Washington Center for Equitable Growth

1500 K Street NW, Suite 850
Washington, DC 20005

Working paper series

Geographic cross-sectional fiscal multipliers: What have we learned?

Gabriel Chodorow-Reich

January 2017

http://equitablegrowth.org/working-papers/cross-sectional-fiscal-multipliers/

Geographic Cross-Sectional Fiscal Multipliers: What Have We Learned?
Gabriel Chodorow-Reich
January 2017

Abstract

A geographic cross-sectional fiscal multiplier measures the effect of an increase in spending in one region in a monetary union. Empirical studies of such multipliers have proliferated in recent years. I review this research and find a cross-study mean cross-sectional output multiplier of about 2. Economic theory of how to map these multipliers into a national multiplier has also advanced. Drawing on the theoretical literature, I discuss conditions under which the cross-sectional multiplier can provide a rough lower bound for the closed economy deficit-financed constrained monetary policy multiplier. Putting these elements together, the cross-sectional evidence suggests a national multiplier of about 1.7 or above, larger than that found in most studies based on time series evidence. I conclude by offering suggestions for future research on cross-sectional multipliers.

Gabriel Chodorow-Reich
Harvard University
Department of Economics
chodorowreich@fas.harvard.edu

I thank Arin Dube, Emmanuel Farhi, Laura Feiveson, Joshua Hausman, and Emi Nakamura for helpful discussions and comments. Tzachi Raz provided excellent research assistance. I acknowledge financial support from The Frank N. Newman Fund in Economics. Disclosure: I was a staff economist on the Council of Economic Advisers from 2009-2010.

1. Introduction

A geographic cross-sectional fiscal multiplier measures the effect of an increase in spending in one region in a monetary union. The past several years have witnessed a wave of new research on such multipliers. By definition, estimation uses variation in fiscal policy across distinct geographic areas in the same calendar period. This approach has a number of advantages, most notably the potential for much greater variation in policy across space than over time, and variation more plausibly exogenous with respect to the no-intervention paths of outcome variables.

At the same time, cross-sectional multipliers differ in important dimensions from the more commonly studied national government spending multiplier. Thus, along with a wave of new empirical studies, research into the theoretical mappings across cross-sectional multiplier studies and to the national multiplier has also advanced. This research highlights four unique aspects of cross-sectional multipliers: they do not allow for a response of monetary policy, they may induce expenditure switching by local and external agents resulting from output prices rising in response to government spending, they may induce spending by local agents on output produced in other regions via income effects, and they almost always involve an increase in spending without requiring contemporaneous or future increases in local taxes. Recognition of these differences has led to pessimism regarding whether cross-sectional multipliers provide any guidance for the effects of other types of policies such as the national spending multiplier.[1]

In this paper, I assess what we have learned from this research wave. The answer takes

[1]For example, in a recently published paper, Fishback and Kachanovskaya (2015, p. 126) write: "The state multipliers cannot be easily translated into a national multiplier because of spillover effects outside each state's boundaries and because the same state multiplier can lead to a broad range of estimates of the national multiplier under a reasonable set of assumptions in a macroeconomic model." Other recent studies include similar caveats.

three parts. First, section 2 reviews the basic econometric issues arising with cross-sectional multipliers and provides a comparison to the time series approach. I illustrate the concepts using an updated example drawn from three papers studying the effects of the 2009 American Recovery and Reinvestment Act (ARRA).

Next, in section 3 I discuss the theoretical considerations. I argue the literature's retreat regarding its informativeness for other interventions is premature. To make this point, I successively compare cross-sectional multipliers to two other policy experiments of interest, following closely the theoretical results in Shoag (2015), Nakamura and Steinsson (2014), and Farhi and Werning (2016).

I start with a comparison to local deficit-financed government spending, for example by a single state in the United States or a country in Europe. The difference between this policy and essentially all cross-sectional multiplier studies is that in the latter the spending does not affect the present value of local tax burdens, for example, because the spending is paid for by the federal government. However, standard economic theory suggests that such outside financing can have a small effect on local output. Intuitively, fully Ricardian agents will increase their private spending by only the annuity value of a transfer, which for transitory spending implies a small increase relative to the direct change in government purchases, while spending by fully rule-of-thumb or liquidity-constrained agents does not depend at all on the present value of the tax burden. Moreover, the salience of the transfer component may be low. Thus, in many cases the outside-financed cross-sectional multiplier is likely to provide a rough guide to the local deficit-financed multiplier.

I then discuss the mapping from a local deficit-financed government spending multiplier to a closed economy zero lower bound deficit-financed aggregate multiplier. Here theory predicts that expenditure switching and import leakage reduce locally-financed multipliers relative to the relevant aggregate multiplier. Combining these two arguments, I conclude that in many cases the cross-sectional multiplier may provide a rough lower bound for the closed economy zero lower bound deficit-financed aggregate multiplier.

I review the recent empirical literature in section 4. I divide this section into two parts. The first groups together a set of papers which have examined various components of the ARRA. These studies all exploit variation homogenous along the dimensions of the outside nature of the financing and the short persistence of the intervention, and also all focus on employment rather than output effects of spending. The cost-per-job across these studies ranges from roughly \$25K to \$125K, with around \$50K emerging as a preferred number. Using a production function approach, this magnitude translates loosely into an output multiplier of about 2. I then turn to papers using other sources of variation, many quite creative. The diversity of outcome variables and policy experiments makes reaching a synthesized conclusion across these studies harder; nonetheless, those which estimate a cost-per-job find numbers around \$30K, and, with one or two notable exceptions, those which estimate income or output multipliers find numbers in the range of 1-2.5.

Section 5 summarizes what we have learned. Regarding the informativeness for national multipliers, the median implied cross-sectional output multiplier is 1.8 and the mean is 2.1. Applying the rough lower bound result, a cross-sectional multiplier of around 2 implies a zero lower bound deficit-financed national multiplier of about 1.7 or above. This magnitude falls at the very upper end of the range found in a recent review article based mostly on time series evidence (Ramey, 2011). Many studies also find evidence of higher multipliers in periods and regions with greater economic slack, pointing to the presence of forces such as lower factor prices in generating state-dependent multipliers. I relate these results to other policy experiments for which cross-sectional studies offer guidance, such as enhanced fiscal integration in Europe.

Finally, section 6 offer suggestions to help increase the impact of future cross-sectional multiplier studies, including how to further bridge the gap to the national multiplier.

2. What is a Cross-Sectional Multiplier?

Consider the relationship:

$$Y_{s,t} = \alpha_t + \beta^{xs\prime} F_{s,t} + \gamma' X_{s,t} + \epsilon_{s,t}, \tag{1}$$

where $Y_{s,t}$ is an outcome such as output or employment growth in geographic area s at time t, α_t is a time fixed effect, $F_{s,t}$ is a vector of components of fiscal policy such as government spending and taxes, and $X_{s,t}$ is a vector of covariates.[2] The time fixed effect α_t in equation (1) characterizes β^{xs} as a cross-sectional multiplier (xs for cross-section). Identification comes only from variation in fiscal policy across space within the same calendar period. Within each calendar period this variation must, conditional on $X_{s,t}$, be uncorrelated with the trajectories of economic activity across areas absent differences in fiscal policy.

[2]The notation $F_{s,t}$ is meant to be quite general. For example, the vector could include lags of government spending and taxes and expectations of future spending and taxes. In practice, however, most studies consider only contemporaneous spending.

2.1. Comparison to Time Series

It is informative to compare equation (1) to the time series regression (ts for time series):

$$Y_t = \alpha + \beta^{ts\prime} F_t + \gamma' X_t + \epsilon_t, \quad (2)$$

where variables without s subscripts denote aggregation across all regions s.

Two main challenges arise in estimating equation (2). First, fiscal policy may adjust in response to a changing economic trajectory. This reverse causality affects both discretionary fiscal policy and automatic stabilizers. Researchers must then identify some subset of changes in F_t which are orthogonal to ϵ_t. Approaches include war spending (Barro, 1981; Ramey and Shapiro, 1998; Hall, 2009), narrative cataloging of policy changes taken for reasons unrelated to business cycle management (Romer and Romer, 2010), and VAR recursive or sign restrictions (Blanchard and Perotti, 2002; Mountford and Uhlig, 2009).

The second challenge comes from policy variables which coincide with or respond to changes in government spending. The response of monetary policy and what happens to taxes provide leading examples.[3] An estimate of β^{ts} to exogenous changes in government spending gives the average effect over the behavior of monetary policy and taxes in the researcher's sample.

The cross-sectional approach impacts both of these issues. The time effect α_t in equation (1) eliminates any concerns of endogenous fiscal response at the highest (e.g. federal) level. The researcher need then only specify a reason why $F_{s,t}$ varies across geographic areas. The time effect also absorbs any monetary policy response or change in other federal fiscal variables. This

[3] Theories emphasizing the co-determination of monetary and fiscal policy suggest these two cases are one and the same (Leeper, 1991). In principle, F_t could include the expected paths of government spending and taxes, but it rarely does.

consequence of cross-sectional estimation creates both opportunities and challenges. On the one hand, removing the effect of the endogenous response of monetary policy or taxes makes the estimate of β^{xs} more directly tied to primitives of the economic environment and hence potentially more stable across studies, a point emphasized by Nakamura and Steinsson (2014). On the other, it creates some distance between the cross-sectional multiplier β^{xs} and the more commonly studied aggregate multiplier β^{ts}, an issue I return to in section 3.

2.2. Typical Approach

The typical cross-sectional econometric study starts from some variable $Z_{s,t}$ which satisfies the conditions for an instrument: it is correlated with fiscal policy and the researcher can make an a priori plausible case for the exclusion restriction $Z_{s,t} \perp\!\!\!\perp \epsilon_{s,t}|\alpha_t, X_{s,t}$, or in words, that the variable $Z_{s,t}$ is conditionally independent of local economic trends. In some instances, $Z_{s,t}$ does not have a monetary representation. For example, some states have more restrictive balanced budget requirements than others. Estimation proceeds by using $Z_{s,t}$ as an instrument for $F_{s,t}$. In many instances, however, $Z_{s,t}$ consists of some component of government spending or taxes. For example, suppose federal government spending per capita in state s, $G_{s,t}$, consists of a part constant across states, $\bar{G}_t$, a part which responds endogenously to a state's economy, $\tilde{G}_{s,t}$, and a randomly allocated part $\hat{G}_{s,t}$. Clearly, the common component $\bar{G}_t$ provides no variation across states, and by assumption $\tilde{G}_{s,t} \not\perp\!\!\!\perp \epsilon_{s,t}$. Therefore, the researcher sets $Z_{s,t} = \hat{G}_{s,t}$. Estimation may proceed either by substituting $Z_{s,t}$ for $F_{s,t}$ in equation (1), or by using $Z_{s,t}$ as an instrument for $F_{s,t}$. If $Z_{s,t}$ truly is as good as randomly assigned, and other spending does not endogenously adjust, then (i) $Z_{s,t} \perp\!\!\!\perp F_{s,t} - Z_{s,t}$, i.e. the exogenous part of spending is uncorrelated with the rest of spending, (ii) the coefficient in the first stage regression should equal one in the IV case, and (iii) the researcher will (asymptotically) obtain the same estimate of β whether or not she estimates the instrumental variables or the reduced form relationship. Alternatively, if $Z_{s,t} \not\perp F_{s,t} - Z_{s,t}$, then the two approaches will yield different multipliers.[4]

2.3. Example

I illustrate the cross-sectional approach using cross-state variation generated by the American Recovery and Reinvestment Act (ARRA). Enacted in 2009 with the explicit intent of mitigating the recession then already underway, the ARRA offers little useful time series variation for assessing the consequences of fiscal policy.[5] Instead, researchers have identified aspects of the spending allocation which resulted in geographic variation plausibly exogenous to geographic variation in economic trends. A relatively small part of the ARRA consisted of direct purchases of output by the federal government. I follow much of the literature and treat other components such as transfers to state governments as if they ultimately resulted in additional purchases and use the term "spending" to cover all non-tax aspects of the ARRA.

