Partial F stat.	—	248.5	—	187.9
County Controls/ State Fixed Effects	No	No	Yes	Yes
# Counties	3,119	3,119	3,047	3,047

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.

3.2.3 Summing the Consumption Spending Categories

We found a local retail spending multiplier from Nielsen Retail Scanner equal to 0.11 (Table 3). Using CEX data, we translated this estimate into a broader local non-durable multiplier between 0.20 and 0.38 (Table 4). Finally, we found a local auto spending multiplier from Equifax equal to 0.09 (Table 5). Choosing the narrower CEX bundle that corresponds to a multiplier of 0.20 and adding the local auto multiplier of 0.09, we arrive at an estimate of the local consumption multiplier equal to 0.29.

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 $N = 2$ regions. Each region i has its own wage w_i and inflation rate π_i. 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.[10]

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 region. 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. Households in both regions face the same nominal interest rate R (currency union).

Population of region i is denoted μ_i with $\sum_i \mu_i = 1$. Household-level variables are denoted with a small letter. Per-capita regional variables are denoted with capital letters. Aggregate variables are per-capita variables times the population rate. For example, consumption of a household in region i is c_i, per-capita consumption in region i is C_i, and aggregate consumption in region i is $\mu_i C_i$.

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

$$U = \mathbf{E}_0 \left[\sum_{t=0}^{\infty} \beta^{t-1} \left\{ \frac{c_{i,t}^{1-\sigma}}{1-\sigma} + \psi \frac{(1-h_{i,t})^{1-\theta}}{1-\theta} \right\} \right] \tag{5}$$

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. Their effective labor supply is xh where x is an idiosyncratic shock that follows an AR(1) process in logs:

$$\log x_{t+1} = \rho \log x_t + \eta_{t+1}, \qquad \text{with} \quad \eta_{t+1} \sim \text{ iid } N(0, \sigma_\eta^2). \tag{6}$$

[10] House, Proebsting, and Tesar (2017) explore fiscal policy in a multi-country DSGE setup with explicit trade linkages. In their model, each country has a representative household.

Therefore, households are heterogeneous because they receive in every period different shocks to their productivity. The differences in their labor earnings result in differences in consumption and asset holdings. 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, a household with productivity x gets $\delta(x)$ 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 $T(.)$.

Households can insure against idiosyncratic shocks using a nominal bond, which 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.

$$V_t(x_t, b_t; \phi_{i,t}) = \max_{c_t, b_{t+1}, h_t} \left\{ \frac{c_t^{1-\sigma}}{1-\sigma} + \psi \frac{(1-h_t)^{1-\theta}}{1-\theta} + \beta \sum_{x_{t+1}} \Gamma_{x_t, x_{t+1}} V_{t+1}(x_{t+1}, b_{t+1}; \phi_{i,t+1}) \right\} \quad (7)$$

$$\textbf{s.t.} \quad c_t + (1 + \pi_{i,t+1}) b_{t+1} = w_{i,t} x_t h_t - T(w_{i,t} x_t h_t) + (1 + R_{t-1} + \kappa \mathbf{I}_{[b_t < 0]}) b_t + \delta(x) D_{i,t} \quad (8)$$

$$b_{t+1} \geq \underline{b} \quad (9)$$

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

$$\pi_{i,t+1} = \frac{P_{i,t+1}}{P_{i,t}} - 1 \quad (10)$$

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 $\omega_{i,i',j}$. It is purchased at price $p_{i',j}$. The production technology is

$$Y_i = \left[\sum_{i'=1}^{N} \gamma_{ii'}^{\frac{1}{\epsilon}} \int_j \omega_{i,i',j}^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \tag{11}$$

Parameter $\gamma_{ii'}$ denotes the preference of firm i for inputs from region i'. We assume that $\sum_{i'} \gamma_{ii'} = 1$. Home bias for Region 1 is given by $\gamma_{11} = \alpha$ so that $\gamma_{12} = 1 - \alpha$. If Region 1 imports $1 - \alpha$, then Region 2 imports $\gamma_{21} = \frac{\mu_1}{\mu_2} \times (1 - \alpha)$ and home bias for Region 2 is $\gamma_{22} = 1 - \frac{\mu_1}{\mu_2}(1 - \alpha)$. The parameter ϵ captures the substitutability between intermediate inputs. Demand of final good firm i for input j located at i' is:

$$\omega_{i,i',j} = \gamma_{ii'} \left[\frac{p_{i',j}}{P_i} \right]^{-\epsilon} Y_i \tag{12}$$

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

$$P_i = \left[\sum_{i'=1}^{N} \gamma_{ii'} \int_j p_{i',j}^{1-\epsilon} dj \right]^{\frac{1}{1-\epsilon}} \tag{13}$$

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

$$y_{i,j} = L_{i,j} \tag{14}$$

where $L_{i,j}$ is labor demanded by firm j in region i. The intermediate good firm faces demand both from the local and the foreign final good firm. As mentioned, firm j located in region i' faces demand by final good firm i equal to $\omega_{i,i',j}$. The aggregate demand for region i intermediate good firm j will be

$$y_{i,j} = \sum_{i'} \mu_{i'} \omega_{i',i,j} \tag{15}$$

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:

$$\max_{p^*_{i,j,t}} \sum_{s=0}^{\infty} ((1-\lambda)\beta)^s \left\{ p^*_{i,j,t+s} y_{i,j,t+s} - W_{i,t+s} L_{i,j,t+s} \right\} \tag{16}$$

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

$$\frac{p^*_{i,j,t}}{P_{i,t}} = \frac{\epsilon}{\epsilon - 1} \frac{\sum_{i'=1}^{N} \mu_{i'} \gamma_{i'i} Q^{\epsilon}_{i',i,t} \left[w_{i,t} Y_{i',t} + (1-\lambda)\beta(1+\pi_{i',t+1})^{1+\epsilon} \mathcal{X}_{i',i,t+1} \right]}{\sum_{i'=1}^{N} \mu_{i'} \gamma_{i'i} Q^{\epsilon}_{i',i,t} \left[Y_{i',t} + (1-\lambda)\beta(1+\pi_{i',t+1})^{\epsilon} \mathcal{Z}_{i',t+1} \right]} \tag{17}$$

with

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

$$\mathcal{Z}_{i',i,t} = Y_{i',t} \;\; + \;\; (1-\lambda)\beta(1+\pi_{i',t+1})^{\varepsilon} \mathcal{Z}_{i',i,t+1} \tag{19}$$

Finally, the real profits for intermediate firm j in region i are

$$d_{i,j,t} = \frac{p_{i,j,t}}{P_{i,t}} * y_{i,j,t} - w_{i,t} * y_{i,j,t} \tag{20}$$

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

4.4 Monetary Authority

Regions are part of 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,

$$R_t = R_{ss} + \zeta \hat{\pi}_t \tag{21}$$

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. Per-capita government spending in region i 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 $(1+R_{t-1})b_t$ if $b_t > 0$ and charges $(1+R_{t-1}+\kappa)b_t$ if

$b_t < 0$.[11] The government budget constraint reads:

$$\sum_i \mu_i(1+\pi_{i,t+1}) \int_{\phi_{i,t}} b_{t+1} - \sum_i \mu_i[(1+R_{t-1}) \int_{\phi_{i,t}} b_t + \int_{\phi_{i,t}} \kappa b_t \mathcal{I}_{b_t<0}] = \sum_i \mu_i G_{i,t} - \sum_i \mu_i \int_{\phi_{i,t}} T(w_{i,t} x_t h_t) \tag{22}$$

4.6 Regional Accounts

We describe the regional income accounts abstracting from time subscript t. Regional income is equal to the total value added by all intermediate firms in that region: $\mu_i \mathcal{Y}_i = \int_j \sum_{i'} \mu_{i'} \omega_{i',i,j} dj$. Per-capita income for every region i is equal to $\mathcal{Y}_i = w_i L_i + D_i$. Per-capita final good Y_i is equal to per-capita consumption C_i plus per-capita government spending 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

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

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

$$\int_j y_{i,j,t} = \mu_i \mathcal{Y}_{i,t} = \sum_{i'} \mu_{i'} \gamma_{i'i} \left[\frac{\int_j p_{i,j,t}}{P_{i',t}} \right]^{-\epsilon} Y_{i',t} \tag{23}$$

$$= \left[\lambda \left(\frac{p^*_{i,j,t}}{P_{i,t}} \right)^{-\epsilon} + (1-\lambda)(1+\pi_{i,t})^{\epsilon} \right] \cdot \sum_{i'} \mu_{i'} \gamma_{i'i} Q^{\epsilon}_{i',i,t} Y_{i',t} \tag{24}$$

Since trade linkages are a function of home bias in Region 1 (denoted α) we can derive the following expressions for per-capita income:

$$\mathcal{Y}_{1,t} = \left[\lambda \left(\frac{p^*_{1,j,t}}{P_{1,t}} \right)^{-\epsilon} + (1-\lambda)(1+\pi_{1,t})^{\epsilon} \right] \left[\alpha Y_{1,t} + (1-\alpha) Q^{\epsilon}_{2,1,t} Y_{2,t} \right]$$

$$\mathcal{Y}_{2,t} = \left[\lambda \left(\frac{p^*_{2,j,t}}{P_{2,t}} \right)^{-\epsilon} + (1-\lambda)(1+\pi_{2,t})^{\epsilon} \right] \left[\frac{\mu_1}{\mu_2}(1-\alpha) Q^{\epsilon}_{1,2,t} Y_{1,t} + (1 - \frac{\mu_1}{\mu_2}(1-\alpha)) Y_{2,t} \right]$$

The above expressions are the key equations linking the trade flows between regions. Per-

[11] The government in our model is involved in lending activities usually conducted by the banking sector. We assign this additional role to the government to avoid further complicating the model.

capita income in 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 strength of trade linkages α, the relative populations μ_i, and the relative price of final good $Q^{\epsilon}_{i',i,t}$.

