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

May 2021

Working Paper 2018-04

Suggested citation:

The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Federal Reserve Bank of San Francisco or the Board of Governors of the Federal Reserve System.
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
and CEPR

M. Saif Mehkari
University of Richmond

April 11, 2021

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 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: billdupor@gmail.com); 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, Robin School of Business, University of Richmond, 1 Gateway Road, Richmond, VA, 23173, USA (email: smehkari@richmond.edu). We thank Dirk Krueger and four 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. The views expressed here are those of the authors and do not necessarily represent the views of the Federal Reserve Bank of St. Louis, the Federal Reserve Bank of Richmond, the Federal Reserve Bank of San Francisco, or the Federal Reserve System.
1 Introduction

If the government purchases $1 worth of goods, by how much does private consumption increase or decrease? Although the question of the consumption response to government spending is very old, the literature still lacks consensus. For example, Ramey and Shapiro (1998) find that exogenous increases in defense spending decrease private consumption. On the other hand, Blanchard and Perotti (2002) and Gali, Lopez-Salido, and Valles (2007) find that exogenous fiscal expansions increase private consumption.¹ This disconnect is worrisome since consumer spending is the largest component of national income and its response is a key determinant of the fiscal multiplier.

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

The 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 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 show that ARRA funding did not significantly target low-income areas. Nonetheless, we address potential endogeneity using a narrative instrumental variable approach. In particular, we identify components of ARRA funding that did not explicitly target local economic recovery.

We translate our estimated local fiscal multiplier to an aggregate fiscal multiplier using a general equilibrium, two region, New Keynesian 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

¹In 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).

²It is well understood that estimates based on regional variation are not always representative of aggregate effects. Such estimates ignore general equilibrium effects that cannot be separately identified in the cross-regional regressions. For discussions of this point, see Nakamura and Steinsson (2018) and Chodorow-Reich (2019).
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. 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 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. The average MPC in our model is 0.37, which is consistent with the empirical evidence on the magnitude of non-durable consumption

---

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).
responses to unexpected income transfers (Carroll, Slacalek, Tokuoka, and White, 2017). The combined evidence of the local consumption multiplier and 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 results from the 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 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 balance its budget 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.

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.

Foremost, our paper contributes to the extensive literature on the consumption multiplier. One 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 typically rely on defense spending variation. Second, we translate the cross-regional variation into an aggregate consumption response using a quant-\(^4\)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.
tative 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 generates a positive local consumption multiplier due to incomplete markets.

We also contribute to the literature that uses regional variation to estimate aggregate effects of shocks or policies. These include work on the regional effects of house prices shocks on consumer spending (Mian, Sufi, and Rao, 2013) and the effect of unemployment insurance across regions (Hagedorn, Karahan, Manovskii, and Mitman, 2016). Another strand explicitly analyzes the effect of fiscal stimulus and, in particular, the Recovery Act on employment and income including Wilson (2012), Chodorow-Reich, Feiveson, Liscow, and Woolston (2012), Conley and Dupor (2013), Serrato and Wingender (2016), Leduc and Wilson (2017), to name a few. The above literature typically ignores general equilibrium effects. In contrast, we show how local estimates can vary from the aggregate using a general equilibrium model.

Finally, we contribute to the growing literature that incorporates household heterogeneity and incomplete markets to 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 response of consumer spending to government spending. Section 4 sets up the model. Section 5 describes our calibration and our main quantitative experiment. Section 6 analyzes our results under different model specifications, 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 American Recovery and Reinvestment Act (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.\textsuperscript{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).\textsuperscript{6}

<table>
<thead>
<tr>
<th>Spending category</th>
<th>Source</th>
<th># Stores/Individuals</th>
<th>Time period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail spending</td>
<td>Nielsen Retail Scanner</td>
<td>40,000 stores</td>
<td>2006-2014</td>
</tr>
<tr>
<td>Auto spending</td>
<td>CCP/Equifax</td>
<td>10 million individuals</td>
<td>2001-2015</td>
</tr>
</tbody>
</table>

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

\textsuperscript{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/.

\textsuperscript{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.
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 Recovery Act had three major components—tax benefits, entitlements, and federal contracts and grants—with roughly a third of the total spending going to each. In this paper, we focus on the 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, per-capita spending by county.

<table>
<thead>
<tr>
<th>Percentile</th>
<th>10\textsuperscript{th}</th>
<th>25\textsuperscript{th}</th>
<th>50\textsuperscript{th}</th>
<th>75\textsuperscript{th}</th>
<th>90\textsuperscript{th}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$172</td>
<td>$259</td>
<td>$420</td>
<td>$739</td>
<td>$1,312</td>
</tr>
</tbody>
</table>
Notes: Total amount of government spending during the period 2009-2012 by U.S. counties (in millions of dollars).

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.\footnote{For a more detailed analysis of the selection criteria driving our narrative instrumental variable approach, see \textit{Dupor and Mehkari} (2016) and \textit{Dupor and McCrory} (2017).}

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 assis-
tance 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:

\begin{equation}
G_j = a + D_s + \beta \times X_j + \varepsilon_j
\end{equation}

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.\footnote{When we expand the set of control variables to include the 2008 per-capita county income and unemployment, the results are little changed.} We run a separate regression for each local economic characteristic and report the estimates in Table 3.

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 \textit{Boone, Dube, and Kaplan} (2014), who also find that there was not
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.
Table 3: Recovery Act Spending and Local Economic Characteristics

<table>
<thead>
<tr>
<th>Recovery Act Spending (2009-2012)</th>
<th>Total</th>
<th>Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per-capita county income 2007 ($/10,000)</td>
<td>51.8</td>
<td>11.1</td>
</tr>
<tr>
<td>Change in per-capita county income 2007-2009 ($/10,000)</td>
<td>-80.5</td>
<td>13.2</td>
</tr>
<tr>
<td>County unemployment rate 2007 (p.p)</td>
<td>-57.1</td>
<td>22.1</td>
</tr>
<tr>
<td>Change in county unemployment rate 2007-2009 (p.p.)</td>
<td>-183.2***</td>
<td>-34.5**</td>
</tr>
</tbody>
</table>

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.

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:

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

Our benchmark econometric model is

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

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: \( \beta \) 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, 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.\(^{10}\)

\(^{10}\)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...
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).