Table 1 reports a unified set of results for three measures of $Z_{s,t}$ used in prior studies. The first comes from Chodorow-Reich et al. (2012), who note that roughly \$90 billion of federal aid to state governments came in the form of an increase in the federal share of Medicaid expenditure (the FMAP), effectively giving larger grants to states with higher secular per capita Medicaid spending. Because the increase in the FMAP also depended on the state's unemployment rate, which is clearly endogenous to the economic trajectory, Chodorow-Reich et al. (2012) use pre-recession Medicaid spending as an instrument for the FMAP transfer

[4] Of course, if $Z_{s,t} \not\perp F_{s,t} - Z_{s,t}$, one should either have a good institutional reason for why other categories of government spending endogenously respond to the randomly assigned part or share a common formulaic determination, or there is reason for concern that the variation underlying $Z_{s,t}$ is truly as good as random.

[5] A few papers have used historical time series patterns to study the ARRA. See e.g. Cogan and Taylor (2012); Carlino and Inman (2014).

component. The second proposed $Z_{s,t}$ comes from Wilson (2012) and Conley and Dupor (2013). As described by these authors, the distribution of $27 billion of highway construction spending depended formulaicly on total lane miles of federal highway, total vehicle miles traveled on federal highways, tax payments paid into the federal highway trust fund, and Federal Highway Administration obligation limitations. I follow Wilson (2012) and use a linear combination of these four factors as an instrument for Department of Transportation spending. Dupor and Mehkari (2016) take the idea of identifying spending allocated according to pre-recession formulas to its logical extreme and aggregate all components of the ARRA which fit this description. The components identified by Dupor and Mehkari (2016) constitute the third proposed $Z_{s,t}$.[6]

Columns (1)-(4) of table 1 report "job-year" regressions corresponding to each of these sources of variation. While national multipliers typically take the form of dollars of GDP per dollar of spending, at the state level the Bureau of Economic Analysis has only just begun to report real gross state product (GSP) at a quarterly frequency. In contrast, the Bureau of Labor Statistics reports monthly employment by state or county based on high quality administrative data generated by firms' reporting into the unemployment insurance system. Just as a GDP multiplier measures the increment to output over a fixed period of time, job-years measure the increment in average employment over the course of a year. Specifically, I fix the pre-treatment period and first-difference equation (1) to obtain a purely cross-sectional regression of the change in per capita employment on a measure of spending, and then sum over months

[6] I make the following changes to the instruments used in these papers. For Wilson (2012), I update the projection of ARRA highway obligations on the four formulaic components to include obligations in 2010. For Dupor and Mehkari (2016), I use the agency-reported spending in the identified programs rather than the spending as reported by recipients. The Dupor and Mehkari (2016) use of local recipient reporting means that their list of programs excludes the FMAP increase and the highway spending.

holding the spending variable fixed:

$$Y_s = \alpha + \beta^{xs} \hat{F}_s + \gamma' X_s + \epsilon_s, \tag{3}$$

$$F_s = \Pi_0 + \Pi_1' Z_s + \Pi_2' X_s + \nu_s, \tag{4}$$

where $Y_s = \frac{1}{12} \sum_{t=2008M12}^{2010M12} \frac{\text{Employment}_t - \text{Employment}_{2008M12}}{\text{Working age population}_{2008M12}}$, F_s is total ARRA outlays through $2010M12$, and Z_s is an instrument set. Intuitively, the IV coefficient from a regression of the change in per capita employment between the pre-ARRA month $2008M12$ and some period h months later gives the impulse response of employment at horizon h; summing over these impulse responses and dividing by 12 gives the cumulative additional employment in job-years. Collapsing these effects as in equation (3) makes calculations of standard errors straightforward. For parsimony I include three measures of economic conditions in X_s: the employment change from $2007M12$ to $2008M12$, the growth rate of GSP from $2007Q4$ to $2008Q4$, and the $2008M12$ employment-population ratio.[7]

Columns (1)-(3) report the coefficient associated with each instrument separately. While the correlation coefficient between the DOT and DM instruments is fairly high (0.74), perhaps explaining the large first stage coefficients in columns (2) and (3), neither variable is highly correlated with the FMAP instrument (0.04 for DOT and 0.14 for DM).[8] Nonetheless, the estimated employment effect is remarkably stable across columns. Column (4) groups the three instrument sets together. The coefficient of 1.99 has the interpretation of an additional \$100K

[7]The employment data come from the Bureau of Labor Statistics Current Employment Statistics, an establishment-based count of payroll jobs each month. For these columns I translate all variables into per capita by dividing by the civilian population 16+ in $2008M12$. Each of Chodorow-Reich et al. (2012), Wilson (2012), and Dupor and Mehkari (2016) contains a more exhaustive set of control variables and I refer the reader to those papers for additional details.

[8]The first stage coefficient in column (1) lies below one because the FMAP increased by 6.2 p.p. and because Medicaid spending in 2009 and 2010 was higher than Medicaid spending in 2007.

Table 1: ARRA Example

	Dependent variable:				
	Job years per $100K spent				GSP
	(1)	(2)	(3)	(4)	(5)
Endogenous variable:					
Total ARRA spending	2.15**	2.06+	1.83**	1.99**	1.76
	(0.65)	(1.16)	(0.66)	(0.55)	(1.26)
Instruments	FMAP	DOT	DM	ALL	ALL
Estimator	2sls	2sls	2sls	2sls	2sls
First stage coefficient	0.38	1.78	6.71	.	.
First stage F statistic	41.2	11.4	50.4	59.4	151.8
First stage R^2	0.48	0.29	0.57	0.80	0.89
Hansen J statistic p-value				0.88	0.36
Observations	50	50	50	50	50

Notes: All specifications also control for the employment change from December 2007 to December 2008, gross state product (GSP) growth from the fourth quarter of 2007 to the fourth quarter of 2008, and the December 2008 employment-population ratio. Eicker-White standard errors in parentheses. **,+ denote significance at the 1 and 10 percent levels, respectively.

of ARRA spending in a state increases employment by the equivalent of 1.99 jobs each of which lasts for one year, or a "cost-per-job" of $\frac{\$100K}{1.99 \text{ jobs}} = \$50,250$. The first stage R^2 rises substantially in column (4) and the second stage standard error falls, indicating improved efficiency by combining the instruments together. The J statistic fails to reject exogeneity. Column (5) uses newly available gross state product (GSP) data to estimate an output multiplier of 1.76, although with less precision than the employment results.[9]

[9] In column (5) I normalize all variables except employment by the level of GSP in 2008Q4. The degree of measurement error in real GSP data – especially as compared to the employment data which derive solely from administrative tax records – may explain the larger standard error for the output multiplier. The methodology underlying the real GSP data further invites caution in their use for studying multipliers. For example, their construction does not allow for a local price response to increased government purchases (Cao et al., 2016), an issue of potential importance as discussed below.

3. Cross-sectional Multipliers in Theory

Economic theory predicts geographic cross-sectional multipliers may depend on the source of financing (local versus external), on the persistence of spending, and on the openess of the local region. Each of these factors then affects the mapping to a closed economy multiplier. To illustrate, I relate cross-sectional multipliers to successive policy interventions and provide conditions under which the cross-sectional multipliers can provide a lower bound for a closed economy multiplier. Many of the concepts discussed arise in the traditional static Old Keynesian model and its open economy counterpart Mundell-Fleming; others affect intertemporal budget constraints and arise only in more modern treatments. My discussion in the text focuses on the economic concepts and refers only briefly to particular models. Appendix A presents the details of one such model based on Farhi and Werning (2016). Shoag (2015) and Nakamura and Steinsson (2014) also develop many of these points formally.

I then discuss the relationship between output multipliers and employment multipliers. Most time series studies of fiscal policy and most theoretical treatments focus on output multipliers, but for reasons of data availability, many geographic cross-sectional studies calculate employment multipliers instead. Using a production function approach, I derive a mapping between the two useful for comparing across studies.

3.1. Crosswalk from Cross-sectional to Closed Economy Multiplier

I develop a relationship between cross-sectional multipliers and a particular closed economy multiplier of interest, the deficit-financed zero lower bound closed economy multiplier, in two steps.

3.1.1. Relationship to Deficit-financed Currency Union Spending Multiplier

Geographic cross-sectional multipliers have a close relationship to deficit-financed stimulus policies by individual states or countries operating inside a monetary union. For example, the consequences of fiscal austerity by members of the euro area has received a great deal of attention. The possible difference between such policies and the cross-sectional multipliers reviewed below arises because in nearly all cases the spending used to identify cross-sectional multipliers does not require higher contemporaneous or future local taxes. For example, when the ARRA directs additional highway funds into a particular state, the tax burden associated with paying for the additional spending falls on residents of all states equally. I refer to such examples as financed by outside transfers, although in practice they may also involve windfalls generated by other factors such as pension fund abnormal returns.

To understand the difference between multipliers financed by outside transfers and deficit-financed spending, it helps to fix some terminology. Call the region in which the additional spending occurs local and other regions external. Let $\beta^{xs,transfer}$ denote the cross-sectional multiplier when spending is financed by external transfers and $\beta^{xs,deficit}$ the cross-sectional multiplier when spending is locally deficit-financed. One can think of the outside-financed multiplier as comprising an increase in locally-deficit financed spending and the immediate purchase and cancellation of the debt by the central government. Let $\beta^{transfer}$ denote the contemporaneous multiplier associated with the resources used by the central government to cancel the locally-issued debt, ΔG_t the increase in spending at date t, and $V = \int_0^\infty e^{-rt}\Delta G_t dt$

the present value of the transfer component, where r is the interest rate. It follows that:

$$\beta^{xs,transfer}\Delta G_t = \beta^{xs,deficit}\Delta G_t + \beta^{transfer}V. \quad (5)$$

I next consider the two polar cases of an economy inhabited by fully rational agents who can borrow and lend freely and where Ricardian equivalence holds, and economies in which Ricardian equivalence fails. In the first, $\beta^{transfer}V$ is small as long as the increase in spending is transient and the local economy is not too closed. In the second, $\beta^{transfer}V$ can go to zero.

When Ricardian equivalence holds. If Ricardian equivalence holds, the wedge between the outside-financed multiplier and the local deficit-financed multiplier depends on the size of the transfer, which in turn depends on its persistence, and on the region's openness. A simple calculation helps to illustrate. Consider an increase in spending in a state of ΔG financed by the federal government and which decays according to a continuous time AR(1) process with persistence parameter ρ. Then the present value of the transfer is $V = \Delta G \times 1/(r + \rho)$. In a Ricardian setting where local agents obey the permanent income hypothesis, the short-run direct effect on consumption demand by local residents equals the annuity value of the transfer, $\Delta G \times r/(r + \rho)$. When the transfer is transient (ρ is large), the direct effect is to increase private demand by only a small amount relative to the increase in government purchases. The small direct effect on local consumption demand for transient spending explains why the $\beta^{transfer}V$ term can be small in the Ricardian case. Conversely, a permanent increase in outside-financed spending ($\rho \to 0$) raises local consumption demand by fully the amount of the increase in government spending. Openness matters because in general equilibrium the sensitivity of the local *output* multiplier to higher *consumption* demand by local residents depends on whether and how much local residents concentrate their purchases on locally-produced output. Appendix equation (A.26) provides a simple expression combining these elements for the impact transfer multiplier on local output in a fully intertemporal, Ricardian setting:

$$\beta^{transfer,impact} V = \left(\frac{1-\alpha}{\alpha}\right)\left(\frac{r}{r+\rho}\right)\Delta G, \tag{6}$$

where α is the share of exports in private demand for local output. Setting for illustrative purposes $\alpha = 1/3$, $r = 0.03$, and $\rho = 0.8$ (the last implies about 80% of the increased spending occurs by date $t = 2$), the fact that the spending is outside financed raises local output on impact by only $0.07\Delta G$. Appendix equation (A.35) shows that the transfer multiplier declines after impact as relative prices adjust.[10]

Failures of Ricardian equivalence. Failures of Ricardian equivalence can drive $\beta^{transfer} \to 0$ such that the outside-financed and locally deficit-financed multipliers exactly coincide. It is informative to consider three leading cases. In the first, private agents do not internalize the prospect of higher future taxes to pay for current spending into their budget constraints due to life cycle considerations and non-altruistic motives (Weil, 1987). There is an exact analog between expecting other future agents to pay for current deficits and having other current agents pay through a transfer. Thus, if agents do not incorporate future tax liability into their private intertemporal budget constraints, then the outside-financed and locally deficit-financed

[10] According to equation (6), the difference between outside-financed and deficit-financed spending multipliers can become arbitrarily large as the local economy becomes closed. Intuitively, in cashless, intertemporal models the local region's current account must balance in present value, so a \$1 dollar transfer to local residents in equilibrium requires local residents to purchase an additional \$1 of goods from other regions. If the local economy is quite closed, it requires a large increase in local consumption to induce any purchases from outside. On the other hand, the difference vanishes as the economy becomes fully open, since then private spending by local agents does not fall disproportionately on local products. As prices adjust, the transfer exerts a negative effect on local output due to a wealth effect on labor supply.

multipliers coincide.

