The Young, the Old, and the Government: Demographics and Fiscal Multipliers

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Abstract

We document that government spending multipliers depend on the population age structure. Using the variation in military spending and birth rates across U.S. states, we show that the local fiscal multiplier is 1.5 and increases with the population share of young people, implying multipliers of 1.1-1.9 in the inter-quartile range. A parsimonious life-cycle open-economy New Keynesian model with credit market imperfections and age-specific differences in labor supply and demand explains 87% of the relationship between local multipliers and demographics. The model implies that the U.S. population aging between 1980 and 2015 caused a 38% drop in national government spending multipliers.

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1 Introduction

Every time a government considers a plan of fiscal stimulus or fiscal consolidation, there is a strong debate among policymakers, journalists, and economists on the effectiveness of such a policy. This effectiveness is often summarized by the size of the fiscal multiplier, which measures how much output expands following a rise in government spending. Nevertheless, fiscal multipliers are not constant structural parameters, but rather they depend on the characteristics of the economy.

This paper sheds light on a novel determinant of the size of the government consumption spending multiplier: the age structure of the economy. We study a panel of output, military spending, and demographic characteristics across U.S. states and document that local fiscal multipliers rise with the share of young people in total population. We show that a parsimonious life-cycle open-economy New Keynesian model with credit market imperfections and age-specific differences in labor supply and demand explains 87% of the link between local fiscal multipliers and demographics. The model implies that the aging of the U.S. population between 1980 and 2015 caused a 38% drop in national government spending multipliers.

We focus on the differences across U.S. states to uncover the causal effect of demographics on fiscal multipliers. To identify the role of the age structure of the population, we focus on the cross-state variation in the share of young people in total population. As states' age structure can respond to government spending shocks through migration flows, we exploit the heterogeneity in fertility across U.S. states and instrument the share of young people with lagged birth rates. Then, we identify the government spending shocks by leveraging the heterogeneity in the geographical distribution of government military spending, as in Nakamura and Steinsson (2014a). Our identification approach is further corroborated by the lack of correlation across states between the geographical distribution of military spending and the age structure.

In our benchmark regression, the size of fiscal multipliers depends positively on the share of young people (aged 20 - 29) in total population: increasing the share of young people by 1% above the average share across U.S. states raises the local output fiscal multiplier by 3.1%, from 1.51 up to 1.56. These estimates imply that local multipliers vary from 1.1 to 1.9 within the inter-quartile range over all the state-year observations of the share of young people in our sample.

We run a comprehensive battery of robustness checks and find that the age sensitivity of local fiscal multipliers is always highly economically and statistically significant. Importantly, the age-sensitivity of local multipliers holds above and beyond any effect that alternative confounding factors (e.g., differences across states in taxation, transfers, unemployment, house prices, the sectoral composition of value added, and the cross-sectional distribution of labor earnings) have on the propagation of military spending on output. Finally, we replace the share of young people with the share of either mature people or old people, and find that the response of output to government spending shrinks down as the population shifts towards older ages. Thus, fiscal multipliers do not depend on the share of young people in isolation, but rather on the entire age structure of the population.

Our instrumental variable estimator leverages regional heterogeneity to identify the causal link between the age structure in a given U.S. state and the output effect of local government spending. However, since this analysis abstracts from general equilibrium effects, it does not map directly into the aggregate effects of fiscal policy (Nakamura and Steinsson, 2014a; Chodorow-Reich, 2019). To address this concern, we build a general equilibrium model to bridge the empirical evidence on local multipliers with the analysis on national multipliers. In this way, we can use the model to both isolate the mechanisms driving our results on local multipliers, and infer the effects of demographic changes on national fiscal multipliers.

In particular, we consider a life-cycle open-economy New Keynesian model with age-specific differences in labor supply and labor demand, and credit market imperfections. We consider a staggered price setting model with two countries that belong to a monetary union. The household sector has a life-cycle structure, whereby households face three stages of life: young, mature, and old. Following Gertler (1999), we define a framework in which the optimal choices of the households within each age group aggregate linearly. Although this approach reduces the relevance of differences *within* age groups, it allows us to emphasize the heterogeneity *across* age groups and incorporate nominal rigidities and open economy interactions into a tractable environment. In this way, our model extends a standard two-country New Keynesian economy with a rich life-cycle structure.

The model features age-specific differences in both labor supply and labor demand. On the one hand, the labor supply elasticity varies exogenously across the three age groups. In the empirically relevant case, young and old workers have a higher labor supply elasticity than mature workers. On the other hand, we follow Jaimovich et al. (2013) and posit that the production function is characterized by capital-experience complementarity. The demand of experience labor is relatively more persistent over the cycle as it is tied to the stock of capital. Instead, young labor is less complementary to capital, and thus its demand is relatively more volatile. These two mechanisms allow the model to be consistent with the high volatility of hours worked and hourly wages of young workers observed in the data (e.g., Ríos-Rull, 1996; Jaimovich and Siu, 2009).

We also consider credit market imperfections. Households can trade capital and bonds but cannot perfectly smooth consumption because markets are incomplete. In the baseline model, we restrict further households' borrowing capacity with an ad-hoc constraint which does not allow any borrowing at all. Since young households face a hump-shaped labor income over the life-cycle, they want to borrow and smooth lifetime consumption. Yet, credit market imperfections limit the consumption smoothing and boost the marginal propensity to consume of young households well above the one of mature households, as it is in the data.[1]

[1] Young households have a number of characteristics associated with a higher marginal propensity to

In the model, young households are then characterized by very elastic employment outcomes and a relatively high marginal propensity to consume. Consequently, as the proportion of young workers increases, a government consumption spending shock triggers a larger response of both labor and consumption, implying a larger output fiscal multiplier.