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.\(^\text{11}\)

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

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

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.
Table 4: Local Retail Spending Multipliers

<table>
<thead>
<tr>
<th>Spending Category</th>
<th>Retail Consumer Spending (Nielsen, Retail Scanner)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
</tr>
<tr>
<td>Government Spending</td>
<td>0.20***</td>
</tr>
<tr>
<td></td>
<td>(0.06)</td>
</tr>
<tr>
<td>Partial F stat.</td>
<td>—</td>
</tr>
<tr>
<td>County Controls/State F.E.</td>
<td>No</td>
</tr>
<tr>
<td># of Counties</td>
<td>367</td>
</tr>
</tbody>
</table>

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.

and 0.26, respectively. Including county controls and state fixed effects decreases both the OLS and IV estimated multipliers to 0.11.

Why do state fixed effects decrease the estimates? As we discussed in Section 2.2.2, state governments increased their own spending by around 50 cents for every dollar they received from the federal government. This means that the specification without state fixed effects is biased upward since it does not control for the confounding government spending at the state level. When we include state fixed effects, the multipliers decrease because the confounding increase in spending by the state governments (or some part of it) shows up in the state fixed effect. 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. For this reason, the specification that includes state fixed effects and uses the instrument is our preferred specification.

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 compare Nielsen-type purchases from the CEX (food at home, alcohol and beverage, detergents, cleaning products and other household products, small appliances, and personal care products) to 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 our Nielsen-based bundle, spending on apparel, tobacco, and read-
Table 5: Nielsen and Consumption Expenditure Survey

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

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.

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

\[
\log C_{i,t}^j = a + \psi \times \log C_{i,t}^{Nielsen} + X_{i,t} \Phi' + \varepsilon_{i,t} \quad (4)
\]

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 underreport their spending relative to low-income households. To alleviate potential measurement error...
Table 6: Local Auto Spending Multipliers

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

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.

corns, 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 $C_{Nielsen}^{i,t}$ 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. Multiplying by 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 (CCP)

We estimate a positive response of fiscal stimulus to auto spending (Table 6). 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

---

12 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.
and county controls/state fixed effects reduce the difference between OLS and IV estimates. The CCP provides a much richer geographical representation of the U.S. relative to Nielsen. This explains the differences in the number of counties.

### 3.2.4 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. 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 around 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

---

13In Appendix C.1, we test the implications of the limited geographical coverage in Nielsen by estimating auto multipliers for counties only present in the retail scanner data. We find the estimates are slightly lower compared to the benchmark CCP sample.
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.

Using the trade flows, we group the counties in our data into high-trade, medium-trade, and low-trade groups. Note that in each case we use the full sample of counties in our data but we create different formations of counties. High-trade groups are formed as follows. We start the group by picking a random county in our sample and augment the group by sequentially picking counties with a high trade exposure (either importing or exporting in relative large volumes based on the CFS) with the existing county/counties in the group. Once the group reaches a pre-specified maximum number of members, we construct a new high-trade group using the same method with the remaining counties in the sample. We choose each group to have at most nine members, resulting in a total of \( N = 41 \) groups.

Low-trade groups are formed by randomly assigning new matches to a group independent of their trade linkages. The middle case (“Medium-trade” groups) are formed by using a combination of trade flow and random assignment methods. We formally describe our algorithm in Appendix D.

Table 7: Summary Statistics on Trade Groups

<table>
<thead>
<tr>
<th>Groups</th>
<th>Low-trade</th>
<th>Medium-trade</th>
<th>High-trade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of groups w/ counties</td>
<td>0%</td>
<td>0%</td>
<td>41%</td>
</tr>
<tr>
<td>from the same state</td>
<td>0%</td>
<td>12%</td>
<td>36%</td>
</tr>
<tr>
<td>from 2 states</td>
<td>100%</td>
<td>88%</td>
<td>21%</td>
</tr>
<tr>
<td>from &gt;2 states</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average group size (in miles)</td>
<td>1016</td>
<td>982</td>
<td>426</td>
</tr>
<tr>
<td>Average group export share</td>
<td>2.2%</td>
<td>2.4%</td>
<td>6.1%</td>
</tr>
<tr>
<td>Number of groups</td>
<td>N= 41</td>
<td>N=41</td>
<td>N=41</td>
</tr>
</tbody>
</table>

Notes: The average distance of a group is the average county-to-county distance in miles. The export share of a group is computed for the subset of counties in the group that belong to separate states.

As Table 7 shows, 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 trades.

\[ ^{14} \text{The trade flows of counties from separate states are based on the export shares of their respective states. In case the counties belong to the same state, we use the share of shipments that stay within the state (one minus the export share) as a measure of within-state county trade flows.} \]
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.

is 6.1 percent. Low-trade groups are formed with random assignment. Thus, in this case, all 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 for the case of low-trade groups, as an example):

\[
\frac{\Delta C_j}{C_{j,2008}} = a + \beta_{\text{low}} \times \frac{G_j}{C_{j,2008}} + X_j \Phi' + \sum_{1}^{N} D_{j \in G} + \varepsilon_j. \tag{5}
\]

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. \( D_{j \in G} \) is a group dummy: it takes the value of one if county \( j \) belongs to a group \( G \) 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 \( \beta_{\text{medium}} \) and \( \beta_{\text{high}} \), 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 $\beta$'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. All estimates are statistically different from zero at the 1 percent.\textsuperscript{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.

\section{Model}

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

\subsection{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 $\pi_i$. 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.\textsuperscript{16}

\textsuperscript{15}Detailed estimates used to construct the plots appear in Table D-9 in Appendix D. 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.

\textsuperscript{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,
The region $i$ population is denoted $\mu_i$ 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 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

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

where $\psi$ affects the utility from leisure and $\theta$ affects the Frisch elasticity of labor supply. $\beta$ 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

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.

$^{17}$Given the utility specification, the Frisch elasticity of labor supply depends on both $\theta$ and the hours worked $h$. In Section 6, we analyze a utility function specified in terms of disutility of hours worked where $\theta$ is directly interpreted as the labor supply elasticity.
labor supply is $xh$ where $x$ is an idiosyncratic shock that follows an AR(1) process in logs:

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

(7)

Therefore, households are heterogeneous for two reasons. First, because they have different 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 $\delta(x) = \frac{\bar{x}}{x}$ 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 $\phi_i$.