Liquidity constraints provide a second leading reason Ricardian equivalence may fail.[11] If households consume and firms invest based on current income rather than permanent wealth, then $\beta^{transfer} = 0$ and an increase in temporary income resulting from a deficit-financed stimulus package will have equivalent effects to an outside-financed increase in spending.

A third failure stems from myopic or boundedly rational beliefs (Gabaix, 2015). If agents simply ignore the intertemporal aspect of their spending problem, then the outside-financed and locally deficit-financed multipliers again coincide. Similarly, if agents do not know their region has received an outside transfer, then their private spending cannot react to the transfer. The low salience case appears plausible in many instances. In the example from section 2.3, households would have to know of the differential spending pattern of the ARRA across regions in order to react to the transfer component.

These examples make clear that in the non-Ricardian case the coincidence result requires a comparison to a deficit-financed local stimulus package. Otherwise, there is an offsetting decline in spending from the contemporaneously higher taxes which does not occur in the outside-financed case.[12] The distinction sheds light on an example adapted from Ramey (2011, p. 681) in which agents have a mechanical marginal propensity to consume (mpc) of 0.6 and a subset of households in Mississippi receive a government transfer of \$1. If the transfer is financed by a lump sum tax levied on households in other states, then, as Ramey points out, the increase in output in Mississippi will equal $mpc/(1-mpc) = 1.5$ but the national multiplier

[11]Evidence for liquidity constraints comes from households' responses to one-time stimulus payments (Johnson et al., 2006; Sahm et al., 2012; Parker et al., 2013; Hausman, 2016), from direct examination of households' liquidity positions (Lusardi et al., 2011; Kaplan et al., 2014), and from firms' responses to to temporary cash flows (Fazzari et al., 1988; House and Shapiro, 2008; Mahon and Zwick, 2015).

[12]By assumption, newly issued debt is not purchased by liquidity-constrained agents.

is 0. Changing the example slightly, if Mississippi finances the transfer by levying a lump sum tax on other households in Mississippi, the increases in output in Mississippi and nationally both equal 0. However, changing the financing to debt issued by Mississippi and purchased by permanent income agents, the local deficit-financed multiplier would equal 1.5, the same as the outside-financed multiplier.

Quantitative magnitude. How much could the transfer component matter quantitatively? In models similar to that of appendix A in which private agents internalize all future taxes into their budget constraints and calibrated to match approximately the openness and persistence of government spending in many of the studies reviewed below, Nakamura and Steinsson (2014) and Farhi and Werning (2016) both find outside financing raises multipliers by about 0.05 to 0.2, that is, a locally deficit-financed multiplier of 1.2 becomes a multiplier of 1.25 to 1.4, depending on the exact calibration. This range matches the illustrative calculation reported above. Intuitively, low persistence of stimulus spending and fairly open local regions mean that the increase in local purchases of local output in response to the transfer component is small. Farhi and Werning (2016) find this difference remains small even in the presence of non-Ricardian hand-to-mouth agents as long as the comparison remains to a local deficit-financed multiplier.

3.1.2. Relationship to Closed Economy Zero Lower Bound Multiplier

Multipliers associated with spending by one entity in a currency union differ from closed economy multipliers because of the absence of the possibility of a reaction by monetary policy, because relative price effects can cause agents to expenditure-switch toward output produced in other regions, and because any change in private spending by local agents falls partly on output produced in other regions.

Monetary policy reaction. The first difference – offsetting interest rate changes by monetary policy makers – can matter substantially. However, when monetary policy faces a binding lower bound, it cannot react to changes in national fiscal policy. Fortunately, the case when monetary policy cannot react, what I will call the closed economy zero lower bound multiplier, is of particular interest for the study of fiscal policy.

Expenditure switching. By purchasing local output, government spending can cause the price of local output to rise relative to goods produced in other regions. As a result of this terms of trade effect, both local and external agents shift expenditure toward output produced in other regions, causing total private purchases of locally-produced output to fall. This effect makes the currency union multiplier smaller than the closed economy multiplier. Its magnitude depends on factors such as the nature of price setting, the degree of segmentation between goods purchased by government and the private sector, and the substitutability between locally-produced and externally-produced goods.[13] Appendix A again provides further details. I elaborate briefly here, focusing on elements where future research might contribute to a better quantitative understanding.

First, the expenditure-switching channel requires that higher government spending cause local prices to rise. Absence of high frequency, high quality local price measures has made

[13] The magnitude does not depend monotonically on the openness of the local region. On the one hand, when local agents purchase a large share of their consumption from local producers, their desire to reduce total consumption when the price of a unit of utility (i.e. the real interest rate) is temporarily high causes a larger direct reduction in demand from local producers. On the other hand, this reduction in demand by local purchasers mitigates the rise in the relative price of locally-produced output, which in turn mitigates the decline in demand from external purchasers. As a result, the increase in the relative real interest rate emphasized by Nakamura and Steinsson (2014) is not strictly necessary to generate a reduction in private demand for local goods. In fully open regions with a private sector "home bias" share of zero, consumption baskets and consumer price indexes of local and external consumers coincide, and hence real interest rates coincide, but total private demand for local output still falls because of the relative rise in the local producer price index.

estimating the relative price effect difficult. In the context of spending multipliers, Nakamura and Steinsson (2014) find no evidence of local prices responding to government spending. The stability of inflation throughout the Great Recession has also led to some suggestions of a recent divorce between output and inflation (Hall, 2011). On the other hand, using geographic variation in local demand caused by factors other than government spending, Fitzgerald and Nicolini (2014), Stroebel and Vavra (2016), and Beraja et al. (2016) all find evidence of local prices responding to local demand conditions.

Second, by assumption, government spending concentrates on goods and services from the local region; otherwise the cross-sectional multiplier experiment lacks variation in treatment across regions. Even if the higher government demand for local goods increases their relative price, this price increase must spillover into goods and services purchased by private agents to affect their spending. Such spillovers can happen either through competition in output markets (for example, if government and private agents purchase the same goods), or through competition in input markets (for example, due to labor mobility across sectors and a common wage). Segmentation on either dimension will dampen the amount of expenditure switching.

Third, the transmission from relative price changes to expenditure switching depends on the elasticity of substitution between locally-produced and externally-produced goods. For temporary government spending shocks, the short-run elasticity is most relevant.

Income effects. The currency union multiplier also differs if total private spending by local agents changes, as the change in demand by local agents "leaks" abroad. A leading case occurs with liquidity-constrained workers whose labor income rises in response to the increase in government spending and who then increase their consumption of both locally-produced and external goods. Such effects may also arise due to, *inter alia*, complementarity in the utility function between consumption and hours worked or excess sensitivity of firm investment to cash flow. Conversely, negative wealth effects may dampen local private consumption. This channel is distinct from expenditure switching because it does not require any change in relative prices to occur. Once again, however, leakage abroad makes the currency union multiplier a lower bound for the aggregate multiplier.

3.1.3. Summary

Subject to the points raised in section 3.1.1, multipliers for transitory increases in local spending not financed locally map roughly into locally deficit-financed currency union multipliers. Section 3.1.2 showed that locally-financed currency union spending multipliers likely provide a lower bound for closed economy zero lower bound multipliers due to the expenditure-switching and leakage effects. Combining these two results, theory suggests that cross-sectional multipliers may provide a rough lower bound for deficit-financed zero lower bound closed economy multipliers. While shared by Nakamura and Steinsson (2014) and Farhi and Werning (2016), this conclusion is sharply at odds with much of the conventional wisdom extant at the start of this wave of research.[14] It remains to ask whether the rough lower bound still admits interesting results.

[14]For example, Giavazzi (2012, p. 144) writes that "local multipliers deliver an *upward* biased estimate of total spending multipliers" (emphasis mine). A recent literature has questioned the plausibility of some of the forward-looking elements of the New Keynesian model which give rise to potentially very large closed economy zero lower bound multipliers (McKay et al., Forthcoming; Kaplan et al., 2016). The rough lower bound result does not depend on these particular features. Indeed, aspects which make the New Keynesian model less forward-looking also rule out the one case discussed by Farhi and Werning (2016) in which closed economy zero lower bound deficit-financed spending may generate a contemporaneous multiplier of less than the locally-financed currency union multiplier, wherein the presence of liquidity constrained agents results in expectations of a recession in the future at the time taxes rise, thereby generating in the closed economy case a deflationary spiral which reduces current expenditure by unconstrained agents. Enough price rigidity also rules out this outcome.

3.2. Relationship Between Employment and Spending Multipliers

For reasons of data availability, many geographic cross-sectional studies calculate employment rather than output multipliers. I derive a mapping between the two using a production function approach.

Let β_Y denote the output multiplier and β_E the employment multiplier. That is, for an increase in spending of ΔG, by definition:

$$\Delta Y_t = \beta_Y \Delta G_t,$$

$$\Delta E_t = \beta_E \Delta G_t,$$

where Y_t is total GDP, E_t is total employment, G_t is government spending, and Δ denotes the deviation from some steady state level. Let $e_t = \Delta E_t/E$, $y_t = \Delta Y_t/Y$, and $g_t = \Delta G_t/Y$, where variables without subscripts denote the steady state values. It will be useful to write:

$$e_t = \beta_E \frac{Y}{E} g_t.$$

The production function approach assumes a relationship between outputs and inputs $Y_t = A\left(H_t E_t\right)^{1-\xi}$, where H_t denotes hours per worker. Implicitly, this functional form assumes capital does not adjust in the short run. Let $h_t = \Delta H_t/H$. Then:

$$\beta_Y = \frac{y_t}{g_t} = \frac{y_t}{e_t}\frac{e_t}{g_t} \approx \left(1-\xi\right)\left(1+\chi\right)\frac{Y}{E}\beta_E, \tag{7}$$

where $\chi = h_t/e_t$ denotes the elasticity of hours per worker to total employment. For the United States, $\xi \approx 1/3$ and $\chi \approx 0.5$, yielding a combined multiplicative factor of $\left(1-\xi\right)\left(1+\chi\right) \approx 1$.[15]

[15] The estimate of $\xi = 1/3$ based on factor income shares is standard. Okun (1962) provides an early estimate of the relative movement of hours per worker and employment, and Elsby et al. (2010) an updated estimate.

As an alternative, Nakamura and Steinsson (2014) report estimates of both β_Y and the combined factor $\beta_E \times Y/E$, the latter being the coefficient from a regression of e_t on g_t. Reassuringly, the ratio of these two estimates is close to unity. Therefore, a rough translation from employment to output multipliers is to divide output per worker Y/E by the cost-per-job $1/\beta_E$. Output per worker Y/E is available from national accounts; for example, in 2009 it was \$105K. Applying this number to the cost-per-job estimated in column (4) of table 1 yields an implied output multiplier of around two, also reassuringly close to the direct estimate of the output multiplier of 1.76 in column (5).

This calculation also motivates the functional form equation (3) for estimating employment multipliers. A GDP multiplier is a flow of output divided by a flow of government spending. The denominator in an employment multiplier is the same. Therefore, to facilitate comparison, the numerator should be the equivalent of a flow of output, which from the production function corresponds to the average employment increase over the duration of the policy's effects. Specifications such as equation (3) provide a convenient way to estimate this average employment increase and should be reported in addition to any "point-in-time" employment effects.

4. Emprical Cross-sectional Multipliers

I now review recent empirical studies of geographic cross-sectional multipliers.[16]

[16] A closely related literature and one that predates many of the papers reviewed here studies the direct effect of various fiscal stimulus policies using some cross-sectional variation in the eligibility or timing of the policy. See e.g. Johnson et al. (2006); House and Shapiro (2008); Parker et al. (2013); Mian and Sufi (2012); Hausman (2016); Mahon and Zwick (2015). Davis et al. (1997) and Hooker and Knetter (1997) are examples of earlier papers which estimate a specification similar to equation (1).

