ECONOMIC RESEARCH
FEDERAL RESERVE BANK OF ST. LOUIS

WORKING PAPER SERIES

Regional Consumption Responses and the Aggregate Fiscal Multiplier

Authors	Bill Dupor, Marios Karabarbounis, Marianna Kudlyak, and M. Saif Mehkari
Working Paper Number	2018-004D
Revision Date	September 2022
Citable Link	https://doi.org/10.20955/wp.2018.004
Suggested Citation	Dupor, B., Karabarbounis, M., Kudlyak, M., Mehkari, M.S., 2022; Regional Consumption Responses and the Aggregate Fiscal Multiplier, Federal Reserve Bank of St. Louis Working Paper 2018-004. URL https://doi.org/10.20955/wp.2018.004

Federal Reserve Bank of St. Louis, Research Division, P.O. Box 442, St. Louis, MO 63166

Regional Consumption Responses and the Aggregate Fiscal Multiplier*

Bill Dupor
Federal Reserve Bank of St. Louis

Marios Karabarbounis
Federal Reserve Bank of Richmond

Marianna Kudlyak
Federal Reserve Bank of San Francisco

M. Saif Mehkari
University of Richmond

February 3, 2022

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 the Nielsen scanner data and auto purchases from Equifax credit balances. We estimate that a \$1 increase in county-level government spending increases local non-durable consumer spending by \$0.29 and local auto spending by \$0.09. We translate the regional consumption responses to an aggregate fiscal multiplier using a multi-region, New Keynesian model with heterogeneous agents, incomplete markets, and trade linkages. Our model is consistent with the estimated positive local multiplier, a result that distinguishes our incomplete markets model from models with complete markets. At the zero lower bound, the aggregate consumption multiplier is twice as large as the local multiplier because trade linkages propagate the effect of government spending across regions.

Keywords: Consumer Spending, Fiscal Multiplier, Regional Variation, Heterogeneous Agents. **JEL Classification:** E21, E62, H31, H71

---

*Corresponding author: Marios Karabarbounis, Research Department, Federal Reserve Bank of Richmond, 701 E Byrd St, Richmond VA, 23219, USA, 8046978923 (email: marios.karabarbounis@rich.frb.org). Contributing authors: Bill Dupor, Research Division, Federal Reserve Bank of St. Louis, 1 Broadway, St. Louis, MO 63102, USA (email: william.d.dupor@stls.frb.org); Marianna Kudlyak, Research Department, Federal Reserve Bank of San Francisco, 101 Market St., CA 94105, USA (email: marianna.kudlyak@sf.frb.org); M. Saif Mehkari, University of Richmond, 1 Gateway Road, Richmond, VA, 23173, USA (email: smehkari@richmond.edu). We thank Dirk Krueger and five anonymous referees for extremely valuable advice. We also thank our discussants Karel Mertens and Claudia Sahm, as well as Yongsung Chang, Gabriel Chodorow-Reich, Olivier Coibion, Erik Hurst, Greg Kaplan, Pete Klenow, David Lagakos, Alisdair McKay, Emi Nakamura, Valerie Ramey, Morten Ravn, Jon Steinsson, Gianluca Violante, and seminar participants at USCD, Wisconsin-Madison, UCL, Federal Reserve Bank of Minneapolis, Columbia GSB, NBER conference on Micro Data for Macro Models, Barcelona Summer Forum 2018, and the Richmond Fed Conference on Fiscal Policy.

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 first 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. The local effect is the relative change in regional outcomes in response to a relative change in government spending across regions.[2]

Second, we translate the local fiscal multiplier to an aggregate fiscal multiplier using a multi-region, New Keynesian model with heterogeneous agents and incomplete markets. This is because estimates based on regional variation are not always representative of aggregate effects. Such estimates ignore general equilibrium effects that cannot be separately identified in cross-regional regressions (Nakamura and Steinsson, 2018; Chodorow-Reich, 2019).

The ARRA, implemented between 2009-2012, 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 the FRB NY Consumer Credit Panel/Equifax.

We estimate that a \$1 increase in ARRA spending within a county increases local non-durable spending by \$0.29 and local auto spending by \$0.09. We address potential endogeneity of government spending in two ways. First, we show that ARRA funding did not significantly target low-income areas. Second, we use a narrative instrumental variable approach. In particular, we identify components of ARRA funding that did not explicitly target local economic recovery.

We translate our estimated local fiscal multiplier to an aggregate fiscal multiplier using a

[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]Nakamura and Steinsson (2014) refer to this object, in a fiscal policy context, as the open economy relative multiplier.

general equilibrium, two region, New Keynesian model. In the model, each region produces a final good, which is purchased by the local consumers as well as the government. The final good is produced using both local and foreign intermediate inputs. Due to home bias, final goods are produced using a larger share of local inputs. Trade linkages—expressed in the degree of home bias—provide one channel for government spending to affect economic activity across regions. The government maintains a fiscal union because it finances spending using federal taxes. The monetary authority targets a common 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 incomplete asset markets (Huggett, 1993; Aiyagari, 1994). Heterogeneity in our model takes the form of idiosyncratic labor-income shocks as well as permanent differences in the discount rate. Households self-insure using a risk-free government bond. Hence, our model combines a multi-region currency union model (e.g., Gali and Monacelli, 2008; Nakamura and Steinsson, 2014) with a heterogeneous agent, New Keynesian model (e.g., McKay, Nakamura, and Steinsson, 2016; Kaplan, Moll, and Violante, 2018).

We calibrate the model using standard parameter values and targets as in typical New Keynesian models with heterogeneous agents. For the strength of trade linkages, we use data on shipments of goods across U.S. regions from the Commodity Flow Survey (CFS). Without explicitly targeting the response, our model generates a local, non-durable consumption multiplier equal to 0.20—fairly close to our estimate from the regional data. The aggregate consumption multiplier in our model is equal to 0.41.

Our model generates positive consumption responses at the local and the aggregate level, which is generally difficult to deliver in more standard models.[3] The key necessary element to generate a positive local 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, 2019).

Heterogeneity is not necessary 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 a New Keynesian model with a representative agent in each region and

[3]The standard neoclassical model without capital exhibits a negative aggregate consumption multiplier (and thus a less-than-one output multiplier); 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).

incomplete markets across regions generates a positive but small local multiplier equal to 0.09. The main reason for the larger consumption responses in our benchmark model is the substantial response of high-marginal-propensity to consume (MPC), labor-income-dependent households who experience an increase in their labor earnings. At an annual frequency, the average MPC in our model is 0.37, which is consistent with the empirical evidence on the magnitude of non-durable consumption responses to unexpected income transfers (Carroll, Slacalek, Tokuoka, and White, 2017). The combined evidence of our local consumption multiplier and existing estimates of the MPC favor a New Keynesian model with heterogeneous agents over a New Keynesian model with a representative agent.

The positive aggregate multiplier in the model also depends on our assumed passive monetary response to the fiscal stimulus. In our period of analysis, 2008-2012, the Federal Reserve was at the zero lower bound (ZLB) on its policy rate and would not raise the rate in response to potential inflation pressures driven by the ARRA. Increased expected inflation in the face of an unchanged nominal rate reduces the real interest rate leading households to increase consumption. Besides this standard effect of fiscal policy at the ZLB, a lower real interest rate also decreases the government's debt service cost which allows the government to engage in fiscal stimulus with a relatively small increase in taxes.[4]

The aggregate multiplier is twice as large as the local multiplier because trade linkages propagate government spending across regions. As trade linkages become stronger, regional consumption responses comove to a larger degree and the local multiplier—which is identified by the relative cross-regional responses—decreases. We empirically validate this mechanism using trade flows from the CFS. The local multiplier is lower when estimated from regions in close trade relationships than when estimated using regions in distant trade relationships.

We show that one additional reason the aggregate multiplier is higher than the local multiplier is the passive stance of the monetary authority. If in our model the monetary policy actively responds to inflation pressures, the aggregate multiplier turns negative. Nonetheless, the local multiplier remains positive and unaffected because the monetary policy is common across regions.

Our model maps the empirical evidence on the local multiplier to an estimate for the aggregate multiplier. We show that when the model is also informed by the local multiplier it delivers a tighter range of estimates for the aggregate multiplier relative to a model that is only informed by the MPC.

Our paper contributes to the extensive literature on the consumption multiplier. One

[4]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 (2019) analyzes the redistribution channel from monetary policy to consumer spending.

strand of the literature estimates the aggregate consumption multiplier using aggregate VARs (e.g., Ramey and Shapiro, 1998; Blanchard and Perotti, 2002; Perotti, 2005; Barro and Redlick, 2011). A second strand 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 differs from this literature on two points. First, we use cross-regional variation to identify the (local) effect of fiscal stimulus on consumer spending. With disaggregate, geographical data, we use many more observations than typically used in the VAR studies. Moreover, we can identify exogenous variation in a much broader class of government spending than time-series studies which often rely on defense spending variation. Second, we translate the cross-regional variation into an aggregate consumption response using a quantitative model. Typical dynamic equilibrium models do not rely on any cross-regional or cross-sectional evidence.

The closest paper to ours methodologically is Nakamura and Steinsson (2014), who use cross-state evidence to analyze the output effect of defense spending. Our paper analyzes the cross-regional response of consumption using detailed micro-level evidence. Additionally, 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. Our model, in contrast, generates a positive local consumption multiplier due to incomplete markets.

We also contribute to the literature that uses regional variation to estimate regional effects of shocks or policies. These include work on the regional effects of house price 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 on employment and income including Wilson (2012), Chodorow-Reich, Feiveson, Liscow, and Woolston (2012), Conley and Dupor (2013), Leduc and Wilson (2017), Serrato and Wingender (2016), for example. 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.

Finally, we contribute to the growing literature that incorporates household heterogeneity and incomplete markets into 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. We extend this literature by incorporating multiple regions that are linked through trade, fiscal, and monetary policy. We show that, with multiple regions, the transmission of local fiscal policy depends on relative price adjustments and the strength of trade linkages, which are not considered in single-region heterogeneous agents models.

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 local response of consumer spending to local 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, and section 7 concludes.

2 Data

Our empirical analysis employs regional variation in government spending and consumer spending. We analyze data on government spending from the ARRA. We use the Nielsen Retail Scanner dataset to measure retail purchases. 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 a store/individual level with detailed geographical information (zip code).

2.1 Consumer Spending

The Nielsen Retail Scanner data cover 2006 through 2014.[5] Approximately 40,000 stores from ninety retail chains provide weekly point-of-sale information on units sold, average prices, UPC codes, and product characteristics. In 2010, the total sales in Nielsen stores constituted 42 percent of total sales in grocery stores and about 7 percent of total retail sales (excluding vehicle purchases).[6]

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 include cameras and office supplies. We find that around 53 percent of

[5]All results are calculated (or derived) based on data from the Nielsen Company (U.S.), LLC, and marketing databases provided by the Kilts Center for Marketing Data Center at the University of Chicago Booth School of Business. The conclusions 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/.

[6]A second source for consumer spending is the Nielsen HomeScan Consumer Panel Dataset which is a longitudinal panel of approximately 60,000 U.S. households who record information about their retail purchases, including shopping trip dates, the number of units purchased, UPC codes, and the total spending amounts. 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.

Table 1: Data Sources for Consumer Spending

Spending category	Source	# Stores/Individuals	Time period
Retail spending	Nielsen Retail Scanner	40,000 stores	2006-2014
Auto spending	CCP/Equifax	10 million individuals	2001-2015

annual spending takes place in Grocery and Discount Stores. Hardware, Home Improvement, and Electronics Stores account for just 4 percent of annual spending.

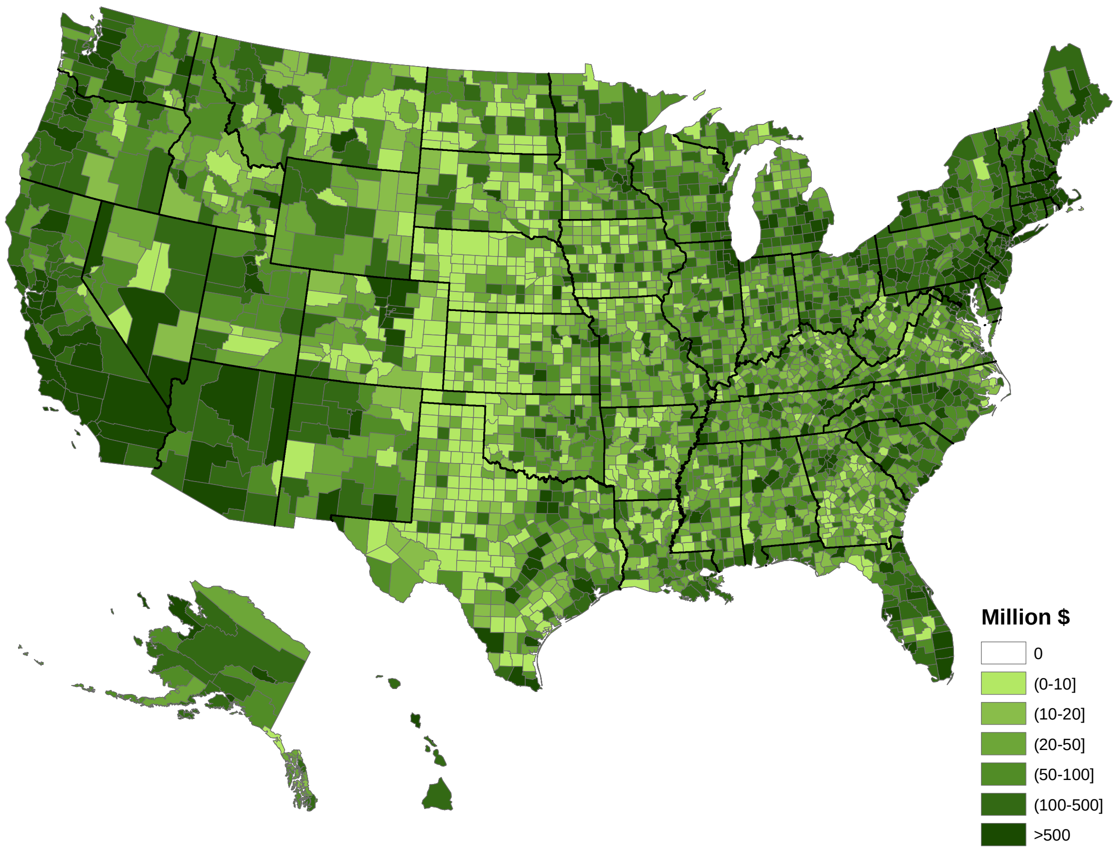
We measure auto spending using information on household auto finance loans, recorded in detailed data on individual debt for the Federal Reserve Bank of New York consumer credit panel. The CCP is a quarterly panel of administrative, individual-level data, including consumer liabilities, some demographic information, credit scores, and home address zip codes. The total number of individuals in the Equifax panel is approximately 10 million. The number of vehicles purchased in our panel (we identify a purchase to have occurred when an individual's auto balance increases between the previous and the current quarter) closely tracks the number of newly (first-time) registered passenger cars across time (see Appendix A). Table 1 provides a summary of our consumer spending data.

2.2 Government Spending

The ARRA 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 contracts and grants, which awarded roughly $228 billion. Contracts and grants were spread across many industries, including large amounts to transportation, infrastructure, energy and (most significantly) education.

To promote transparency, the federal government posted detailed information about each award on its Recovery.gov website, including the total amount awarded, the total amount spent to date, the award date, and funding agency. The website also provided zip code identifiers not only for primary recipients, but also for vendors, subcontractors, and other entities for each award. We assign spending to localities based on the ultimate receivers of each part of the award. For example, suppose an award was dispersed through a federal agency, which in turn was given to a state-level agency, which was then apportioned to several private entities. We locate spending using the various zip codes of those private entities. Figure 1 contains a county-level map of ARRA spending through 2012. Table 2 reports, at various percentiles,

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).

per-capita spending by county.

Table 2: Cross-sectional Distribution of County-level Government Spending (per capita)

Percentile	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}
	\$172	\$259	\$420	\$739	\$1,312

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 potential endogeneity, we determine components of the Act that were allocated using criteria orthogonal to the state of 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 from awards that did not. For example, the ARRA's Department of Education support for children with disabilities was apportioned according to a county's relative population of children with disabilities rather than the local business cycle. As a second example, money provided through the Federal Highway Administration for road improvement and maintenance was distributed based upon population density and passenger miles traveled. 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.[7]

Our instrument is the sum within a county of all funds allocated based on these criteria. The total amount of all dollars awarded through 2012 was \$228 billion, with 20.2 percent satisfying our selection criteria and therefore belonging to our instrument.

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:

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

where G_j denotes the money awarded per household at county j during the period 2009-2012. We run the regression when G_j is the total money awarded per household (denoted "Total") and separately for the case where G_j is the subset of money allocated using our selected criteria (denoted "Instrument"). D_s is a state dummy and X_j denotes pre-Recovery Act county-level economic characteristics. These include per-capita income in 2007, unemployment rate in 2007, the change in per-capita income between 2007 and 2009, and the change in the unemployment rate between 2007 and 2009.[8] We run a separate regression for each local

[7]For a more detailed analysis of the selection criteria driving our narrative instrumental variable approach, see Dupor and Mehkari (2016) and Dupor and McCrory (2017).

[8]When we expand the set of control variables to include the 2008 per-capita county income and unemployment, the results are little changed.

economic characteristic and report the estimates in Table 3.

Table 3: Recovery Act Spending and Local Economic Characteristics

Recovery Act Spending (2009-2012)	Total	Instrument
Per-capita county income 2007 (/$10,000)	51.8	11.1
	(39.0)	(12.1)
Change in per-capita county income 2007-2009 (/$10,000)	-80.5	13.2
	(181.7)	(46.9)
County unemployment rate 2007 (p.p)	-57.1	22.1
	(53.7)	(23.0)
Change in county unemployment rate 2007-2009 (p.p.)	-183.2***	-34.5**
	(60.7)	(16.6)

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 weight 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 percent, 5 percent, and 1 percent levels, respectively.

Total spending is, for the most part, positively and not negatively correlated with economic characteristics, as economic targeting would imply. For example, counties with $10,000 higher per-capita income in 2007 received an additional $52 per capita. Our results are consistent with the analysis of Boone, Dube, and Kaplan (2014), who also find that there was no particular economic targeting in the Recovery Act. In all cases, our instrument mitigates the correlation between spending and pre-Recovery Act local economic conditions. We view this as supporting evidence that our selected criteria for the construction of the instrument are largely uncorrelated with the local business cycle.