In the quantitative analysis, the model explains almost entirely the size of fiscal multipliers and 87% of the link between fiscal multipliers and demographics: increasing the share of young people by 1% above the average share across U.S. states raises the local output fiscal multiplier by 2.7%, from 1.46 up to 1.50. We then measure the contribution of the different mechanisms of the model to this result. We find that the ad-hoc borrowing constraint and incomplete credit markets account each one for 30% of the age sensitivity of local multipliers, whereas the age-specific labor demand through the capital-experience complementarity accounts for 33% of it. Instead, the age-specific labor supply elasticities play a minor role and explain only the remaining 7%.

Since our theoretical model is consistent with the empirical evidence on local multipliers, it represents an ideal laboratory to study the evolution of national fiscal multipliers in light of the progressive aging of the U.S. population. The model implies that the drop in the share of young people from 1980 to 2015 caused a 38% reduction in the size of the national output fiscal multiplier. Since most advanced economies are experiencing a gradual population aging, the model suggests that over time fiscal stimulus through government consumption spending could become a relatively less effective tool to spur economy activity.[2]

This paper is related to the literature that focuses on the implications of demographics for long-run trends (Krueger and Ludwig, 2007; Carvalho et al., 2016; Aksoy et al., 2019), and short-term fluctuations (Jaimovich and Siu, 2009; Leahy and Thapar, 2019; Wong, 2019). The implications of demographics for the aggregate effects of fiscal policy have been highlighted by Anderson et al. (2016), Janiak and Monteiro (2016), and Ferraro and Fiori (2020). Our paper differs from this strand of the literature on two main dimensions. First, we focus on the elasticity of output to fiscal shocks. Following Nakamura and Steinsson (2014a) and Chodorow-Reich (2019), we exploit the heterogeneity across U.S. states and estimate the causal effect of demographics on fiscal multipliers.[3] Second, we build a quantitative model that can be used as a laboratory to measure the effects of changes in the age structure of the economy on fiscal multipliers.

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consume. For instance, young households own much less liquid assets than older households and the marginal propensity to consume depends negatively on the amount of liquid assets (Kaplan and Violante, 2014)

[2]This result refers to the effectiveness of fiscal policy in normal times. The literature has highlighted cases in which fiscal multipliers are very high, e.g., when the economy is at zero lower bound (Woodford, 2011) or there is slack in the economy (Auerbach and Gorodnichenko, 2012)

[3]Anderson et al. (2016) and Ferraro and Fiori (2020) exploit the variation across age groups at the national level and derive the responses of consumption and unemployment to tax shocks identified with the narrative approach. Instead, we leverage the variation at a relatively more disaggregated level, by looking at the variation at the age group-state level.

2 Empirical Evidence

This section shows that local fiscal multipliers depend on demographics: fiscal multipliers are larger in states with higher shares of young people in total population.

We study a panel of output, government military spending, and demographic characteristics across U.S. states. To estimate the effect of government spending on output - and how this effect depends on the age structure of each state - we use the variation across U.S. states in both military buildups and birth rates. This procedure identifies the *local fiscal multiplier*, which is a federally-financed open-economy relative multiplier. This multiplier estimates the response of output in a specific state (say, California) relative to the response of output of all the other U.S. states when the federal government spends one extra dollar in California, and this dollar is financed by taxing individuals in all U.S. states.

2.1 Data

We build a data set of government military spending, output, and demographic characteristics across the 50 U.S. states and the District of Columbia at the annual frequency from 1967 until 2015.

We complement the data of Nakamura and Steinsson (2014b) with information from the U.S. Office of Management and Budget (2015) for geographical distribution of military spending (The data cover any procurement of the U.S. Department of Defense above 10,000$ up to 1983, and above 25,000$ from 1983 on.), from the U.S. Bureau of Economic Analysis (2015a) for U.S. states GDP and from the U.S. Bureau of Economic Analysis (2015b) for U.S. states population.

The data on births rates are hand-collected from the National Center for Health Statistics (1995). The data on births rates are from 1930 onwards. The birth rates of Alaska and Hawaii are available only from 1960 onwards. The data on the state demographic structure by age, race, and sex are from the Surveillance, Epidemiology, and End Results Program of the National Cancer Institute (2015).

2.2 Econometric Specification

We estimate the causal effect of demographics on local output fiscal multipliers using the following panel regression:

$$\frac{Y_{i,t} - Y_{i,t-2}}{Y_{i,t-2}} = \alpha_i + \delta_t + \beta \frac{G_{i,t} - G_{i,t-2}}{Y_{i,t-2}} + \gamma \frac{G_{i,t} - G_{i,t-2}}{Y_{i,t-2}} \left(D_{i,t} - \bar{D}\right) + \zeta D_{i,t} + \epsilon_{i,t} \quad (1)$$

where $Y_{i,t}$ denotes per capita real output in state i at time t, $G_{i,t}$ refers to per capita real federal military spending allocated to state i at time t, $D_{i,t}$ is the measure that represents the age structure of the population in state i at time t and $\bar{D} = \sum_i \sum_t \frac{D_{i,t}}{n_i n_t}$ is its average across all state-year observations, with n_i denoting the number of states and n_t the number of years in the sample. The parameter α_i is a state fixed effect, and δ_t denotes time fixed effects.[4] The fixed effects capture any state-specific trend in output, government spending, and demographics, and control for aggregate shocks, such as variations in the national monetary policy stance.[5,6]

The baseline regression captures the effects of the age structure on local multipliers in a parsimonious way, by letting the variable $D_{i,t}$ to equal the log-share of young people in total population. We compute this share with the ratio of 20-29 years old white males over the total population of white males. As we discuss in the calibration analysis in Section 4.1, the focus on white males allows us to abstract from any other source of heterogeneity, such as sex and race, when disciplining the general equilibrium model with the empirical results on local multipliers. Nonetheless, we also report the results of the case in which we compute the share of all young men and women in total population.[7] We also show that the same qualitative interpretation of the age sensitivity of local multipliers keeps holding when replacing the share of young people with that of either mature (30-65 year old) or old people (above 65 year old). Thus, our results do not depend on the share of young people in isolation, but rather on the entire age structure of the population.