4.1. Evidence from the ARRA

A number of studies of cross-sectional multipliers have used variation in the geographic distribution of funds under the 2009 federal fiscal stimulus bill in the United States, the American Recovery and Reinvestment Act (ARRA). Enacted in February 2009, the ARRA included new spending, transfers, and tax reductions totaling roughly $800 billion, with three-quarters (90%) outlaid by the end of 2010 (2011). Crucially, more than half of the budgetary outlays went either to contractors directly or to subnational governments, and an unusual provision of the bill, section 1512, tracked such spending by requiring federal agencies to report outlays in each state and all prime recipients to report the funds received. The combination of the variation in geographic entitlement in many of the act's programs and the detailed data collection facilitated research efforts. Because the studies using geographic variation in the allocation of the ARRA all cover roughly the same time period and intervention, I treat them as a separate group. Importantly from the lens of the theoretical discussion, all of the ARRA studies involve fiscal transfers of approximately the same persistence, the approximately two year time frame of payouts from the bill.

Table 2 summarizes the results from these papers. As a concise summary measure, the final column reports the number of job-years associated with an additional $100K of ARRA spending implied by each study. Where possible, I report the 90% confidence interval for this number in brackets.

The largest cross-state estimated employment effects come from the Chodorow-Reich et al. (2012) study of aid to state governments through the Medicaid matching program described in

Table 2: ARRA Papers

Study	Identification	Geography	Headline Result	Job-years per $100K
Chodorow-Reich et al. (2012)	Pre-recession Medicaid spending as instrument for state fiscal relief	Cross-state	$100K increases employment by 3.8 [1.2,6.4] job-years	3.8 [1.2,6.4].
Conley and Dupor (2013)	ARRA highway obligations and state tax revenue cyclicality as instruments for ARRA spending net of change in tax revenue	Cross-state	$100K increases employment by 0.5 [0.05,0.94] job-years if fungibility between ARRA and lost tax revenue imposed; 0.76 [-0.1,1.64] job-years if fungibility not imposed.	0.76 [-0.1,1.64].[a]
Dube et al. (2014)	County-level fixed effects regression with state×year fixed effects and Bartik and demographic controls	Cross-county	$100K increases employment in own county by 1.00 [0.79,1.54] job-years and in all counties within 120 miles of county by 3.93 [2.14,5.71] job-years. Employment effects larger in counties with greater excess capacity.	3.93 [2.14,5.71].[b]
Dupor and McCrory (Forthcoming)	Recovery Act spending by federal agencies not instructed to target harder hit regions	Subregional spillovers within local labor markets	$100K increases employment by 1.03 [0.39,1.66] and 0.85 [0.39,1.31] job-years in own and neighboring subregion jobs, respectively, and increases wages by $64K [$28K,$100K] and $50K [$22K,$78K], respectively.	1.85.[c]
Dupor and Mehkari (2016)	Recovery Act spending by federal agencies not instructed to target harder hit regions	Local labor markets	$100K increases employment by 0.95 [0.45,1.46] job-years and wage bill by $102K [$48K,$156K].	0.95 [0.45,1.46].
Feyrer and Sacerdote (2012)	Mean seniority of a state's Congressional delegations as instrument for ARRA spending	Cross-state	$100K increases employment by 2.16 [0.99,3.33] (IV) or 0.93 [0.42,1.44] (OLS) jobs in October 2010.	1.99 [0.78,3.21].[d]
Wilson (2012)	Pre-recession Medicaid spending, statutory determinants of highway spending allocation, and schooling age population as instruments for ARRA spending	Cross-state	$100K of funding announcements increases employment in February 2010 by 0.81 [0.23,1.39] jobs; $100K of funding obligations increases employment in February 2010 by 1.02 [0.43,1.61] jobs.	1.75 [0.58,2.9].[e]

Notes: *a*. Fungibility not imposed specification.
b. Based on specification including spillovers.
c. Summing direct and spillover effects. The covariance between the two is not reported.
d. Feyrer and Sacerdote (2012) baseline IV regression re-estimated with the dependent variable $Y_s = \frac{1}{12}\sum_{t=2009M3}^{2010M10}\left(\frac{\text{Employment}_t}{\text{Population}_t} - \frac{\text{Employment}_{2009M2}}{\text{Population}_{2009M2}}\right)$. The corresponding range for the OLS specification is 0.98 [0.42,1.53].
e. Wilson (2012) baseline regression re-estimated with the right hand side variable outlays through March 2011 and the dependent variable $Y_s = \frac{1}{12}\sum_{t=2009M3}^{2011M3}\left(\frac{\text{Employment}_t}{\text{Population}_t} - \frac{\text{Employment}_{2009M2}}{\text{Population}_{2009M2}}\right)$.

section 2.3.[17] Two aspects of the program may have led to high employment multipliers. First, fungible aid allows state governments to direct the funds to their best use. Chodorow-Reich et al. (2012) report a concentration of effects in reduced layoffs of workers in sectors funded by state and local government. Second, states began receiving money under this program immediately after the bill's passage, in contrast to other programs such as highway construction reimbursements most of which came one to two years later. Thus, states received the Medicaid matching transfers exactly when state budget shortfalls first materialized.

Conley and Dupor (2013) report the smallest employment effects. They construct two endogenous fiscal policy variables, ARRA spending and lost tax revenue plus increased Medicaid spending, and two instruments, the formulaic component of highway spending and state tax revenue cyclicality. In their *fungibility constrained* specification, the endogenous variable is collapsed into ARRA spending net of lost tax revenue, such that the employment effect of a dollar of ARRA aid is constrained to have the same employment effect as an additional dollar of tax revenue. This specification gives rise to a cost-per-job estimate of $200K. But as discussed in section 3.1.1, economic theory dictates at most equivalence between state spending financed by ARRA transfers and a deficit-financed increase in state spending; the fungibility assumption instead imposes equivalence between ARRA-financed spending and a balanced budget increase in state spending. Since the presence of either Ricardian or hand-to-mouth agents will deflate the balanced budget multiplier relative to ARRA-financed spending, theory suggests the constrained cost-per-job is too high. In their second specification which does not

[17] A number of changes in specification explain the small differences between the result in column (1) of table 1 and Chodorow-Reich et al. (2012). These include the sample period, whether DC is included, and whether the endogenous variable is FMAP or total ARRA. Dupor (2013) provides a more pessimistic view of the efficacy of state transfers.

collapse the endogenous variable, Conley and Dupor (2013) find an employment multiplier 50% larger and closer in magnitude to other papers.

Wilson (2012) develops three formulaic allocation instruments based on pre-recession Medicaid spending as in Chodorow-Reich et al. (2012), the schooling age population which partly determined the allocation of spending by the Department of Education, and the highway instrument described in section 2.3, and reports a headline cost-per-job of $125K. A complication arises in comparing this number to other studies, however, because it corresponds to additional employment in February 2010 relative to total announced ARRA state-level spending allocation by that month, while much of the actual spending occurred later. Using instead actual spending or spending obligated to specific entities results in lower cost-per-job estimates because spending as of February 2010 is correlated with spending after February 2010. A simple alternative specification which elides this problem follows equation (3) and estimates the integral of additional jobs through some terminal date as a function of spending by that terminal date. Using March 2011 as the terminal month – the last month in the Wilson (2012) data set and after more than 80% of the ARRA had been outlaid – but keeping the specification and control variables otherwise identical to Wilson (2012), I estimate a jobs coefficient of 1.75 (se=0.71). This estimate translates into a cost-per-job of $57K ($100K/1.75).[18]

The last of the cross-state studies of the ARRA is due to Feyrer and Sacerdote (2012). The paper reports estimates from OLS regressions of employment on ARRA by state and from IV estimates where ARRA transfers are instrumented using the mean seniority of a state's congressional delegation. The paper finds employment effects more than twice as large when

[18] Using instead funding announcements through March 2011, the jobs per $100K spent falls only slightly to 1.42 from 1.75.

using IV.[19] To obtain a result comparable to other studies, I re-estimate a version of equation (3) using the Feyrer and Sacerdote (2012) data and IV specification and find a jobs coefficient of 1.99 (se=0.74), which translates into a cost-per-job of $50K.

A few studies have examined employment effects of the ARRA at a sub-state level. Unlike the state-level studies whose data come from reporting by federal agencies of the state allocation of all ARRA outlays, allocating spending at the sub-state level requires using the recipient reporting of spending and the location of the recipients. Spending reported by recipients likely corresponds more closely to the national accounts definition of direct government purchases than does the full ARRA, which includes transfers to both individuals and state governments. Dube et al. (2014) use panel regressions at the county level controlling for a large set of determinants of county economic conditions. They find a cost-per-job in the recipient county of $100K but substantial spillovers across counties, with a cost-per-job including all counties within 120 miles of the recipient of $25K.[20]

Finally, Dupor and Mehkari (2016) and Dupor and McCrory (Forthcoming) develop an instrument for county-level recipiency of ARRA funds based on the formulaic components of the ARRA. Their instrument forms the basis for the "DM" instrument in table 1. Similar to Dube et al. (2014), Dupor and McCrory (Forthcoming) report evidence of substantial geographic spillovers, with the employment effect of $100K in spending rising from 1 job-year in the

[19] The instrument in Feyrer and Sacerdote (2012) is the mean seniority of the entire Congressional delegation, where House members are ordered 1-435 and Senate members 1-100, and not the mean seniority of the state's House delegation as reported in the paper. Using either seniority measure separately does not predict spending allocation. Boone et al. (2014) also investigate the political economy of the distribution of ARRA spending and find little evidence of legislative seniority mattering.

[20] The ARRA reporting system may partly explain the estimates of large cross-county spillovers. As pointed out by Garin (2016), vendors reported spending in the county where a project occurred rather than the county containing the payroll office of the vendor. Employment data sets including the QCEW and CBP instead attribute employment to the county of the vendor's payroll office.

recipient's region to 1.85 when including employment effects in other subregions belonging to the same local labor market. Dupor and Mehkari (2016) find a smaller employment effect of 0.95 job-years at the local labor market level.

Summing up, the estimate of 2 job-years per $100K in column (4) of table 1 appears broadly representative. Put on common footing, the ARRA studies find estimates in the range of 0.76 to 3.93, with a cross-study mean of 2.15 and median of 1.85.

4.2. Other Evidence

Estimation of geographic cross-sectional multipliers has proceeded in numerous other directions, making use of clever identification strategies and developing new data sets. Table 3 summarizes these studies.

Table 3: Non-ARRA Papers

Study	Identification	Geography/ Financing/ Persistence	Result
Acconcia et al. (2014)	Provincial expenditure cuts in Italy following expulsion of Mafia-infiltrated city council members	Cross-province/ Outside financing/ Unknown	Output multiplier of 1.55 [0.84,2.26]
Adelino et al. (2015)	Variation on U.S. municipal bond ratings due to the 2010 Moody's ratings scale recalibration	Cross-municipalities/ Outside financing/ Persistent	$100K spending increases employment by 4.78 (1.18 [0.18,2.18] government and 3.60 [0.87,6.32] private) job-years; income multiplier of 2.4. Effects are larger when slack is higher.
Brückner and Tuladhar (2014)	System GMM on annual Japanese prefecture spending data controlling for lagged output and prefecture fixed effects	Cross-prefrecture/ Mixed financing/ Transitory	Public investment multiplier of 0.93 [0.63,1.23], local government expenditure multiplier of 0.78 [0.45,1.11]
Clemens and Miran (2012)	Variation in state's budget rules	Cross-state/ Local financing/ Transitory shocks	"On-impact" multiplier of 0.29 [-0.22,0.79]

Cohen et al. (2011)	Instrument state-level federal expenditures with changes in congressional committee chairmanships	Cross-state/ Outside financing/ Throughout chairman term	1 percent increase in state-level annual earmarks cause 0.8 [0.6 , 1] percent reduction in the representative firm's capital expenditures. Crowding out smaller when slack is higher.
Fishback and Kachanovskaya (2015)	Shift-share instrument - variations in states sensitivity to national changes in federal spending	Cross-state/ Outside financing/ Transitory shocks	A multiplier of 0.96 [0.31,1.61] when transfer payments are excluded and 0.83 [0.39,1.27] when transfers are included
Hausman (2016)	1936 veteran's bonus	Cross-state and city/ Outside financing/ One-time	An additional veteran in a state was associated with 0.3 [0.20,0.41] more new cars sold; An additional veteran in a city was associated with $200 [$73,$327] more residential building
Leduc and Wilson (2012)	Panel local projection on revision to present value of federal highway transfer funds	Cross-state/ Mixed financing/ Present value shocks	Impact multiplier of 1.4. Cumulative multiplier of 6.6
Nakamura and Steinsson (2014)	Regional variation in military buildups	Cross-state and region/ Outside financing/ Transitory shocks	GDP multiplier of 1.43 [0.84,2.02]; employment multiplier per percent of GDP of 1.28 [0.80,1.76]. GDP multiplier is larger when slack is higher.
Porecelli and Trezzi (2016)	Allocation of reconstruction grants to municipalities following the 2009 "Aquilano" earthquake	Cross-municipalities/ Outside financing/ One-time	One year "Grants multiplier" of 0.15 [0.05,0.25] and of 0.36 [0.21,0.52] when earthquake damages are instrumented
Shoag (2015)	Windfall component of returns on state's defined-benefit pension plans	Cross-state/ Outside financing/ Transitory	Income multiplier of 2.1; $100K spending increases employment by 2.89 [1.25,4.54] job-years. Effects are larger when slack is higher.
Suárez Serrato and Wingender (2016)	Variation in federal spending due to variation in local population estimates during Census years	Cross-counties/ Outside financing/ Decadal	Local income multiplier of 1.7-2; $100K spending increases employment by 3.25 [0.35,6.15] job-years

Shoag (2015) builds a data set of idiosyncratic returns of state pension funds. These returns relax state budget constraints and empirically predict increased government spending (but not lower tax revenue). Shoag (2015) therefore uses the pension returns as an instrument for state spending and finds a $1 increase in spending raises personal income by $2.12, and that $100K of spending raises employment by 2.9 job-years.[21] While the first stage indicates states spend

[21] Shoag (2015) argues that personal income closely tracks output but provide a more reliable measure of state-level economic activity over his sample.

roughly 50% of the windfall in the first year, Shoag argues that private agents are unlikely to react to the windfall component other than due to the government spending because of an absence of publicity of state pension returns.