An additional important question is whether government spending is correlated with pre-trends in consumer spending. We find that government spending does not correlate with either retail or auto spending during 2007 and 2008 (i.e., prior to the Act). Therefore, consumption pre-trends were broadly similar between the large-dollar and small-dollar recipient counties. Details about this experiment can be found in Appendix C.1.

2.2.2 Federal and Local Spending

We examine if Recovery Act spending interacted with local government spending. To assess the importance of this possibility, we use data from the Annual Survey of State Government Finances, which contains annual state-level spending on current operations, capital outlays, and intergovernmental expenditures. We compute the cumulative difference of the sum of these three components between 2008 and 2012 at the state level. We find that for every Recovery Act dollar, states increased their own spending (relative to 2008) by around 50 cents.[9] We discuss in more detail how the interaction between federal and state spending affects our multipliers in Section 3.2.

3 The Local Fiscal Multiplier

3.1 Definitions and Basic Specification

This section describes our empirical specification. We use two categories of consumer spending: retail spending and auto spending, available at the store and the household level, respectively. Let $c_{i,j,t}$ denote total spending of the household/store i located in county j during year t. N_j is the number of households/stores in county j. We use a balanced panel (no new entry or exit of households/stores) and fix the population at its 2008 level. We construct the average household/store spending by averaging across all households/stores that are located in the county. Thus, $C_{j,t} = \frac{\sum_{i \in j} c_{i,j,t}}{N_j}$ is the average spending in county j.

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

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

Our benchmark econometric model is

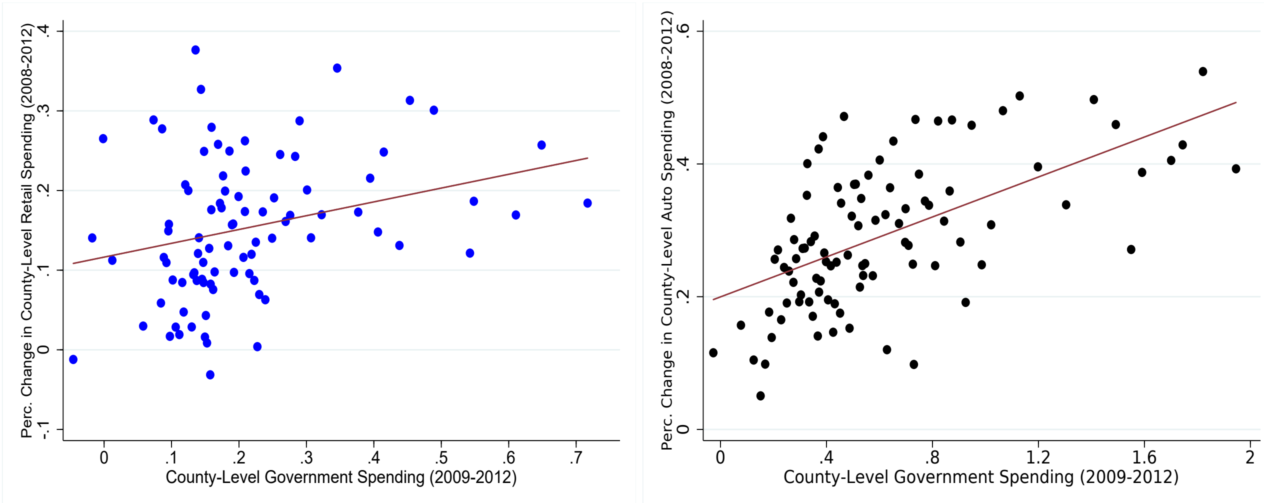
$$\frac{\Delta C_j}{C_{j,2008}} = a + \beta \times \frac{G_j}{C_{j,2008}} + X_j \ \ \Phi' + D_s + \varepsilon_j. \tag{3}$$

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 per-capita Recovery Act spending, 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: $\frac{G_j}{C_{j,2008}}$.

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 include county-level controls through the vector X_j. These are population,

[9] The crowding-in of state spending in response to the Recovery Act is also documented by Leduc and Wilson (2017) and Chodorow-Reich (2019). Additional details on the underlying regression appear in Appendix B.1.

Figure 2: Government Spending and Percentage Change in Retail and Auto Spending (2008-2012), by Counties



Notes: Binned scatter plots between government spending (Recovery Act through 2012) and the percentage change in consumer spending, between 2008-2012, by county. The left panel shows changes in retail spending (Nielsen, Retail Scanner), and the right panel shows changes in auto spending (CCP/Equifax). The regression lines in both panels are estimated using population weights.

2007 and 2008 (per capita) incomes, and the 2007 and 2008 unemployment rates. Finally, we include a state fixed effect, D_s, in which s is the state of county j. We estimate the model using, in turn, least squares and instrumental variables. Our instrument is non-targeted Recovery Act dollars. In each specification, we weight each county by its population. Ramey (2019) highlights the importance of using population weights when using cross-regional variation.[10] Furthermore, we cluster standard errors at the state level and winsorize the dependent and independent variable at the 1 percent.

3.2 The Effect of the Recovery Act on Consumer Spending

Figure 2 contains a simple (by county) scatter plot of consumption growth from 2008 to 2012, for retail spending (left panel) and auto spending (right panel), against Recovery Act spending scaled by 2008 consumption spending. In both panels, higher government spending is associated with a higher consumption growth rate.[11]

[10] 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. We also use weights that take into account the relatively limited geographical coverage in Nielsen as in Aladangady et al. (2016). See Appendix C for details.

[11] The range of government spending values in the x-axis is wider in the auto spending case because Equifax has a richer geographical representation relative to Nielsen.

3.2.1 The Recovery Act's Effect on Retail Spending (Nielsen)

Table 4: Local Retail Spending Multipliers

Spending Category	Retail Consumer Spending (Nielsen, Retail Scanner)			
	OLS	IV	OLS	IV
Government Spending	0.20*** (0.06)	0.26*** (0.07)	0.11*** (0.04)	0.11** (0.05)
Partial F stat.	—	137.1	—	92.3
County Controls/State F.E.	No	No	Yes	Yes
# of Counties	367	367	367	367

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. The standard errors are given in parentheses. One, two, and three stars denote significance at the 10%, 5%, and 1% levels, respectively.

In Table 4, we report estimates of our main regression (Equation 3) for retail consumer spending. We report separately OLS and IV estimates as well as estimates with and without county controls/state fixed effects.

In each specification, the local response of retail consumer spending to fiscal stimulus is positive. Excluding county controls and state fixed effects, the OLS and IV estimates are 0.20 and 0.26, respectively. Including county controls and state fixed effects decreases both the OLS and IV estimated multipliers to 0.11.

The specification that includes state fixed effects and uses the instrument is our preferred specification. In Section 2.2.2, we show that state governments increased their own spending by around 50 cents for every dollar they received from the federal government. As long as counties within the state received the additional state spending in a uniform manner, the specification with state fixed effects mitigates the upward bias since it controls for the confounding government spending at the state level. Indeed, if we divide the increase in consumer spending without state fixed effects (but with county controls) by 1.5, we would derive a multiplier between 0.12-0.15, which is close to the specification with fixed effects.

3.2.2 Broader Consumption Multipliers using the Consumption Expenditure Survey (CEX)

A possible concern with using the Nielsen dataset is that it captures a relatively narrow set of consumer purchases. To translate our Nielsen estimates into a broader multiplier, we

Table 5: Nielsen and Consumption Expenditure Survey

Bundle	Spending categories	Nielsen estimate	Bundle size	Elasticity	Multiplier
Nielsen	food at home, alcohol and beverage, detergents, cleaning/hh products, small appliances, personal care products	0.11 ×	1.0 =	—	0.11
Non-durables	Nielsen + apparel, tobacco, reading	0.11 ×	1.3 ×	0.98 =	0.14
Non-durables & Services	Non-durables + food away from home, entertainment, telephone services, utilities, gas, public transportation	0.11 ×	3.6 ×	0.75 =	0.29
Non-durables h & Services & Durables	Non-durables & Services + education, furniture, car maintenance, health	0.11 ×	4.5 ×	0.74 =	0.36

Notes: Bundles of goods are constructed from the Consumption Expenditure Survey 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). Broader multipliers are computed by multiplying the Nielsen estimate times the bundle size times the elasticity.

compare Nielsen-type purchases from the Interview survey of the CEX (food at home, alcohol and beverage, detergents, cleaning products and other household products, small appliances, and personal care products) to more general types of spending. We focus on three consumption bundles. First, similarly to Kaplan, Mitman, and Violante (2020), we construct a set of non-durable goods that includes, in addition to our Nielsen-based bundle, spending on apparel, tobacco, and reading. In this CEX-based bundle, spending is on average 1.3 times larger than the Nielsen-based one. Second, we construct an even broader spending group that adds services, such as food away from home, spending on entertainment, telephone services, utilities, gas, and public transportation. Spending on this bundle is on average 3.6 times larger than the Nielsen-based one. Finally, we construct a bundle that also adds durables, such as spending on education, furniture, car maintenance, and health. This bundle is on average 4.5 times larger than the Nielsen-based one.[12] Table 5 shows a summary of goods included in each of the various bundles.

[12] The expenditure shares for similar bundles of goods in the Diary Survey are significantly larger. Nonetheless, according to Bee, Meyer, and James (2012), the Interview survey tracks aggregate spending more closely than the Diary survey. The Interview is designed to collect relatively larger expenditures and those that occur regularly. The Diary is designed to capture small, infrequent purchases that may be missed in the Interview part. A detailed analysis of estimation results based on different surveys can be found in Appendix D.

We next estimate the elasticity of each broader spending measure to Nielsen-type spending. We estimate the following household-level regression using CEX data between 2000-2015

$$\log C^{j}_{i,t} = a + \psi \times \log C^{\text{Nielsen}}_{i,t} + X_{i,t}\ \Phi' + \varepsilon_{i,t} \tag{4}$$

where i denotes household, t denotes time, and j denotes one of the three broader bundles. We include, as household controls, a cubic on age and dummies on race, education, family type, and region, and use the weights provided by the survey.

According to Aguiar and Bils (2015), high-income households in the CEX tend to underreport their spending relative to low-income households. To alleviate potential measurement error concerns, we follow the approach in Aguiar and Bils (2015) and instrument the households' current spending with their lagged spending. Table 5 shows the elasticities estimated by Equation (4) when $C^{\text{Nielsen}}_{i,t}$ is instrumented by its lagged spending.

We find that a 1 percent increase in Nielsen-type categories is associated with a 0.98 percent increase in non-durable consumer spending, a 0.75 percent increase in combined spending on non-durable goods and services, and a 0.74 percent increase on overall spending that also includes durables. The estimated elasticities without the instrument are lower. A 1 percent increase in Nielsen-type categories is associated with a 0.90 percent increase in non-durable consumer spending, a 0.57 percent increase in combined spending on non-durable goods and services, and a 0.54 percent increase on overall spending that also includes durables (see Table D-1 in Appendix D).

Multiplying the elasticity from the IV estimation with the expenditure share and combining with our preferred estimate from Table 4, we arrive at a local consumption multiplier equal to 0.14 for non-durable spending, equal to 0.29 for spending on non-durable goods and services, and equal to 0.36 for overall spending that also includes durables.

3.2.3 The Effect of the Recovery Act on Auto Spending (FRB NY Equifax data)

We estimate a positive response of fiscal stimulus to auto spending (Table 6).[13] In our preferred specification, which includes county controls/state fixed effects and uses the IV, we 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.

[13] 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. The 2008 payments were about twice the 2001 payments which may explain the differences between the studies. With respect to non-durable goods, both studies find similar results: a significant increase in non-durable spending.

Table 6: Local Auto Spending Multipliers

Spending Category	Auto Spending (CCP/Equifax)			
	OLS	IV	OLS	IV
Government Spending	0.07*** (0.01)	0.11*** (0.01)	0.06*** (0.01)	0.09*** (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. The standard errors are given in parentheses. One, two, and three stars denote significance at the 10%, 5%, and 1% levels, respectively.

This explains the differences in the number of counties.

3.2.4 Summing the Consumption Spending Categories

We found a local retail spending multiplier from Nielsen Retail Scanner equal to 0.11 (Table 4). Using CEX data, we translated this estimate into a broader local multiplier equal to 0.14 for non-durable goods, 0.29 for combined spending on non-durable goods and services, and 0.36 for the bundle that also includes durable purchases (Table 5). Finally, we found a local auto spending multiplier from Equifax equal to 0.09 (Table 6). Since our definition of durable purchases did not include auto spending, by adding the local auto multiplier, we arrive at an estimate of the local consumption multiplier for overall spending equal to 0.45.

Our target multiplier in the model is the consumption multiplier derived from estimates of the bundle including non-durable goods and services (equal to 0.29). We find this appropriate as our model does not include investment in durable goods.

3.3 The Effect of Trade Linkages on the Local Consumption Multiplier

The local consumption multiplier is identified from the relative cross-regional responses to relative cross-regional differences in government spending. Trade linkages are an important channel for government spending to affect economic activity across regions. When regions trade intensively with each other (a case resembling a low preference for local goods), the fiscal stimulus must generate a smaller relative response since government spending is spread through trade flows. In contrast, when counties are in distant trade relationships, the local multiplier must be relatively large since government spending is mostly absorbed by the recipient county. This mechanism is at the heart of our model (presented in the next section) and explains why the local multiplier turns out to be around half the aggregate multiplier.

We test this mechanism using data on shipments of goods across U.S. states from the Commodity Flow Survey (CFS). The data include information on commodities shipped, their value, and the origin and destination of the shipments. The largest trading partners of a state (based on the share of shipments exported) are often neighboring states, although it is possible for states to trade intensively with relatively distant regions that maintain large economies. For example, the top two trading partners of Texas are Louisiana and California, of Minnesota are Wisconsin and Illinois, and of Florida are Georgia and Texas.

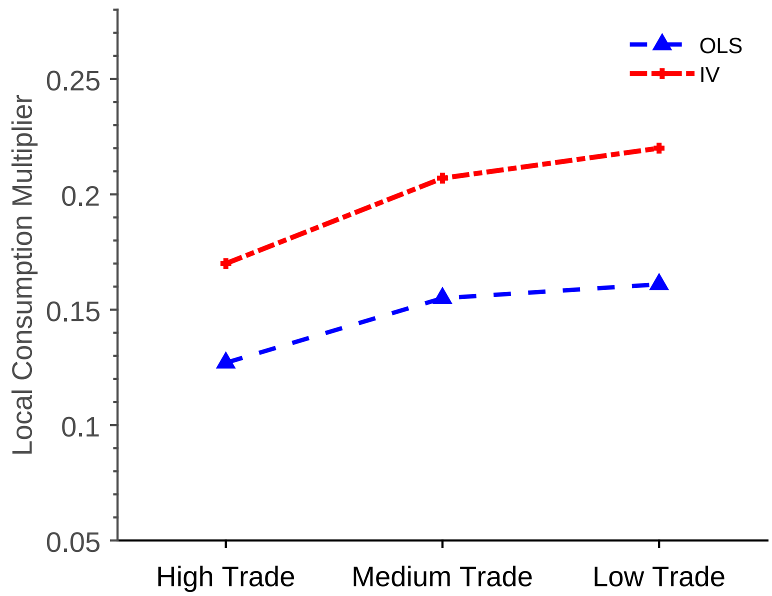
Our objective is to split counties into high-trade, medium-trade, and low-trade groups. The local multiplier should be relatively higher in low-trade groups, since the stimulus remains largely local, and relatively lower in high-trade groups since the stimulus is shared between the regions. We formulate trade groups sequentially. In the case of high- (low-) trade groups, we start a group from an initial—unmatched—county and assign new counties in the group that have the largest (smallest) trade exposure with the existing counties in the group.[14] We also consider a middle case where assignment of counties to groups occurs with half probability based on high-trading partners and half based on low-trading partners (called "middle-trade groups"). We formally describe our algorithm in Appendix E.

From the high-trade groups formed, 41 percent consist of groups with counties from the same state, 36 percent of counties that belong to two separate states, and 21 percent that belong to three or more states. The average distance between two counties in a group is 426 miles. On average, the share of exports toward counties in the same group is 6.1 percent. All low-trade groups consist of counties belonging to three or more states, the average distance between two counties in the group is equal to 1016 miles, and the average share of exports is equal to 2.2 percent.

We estimate the local consumption multiplier for each case: (i) low-trade groups, (ii) medium-trade groups, and (iii) high-trade groups. We use the following specification (written

[14]Given our base sample of around 365 counties we pick the number of counties in each group to be nine which gives around 40 groups (as many as the number of states in our data).

Figure 3: Local Consumption Multiplier and Trade Linkages



Notes: The figure shows the estimate of the local consumption multiplier based on retail spending data. We run the regression in Equation (5) for three cases: high-, medium-, and low-trade groups.

for the case of low-trade groups, as an example):

$$\frac{\Delta C_j}{C_{j,2008}} = a + \beta^{\mathrm{low}} \times \frac{G_j}{C_{j,2008}} + X_j \ \ \Phi' + \sum_{1}^{N} D_{j\in\mathcal{G}} \ \ + \varepsilon_j. \tag{5}$$

The left-hand side variable is the cumulative growth rate of retail spending at county j relative to 2008, and G_j is the total money awarded per household in county j during the period 2009-2012. X_j includes county-level controls which are population, 2007 and 2008 (per capita) incomes, and the 2007 and 2008 unemployment rates. $D_{j\in\mathcal{G}}$ is a group dummy: it takes the value of one if county j belongs to a group $\mathcal{G}$ and zero otherwise. We use, in turn, least squares and instrumental variable regression. We run the same regressions for medium- and high-trade groups and derive β^{medium} and β^{high}, respectively.

The local multiplier, which is estimated from the response of the treated relative to the untreated, reflects the type of the trade group. Our hypothesis is that the relative response of the treated counties in a high-trade group should be smaller compared to the relative response of the treated counties in a low-trade group.

Figure 3 plots the estimated local multipliers (the β's) for the case of high-, medium-, and low-trade groups (ordered from high to low to facilitate comparison with our model). The local consumption multiplier (both OLS and IV) clearly increases as trade openness decreases. According to our IV estimates, the local multiplier can increase by 30% if the stimulus is directed from high- to low-trade regions. All estimates are statistically different from zero at the 1 percent.[15] We demonstrate a similar relationship between trade intensity and the local consumption multiplier in our model by computing the local multiplier as we vary the underlying parameter that determines trade intensity.