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

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

(8)

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

(9)

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

(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:

\[ V_{i,t}^m = (1 + R_{t-1})B_{i,t}^m + (q_{i,t} + (1 - \tau_d)\omega D_{i,t})s_{i,t} - (1 + \pi_{i,t+1})B_{i,t+1}^m - q_{i,t}s_{i,t+1} + \frac{1}{1 + r_{i,t+1}}V_{i,t+1}^m. \] (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

\[ \pi_{i,t+1} = \frac{P_{i,t+1}}{P_{i,t}} - 1 \] (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 \(\omega\) 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):

\[ (1 + r_{i,t})A_{i,t} = (1 + R_{t-1})B_{i,t}^m + (q_{i,t} + (1 - \tau_d)\omega D_{i,t})s_{i,t}. \] (13)

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

\[ 1 + r_{i,t+1} = \frac{1 + R_{t}}{1 + \pi_{i,t+1}} = \frac{q_{i,t+1} + (1 - \tau_d)\omega D_{i,t}}{q_{i,t}}. \] (14)

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

\[ A_{i,t+1} = (1 + \pi_{i,t+1})B_{i,t+1}^m + q_{i,t}s_{i,t+1}. \] (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

$$Y_i = \left[ \sum_{i' = 1}^{N} \gamma_{ii'} \int_{j}^{l_{i',j}} \omega_{i',j} dj \right]^{\frac{1}{\epsilon}}.$$  \hspace{1cm} (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 $\epsilon$ captures the substitutability between intermediate inputs. Demand of final good firm $i$ for input $j$ located at $i'$ is

$$\omega_{i,i',j} = \gamma_{ii'} \left[ \frac{p_{i',j}}{P_i} \right]^{-\epsilon} Y_i.$$  \hspace{1cm} (17)

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

$$P_i = \left[ \sum_{i' = 1}^{N} \gamma_{ii'} \int_{j}^{l_{i',j}} \frac{p_{i',j}}{p_i} dj \right]^{\frac{1}{1-\epsilon}}.$$  \hspace{1cm} (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

$$y_{i,j} = L_{i,j}$$  \hspace{1cm} (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

$$y_{i,j} = \sum_{i'} \mu_{i'} \omega_{i',i,j}.$$  \hspace{1cm} (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 $\beta_i = \frac{1}{1 + r_{i,t+1}}$. Each firm can adjust its price with probability $\lambda$. 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

$$\max_{p_{i,j,t}} \sum_{s = 0}^{\infty} (1 - \lambda)^s \frac{1}{\Pi_{h=1}^{s}(1 + r_{t+h})} \left\{ p_{i,j,t+s}^* y_{i,j,t+s} - W_{i,t+s} L_{i,j,t+s} \right\}$$  \hspace{1cm} (21)
where $W_{i,t}$ is the nominal wage. This leads to the optimal pricing equation

$$\frac{p_{i,j,t}^*}{P_{i,t}} = \frac{\epsilon}{\epsilon - 1} \frac{\sum_{i'=1}^{N} \mu_{i'} \gamma_{i'} Q_{i',t}^* [w_{i,t} Y_{i',t} + (1 - \lambda) \tilde{\beta}_i (1 + \pi_{i',t+1})^{1+\epsilon} X_{i',i,t+1}]}{\sum_{i'=1}^{N} \mu_{i'} \gamma_{i'} Q_{i',t}^* [Y_{i',t} + (1 - \lambda) \tilde{\beta}_i (1 + \pi_{i',t+1})^\epsilon Z_{i',i,t+1}]}$$

(22)

with

$$X_{i',i,t} = w_{i,t} Y_{i',t} + (1 - \lambda) \tilde{\beta}_i (1 + \pi_{i',t+1})^{1+\epsilon} X_{i',i,t+1}$$

(23)

$$Z_{i',i,t} = Y_{i',t} + (1 - \lambda) \tilde{\beta}_i (1 + \pi_{i',t+1})^\epsilon Z_{i',i,t+1}.$$

(24)

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

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

(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 $\tilde{\pi}$. In particular,

$$R_t = R_{ss} + \zeta \tilde{\pi}_t.$$ 

(26)

The aggregate inflation rate $\tilde{\pi} = \sum_i \mu_i \pi_{i,t}$ 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 $\tau$:

$$T_t = -T + \tau [w_{i,t} x_{i,t} + \delta(x_t)(1 - \omega)D_{it}].$$

The government budget constraint reads

$$\sum_i \mu_i (1 + \pi_{i,t+1}) B_{i,j+1}^m - (1 + R_{t-1}) \sum_i \mu_i B_{i,j}^m = \sum_i \mu_i G_{i,t} - \sum_i \mu_i \int_{\phi_{i,t}} T_t - \tau_d \omega \sum_i \mu_i D_{it}$$

(27)
where $B_{i,t}^{m}$ 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: $\sum_i \mu_i B_{i,t}^{m} = B_t^g$.

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

$$y_{i,j,t} = \sum_{i'} \mu_{i'} \omega_{i',i,j,t} = \sum_{i'} \mu_{i'} \gamma_{i'} \left[ \frac{p_{i,j,t}}{P_{i',t}} \right]^{-\epsilon} Y_{i',t}. \tag{28}$$

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

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

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

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

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

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

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 $\alpha$, the
relative populations $\mu_i$, and the relative price of final good $Q_{1,i,t}$.

### 4.9 Definition of the Equilibrium

We describe the equilibrium over the transition and leave the description of the steady-state equilibrium for Appendix E. For an exogenous sequence of regional government spending \(G_{i,t}\), the equilibrium over the transition is a time sequence of equilibrium variables. In particular, we are looking to solve for \(\{C_{i,t}\}_{i=1}^2, \{L_{i,t}\}_{i=1}^2, \{A_{i,t+1}\}_{i=1}^2, \{B_{i,t+1}\}_{i=1}^2, \{Y_{i,t}\}_{i=1}^2, \{\pi_{i,t}\}_{i=1}^2, \{w_{i,t}\}_{i=1}^2, \{\tau_{i,t}\}_{i=1}^2, \{\gamma_{i,t}\}_{i=1}^2, \{\phi_{i,t}\}_{i=1}^2\), 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 \(i\): \(Y_{i,t} = C_{i,t} + G_{i,t}\) \(\forall i\). The inflation rates that clear the goods market \(\{\pi_{i,t}\}_{i=1}^2\) are derived using the following equations:

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

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

2) Regional income in region \(i\), \(\mu_i Y_{i,t}\), is a weighted sum of regional final goods:

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

3) Labor Market Equilibrium: The labor supply satisfies the household’s problem and the aggregate labor supply in region \(i\) is \(\mu_i \int_{\phi_{i,t}} x_t h_t\). Since we have a linear technology, the aggregate labor demand \(\mu_i L_{i,t}\) equals aggregate income \(\mu_i Y_{i,t}\). 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:

\[
\frac{(1 + \pi_{1,t})}{(1 + \pi_{2,t})} = \frac{P_{2,t-1} P_{1,t}}{P_{1,t-1} P_{2,t}} = Q_{2,1,t-1} Q_{1,2,t}.
\]
5) Dividends are given by:

\[ D_{i,t} = \lambda \left( \frac{p_{i,t}^s}{P_{i,t}} \right)^{1-\epsilon} + (1 - \lambda) \left( 1 + \pi_{i,t} \right)^{\epsilon - 1} \cdot \sum_{i'} \mu_{i'} \gamma_{i'i} Q_{i',t}^e Y_{i',t} - w_{i,t} L_{i,t} \forall i. \]

6) Household savings equal the demand for government bonds and equity shares by the mutual funds

\[ \sum_i \mu_i A_{i,t+1} = \sum_i \mu_i (1 + \pi_{i,t+1}) B_{i,t+1}^m + \sum_i \mu_i q_{i,t} \]

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: \( \sum_i \mu_i B_{i,t}^m = B_{g,t}^q \). The supply of bonds along the transition is given by the following fiscal rule: \( B_{t}^q = B_{ss}^q - \sum_i \mu_i (q_{i,t} - q_{i,ss}) \). 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 \( \tau \) is found by balancing the government budget constraint:

\[ \sum_i \mu_i (1 + \pi_{i,t+1}) B_{i,t+1}^m - (1 + R_{t-1}) \sum_i \mu_i B_{i,t}^m = \sum_i \mu_i G_{i,t} - \sum_i \mu_i \int_{\phi_{i,t}} T_t - \tau d\omega \sum_i \mu_i D_{i,t}. \]

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: \( \frac{p_{i,j}}{P_{i,t}} = 1 \forall i \) and \( Q_{i'i'} = 1 \forall i, i' \).

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 prices are equal to their 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. Nonetheless, our numerical simulations do not show any signs of discontinuity, suggestive that, at least locally, the model does not alternate between
equilibrium paths. Small changes to model parameters result in gradual and consistent changes in the equilibrium variables (see Section 5 for multiple comparative statics including the monetary regime).\textsuperscript{18}

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.\textsuperscript{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 8 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 $\psi$ is set so that on average households work 42 percent of their time endowment.\textsuperscript{20} Parameter $\theta$ 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). Using our model, we simulate labor-income paths and then annualize the simulated data to match a persistence of $\rho = 0.92$ and $\sigma^2_{\eta} = 0.04$. We set steady-state government spending $G$ to match a government spending to income ratio equal to 20 percent. The lump-sum transfer

\textsuperscript{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.

\textsuperscript{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.

\textsuperscript{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 8: Benchmark Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Notation</th>
<th>Value</th>
<th>Target / Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean discount factor</td>
<td>$\bar{\beta}$</td>
<td>0.985</td>
<td>Annual real rate=4%</td>
</tr>
<tr>
<td>Dispersion in discount factor</td>
<td>$\epsilon_\beta$</td>
<td>0.005</td>
<td>%Households with $a/y &lt; 1%</td>
</tr>
<tr>
<td>Labor supply elasticity</td>
<td>$1/\theta$</td>
<td>1.0</td>
<td>Beraja, Hurst, and Ospina (2019)</td>
</tr>
<tr>
<td>Disutility of labor</td>
<td>$\psi$</td>
<td>5.8</td>
<td>Hours worked=42%</td>
</tr>
<tr>
<td>Persistence of $x$</td>
<td>$\rho$</td>
<td>0.955</td>
<td>Persistence of log-wages = 0.92</td>
</tr>
<tr>
<td>Variance of innovation to $x$</td>
<td>$\sigma^2_\eta$</td>
<td>1.5%</td>
<td>Variance of log-wages = 0.04</td>
</tr>
<tr>
<td>Per-capita gov. spending</td>
<td>$G$</td>
<td>0.10</td>
<td>$G/Y=20%$</td>
</tr>
<tr>
<td>Dividend allocation</td>
<td>$\omega$</td>
<td>0.32</td>
<td>NIPA Tables</td>
</tr>
<tr>
<td>Elasticity of substitution</td>
<td>$\epsilon$</td>
<td>6</td>
<td>Christiano, Eichenbaum, and Rebelo (2011)</td>
</tr>
<tr>
<td>Price reset probability</td>
<td>$\lambda$</td>
<td>0.15</td>
<td>McKay, Nakamura, and Steinsson (2016)</td>
</tr>
<tr>
<td>Taylor rule coefficient</td>
<td>$\zeta$</td>
<td>0.0</td>
<td>–</td>
</tr>
<tr>
<td>Stock of liquid assets</td>
<td>$B^g$</td>
<td>1.2× Annual income</td>
<td>Survey of Consumer Finances</td>
</tr>
<tr>
<td>Dividend tax</td>
<td>$\tau_d$</td>
<td>0.25</td>
<td>Gourio and Miao (2010)</td>
</tr>
<tr>
<td>Lump-sum transfer</td>
<td>$T$</td>
<td>0.03</td>
<td>$T/Y=6%$</td>
</tr>
<tr>
<td>Size of Region 1</td>
<td>$\mu_1$</td>
<td>3.1%</td>
<td>Relative county population</td>
</tr>
<tr>
<td>Home bias</td>
<td>$\alpha$</td>
<td>0.58</td>
<td>Commodity Flow Survey</td>
</tr>
</tbody>
</table>

$T$ 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).\(^\text{21}\)

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 $\epsilon_\beta$, 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) 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 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.
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 D) regional spillovers stabilize for geographical regions larger than 1000 miles, which roughly corresponds to the size of a U.S. Census region.\textsuperscript{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, $\alpha$. 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 $\alpha$ and exports $1 - \alpha$. The 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

\footnote{The U.S. Census Bureau considers four regions: the Northeast, the Midwest, the South, and the West.}
received the dollar. As a result, we can write the state-level home bias using the formula

\[ S = \alpha + (1 - \alpha) \cdot \frac{\mu - \mu}{\mu - \mu}. \]

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

### 5.2 Steady-State Results

In Table 9, 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 9 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, 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

<table>
<thead>
<tr>
<th>Statistic</th>
<th>SCF (1998-2007)</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households with ( a/y &lt; 1% )</td>
<td>0.29</td>
<td>0.30</td>
</tr>
<tr>
<td>Liquid Assets/Income</td>
<td>1.20</td>
<td>1.20</td>
</tr>
<tr>
<td>Liquid Assets Gini</td>
<td>0.93</td>
<td>0.75</td>
</tr>
<tr>
<td>Median MPC</td>
<td></td>
<td>0.11</td>
</tr>
<tr>
<td>Average MPC</td>
<td></td>
<td>0.37</td>
</tr>
</tbody>
</table>