Suárez Serrato and Wingender (2016) start from the observation that a multitude of federal transfers to local governments depend on local population, but censuses of population by area occur only every ten years. In the interim, the Census Bureau estimates local population growth using birth and death records and migration flows. The benchmarking to the Census count every ten years therefore induces jumps in federal payments to a local area caused by the sudden dissipation of measurement error. Suárez Serrato and Wingender (2016) study the response of local private income and total employment to these jumps in payments and find an income multiplier of 1.7-2 and a cost-per-job of roughly $31K. Notably, relative to many of the other studies reviewed, the persistence of these transfers is fairly high, since future federal funds are also higher as a result of an upward revision to the population estimate.

Nakamura and Steinsson (2014) adapt the time series approach of measuring the response of output to increases in federal purchases associated with defense build-ups (Barro, 1981; Ramey and Shapiro, 1998; Hall, 2009) to a cross-sectional setting. In particular, when defense purchases rise, they rise by more in states with larger concentrations of defense contractors. Nakamura and Steinsson (2014) implement a version of equation (1) where the endogenous variable $F_{s,t}$ consists of federal defense purchases in state s in year t, and the purchases are instrumented by state-specific loadings on the growth of national defense purchases. They estimate a state output multiplier of roughly 1.4 and a slightly larger multiplier of 1.9 when expanding the geographic unit to the region level. The persistence of the purchases is similar to the persistence of a defense build-up, that is, higher than in a one-time stimulus bill, but lower than a population update.

Two studies use historical variation from spending during the 1930s. Fishback and Kachanovskaya (2015) examine New Deal spending and transfers using a state-year panel and a shift-share instrument for spending in a state. They find income multipliers of close to but below one. Hausman (2016) uses variation in the geographic distribution of World War I veterans interacted with the large, one-time Veteran's bonus payment in 1936. While lacking in overall measure of private spending, he finds substantial increases in auto purchases and new building in states and cities with more veterans.

Adelino et al. (2015) exploit a change in borrowing costs resulting from a recalibration of municipal bond ratings by Moody's. They find a local income multiplier of 2.4 at the county level and a cost-per-job of $21K. While the recalibration implies a persistent lowering of borrowing costs, the magnitude of the decline in interest payments appears too small for a response of private consumption to the relaxation of the county's budget constraint to explain the large employment effects.

Leduc and Wilson (2012) study the response of state output to innovations in the present value of federal highway grants. They find large output multipliers, but with the caveat they cannot precisely estimate the response of state spending to the federal grants. Using their most conservative results, they find an impact response of $1.40 of state GDP to an increase in present value of spending of $1, and a cumulative multiplier of 6.6. The persistence of the output response suggests part of the cumulative multiplier reflects higher productivity from the capital improvements in addition to any short-run demand effects.

A few studies have used data from outside the U.S. Acconcia et al. (2014) exploit the introduction of an anti-corruption law in Italy which resulted in the dismissal of city councils and their replacement by external commissioners who reduced public expenditure. They estimate an output multiplier of 1.5 to 1.9, where the higher number includes lagged government spending effects. Because the central government finances most local expenditure, these estimates correspond to outside-financed multipliers despite the determination of spending at the local level. Brückner and Tuladhar (2014) use a system GMM estimator to study variation in annual spending across prefectures in Japan in the 1990s. Effectively, identification comes from a timing assumption similar to that in Blanchard and Perotti (2002) that fiscal policy not have a forward-looking component. They find multipliers below but close to 1. Interestingly, they find larger multipliers for locally-financed than centrally-financed public investment. Porecelli and Trezzi (2016) exploit discontinuities in the provision of reconstruction grants to municipalities following the 2009 L'Aquila earthquake in Italy. While their "grants multiplier" of 0.3 is lower than most other studies, if one assumes municipalities would have engaged in the same rebuilding effort with or without the grants, then this 0.3 estimate corresponds more directly to a pure windfall transfer multiplier and as such is in the range of calibrated estimates reported in Nakamura and Steinsson (2014) and Farhi and Werning (2016).

Finally, two important studies find much smaller or even negative effects of local spending. Clemens and Miran (2012) use variation in the strictness of state balanced budget requirements and find a spending multiplier with a point estimate close to zero and an upper bound of 0.8. They interpret the smaller estimated multiplier as reflecting the absence of a windfall transfer since, while a laxer balanced budget requirement allows a state to run a temporarily larger deficit, it does not affect the local region's intertemporal budget constraint. Even so, the transfer component of the other studies reviewed appears by itself too small to explain the difference, suggesting other econometric or institutional factors may also matter. Cohen et al. (2011) exploit the increase in federal spending in a state when a member of the state's Congressional delegation becomes the chair of an important committee. They estimate statistically significant *negative* effects of spending on investment, employment, and sales at publicly-traded firms headquartered in the state. Cohen et al. (2011) interpret their results as reflecting a wealth effect from the windfall transfer. However, they also report negative albeit imprecisely estimated effects on overall state output which would require more than just a labor supply response to justify.

5. What We've Learned

Informativeness for national multiplier. Cross-sectional multipliers can be large. Using the relationship in equation (7) to translate employment multipliers into output multipliers and aggregating over all studies described in tables 2 and 3 for which I could calculate an output multiplier, the median output multiplier is 1.8 and the mean is 2.1.[22] According to the theory reviewed in section 3, the cross-sectional multiplier provides a rough lower bound for the magnitude of the closed economy zero lower bound deficit-financed multiplier. Accounting for the outside financing might lower the corresponding national multiplier by about 0.2. Thus, the cross-sectional evidence suggests a closed economy zero lower bound deficit-financed multiplier

[22]Providing a confidence band for the cross-study mean or median is complicated by the possibility of correlation across studies, especially for papers studying the ARRA, and I do not attempt it. The studies reviewed in table 2 and table 3 and excluded from the cross-study mean and median are Cohen et al. (2011), Hausman (2016), Leduc and Wilson (2012), and Porecelli and Trezzi (2016).

of about 1.7 or above.

Is a national multiplier of 1.7 large? In a recent review article, Ramey (2011) concludes the multiplier for a deficit-financed increase in government purchases similar to the ARRA "is probably between 0.8 and 1.5. Reasonable people can argue, however, that the data do not reject 0.5 or 2.0." If this range serves as a prior, then the evidence from cross-sectional multiplier studies ought to move posteriors toward the upper end of the range.

State-dependence. Many of the studies also shed light on an important debate on whether and why multipliers may be state dependent. Here again, the time series literature has not reached a consensus (Auerbach and Gorodnichenko, 2013; Ramey and Zubairy, 2016). Cohen et al. (2011); Shoag (2015); Nakamura and Steinsson (2014); Dube et al. (2014); Adelino et al. (2015) all test for and find evidence of higher multipliers or less crowd-out in regions and periods with more unused resources. Because the cross-sectional studies hold the response of monetary policy fixed, passive monetary policy in slack periods, as emphasized in Christiano et al. (2011) and Woodford (2011), cannot explain the findings of state-dependent multipliers in these studies. Instead, other forces related to slack such as lower factor prices appear also to matter.

Other policies. Cross-sectional multipliers also inform the effects of a broader set of policies than just national counter-cyclical stimulus. For example, high and uneven unemployment in the euro area has renewed interest in further fiscal integration. How effective as counter-cyclical stimulus would be spending by the European Union in targeted regions with high cyclical unemployment? Cross-sectional multiplier studies provide a direct and generally optimistic answer to this question.

The evaluation of place-based policies offers another example. Similar to many of the cross-sectional studies, place-based policies direct federal resources toward particular geographic areas.[23] On the other hand, place-based policies typically combine grants for spending with targeted hiring incentives and other business tax breaks, involve very persistent interventions, and apply to very small geographic areas. Relative to cross-sectional multiplier studies, the small geographic concentration reduces the effects of transfers into the region on local output but the longer persistence means the transfers are larger. The persistence has also led the place-based literature to analyze spatial equilibrium models which allow for a migration response, an aspect ignored in the theoretical treatments of cross-sectional multipliers, but at the expense of abstracting from short-run demand effects. These differences aside, the evidence from cross-sectional multiplier studies appears more optimistic of the scope for positive local effects than are many studies of placed-based policies. Both literatures would benefit from greater integration.

6. Lessons for Future Research

While much progress has occurred, there remains scope for further integration of empirical and theoretical investigations of cross-sectional multipliers. One aspect concerns empirical studies of natural experiments in which spending rises without a concomitant increase in the local tax burden. These studies should quantify the magnitude of the outside transfer or windfall. A useful summary metric is the ratio of the annuity value of the transfer to the contemporaneous increase in government spending. These studies should also discuss the salience of the

[23]Empowerment Zones are the most well known. See Glaeser and Gottlieb (2008) and Neumark and Simpson (2015) for recent surveys of place-based policies.

windfall component. Did private agents plausibly understand that they had received a transfer of resources or a windfall? On the theory side, the rough lower bound result depends on the small difference between outside-financed and locally-financed multipliers in modern macroeconomic models. Future research should explore and try to quantify other mechanisms which might amplify this difference. For example, allowing for factor mobility in response to local but not national spending might amplify local relative to national multipliers. Again, however, such a difference seems likely to be small for non-persistent spending.

More research is also needed to quantify the differences between deficit-financed local multipliers and national multipliers. Most important, we have little evidence of how relative prices change in response to local government spending shocks. While regional price data in the United States is haphazard, studies of euro area members each of which collects its own CPI may prove more fruitful.

Finally, while the dependence of "the" government purchases multiplier on other variables such as the monetary policy response is widely recognized, empirical studies have paid less attention to heterogeneity stemming from what the government actually purchases.[24] This aspect may matter even more in cross-sectional studies where the source of variation is the quasi-randomness of the allocation of a particular government program, even if the estimation uses instrumental variables with total spending the endogenous variable (Imbens and Angrist, 1994). On the other hand, budgetary fungibility would negate such differences. Where relevant, future studies should highlight the source of transfers or increase in purchases both to better compare themselves to the literature and to facilitate future research into the effects of different types of policies.

[24]Boehm (2015) is a recent exception.

References

Acconcia, Antonio, Giancarlo Corsetti, and Saverio Simonelli, "Mafia and Public Spending: Evidence on the Fiscal Multiplier from a Quasi-experiment," *American Economic Review*, July 2014, *104* (7), 2185–2209.

Acemoglu, Daron, Jonathan Parker, and Michael Woodford, *NBER Macroeconomics Annual 2012, Volume 27*, University of Chicago Press, 2013.

Adelino, Manuel, Igor Cunha, and Miguel Ferreira, "The Economic Effects of Public Financing: Evidence from Municipal Bond Ratings Recalibration," 2015.

Auerbach, Alan J. and Yuriy Gorodnichenko, "Fiscal Multipliers in Recession and Expansion," in Alberto Alesina and Francesco Giavazzi, eds., *Fiscal Policy after the Financial Crisis*, The University of Chicago Press, 2013.