4 Model

This section presents our model. It features multiple regions that engage in intermediate-input trade, heterogeneous households, and incomplete markets.

4.1 Description of the Economy

The model is dynamic and solved in general equilibrium. In the model description below, we abstract from the time subscript t. The economy has $N = 2$ regions: one (small) region and the rest of the economy. Nakamura and Steinsson (2014) also assume this geographical representation. To be consistent with our empirical evidence (which is based on county-level responses), we calibrate the size of the small region according to the population size of the average county in the United States.

Each region i has its own real 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 in each region, indexed by (i, j). Intermediate good firm j located in region i produces $y_{i,j}$ at price $p_{i,j}$. Regional trade takes place through trade in intermediate inputs. Regional trade flows are calibrated based on data from the CFS that combine shipments of final and intermediate goods. Through the lens of the model, we interpret all trade flows (including tradeable services) as trade in the intermediate sector and assume that the final goods are only locally consumed.[16]

The region i population is denoted μ_i with $\sum_i \mu_i = 1$. Populations do not vary across time. The regions are symmetric, i.e., per-capita variables are identical across regions at the steady state. In each region there is a continuum of households making consumption, working, and saving decisions. Finally, there is a government buying final goods from each region. To

[15] Detailed estimates used to construct the plot appear in Table E-1 in Appendix E. As an additional exercise, we form groups based on geographical distance instead of trade flows. We find that as a group's geographical borders expand, the local multiplier increases since trade flows within the group likely become weaker.

[16] Our model allows trade in goods but not labor movement between regions. Auerbach, Gorodnichenko, and Murphy (2019) show that local federal spending does not pull in labor from nearby locations. House, Proebsting, and Tesar (2020) also explore fiscal policy in a multi-country DSGE setup with explicit trade linkages. In their model, each country has a representative household.

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). Therefore, there are two sources of market incompleteness in the model: first, across regions, and second, within regions.

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. The good is fully consumed at the time of the purchase and does not provide any service beyond the current period. Hence, consumption corresponds to non-durable spending. 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

$$U = \mathbf{E}_0 \left[\sum_{t=0}^{\infty} \beta^{t-1} \left\{ \log(c_{i,t}) + \psi \frac{(1-h_{i,t})^{1-\theta}}{1-\theta} \right\} \right] \tag{6}$$

where ψ affects the utility from leisure and θ affects the Frisch elasticity of labor supply.[17] β is the household's idiosyncratic discount factor which does not vary across time (Krueger, Mitman, and Perri, 2016; Hagedorn, Manovskii, and Mitman, 2017). Half of the households in each region are impatient ($\beta = \bar{\beta} - \epsilon_\beta$) and half are patient ($\beta = \bar{\beta} + \epsilon_\beta$). Discount factor heterogeneity allows the model to be consistent with evidence of non-durable consumption responses to tax rebates.

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:

$$\log x_{t+1} = \rho \log x_t + \eta_{t+1}, \qquad \text{with} \quad \eta_{t+1} \sim \text{ iid } N(0, \sigma_\eta^2). \tag{7}$$

Therefore, households are heterogeneous for two reasons. First, because they have different

[17] Given the utility specification, the Frisch elasticity of labor supply depends on both θ and the hours worked h. In Section 6, we analyze a utility function specified in terms of disultility of hours worked where θ is directly interpreted as the labor supply elasticity.

discount factors and second, because they receive in every period different shocks to their productivity. The differences in patience and labor earnings result in differences in consumption and asset holdings. The transition matrix that describes the autoregressive process in Equation (7) is given by $\Gamma_{xx'}$.

In each period t, a household residing in region i saves $a_{i,t+1}$ in a regional mutual fund. The mutual fund is discussed in detail below. One period later, the household receives from the mutual fund a real return equal to $r_{i,t+1}$. Following Kaplan, Moll, and Violante (2018) we assume that households receive a $1-\omega$ fraction of real dividends, $D_{i,t}$, directly from the local intermediate firms. This additional income is interpreted as the profit-sharing component of worker compensation such as bonuses, commissions, and stock options. The residual share of dividends $(1-\omega)D_{i,t}$ is distributed proportionately to workers' labor productivity $\delta(x) = \frac{x}{\bar{x}}$ where $\bar{x}$ is the average labor productivity. Finally, households pay income taxes on the sum of wage payments and bonuses, based on the tax schedule $\mathcal{T}(.)$. We denote the regional distribution of households across productivity, asset holdings, and discount rates 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.

$$V_t(x_t, a_t, \beta; \phi_{i,t}) = \max_{c_t, a_{t+1}, h_t} \left\{ \log(c_t) + \psi \frac{(1-h_t)^{1-\theta}}{1-\theta} + \beta \sum_{x_{t+1}} \Gamma_{x_t, x_{t+1}} V_{t+1}(x_{t+1}, a_{t+1}, \beta; \phi_{i,t+1}) \right\} \tag{8}$$

$$\textbf{s.t.} \quad c_t + a_{t+1} = w_{i,t} x_t h_t - \mathcal{T}(.) + (1 + r_{i,t}) a_t + (1-\omega)\delta(x_t) D_{i,t} \tag{9}$$

$$a_{t+1} \geq 0. \tag{10}$$

4.3 Mutual Fund

There is a mutual fund in each region. The fund collects savings from local households, $A_{i,t+1} = \int_{\phi_{i,t}} a_{i,t+1}$. The fund next purchases government bonds, $B^m_{i,t+1}$, and shares, $s_{i,t+1}$, that represent claims on the profits of intermediate firms in region i. The price of each share (relative to the price of the final good) is $q_{i,t}$. The mutual fund chooses $B^m_{i,t+1}$ and $s_{i,t+1}$ to maximize its real long-run profits:

$$V^m_{i,t} = (1+R_{t-1})B^m_{i,t} + (q_{i,t} + (1-\tau_d)\omega D_{i,t}) s_{i,t} - (1+\pi_{i,t+1}) B^m_{i,t+1} - q_{i,t} s_{i,t+1} + \frac{1}{1+r_{i,t+1}} V^m_{i,t+1}. \tag{11}$$

The government bond costs \$1 and pays $(1+R)$ dollars where R is the nominal interest rate. $\pi_{i,t+1}$ is the region-specific inflation rate defined as

$$\pi_{i,t+1} = \frac{P_{i,t+1}}{P_{i,t}} - 1 \tag{12}$$

where P_i is the price of the final good in region i (defined below). Each period, the mutual fund receives after-tax dividends $(1-\tau_d)\omega D_{i,t}$, where ω is the fraction of dividends not distributed directly as employment compensation. The mutual fund pays back households using the revenues from holding government bonds and shares (zero profit condition):

$$(1+r_{i,t})A_{i,t} = (1+R_{t-1})B^m_{i,t} + (q_{i,t} + (1-\tau_d)\omega D_{i,t})s_{i,t}. \tag{13}$$

Solving the mutual fund's problem gives rise to a no-arbitrage condition:

$$1 + r_{i,t+1} = \frac{1+R_t}{1+\pi_{i,t+1}} = \frac{q_{i,t+1} + (1-\tau_d)\omega D_{i,t}}{q_{i,t}}. \tag{14}$$

Combining Equations (13) and (14) gives the total amount of savings in region i:

$$A_{i,t+1} = (1+\pi_{i,t+1})B^m_{i,t+1} + q_{i,t}s_{i,t+1}. \tag{15}$$

4.4 Firms

We describe here the problem of the final good firm and of the intermediate good firms. Unless stated otherwise, we abstract from the time subscript t.

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

$$Y_i = \left[\sum_{i'=1}^{N} \gamma_{ii'}^{\frac{1}{\epsilon}} \int_j \omega_{i,i',j}^{\frac{\epsilon-1}{\epsilon}} dj\right]^{\frac{\epsilon}{\epsilon-1}}. \tag{16}$$

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

$$\omega_{i,i',j} = \gamma_{ii'} \left[\frac{p_{i',j}}{P_i}\right]^{-\epsilon} Y_i. \tag{17}$$

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

$$P_i = \left[\sum_{i'=1}^{N} \gamma_{ii'} \int_j p_{i',j}^{1-\epsilon} dj\right]^{\frac{1}{1-\epsilon}}. \tag{18}$$

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

$$y_{i,j} = L_{i,j} \tag{19}$$

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

$$y_{i,j} = \sum_{i'} \mu_{i'} \omega_{i',i,j}. \tag{20}$$

Due to monopolistic competition, the intermediate good firm takes the demand into account when setting its price $p_{i,j}$. The intermediate good firm discounts the future based on the rate of return r. We denote $\tilde{\beta}_i = \frac{1}{1+r_{i,t+1}}$. Each firm can adjust its price with probability λ. Since the intermediate good firm is solving a dynamic problem we re-introduce the time subscript t into our equations. The reset price p^* is found by maximizing the value of firm

$$\max_{p^*_{i,j,t}} \sum_{s=0}^{\infty} (1-\lambda)^s \frac{1}{\Pi_{h=1}^{s}(1+r_{t+h})} \left\{p^*_{i,j,t+s} y_{i,j,t+s} - W_{i,t+s} L_{i,j,t+s}\right\} \tag{21}$$

where $W_{i,t}$ is the nominal wage. This leads to the optimal pricing equation

$$\frac{p^*_{i,j,t}}{P_{i,t}} = \frac{\epsilon}{\epsilon-1} \frac{\sum_{i'=1}^{N} \mu_{i'} \gamma_{i'i} Q^{\epsilon}_{i',i,t} \left[w_{i,t} Y_{i',t} + (1-\lambda)\tilde{\beta}_i (1+\pi_{i',t+1})^{1+\epsilon} \mathcal{X}_{i',i,t+1}\right]}{\sum_{i'=1}^{N} \mu_{i'} \gamma_{i'i} Q^{\epsilon}_{i',i,t} \left[Y_{i',t} + (1-\lambda)\tilde{\beta}_i (1+\pi_{i',t+1})^{\epsilon} \mathcal{Z}_{i',t+1}\right]} \tag{22}$$

with

$$\mathcal{X}_{i',i,t} = w_{i,t} Y_{i',t} \;+\; (1-\lambda)\tilde{\beta}_i (1+\pi_{i',t+1})^{1+\epsilon} \mathcal{X}_{i',i,t+1} \tag{23}$$

$$\mathcal{Z}_{i',i,t} = Y_{i',t} \;+\; (1-\lambda)\tilde{\beta}_i (1+\pi_{i',t+1})^{\varepsilon} \mathcal{Z}_{i',i,t+1}. \tag{24}$$

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

$$d_{i,j,t} = \frac{p_{i,j,t}}{P_{i,t}} y_{i,j,t} - w_{i,t} y_{i,j,t} \tag{25}$$

and the per-capita real dividends in region i are $D_i = \int_j d_{i,j}$.

4.5 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,

$$R_t = R_{ss} + \zeta \hat{\pi}_t. \tag{26}$$

The aggregate inflation rate $\hat{\pi} = \sum_i \mu_i \pi_{i,t}$ is a weighted average of the regional inflation rates. Since after 2008 the short-term nominal rates were nearly zero, we set $\zeta = 0$ in our benchmark calibration. This case captures the effect of government spending in an environment where the monetary authority is unresponsive to inflation pressures.

4.6 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 and dividend taxes. Labor-income taxes are the sum of a lump-sum component T and a proportional tax τ:

$$\mathcal{T}_t = -T + \tau[w_{it} x_t h_t + \delta(x_t)(1-\omega) D_{it}].$$

The government budget constraint reads

$$\sum_i \mu_i (1+\pi_{i,t+1}) B^m_{i,t+1} - (1+R_{t-1}) \sum_i \mu_i B^m_{i,t} = \sum_i \mu_i G_{i,t} - \sum_i \mu_i \int_{\phi_{i,t}} \mathcal{T}_t - \tau_d \omega \sum_i \mu_i D_{it} \tag{27}$$

where $B^m_{i,t}$ is the bond holdings of the regional mutual fund. In equilibrium, the demand for government bonds by the regional mutual funds is equal to the supply of government bonds by the government: $\sum_i \mu_i B^m_{i,t} = B^g_t$.

4.7 Regional Accounts

We describe the regional income accounts once more 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.

4.8 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

$$\int_j y_{i,j,t} = \mu_i \mathcal{Y}_{i,t} = \sum_{i'} \mu_{i'} \gamma_{i'i} \left[\frac{\int_j p_{i,j,t}}{P_{i',t}} \right]^{-\epsilon} Y_{i',t} \tag{28}$$

$$= \left[\lambda \left(\frac{p^*_{i,j,t}}{P_{i,t}} \right)^{-\epsilon} + (1-\lambda)(1+\pi_{i,t})^{\epsilon} \right] \cdot \sum_{i'} \mu_{i'} \gamma_{i'i} Q^{\epsilon}_{i',i,t} Y_{i',t}. \tag{29}$$

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-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 $Q^{\epsilon}_{i',i,t}$.

4.9 Definition of the Equilibrium

We describe the equilibrium over the transition and leave the description of the steady-state equilibrium for Appendix F. 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 $\{C_{i,t}\}_{i=1}^2$, $\{L_{i,t}\}_{i=1}^2$, $\{A_{i,t+1}\}_{i=1}^2$, $\{B^m_{i,t+1}\}_{i=1}^2$, $\{Y_{i,t}\}_{i=1}^2$,

$\{\mathcal{Y}_{i,t}\}_{i=1}^2$, $\{w_{i,t}\}_{i=1}^2$, $\{\pi_{i,t}\}_{i=1}^2$, $\{q_{i,t}\}_{i=1}^2$, $\{\frac{p^*_{i,j,t}}{P_{i,t}}\}_{i=1}^2$, $Q_{12,t}$, $\{D_{i,t}\}_{i=1}^2$, 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.

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:

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

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

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

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

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 $\mu_i \mathcal{Y}_{i,t}$. 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) Household savings equal the demand for government bonds and equity shares by the mutual

funds

$$\sum_i \mu_i A_{i,t+1} = \sum_i \mu_i (1+\pi_{i,t+1}) B^m_{i,t+1} + \sum_i \mu_i q_{i,t}$$

where the total number of shares is normalized to one and the value of equity, $q_{i,t}$, is given by arbitrage Equation (14).

7) The demand for government bonds by the mutual funds equals the supply of bonds by the government: $\sum_i \mu_i B^m_{i,t} = B^g_t$. The supply of bonds along the transition is given by the following fiscal rule: $B^g_t = B^g_{ss} - \sum_i \mu_i (q_{i,t} - q_{i,ss})$. The rule requires that any gains/losses in equity value are compensated by an equivalent injection or withdrawal of government bonds from the asset market. We discuss this rule in the next section.

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

$$\sum_i \mu_i (1+\pi_{i,t+1}) B^m_{i,t+1} - (1+R_{t-1}) \sum_i \mu_i B^m_{i,t} = \sum_i \mu_i G_{i,t} - \sum_i \mu_i \int_{\phi_{i,t}} \mathcal{T}_t - \tau_d \omega \sum_i \mu_i D_{it}.$$

9) The monetary policy does not respond to inflation: $R_t = R_{ss}$.

10) National inflation rate is given by: $\hat{\pi}_t = \sum_{i=1}^2 \mu_i \pi_{i,t}$.

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

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 $Q_{ii'} = 1 \, \forall i, i'$.

4.10 Properties of the Equilibrium

In our equilibrium, we restrict attention to transition paths for which at a sufficiently long time after the fiscal stimulus is over, the inflation rate in both regions is equal to its steady-state value, i.e., $\pi_{i,t^*} = 0$, for all regions, and the relative price is equal to its steady-state value, i.e., $Q_{12,t^*} = 1$, where t^* is sufficiently large. As such, equilibrium paths converge over time to the initial steady state. Since the monetary policy (i.e., the nominal interest rate) does not respond to inflation, it is possible that there are multiple equilibrium paths that lead to the original steady state.

We focus on the minimum state variable equilibrium (MSV) which arises when the optimal choices depend on a minimal set of state variables. In the MSV equilibrium, it is not possible to delete a single state variable (or a group of state variables) from agents' policy functions and continue to obtain a solution that satisfies the model's equilibrium conditions (McCallum, 1983). Alternative equilibria would require extraneous state variables (e.g. sunspot shocks) whose inclusion could still give a solution satisfying the equilibrium conditions but would not be necessary in order to obtain one.[18]

There are good reasons to focus on the minimum state variable equilibrium. According to Angeletos and Lian (2021), an infinitesimally small memory loss on behalf of future agents can render all but one equilibria, the minimum state variable equilibrium, explosive. Thus, as long as someone restricts attention to paths converging to the initial steady state (as we do), the minimum state variable equilibrium is the unique non-explosive equilibrium path.

According to our fiscal rule, any decline in equity value is met with an equivalent increase in government debt. As is typical in models with sticky prices, government spending increases the nominal wages, reducing the markup and therefore the firms' dividends and the value of equity. The equity shares are implicitly held by households (together with government bonds). We neutralize the effect of movements in equity value by making the assumption that the government intervenes and injects liquidity in the economy in the form of an additional supply of government bonds.[19]

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 7 summarizes our parameter choices. The model period is a quarter. The average discount factor, $\bar{\beta}$, is set to match an annual steady-state real interest rate equal to 4 percent. The utility from leisure parameter ψ is set so that on average households work 42 percent of their time endowment.[20] Parameter θ that governs the Frisch elasticity of labor supply, is set to 1 based on Beraja, Hurst, and Ospina (2019). This value reflects a combined labor supply response at the intensive and extensive margin.

The productivity process is calibrated based on the estimates of Floden and Linde (2001).

[18] Hagedorn (2017) and Hagedorn, Manovskii, and Mitman (2017) offer an alternative possibility to avoid multiple equilibria. In their framework, uniqueness of equilibrium is guaranteed by a combination of incomplete markets (and thus, precautionary savings) and nominal bond targeting. This result does not apply to our case where we make the more standard assumption that the government targets real debt.

[19] In Kaplan, Moll, and Violante (2018) the equity is part of illiquid assets. As a result, they can neutralize the effects of a countercyclical movement in equity value by assuming a profit distribution rule that guarantees an illiquid income flow that is independent of the markup. We cannot rely on a similar assumption as our model features a single asset.