4.8 Equilibrium

We describe the equilibrium over the transition and then briefly discuss the steady-state equilibrium. For an exogenous sequence of regional government spending $\{G_{i,t}\}_{i=1}^2$, the equilibrium over the transition is a time sequence of equilibrium variables. In particular, we are looking to solve for $\{C_{i,t}\}_{i=1}^2$, $\{L_{i,t}\}_{i=1}^2$, $\{Y_{i,t}\}_{i=1}^2$, $\{\mathcal{Y}_{i,t}\}_{i=1}^2$, $\{w_{i,t}\}_{i=1}^2$, $\{\pi_{i,t}\}_{i=1}^2$, $\{\frac{p^*_{i,j,t}}{P_{i,t}}\}_{i=1}^2$, $Q_{12,t}$, $\{D_{i,t}\}_{i=1}^2$, R_t, $\hat{\pi}_t$, τ_t, and $\{\phi_{i,t}\}_{i=1}^2$, for $t = \{t_0, \infty\}$ where t_0 is the time of the policy change. The only restriction is that at a sufficiently long time after the fiscal stimulus is over, relative prices are equal to their steady-state value, e.g., $Q_{12,t^*} = 1$, for t^* sufficiently large.

1) Goods Market Equilibrium: The demand for goods by households in region i, $C_{i,t}$, is derived by the household's problem and together with local government spending $G_{i,t}$, give the total demand for final good i: $Y_{i,t} = C_{i,t} + G_{i,t} \quad \forall i$. The inflation rates that clear the goods market $\{\pi_{i,t}\}_{i=1}^2$ are derived using the following equations:

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

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

2) Regional income in region i, $\mu_i\mathcal{Y}_{i,t}$, is a weighted sum of regional final goods:

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

3) Labor Market Equilibrium: The labor supply satisfies the household's problem and the aggregate labor supply in region i is $\mu_i \int_{\phi_{i,t}} x_t h_t$. Since we have a linear technology, the aggregate labor demand $\mu_i L_{i,t}$ equals aggregate income $\mu_i\mathcal{Y}_{i,t}$. Therefore, the wage rate $w_{i,t}$ that clears the labor market in region i is found using the following labor market condition:

$$\mu_i L_{i,t} = \mu_i \int_{\phi_{i,t}} x_t h_t.$$

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

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

5) Dividends are given by:

$$D_{i,t} = \left[\lambda\left(\frac{p^*_{i,j,t}}{P_{i,t}}\right)^{1-\epsilon} + (1-\lambda)(1+\pi_{i,t})^{\epsilon-1}\right] \cdot \sum_{i'} \mu_{i'}\gamma_{i'i}Q^{\epsilon}_{i',i,t}Y_{i',t} - w_{i,t}L_{i,t} \;\; \forall i.$$

6) The tax rate τ is found by balancing the government budget constraint:

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

7) Interest rate is given by a standard Taylor rule: $R_t = R_{ss} + \zeta\hat{\pi}_t$.
8) National inflation rate is given by: $\hat{\pi}_t = \sum_{i=1}^{2} \mu_i \pi_{i,t}$.
9) The regional measures $\phi_{i,t}$ evolve based on the policy functions and the transition matrices described in the model.

If all the above conditions hold, then the bond market automatically clears $\bar{B} = \sum \mu_i B_{i,t+1} = \sum_i \mu_i \int_{\phi_{i,t}} b_{t+1}$. For the steady-state equilibrium we assume inflation is zero and prices are symmetric within and across regions: $\frac{p_{i,j}}{P_i} = 1 \, \forall i$ and $Q_{ii'} = 1 \, \forall i, i'$. We provide a detailed description of the steady-state equilibrium in Appendix D.

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: temporary regional government spending shocks.

5.1 Calibration

Table 6 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 disutility of labor ψ is set so that on average households work 42% of their time endowment.[12] Parameter $1/\theta$, which governs the Frisch elasticity of labor supply, is set to 0.5 based on Chetty (2012). Finally, we set $\sigma = 1$. The productivity process is calibrated based on the estimates of Floden

[12] In the Panel Study of Income Dynamics prime-age, full-time employed males work around 2,200 hours per year. We normalize this value by a time endowment of 5,200 hours per year.

Table 6: Benchmark Parameters

Parameter	Notation	Value	Target / Source
Risk aversion	σ	1	–
Discount factor	β	0.985	Annual nominal rate=2%
Labor supply elasticity	$1/\theta$	0.5	Chetty (2012)
Disutility of labor	ψ	5.8	Hours worked=42%
Persistence of x	ρ	0.955	Floden and Linde (2001)
Variance of innovation to x	σ_η^2	1.5%	Floden and Linde (2001)
Per-capita gov. spending	G	0.10	G/Y=20%
Dividend allocation	$\delta(x)$	See text	c_{75}/c_{25} and c_{90}/c_{10}
Elasticity of substitution	ϵ	4	Christiano, Eichenbaum, and Rebelo (2011)
Price reset probability	λ	0.15	McKay, Nakamura, and Steinsson (2016)
Taylor rule coefficient	ζ	0.0	–
Stock of liquid assets	$\bar{B}$	1.2× Annual income	Survey of Consumer Finances
Credit spread	κ	0.01	%Households with $b/y < 1\%$
Borrowing limit	$\underline{b}$	0.25× Quarterly labor income	Kaplan, Moll, and Violante (2018)
Size of Region 1	μ_1	9.71%	County/state population
Home bias	α	0.61	Commodity Flow Survey

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 steady-state government spending G to match a government spending to income ratio equal to 20%. We set the elasticity of substitution $\epsilon = 4$ based on Christiano, Eichenbaum, and Rebelo (2011). The probability of changing price $\lambda = 0.15$ is based on McKay, Nakamura, and Steinsson (2016).

Since after 2008 the short-term nominal rates were nearly zero, we set $\zeta = 0$. This case captures the effect of government spending in an environment where the monetary authority is unresponsive.[13] We evaluate the role of a responsive monetary policy by considering different values for the Taylor rule coefficient ζ in Section 6.4.

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

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

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 whose liquid assets are less than 1% of their annual income and we follow Kaplan, Moll, and Violante (2018) to 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. We use the broad definition of non-durable consumer spending, described in Section 3.2. We find that $c_{75}/c_{25} = 3.8$ and $c_{90}/c_{10} = 6.5$. We then normalize $\delta(x)$ so that $\sum_x \int_b \phi(b,x)\delta(x) = 1$. Our parametrization implies that households with the highest productivity acquire seven times more dividends than the average household.

5.1.1 Regional Parameters

Our empirical targets are based on a specification that uses county-level variation within states. To be consistent with our empirical exercise, we think of the economy as a representative U.S. state, Region 1 as a county (with size μ_1), and Region 2 as the rest of the state (size $\mu_2 = 1 - \mu_1$). The average county-to-state population is very small, around 1%. But when weighted by county-level income (in 2010), the average county-to-state population increases to 9.7%. In the model, we think of our regions more as zones of economic activity rather than strict geographical areas. As a result, we set $\mu_1 = 9.7\%$.

The next parameter to calibrate is the preference of the final good firm for home versus foreign inputs. We calibrate home bias using direct evidence from shipments of goods from the Commodity Flow Survey (CFS) for 2012. The data include information on commodities shipped, their value, weight, and the origin and destination of the shipments across Metropolitan Areas (MAs) and U.S. states. We define as home bias the fraction of shipments that stay in the metro area relative to total shipments in the state. We find an average metro area home bias equal to 0.66.

To calibrate a county-level home bias, we use the metro area home bias and the relative populations of these two geographical areas. Let M denote the size of the metro area that

includes the county ($\mu \leq M$). Let $\mathcal{S}$ denote the home bias of the metro, which we found to be 0.66 and is at least as large as the home bias of the county (denoted as α), so that $\alpha \leq \mathcal{S}$. If demand increases by \$1 in a random county that is part of the metro, then the county keeps α and exports $1-\alpha$. The exports will be absorbed by the other counties of the same metro area with probability $\frac{\mu}{1-\mu}\frac{\mathcal{M}-\mu}{\mu}$. The first term $\frac{\mu}{1-\mu}$ is the probability a random county anywhere in the state absorbs the exports while $\frac{\mathcal{M}-\mu}{\mu}$ is the relative size of the metro area, excluding the original county that received the dollar. As a result, we can write the metro area home bias using the formula

$$\mathcal{S} = \alpha + (1-\alpha) * \frac{\mu}{1-\mu}\frac{\mathcal{M}-\mu}{\mu}.$$

We compute the size of the average metro area using the average MA-to-state population weighted by MA-level income in 2010. We find $\mathcal{M} = 20\%$. This implies a county-level home bias equal to $\alpha = 0.61$.

In our calibration of home bias we didn't take into account the service sector because most of ARRA awards were used to purchase physical goods (maintaining infrastructure, weatherizing buildings, etc). We externally validate our estimate by looking at the fraction of ARRA spending allocated to out-of-county contractors versus in-county contractors. We find that on average 69% of money spent in a county was allocated to in-county contractors. This number is close to our CFS estimate that used shipments of physical goods.

5.2 Steady-State Results

In Table 7 we compare the model to data regarding the liquid asset distribution. We also report the median and the average marginal propensity to consume. Our model is calibrated to capture the average liquid asset-to-income ratio as well as the fraction of households with asset-to-income ratio less than 1%. 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 0.76 in our model, lower than the empirical value of 0.93 but considerably higher than typical Aiyagari models. The reason we are able to do so is that we include an unequal distribution of dividends that is correlated with productivity.