In Equation (1) the coefficient β denotes the local output fiscal multiplier: it defines the dollar increase in per-capita output following a one dollar increase in per-capita federal government spending in a state with the average share of young people. The parameter γ is associated to our regressor of interest, which is the interaction between changes in federal government spending and the share of young people in total population. This parameter defines how fiscal multipliers vary with the age structure of a state: when the share of young people rises by 1% above the average, the fiscal multiplier increases from β up to $\beta + \gamma$. Importantly, the inclusion of the average share $\bar{D}$ in Equation (1) does not affect the estimation of the age sensitivity γ. Rather, the normalization with $\bar{D}$ allows us to directly interpret the parameter β as the effect of government spending on output for a state with an average share of young people (i.e., conditional on

[4] State-level real variables are computed by deflating state-level nominal variables with the aggregate CPI index, as in Nakamura and Steinsson (2014a).

[5] Following Nakamura and Steinsson (2014a), we consider two-year changes in output and government spending to capture in a parsimonious way the dynamic effects of fiscal policy. Section A.5 of the Online Appendix shows that controlling for dynamics by adding lag terms of both output and government spending does not alter our conclusions. The same applies if we control for state-specific time trends. The results do not change even if we consider impact multiplier computed over between one-year and five-year changes, or if we consider two-year cumulative multiplier.

[6] Section A.4 of the Online Appendix reports the results of a similar regression in which the dependent variable is the change in the state-level employment to population ratio, rather than the change in state-level per capita real output.

[7] Section A.1 of the Online Appendix shows that the results do not change if we alter the definition of the young, focusing on the individuals between either 15-29 years old, or 15-34 years old, or 20-34 years old. We also report the cases in which the share of young people is computed as the ratio of either young workers over total workers, or young individuals in the labor force over the total labor force.

$D_{i,t} = \bar{D}$).[8]

We identify government spending shocks following the approach of Nakamura and Steinsson (2014a), which exploits the heterogeneous sensitivity of states' military procurements to an increase in federal military spending.[9,10] This IV strategy implies a first stage regression in which per capita state military procurement (as a fraction of per capita state GDP) is regressed against the product of per capita national military spending (as a fraction of per capita national GDP) and state fixed effects:

$$\frac{G_{i,t} - G_{i,t-2}}{Y_{i,t-2}} = \alpha_i + \delta_t + \eta_i \frac{G_t - G_{t-2}}{Y_{t-2}} + \varphi X_{i,t} + \epsilon_{i,t} \tag{2}$$

where $X_{i,t}$ includes the instruments for both the share of young people and its interaction with the changes in government spending. The coefficient η_i captures the heterogeneous exposure of each state to a rise in federal military spending. This first stage allows us to capture the systematic fixed state-level sensitivity to changes in federal spending, which by construction is orthogonal to any variation in either the political process or the local business cycle that may alter the allocation of spending across states. Furthermore, from 2000 to 2015 the correlation between state-level measures of federal military purchases and the spending of local and state governments is close to zero, suggesting that the bulk of the variation in the allocation of military spending is not driven by state-specific dynamics.[11]

Then, we evaluate whether the effects of government spending shocks on output and employment depend on states' age structure. The panel dimension of the data is crucial to identify the link between demographics and fiscal multipliers. Since our baseline regression features state and time fixed effects, the identification comes from the cross-state variation - and its changes over time - in the share of young people in total population. At any point in time, there is a large dispersion across states in the share of young people. For instance, in 2015 the share of young people ranges between the 12% of Maine and the 23% of D.C.

[8]As $\bar{D}$ does not depend on neither i nor t, our specification is equivalent to estimating $\frac{Y_{i,t}-Y_{i,t-2}}{Y_{i,t-2}} = \alpha_i + \delta_t + \theta \frac{G_{i,t}-G_{i,t-2}}{Y_{i,t-2}} + \gamma \frac{G_{i,t}-G_{i,t-2}}{Y_{i,t-2}} D_{i,t} + \zeta D_{i,t} + \epsilon_{i,t}$, where $\hat{\theta} = \hat{\beta} - \hat{\gamma}\bar{D}$.

[9]E.g., federal military spending as a fraction of national GDP dropped by 1.5% following the U.S. withdrawal from Vietnam. The withdrawal had large heterogeneous effects across U.S. states: in California federal military procurements as a fraction of the state GDP decreased by 2.5%, while Illinois experienced a drop of just 1%.

[10]The use of military spending to estimate national fiscal multipliers follows the work of Barro (1981) and Ramey (2011), among many others. This strand of the literature considers national military spending as exogenous. The implicit assumption is that the U.S. do not embark in a war because national output is low. Our instrument relies on a much weaker exogeneity restriction: we posit that the U.S. do not embark in a war because the output of a specific state is lower than the output of all other states.

[11]We estimate local multipliers by leveraging the variation in military procurements to explicitly rule out the components of government spending that relate to public wage bill, transfers, and the provision of public services. In this way, our estimates can hardly be due to the fact that households in young states are more likely to be transfer recipients. This claim is further corroborated by the low correlation between state-level measures of military purchases and the spending of local and state government.