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

We analyze the effect of a government spending shock on consumer spending. Figure 4

---

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.
shows average county-level Recovery Act spending between 2009-2012. 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 \( \rho_1, \rho_2 \) 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\textsuperscript{th} percentile of the distribution of ARRA funds was around 36 percent lower than at the 75\textsuperscript{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 \( \pi_1 \) 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. 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 \( Q_{i'} = \frac{P_{i'}}{P_i} \). The appreciation induces an expenditure switching effect. The final good firm in Region 1 substitutes local with now cheaper foreign intermediate inputs. This tends to make the comovement of economic aggregates between the regions even higher. Moreover, federal taxes adjust to keep the budget balanced. However, due to higher inflation, which decreases some of the government’s debt service cost, the need to adjust taxes is relatively small. 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). Region 1 consumes more than Region 2 not only on impact but throughout the transition.

\(^{24}\) 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.
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 10: Consumption Multipliers: Data vs. Model

<table>
<thead>
<tr>
<th>Horizon</th>
<th>$t = 8$</th>
<th>$t = 16$</th>
<th>$t = 32$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>–</td>
<td>0.29</td>
<td>–</td>
</tr>
<tr>
<td><strong>Model</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local</td>
<td>0.15</td>
<td>0.20</td>
<td>0.26</td>
</tr>
<tr>
<td>Aggregate</td>
<td>0.41</td>
<td>0.41</td>
<td>0.47</td>
</tr>
</tbody>
</table>

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

$$\sum_i \mu_i \Delta C_{i,t} \over \sum_i \mu_i \Delta G_{i,t}$$

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 10 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 11 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 for labor. Higher labor income affects mainly low wealth, labor-income-dependent households
Table 11: Change in Consumption: Decomposition

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Consumption (percentage deviation from steady state)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>10</td>
</tr>
<tr>
<td>0</td>
<td>-4</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>-4</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>-4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Benchmark consumption</th>
<th>Change due to wages</th>
<th>Change due to dividends</th>
<th>Change due to inflation</th>
<th>Change due to taxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption Multiplier</td>
<td>Local</td>
<td>Aggregate</td>
<td>Due to Wages</td>
<td>0.28</td>
<td>0.48</td>
</tr>
<tr>
<td>Due to Dividends</td>
<td>-0.05</td>
<td>-0.06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Due to Inflation</td>
<td>-0.02</td>
<td>-0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Due to Taxes</td>
<td>0.00</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.20</td>
<td>0.41</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

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 markets, representative agent, New Keynesian model also generates positive local and ag-

26We 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).
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 12). In contrast, there is no effect of government spending on inflation (Right Panel, Figure 6 and Table 12). 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 stickiness. Moreover, the local multiplier associated with labor income is positive, consistent
Table 12: Responses of Labor Income and Inflation to Government Spending (2008-2012)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data Source</th>
<th>Labor Income</th>
<th>Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>OLS</td>
<td>IV</td>
</tr>
<tr>
<td>Government Spending</td>
<td>QCEW</td>
<td>1.33***</td>
<td>0.81*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.34)</td>
<td>(0.41)</td>
</tr>
<tr>
<td>Partial F stat.</td>
<td></td>
<td>—</td>
<td>272.7</td>
</tr>
<tr>
<td>County Controls/ State Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td># Counties</td>
<td></td>
<td>2,916</td>
<td>2,852</td>
</tr>
</tbody>
</table>

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.

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 $\alpha$ 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 for the aggregate consumption response.

We can also see that the local consumption multiplier decreases when home bias approaches
Notes: We vary parameter $\alpha$ 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.

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

For our benchmark value of $\alpha = 0.58$, the local stimulus is sufficiently shared so that the local inflation rates comove to a large degree. As a result, there is no need for subsequent period of deflation.\footnote{The relatively high degree of price stickiness also plays a role here. If prices were more flexible then we would observe some deflation even for $\alpha = 0.58$.} When $\alpha$ 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. As a result, for very high values of $\alpha$, consumption in Region 1 initially increases more (due to higher local demand and income) but, in anticipation of higher real interest rates, quickly falls (even below the consumption in Region 2).
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 standard 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 \( \zeta \) and keep all other parameters as in the benchmark parametrization.

![Figure 8: Consumption Multipliers and Monetary Policy](image)

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

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

In contrast, the local consumption multiplier is largely unaffected by the responsiveness of monetary policy. This exercise confirms the intuition of the literature claiming that first,
monetary authority is critical for the value of the aggregate fiscal multiplier (Christiano, Eichenbaum, and Rebelo, 2011), and second, monetary policy does not affect the local multiplier so that local estimates are an upper bound for the multiplier during times of conventional monetary policy (see for example, Chodorow-Reich, 2019).

Although the weak response of monetary policy is necessary to generate a positive consumption response, it is not the only element generating high aggregate consumption multipliers. The next section shows that even at the zero lower bound, in a model without heterogeneity, the aggregate consumption multiplier is still positive but small.

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. Finally, we analyze an economy with higher wealth than the benchmark economy. 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, $\phi_i$, 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 \( i \):

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

(30)

\[\text{s.t. } c_t + (1 + \pi_{i,t+1})a_{t+1} = w_{i,t}h_t - T + (1 + R_{t-1} + \chi)a_t + (1 - \tau_d)D_{i,t}\]

(31)

\[a_{t+1} \geq 0.\]

(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 \( \Delta \) 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 13 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 is 0.05, while in our benchmark economy it is 0.37.

<table>
<thead>
<tr>
<th>Table 13: Steady State: Benchmark vs. RA-NK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>Liquid Assets/Income</td>
</tr>
<tr>
<td>Liquid Assets Gini</td>
</tr>
<tr>
<td>Median MPC</td>
</tr>
<tr>
<td>Average MPC</td>
</tr>
</tbody>
</table>

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

Figure 9 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

\(^{28}\)We set \( \Delta = -0.5\% \) to match the percentage change of asset holdings relative to the steady state between RA-NK and Benchmark.
Figure 9: 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.

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.