Table 7 also reports the median and the average marginal propensity to consume. The annual average MPC in our model is 0.28, which corresponds to a quarterly MPC of 0.08. This is within the range of the empirical evidence. There has been ample recent evidence on the magnitude of consumption responses to unexpected income transfers. Most studies find annual estimates of MPC between 0.2-0.6 (Carroll, Slacalek, Tokuoka, and White, 2017). Sahm, Shapiro, and Slemrod (2010) analyze survey responses and find that roughly one-third of the

Table 7: Statistics over Liquid Assets and MPC

Statistic	SCF (1998-2007)	Model
Households with $b/y < 1\%$	28.5%	28.8%
Liquid Assets/Income		
Mean	1.20	1.20
25th percent.	0.01%	-3.25%
50th percent.	0.04	0.53
75th percent.	0.32	2.84
90th percent.	1.68	7.70
99th percent.	18.8	21.8
Liquid Assets Gini	0.93	0.76
Median MPC		0.13
Average MPC		0.28

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 $1 - (1 - \text{quarterly MPC})^4$.

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. Similar to the evidence provided by Jappelli and Pistaferri (2014), in our model, households with the lowest asset holdings or negative net worth feature the highest MPCs.

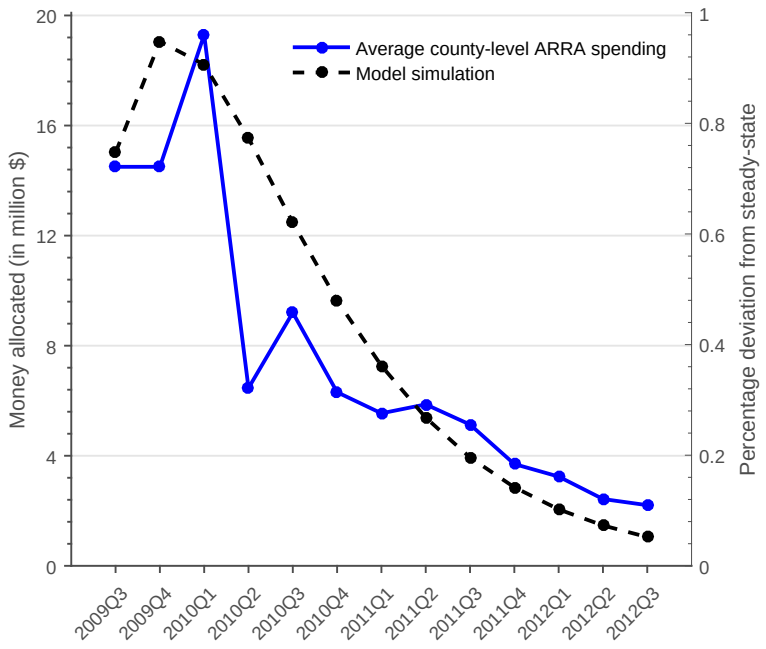
5.3 Government Spending Shock and Transition

We analyze the effect of a government spending shock on consumer spending. Figure 3 shows average county-level Recovery Act spending between 2009-2012.[14] We approximate the process using an AR(2) for the government spending shock: $G_t = (1 - \rho_1 - \rho_2)G_{ss} + \rho_1 G_{t-1} + \rho_2 G_{t-2}$. Parameters ρ_1, ρ_2 are chosen to match the county-level spending in the data. We pick the impact shock in Region 1 so that the peak of the simulated path is 1% higher than the

[14]We do not have data for projects in 2009 so we use numbers from Uhlig (2010). However, this does not affect our calculations since these projects show up in cumulative spending of the following years, provided they did not finish before the first quarter of 2010.

steady state. We calibrate the shock for Region 2 to be 36% lower than the shock in Region 1 since per-capita spending at the 25th percentile of the distribution of ARRA funds was around 36% lower than at the 75th percentile. The shock is assumed to be a one-time unexpected innovation and households can perfectly foresee the future evolution of prices and quantities.

Figure 3: Recovery Act Spending: Data vs. Model



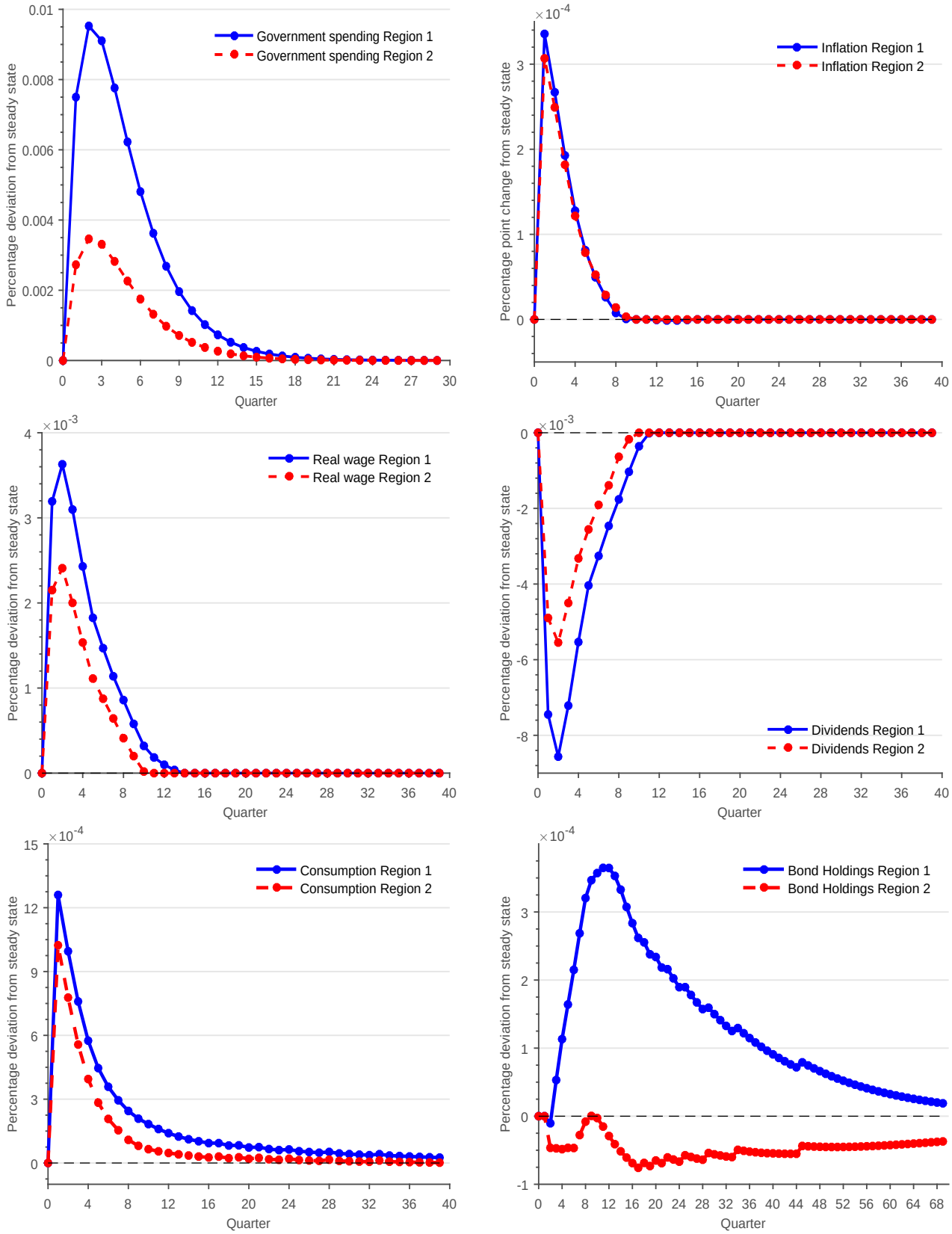
Notes: Average county-level Recovery Act spending (in millions of dollars), by quarter (left axis). Model simulation of government spending shock for Region 1 (right axis).

We plot the impulse response functions for macroeconomic aggregates in Figure 4. All quantities are expressed in per-capita terms. The increase in government spending G_1 increases the demand for final good Y_1. As a result, local inflation π_1 increases (upper right panel). To accommodate the extra demand, intermediate good firms in Region 1 demand more labor, which increases the local real wage w_1 (middle left panel). The percentage increase in labor income turns out to be higher than the percentage increase in total income so that dividends decrease (middle right panel).

Per-capita government spending in Region 2 is less than per-capita government spending in Region 1. However, 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 in both regions respond almost equally.[15] Wages w_2 also increase in Region 2, both due to the local fiscal

[15]The nearly perfect comovement of inflation in two regions is also related to the relatively high degree of price stickiness. We discuss the empirical validity of our calibration in Section 5.3.1.

Figure 4: Impulse Responses to a Government Spending Shock



Notes: Impulse response functions for a temporary government spending shock. All units are in per-capita terms and are expressed as percentage deviations from their steady state. For the inflation rate we report the deviation from the steady state in levels.

stimulus and the increased demand for local inputs coming from Region 1.

Higher inflation in Region 1 relative to Region 2 implies an initial small 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. This tends to make the comovement of economic aggregates between the regions even higher. Moreover, federal taxes adjust to keep the budget balanced. However, due to higher inflation, which decreases some of the government's debt service cost, the need to adjust 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).

Table 8: Consumption Multipliers: Data vs. Model

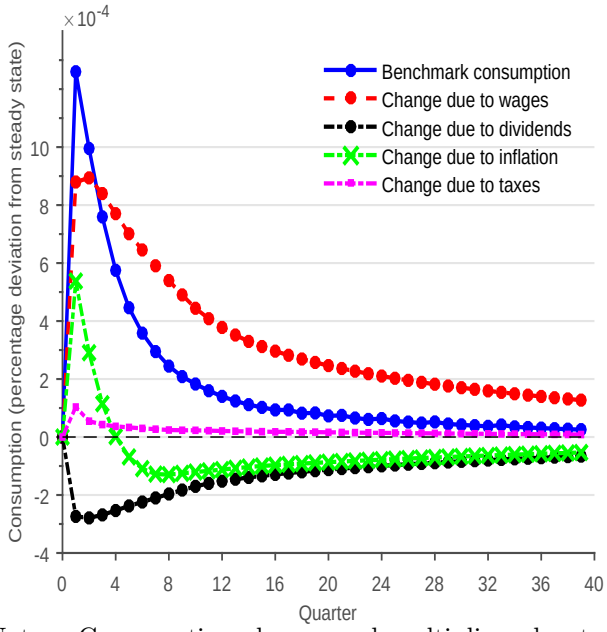
Horizon	$t = 8$	$t = 16$	$t = 32$
Data			
Local	–	0.29	–
Model			
Local	0.16	0.23	0.29
Aggregate	0.64	0.64	0.68

Notes: Data estimates use our combined findings from Table 3, Table 4, and Table 5. The empirical target of 0.29 is derived by adding the adjusted Nielsen multiplier of 0.20 (using narrow CEX bundle) with the auto spending multiplier of 0.09.