Moreover, the relative ranking across states has been changing over time. As an example, in 1980 New York had the fourth lowest share of young people in the U.S. Yet, in 2015 the share of young people of New York has become the tenth highest in the U.S.

States' age structure would not be exogenous to government spending shocks if they trigger migration flows. To avoid any concern on the endogeneity of demographics, we follow Shimer (2001) and instrument the share of young people with lagged birth rates.[12] This IV strategy allows us to identify the causal effect of states' age structure on fiscal multipliers. In our baseline specification, we instrument the share of young people using a rolling window of 20-30 year lagged birth rates: we use the average birth rate between 1939 and 1949 to instrument the share of young people in 1969, then we use the average birth rate between 1940 and 1950 to instrument the share of young people in 1970, and so forth.[13] Finally, including the share of young people independently from the interaction with government spending – through the presence of the term $\zeta D_{i,t}$ in Equations (1) – allows us to control for the potential direct channel whereby changes in the age-structure of population and fertility rates affect per-capita output. In this way, the interaction term captures any effect through which demographics shape the output effects of government spending that hold above and beyond the direct impact that demographics have on per-capita GDP.

2.3 Results

Table 1 reports the results on the age sensitivity of local fiscal multipliers based on regressions estimated using instrumental variables for both military spending and the share of young people.

Column (1) refers to the baseline regression in which we proxy the age structure variable $D_{i,t}$ with the log-share of young white males between 20 and 29 years old in total white male population. The first entry shows that the local output fiscal multiplier for a state with an average share of young people is statistically significant at the 1% level and equals 1.51. This result implies that – in a state with the average share of young people in total population – one additional dollar of per-capita federal military spending raises per-capita output by 1.51 dollars.[14] Also the estimated value of the parameter γ associated with the interaction term is highly statistically significant, with a p-value of 0.005. The value of the estimated parameter indicates that the effect of demographics on local output fiscal multipliers is also highly economically significant: increasing

[12]Section A.8 of the Online Appendix shows that lagged birth rates explain the bulk of the variability of the age structure of the population across states and time.

[13]The birth rates for Alaska and Hawaii start in 1960. The results do not change if we consider either an unbalanced panel of birth rates, or we use 9 year lagged birth rates for Alaska and Hawaii.

[14]Dupor and Guerrero (2017) show that including the years of the Korean war yields an estimate of the local fiscal multiplier which is not statistically different from zero. This result hinges on two particular years, 1953 and 1954. In the robustness checks, we show that although the level of local multipliers may vary across specifications, the age sensitivity barely changes.

Table 1: Output Response to a Government Expenditure Shock across U.S. States

	(1) Baseline	(2) Driscoll-Kraay Errors	(3) No DC	(4) All Men and Women
$\frac{G_{i,t}-G_{i,t-2}}{Y_{i,t-2}}$	1.511	1.511	1.538	1.622
	(0.406)	(0.466)	(0.480)	(0.440)
$\frac{G_{i,t}-G_{i,t-2}}{Y_{i,t-2}} \times \left(D_{i,t} - \bar{D}\right)$	0.047	0.047	0.052	0.057
	(0.017)	(0.015)	(0.025)	(0.025)
$D_{i,t}$	0.002	0.002	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)
R^2	0.374	0.374	0.379	0.365
N. Observations	2374	2374	2327	2374

The table reports the estimates of a panel regression across U.S. states using annual data from 1967 to 2015. In all regressions, the dependent variable is the change in real output per capita. The independent variables are the change in state-level per capita real government spending (as a fraction of state-level per capita real GDP), $\left(G_{i,t} - G_{i,t-2}\right)/Y_{i,t-2}$, the log-share of young people in total population times 100, $D_{i,t}$, and the interaction between the change in per capita state government spending (as a fraction of per capita state GDP) and the log-share of young people, $\left[\left(G_{i,t} - G_{i,t-2}\right)/Y_{i,t-2}\right] \times \left(D_{i,t} - \bar{D}\right)$. In all cases, state-level government spending is instrumented with the product of state fixed effects and the change in national per capita real government spending (as a fraction of national per capita real GDP). The share of young people is instrumented with lagged birth rates. Column (1) computes the share of young people as the ratio of 20-29 years old white males over the total population of white males, and uses robust standard errors clustered at the state level, Column (2) considers Driscoll-Kraay standard errors, Column (3) abstracts from the observations of the District of Columbia, and Column (4) computes the share of young people as the ratio of all young men and women over total population. We include time and state fixed effects in all regressions. Standard errors are reported in brackets.

the share of young people by 1% above the average raises output fiscal multipliers by 3.1%, from 1.51 up to 1.56. To put these results within the heterogeneity in the age structure of the population across states, consider that the average share of young people equals 16%, and ranges between a minimum of 11% and a maximum of 29%. Moreover, the inter-quartile range over all the 2397 state-year observations is 14% and 18%. Hence, our estimates imply that fiscal multipliers vary from 1.1 to 1.9 within the inter-quartile range.