[20] 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 7: Benchmark Parameters

Parameter	Notation	Value	Target / Source
Mean discount factor	$\bar{\beta}$	0.985	Annual real rate=4%
Dispersion in discount factor	ϵ_{β}	0.005	%Households with $a/y < 1\%$
Labor supply elasticity	$1/\theta$	1.0	Beraja, Hurst, and Ospina (2019)
Disutility of labor	ψ	5.8	Hours worked=42%
Persistence of x	ρ	0.955	Persistence of log-wages = 0.92
Variance of innovation to x	σ_{η}^2	1.5%	Variance of log-wages = 0.04
Per-capita gov. spending	G	0.10	G/Y=20%
Dividend allocation	ω	0.32	NIPA Tables
Elasticity of substitution	ϵ	6	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	B^g	1.2× Annual income	Survey of Consumer Finances
Dividend tax	τ_d	0.25	Gourio and Miao (2010)
Lump-sum transfer	T	0.03	T/Y=6%
Size of Region 1	μ_1	3.1%	Relative county population
Home bias	α	0.58	Commodity Flow Survey

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 percent. The lump-sum transfer T is equal to 6 percent of annual income (Kaplan, Moll, and Violante, 2018). We set the elasticity of substitution $\epsilon = 6$ based on Christiano, Eichenbaum, and Rebelo (2011). The probability of changing price $\lambda = 0.15$ is based on McKay, Nakamura, and Steinsson (2016).[21]

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 and the discount factor dispersion, represented by the parameter ϵ_{β}, to match the fraction of households whose liquid assets are less than 1 percent of their annual 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 are 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)

[21] This is on the lower end of the empirical estimates, but it is supported by the absence of inflation pressures during and in the aftermath of the Recovery Act.

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. We also find that the fraction of households whose liquid assets are less than 1 percent of their annual income is 29 percent.

Based on national income accounts, we find that for the period 2007-2008, the undistributed corporate profits were, on average, \$394 billion, while dividend income was \$809 billion. Thus, undistributed corporate profits as a share of total dividends (both undistributed and distributed as income) is around 32 percent. Therefore, we use a value of $\omega = 0.32$, which is slightly lower than the value of 0.33 used by Kaplan, Moll, and Violante (2018). The dividend tax equals 0.25 based on Gourio and Miao (2010).

There are two regions in the model: one small region and the rest of the economy. Consistent with our empirical exercise, we interpret Region 1 as a county. According to our analysis (presented in Appendix E) regional spillovers stabilize for geographical regions larger than 1000 miles, which roughly corresponds to the size of a U.S. Census region.[22] Thus, we set $\mu_1 = 0.031$ which represents the average size of a county relative to the Census region (weighted by county-level income in 2010).

The second regional parameter to calibrate is the preference of the final good firm for home versus foreign inputs, α. We calibrate home bias using direct evidence on shipments of goods from the CFS for 2012. As mentioned, the data include information on commodities shipped, their value, weight, and the origin and destination of the shipments across U.S. states. For every state, we compute the total value of shipments that originated and shipped inside the state, as well as the total value of shipments that originated in the state but were exported to other states. We find that on average 42 percent of shipments of goods stay within state borders.

Nonetheless, a large fraction of spending is directed toward services. According to NIPA tables for 2010, services absorb 68 percent of total spending. Services are traditionally considered non-tradable, but a substantial fraction can be delivered over a distance (e.g., financial or legal services). Gervais and Jensen (2019) document that the United States was exporting around 30 percent of its services in 2007. To account for both goods and services we estimate home bias as $(1 - 0.68) \times 0.42 + 0.68 \times 0.70 = 0.61$.

To calibrate a county-level home bias, we use the state-level home bias and the relative populations of these two geographical areas. Let $\mathcal{M}$ denote the size of the state that includes the county ($\mu \leq \mathcal{M}$). Let $\mathcal{S}$ denote the home bias of the state, which we found to be 0.61 and is at least as large as the home bias of the county, so that $\alpha \leq \mathcal{S}$. If demand increases by \$1 in a random county that is part of the state, then the county keeps α and exports $1 - \alpha$. The

[22]The U.S. Census Bureau considers four regions: the Northeast, the Midwest, the South, and the West.

exports will be absorbed by the other counties of the same state 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 whole economy absorbs the exports, while $\frac{\mathcal{M}-\mu}{\mu}$ is the relative size of the state area, excluding the original county that received the dollar. As a result, we can write the state-level home bias using the formula

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

Based on population measures, we calculate the relative size of the state as $\mathcal{M} = 0.10$. This implies a county-level home bias equal to $\alpha = 0.58$.

5.2 Steady-State Results

In Table 8, we compare the model to data with respect to 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 percent. The wealth Gini is 0.75 in our model, which is lower than the empirical value of 0.93 but somewhat higher than in typical Aiyagari models.

Table 8 also reports the median and the average marginal propensity to consume. We transform the quarterly into an annual MPC using the formula $1 - (1 - \text{quarterly MPC})^4$. The annual average MPC in our model is 0.37, which corresponds to a quarterly MPC of 0.11.

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). Our MPC estimate is within this range. Sahm,

Table 8: Statistics over Liquid Assets and MPC

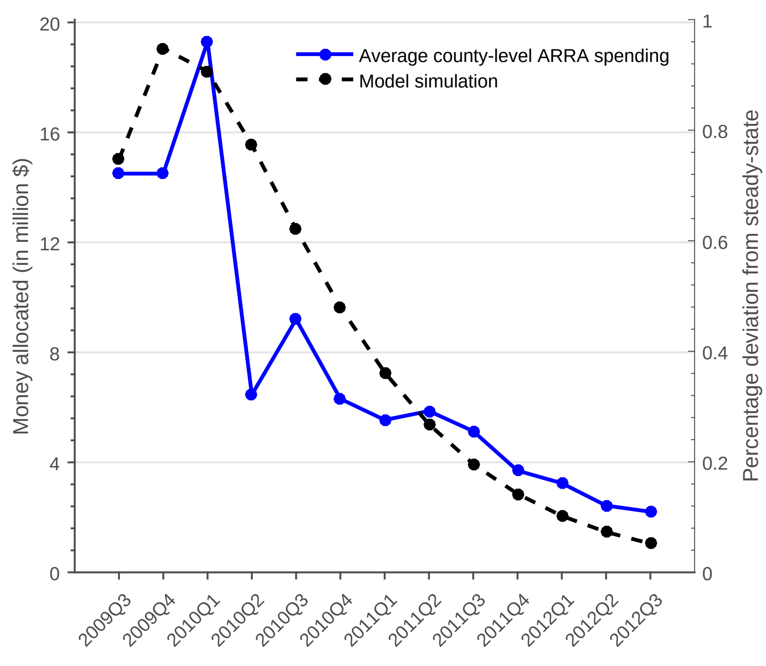
Statistic	SCF (1998-2007)	Model
Households with $a/y < 1\%$	0.29	0.30
Liquid Assets/Income	1.20	1.20
Liquid Assets Gini	0.93	0.75
Median MPC		0.11
Average MPC		0.37

Notes: The table presents summary statistics regarding wealth and the marginal propensity to consume. All statistics are reported at an annual frequency.

Shapiro, and Slemrod (2010) analyze survey responses and find that roughly one-third of the 2008 economic stimulus rebate income was spent and that the spending was concentrated in the few months after the receipt.[23] Also analyzing the tax rebates of the 2008 economic stimulus, Parker, Souleles, Johnson, and McClelland (2013) find that during the first three months households spend between 12-30 cents of every dollar received in non-durable goods. Once durable spending is taken into account, the authors find a marginal propensity to consume between 50-90 cents per dollar. Our quarterly MPC estimate is at the lower bound of their estimates regarding non-durable spending. 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 net worth feature the highest MPCs.

5.3 Government Spending Shock and Transition

Figure 4: 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).

[23]Their estimate of one-third is likely biased downward as the propensity to consume is bounded at one when they translate the “mostly spend” responses to a MPC. Sahm, Shapiro, and Slemrod (2012) document that the way the stimulus is delivered (reduction in tax withholdings versus one-time payments) matters for how much households spend.

We analyze the effect of a government spending shock on consumer spending. Figure 4 shows average county-level Recovery Act spending between 2009-2012.[24] 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 percent higher than the steady state. We calibrate the shock for Region 2 to be 36 percent lower than the shock in Region 1 since per-capita spending at the 25^{th} percentile of the distribution of ARRA funds was around 36 percent lower than at the 75^{th} percentile. The shock is assumed to be a one-time unexpected innovation, and households can perfectly foresee the future evolution of prices and quantities.

We plot the impulse response functions for macroeconomic aggregates in Figure 5. 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 responds almost equally.[25] Wages w_2 also increase in Region 2, both due to the local fiscal stimulus and the increased demand for local inputs coming from Region 1.

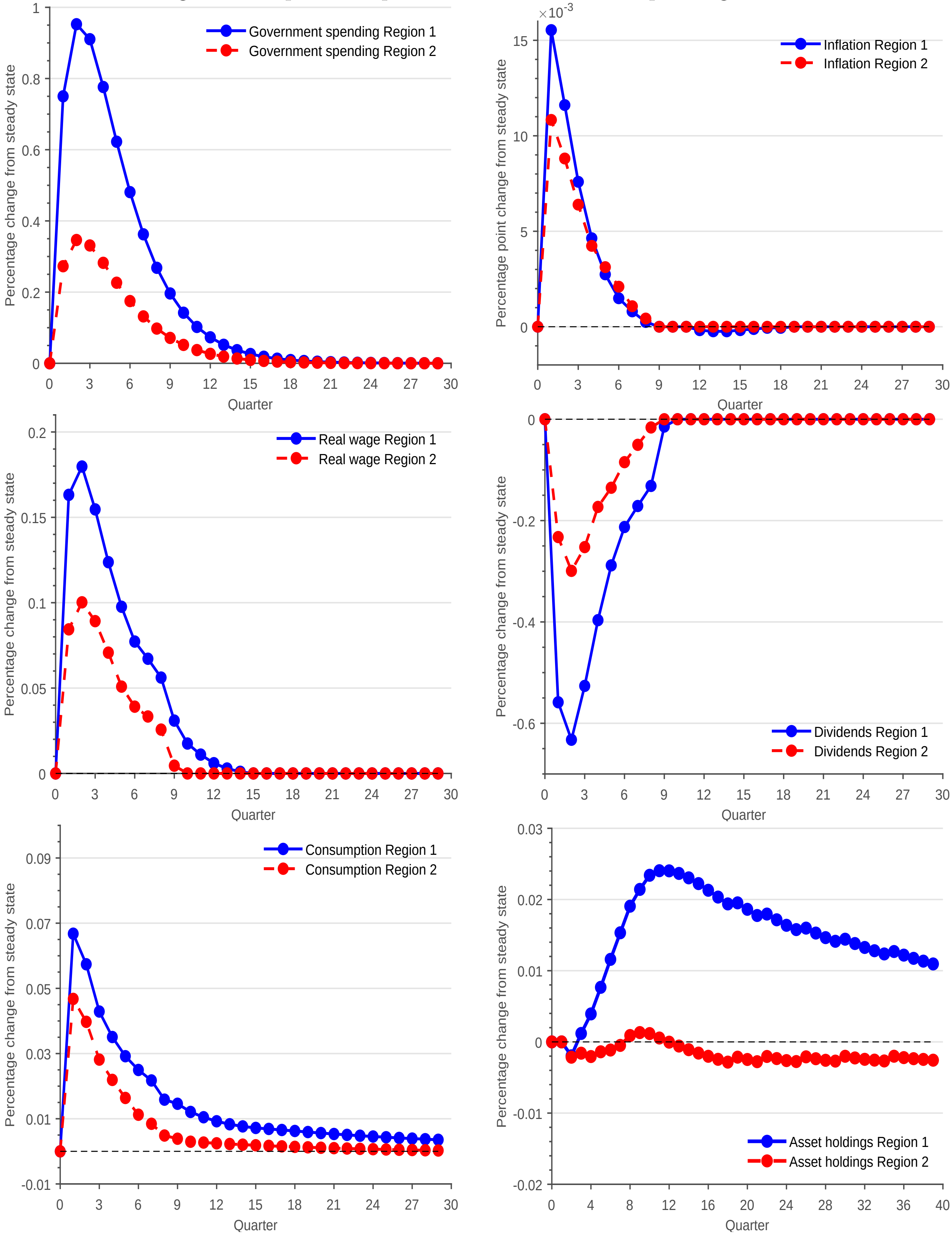
Higher inflation in Region 1 relative to Region 2 implies an initial small appreciation of the real exchange rate $Q_{i'i} = \frac{P_i'}{P_i}$. The appreciation induces an expenditure switching effect. The final good firm in Region 1 substitutes local with cheaper foreign intermediate inputs. This tends 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. 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.

Both regions increase consumer spending as a response to fiscal stimulus (lower left panel).

[24] 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.

[25] Both the aggregate and the relative response of inflation are small due the relatively high degree of price stickiness. We discuss the empirical validity of our calibration in Section 5.4.

Figure 5: 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.

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 asset holdings (lower right panel).

Table 9: Consumption Multipliers: Data vs. Model

Horizon	$t = 8$	$t = 16$	$t = 32$
Data			
Local	–	0.29	–
Model			
Local	0.15	0.20	0.26
Aggregate	0.41	0.41	0.47

Notes: The empirical target of 0.29 is the consumption multiplier for spending on non-durable goods and services (Table 5).

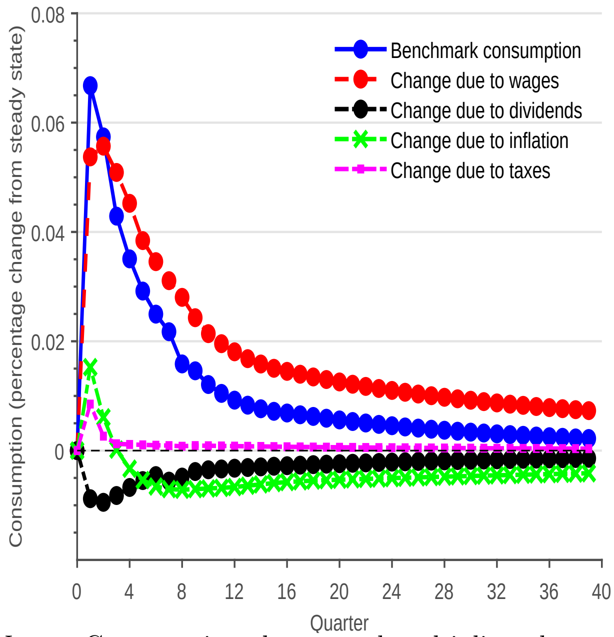
We compute local and aggregate consumption multipliers using the model-generated impulse responses. The local consumption multiplier is computed from the model-generated regional data using the same specification as in our empirical analysis (see Equation 3). The aggregate multiplier is computed as $\frac{\sum_i \mu_i \Delta C_{i,t}}{\sum_i \mu_i \Delta G_{i,t}}$ 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 9 presents our main two findings. First, the model generates a positive local multiplier reasonably close to the empirical target. Second, we find an aggregate fiscal multiplier equal to 0.41.

Table 10 decomposes the change in consumer spending due to wages, dividends, inflation, and taxes. In particular, we set a variable equal to its equilibrium path 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 left panel 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 interaction 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

Table 10: Change in Consumption: Decomposition



Consumption Multiplier	Local	Aggregate
Due to Wages	0.28	0.48
Due to Dividends	-0.05	-0.06
Due to Inflation	-0.02	-0.08
Due to Taxes	0.00	0.05
Total	0.20	0.41

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.

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 0.28 while the aggregate would be 0.48. 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 -0.05 while the aggregate would be -0.06. The combined effect of the two yields an aggregate multiplier of 0.42.

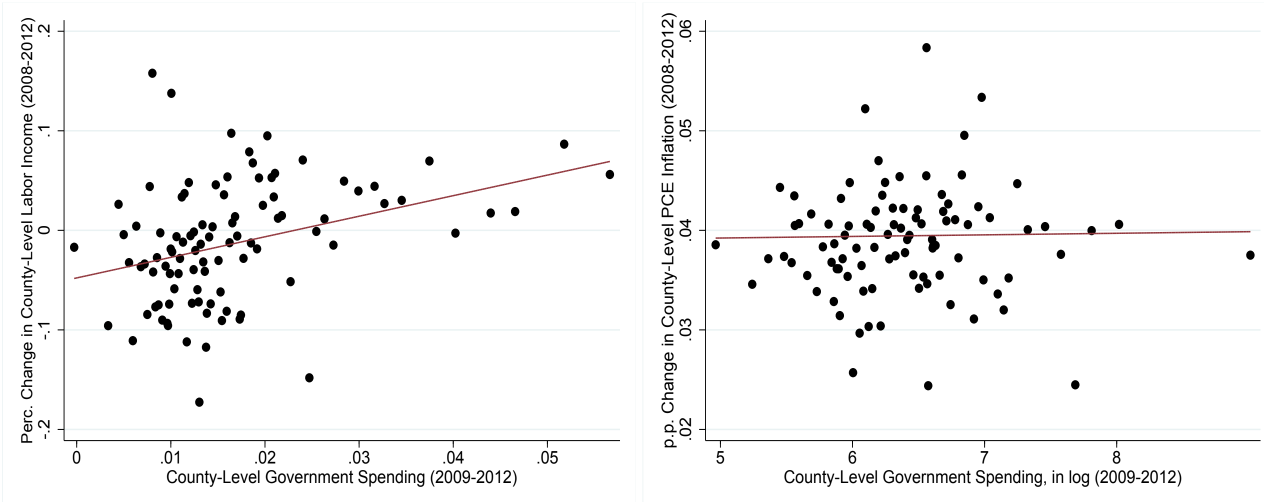
If only inflation had changed, the local multiplier would be -0.02 and the aggregate multiplier -0.08. The contribution of inflation to consumer spending is quantitatively small relative to the contribution of wages.[26]

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 0.05. 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 heterogeneous agents, incomplete markets model generates positive consumption responses both at the local and the aggregate level. In Section 6.1 we show that an incomplete

[26] 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).

Figure 6: 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 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.

markets, representative agent, New Keynesian model also generates positive local and aggregate multipliers, albeit much smaller than our Benchmark. In contrast, in models with complete markets, the local consumption multiplier is negative (see for example, Nakamura and Steinsson, 2014; Farhi and Werning, 2016; Chodorow-Reich, 2019). In addition, we show in Section 5.6 that the positive aggregate consumption multiplier is related to the weak response of monetary policy to fiscal stimulus.