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 3). The aggregate multiplier is computed as $\frac{\sum_i \mu_i \Delta C_{i,t}}{\sum_i \mu_i \Delta G_{i,t}}$, where $\Delta C_{i,t}$ and $\Delta G_{i,t}$ denote the cumulative change of consumption and government spending, respectively, in region i and in year t, relative to the steady state.

Table 8 presents our main two findings. First, the model successfully generates a positive local multiplier very close to the empirical target. Second, we find an aggregate fiscal multiplier

Table 9: Change in Consumption: Decomposition



Consumption Multiplier	Local	Aggregate
Due to Wages	0.36	0.89
Due to Dividends	-0.13	-0.31
Due to Inflation	-0.006	-0.04
Due to Taxes	0.00	0.08
Total	0.23	0.64

Notes: Consumption change and multipliers due to wage, dividends, inflation, and taxes. Each case sets a variable to its equilibrium path and all others to their steady state value. The table reports four-year consumption multipliers. Equilibrium paths are shown only for Region 1.

equal to 0.64.

Table 9 decomposes the change in consumer spending due to 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. The figure in Table 9 plots the consumer spending path for every case as well as when all effects are considered (Benchmark). The table reports the four-year consumption multiplier in each case as well as the total effect. The total effect does not necessarily equal the sum of the individual effects due to interactions effects. We consider only Region 1, but the effects for Region 2 are qualitatively similar.

As mentioned, wages increase along the transition path as a response to higher demand for labor. Higher labor income affects mainly low wealth, labor-income-dependent households who have high MPC and increase substantially their spending. If only wages had changed, the local multiplier would be 0.36 while the aggregate would be 0.89. On the other hand, the decrease in dividends hurts mainly low-MPC households who are less responsive. If only dividends had changed, the local multiplier would be -0.13 while the aggregate would be -0.31. The combined effect of the two yields an aggregate multiplier of 0.58.

If only inflation had changed, the local multiplier would be -0.006 and the aggregate

multiplier -0.04. The contribution of inflation to consumer spending is quantitatively small relative to the contribution of wages.[16]

If only tax rates had changed, the local multiplier would be zero since taxes occur at the federal level. The aggregate multiplier is equal to 0.08. 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.

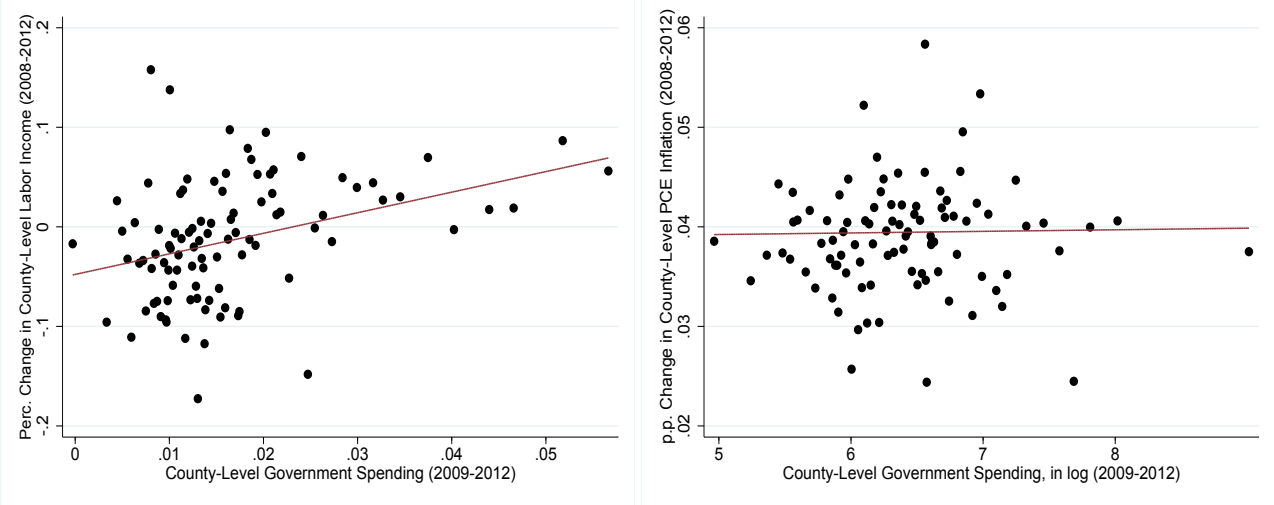
Our model generates positive consumption responses both at the local and the aggregate level. The key necessary element to generate a positive *local* consumption multiplier is incomplete markets. With complete markets, any change in regional income is offset by transfers due to state-contingent claims. As a result, differences in regional consumer spending are pinned down only by differences in regional prices. And since regions with larger fiscal stimulus injections also experience higher inflation, the local consumption multiplier is negative (see for example, Nakamura and Steinsson (2014), Farhi and Werning (2016), and Chodorow-Reich (2018)).

Heterogeneity is not a necessary ingredient to generate a positive local or aggregate consumption response. In Section 6.1 we show that an incomplete markets, representative agent, New Keynesian model can also generate positive local and aggregate multipliers, albeit much smaller than our Benchmark. Therefore, heterogeneity is not necessary to generate a positive consumption response but it is crucial to generate substantial consumption responses consistent with the data. The main mechanism underlying the larger consumption responses in our Benchmark, is the substantial response of high-MPC, labor-income-dependent households who experience increase in their labor earnings.

In Section 6.4, we show that the necessary element for a positive *aggregate* consumption multiplier is the weak response of monetary policy to fiscal stimulus. In our model, the monetary authority does not adjust the nominal rate in response to inflationary pressures. The subsequent decrease in the real interest rate induces consumers to save less and also decreases the government's debt service cost. As a result, the government can balance its budget with a relatively small change in taxes. This redistribution of resources from the private to the public sector hurts net savers, namely wealthy, low-MPC households. In contrast, the small adjustment in taxes affects a broader group of consumers including low-income, high-MPC households. Therefore, for a positive aggregate consumption response, it is necessary that the monetary authority does not respond aggressively to the fiscal stimulus. However, the weak monetary response is not the only element generating high aggregate consumption multipliers.

[16] 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 (2018). However, we show in Section 6.3 that the inflation channel can be an important determinant of the consumption response depending on the strength of trade linkages and the size of the regions.

Figure 5: 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.

As we show, without heterogeneity the consumption response is still positive but relatively modest.

5.3.1 Empirical Evidence on Labor Income and Inflation

The model predicts a strong positive local effect of government spending on labor income and a 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 labor income 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).

The Recovery Act had a positive effect on county-level labor income (left panel, Figure 5 and Table 10). In contrast, there is no effect of government spending on inflation (Right Panel, Figure 5 and Table 10). Our model is consistent with these patterns. The local effect of government spending on inflation is nearly zero as both regions increase inflation by the same amount (Figure 4). This result arises due to our relatively high degree of price stickiness. Moreover, the local multiplier associated with labor income is positive, consistent with the empirical evidence.

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	1.33***	0.81*	-0.000	-0.0002
	(0.34)	(0.41)	(0.001)	(0.002)
Partial F stat.	—	272.7	—	166.5
County Controls/ State Fixed Effects	Yes	Yes	Yes	Yes
# Counties	2,916	2,852	1,116	1,111

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.

6 Inspecting the Mechanism

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 within-region heterogeneity. This is equivalent to a representative agent, New Keynesian (RA-NK) model with two regions. Second, we analyze how trade flows affect the consumption responses. Third, we analyze an economy with a single, representative region. Finally, we examine the case where the monetary authority can respond to inflation.

6.1 Heterogeneous Agents New Keynesian vs. Representative Agent New Keynesian Model

Our benchmark model combines a regional framework with a heterogeneous agents model. A natural question is what would the local and aggregate multiplier be without 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 $\phi_i(x_t, b_t)$ is degenerate. We call this economy a representative agent, New Keynesian model (RA-NK). Note however that regions are still different across the transition because they receive different amounts of 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:

$$V_{i,t}(b_t) = \max_{c_t, b_{t+1}, h_t} \left\{ \frac{c_t^{1-\sigma}}{1-\sigma} + \psi \frac{(1-h_t)^{1-\theta}}{1-\theta} + \beta V_{i,t+1}(b_{t+1}) \right\} \tag{25}$$

$$\textbf{s.t.} \quad c_t + (1+\pi_{i,t+1})b' = w_{i,t}h_t - T(w_{i,t}h_t) + (1+R_{t-1}+\chi)b_t + D_{i,t} \tag{26}$$

$$b_{t+1} \geq \underline{b} \tag{27}$$

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. A negative Δ means that the savings interest rate is lower when agents save more than the steady-state bond holdings and vice versa.[17] Moreover, the assumption of a borrowing constraint is irrelevant as the representative household never holds a negative net worth. Table 11 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 0.05 while in our benchmark economy it is 0.28.