Table 14: Consumption Decomposition: RA-NK vs. Benchmark

<table>
<thead>
<tr>
<th>Consumption Multiplier</th>
<th>RA-NK Local</th>
<th>Aggregate</th>
<th>Benchmark Local</th>
<th>Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Due to Wages</td>
<td>0.13</td>
<td>0.17</td>
<td>0.28</td>
<td>0.48</td>
</tr>
<tr>
<td>Due to Dividends</td>
<td>-0.03</td>
<td>-0.04</td>
<td>-0.05</td>
<td>-0.06</td>
</tr>
<tr>
<td>Due to Inflation</td>
<td>-0.01</td>
<td>-0.04</td>
<td>-0.02</td>
<td>-0.08</td>
</tr>
<tr>
<td>Due to Taxes</td>
<td>0.00</td>
<td>-0.01</td>
<td>0.00</td>
<td>0.05</td>
</tr>
<tr>
<td>Total</td>
<td>0.09</td>
<td>0.06</td>
<td>0.20</td>
<td>0.41</td>
</tr>
</tbody>
</table>

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).

The difference is related to the response of consumer spending due to the change in wages (Table 14). If only wages had changed in our Benchmark, the local multiplier would be 0.28, and the aggregate multiplier would be 0.48. 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 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 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

Local Taxes In the benchmark model, taxation occurs at the federal level. Here, we assume that regions pay taxes proportional to the stimulus injected in the region. In particular, since Region 2 receives 36 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.

Deficit Financing 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 $\theta$ and the hours of work. We also solve the model when we specify the utility function as disutility in hours: $U = \log(c) - \psi \frac{h^{1+\frac{\theta}{2}}}{1+\frac{\theta}{2}}$. We set $\theta$ and $\psi$ 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:

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

We set $\tau_0$ to match the same government-output ratio as in the benchmark model and $\tau_1=0.036$ 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 slightly 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.

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
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 consumption multiplier equal to 0.41. This falls in the upper bound of estimates found in the literature (Hall, 2009).
References


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

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.

²⁹Table 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 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/households. 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

<table>
<thead>
<tr>
<th>Spending Category</th>
<th>Retail Consumer Spending (Nielsen, HomeScan)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
</tr>
<tr>
<td>Government Spending</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
</tr>
<tr>
<td>Partial F stat.</td>
<td>—</td>
</tr>
<tr>
<td>County Controls/State F.E.</td>
<td>No</td>
</tr>
<tr>
<td># Counties</td>
<td>272</td>
</tr>
</tbody>
</table>

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. 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)

![Graph showing the relationship between auto loans and car registrations over time.]

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.

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

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

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.
Table B-2 summarizes the total amount of awards used in our instrument as a fraction of the total awards given. The total amount of money awarded in all of the U.S. during the period 2009-2012 was $228 billion. Out of this amount, 20.2% was allocated based on our selected criteria. Departments of Transportation, Education, and Energy were the main recipients of Recovery Act awards. We identify 16.7%, 15.6%, and 43.5%, respectively, of total money allocated to be awarded based on our selected criteria. For other departments, the fraction is much larger but the total money awarded was relatively small.

B.1 Recovery Act and Total State-Level Spending

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

![Graph showing the relationship between State-Level Recovery Act Spending and Change in State-Level Total Gov. Spending](image)

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 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
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

\[ \Delta G_{s,Total}^s = a + \beta G_{s,ARRA} + \varepsilon_s \] (33)

If \( \beta \) 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 \( \beta \) is higher than one, then the state increased its own spending relative to 2008 (crowding in). \( \beta \) turns out to be 1.5 and is statistically significant at the 1% level. Figure B-3 gives a visual representation of our regression. The crowding in of state-level spending in response to the Recovery Act is also documented by Leduc and Wilson (2017) and Chodorow-Reich (2019).

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.

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
Table C-4: Robustness Analysis

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

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.
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 simply 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. Table C-5 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 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-6 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
Table C-5: Estimates based on Placebo (1)

<table>
<thead>
<tr>
<th>Spending Category</th>
<th>Retail Spending</th>
<th>Auto Spending</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Nielsen)</td>
<td>(Equifax)</td>
</tr>
<tr>
<td></td>
<td>OLS</td>
<td>IV</td>
</tr>
<tr>
<td>Government Spending</td>
<td>-0.007</td>
<td>-0.007</td>
</tr>
<tr>
<td></td>
<td>(0.025)</td>
<td>(0.026)</td>
</tr>
<tr>
<td># Counties</td>
<td>367</td>
<td>367</td>
</tr>
</tbody>
</table>

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 county controls and 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-6: Estimates based on Placebo (2)

<table>
<thead>
<tr>
<th>Spending Category</th>
<th>Retail Spending</th>
<th>Auto Spending</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Nielsen)</td>
<td>(Equifax)</td>
</tr>
<tr>
<td></td>
<td>OLS</td>
<td>IV</td>
</tr>
<tr>
<td>Government Spending</td>
<td>0.07</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.07)</td>
</tr>
<tr>
<td># Counties</td>
<td>367</td>
<td>367</td>
</tr>
<tr>
<td>State F.E</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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.

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-7, 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 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.
Table C-7: Auto Spending Multipliers (Restricted Sample)

<table>
<thead>
<tr>
<th>Spending Category</th>
<th>Auto Spending (CCP/Equifax)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
</tr>
<tr>
<td>Government Spending</td>
<td>0.07***</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
</tr>
<tr>
<td>Partial F stat.</td>
<td>—</td>
</tr>
<tr>
<td>County Controls/</td>
<td>No</td>
</tr>
<tr>
<td>State Fixed Effects</td>
<td></td>
</tr>
<tr>
<td># Counties</td>
<td>367</td>
</tr>
</tbody>
</table>

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.

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 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-8 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 Algorithm to Form Trade Groups

In this section we describe the algorithm for forming high-, middle-, and low-trade groups. We refer to an “origin” county as the first county in a group and a “match” county as a county in the same group as the origin county. All the counties already part of a group (matched)
Table C-8: Retail spending estimates with re-scaling of observations

<table>
<thead>
<tr>
<th>Spending Category</th>
<th>Retail Spending (Nielsen)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
</tr>
<tr>
<td>Government Spending</td>
<td>0.20***</td>
</tr>
<tr>
<td>Weight</td>
<td>(0.06)</td>
</tr>
<tr>
<td># Counties</td>
<td>367</td>
</tr>
</tbody>
</table>

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.

are part of the set $M$.

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

2. Generate a random number $x \in (0, 1)$. If $x < \lambda$ (where $\lambda$ will be specified below) then go to 2(a). Otherwise go to 2(b).