Barro, Robert J., "Output Effects of Government Purchases," *Journal of Political Economy*, 1981, *89* (6), 1086–1121.

Beraja, Martin, Erik Hurst, and Juan Ospina, "The Aggregate Implications of Regional Business Cycles," 2016.

Blanchard, Olivier and Roberto Perotti, "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output," *The Quarterly Journal of Economics*, 2002, *117* (4), 1329–1368.

Boehm, Christopher, "Fiscal Policy and Durable Goods," 2015.

Boone, Christopher, Arindrajit Dube, and Ethan Kaplan, "The Political Economy of Discretionary Spending: Evidence from the American Recovery and Reinvestment Act," *Brookings Papers on Economic Activity*, 2014, pp. 375–428.

Brückner, Markus and Anita Tuladhar, "Local Government Spending Multipliers and Financial Distress: Evidence from Japanese Prefectures," *The Economic Journal*, 2014, *124* (581), 1279–1316.

Cao, Lam X., Todd P. Siebeneck, and Clifford H. Woodruff III, "Quarterly Gross Domestic Product by State," *Survey of Current Business*, January 2016, pp. 1–7.

Carlino, Gerald and Robert Inman, "Macro Fiscal Policy in Economic Unions: States as Agents," 2014.

Chodorow-Reich, Gabriel, Laura Feiveson, Zachary Liscow, and William Gui Woolston, "Does State Fiscal Relief during Recessions Increase Employment? Evidence from the American Recovery and Reinvestment Act," *American Economic Journal: Economic Policy*, September 2012, *4* (3), 118–45.

Christiano, Lawrence, Martin Eichenbaum, and Sergio Rebelo, "When Is the Government Spending Multiplier Large?," *Journal of Political Economy*, 2011, *119* (1), pp. 78–121.

Clemens, Jeffrey and Stephen Miran, "Fiscal Policy Multipliers on Subnational Government Spending," *American Economic Journal: Economic Policy*, 2012, *4* (2), 46–68.

Cogan, John and John Taylor, "What the Government Purchases Multiplier Actually Multiplied in the 2009 Stimulus Package," in Lee Ohanian, John Taylor, and Ian Wright, eds., *Government Policies and the Delayed Economic Recovery*, Hoover Press, 2012, pp. 85–114.

Cohen, Lauren, Joshua Coval, and Christopher Malloy, "Do Powerful Politicians Cause Corporate Downsizing?," *Journal of Political Economy*, 2011, *119* (6), 1015–1060.

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

Davis, Steven J., Prakash Loungani, and Ramamohan Mahidhara, "Regional Labor Fluctuations: Oil Shocks, Military Spending, and Other Driving Forces," 1997.

Dube, Arin, Ethan Kaplan, and Ben Zipperer, "Excess Capacity and Heterogeneity in the Fiscal Multiplier: Evidence from the Obama Stimulus Package," 2014.

Dupor, Bill, "Creating Jobs Via the 2009 Recovery Act: State Medicaid Grants Compared to Broadly-Directed Spending," Unpublished 2013.

_ and M. Saif Mehkari, "The 2009 Recovery Act: Stimulus at the extensive and intensive labor margins," *European Economic Review*, 2016, *85*, 208 – 228.

_ and Peter McCrory, "A Cup Runneth Over: Fiscal Policy Spillovers from the 2009 Recovery Act," *Economic Journal*, Forthcoming.

Elsby, Michael, Bart Hobjin, and Aysegul Sahin, "The Labor Market in the Great Recession," *Brookings Papers on Economic Activity*, 2010, *(Spring)*, 1–69.

Farhi, Emmanuel and Ivan Werning, "Fiscal Multipliers: Liquidity Traps and Currency Unions," in "Handbook of Macroeconomics" 2016. Harvard University mimeo.

Fazzari, Steven, Glen Hubbard, and Bruce Petersen, "Financing Constraints and Corporate Investment," *Brookings Papers on Economic Activity*, 1988, *(Spring)*, 141–195.

Feyrer, James and Bruce Sacerdote, "Did the Stimulus Stimulate? Effects of the American Recovery and Reinvestment Act," 2012.

Fishback, Price and Valentina Kachanovskaya, "The Multiplier for Federal Spending in the States During the Great Depression," *The Journal of Economic History*, 2015, *75* (1), 125–162.

Fitzgerald, Terry J. and Juan Pablo Nicolini, "Is There a Stable Relationship between Unemployment and Future Inflation? Evidence from U.S. Cities," 2014.

Gabaix, Xavier, "Behavioral Macroeconomics Via Sparse Dynamic Programming," 2015.

Garin, Andy, "Putting America to Work, Where? The Limits of Infrastructure Construction as a Locally-Targeted Employment Policy," 2016.

Giavazzi, Francesco, "Comment on Roads to Prosperity or Bridges to Nowhere? Theory and Evidence on the Impact of Public Infrastructure Investment." In Acemoglu et al. (2013) pp. 143–146.

Glaeser, Edward L. and Joshua D. Gottlieb, "The Economics of Place-Making Policies," *Brookings Papers on Economic Activity*, 2008, *2008*, 155–239.

Hall, Robert, "By How Much Does GDP Rise If the Government Buys More Output?," *Brookings Papers on Economic Activity*, 2009, *2009*, pp. 183–231.

_ , "The Long Slump," *American Economic Review*, April 2011, *101*, 431–469.

Hausman, Joshua K., "Fiscal Policy and Economic Recovery: The Case of the 1936 Veterans' Bonus," *American Economic Review*, April 2016, *106* (4), 1100–1143.

Hooker, Mark A. and Michael M. Knetter, "The Effects of Military Spending on Economic Activity: Evidence from State Procurement Spending," *Journal of Money, Credit and Banking*, 1997, *29* (3), 400–421.

House, Christopher L. and Matthew D. Shapiro, "Temporary Investment Tax Incentives: Theory with Evidence from Bonus Depreciation," *American Economic Review*, June 2008, *98* (3), 737–68.

Imbens, Guido W. and Joshua D. Angrist, "Identification and Estimation of Local Average Treatment Effects," *Econometrica*, 1994, *62* (2), 467–475.

Johnson, David S., Jonathan A. Parker, and Nicholas S. Souleles, "Household Expenditure and the Income Tax Rebates of 2001," *American Economic Review*, 2006, *96* (5), 1589–1610.

Kaplan, Greg, Benjamin Moll, and Giovanni L. Violante, "Monetary Policy According to HANK," 2016.

_ , Giovanni Violante, and Justin Weidner, "The Wealthy Hand-to-Mouth," *Brookings Papers on Economic Activity*, 2014, pp. 77–138.

Leduc, Sylvain and Daniel Wilson, "Roads to Prosperity or Bridges to Nowhere? Theory and Evidence on the Impact of Public Infrastructure Investment." In *NBER Macroeconomics Annual 2012* Acemoglu et al. (2013) pp. 89–142.

Leeper, Eric M., "Equilibria under active and passive monetary and fiscal policies," *Journal of Monetary Economics*, 1991, *27* (1), 129 – 147.

Lusardi, Annamaria, Daniel Schneider, and Peter Tufano, "Financially Fragile Households: Evidence and Implications," *Brookings Papers on Economic Activity*, 2011, pp. 83–150.

Mahon, James and Eric Zwick, "Tax Policy and Heterogeneous Investment Behavior," 2015.

McKay, Alisdair, Emi Nakamura, and Jón Steinsson, "The Power of Forward Guidance Revisited," *American Economic Review*, Forthcoming.

Mian, Atif and Amir Sufi, "The Effects of Fiscal Stimulus: Evidence from the 2009 Cash for Clunkers Program*," *The Quarterly Journal of Economics*, 2012, *127* (3), 1107–1142.

Mountford, Andrew and Harald Uhlig, "What are the effects of fiscal policy shocks?," *Journal of Applied Econometrics*, 2009, *24* (6), 960–992.

Nakamura, Emi and Jón Steinsson, "Fiscal Stimulus in a Monetary Union: Evidence from US Regions," *American Economic Review*, 2014, *104* (3), 753–92.

Neumark, David and Helen Simpson, "Chapter 18 - Place-Based Policies," in J. Vernon Henderson Gilles Duranton and William C. Strange, eds., *Handbook of Regional and Urban Economics*, Vol. 5, Elsevier, 2015, pp. 1197 – 1287.

Okun, Arthur, "Potential GNP: Its Measurement and Significance," *Proceedings of the Business and Economics Statistics Section*, 1962, pp. 98–103.

Parker, Jonathan A., Nicholas S. Souleles, David S. Johnson, and Robert McClelland, "Consumer Spending and the Economic Stimulus Payments of 2008," *American Economic Review*, 2013, *103* (6), 2530–53.

Porecelli, Francesco and Riccardo Trezzi, "Reconstruction Multipliers," 2016.

Ramey, Valerie A., "Can Government Purchases Stimulate the Economy?," *Journal of Economic Literature*, September 2011, *49* (3), 673–85.

_ and Matthew D. Shapiro, "Costly capital reallocation and the effects of government spending," *Carnegie-Rochester Conference Series on Public Policy*, 1998, *48*, 145 – 194.

_ and Sarah Zubairy, "Government Spending Multipliers in Good Times and in Bad: Evidence from U.S. Historical Data," 2016.

Romer, Christina D. and David H. Romer, "The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks," *American Economic Review*, 2010, *100* (3), 763–801.

Sahm, Claudia, Matthew Shapiro, and Joel Slemrod, "Check in the Mail or More in the Paycheck: Does the Effectiveness of Fiscal Stimulus Depend on How It Is Delivered?," *American Economic Journal: Economic Policy*, April 2012, *4* (3), 216–50.

Shoag, Daniel, "The Impact of Government Spending Shocks: Evidence on the Multiplier from State Pension Plan Returns," 2015.

Stroebel, Johannes and Joseph Vavra, "House Prices, Local Demand, and Retail Prices," 2016.

Suárez Serrato, Juan Carlos and Philippe Wingender, "Estimating Local Fiscal Multipliers," 2016.

Weil, Philippe, "Love thy children," *Journal of Monetary Economics*, 1987, *19* (3), 377 – 391.

Wilson, Daniel J., "Fiscal Spending Jobs Multipliers: Evidence from the 2009 American Recovery and Reinvestment Act," *American Economic Journal: Economic Policy*, 2012, *4* (3), 251–82.

Woodford, Michael, "Simple Analytics of the Government Expenditure Multiplier," *American Economic Journal: Macroeconomics*, September 2011, *3* (1), 1–35.

Appendix

A. A Model of Cross-sectional Multipliers

This appendix derives cross-sectional government spending and transfer multipliers in a model economy. The setup and results closely follow Farhi and Werning (2016). My presentation makes a few functional form assumptions at the outset in order to streamline the derivations and provides sufficient algebraic detail to allow a reader to follow along with minimal interruption.

A.1. Setup

Time is continuous. The economy consists of a unit continuum of local areas inside a currency union. All areas have symmetric preferences. The objective of the model is to determine the relative change in output in a single local area when spending in that area rises or it receives a transfer from the rest of the economy. I will denote the single local region as "Home". In describing the model's equations, it will prove easiest in some cases to invoke the symmetry assumption and treat all areas other than "Home" as a composite rest-of-the-economy called "Foreign". Since the Home region is infintesimal, Foreign also corresponds to the total closed economy.

Residents in Home produce output $Y_{H,t}$ and consume C_t, where C_t is an aggregate of consumption of Home output, $C_{H,t}$, and imports, $M_{H,t}$. All residents choose the same bundle of consumption and labor supply L_t. Formally, agents have intertemporal preferences:

$$\text{Intertemporal preferences:} \qquad U_0 = \int_0^\infty e^{-rt} \left(\ln C_t - \frac{1}{1+\phi} L_t^{1+\phi} \right) dt, \tag{A.1}$$

where:

$$\text{Home consumption:} \qquad C_t = C_{H,t}^{1-\alpha} M_{H,t}^{\alpha}, \tag{A.2}$$

$$\text{Imported consumption:} \qquad \ln M_{H,t} = \int_0^1 \ln M_{H,t}^j dj, \tag{A.3}$$

and $M_{H,t}^j$ denotes imports from area j. The parameter r is the discount rate and in equilibrium also the real interest rate in Foreign. The parameter α controls the "Home bias". The assumption of unitary elasticity of substitution in each of equations (A.2) and (A.3) simplifies substantially the algebra which follows. Farhi and Werning (2016) provide expressions for non-unitary elasticities.