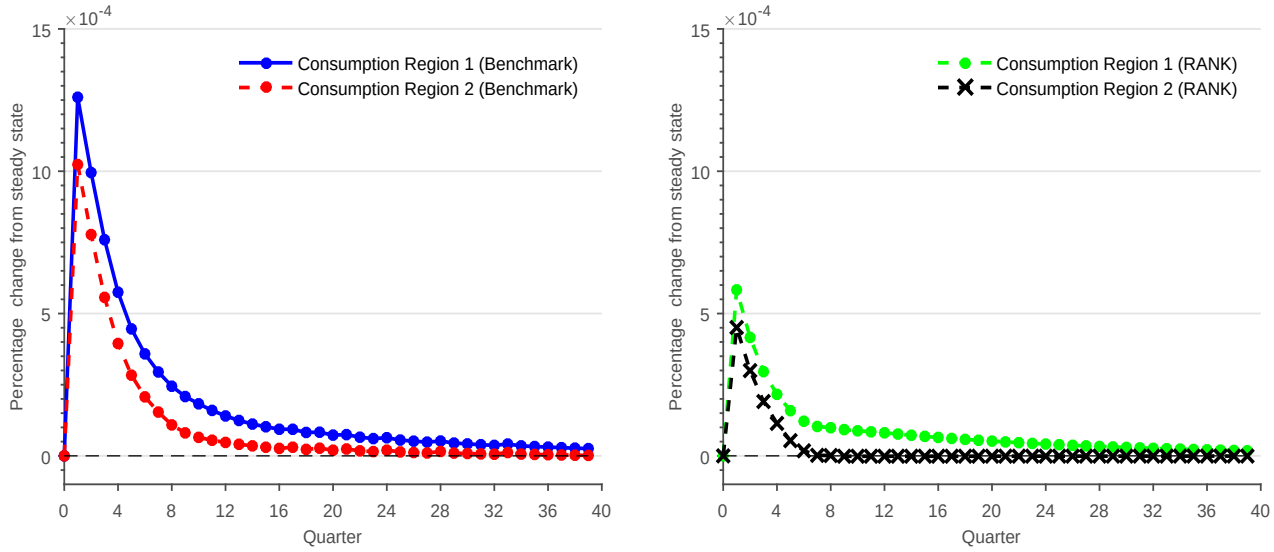
Table 11: Steady State: Benchmark vs. RA-NK

	Benchmark	RA-NK
Liquid Assets/Income	1.20	1.20
Liquid Assets Gini	0.76	0.00
Median MPC	0.13	0.05
Average MPC	0.28	0.05

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

[17] We set $\Delta = -0.5\%$ to match the percentage change of bond holdings relative to the steady state between RA-NK and Benchmark.

Figure 6: Consumption Responses to a Government Spending Shock: Benchmark vs. RA-NK



Notes: Impulse response functions for consumption in the benchmark case and RA-NK model. In RA-NK there is no heterogeneity within regions. All units are expressed in percentage deviations from their steady state.

Figure 6 plots the consumption impulse response functions in our Benchmark (left panel) and the RA-NK model (right panel). In the RA-NK model, consumer spending responds less to government spending as the average MPC is lower. Both the local and the aggregate fiscal multiplier are lower relative to our Benchmark. In particular, in the RA-NK model the local multiplier is equal to 0.15 and the aggregate is equal to 0.20.

The difference is related to the response of consumer spending due to the change in wages (Table 12). If only wages had changed in our Benchmark, the local multiplier would be 0.36 and the aggregate multiplier would be 0.89. In the RA-NK, the effect decreases to 0.26 and 0.53, respectively. Consumer spending decreases more in our Benchmark due to dividends compared to the RA-NK, but the difference is not enough to counteract the large differential response in consumption due to wages. Inflation affects consumer spending in both economies the same way. Finally, consumer spending increases due to taxes in the Benchmark while it slightly decreases in RA-NK. However, overall, the effect of taxes seems relatively small.

We conclude that the large difference between the Benchmark and the RA-NK multipliers come from the differential response of consumer spending to increases in labor income. In our Benchmark, the average MPC is 0.28 while in the RA-NK it is 0.05. With higher average MPC the increase in labor income generates a substantial consumption response. This results in larger consumption multipliers both at the local and the aggregate level.

According to Nakamura and Steinsson (2018), local variation can be a powerful diagnostic tool to distinguish between competing models. The RA-NK model generates a local con-

sumption multiplier equal to 0.15 much lower than what the data imply. In contrast, our Benchmark with MPC heterogeneity generates a local consumption multiplier closer to the data. Therefore, our empirical estimate of the local consumption multiplier favors the substantial consumption response generated by a heterogeneous agents, New Keynesian model relative to a representative agent, New Keynesian model.

Table 12: Consumption Decomposition: RA-NK vs. Benchmark

	RA-NK		Benchmark	
Consumption Multiplier	Local	Aggregate	Local	Aggregate
Due to Wages	0.26	0.53	0.36	0.89
Due to Dividends	-0.10	-0.23	-0.13	-0.31
Due to Inflation	-0.005	-0.06	-0.006	-0.04
Due to Taxes	0.00	-0.01	0.00	0.08
Total	0.15	0.20	0.23	0.64

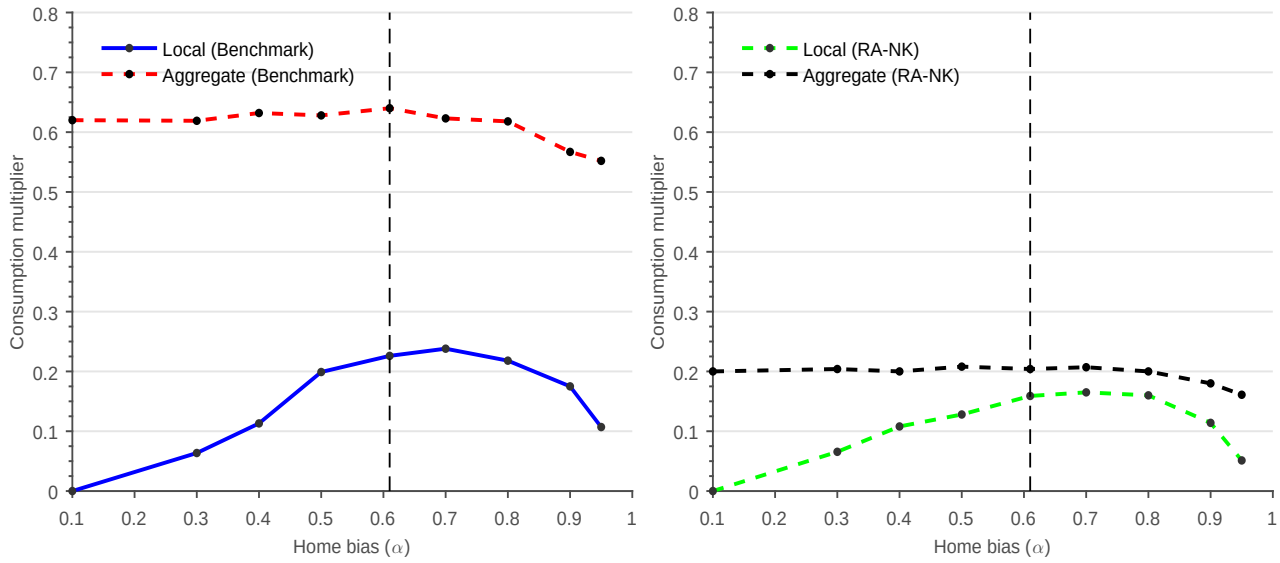
Notes: Multiplier decomposition due to wages, dividends, inflation, and taxes in the benchmark model and an economy with a representative agent in each region (RA-NK).

6.2 The Role of Trade Linkages

Figure 7 shows the local and the aggregate consumption multiplier as we vary the degree of home bias α. The left panel shows the multipliers for our Benchmark and the right panel for the RA-NK economy. Consumption multipliers are reported at a four-year horizon. In our calibration, we set home bias equal to 0.61 using information on shipments of goods from the CFS (vertical line). This corresponds to a local consumption multiplier equal to 0.23 and an aggregate consumption multiplier equal to 0.64. For the RA-NK model, the multipliers are 0.15 and 0.20, respectively.

For both economies, the local consumption multiplier is zero when $\alpha = \mu_1$. At this value, the home bias of Region 1 equals the home bias in Region 2, adjusted for population size. We explain this result in detail in the next section. The relationship between home bias and local consumption multiplier is non-monotonic. On the one hand, as the degree of home bias increases, Region 1 keeps more of the local fiscal stimulus. As a result, consumption in Region 1 increases more relative to consumption in Region 2. On the other hand, as home bias increases, the response of relative prices (real exchange rate) is stronger. This increases the real interest rate in Region 1 relative to Region 2 and decreases the relative consumption response. We explain the relative price mechanism in more detail below.

Figure 7: Consumption Multipliers as a function of Trade Linkages: Benchmark and RA-NK



Notes: We vary parameter α which captures the degree of home bias for Region 1. The benchmark calibration is $\alpha = 0.61$ (vertical line). We show the local and the aggregate consumption multiplier for a four-year horizon. The left panel is our benchmark economy with heterogeneity and the right panel is the representative-agent economy.