   (a) For all $j \neq i$ calculate the export share of county $i$ to county $j$, $s_{ij}$, as well as of county $j$ to county $i$, $s_{ji}$. Denote $\bar{s}_j = (s_{ij} + s_{ji})/2$. We match county $j'$ to the group if $\bar{s}_{j'} = \max(\bar{s}_i)$, where $\bar{s}_i$ is a vector of export shares with respect to all unmatched $j$'s, i.e., $j \notin M$. If a tie exist between counties $j'$ and $j''$ we randomly pick one of the two. When we have more than one county in the group (for example, $i$ and $i'$) then we compute $\bar{s}_i$ and $\bar{s}_{i'}$ and pick the county $j'$ such that $\bar{s}_{j'} = \max(\bar{s}_i) > \max(\bar{s}_{i'})$.

   (b) For all $j \neq i$ choose randomly a county from the set of ungrouped counties, i.e., for $j \notin M$.

3. Continue adding trading partners 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, we pick $\lambda$ to differentiate between high-, middle-, and low-trade groups. In the case of high-trade groups we set $\lambda = 1$ so that the assignment is always based on the trade flows with the existing counties in the group. In the case of low-trade groups we set $\lambda = 0$. Here, counties are assigned randomly to groups without
reference to the trade flows. Finally, for the case of middle-trade groups we pick $\lambda = 0.5$. This is a combination of assignment based on trade flows data and random assignment. Secondly, we set $C = 9$. We pick this threshold since our sample is around 360 counties and a group of 9 counties gives roughly 40 groups.

For the cases of $\lambda = 0$ and to some extent $\lambda = 0.5$, groups are based on random assignment. To make sure our results are not driven by a particular random association between counties we run our algorithm 100 times. The coefficients reported in Figure 3 are the mean of the estimates we obtained after running our regression 100 times. Table D-9 shows the mean estimate (as in Figure 3) but also the standard error of the estimate.

Table D-9: Local Consumption Multiplier and Trade Linkages (Data)

<table>
<thead>
<tr>
<th>Spending Category</th>
<th>Retail Spending (Nielsen)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High-Trade</td>
</tr>
<tr>
<td></td>
<td>OLS</td>
</tr>
<tr>
<td>Government Spending</td>
<td>0.13***</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
</tr>
<tr>
<td># Counties</td>
<td>367</td>
</tr>
</tbody>
</table>

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 for each case for 100 cases. 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.

Trade flows are likely declining in the geographical distance between two counties. 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 $D_j \in G$ takes the value of one if county $j$ belongs to a geographical group $G$ and zero otherwise. Figure D-4 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 $i$
Notes: The figure shows the estimate of the local consumption multiplier (coefficient $\beta$) 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.

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., $\bar{d}_j = \min(d^i)$, where $d^i$ 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 $\bar{d}^i$ and $\bar{d}^{i'}$ and pick the county $j'$ such that $\bar{d}_{i,j'} = \min(\bar{d}^i) < \min(\bar{d}^{i'})$.
   (a) If $d_{i,j} < D$ then include county $j$ as part of the group with county $i$.
   (b) If $d_{i,j} \geq D$ 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 \( D \) which increases in steps of 100 miles and second, the maximum number of counties allowed in the group which we set to \( C = D/10 \). 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.

### E 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: \( \frac{p_{i,t}}{p_i} = 1 \forall i \) 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:

\[
\{C_i\}_{i=1}^2, \{L_i\}_{i=1}^2, \{A_i\}_{i=1}^2, \{B_i^m\}_{i=1}^2, \{Y_i\}_{i=1}^2, \{q_i\}_{i=1}^2, \{D_i\}_{i=1}^2, \{\phi_i\}_{i=1}^2,
\]

and two aggregate variables, the nominal interest rate \( R \) (which equals the real interest rate) and the federal tax rate \( \tau \).

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 \( i \): \( C_i + G_i \forall i \). 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 \( i \), \( \mu_i Y_{i,t} \), is a weighted sum of regional final goods

\[
\mu_i Y_i = \sum_{i'} \mu_{i'i'} \gamma_i \gamma_i' Y_{i'}.
\]

3) Labor Market Equilibrium: The real wage is given by \( w_i = \frac{1}{\epsilon} \forall i \) 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 \( \mu_i Y_i \).

4) Dividends are given by \( D_i = Y_i - w_i L_i \forall i \).

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: \( \sum_i \mu_i B^m_i = B^g_s \).

7) The government balances its budget

\[
R \sum_i \mu_i \int \phi_i B^m = \sum_i \mu_i G_i - \sum_i \mu_i \int T - \tau_d \omega \sum_i \mu_i D_i
\]

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

\section*{F Derivation of Equations}

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

\[
Y_i = \left[ \sum_{i' = 1}^{N} \gamma_{ii'}^\frac{1}{2} \int_j \omega_{ii'j}^{\frac{1}{2}} \right]^{\frac{1}{2}}
\]

The maximization problem for the firm \( i \) reads:

\[
\max_{\omega_{ii'j}} \quad P_i Y_i - \sum_{i'} \int p_{i'j} \omega_{ii'j}
\]

\[
\Rightarrow \quad \omega_{ii'j}^{-\frac{1}{2}} = \frac{1}{\gamma_{ii'}^\frac{1}{2} P_i} \left[ \sum_{i'} \gamma_{ii'}^{\frac{1}{2}} \int_j \omega_{ii'j}^{\frac{1}{2}} \right]^{\frac{1}{1}}
\]

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

The zero profit condition leads to the price aggregator:

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

\[
\Rightarrow \quad P_i = \sum_{i'} \gamma_{ii'} P_i \int p_{i'j}^{-\epsilon} \quad \Rightarrow \quad P_i^{1-\epsilon} = \sum_{i'} \gamma_{ii'} \int p_{i'j}^{1-\epsilon}
\]

\[
\Rightarrow \quad P_i = \left[ \sum_{i' = 1}^{N} \gamma_{ii'} \int p_{i'j}^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}}
\]
Let \( \lambda \) 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

\[
1 = \sum_{i'=1}^{N} \gamma_{ii'} \left[ \lambda \left( \frac{p^*_{ij'}}{P_{s'}} \right)^{1-\epsilon} Q^{1-\epsilon}_{s'i} + (1 - \lambda)(1 + \pi_{i't})^{\epsilon-1} Q^{1-\epsilon}_{s'i} \right] \Rightarrow \\
1 = \sum_{i'=1}^{N} \gamma_{ii'} Q^{1-\epsilon}_{s'i} \left[ \lambda \left( \frac{p^*_{ij'}}{P_{s'}} \right)^{1-\epsilon} + (1 - \lambda)(1 + \pi_{i't})^{\epsilon-1} \right]
\]