In the baseline regressions the standard errors are clustered at the state level. Column (2) reports the standard errors computed following the Driscoll and Kraay (1998) procedure. In this case, γ becomes even more precisely estimated. Hence, the clustering at the state-level is a more conservative approach to estimate the age sensitivity of fiscal multipliers. Column (3) addresses the concern that the age sensitivity could be driven by the observations of the District of

Columbia, which is the state with the highest share of young people. In this case, we take out these observations and find that abstracting from DC reduces slightly the size of the average local multiplier and raises slightly the age sensitivity. Finally, Column (4) refers to the regression in which $D_{i,t}$ is the log-share of all young in total population. The estimated effect of a change in demographics on fiscal multipliers becomes even larger: a 1% increase in the share of young people rises the size of fiscal multipliers by around 3.7%. This is consistent with the fact that white males have a much lower elasticity of labor supply than females and individuals of other racial groups.[15]

To further assess whether the age sensitivity of local fiscal multipliers hinges on a particular econometric specification, we run a comprehensive battery of robustness checks. Table 2 reports the results. The first column displays the results of the baseline regression. The following columns show the results for a regression which abstracts from the interaction with demographics, the OLS regression, the "partial" IV regressions in which we instrument either only the state government spending or only the share of young, and finally the case in which we use the normalization $D_{i,t} - \bar{D}_t \equiv D_{i,t} - \sum_i \frac{D_{i,t}}{n_i}$ instead of $D_{i,t} - \bar{D} \equiv D_{i,t} - \sum_i \sum_t \frac{D_{i,t}}{n_i n_t}$.

The difference in magnitude between IV and the OLS estimates tend to be analogously large in the entire strand of the literature on local fiscal multipliers, independently on the instrumenting approach or the type of government spending or tax under study (e.g., Nakamura and Steinsson, 2014a; Suárez Serrato and Wingender, 2016; Chodorow-Reich, 2019). This finding indicates that the OLS estimates of Column (1) and the "partial" IV estimates of Column (4) are affected by both the attenuation bias generated by measurement errors in federal military spending and fiscal foresight dynamics. Our instrumenting strategy corrects for these biases.

The "partial" IV regression of Column (5) in which only government spending is instrumented yields an estimated coefficient of the interaction between changes in government spending and the share of young people which is larger for the response of output than in the baseline IV regression. This difference could be driven by the endogenous reaction of states' migration flows to a government spending shock, in line with the findings of Blanchard and Katz (1992). If migration raises the population, then it would boost further the change in output. Section A.6 of the Online Appendix confirms this conjecture by showing that although total population does not change following a fiscal shock, the population of young people does rise. This evidence strengthen the relevance of instrumenting the share of young people to avoid any endogeneity concern driven by state

[15] As discussed in Nakamura and Steinsson (2014a), the partial R^2 of the excluded instruments is a better measure of the "strength" of the instruments than the standard Cragg and Donald (1993) F-statistics in regressions saturated with many instruments. Nakamura and Steinsson (2014a) report a value of 12%. Also in our baseline regression the partial R^2 associated to the instrument of government spending is 12%. Instead, the partial R^2 associated to the instrument of either the interaction or the share of young people are higher and equal 15% and 32%. Hence, the age sensitivity of local multipliers has an instrument which is relatively "stronger" than the one of the level of local multipliers.

Table 2: Response of Output to Government Shocks - Robustness Checks

	(1) Baseline	(2) No Age Interaction	(3) Baseline	(4) No IV Govt. Spending	(5) No IV Birth Rates	(6) Age Interaction $(D_{i,t} - \bar{D}_t)$
	IV	IV	OLS	"Partial" IV	"Partial" IV	IV
$\frac{G_{i,t}-G_{i,t-2}}{Y_{i,t-2}}$	1.511	1.693	0.109	0.191	1.515	1.498
	(0.409)	(0.572)	(0.112)	(0.131)	(0.468)	(0.399)
$\frac{G_{i,t}-G_{i,t-2}}{Y_{i,t-2}} \times (D_{i,t} - \bar{D})$	0.047		0.011	0.003	0.067	0.060
	(0.017)		(0.006)	(0.015)	(0.028)	(0.023)
$D_{i,t}$	0.002	0.002	0.002	0.003	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
R^2	0.374	0.343	0.390	0.404	0.331	0.388
N. Observations	2374	2397	2397	2374	2397	2374

The table reports the estimates of panel regressions across U.S. states on annual data from 1967 to 2015. In all regressions, if not stated otherwise, the dependent and independent variables – as well the instrumental variables – are those defined in the Note to Table 1. Column (1) reports the baseline regression. Column (2) shows the results of the regression which abstracts from the interaction of government spending with demographics. Column (3) shows the results of the regression estimated by OLS. In Column (4) we instrument the share of young people but we do not instrument state-level government spending. In Column (5) we instrument state government spending but we do not instrument the share of young people. Column (6) considers the normalization $D_{i,t} - \bar{D}_t \equiv D_{i,t} - \sum_i \frac{D_{i,t}}{n_i}$ instead of $D_{i,t} - \bar{D} \equiv D_{i,t} - \sum_i \sum_t \frac{D_{i,t}}{n_i n_t}$. We include time and state fixed effects in all the regressions. Robust standard errors clustered at the state level are reported in brackets.

migration flows.

The normalization of the baseline regression with the term $D_{i,t} - \bar{D}$ aims only at easing the interpretation of the estimated coefficients without affecting whatsoever either their economic or statistical significance. However, the alternative normalization which considers the difference between the share of young people in each state and the average share of young people in the U.S. at each point of time $D_{i,t} - \bar{D}_t$ tests whether the variation in demographics we exploit has a relevant cross-sectional component vis-à-vis the opposing hypothesis that the variation is mostly driven by changes in population shares which are common across states. Column (6) shows that altering the normalization has little impact on the results, indicating that the relevant variation driving the age sensitivity of fiscal multipliers comes from the cross-section heterogeneity.