5.4 Empirical Evidence on Labor Income and Inflation

The model generates 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 6 and Table 11). In contrast, there is no effect of government spending on inflation (Right Panel, Figure 6 and Table 11). Our model is consistent with these patterns. The local effect of government spending on inflation is nearly zero as both regions increase inflation by almost the same amount (Figure 5). This result arises due to our relatively high degree of price

Table 11: 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*** (0.34)	0.81* (0.41)	-0.000 (0.001)	-0.0002 (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: The 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. The 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.

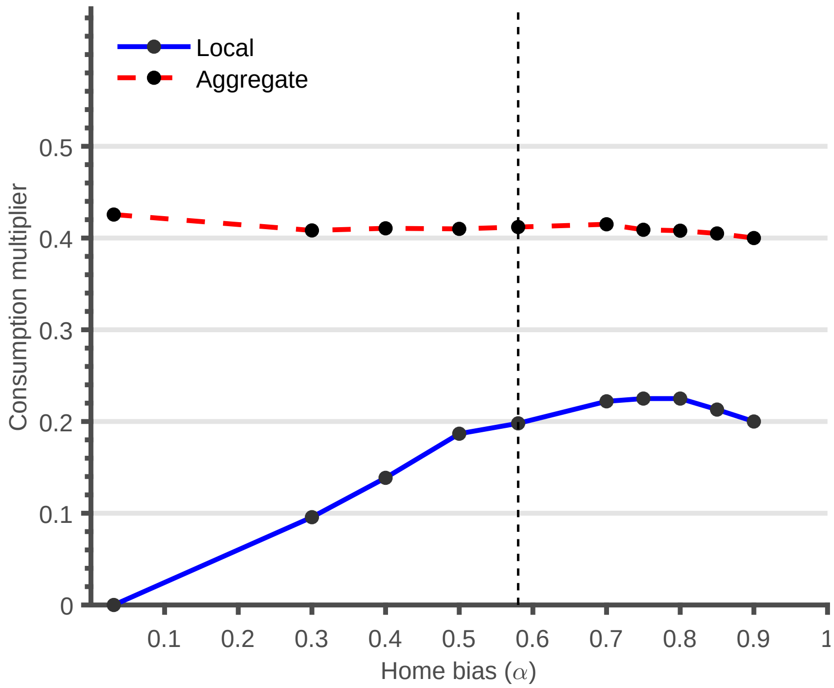
stickiness. Moreover, the local multiplier associated with labor income is positive, consistent with the empirical evidence.

5.5 The Role of Trade Linkages

Figure 7 shows the local and the aggregate consumption multiplier as we vary the degree of home bias α and keep all other parameters same as in the benchmark model. Consumption multipliers are reported at a four-year horizon. In our calibration, we set home bias equal to 0.58 using information on shipments of goods from the CFS (vertical line). This corresponds to a local consumption multiplier equal to 0.20 and an aggregate consumption multiplier equal to 0.41.

The local consumption multiplier is zero when $\alpha = \mu_1$. When home bias increases, trade flows between the two regions decline and Region 1 keeps more of the local fiscal stimulus. As a result, consumption in Region 1 increases more relative to consumption in Region 2. Thus, our model is consistent with the empirical evidence presented in Section 3.3: Lower home bias (stronger trade linkages) decreases the local consumption multiplier. The aggregate consumption multiplier is largely unaffected by the strength of trade linkages. Since the two regions are (per-capita) symmetric, the final division of government spending does not matter

Figure 7: Consumption Multipliers and Trade Linkages (Model)



Notes: We vary parameter α which captures the degree of home bias for Region 1. The benchmark calibration is $\alpha = 0.58$ (vertical line). We show the local and the aggregate consumption multiplier for a four-year horizon.

for the aggregate consumption response.[27]

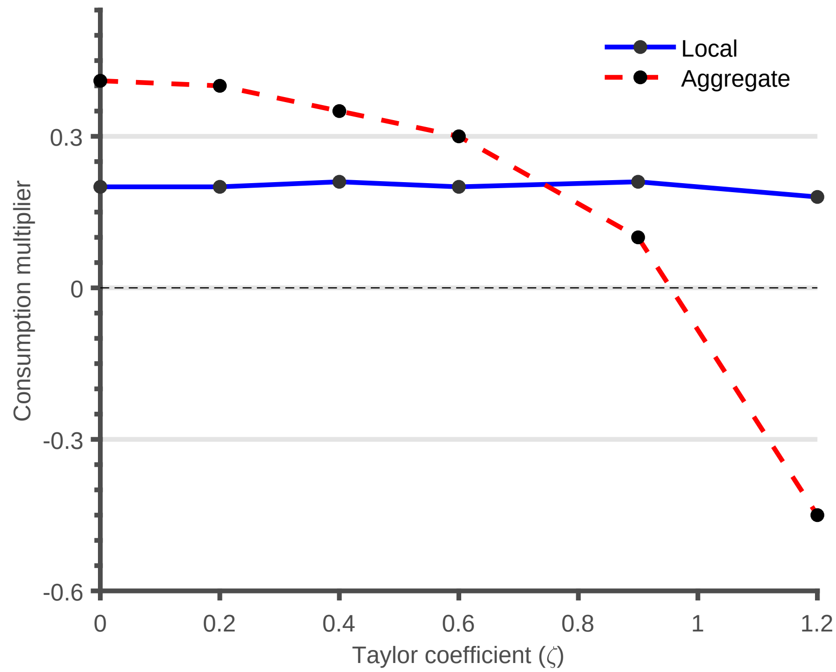
5.6 The Role of Monetary Policy

We analyze how monetary policy affects the response of consumption to fiscal stimulus. The nominal interest rate is given by a Taylor rule: $R_t = R_{ss} + \zeta \hat{\pi}_t$. For our benchmark parametrization, we have $\zeta = 0$, which corresponds to a monetary policy that is unresponsive to inflationary pressures, a case resembling the zero lower bound. Figure 8 shows the local and aggregate four-year consumption multiplier when we vary the Taylor rule coefficient ζ and keep all other parameters as in the benchmark parametrization.

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.

[27]When α is closer to one, 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. This explains why the local consumption multiplier decreases when home bias approaches one.

Figure 8: Consumption Multipliers and Monetary Policy



Notes: Taylor rule is given by $R_t = R_{ss} + \zeta \hat{\pi}_t$. In Benchmark, we have $\zeta = 0$. We vary parameter ζ and report the four-year local and aggregate consumption multiplier.

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.

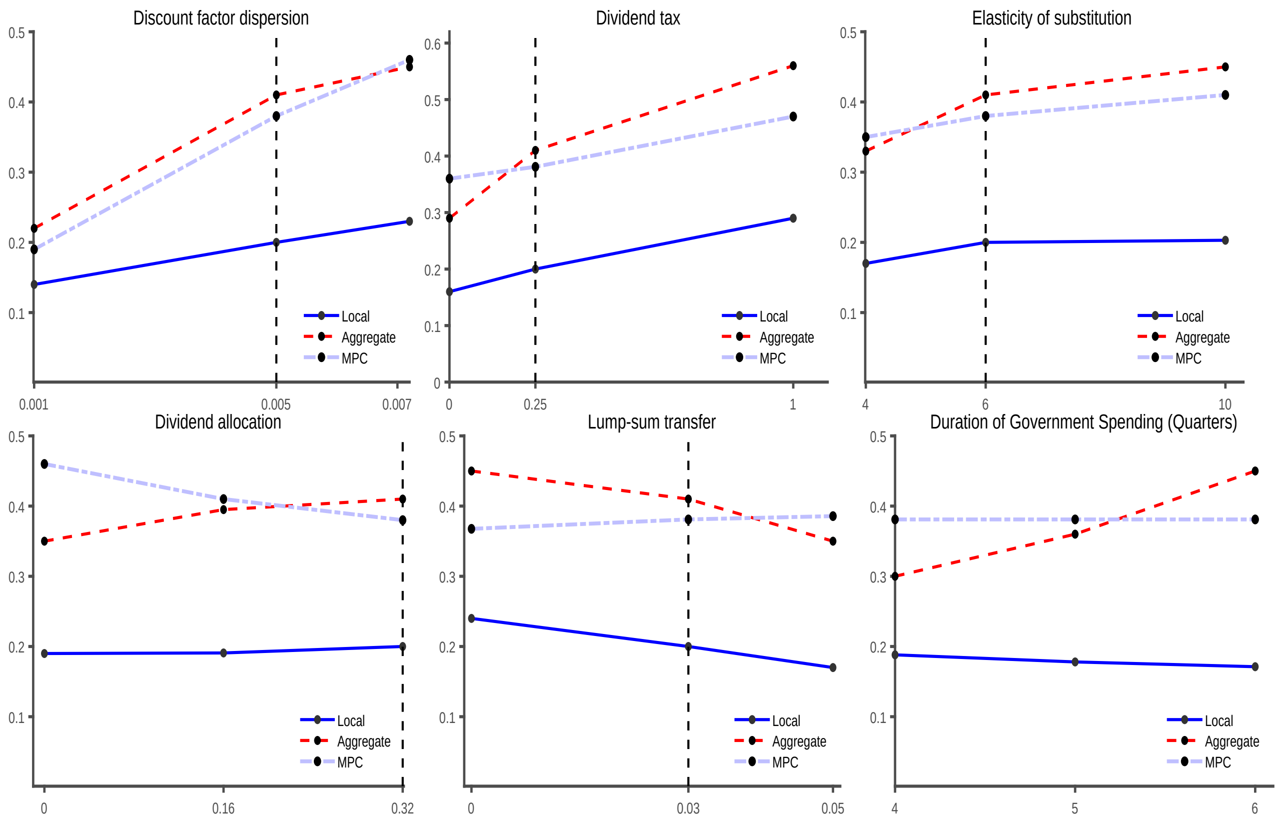
In contrast, the local consumption multiplier is largely unaffected by the responsiveness of monetary policy. This exercise confirms the intuition of the literature claiming that first, monetary authority is critical for the value of the aggregate fiscal multiplier (Christiano, Eichenbaum, and Rebelo, 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, 2019).

5.7 Using the Local Multiplier to Inform the Aggregate Multiplier

Our model maps the empirical evidence on the local multiplier to an estimate for the aggregate multiplier. In this section we show that when the model is also informed by the local multiplier it delivers a tighter range of estimates for the aggregate multiplier relative to a model that is only informed by the MPC.

Specifically, for selected model parameters, we change the parameter value to a plausible alternative (one parameter at a time) and report the average MPC, the local multiplier, and the aggregate multiplier. Figure 9 shows the model's multipliers and the MPC for three different values of each of the following parameters—the dispersion of the discount factor, dividend tax, elasticity of substitution, dividend allocation, lump-sum transfer, and duration of the government spending shock.

Figure 9: Sensitivity Analysis: MPC, Local, and Aggregate Multiplier

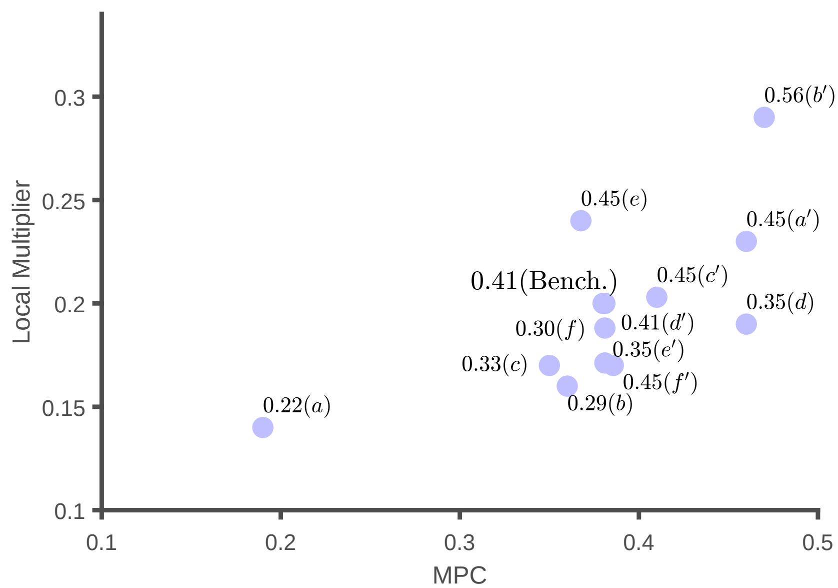


Notes: We vary a parameter away from its benchmark value and explore how the MPCs and the multipliers respond. The vertical dashed line shows the benchmark value for the parameter. For the duration of government spending case, government spending equals the initial benchmark amount for a given number of quarters and then is set to zero. We do not recalibrate the other parameters to hit the benchmark targets.

First, the figure shows that the local and the aggregate multiplier vary in a systematic way. For the most part, larger values of the local multiplier are associated with larger values of the aggregate multiplier. Hence, the local multiplier is a useful predictor of the aggregate multiplier.

Second, and more importantly, the local multiplier is a useful statistic even if we take into account the value of the MPC. To demonstrate this, Figure 10 shows the model's MPC, local, and aggregate multipliers from Figure 9 in one scatterplot. Each dot represents a combination of the MPC and the local multiplier (with the MPC on the x-axis and the local multiplier on the y-axis), with the value of the aggregate multiplier listed next to the dot. The values of the MPC between 0.35 and 0.45 are considered within the empirical estimates. As can be seen from the figure, for this range, the aggregate multiplier varies substantially, from 0.29 to 0.56. This demonstrates that the MPC is not the only factor influencing the aggregate multiplier. To pin down the value of the aggregate multiplier, we can use the local multiplier. Even conditional on MPC, the local and the aggregate multiplier vary in a systematic (positive) way. A value of the local multiplier equal to or above 0.20—which is in line with our empirical estimates—narrows the range of the aggregate multiplier to 0.41-0.56. Thus, the local multiplier is informative of the aggregate multiplier beyond the estimates of the MPC.

Figure 10: MPC, Local, and Aggregate Multiplier Under Different Specifications



Notes: The figure shows a scatter of the MPC and the local multiplier under different specifications: (a) discount factor dispersion, (b) dividend tax, (c) elasticity of substitution, (d) dividend allocation, (e) lump sum transfer, and (f) duration of government spending. We denote the high parameter values of each specification with a prime. Next to each specification we report the value of the aggregate multiplier.

6 Alternative Models and Specifications

We test how sensitive our main results are to alternative models and 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 alternative fiscal regimes such as taxation at the local instead of the federal level as well as deficit-financed spending. Third, we consider a utility specification that depends on disutility of hours. Fourth, we analyze the implications of a Benabou-type tax schedule. Fifth, we analyze an economy with higher wealth than the benchmark economy. Sixth, we consider a liquidity trap experiment. Finally, we compute a "normal times" fiscal multiplier. In all our experiments, we recalibrate the models to match the benchmark targets.

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 and discount factor heterogeneity. We assume that there is a single, representative household who receives 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, assets, and discount rates, ϕ_i, is degenerate. In addition, dividends are collected directly by the household. 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 asset holdings to exist, we have to assume that $\beta(1+R)=1$. We write the problem of the representative household in region i:

$$V_{i,t}(a_t) = \max_{c_t, a_{t+1}, h_t} \left\{ \frac{c_t^{1-\sigma}}{1-\sigma} + \psi \frac{(1-h_t)^{1-\theta}}{1-\theta} + \beta V_{i,t+1}(a_{t+1}) \right\} \tag{30}$$

$$\textbf{s.t.} \quad c_t + (1+\pi_{i,t+1})a_{t+1} = w_{i,t}h_t - \mathcal{T} + (1+R_{t-1}+\chi)a_t + (1-\tau_d)D_{i,t} \tag{31}$$

$$a_{t+1} \geq 0. \tag{32}$$

The main difference in the budget constraint is that we have introduced the function

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

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 asset holdings and vice versa.[28] Moreover, the assumption of a borrowing constraint is irrelevant as the representative household never holds a negative net worth. Table 12 compares the steady state between our Benchmark and the RA-NK economy. The RA-NK model features a substantially lower MPC compared to our Benchmark. The average MPC (at an annual frequency) is 0.05, while in our benchmark economy it is 0.37.

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

	Benchmark	RA-NK
Liquid Assets/Income	1.20	1.20
Liquid Assets Gini	0.75	0.00
Median MPC	0.11	0.05
Average MPC	0.37	0.05

Notes: Selected steady-state statistics in the benchmark model and an economy with a representative agent in each region (RA-NK). The MPC is reported at an annual frequency.

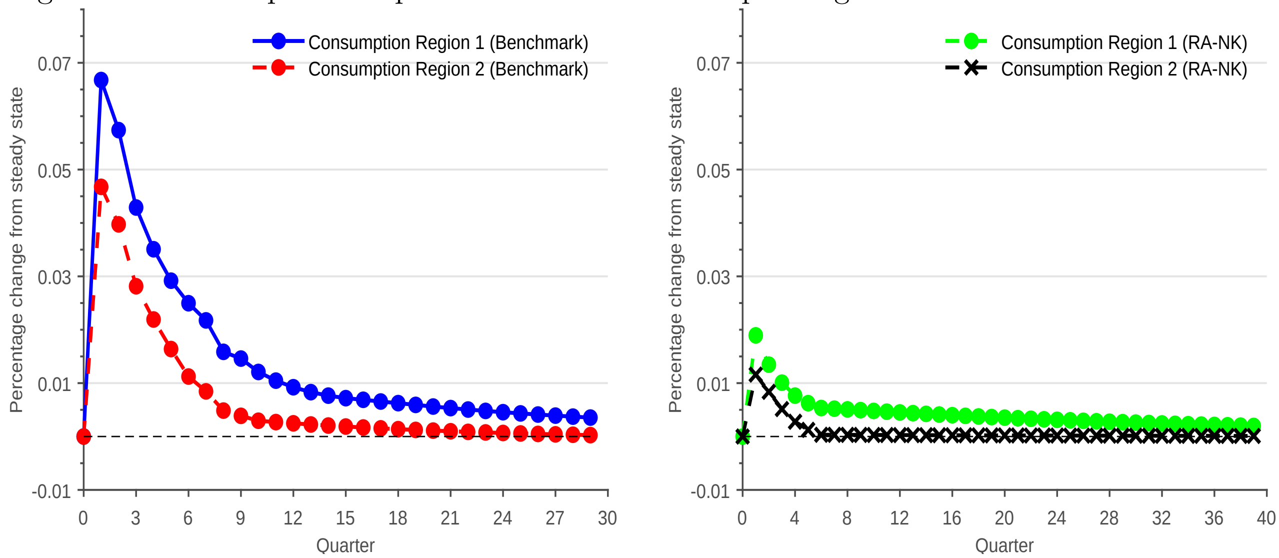
Figure 11 plots the consumption impulse response functions in our Benchmark (left panel) and the RA-NK model (right panel). In the RA-NK model, consumer spending responds less to government spending as the average MPC is lower. Both the local and the aggregate fiscal multiplier are lower relative to our Benchmark. In particular, in the RA-NK model, the local multiplier is equal to 0.09, and the aggregate is equal to 0.06.