Total consumption in Foreign is given by:

$$\text{Foreign consumption:} \qquad C_t^* = C_{F,t}^{1-\alpha} M_{F,t}^{\alpha}. \tag{A.4}$$

Also define $X_{j,t} = M_{F,t}^j$ as exports from j to F.

Let $P_{H,t}$ denote the price of a unit of $Y_{H,t}$ (in terms of the common currency), $P_{M,t}$ the price of the imported good, P_t the domestic CPI, and P_t^* the Foreign CPI, where:

$$\text{Imports price index:} \qquad \ln P_{M,t} = \int_0^1 \ln P_{j,t} dj, \tag{A.5}$$

$$\text{Domestic CPI:} \qquad P_t = P_{H,t}^{1-\alpha} P_{M,t}^{\alpha}, \tag{A.6}$$

$$\text{Foreign CPI:} \qquad P_t^* = P_{F,t}^{1-\alpha} P_{M,t}^{\alpha}. \tag{A.7}$$

By the symmetry assumption, $P_{M,t} = P_t^* = P_{F,t}$.

Finally, the government can purchase Home output in quantity $G_{H,t}$ at the same price as private agents. The Home flow budget constraint is therefore:

$$\text{NFA:} \qquad \dot{N}_t = \left(P_{H,t}\left(Y_{H,t} - G_{H,t}\right) - P_t C_t\right) + i_t N_t, \tag{A.8}$$

where N_t stands for the region's net foreign assets, i_t is the instantaneous nominal interest rate and is common across areas, and a dot over a variable denotes the derivative with respect to time.

The following first order and market clearing conditions obtain:

$$\text{Local consumption:} \qquad C_{H,t} = (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-1} C_t, \tag{A.9}$$

$$\text{Imports:} \qquad M_{H,t} = \alpha\left(\frac{P_t^*}{P_t}\right)^{-1} C_t, \tag{A.10}$$

$$\text{Exports:} \qquad X_{H,t} = \alpha\left(\frac{P_{H,t}}{P_t^*}\right)^{-1} C_t^*, \tag{A.11}$$

$$\text{Output market:} \qquad Y_{H,t} = C_{H,t} + X_{H,t} + G_{H,t}, \tag{A.12}$$

$$\text{PPI inflation:} \qquad \pi_{H,t} = \frac{\dot{P}_{H,t}}{P_{H,t}}, \tag{A.13}$$

$$\text{CPI inflation:} \qquad \pi_t = \frac{\dot{P}_t}{P_t}, \tag{A.14}$$

$$\text{Euler equation:} \qquad \frac{\dot{C}_t}{C_t} = \left(i_t - \pi_t - r\right), \tag{A.15}$$

$$\text{No Ponzi:} \qquad N_0 = -\int_0^\infty e^{-\int_0^t i_s ds}\left(P_{H,t}\left(Y_{H,t} - G_{H,t}\right) - P_t C_t\right) dt, \tag{A.16}$$

$$\text{Backus-Smith:} \qquad P_t C_t = \Theta_t P_t^* C_t^*. \tag{A.17}$$

Equations (A.9) to (A.11) follow from the first order conditions for within-period expenditure maximization. Equation (A.12) is the market clearing condition for puchases of Home output. Equations (A.13) and (A.14) are definitional. Equation (A.15) is the intertemporal Euler equation. Equation (A.16) requires that the initial net foreign assets (i.e. transfers) exactly equal the present value of all current account deficits. In equation (A.17), Θ_t is a variable which defines the expenditure wedge between Home and Foreign.

A.2. Linearized System

At time $t = 0$, paths of government spending and any transfers are revealed; after $t = 0$ the economy is deterministic. I solve for a system of equations in the quantity and price of domestic output. I linearize around a steady state with no deviation of government spending and no transfers. Let variables without time subscripts denote the steady state values. For quantity variables $Z_t \in \{Y_{H,t}, C_t, C_{H,t}, X_{H,t}, G_{H,t}, N_t\}$, define the lower case variable $z_t = \ln(Z_t/Z) \times Z/Y_H \approx (Z_t - Z)/Y_H$. Let $\mathcal{G}$ denote the steady state level of government spending, i.e. $Y_H = C_H + X_H + G_H$ and $\mathcal{G} = G_H/Y_H$. For variables $Z_t \in \{P_{H,t}, P_t^*, P_t, \Theta_t\}$, define the lower case variable $z_t = \ln(Z_t/Z)$. Because the local area is small, variables pertaining to the whole economy remain at their steady state level, i.e. $c_t^* = p_t^* = 0$ and $i_t = r\ \forall t$.

Backus-Smith wedge. Take logs and differentiate equation (A.17) and substitute the Home Euler equation (A.15) and the Foreign equivalent:

$$\text{Take logs of (A.17):} \qquad p_t + c_t = \theta_t + p_t^* + c_t^*,$$

$$\text{Time differentiate:} \qquad \pi_t + \frac{\dot{C}_t}{C_t} = \dot{\theta}_t + \pi_t^* + \frac{\dot{C}_t^*}{C_t^*},$$

$$\text{Substitute (A.15):} \qquad i_t - r = \dot{\theta}_t + i_t - r.$$

The requirement that the Home and Foreign pricing kernels both must price a bond with interest rate i_t implies $\dot{\theta}_t = 0$. Thus, any expenditure wedge θ remains constant over time and expenditure grows at the same rate in all regions. I therefore drop the t subscript on θ.

Consumption Euler equation. In the steady state, $C_H = (1-\alpha) C$ and $X_H = M_H = \alpha C$, so $Y_H = C + G_H$ and $C/Y_H = (1-\mathcal{G})$. The log-linearized Euler equation is therefore:

$$\text{(A.15) and } C/Y_H = (1-\mathcal{G}): \qquad \dot{c}_t = (1-\mathcal{G})(i_t - \pi_t - r). \tag{A.18}$$

Demand. Substitute equations (A.9), (A.11) and (A.17) into equation (A.12), linearize, take a time derivative and substitute using equation (A.18) to find:

$$\begin{aligned}
\text{(A.9) and (A.11) into (A.12):} \quad Y_{H,t} &= (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-1} C_t + \alpha\left(\frac{P_{H,t}}{P_t^*}\right)^{-1} C_t^* + G_{H,t} \\
\text{(A.17) into above:} \quad &= (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-1} C_t + \alpha\Theta^{-1}\left(\frac{P_{H,t}}{P_t}\right)^{-1} C_t + G_{H,t}, \\
\text{Linearize:} \quad y_{H,t} &= -(1-\mathcal{G})\left[\alpha\theta + (p_{H,t} - p_t)\right] + c_t + g_{H,t}, \qquad \text{(A.19)} \\
\text{Time differentiate:} \quad \dot{y}_{H,t} &= -(1-\mathcal{G})(\pi_{H,t} - \pi_t) + \dot{c}_t + \dot{g}_{H,t} \\
\text{Substitute (A.18):} \quad &= -(1-\mathcal{G})(\pi_{H,t} - \pi_t) + (1-\mathcal{G})(i_t - \pi_t - r) + \dot{g}_{H,t} \\
\text{Simplify:} \quad &= (1-\mathcal{G})(i_t - \pi_{H,t} - r) + \dot{g}_{H,t}. \qquad \text{(A.20)}
\end{aligned}$$

Net foreign assets. Next derive a relationship between the Backus-Smith wedge θ and the initial net foreign assets n_0 by linearizing equation (A.16) and using $i_t = r$:

$$\begin{aligned}
\text{Linearize (A.16):} \quad n_0 &= -\int_0^\infty e^{-rt}\left[(1-\mathcal{G})(p_{H,t} - p_t) + y_{H,t} - (g_{H,t} + c_t)\right] dt \\
\text{Substitute (A.19):} \quad &= \int_0^\infty e^{-rt}(1-\mathcal{G})\,\alpha\theta dt \\
\text{Evaluate integral:} \quad &= (1-\mathcal{G})\frac{\alpha}{r}\theta. \qquad \text{(A.21)}
\end{aligned}$$

Intuitively, equation (A.21) states that the difference between Home and foreign expenditure, θ, is proportional to the initial net foreign asset position between the two.

Supply side. I omit a full description of the supply side of the model and instead directly assume a Phillips curve in Home output:

$$\dot{\pi}_{H,t} = r\pi_{H,t} - \left[\kappa\left(y_{H,t} - \Gamma g_{H,t}\right) + \lambda r n_0\right], \tag{A.22}$$

where $\lambda > 0$ is a parameter which is increasing in the amount of price flexibility, $\kappa = \lambda\left(\frac{1}{1-\mathcal{G}} + \phi\right)$ where ϕ is the labor Frisch elasticity defined in equation (A.1), and $\Gamma = \frac{1}{1+(1-\mathcal{G})\phi} < 1$ is the flexible price closed economy government purchases multiplier. One can derive this relationship from Calvo pricing.

Initial condition. To obtain an initial condition, note that the price level cannot jump, and so using equation (A.17):

$$\text{Linearize (A.17):} \qquad c_0 = (1-\mathcal{G})\,\theta \tag{A.23}$$

$$\text{Substitute (A.21):} \qquad = \frac{r}{\alpha} n_0. \tag{A.24}$$

Evaluate equation (A.19) at time $t = 0$, again using the fact that $p_{H,0} = p_0 = 0$, and substitute equations (A.23) and (A.24) to find:

$$\text{(A.19) at } t=0: \qquad y_{H,0} = -(1-\mathcal{G})\,\alpha\theta + c_0 + g_{H,0}$$

$$\text{Substitute (A.23):} \qquad = (1-\mathcal{G})(1-\alpha)\,\theta + g_{H,0}$$

$$\text{Substitute (A.24):} \qquad = \left(\frac{1-\alpha}{\alpha}\right) r n_0 + g_{H,0}. \tag{A.25}$$

A.3. Impact Multipliers

The initial condition (A.25) fully characterizes the impact output multipliers for unanticipated transfers n_0 or government spending $g_{H,0}$ which occur at time 0.

Transfers, impact. The impact transfer multiplier is:

$$\beta^{transfer,impact} = \left(\frac{1-\alpha}{\alpha}\right) r. \tag{A.26}$$

The annuity value of the transfer is rn_0. According to equation (A.24), the impact increase in Home consumption is the annuity value scaled by openness $1/\alpha$. However, some of Home consumption falls on foreign output. With the Cobb-Douglas preferences (A.2), the general equilibrium increase in Home output is $\beta^{transfer,impact} n_0$.

Government purchases, impact. The impact government purchases multiplier is:

$$\beta^{xs,impact,no\ transfers} = 1. \tag{A.27}$$

Since prices cannot jump, there is no expenditure-switching effect for unanticipated purchases on impact. As a result, there is no change in private demand for Home output, so the impact output multiplier is 1.

A.4. Dynamic System Summary

It remains to solve the dynamic system to characterize multipliers at other horizons.

Let $z_{H,t} = y_{H,t} - g_{H,t}$ denote total private demand for Home output (in deviation from steady state). Combine equations (A.20) and (A.22) into a system of differential equations using $i_t = r$:

$$\text{(A.20) and (A.22):} \quad \begin{pmatrix} \dot{z}_{H,t} \\ \dot{\pi}_{H,t} \end{pmatrix} = \begin{pmatrix} 0 & -(1-\mathcal{G}) \\ -\kappa & r \end{pmatrix} \begin{pmatrix} z_{H,t} \\ \pi_{H,t} \end{pmatrix} - E_2 \left[\kappa (1-\Gamma) g_{H,t} + \lambda r n_0\right], \tag{A.28}$$

where $E_2 \equiv \begin{pmatrix} 0 & 1 \end{pmatrix}'$. Equation (A.25) gives the initial condition of the system.

Equation (A.28) is a linear non-homogenous system of differential equations with two forcing variables, $g_{H,t}$ and n_0. The variable $g_{H,t}$ defines the path of government spending. The variable n_0 describes the magnitude of transfers. An outside-financed multiplier consists of a simultaneous increase in $g_{H,t}$ and transfer $n_0 = \int_0^\infty e^{-rt} g_{H,t} dt$. However, in a linear system the combined effect equals the sum of the separate effects. I therefore proceed by solving separately for the response of local output to each forcing variable.