As further robustness, in Section A.1 of the Online Appendix we show that the share of young people captures in a parsimonious way the effect of the age structure of the population on local multipliers. To do so, we replace the share of young with either the share of mature (30 - 65 year old) or the share of old (above 65 year old) and find the opposite results comparing to the baseline model: local multipliers decrease with either the share of mature people or the share of old people. Therefore, our evidence indicates that fiscal multipliers do not depend on the share of young people in isolation, but rather on the entire age structure of the population. As the population shifts towards older ages, the response of output to government spending shrinks down. Our evidence is consistent with the findings of Leahy and Thapar (2019) and Wong (2019), which point out the propagation of another demand shock – a monetary policy shock – is largest for young people and decreases with the age of the individuals.

2.4 Validation of Exclusion Restrictions on Demographics

Our identification of the age-sensitivity of local fiscal multipliers hinges on instrumenting the current share of young people in total population with lagged birth rates. Our implicit exclusion restriction posits that, conditional on state and time fixed effects, whatever determines the cross-sectional variation in births rates has no other long lasting effect on the size of fiscal multipliers 20-30 years later. Our IV approach would not be valid if the sensitivity to federal government shocks - i.e., η_i of Equation (2) - is related to states' age structure. Yet, in the data the correlation between states' demographic structures and sensitivity to federal government shocks is virtually zero. Thus, the geographical distribution of military spending is not related to demographics, corroborating our identification approach.

Local fiscal multipliers could also depend on several alternative sources of heterogeneity across states. The omitted heterogeneity across states could violate our identification restriction if it correlates (within states and within years) with both current military spending shocks and lagged birth rates.[16]

Our first concern regards the heterogeneity across states in taxation. In our approach, the presence of the time fixed-effects absorbs any variation in the financing side of federal spending if the incidence of federal taxes does not vary across states. However, this condition could be violated even if the statutory federal tax rate is common across states as long as state-level differences in the demographic composition of the population across states translate into state-level differences in the effective average and average marginal tax rates. To address this concern, we investigate the role of five state-level measures of taxation as potential confounding factors: (*i*) state personal income taxes, (*ii*) local personal taxes, (*iii*) federal personal taxes, (*iv*) a measure of tax incidence on the top-10

[16]We are not concerned about mechanisms that hinge on demographics and affect local fiscal multipliers, such as the role of changes in the cross-sectional distribution of consumption, labor earnings, and wealth that depend *uniquely* on the variation in the age structure of the population. Although not all these mechanisms are active in our quantitative model, they still belong to the causal effect of changes in the age structure of the population on local fiscal multipliers.

percentile of the income distribution, and (*v*) an equivalent measure for bottom-90 percentiles. The last two variables are taken from Zidar (2019).

Our second concern is about the heterogeneity across states in transfers. As emphasized by Oh and Reis (2012), transfers play a crucial role in the propagation of fiscal policy. In this case, we look at five state-level measures of transfers: (*i*) unemployment benefit, (*ii*) total personal transfers, (*iii*) government transfers, (*iv*) transfers from nonprofit institutions, and (*v*) business transfers.

Our third concern is on the potential correlation between the age structure and the sectoral composition of the value added in each state. This correlation could affect our estimates since Bouakez et al. (2019) show that the propagation of government spending varies across sectors. The second set of confounding factors are then the state-level measures of the value-added shares of (*i*) manufacturing, (*ii*) construction, (*iii*) services, (*iv*) personal services, and (*iv*) health care services.

We also consider a fourth set of confounding factors, which consist in state-level measures of (*i*) house prices, (*ii*) the unemployment rate, (*iii*) the Gini index of labor earnings, (*iv*) female labor participation, and (*v*) the skilled labor composition. The choice of these variables is motivated by previous evidence in the literature highlighting how each of these dimensions can influence either the size of the fiscal multiplier or the cyclicality of business cycles.

All these confounding factors are unlikely to drive the age sensitivity of local multipliers, as their correlation with the share of young people tend to be small. For instance, the variable with the highest co-movement with the state-level age structure is the value added share of health care services, which displays a correlation of around -0.53 with the share of young people. To validate the exclusion restriction of our IV approach and further corroborate our results, we report in Section A.2 of the Online Appendix the full results of regressions in which we estimate the age sensitivity of local fiscal multipliers controlling for both the level of each of these key variables and also their interaction with military spending. We find that the estimated age sensitivity γ is remarkably constant across specifications and always highly statistically significant. Overall, these results show that the age-sensitivity of local fiscal multipliers holds *above and beyond* any effect that state heterogeneity in taxation, transfers, sectoral composition, and labor market dynamics have on the propagation of military spending.

Finally, national-level shocks could propagate in an asymmetric way across U.S. states. This heterogeneity would not be absorbed by the time fixed effects, then biasing the estimates of the local fiscal multipliers. If this heterogeneity correlates with the evolution of the age structure across states, then also the estimate of the age sensitivity of local multipliers would be biased. To address this concern, we introduce additional national-level variables, such as the change in the oil price, the households' debt to GDP ratio, the federal debt to GDP ratio, Ramey (2011)'s series on news about future government spending, and the real interest rate, and interact all of them with state fixed effects. Section A.3 of the Online Appendix shows that the economic and statistical significance of the age sensitivity of local fiscal multipliers does not change.

3 The Model

Our empirical analysis leverages regional heterogeneity to identify the causal link between the age structure in a given U.S. state and the output effect of a local government spending shock. However, since this analysis abstracts from general equilibrium effects, it does not map directly into the aggregate effects of fiscal policy (Nakamura and Steinsson, 2014a; Chodorow-Reich, 2019). To address this concern, we build a general equilibrium model and discipline it with our state-level evidence, with two objectives in mind. First, we isolate the mechanisms driving our results on local multipliers. Second, we use the model to make inference on the effects of demographic changes on national fiscal multipliers.