The difference is related to the response of consumer spending due to the change in wages (Table 13). If only wages had changed in our Benchmark, the local multiplier would be 0.28, and the aggregate multiplier would be 0.48, whereas in the RA-NK, the effect decreases to 0.13 and 0.17, 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 in broadly the same way. Finally, consumer spending increases due to taxes in the Benchmark while it slightly decreases in the RA-NK. However, overall, the effect of taxes seems relatively small.

In sum, 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 0.37 while in the RA-NK it is 0.05. With higher average

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

Figure 11: 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.

Table 13: Consumption Decomposition: RA-NK vs. Benchmark

	RA-NK		Benchmark	
Consumption Multiplier	Local	Aggregate	Local	Aggregate
Due to Wages	0.13	0.17	0.28	0.48
Due to Dividends	-0.03	-0.04	-0.05	-0.06
Due to Inflation	-0.01	-0.04	-0.02	-0.08
Due to Taxes	0.00	-0.01	0.00	0.05
Total	0.09	0.06	0.20	0.41

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).

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.

An intermediate case between the Benchmark and the RA-NK model is a model with idiosyncratic income shocks but no discount factor heterogeneity. In this model, the average annual MPC is 0.30. The resulting local consumption multiplier is 0.13, and the aggregate consumption multiplier is 0.19. Thus, our empirical evidence on the local consumption multiplier favors a New Keynesian model with rich heterogeneity (labor productivity and discount factor) over a model with only income risk and especially compared to a model with a representative agent.

6.2 Alternative Specifications

Alternative Fiscal Rules 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 percent 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 0.26. The aggregate multiplier is not affected and is equal to 0.41. Next, we allow for the government to finance all of the spending using 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 $T = \{1, 4, 10\}$. The local multiplier is 0.20, 0.12, and 0.16 while the aggregate consumption multiplier is 0.35, 0.41, and 0.74, respectively. The aggregate multiplier is higher when spending is tax financed than when it is deficit financed for a short horizon (less than four 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 to adjust generates higher multipliers. Since this effect lasts only for the first couple of years, deficit financing for ten years ahead generates larger consumption multipliers.

Preferences with disutility of labor In the benchmark utility specification, the labor supply elasticity depends jointly on parameter θ and the hours of work. We also solve the model when we specify the utility function as disutility in hours: $U = \log(c) - \psi \frac{h^{1+\frac{1}{\theta}}}{1+\frac{1}{\theta}}$. We set θ and ψ to match the same labor supply elasticity and average hours as in the benchmark model. The local multiplier in this case is 0.19 and the aggregate 0.38.

Benabou tax function Our benchmark tax function consists of a transfer and a linear tax in household earnings. As an alternative, we use a Benabou-type of parametric tax function:

$$\mathcal{T}_t = [wxh + \delta(1-\omega)D] - (1-\tau_0)[wxh + \delta(1-\omega)D]^{1-\tau_1}.$$

We set τ_0 to match the same government-output ratio as in the benchmark model and τ_1= 0.036 based on Guner, Kaygusuz, and Ventura (2014). With this specification, the local multiplier is 0.17, and the aggregate multiplier is 0.30.

High-Wealth Economy In our benchmark calibration, we abstract from other illiquid forms of wealth (for example, houses). As a robustness exercise, we consider an alternative steady-state economy that features a much higher wealth-output ratio relative to the benchmark model. But we assume that only the patient households hold this additional wealth. We do so by calibrating the discount factor parameters (mean and dispersion) jointly to achieve (i) a wealth-output ratio three times higher the benchmark target and (ii) that the impatient households hold the same amount of assets as in the benchmark model. Adding very wealthy individuals decreases the annual MPC from 0.37 to 0.34. The wealthy households already have a very low MPC, so making them even wealthier does not significantly affect the average.

Liquidity trap We examine the size of the multiplier when the economy suffers a large drop in consumption, similar in magnitude to the decline during the 2007-09 recession. We engineer a recession by introducing a temporary discount factor shock. Consumption drops because consumers temporarily allocate a larger fraction of their income toward savings (a key characteristic of a liquidity trap). The size and persistence of the shock are calibrated based on the drop in consumption growth during the 2007-09 recession. In this case, the local multiplier is equal to 0.18 and the aggregate multiplier is equal to 0.64.

Normal times multiplier We compute a "normal times" fiscal multiplier by adjusting the model in two dimensions. First, we switch from an interest rate peg (as in the Benchmark) to a conventional Taylor rule of the form $R_t = (1-\rho_R)R_{ss} + \rho_R[R_{t-1} + \phi_\pi \hat{\pi} + \phi_y \hat{y}]$ where $\rho_R = 0.8$, $\phi_y = 0.2$, and $\phi_\pi = 1.5$. Second, we calibrate the government spending process based on U.S. historical data. Specifically, we use a simple AR(1) with a persistence parameter of 0.85 as in Nakamura and Steinsson (2014). The normal times two- and four-year output multipliers are 0.46 and 0.25, respectively which are consistent with the values reported by Ramey and Zubairy (2018) (equal to 0.26 and 0.21, respectively).

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 non-durable spending and \$0.09 in auto purchases.

We estimate the aggregate response of consumer spending to fiscal stimulus using a quantitative model. Our model is novel in that it embeds a regional framework into a heterogeneous agents, incomplete markets, New Keynesian model. The model generates a positive local non-durable consumption multiplier consistent with the data. This is a new finding and distinguishes our incomplete markets model from previous literature that employed regional models with complete markets. The model predicts an aggregate non-durable consumption multiplier equal to 0.41. This falls in the upper bound of estimates found in the literature (Hall, 2009).

References

Aguiar, M., and Bils, M. (2015). "Has consumpton inequality mirrored income inequality?". *American Economic Review*, *105*(9), 2725-2756.

Aiyagari, S. R. (1994). "Uninsured idiosyncratic risk and aggregate saving". *Quarterly Journal of Economics*, *109*(3), 659-684.

Aladangady, A., Aron-Dine, S., Dunn, W., Feiveson, L., Lengermann, P., and Sahm, C. (2016). "The effect of hurricane Matthew on consumer spending". *FEDS Notes. Washington: Board of Governors of the Federal Reserve System.*

Angeletos, M., and Lian, C. (2021). "Determinacy without the Taylor principle". *Working Paper*.

Auclert, A. (2019). "Monetary policy and the redistribution channel". *American Economic Review*, *109*(6), 2333-2367.

Auclert, A., Rognlie, M., and Straub, L. (2018). "The intertemporal Keynesian cross". *Working Paper, Northwestern University*.

Auerbach, A., and Gorodnichenko, Y. (2012). "Measuring the output responses to fiscal policy". *American Economic Journal: Economic Policy*, *4*(2), 1-27.

Auerbach, A., Gorodnichenko, Y., and Murphy, D. (2019). "Local fiscal multipliers and fiscal spillovers in the United States". *NBER Working Paper, 25457*.

Barro, R. J., and King, R. G. (1984). "Time-separable preferences and intertemporal-substitution models of business cycles". *Quarterly Journal of Economics*, *99*(4), 817-839.

Barro, R. J., and Redlick, C. J. (2011). "Macroeconomic effects from government purchases and taxes". *Quarterly Journal of Economics*, *126*(1), 51-102.

Baxter, M., and King, R. G. (1993). "Fiscal policy in general equilibrium". *American Economic Review*, *83*(3), 315-334.

Bee, A., Meyer, B., and James, S. (2012). "the validity of consumption data: Are the consumer expenditure interview and diary surveys informative?". *NBER Working Paper No. 18308*.

Beraja, M., Hurst, E., and Ospina, J. (2019). "The aggregate implications of regional business cycles". *Econometrica*, *8*(6), 1789-1833.

Bhandari, A., Evans, D., Golosov, M., and Sargent, T. J. (2018). "Inequality, business cycles, and monetary-fiscal policy". *Working Paper*.

Blanchard, O., and Perotti, R. (2002). "An empirical characterization of the dynamic effects of changes in government spending and taxes on output". *Quarterly Journal of Economics*, *117*(4), 1329-1368.

Boone, C., Dube, A., and Kaplan, E. (2014). "The political economy of discretionary spending: Evidence from the American Recovery and Reinvestment Act". *Brookings Papers on Economic Activity*, 375-428.

Broda, C., and Parker, J. (2014). "The Economic Stimulus Payments of 2008 and the aggregate demand for consumption". *Journal of Monetary Economics*, S20-S34.

Carroll, C., Slacalek, J., Tokuoka, K., and White, M. N. (2017). "The distribution of wealth and the marginal prospensity to consume". *Quantitative Economics*, *8*(3), 977-1020.

Chodorow-Reich, G. (2019). "Geographic cross-sectional fiscal spending multipliers: What have we learned?". *American Economic Journal: Economic Policy*, *11*(2), 1-34.

Chodorow-Reich, G., Feiveson, L., Liscow, Z., and Woolston, W. G. (2012). "Does state fiscal relief during recessions increase employment? Evidence from the American Recovery and Reinvestment Act". *American Economic Journal: Economic Policy*, *4*(3), 118–145.

Christiano, L., Eichenbaum, M., and Rebelo, S. (2011). "When is the government spending multiplier large?". *Journal of Political Economy*, *119*(1), 78-121.

Conley, T. G., and Dupor, B. (2013). "The American Recovery and Reinvestment Act: Solely a government jobs program?". *Journal of Monetary Economics*, *60*(5), 535-549.

Drautzburg, T., and Uhlig, H. (2015). "Fiscal stimulus and distortionary taxation". *Review of Economic Dynamics*, *18*(4), 894-920.

Dupor, B., and McCrory, P. B. (2017). "A cup runneth over: Fiscal policy spillovers from the 2009 Recovery Act". *Economic Journal*, *128*(611), 1476-1508.

Dupor, B., and Mehkari, M. S. (2016). "The 2009 Recovery Act: Stimulus at the extensive and intensive labor margins". *European Economic Review*, *85*, 208-228.

Farhi, E., and Werning, I. (2016). "Fiscal multipliers: Liquidity traps and currency unions". *Handbook of Macroeconomics*(2), 2417-2492.

Floden, M., and Linde, J. (2001). "Idiosyncratic risk in the United States and Sweden: Is there a role for government insurance?". *Review of Economic Dynamics*, *4*(2), 406-437.

Gali, J., Lopez-Salido, D., and Valles, J. (2007). "Understanding the effects of government spending on consumption". *Journal of the European Economic Association*, *5*(1), 227-270.

Gali, J., and Monacelli, T. (2008). "Optimal monetary and fiscal policy in a currency union". *Journal of International Economics*, *76*(1), 116-132.

Gervais, A., and Jensen, B. (2019). "The tradability of services: Geographic concentration and trade costs". *Journal of International Economics*, *118*, 331-350.

Gourio, F., and Miao, J. (2010). "Firm heterogeneity and the long-run effects of dividend tax reform". *American Economic Journal: Macroeconomics*, *2*(1), 131-168.

Guner, N., Kaygusuz, R., and Ventura, G. (2014). "Income taxation of U.S. households: Facts and parametric estimates". *Review of Economic Dynamics*, *17*(4), 559-581.

Hagedorn, M. (2017). "A demand theory of the price level". *Working Paper, University of Oslo*.

Hagedorn, M., Karahan, F., Manovskii, I., and Mitman, K. (2016). "Unemployment benefits and unemployment in the Great Recession: The role of macro effects". *NBER Working Paper, 19499*.

Hagedorn, M., Manovskii, I., and Mitman, K. (2017). "The fiscal multiplier". *Working Paper*.

Hall, R. E. (2009). "By how much does GDP rise if the government buys more output?". *Brookings Papers on Economic Activity*, *40*(2), 183-249.

House, C. L., Proebsting, C., and Tesar, L. (2020). "Austerity in the aftermath of the Great Recession". *Journal of Monetary Economics*, *115*, 37-63.

Huggett, M. (1993). "The risk-free rate in heterogeneous-agent incomplete-insurance economies". *Journal of Economic Dynamics and Control*, *17*(5-6), 953-969.

Jappelli, T., and Pistaferri, L. (2014). "Fiscal policy and MPC heterogeneity". *American Economic Journal: Macroeconomics*, *6*(4), 107-136.

Johnson, D. S., Parker, J. A., and Souleles, N. S. (2006). "Household expenditure and the income tax rebates of 2001". *American Economic Review*, *96*(5), 1589-1610.

Kaplan, G., Mitman, K., and Violante, G. L. (2020). "Non-durable consumption and housing net worth in the Great Recession: Evidence from easily accessible data". *Journal of Public Economics*, *189*, 104-176.

Kaplan, G., Moll, B., and Violante, G. L. (2018). "Monetary policy according to HANK". *American Economic Review*, *108*(3), 697-743.

Kaplan, G., and Violante, G. L. (2014). "A model of the consumption responses to fiscal stimulus payments". *Econometrica*, *82*(4), 1199-1239.

Krueger, D., Mitman, K., and Perri, F. (2016). "Macroeconomics and household heterogeneity". *Handbook of Macroeconomics*, *2*, 843-921.

Leduc, S., and Wilson, D. (2017). "Are state governments roadblocks to federal stimulus? Evidence on the flypaper effect of highway grants in the 2009 Recovery Act". *American Economic Journal: Economic Policy*, *9*(2), 253-292.

McCallum, B. T. (1983). "On non-uniqueness in rational expectations models: An attempt at perspective". *Journal of Monetary Economics*, *11*.

McKay, A., Nakamura, E., and Steinsson, J. (2016). "The power of forward guidance revisited". *American Economic Review*, *106*(10), 3133-3158.

McKay, A., and Reis, R. (2016). "The role of automatic stabilizers in the U.S. business cycle.". *Econometrica*, *84*(1), 141-194.

Mian, A., Sufi, A., and Rao, K. (2013). "Household balance sheets, consumption, and the economic slump". *Quarterly Journal of Economics*, *128*(4), 1687-1726.

Nakamura, E., and Steinsson, J. (2014). "Fiscal stimulus in a monetary union: Evidence from U.S. regions". *American Economic Review*, *104*(3), 753-792.

Nakamura, E., and Steinsson, J. (2018). "Identification in macroeconomics". *Journal of Economic Perspectives*, *32*(3), 59-86.

Oh, H., and Reis, R. (2012). "Targeted transfers and the fiscal response to the Great Recession". *Journal of Monetary Economics*, *59*(S), S50-S64.

Parker, J. A., Souleles, N. S., Johnson, D. S., and McClelland, R. (2013). "Consumer spending and the economic stimulus payments of 2008". *American Economic Review*, *103*(6), 2530-2553.

Perotti, R. (2005). "Estimating the effects of fiscal policy in OECD countries". *CEPR Discussion Paper No. 4842*.

Ramey, V. A. (2011). "Identifying government spending shocks: It's all in the timing". *Quarterly Journal of Economics*, *126*(1), 1-50.

Ramey, V. A. (2016). "Macroeconomic shocks and their propagation". *Handbook of Macroeconomics*, *2*, 71-162.

Ramey, V. A. (2019). "Ten years after the financial crisis: What have we learned from the Renaissance in fiscal research?". *Journal of Economic Perspectives*, *33*(2), 89-114.

Ramey, V. A., and Shapiro, M. D. (1998). "Costly capital reallocation and the effects of government spending". *Carnegie-Rochester Conference Series on Public Policy*, *48*, 145-194.

Ramey, V. A., and Zubairy, S. (2018). "Government spending multipliers in good times and in bad: Evidence from U.S. historical data". *Journal of Political Economy*, *126*(2), 850-901.

Sahm, C. R., Shapiro, M. D., and Slemrod, J. B. (2010). "Household response to the 2008 tax rebate: Survey evidence and aggregate implications". *Tax Policy and the Economy*, *24*(1), 69-110.

Sahm, C. R., Shapiro, M. D., and Slemrod, J. B. (2012). "Check in the mail or more in the paycheck: Does the effectiveness of fiscal stimulus depend on how it is delivered?". *American Economic Journal: Economic Policy*, *4*(3), 216-250.

Serrato, J. C. S., and Wingender, P. (2016). "Estimating local fiscal multipliers". *NBER Working Paper No. 22425*.

Uhlig, H. (2010). "Some fiscal calculus". *American Economic Review*, *100*(2), 30-34.

Wilson, D. J. (2012). "Fiscal spending jobs multipliers: Evidence from the 2009 American Recovery and Reinvestment Act". *American Economic Journal: Economic Policy*, *4*(3), 251-282.

Woodford, M. (2011). "Simple analytics of the government expenditure multiplier". *American Economic Journal: Macroeconomics*, *3*(1), 1-35.

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 types of durable goods are fast-moving products and typically not very expensive. Examples of these durable goods include cameras and office supplies.[29]

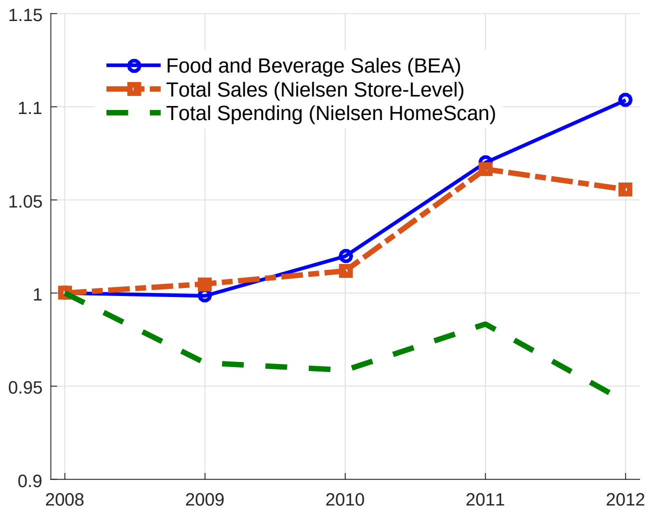
Table A-1: Fraction of Spending by Store Type–Nielsen HomeScan

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.

[29] Table A-1 reports the fraction of spending for each type of store in the Nielsen data. 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 data.