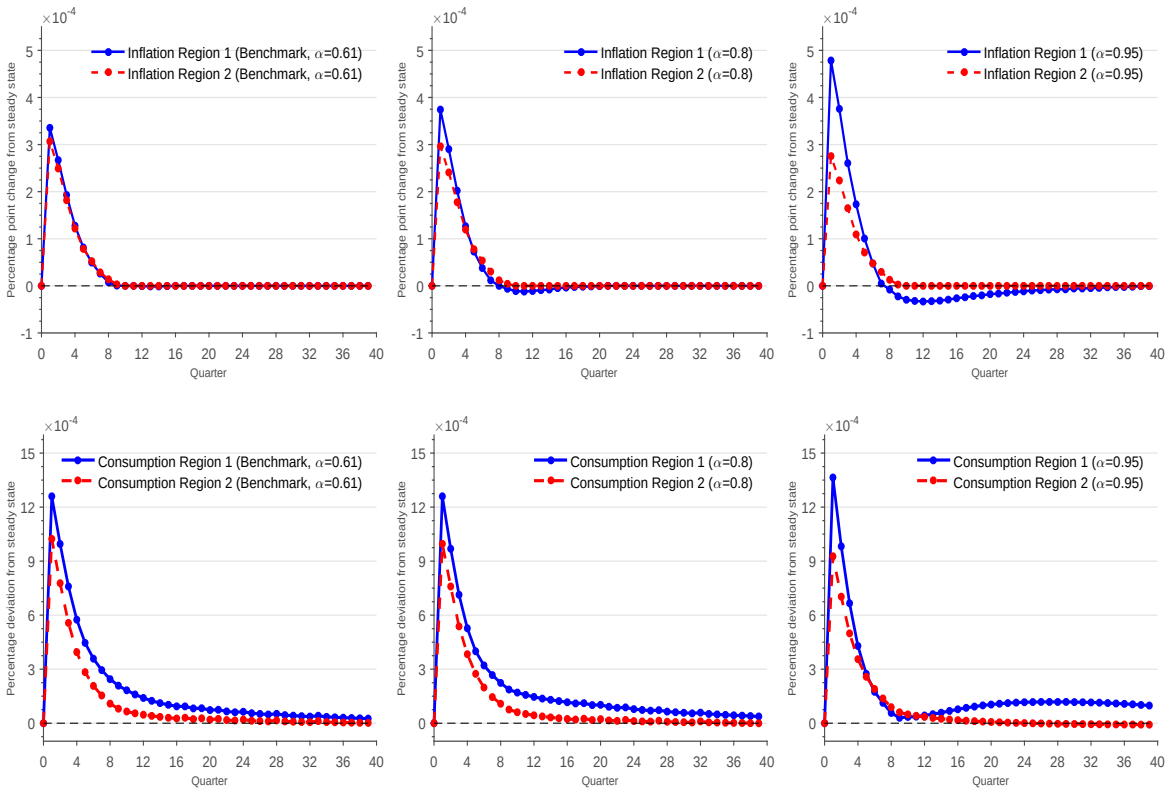
The aggregate fiscal multiplier is weakly decreasing in the degree of home bias. For values of home bias that correspond to the increasing part of the local multiplier schedule, the aggregate consumption multiplier is largely constant. Since the two regions are (per-capita) symmetric, the final division of funds does not matter for the aggregate consumption response. For higher values of home bias – where the relative price mechanism becomes stronger – the aggregate consumption multiplier decreases.

Figure 8 explains the decreasing local and aggregate consumption multipliers for high values of the home bias. The upper panels show the response of inflation, while the lower panels show the response of consumption for the benchmark model. We show the responses for three values of home bias: $\alpha = \{0.61, 0.8, 0.95\}$. Hence, the upper left and lower left panels show again the benchmark responses for inflation and consumption similar to Figure 4.

The higher home bias is, the higher the initial inflation response is in Region 1 relative to Region 2. Since government spending does not spill over, there is a higher demand for local intermediate inputs, which increases local inflation more. But when the fiscal stimulus is over, Region 1 experiences a period of deflation so that the real exchange rate converges back to its steady-state value. The higher the initial difference in inflation rates, the more significant subsequent deflation will be.

When $\alpha = 0.61$, the local stimulus is sufficiently shared so that the local inflation rates

Figure 8: Inflation and Consumption for $\alpha = \{0.61, 0.8, 0.95\}$



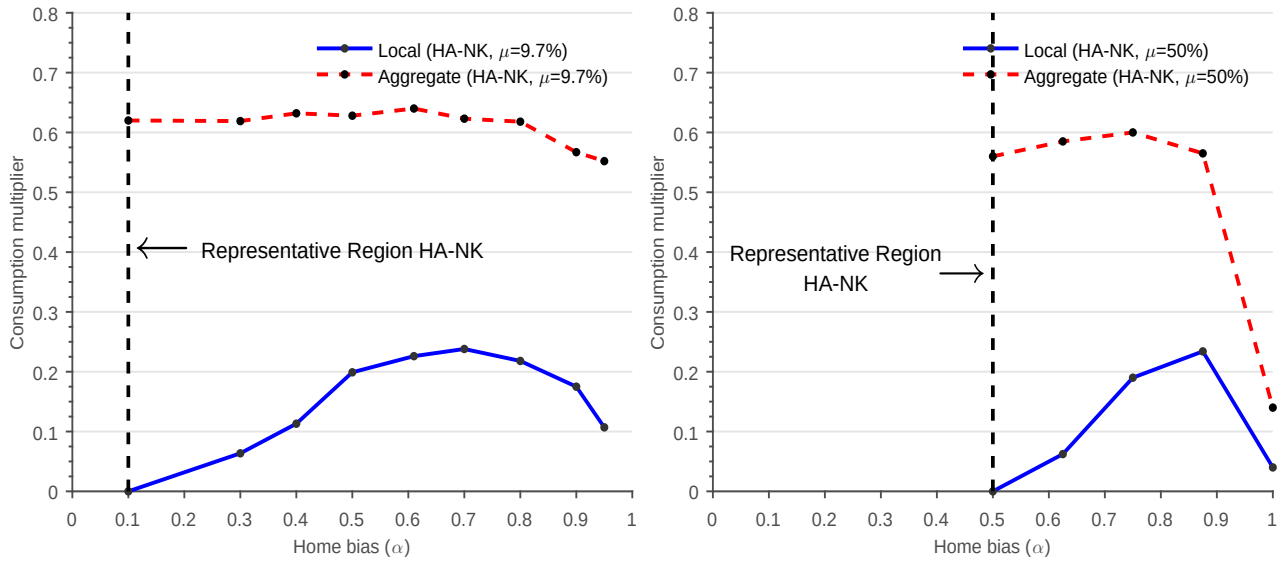
Notes: We show inflation (upper panels) and consumption responses (lower panels) for for $\alpha = \{0.61, 0.8, 0.95\}$. All figures are for the benchmark economy with heterogeneity and incomplete markets.

comove to a large degree. As a result, there is no need for subsequent period of deflation.[18] When $\alpha = 0.95$, the increase in government spending increases substantially demand for goods and inflation in Region 1 and generates expected deflation going forward. Deflation increases the real interest rate, inducing consumers to save, and therefore depresses consumption. As a result, when $\alpha = 0.95$, consumption in Region 1 initially increases more (due to higher local demand and income) but, in anticipation of higher real interest rates, quickly falls even below consumption in Region 2.

In sum, when trade linkages are strong ($\alpha \to \mu_1$), the relative price response is weak because both regions help supply the increase in demand. As a result, local inflation rates are more correlated and the regions do not have to experience significant deflation. Hence, aggregate consumption increases more.

[18]The relatively high degree of price stickiness also plays a role here. If prices where more flexible then we would observe some deflation even for $\alpha = 0.61$. Hence, the peak of the local consumption multiplier would occur earlier than the value of 0.7.

Figure 9: Consumption Multipliers in a Representative vs. Multiple Regions HA-NK for different populations (μ_1)



Notes: We vary parameter α which captures the degree of home bias for Region 1. We show local and aggregate consumption multipliers for a four-year horizon when $\mu_1 = 9.7\%$ and $\mu_1 = 50\%$. $\alpha = \mu_1$ corresponds to the single, representative region version of our model.

6.3 Multiple Regions HA-NK vs. Representative Region HA-NK

Does our multiple regions, heterogeneous agents, New Keynesian model bring new insights on the effects of fiscal policy on consumption relative to a model with a single, representative region? The representative region version of our model is derived by setting $\alpha = \mu_1$. In this case, home bias in Region 1 is α and in Region 2 is $1-\alpha$. Moreover, each sub-region of size μ_1 located within Region 2 has home bias $\frac{\mu_1}{\mu_2}(1-\alpha) = \alpha$. Therefore, both Region 1 and all sub-regions within Region 2 (of the same size as Region 1) have the same home bias (symmetric case). Since the behavior of individual regions are similar, we can analyze the behavior of a single, representative region.

Figure 9 shows the local and the aggregate consumption multiplier for a single, representative region model ($\alpha = \mu_1$) and for a model with multiple regions ($\alpha > \mu_1$). We analyze separately a case where $\mu_1 = 9.7\%$ (benchmark model) and a case where $\mu_1 = 50\%$. Notice that when we have a single, representative region, the local consumption multiplier is zero.

There are two important differences between a model with multiple regions and a model with a single, representative region. First, provided regions are sufficiently isolated ($\alpha \to 1$) and that both regions have considerable size ($\mu_1 \to 0.5$), the aggregate multiplier in the model with multiple regions can deviate substantially from the aggregate multiplier in the model with a representative region. As explained in the previous section, if government spending shocks

Table 13: Consumption Decomposition in a Representative Region vs. Multiple Regions (with $\mu_1 = 0.5$)

Home bias	(Representative region) α=0.5		(Multiple Regions) α=0.75		(Multiple Regions) α=1.00	
Consumption Multipliers	Local	Aggregate	Local	Aggregate	Local	Aggregate
Due to Wages	0.0	0.82	0.32	0.87	0.75	0.79
Due to Dividends	0.0	-0.29	-0.12	-0.30	-0.28	-0.27
Due to Inflation	0.0	-0.04	-0.004	-0.04	-0.42	-0.22
Due to Taxes	0.0	0.05	0.0	0.06	0.0	-0.04
Total	0.0	0.56	0.19	0.60	0.03	0.14