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

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

Total demand for intermediate inputs of region \( i \) is

\[
\int_{j} y_{ij} = \gamma_i = \sum_{i'} \gamma_{ii'} \left[ \frac{f_{ij} p_{ij}}{P_{s'}} \right]^{-\epsilon} Y_{s'} = \sum_{i'} \gamma_{ii'} \left[ \lambda \left( \frac{p^*_{ij}}{P_{s'}} \right)^{-\epsilon} Y_{s'} + (1 - \lambda) \left( \frac{P_{it-1}}{P_{i't}} \right)^{-\epsilon} Y_{s'} \right] = \sum_{i'} \gamma_{ii'} Y_{i'} \left[ \lambda \left( \frac{p^*_{ij}}{P_{i}} \right)^{-\epsilon} \left( \frac{P_{i}}{P_{i'}} \right)^{-\epsilon} + (1 - \lambda) \left( \frac{P_{it-1} P_{i}}{P_{i't} P_{i}} \right)^{-\epsilon} \right] = \sum_{i'} \gamma_{ii'} Y_{i'} \left[ \lambda \left( \frac{p^*_{ij}}{P_{i}} \right)^{-\epsilon} Q^{\epsilon}_{s'i} + (1 - \lambda)(1 + \pi_{i't})^{\epsilon} Q^{\epsilon}_{s'i} \right] \Rightarrow \gamma_i = \left[ \lambda \left( \frac{p^*_{ij}}{P_{i}} \right)^{-\epsilon} + (1 - \lambda)(1 + \pi_{i't})^{\epsilon} \right] \sum_{i'} \gamma_{ii'} Q^{\epsilon}_{s'i} Y_{s'}
\]

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 \( t \):

\[
\max_{p^*_{ij}} p^*_{ij} y_{ijt} - W_{it} y_{ijt} + \frac{1 - \lambda}{(1 + r_{t+1})} [p^*_{ijt} y_{ijt+1} - W_{it+1} y_{ijt+1}] + \frac{(1 - \lambda)^2}{\Pi_{h=1}^{2} (1 + r_{t+h})} [p^*_{ijt} y_{ijt+2} - W_{it+2} y_{ijt+2}] + \ldots
\]

This gives
$p_{ij}^* = \frac{\epsilon}{\epsilon - 1} \sum_{i' = 1}^{N} \gamma_{i'i} \left[ w_{it} \frac{Y_{i't}}{P_{i't}} + \frac{1 - \lambda}{(1 + r_{t+1})} \frac{Y_{i't+1}}{P_{i't+1}} + \frac{(1 - \lambda)^2}{\Pi_{h=1}^{t}(1 + r_{h+1})} \frac{Y_{i't+h}}{P_{i't+h}} + \ldots \right]
\sum_{i' = 1}^{N} \gamma_{i'i} \left[ \frac{Y_{i't}}{P_{i't}} + \frac{1 - \lambda}{(1 + r_{t+1})} \frac{Y_{i't+1}}{P_{i't+1}} + \frac{(1 - \lambda)^2}{\Pi_{h=1}^{t}(1 + r_{h+1})} \frac{Y_{i't+h}}{P_{i't+h}} + \ldots \right]
\sum_{i' = 1}^{N} \gamma_{i'i} Q_{i'i}^{\epsilon} \left[ w_{i't} Y_{i't} + (1 - \lambda) \tilde{\beta}_i (1 + \pi_{i't+1})^{1+\epsilon} X_{i'i}^{t+1} \right]
\sum_{i' = 1}^{N} \gamma_{i'i} Q_{i'i}^{\epsilon} \left[ Y_{i't} + (1 - \lambda) \tilde{\beta}_i (1 + \pi_{i't+1})^{\epsilon} Z_{i'i}^{t+1} \right]
$

with

$X_{i'i}^{t+1} = w_{i't} Y_{i't} + (1 - \lambda) \tilde{\beta}_i (1 + \pi_{i't+1})^{1+\epsilon} X_{i'i}^{t+1}$

$Z_{i'i}^{t+1} = Y_{i't} + (1 - \lambda) \tilde{\beta}_i (1 + \pi_{i't+1})^{\epsilon} Z_{i'i}^{t+1}$

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

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

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

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

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

**G 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 $C_i = m Y_i$, where $m$ is the marginal propensity to consume and $Y_i$ is regional income which is
given by

\[ Y_1 = a(C_1 + G_1) + (1 - a)(C_2 + G_2) \]
\[ Y_2 = (1 - a)(C_1 + G_1) + a(C_2 + G_2) \]

We substitute \( C_i = mY_i \) to derive

\[ Y_1(1 - am) = (1 - a)mY_2 + aG_1 + (1 - a)G_2 \]
\[ Y_2(1 - am) = (1 - a)mY_1 + (1 - a)G_1 + aG_2 \]

We write the equations in matrix form:

\[
\begin{bmatrix}
1 - am & -(1 - a)m \\
-(1 - a)m & 1 - am
\end{bmatrix}
\begin{bmatrix}
Y_1 \\
Y_2
\end{bmatrix} =
\begin{bmatrix}
0 \\
0
\end{bmatrix}
\begin{bmatrix}
G_1 \\
G_2
\end{bmatrix}
\]

The inverse of \( \mathbf{A} \) is

\[
\mathbf{A}^{-1} = \begin{bmatrix}
1 - am & (1 - a)m \\
(1 - a)m & 1 - am
\end{bmatrix} / \frac{(1 - am) - (1 - a)^2m^2}{\lambda}
\]

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

\[
\begin{bmatrix}
Y_1 \\
Y_2
\end{bmatrix} = \begin{bmatrix}
[(m - a(2m - 1))G_1 + (1 - a)G_2]/\lambda \\
[(1 - a)G_1 + (m - a(2m - 1))G_2]/\lambda
\end{bmatrix}
\]

Regional income in region \( i \) is a function of the 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 \( \frac{Y_1 - Y_2}{G_1 - G_2} \) while the aggregate income multiplier is \( \frac{Y_1 + Y_2}{G_1 + G_2} \). Finally, using that \( C_i = mY_i \), we derive the local and aggregate consumption multipliers equal to

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

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, \( \frac{\Delta C_{Agg}}{\Delta G} (m) \).

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

\[
\frac{\Delta C_{Local}}{\Delta G} = \frac{m(2a - 1)(1 - m)^2}{(1 - am)^2 - (1 - a)^2 m^2} \frac{\Delta C_{Agg}}{\Delta G}
\]

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.