We build a two-country New Keynesian model with a rich, yet tractable, life-cycle structure. The two countries - a home and a foreign economy - belong to a monetary union, with a unique Taylor rule which responds to union-level inflation and output gap. In the union there is also a federal government which purchases final consumption goods subject to spending shocks. The government finances its expenditures by levying lump-sum taxes on the households and issuing bonds.

In each country, the household sector has a life-cycle structure whereby households face an idiosyncratic aging risk and live through three stages of life: young, mature, and old. All the households supply labor, accumulate assets, and consume. The model features credit markets imperfections and age-specific differences in labor supply and labor demand.

The two countries differ only in the relative size of the population. Hereafter we just describe the home country. The variables and parameters of the foreign economy are distinguished by a star superscript.

3.1 Households

In each country there is a continuum of households that belong to three different age groups: young agents (y), mature agents (m), and old agents (o). The demographic structure in the home country is described by the measures of young agents $N_{y,t}$, mature agents $N_{m,t}$, and old agents $N_{o,t}$ such that $N_{y,t}+N_{m,t}+N_{o,t} = N_t$. The total population of the monetary union is $N_{U,t} = N_t + N_t^{\star}$.

Agents move through the three different groups of households in a life-cycle manner as in Yaari (1965) and Blanchard (1985). In the home country, in each period $\omega_n N_{y,t}$ new young agents are born and enter the economy. At any given point in time, households face an idiosyncratic probability ω_i, $i = y, m, o$, to change age group in the following period: young agents become mature with a probability $1-\omega_y$, mature agents become old with a probability $1-\omega_m$, and old agents die and leave the economy with a probability $1-\omega_o$. We can define the law of motion of population across the three age groups as

$$N_{y,t+1} = \omega_n N_{y,t} + \omega_y N_{y,t}, \tag{3}$$

$$N_{m,t+1} = (1-\omega_y) N_{y,t} + \omega_m N_{m,t}, \text{ and} \tag{4}$$

$$N_{o,t+1} = (1-\omega_m) N_{m,t} + \omega_o N_{o,t}. \tag{5}$$

Households face aggregate uncertainty due to fiscal shocks and over the lifetime they experience three idiosyncratic shocks: the transition from young to mature, the transition from mature to old, and the exit from the economy. Although agents are born identical, the idiosyncratic and aggregate uncertainty would generate a distribution of ex-post heterogeneous households. Following Gertler (1999), we define a framework in which the optimal choices of the households within each age group aggregate linearly. This approach reduces the relevance of differences *within* age group but it allows us to emphasize the heterogeneity *across* age groups and incorporate nominal rigidities and open economy interactions into a tractable environment. In this way, our model extends a standard two-country New Keynesian economy with a rich life-cycle structure.

First, we introduce a perfect annuity market which insures old agents against the risk of death. Old agents transfer their investment in capital and bonds to financial intermediaries, which pay back the proceedings only to surviving households. Free entry and perfect competition in the annuity market guarantee a premium to the return on investment which compensates old agents for the risk of death.

Second, we assume that households are risk neutral. In this way, the uncertainty on the labor income dynamics due to the transitions from young to mature and from mature to old, and the aggregate fiscal shocks does not affect optimal choices. Nevertheless, we keep a motive for consumption smoothing by assuming that individual preferences belong to the Epstein and Zin (1989) utility family, such that risk neutrality coexists with a positive elasticity of intertemporal substitution.

At time t the agent i of the age group $z = \{y, m, o\}$ chooses consumption $c^i_{z,t}$, labor supply $l^i_{z,t}$, capital $k^i_{z,t+1}$, and nominal bonds $b^i_{z,t+1}$ to maximize

$$\max_{c^i_{z,t}, l^i_{z,t}, k^i_{z,t+1}, b^i_{z,t+1}} v^i_{z,t} = \left\{ \left(c^i_{z,t} - \chi_z \frac{{l^i_{z,t}}^{1+\frac{1}{\nu_z}}}{1+\frac{1}{\nu_z}} \right)^{\eta} + \beta \mathbb{E}_t[v^i_{z',t+1} \mid z]^{\eta} \right\}^{1/\eta} \tag{6}$$

$$\text{s.t.} \quad P_t c^i_{z,t} + P_{I,t} k^i_{z,t+1} + P_{I,t} \varphi^i_{z,t+1} + b^i_{z,t+1} + P_t \tau^i_{z,t} = \dots$$

$$\dots = a^i_{z,t} + W_{z,t} \xi_z l^i_{z,t} + (1-\tau_d) d^i_{z,t} \mathbb{I}_{\{z=m\}} \tag{7}$$

$$\begin{cases} a^i_{z,t} = P_{I,t}(1-\delta)k^i_{z,t} + R_{k,t} k^i_{z,t} + R_{n,t} b^i_{z,t} & \text{if } z = \{y, m\} \\ a^i_{z,t} = \frac{1}{\omega_z} \left[P_{I,t}(1-\delta)k^i_{z,t} + R_{k,t} k^i_{z,t} + R_{n,t} b^i_{z,t} \right] & \text{if } z = \{o\} \end{cases} \tag{8}$$

$$k^i_{z,t+1} = (1-\delta) k^i_{z,t} + x^i_{z,t} - \varphi^i_{z,t+1} \tag{9}$$

$$k^i_{z,t+1} \geqslant 0, \; b^i_{z,t} \geqslant 0 \tag{10}$$

$$c^i_{z,t} = \left[\lambda^{1/\psi_c} {c^i_{H,z,t}}^{\frac{\psi_c - 1}{\psi_c}} + (1-\lambda)^{1/\psi_c} {c^i_{F,z,t}}^{\frac{\psi_c - 1}{\psi_c}} \right]^{\frac{\psi_c}{\psi_c - 1}} \tag{11}$$

$$x^i_{z,t} = \left[\lambda^{1/\psi_I} {x^i_{H,z,t}}^{\frac{\psi_I - 1}{\psi_I}} + (1-\lambda)^{1/\psi_I} {x^i_{F,z,t}}^{\frac{\psi_I - 1}{\psi_I}} \right]^{\frac{\psi_I}{\psi_I - 1}} \tag{12}$$

where β is the time discount factor and χ_z denotes the weight of leisure in the utility. The parameter $(1-\eta)^{-1}$ denotes the elasticity of intertemporal substitution, which drives households' motive to smooth consumption. Finally, ν_z is the labor supply elasticity, which varies exogenously across age groups. Since the utility function displays consumption-labor complementarities,[17] the response of labor supply to a government spending shock depends uniquely on the labor supply elasticity.