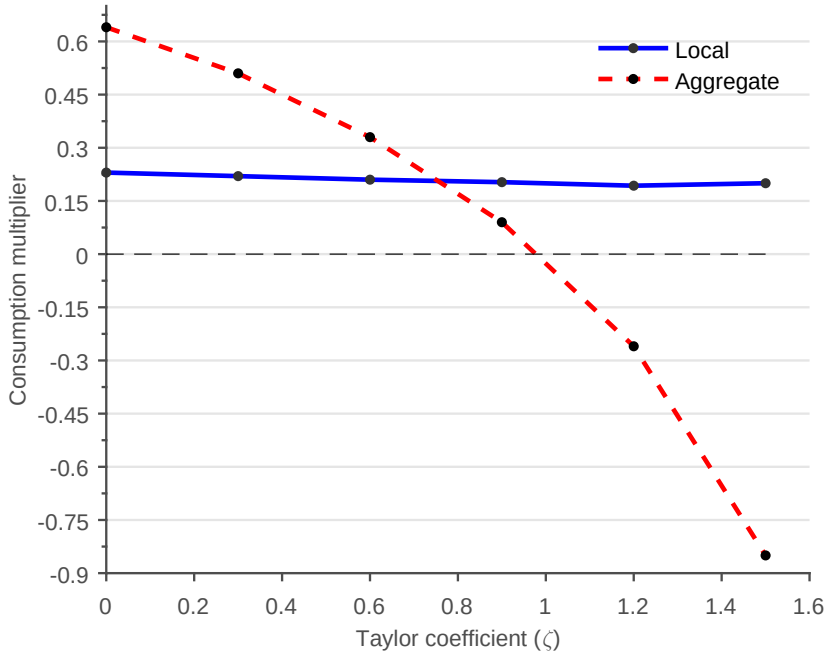
Notes: Multiplier decomposition due to wages, dividends, inflation, and taxes for regions with the same size ($\mu_1 = 0.5$). We consider three cases: $\{\alpha = 0.5, \alpha = 0.75, \alpha = 1.0\}$.

are too localized (α high), the recipient-region experiences higher initial inflation but also higher subsequent deflation. The deflation period is necessary to equalize relative prices when the economy converges to the steady state. As a result, in anticipation of higher real interest rates, households save relatively more and consume relatively less. The strength of this channel depends on the size of the regions. If a region is relatively small, government spending has a small effect on relative prices and the subsequent deflation necessary to equalize relative prices is lower. If a region is relatively large, government spending has a large effect on relative prices and the deflation period can be substantial. This explains why the consumption multipliers decrease substantially when α approaches one, in the case of $\mu_1 = 50\%$.

Table 13 decomposes the effect of wages, dividends, inflation, and taxes on consumer spending when $\mu_1 = 50\%$. In the model with a single, representative region ($\alpha = 0.5$), the transmission mechanism of fiscal policy on consumption occurs mainly through changes in labor income. Inflation has very little effect on the aggregate consumption multiplier (see for example, Hagedorn, Manovskii, and Mitman, 2017 and Kaplan, Moll, and Violante, 2018)). When we set $\alpha = 0.75$ (and thus opening up the economy), the relative strength of wages and inflation remains largely intact. However, when $\alpha = 1.0$, the multiplier decreases substantially and the decrease comes from the inflation rate.

The differences in the transmission mechanism of fiscal policy is the second important distinction between our model that incorporates multiple regions and a model with a single, representative region. Models of fiscal policy with only a single region naturally miss the

Figure 10: Consumption Multipliers and Monetary Policy



Notes: Taylor rule is given by $R_t = R_{ss} + \zeta\hat{\pi}_t$. In Benchmark we have $\zeta = 0.0$. We vary parameter ζ and report the four-year local and aggregate consumption multiplier.

importance of relative prices and trade linkages for the aggregate consumption multiplier.

6.4 The Role of Monetary Policy

In this section, we analyze how monetary policy affects the response of consumption to fiscal policy. For our Benchmark we have assumed a monetary policy that is unresponsive to inflationary pressures, a case resembling the zero lower bound. In this section, we 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: $R_t = R_{ss} + \zeta\hat{\pi}_t$. Figure 10 shows the local and aggregate four-year consumption multiplier when we vary the Taylor rule coefficient ζ.

The aggregate multiplier decreases gradually as we increase the responsiveness of the monetary authority to aggregate inflation. Consumer spending drops for two reasons. First, the 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. Second, the increase in the nominal rate increases the government debt service cost. As a result, to balance the budget, the government increases taxes. The combined effect of higher real interest rates and higher taxes decreases consumer spending.

In contrast, the local consumption multiplier is largely unaffected by the responsiveness

of monetary policy. This exercise confirms the intuition of the literature claiming that first, monetary authority is critical for the value of the aggregate fiscal multiplier (Christiano, Eichenbaum, and Rebelo, 2011), and second, monetary policy does not affect the local multiplier so that local estimates are an upper bound for the multiplier during times of conventional monetary policy (see for example, Chodorow-Reich, 2018).

Although the weak response of monetary policy is necessary to generate a positive consumption response, it is not the only element generating high aggregate consumption multipliers. As mentioned, without heterogeneity the aggregate consumption multiplier would still be positive but relatively modest (equal to 0.20). This means that heterogeneity accounts for almost two-thirds of the positive aggregate consumption response.

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 $0.29 on retail and auto purchases combined.

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 successfully reproduces 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 equal to 0.64. This falls in the upper bound of estimates found in the literature (Hall, 2009).

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Appendix: For Online Publication

A Consumer Spending Data

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.

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 store scanners as well as credit records and thus are less suspect to measurement error. This applies less to Nielsen HomeScan which is based on in-home scanners. Finally, all our datasets can be relatively easily accessed by other researchers.

Purchases in the Nielsen dataset 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 A-1 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.

Figure A-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 slightly decrease relative to 2011, a pattern we do not observe in the BEA data. Our aggregated time series in Nielsen HomeScan seem less able to track the BEA. Household spending – based on Nielsen – decreased in both 2009 and 2010 relative to 2008.

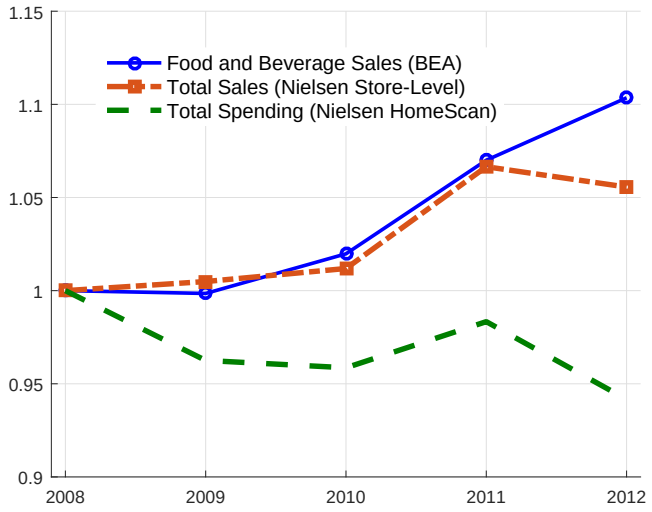
For the Nielsen Retail Scanner/HomeScan data, we impose the following criteria. (1) We keep stores/households for which we have information on their sales/spending for all years between 2008 and 2012. This way we do not have to worry about regions experiencing higher

Table A-1: 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.

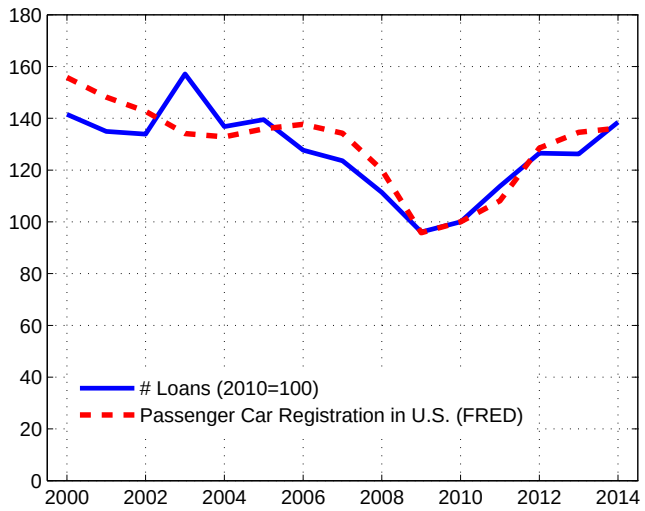
Figure A-1: Total Sales/Spending (Nielsen) vs. Food and Beverage Sales (BEA)



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.

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) For Retail Scanner/HomeScan, we exclude counties with fewer than 20 stores/househoulds. Restrictions (1)-(2) leave us with 31,186 (23,834) stores (households) per year. Restriction (3) leaves us with 21,915 (15,031) stores (households) per year.

Figure A-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.

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-code level. The core of the database constitutes a 5% random sample of all U.S. consumers with a credit record and social security number. This is called the primary sample. The total number of observations is approximately 10 million individuals.

We use auto finance as a proxy for spending on vehicles. We consider auto finance by both banks and car dealerships.[19] 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 A-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.

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

B 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.[20]

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.[21] 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."[22] 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 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.

[20] The information in this section of the appendix also appears as an appendix in Dupor and McCrory (2017).

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

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

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.[23]

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 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)).

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

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.[24]

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.[25] 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."[26] 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. Each LEA was first allocated a minimum of its FFY1999 award.[27] 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

[24]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.

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

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

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

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 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

Table B-2: 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.

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.

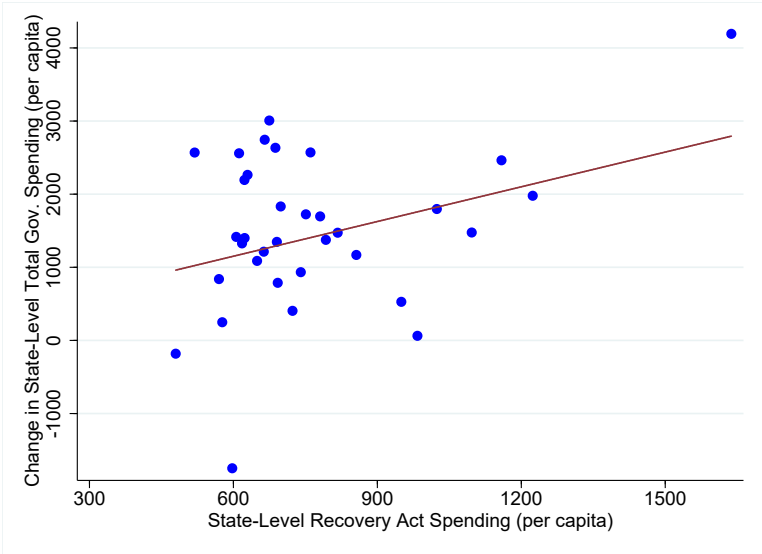
Table B-2 summarizes the total amount of awards used in our instrument as a fraction of the total awards given. The total amount of money awarded in all of the U.S. during the period 2009-2012 was $228 billion. Out of this amount, 20.2% was allocated based on our selected criteria. Departments of Transportation, 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.