As a preliminary step, define $A = \begin{pmatrix} 0 & -(1-\mathcal{G}) \\ -\kappa & r \end{pmatrix}$ and diagonalize $A = FDF^{-1}$, where:

$$\text{Eigenvectors of } A: \qquad F = \begin{pmatrix} -(1-\mathcal{G}) & -(1-\mathcal{G}) \\ d_1 & d_2 \end{pmatrix}, \tag{A.29}$$

$$\text{Eigenvalues of } A: \qquad D = \begin{pmatrix} d_1 & 0 \\ 0 & d_2 \end{pmatrix}, \tag{A.30}$$

$d_1 \equiv \frac{r - \sqrt{r^2 + 4(1-\mathcal{G})\kappa}}{2} < 0$, $d_2 \equiv \frac{r + \sqrt{r^2 + 4(1-\mathcal{G})\kappa}}{2} > 0$ are the eigenvalues of A, and f_1, f_2 are the corresponding eigenvectors defined in equation (A.29) as $F = \begin{pmatrix} f_1 & f_2 \end{pmatrix}$.[25]

A.5. Transfer Multipliers

Consider first the case of a pure transfer, i.e. $g_{H,t} = 0 \; \forall t$ and $n_0 \neq 0$. Then equation (A.28) is a linear non-homogenous system of differential equations with a constant coefficient $E_2 \lambda r n_0$.

[25]The characteristic equation associated with the eigenvalues of A sets the determinant of $A - dI = \begin{pmatrix} -d & -(1-\mathcal{G}) \\ -\kappa & r-d \end{pmatrix}$ to 0, $0 = d^2 - rd - (1-\mathcal{G})\kappa$, giving the two roots d_1 and d_2.

The generic solution to such a system is:

$$\begin{pmatrix} z_{H,t} \\ \\ \pi_{H,t} \end{pmatrix} = A^{-1} E_2 \lambda r n_0 + c_1 e^{d_1 t} f_1 + c_2 e^{d_2 t} f_2, \tag{A.31}$$

where c_1 and c_2 are scalar constants. Discard the explosive term with the exponent of the positive root $c_2 e^{d_2 t} f_2$ and premultiply both sides by $E_1' \equiv \begin{pmatrix} 1 & 0 \end{pmatrix}$ to obtain an expression for private output:

$$\text{Premultiply (A.31):} \qquad \begin{aligned} z_{H,t} &= E_1' A^{-1} E_2 \lambda r n_0 + c_1 e^{d_1 t} E_1' f_1 \\ &= -\frac{\lambda}{\kappa} r n_0 - c_1 \left(1 - \mathcal{G}\right) e^{d_1 t}, \end{aligned} \tag{A.32}$$

where the second equality uses $E_1' f_1 = -\left(1 - \mathcal{G}\right)$ and $E_1' A^{-1} E_2 = -\frac{1}{(1-\mathcal{G})\kappa} \left(\begin{smallmatrix} 1 & 0 \end{smallmatrix} \right) \left(\begin{smallmatrix} r & (1-\mathcal{G}) \\ \kappa & 0 \end{smallmatrix} \right) \left(\begin{smallmatrix} 0 \\ 1 \end{smallmatrix} \right) = -\frac{1}{\kappa}$.

Next evaluate equation (A.32) at $t = 0$ and equate to the initial condition equation (A.25) to solve for c_1:

$$\text{Equate (A.32) at } t = 0 \text{ to (A.25):} \qquad \begin{aligned} \left(\frac{1-\alpha}{\alpha}\right) r n_0 &= -\frac{\lambda}{\kappa} r n_0 - c_1 \left(1 - \mathcal{G}\right), \\ c_1 \left(1 - \mathcal{G}\right) &= -\left(\frac{\lambda}{\kappa} + \frac{1-\alpha}{\alpha}\right) r n_0. \end{aligned} \tag{A.33}$$

Substitute equation (A.33) into equation (A.32):

$$\begin{aligned} z_{H,t} &= \left[e^{d_1 t} \frac{1-\alpha}{\alpha} - \left(1 - e^{d_1 t}\right) \frac{\lambda}{\kappa} \right] r n_0 \\ &= \left[e^{d_1 t} \frac{1-\alpha}{\alpha} - \left(1 - e^{d_1 t}\right) \frac{1}{\frac{1}{1-\mathcal{G}} + \phi} \right] r n_0, \end{aligned} \tag{A.34}$$

where the second equality uses $\frac{\lambda}{\kappa} = \frac{1}{\frac{1}{1-\mathcal{G}}+\phi}$. Thus, the transfer multiplier is:

$$\beta_t^{transfer} = \left[e^{d_1 t} \frac{1-\alpha}{\alpha} - \left(1 - e^{d_1 t}\right) \frac{1}{\frac{1}{1-\mathcal{G}} + \phi} \right] r. \tag{A.35}$$

The annuity value of the transfer is rn_0. The term in brackets in equation (A.35) incorporates the general equilibrium forces. The weight $e^{d_1 t}$ is declining over time ($d_1 < 0$) with speed determined by the degree of price flexibility (the κ term in the definition of d_1). The first term in brackets $(1-\alpha)/\alpha$ translates the direct increase in local consumption demand when prices are sticky into local output. The second term captures the neoclassical wealth effect of a transfer on labor supply as prices adjust and is negative. Comparing the impact transfer multiplier in equation (A.26) to equation (A.35), the peak transfer multiplier occurs on impact.

A.6. Government Spending Multipliers

Consider next the case where transfers $n_0 = 0$ but government spending in the local area deviates from the steady-state level. Then equation (A.28) is a linear non-homogenous system of differential equations with a nonconstant coefficient. The generic solution to this system is:

$$\begin{pmatrix} z_{H,t} \\ \pi_{H,t} \end{pmatrix} = \int_t^\infty e^{-A(h-t)} E_2 \kappa \left(1 - \Gamma\right) g_{H,h} dh + c_3 e^{d_1 t} f_1 + c_4 e^{d_2 t} f_2, \tag{A.36}$$

where c_3 and c_4 are constants. Discard the explosive term with the exponent of the positive root $c_4 e^{d_2 t} f_2$ and premultiply both sides by E_1' to obtain an expression for private output:

$$\begin{aligned} \text{Premultiply:} \quad z_{H,t} &= E_1' \int_t^\infty e^{-A(h-t)} E_2 \kappa \left(1-\Gamma\right) g_{H,h} dh + c_3 e^{d_1 t} E_1' f_1 \\ &= \frac{\left(1-\mathcal{G}\right)\left(1-\Gamma\right)\kappa}{d_2 - d_1} \int_t^\infty \left(e^{-d_1(h-t)} - e^{-d_2(h-t)}\right) g_{H,h} dh - c_3 \left(1-\mathcal{G}\right) e^{d_1 t}, \end{aligned} \tag{A.37}$$

where the second equality again uses $E_1' f_1 = -(1-\mathcal{G})$ and exploits the diagonalization of A to write:

$$
\begin{aligned}
E_1' e^{-Ax} E_2 &= E_1' F e^{-Dx} F^{-1} E_2 \\
&= \begin{pmatrix} 1 & 0 \end{pmatrix} \begin{pmatrix} -(1-\mathcal{G}) & -(1-\mathcal{G}) \\ d_1 & d_2 \end{pmatrix} \begin{pmatrix} e^{-d_1 x} & 0 \\ 0 & e^{-d_2 x} \end{pmatrix} \frac{1}{(1-\mathcal{G})(d_1-d_2)} \begin{pmatrix} d_2 & (1-\mathcal{G}) \\ -d_1 & -(1-\mathcal{G}) \end{pmatrix} \begin{pmatrix} 0 \\ 1 \end{pmatrix} \\
&= -(1-\mathcal{G}) \begin{pmatrix} 1 & 1 \end{pmatrix} \begin{pmatrix} e^{-d_1 x} & 0 \\ 0 & e^{-d_2 x} \end{pmatrix} \frac{1}{(1-\mathcal{G})(d_1-d_2)} (1-\mathcal{G}) \begin{pmatrix} 1 \\ -1 \end{pmatrix} \\
&= \frac{1-\mathcal{G}}{d_2-d_1} \left(e^{-d_1 x} - e^{-d_2 x}\right).
\end{aligned}
$$

Next evaluate equation (A.37) at $t = 0$ and equate to the initial condition equation (A.25) evaluated at $n_0 = 0$ to solve for c_3:

Equate (A.37) at $t = 0$ to (A.25):

$$
\begin{aligned}
0 &= \frac{(1-\mathcal{G})(1-\Gamma)\kappa}{d_2-d_1} \int_0^\infty \left(e^{-d_1 h} - e^{-d_2 h}\right) g_{H,h} dh - c_3 (1-\mathcal{G}), \\
c_3 (1-\mathcal{G}) &= \frac{(1-\mathcal{G})(1-\Gamma)\kappa}{d_2-d_1} \int_0^\infty \left(e^{-d_1 h} - e^{-d_2 h}\right) g_{H,h} dh. \qquad \text{(A.38)}
\end{aligned}
$$

Substitute equation (A.38) into equation (A.37):

$$
\begin{aligned}
z_{H,t} &= \frac{(1-\mathcal{G})(1-\Gamma)\kappa}{d_2-d_1} \left[\int_t^\infty \left(e^{-d_1(h-t)} - e^{-d_2(h-t)}\right) g_{H,h} dh - e^{d_1 t} \int_0^\infty \left(e^{-d_1 h} - e^{-d_2 h}\right) g_{H,h} dh\right] \\
&= -\frac{(1-\mathcal{G})(1-\Gamma)\kappa}{d_2-d_1} \left[\int_0^t e^{-d_1(h-t)} \left(1 - e^{(d_1-d_2)h}\right) g_{H,h} dh + \int_t^\infty e^{-d_2(h-t)} \left(1 - e^{(d_1-d_2)t}\right) g_{H,h} dh\right], \qquad \text{(A.39)}
\end{aligned}
$$

where in the second equality:

$$
\begin{aligned}
&\int_t^{\infty} \left(e^{-d_1(h-t)} - e^{-d_2(h-t)}\right) g_{H,h} dh - e^{d_1 t} \int_0^{\infty} \left(e^{-d_1 h} - e^{-d_2 h}\right) g_{H,h} dh \\
&= -e^{d_1 t} \int_0^t \left(e^{-d_1 h} - e^{-d_2 h}\right) g_{H,h} dh - \int_t^{\infty} \left[\left(e^{-d_1(h-t)} - e^{d_1 t - d_2 h}\right) - \left(e^{-d_1(h-t)} - e^{-d_2(h-t)}\right)\right] g_{H,h} dh \\
&= -\int_0^t \left(e^{-d_1(h-t)} - e^{d_1 t - d_2 h}\right) g_{H,h} dh - \int_t^{\infty} \left(e^{-d_2(h-t)} - e^{d_1 t - d_2 h}\right) g_{H,h} dh \\
&= -\int_0^t e^{-d_1(h-t)} \left(1 - e^{(d_1-d_2)h}\right) g_{H,h} dh - \int_t^{\infty} e^{-d_2(h-t)} \left(1 - e^{(d_1-d_2)t}\right) g_{H,h} dh.
\end{aligned}
$$

Equation (A.37) characterizes the change in private purchases of local output in period t as the result of government spending which occurred in period h, absent transfers:

$$
\beta_{t,h}^{xs,private,no\ transfers} = \begin{cases} -\frac{(1-\mathcal{G})(1-\Gamma)\kappa}{d_2-d_1} e^{-d_1(h-t)} \left(1 - e^{(d_1-d_2)h}\right), & h < t, \\ -\frac{(1-\mathcal{G})(1-\Gamma)\kappa}{d_2-d_1} e^{-d_2(h-t)} \left(1 - e^{(d_1-d_2)t}\right), & h > t. \end{cases} \tag{A.40}
$$

According to equation (A.40), both past and anticipated future spending affects private purchases of local output. Thus, the equation defines the multiplier associated with spending in period h at lag $t-h$. Crucially, the effect of government spending on private purchases of local output is negative at all horizons other than impact $h = t = 0$, when it is 0. In contrast, the closed economy output multiplier when monetary policy does not respond to government purchases is (weakly) above one (Woodford, 2011; Christiano et al., 2011; Farhi and Werning, 2016). Therefore, the local output multiplier is less than the closed economy output multiplier when monetary policy does not respond to government purchases.[26]

[26]Recently, Farhi and Werning (2016) show that the closed economy constrained monetary policy multiplier can be less than one in an economy with a fraction of hand-to-mouth agents if prices are sufficiently flexible and the Phillips curve sufficiently forward-looking that current consumption declines because of a decline in inflation in anticipation of a future recession when taxes rise. I do not consider that case further here.