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.

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 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.

Using the Retail Scanner data, we arrived at a retail spending consumption multiplier equal to 0.11 (Table 4). 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 A-2: Retail Spending Multipliers

Spending Category	Retail Consumer Spending (Nielsen, HomeScan)			
	OLS	IV	OLS	IV
Government Spending	0.10 (0.07)	0.12** (0.08)	0.10 (0.08)	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

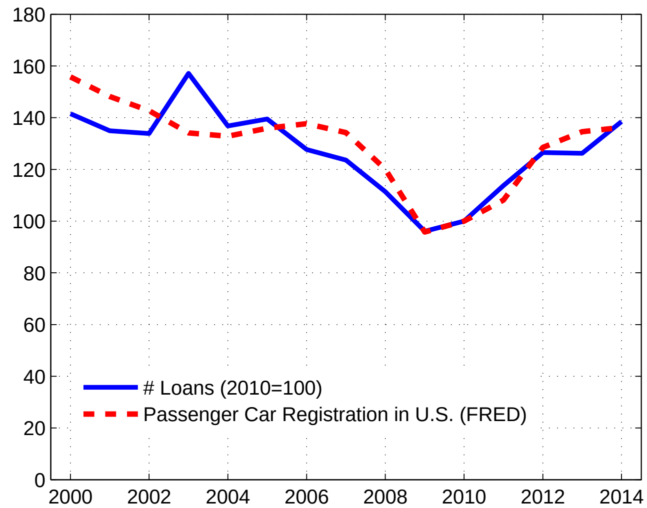
Notes: The table shows the estimates of the regression of the growth rate in retail spending from Nielsen HomeScan on cumulative government spending at the county level during the period 2008-2012. We show results for our OLS and IV specification, with and without county controls/state fixed effects.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

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.[30] 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 on 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 closely tracks the number of registered auto vehicles.

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

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.

B American Recovery and Reinvestment Act

Table B-1 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

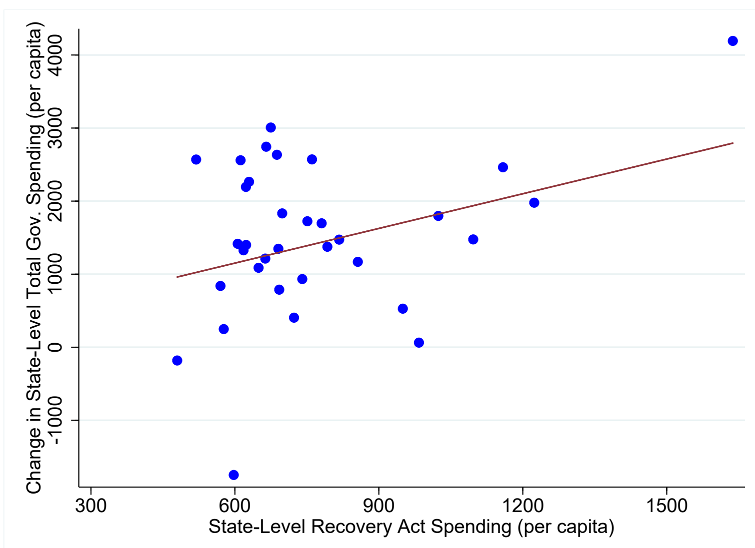
The spending component of the Recovery Act allocated around \$228 billion to local and state governments. One concern is that state governments reduced their own spending in response to the federal fiscal stimulus. We evaluate this hypothesis by using data from the Annual Survey of State Government Finances 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

Table B-1: 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.

Figure B-1: 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.

the period 2008-2012 as

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

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

$$\Delta G_s^{Total} = a + \beta G_s^{ARRA} + \varepsilon_s \tag{33}$$

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 and Table B-2 shows the estimates. The crowding in of state-level spending in response to the Recovery Act is also documented by Leduc and Wilson (2017) and Chodorow-Reich (2019).

Table B-2: Estimates of Recovery Act Spending and Total Spending by States

State Spending		
	OLS	IV
Government Spending	1.58** (0.68)	3.34*** (1.18)
# States	50	50

Notes: Estimates of a regression of total Recovery Act spending (per-capita) during the period 2009-2012 on cumulative change in total state-level spending (per-capita) between period 2008-2012. The standard errors are given in parentheses. One, two, and three stars denote significance at the 10%, 5%, and 1% levels, respectively.

We also use data on transfer receipts from the Bureau of Economic Analysis, and analyze if they are correlated with the spending component of the Recovery Act. The transfers are defined as receipts from the government to individuals without performing any services. They include social security benefits, medical benefits, veterans' benefits, and unemployment insurance benefits. The data reflect among other the increase in transfers that occurred during the period 2009-2012, through the Recovery Act.

We analyze if there is a geographical correlation between the increase in transfers during the period of the Recovery Act and the spending component of the Act. The per-capita amount of transfers for state s at year t is denoted $G_{s,t}^{\mathrm{Tr}}$. The cumulative change in state-level transfers between the period 2008-2012 is

$$\Delta G_s^{\mathrm{Tr}} = \sum_{t=2008}^{2012} \left\{ G_{s,t} - G_{s,2008} \right\}.$$

We regress state-level per-capita transfers to state-level per-capita Recovery Act spending:

$$\Delta G_s^{\mathrm{Tr}} = a + \beta \Delta G_s^{ARRA} + \varepsilon_s. \tag{34}$$

Table B-3: Federal Spending and State Transfers

State Transfers	(OLS)	(IV)	
Recovery Act spending	-0.09 (0.27)	0.15 (0.31)	
# States		51	51

Notes: The table shows the estimates of a regression of the cumulative change in transfers at the state level during the period 2008-2012 on cumulative Recovery Act spending at the state level during the period 2008-2012.

Table B-3 shows the estimates when we use OLS and IV government spending. A larger amount of state transfers during the Recovery Act is not associated with a significantly higher rise in government spending. Hence, the positive response of consumption to the spending component of the Act is not driven by a confounding increase in transfers. The estimates support our collective findings: the Recovery Act was not strongly correlated with local economic conditions or other forms of fiscal stimulus.

C Robustness Analysis

In this section, we analyze the sensitivity of our empirical estimates (Table 4 and Table 6). 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.

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 increases 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.

Table C-1: Robustness Analysis

Specification	Nielsen Retail Scanner	Equifax
Benchmark	0.11**	0.09***
	(0.05)	(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.

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. 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 Placebo and other Experiments

We perform two types of placebo experiments. First, we analyze whether government spending is correlated with past consumption trajectories. For this experiment we replace the left-hand side variable in the main regression (Equation 3 in the main text) with the consumption growth between 2007-2008, i.e., prior to the Recovery Act. We do not include any other control variables but show the estimates with and without state fixed effects. Table C-2 shows the OLS and IV estimates for retail and auto spending. Government spending does not correlate with either type of spending in the 2007-2008 period. Therefore, consumption pre-trends were broadly similar between the main recipients counties and counties that did not benefit much from the Act.

Our second placebo experiment explores if county-level income is the main driving force behind the consumption response (rather than government spending). We allocate counties based on their per-capita income in 2008 to low-income, middle-income, and high-income groups (bottom, middle, and top 33% of the distribution). Next, for every group, we randomly reshuffle the total money allocated by the Recovery Act among the counties within the group so that overall group spending is the same as in the actual program. Hence, the income groups end up with the same amount of money overall but the specific allocation of money at

Table C-2: Estimates based on Placebo

Spending Category	Retail Spending (Nielsen)			
	OLS	IV	OLS	IV
Government Spending	0.012 (0.009)	0.019* (0.011)	0.0003 (0.010)	-0.0015 (0.011)
County Controls	No	No	No	No
State F.E.	No	No	Yes	Yes
# Counties	352	352	352	352

Spending Category	Auto Spending (Equifax)			
	OLS	IV	OLS	IV
Government Spending	-0.000 (0.004)	0.006 (0.007)	0.003 (0.003)	0.001 (0.004)
County Controls	No	No	No	No
State F.E.	No	No	Yes	Yes
# Counties	3120	3120	3120	3120

Notes: The table shows the estimates of the regression of the growth rate in retail and auto spending between 2007-2008 (relative to 2007) on county-level cumulative government spending during the period 2009-2012. We show results for our OLS and IV specification, with and without state fixed effects but without any additional controls. The standard errors are given in parentheses. One, two, and three stars denote significance at the 10%, 5%, and 1% levels, respectively.

the counties within group becomes random. The main idea behind this experiment is that if income is the main driver of consumption responses then the random reshuffling within income groups should leave the estimates broadly unaffected. Since each random draw (corresponding to a random allocation of money) generates a different estimate we perform this experiment 100 times and report in Table C-3 the mean of the estimates, as well as the standard deviation of the estimates. The estimates of retail and auto spending become quantitatively small and insignificant.

Nielsen data have a much more narrow geographical coverage than Equifax. It is useful to analyze the Equifax estimates when we limit the sample to the geographical coverage of the Nielsen sample. Specifically, in Table C-4, we estimate the auto spending multiplier but limit the regression to the same counties in the retail spending data. Restricting the sample to the Nielsen geographical coverage leaves the auto spending estimates unaffected when we perform

Table C-3: Estimates based on Placebo (2)

Spending Category	Retail Spending (Nielsen)		Auto Spending (Equifax)	
Government Spending	0.07 (0.08)	0.01 (0.07)	-0.008 (0.005)	0.001 (0.002)
# Counties	367	367	3048	3048
State F.E	No	Yes	No	Yes

Notes: The table shows the estimates of the growth rate in retail and auto spending to government spending when we randomly re-shuffle spending within income groups. We show results for the OLS specification, with and without county controls/state fixed effects. The standard errors are given in parentheses. One, two, and three stars denote significance at the 10%, 5%, and 1% levels, respectively.

Table C-4: Auto Spending Multipliers (Restricted Sample)

Spending Category	Auto Spending (CCP/Equifax)			
	OLS	IV	OLS	IV
Government Spending	0.07^{***} (0.01)	0.11^{***} (0.02)	0.05^{***} (0.01)	0.07^{***} (0.01)
Partial F stat.	—	75.5	—	73.9
County Controls/ State Fixed Effects	No	No	Yes	Yes
# Counties	367	367	367	367

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. The sample is restricted to the 367 counties that are part of Nielsen. 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.

OLS and IV estimation without any control variables or state fixed effects. The estimates decrease by one and two cents for OLS and IV, respectively, when we use state fixed effects.

We test further the implications of our geographical coverage by using a weighting strategy that accounts for both the county population and differences in population coverage across states. While in the benchmark regression we used population weights here we use the following weight:

$$\text{Weight} = \frac{\text{State Population}}{\text{State Population Coverage in Nielsen}} \times \text{County Population}$$

This implies that we re-weight our observations to take into account that some states are

Table C-5: Retail spending estimates with re-scaling of observations

Spending Category	Retail Spending (Nielsen)			
	OLS	OLS	IV	IV
Government Spending	0.20*** (0.06)	0.21*** (0.05)	0.26*** (0.08)	0.26*** (0.07)
Weight	Ben.	State-pop.	Ben.	State-pop.
# Counties	367	367	367	367

Notes: The table shows the estimates of the growth rate in retail spending to government spending for benchmark weights and when we re-scale to adjust for state population. The standard errors are given in parentheses. One, two, and three stars denote significance at the 10%, 5%, and 1% levels, respectively.

over-represented in the Nielsen sample while others are under-represented. If a state is under-represented in the Nielsen sample, our weight assigns a higher weight to compensate for this difference. Table C-5 shows the estimates for the local retail spending multiplier when we use the Benchmark weights and when we use the new weights that adjust for state population. As can be seen, the results are robust to changing the weighting scheme.

D Consumption Expenditure Survey

There are two considerations when we estimated our broader multiplier using the CEX. First, we used lagged consumption as an instrumental variable to reduce measurement error. Second, we relied on data from the Interview survey. In this section, we document how much these choices matter into the construction of our estimate. Table D-1 shows (i) the expenditure shares and (ii) the OLS and IV estimates we obtain from the Interview Survey. Table D-2 shows (i) the expenditure shares and (ii) the OLS estimates we obtain from the Diary survey. The Interview survey is a panel with households interviewed for four consecutive quarters. In contrast, the Diary survey collects information from households for only a couple of weeks, i.e., it is not useful for a dynamic panel analysis. As a result, only Table D-1 reports the IV estimates.

Table D-1: Nielsen and Consumption Expenditure Survey – *Interview Survey*

Bundle	Spending categories	Bundle size relative to Nielsen	Bundle elasticity relative to Nielsen	
			OLS	IV
Nielsen	food at home, alcohol and beverage, detergents, cleaning/hh products, small appliances, personal care products	1.0	—	—
Non-durables	Nielsen + apparel, tobacco, reading	1.3	0.90	0.98
Non-durables & Services	Non-durables + food away from home, entertainment, telephone services, utilities, gas, public transportation	3.6	0.57	0.75
Non-durables & Services & Durables	Non-durables & Services + education, furniture, car maintenance, health	4.5	0.54	0.74

Notes: Bundles of goods are constructed from the Interview survey of the Consumption Expenditure data (CEX). We report the size of each bundle compared to Nielsen-type spending as well as the elasticity estimated from regression (4). The IV estimation uses lag spending in Nielsen type goods as an instrument.

Table D-2: Nielsen and Consumption Expenditure Survey – *Diary Survey*

Bundle	Spending categories	Bundle size relative to Nielsen	Bundle elasticity relative to Nielsen
			OLS
Nielsen	food at home, alcohol and beverage, detergents, cleaning/hh products, small appliances, personal care products	1.0	—
Non-durables	Nielsen + apparel, tobacco, reading	1.9	0.88
Non-durables & Services	Non-durables + food away from home, entertainment, telephone services, utilities, gas, public transportation	5.1	0.55
Non-durables & Services & Durables	Non-durables & Services + education, furniture, car maintenance, health	6.2	0.55

Notes: Bundles of goods are constructed from the Diary survey of the Consumption Expenditure Survey (CEX).

The discrepancy in the shares between the surveys is large: 1.3 versus 1.9 for non-durable spending, 3.6 versus 5.1 for non-durable spending and services, and 4.5 versus 6.2 for the bundles including non-durable, services, and durables. The OLS elasticities are in the same range though. The expenditure shares differ as the Interview is designed to collect relatively larger expenditures and those that occur regularly while the Diary is designed to capture small, infrequent purchases that may be missed in the Interview part (Bee, Meyer, and James, 2012).[31]

E Algorithm to Form Trade Groups

In this section we describe the algorithm for forming high-, middle-, and low-trade groups. The matching criterion of counties into groups is the bilateral trade flows, i.e., the percentage of exports based on CFS between county i and county j. Since we have information on state-level trade and not county-level trade, we assume that counties within a state display the same trade patterns as the state itself. For example, the export shares of counties in Virginia toward counties in Maryland are equal to the export share of Virginia to Maryland. Let G denote the set of grouped counties and U be the set of ungrouped counties. In the beginning of the algorithm all counties are ungrouped. Once an ungrouped county is added to the set of grouped counties G it is removed from U. The matching algorithm for high-trade, low-trade and middle-trade groups is the following:

High-Trade Groups: Define the average bilateral trade between counties i and j as $\frac{s_{ij}+s_{ji}}{2}$.

- Step 0: Add initial member i to group G. The initial member is picked randomly from the set of unmatched counties U.

- Step 1: Calculate $\frac{s_{iu}+s_{ui}}{2}$ for all $u \in U$ (ungrouped counties). If the group consists already of two or more members calculate $\frac{s_{gu}+s_{ug}}{2}$ for all $u \in U$ (ungrouped counties) and $g \in G$ (currently grouped counties).

- Step 2: Select $u^* = \arg\max_u \frac{s_{gu}+s_{ug}}{2}$. There may be multiple u^* in which case choose one randomly.

- Step 3: Add u^* to G and remove it from U.

[31] An additional consideration with using the CEX to estimate the overall consumer response is that spending in the CEX does not align with consumer spending in the national income accounts (for example, see Broda and Parker (2014)).

We then repeat steps 0-3 until a group has 9 members. We keep creating groups with this method until all counties are in a group.

Low-Trade Groups: Define the average bilateral trade between counties i and j as $\frac{s_{ij}+s_{ji}}{2}$.

• Step 0: Add initial member i to group G. The initial member is picked randomly from the set of unmatched counties U.

• Step 1: Calculate $\frac{s_{iu}+s_{ui}}{2}$ for all $u \in U$ (ungrouped counties). If the group consists already of two or more members calculate $\frac{s_{gu}+s_{ug}}{2}$ for all $u \in U$ (ungrouped counties) and $g \in G$ (currently grouped counties).

• Step 2: Calculate $m_u = \max_g \frac{s_{gu}+s_{ug}}{2}$. That is for each ungrouped county we record the maximum trade with one of the grouped counties in G.

• Step 3: Doing that for all $u \in U$ we have a list $\{m_{u1}, m_{u2}, m_{u3}, ..., m_{un}\}$.

• Step 4: Denote $u^* = \arg\min_{u \in U} m_u$. Add u^* to G and remove it from U.

We then repeat steps 0-4 until a group has 9 members. We keep creating groups with this method until all counties are in a group. The max-min steps in this algorithm help to distinguish and pick the counties that are distant from all the existing group members (as opposed to a subset of counties in the group).

Middle-Trade Groups: A random number is generated randomly from a uniform distribution between 0 and 1. If $x < 0.5$, then we add an ungrouped county to G based on the "high-trade" grouping method. If $x \geq 0.5$, then we add an ungrouped county to G based on the "low-trade" grouping method. We then repeat the steps until a group has 9 members. We keep creating groups with this method until all counties are in a group.

For each group, the initial member is randomly chosen from the set of unmatched regions and the group subsequently expands by including other regions in close trade relationships (as in the case of high-trade groups) or distant trade relationships (as in the case of low-trade groups). As a result, the algorithm generates a possibility for different partitions. For example, when forming high-trade groups, if Texas is the top trading partner for both California and Louisiana, some simulations can form a California-Texas pair, leaving Louisiana to pair with another close trade partner, while others form a Louisiana-Texas pair, leaving California to pair with other regions. Table E-1 shows the mean estimate and standard errors from 1,000 simulations of our algorithm.