B.1 Recovery Act and Total State-Level Spending

The spending component of the Recovery Act allocated around 228$ to local and state governments. One concern is that state governments reduced their own spending in response to the federal fiscal stimulus. We evaluate this hypothesis by using data from the Annual Survey of State Government Finances for the years 2008-2012. For each state s and year t we construct the variable $G_{s,t}^{Total}$, which includes total expenditures on current operations and capital outlays as well as intergovernmental expenditures. We normalize by state-level population. We define the cumulative change in state-level total government spending between the period 2008-2012 as

$$\Delta G_s = \sum_{t=2008}^{2012} \{G_{s,t} - G_{s,2008}\}$$

Figure B-3: Recovery Act Spending and Total Spending by States



Notes: Scatter plot of total Recovery Act spending (per-capita) during the period 2009-2012 and cumulative change in total state-level spending (per-capita) between period 2008-2012.

Our main regressor is per-capita money allocated to each state from the Recovery Act in the period 2009-2012 (denoted as G_s^{ARRA}). We then estimate the relationship between Recovery Act and total state-level spending using the following regression

$$\Delta G_s^{Total} = a + \beta G_s^{ARRA} + \varepsilon_s \tag{28}$$

If β is less than one, then for every dollar allocated from the Recovery Act, total state spending increases less than one dollar. This implies the state decreased its own spending relative to 2008 (crowding out). In contrast, if β is higher than one, then the state increased its own spending relative to 2008 (crowding in). β turns out to be 1.5 and is statistically significant at the 1% level. Figure B-3 gives a visual representation of our regression. The crowding in of state-level spending in response to the Recovery Act is also documented by Leduc and Wilson (2017) and Chodorow-Reich (2018).

C Robustness Analysis

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

Table C-3: Robustness Analysis

Specification	Nielsen Retail Scanner	Equifax
Benchmark	0.11**	0.09***
	(0.04)	(0.01)
Excluding state capitals	0.16*	0.14***
	(0.08)	(0.03)
W/o pop. weights	0.09**	0.26***
	(0.04)	(0.05)
Winsorizing G		
at 0%	0.08**	0.09***
	(0.03)	(0.02)
at 2%	0.14**	0.10***
	(0.05)	(0.02)
at 5%	0.18**	0.14***
	(0.07)	(0.03)
Cluster S.E.		
No Cluster	0.11**	0.09***
	(0.04)	(0.01)
by Census Division	0.11**	0.09***
	(0.03)	(0.02)
Excluding counties		
with #Stores < 3	0.12***	–
	(0.03)	
with #Stores < 6	0.10***	–
	(0.03)	
with #Stores < 9	0.10**	–
	(0.04)	
with #Stores < 12	0.08**	–
	(0.03)	
with #Stores < 15	0.10**	–
	(0.04)	
with #Stores < 30	0.07*	–
	(0.04)	

Note: The table shows the estimates of the regression of the growth rate in retail and auto spending to cumulative government spending at the county level during the period 2008-2012. Our benchmark specification includes state capitals, uses population weights, winsorizes at the 1%, clusters standard errors by state and excludes counties with less than 20 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.

In Table C-3 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, excluding state capitals increase both the Nielsen and the Equifax estimates by 5 cents relative to the Benchmark. Second, 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 do not use population weights, the auto spending multiplier increases from 0.09 to 0.26.

Third, we analyze the implications of winsorizing the independent variable. We make this choice since many low-population counties received very large per-capita funding. When we do not winsorize, the independent variable coefficients remain largely intact. When we winsorize at 2% and 5%, respectively, coefficients increase in Nielsen Retail Scanner (0.14 and 0.18, respectively) while the statistical significance remains the same. 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%.

Fourth, 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 C-3 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 stores. In some counties, Nielsen samples only a few stores. As 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 fewer than 20 stores. Table C-3 shows the results when we vary the minimum number of stores per county. 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.

C.1 Nielsen HomeScan

Using the Retail Scanner data, we arrived at a retail spending consumption multiplier equal to 0.11 (Table 3). In Table C-4 we show the estimates of the regression of the growth rate in retail spending from Nielsen HomeScan on cumulative government spending at the county level during the period 2008-2012. The estimates are more noisy relative to Nielsen Retail Scanner but are in the same range.

Table C-4: Retail Spending Multipliers

Spending Category	Retail Consumer Spending (Nielsen, HomeScan)			
	OLS	IV	OLS	IV
Government Spending	0.10	0.12**	0.10	0.08
	(0.07)	(0.05)	(0.08)	(0.06)
Partial F stat.	—	127.0	—	104.4
County Controls/State F.E.	No	No	Yes	Yes
# Counties	272	272	272	272

Notes: The table shows the estimates of the regression of the growth rate in retail spending from Nielsen HomeScan 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.

D Steady-State Equilibrium

For the steady-state equilibrium, we abstract from time variable t. 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 equal across regions level of per-capita regional government spending $\{G_i\}_{i=1}^2$, a stationary equilibrium is a cross-section of regional variables: $\{C_i\}_{i=1}^2$, $\{L_i\}_{i=1}^2$, $\{Y_i\}_{i=1}^2$, $\{\mathcal{Y}_i\}_{i=1}^2$, $\{w_i\}_{i=1}^2$,$\{D_i\}_{i=1}^2$,$\{\phi_i\}_{i=1}^2$, and two aggregate variables, the nominal interest rate R (which equals the real interest rate) and the federal tax rate τ.

1) Goods Market Equilibrium: The demand for goods by households in region i, C_i, is derived by the household's problem and, together with local government spending G_i, gives the total demand for final good i: $C_i + G_i \quad \forall i$. The goods market is cleared by R, which at the steady state is both the real and the nominal interest rate. Hence the goods market clearing condition is

$$Y_i = C_i + G_i.$$

2) Regional income in region i, $\mu_i \mathcal{Y}_{i,t}$, is a weighted sum of regional final goods

$$\mu_i \mathcal{Y}_i = \sum_{i'} \mu_{i'} \gamma_{i'i} Y_{i'}.$$

3) Labor Market Equilibrium: The real wage is given by $\quad w_i = \frac{\epsilon - 1}{\epsilon} \quad \forall i$ and the aggregate labor supply in region i is $\mu_i \int_{\phi_i} x h_i$ where h is derived by solving the household's problem.

Since we have a linear technology, the aggregate labor demand $\mu_i L_i$ equals aggregate income $\mu_i \mathcal{Y}_i$.
4) Dividends are given by $\quad D_i = \mathcal{Y}_i - w_i L_i \quad \forall i$.
5) The government balances its budget

$$\sum_i \mu_i \int_{\phi_i} Rb - \sum_i \mu_i \int_{\phi_i} \kappa b \mathcal{I}_{b<0} = \sum_i \mu_i G_i - \sum_i \mu_i \int_{\phi} T(w_i x h).$$

6) The stationary regional measures ϕ_i evolve based on the policy functions and the transition matrices described in the model.

If all the above conditions hold, then the bond market automatically clears $\bar{B} = \sum \mu_i B_i = \sum_i \mu_i \int_{\phi_i} b$.

E Alternative Fiscal Rules

Table E-5 analyzes whether alternative fiscal rules matter for model outcomes. First, we consider an economy with region-specific taxes. Second, we allow the government to finance spending by expanding government debt.

Local Taxes In the benchmark model, taxation occurs at the federal level. Here, we assume that regions pay taxes proportional to the stimulus injected in the region. In particular, since Region 2 receives 36% of the spending allocated in Region 1, it pays almost three times less the taxes set in Region 1. Higher initial inflation decreases the government debt service cost and decreases the tax rate for the first couple of years. As a result, Region 1 benefits more when taxes are local than when taxes are federal and the local multiplier increases to 0.29. The aggregate multiplier is slightly lower to 0.61.

Deficit Financing The Recovery Act was mainly financed through a large expansion in government debt. As a result, in this case, we allow for the government to finance the spending by deficit financing. In particular, the government issues (and rolls over) debt up to year T and starts imposing taxes for $t > T$ in order to bring the debt equal to its steady-state value. We consider $T = \{5, 10, 20\}$. The aggregate consumption multiplier increases when the deficit horizon increases. However, even when deficit financing lasts for twenty years the multiplier is around ten cents higher than the Benchmark. Therefore, deficit financing matters for model outcomes but the difference relative to the benchmark case is not sizable.

The aggregate multiplier is higher when spending is taxed financed than when it is deficit financed for five years. As mentioned, higher initial inflation decreases the government debt service cost and decreases the tax rate for the first couple of years. As a result, allowing tax

Table E-5: Alternative Fiscal Rules

Model	Local multiplier	Aggregate multiplier
Benchmark	0.23	0.64
Local Taxes	0.29	0.61
Deficit Financing		
Taxes Paid after 5 years	0.22	0.55
Taxes Paid after 10 years	0.21	0.71
Taxes Paid after 20 years	0.16	0.74

Notes: When taxes are local, each region pays a tax proportional to the stimulus injected in the region. For deficit financing, we assume that for certain number of years taxes cannot adjust but government debt can.

to adjust generates higher multipliers. Since this effect lasts only for the first couple of years, deficit financing for ten or twenty years ahead is preferable to the Benchmark case.

F Derivation of Equations

In this section, we derive the main equations in the text. To ease the notation we assume that both regions have the same population so that we can abstract from weighting variables by population μ. Adding population weights in the equations is straightforward. The production technology of final good firm in region i is

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

The maximization problem for the firm i reads:

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

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

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

The zero profit condition leads to the price aggregator:

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

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

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

Total demand for intermediate inputs of region i is

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

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

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

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

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

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

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

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

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

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

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

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