Table E-1: Local Consumption Multiplier and Trade Linkages

Spending Category	Retail Spending (Nielsen)					
	High-Trade		Medium-Trade		Low-Trade	
	OLS	IV	OLS	IV	OLS	IV
Government Spending	0.12***	0.17***	0.15***	0.20***	0.16***	0.22***
	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)

Notes: The table shows the estimates of the regression of the growth rate in retail spending on cumulative government spending. We report estimates for three cases: high-, medium-, and low-trade groups. The reported estimates represent the mean of the coefficients we obtain by running the algorithm for 1,000 times. We show results for our OLS and IV specification. The standard errors are given in parentheses. One, two, and three stars denote significance at the 10%, 5%, and 1% levels, respectively.

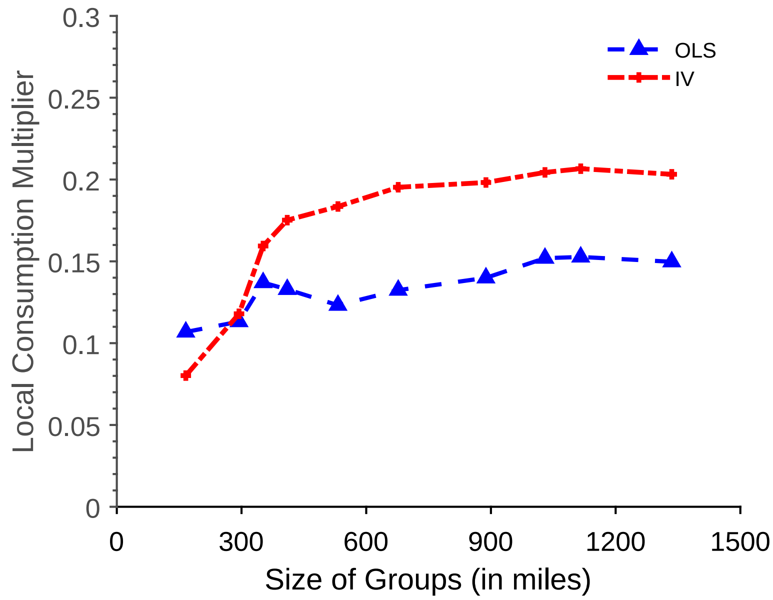
As a second exercise we form groups based on their geographical distance. We start by forming small geographical areas in which all counties are in relative close geographical distance. We sequentially form larger geographical areas—in which counties can be further apart. Once more, we estimate the local consumption multiplier for each level of aggregation using Regression 5 where the dummy variable $D_{j\in\mathcal{G}}$ takes the value of one if county j belongs to a geographical group $\mathcal{G}$ and zero otherwise. Figure E-2 shows how the local multiplier varies with geographical distance. The x-axis reports the median size (in miles) of each geographical group and the y-axis the local consumption multiplier (OLS and IV estimate). The local multiplier increases when we expand the geographical distance between the counties.

Below we describe the algorithm to form geographical groups. County distance data come from the NBER. This dataset contains information on the distance from the center of county i to the center of county j. Distances are calculated as great-circle distances using the Haversine formula from an internal point meant to represent the geographic center of the county.

1. Pick randomly a county i from the set of ungrouped counties i.e., $i \notin M$. This is the origin county.

2. For all $j \neq i$ calculate the distance between county i and county j, d_{ij}. We pick county j with the smaller geographical distance to i, i.e., $d^i_j = \min(\bar{\mathbf{d}}^i)$, where $\mathbf{d}^i$ is a vector of distances with respect to all $j \notin M$. When we have more than one counties in the group (for example, i and i') then we compute $\bar{\mathbf{d}}^i$ and $\bar{\mathbf{d}}^{i'}$ and pick the county j' such that $\bar{d}_{i,j'} = \min(\bar{\mathbf{d}}^i) < \min(\bar{\mathbf{d}}^{i'})$.

Figure E-2: Local Consumption Multiplier and Geographical Distance



Notes: The figure shows the estimate of the local consumption multiplier (coefficient β) from the regression in Equation 3. Each point represents the estimate from a different level of aggregation. The levels are computed using bundles of counties based on geographical proximity. The x-axis represents the median distance in each group.

(a) If $d_{i,j} < \mathcal{D}$ then include county j as part of the group with county i.

(b) If $d_{i,j} \geq \mathcal{D}$ then go back to step 1 and start a new group.

3. Continue adding counties to the group until the size of the group is C counties.

4. Go back to step 1.

Our algorithm consists of two parameters. First, the maximum geographical distance $\mathcal{D}$ which increases in steps of 100 miles and second, the maximum number of counties allowed in the group which we set to $C = \mathcal{D}/10$. That is we will not allow more than 10 counties to exist in the group within an area of 100 miles, 20 within an area of 200 miles, and so on and so forth.

F 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: $\{C_i\}_{i=1}^2$, $\{L_i\}_{i=1}^2$, $\{A_i\}_{i=1}^2$, $\{B_i^m\}_{i=1}^2$, $\{Y_i\}_{i=1}^2$, $\{\mathcal{Y}_i\}_{i=1}^2$, $\{q_i\}_{i=1}^2$, $\{w_i\}_{i=1}^2$,$\{D_i\}_{i=1}^2$,$\{\phi_i\}_{i=1}^2$, 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) Household savings equal the demand for government bonds and equity shares by the mutual funds:

$$\sum_i \mu_i A_i = \sum_i \mu_i B_i^m + \sum_i \mu_i q_i$$

where the total number of shares are normalized to one and the value of equity, q_i, is given by arbitrage Equation (14).
6) The demand for government bonds by the mutual funds equals the supply of bonds by the government: $\sum_i \mu_i B_i^m = B_{ss}^g$.
7) The government balances its budget

$$R \sum_i \mu_i \int_{\phi_i} B^m = \sum_i \mu_i G_i - \sum_i \mu_i \int_{\phi} \mathcal{T} - \tau_d \omega \sum_i \mu_i D_i$$

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

G 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:

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

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

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

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

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

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

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

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

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

$$\max_{p^*_{ijt}} \quad p^*_{ijt} y_{ijt} - W_{it} y_{ijt} + \frac{1-\lambda}{(1+r_{t+1})}[p^*_{ijt} y_{ijt+1} - W_{it+1} y_{ijt+1}] + \frac{(1-\lambda)^2}{\Pi^2_{h=1}(1+r_{t+h})}[p^*_{ijt} y_{ijt+2} - W_{it+2} y_{ijt+2}] + \dots$$

This gives

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

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

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

with

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

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

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

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

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

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

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

H Further Analysis on the Local and the Aggregate Multiplier

H.1 A Static Model of the Multiplier

We use a simple, static version of our model to solve for the local and aggregate consumption multiplier. The government allocates G_i to each region i. Private consumer spending is $C_i = m\mathcal{Y}_i$ where m is the marginal propensity to consume and $\mathcal{Y}_i$ is regional income which is given by

$$\mathcal{Y}_1 = a(C_1 + G_1) + (1-a)(C_2 + G_2)$$
$$\mathcal{Y}_2 = (1-a)(C_1 + G_1) + a(C_2 + G_2)$$

We substitute $C_i = m\mathcal{Y}_i$ to derive

$$\mathcal{Y}_1(1-am) = (1-a)m\mathcal{Y}_2 + aG_1 + (1-a)G_2$$
$$\mathcal{Y}_2(1-am) = (1-a)m\mathcal{Y}_1 + (1-a)G_1 + aG_2$$

We write the equations in matrix form:

$$\underbrace{\begin{bmatrix} 1-am & -(1-a)m \\ -(1-a)m & 1-am \end{bmatrix}}_{\mathbf{A}} \underbrace{\begin{bmatrix} \mathcal{Y}_1 \\ \mathcal{Y}_2 \end{bmatrix}}_{\mathbf{Y}} = \underbrace{\begin{bmatrix} aG_1 + (1-a)G_2 \\ (1-a)G_1 + aG_2 \end{bmatrix}}_{\mathbf{G}}$$

The inverse of $\mathbf{A}$ is

$$\mathbf{A}^{-1} = \begin{bmatrix} 1-am & (1-a)m \\ (1-a)m & 1-am \end{bmatrix} / \underbrace{((1-am)^2 - (1-a)^2 m^2)}_{\lambda}$$

Solving for $\mathbf{Y} = \mathbf{A}^{-1}\mathbf{G}$ we get

$$\begin{bmatrix} \mathcal{Y}_1 \\ \mathcal{Y}_2 \end{bmatrix} = \begin{bmatrix} [(m - a(2m-1))G_1 + (1-a)G_2]/\lambda \\ [(1-a)G_1 + (m - a(2m-1))G_2]/\lambda \end{bmatrix}$$

Regional income in region i is a function of the the fiscal injections in both regions (G_1, G_2), the home bias a and the marginal propensity to consume m. The local income multiplier is given by $\frac{\mathcal{Y}_1 - \mathcal{Y}_2}{G_1 - G_2}$ while the aggregate income multiplier is $\frac{\mathcal{Y}_1 + \mathcal{Y}_2}{G_1 + G_2}$. Finally, using that $C_i = mY_i$ we derive the local and aggregate consumption multipliers equal to

$$\frac{\Delta C^{\text{Local}}}{\Delta G} = \frac{m(2a-1)(1-m)}{(1-am)^2 - (1-a)^2 m^2}$$
$$\frac{\Delta C^{\text{Agg}}}{\Delta G} = \frac{m}{1-m}.$$

The simple model highlights how trade flows affect the local and the aggregate fiscal multiplier. Note that if $a = 1/2$ i.e., equal to the size of the regions, the local consumption multiplier is zero. If $a = 1$, the local and the aggregate multiplier are identical and equal to $\frac{m}{1-m}$. The MPC influences both the local consumption multiplier, $\frac{\Delta C^{\text{Local}}}{\Delta G}(m, a)$, and the aggregate consumption multiplier, $\frac{\Delta C^{\text{Agg}}}{\Delta G}(m)$.

Finally, the local and aggregate multiplier are linked through the following equation:

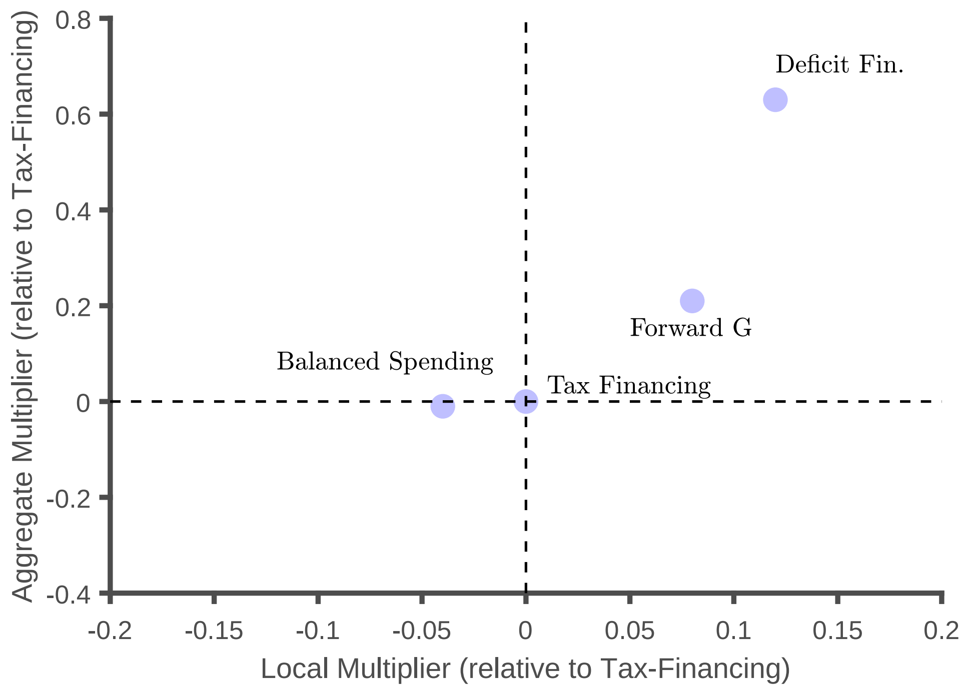
$$\frac{\Delta C^{\text{Local}}}{\Delta G} = \frac{m(2a-1)(1-m)^2}{(1-am)^2 - (1-a)^2 m^2} \frac{\Delta C^{\text{Agg}}}{\Delta G}$$

This implies that there are several sets of values for the marginal propensity to consume and the home bias that can generate a local multiplier equal to the aggregate multiplier.

H.2 The Local and Aggregate Multiplier under Different Financing Schemes

To demonstrate how the local multiplier informs the aggregate multiplier, we consider the effects of alternative financing schemes across which the steady-state distribution of MPCs is held constant.

Figure H-3: Local and Aggregate Consumption Multiplier for Different Specifications of Government Spending



Notes: Local and aggregate multipliers under different model specifications. In “Deficit financing”, stimulus is financed initially with government debt, in “Forward G”, the stimulus occurs with a lag, and in ”Balanced spending” the stimulus is followed by a fiscal tightening. All multipliers are expressed relative to their benchmark values, e.g., under tax financing.

We consider three alternative ways of financing government spending. First, we allow for the government to finance all of the spending using deficit financing (“Deficit Financing.”) Specifically, the government issues (and rolls over) debt up for $T = 10$ years and starts imposing taxes for $t > T$ in order to bring the debt equal to its steady-state value. Second, we consider a case where government spending occurs with a lag of two years and is fully anticipated by the households (“Forward G.”) The spending impulse response follows a similar path as in the Benchmark. Third, we assume that the fiscal stimulus is followed by a fiscal tightening. The cumulative decline during the tightening is equal to the cumulative increase during the stimulus and lasts for 10 years (“Balanced Spending”). For this demonstration, we assume that in each case, price flexibility is close to (but not equal to) zero. We compare these specifications to the case where government spending is financed by taxes as in the Benchmark. In all specifications, the steady-state MPC distribution is constant by construction and equal to the benchmark value, since the way spending is financed over the transition has no effect on the steady-state.

Figure H-3 shows the local and aggregate multiplier under the alternative specifications relative to the benchmark case where the stimulus is financed using taxes. With deficit financing, there is no tax burden for a substantially long period of time so that the aggregate multiplier rises relative to its benchmark value. The local multiplier also rises because households in the home region (the main stimulus recipient) accumulate disproportionately a larger share of bonds to finance the additional debt. This guarantees a higher demand for the local good both in the short and the long run. When government spending occurs in the future, demand is stimulated from the anticipation of higher future wages (especially for the home region) without a contemporaneous increase in taxes. Thus, the local and the aggregate multiplier rise relative to the benchmark. Finally, fiscal future tightening decreases the aggregate and especially the local multiplier.

Our numerical exercises show that the aggregate multiplier moves with the local multiplier, even if the steady-state distribution of the MPCs remains the same.

I Computational Algorithm

At the steady state, we assume inflation is zero and prices are symmetric within and across regions. This problem is no different than a typical one-region model with household heterogeneity. There are well-understood techniques to compute the steady-state in such models (e.g., Aiyagari, 1994; Huggett, 1993). Thus, we proceed and describe the computational process to compute the transition path. The economy moves away from the steady state following the regional government spending shocks, $\{G_{i,t}\}_{i=1}^2$. We are looking to solve for $\{C_{i,t}\}_{i=1}^2$, $\{L_{i,t}\}_{i=1}^2$, $\{A_{i,t+1}\}_{i=1}^2$, $\{B_{i,t+1}^m\}_{i=1}^2$, $\{Y_{i,t}\}_{i=1}^2$, $\{\mathcal{Y}_{i,t}\}_{i=1}^2$, $\{w_{i,t}\}_{i=1}^2$, $\{\pi_{i,t}\}_{i=1}^2$, $\{q_{i,t}\}_{i=1}^2$, $\{\frac{p_{i,j,t}^*}{P_{i,t}}\}_{i=1}^2$, $Q_{12,t}$, $\{D_{i,t}\}_{i=1}^2$, 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. We assume that the economy has returned to steady state after t^*=100 periods (quarters). We find this a sufficiently long time for all the variables to return to their steady state value.

Step 1: We guess a path for the following variables:

$$\{\{w_{i,t}\}_{i=1}^2, \{\pi_{i,t}\}_{i=1}^2, \{q_{i,t}\}_{i=1}^2, Q_{12,t}, \{D_{i,t}\}_{i=1}^2, R_t, \tau_t\}_{t=0}^{t^*}$$

Step 2: Using backwards induction we solve for the optimal household and firm choices. We solve the household's problem using the endogenous grid point method. As typical in this method we use the Euler condition and the budget constraint to solve for the household policy functions: $c(x, a'; \beta)$ and $a(x, a'; \beta)$ then use linear interpolation to back out $a'(x, a; \beta)$. The latter and the budget constraint gives us also $c(x, a; \beta)$. We solve the problem separately for each discount factor type β. With $c(x, a; \beta)$ we can directly compute the labor choice for each type from the static first-order condition for labor supply. Firm prices $\frac{p^*_{ijt}}{P_{it}}$ can be solved analytically as we show in Appendix G.

Step 3: Our initial measure over assets and productivity is given by ϕ_0 which is the steady-state distribution. With the computed policy functions we can aggregate the decisions to derive:

$$\{\{C_{i,t}\}_{i=1}^2, \{L_{i,t}\}_{i=1}^2, \{A_{i,t+1}\}_{i=1}^2, \{B^m_{i,t+1}\}_{i=1}^2, \{Y_{i,t}\}_{i=1}^2, \{\mathcal{Y}_{i,t}\}_{i=1}^2, \{\phi_{i,t+1}\}_{i=1}^2\}$$

for all $t = \{0, t^*\}$. The measure ϕ is consistent with the policy functions derived and the transition probabilities of productivity.

Step 4: At this point we have simulated regional paths for aggregate variables and we have to check if they are consistent with our equilibrium conditions. For example, the labor market equilibrium for region i, in period t requires that $\mu_i L_{i,t} = \mu_i \int_{\phi_{i,t}} x_t h_t$. If this holds then we retain our guess for $w_{i,t}$. If the labor market condition does not hold we incrementally adjust the wage to reduce the difference between demand and supply. We use this new wage as our new guess. Similarly, the relative prices (and hence, the inflation rates) that clear the goods market are derived using the following equation:

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

If regional demand $Y_{i,t} = C_{i,t} + G_{i,t}$ and $Y_{j,t} = C_{j,t} + G_{j,t}$ do not satisfy the above condition we update accordingly our guess for π. We perform a similar updating with respect to all the variables we guessed in Step 1 using the equilibrium conditions.

Step 5: With our new guesses we repeat the algorithm and stop when the transition arising satisfies all equilibrium conditions.