In the budget constraint, each household purchases consumption goods $c^i_{z,t}$ at the price P_t, and invests in capital $k^i_{z,t+1}$ at the price $P_{I,t}$ and nominal bonds $b^i_{z,t+1}$. Capital investment is subject to convex adjustment costs $\varphi^i_{z,t+1}$. Equation (8) defines the total nominal return on assets $a^i_{z,t}$. If the household is either young or mature, the total nominal return on assets equals the sum of the nominal return on capital and the nominal return of bonds. Instead, the return on assets for old households equals the return granted by the annuity market, that is, the return on assets divided by the survival probability of an old agent ω_o.

Each household earns a nominal labor income $W_{z,t}\xi_z l^i_{z,t}$, where $W_{z,t}$ denotes the wage of agents of the age group $z = \{y, m, o\}$ and ξ_z denotes the age-specific efficiency units of hours worked. These parameters allow us to calibrate the model to match the hump-shaped pattern of labor income over the life-cycle. Since in our economy the discount factor varies over the lifecycle, we assume that only mature agents own the firms, so that the firms use their discount factor when setting prices. Dividends are then taxed at a proportional rate τ_d and redistributed by the government to ensure that the model matches the age

[17] Nakamura and Steinsson (2014a) show that consumption-labor complementarities are required to match the level of the local fiscal multiplier. Gnocchi et al. (2016) study data on time use to document that the complementarity between consumption and hours worked is an empirically relevant driver of the response of labor to a government spending shock.

distribution of total business and capital income observed in the data. Households then pay a net lump-sum tax $\tau^i_{z,t}$ to finance government expenditure.

Equation (10) denotes the ad-hoc borrowing constraints that restrict the households from going short in capital and bonds. In equilibrium, mature households save for retirement, the old dissaves, and the constraints bind only for young households. Given the hump-shaped pattern of labor income over the life cycle, young agents would like to borrow and smooth consumption but are prevented from doing so.[18]

Equations (11) and (12) show that households consumption $c^i_{z,t}$ and investment $x^i_{z,t}$ combine final goods produced in both the home and foreign country. The parameter λ captures the degree of home bias of the economy, that is, the amount of home produced goods consumed by households in the home economy,[19] whereas ψ_c is the elasticity of substitution across home and foreign produced consumption goods, and ψ_I denotes the elasticity of substitution across home and foreign produced investment goods.[20]

3.2 Production

In each country the production sector is split into one competitive final goods firm and a continuum $j \in [0,1]$ of intermediate producers under monopolistic competition. In the home country, the final goods firm produces domestic output Y_t with a CES aggregator of the different varieties of the intermediate producers

$$Y_t = \left(\int_0^1 Y_t^{j\,\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{13}$$

where Y^j_t denotes the output produced by the intermediate producer j at time t, and ε is the elasticity of substitution across varieties. The final good firm is perfectly competitive and takes as given the price of the good variety produced by the intermediate producers $P^j_{H,t}$, which yields to the standard isoelastic demand function for each variety j, and sells the final bundle of home produced goods Y_t at the price $P_{H,t}$. The foreign country has the same structure with the only difference that it produces output $Y^\star_t$ for a price $P_{F,t}$.

We follow Jaimovich et al. (2013) and model the technology of the interme-

[18] In the quantitative analysis, we also consider a version of the model which abstracts from the ad-hoc constraint on bonds. Even in this case, in our life-cycle setting a non-contingent bond is not sufficient to ensure perfect consumption smoothing across generations. Gordon and Varian (1988) show that in an overlapping generations economy markets are complete only if young individuals can trade with unborn generations. This missing market prevents an efficient allocation across generations.

[19] High values of λ imply that households' consumption basket is heavily tilted towards home-produced goods. In this case, government spending shocks in the home economy generate a relatively lower demand of goods produced in the foreign economy. As a result, the local fiscal multiplier increases with the level of λ.

[20] Section C of the Online Appendix shows in detail the problems of young, mature, and old agents, and the optimal amounts of home and foreign goods purchased in the home economy.

diate firms that produce the differentiated varieties Y_t^j as

$$Y_t^j = \left(\mu \left[L_t^{j,in}\right]^\sigma + (1-\mu)\left[\alpha\left(K_t^j\right)^\kappa + (1-\alpha)(L_t^{j,ex})^\kappa\right]^{\frac{\sigma}{\kappa}}\right)^{\frac{1}{\sigma}} \tag{14}$$

where K_t^j is physical capital, $L_t^{j,in}$ is the labor of inexperienced workers, and $L_t^{j,ex}$ is the labor for experienced workers. The parameters μ and α pin down the shares of inexperienced labor and experienced labor in the production function, whereas $(1-\sigma)^{-1}$ and $(1-\kappa)^{-1}$ control the elasticity of substitution between inexperienced labor, experienced labor, and capital. In the empirically relevant case in which $\sigma > \kappa$, the production function has capital-experience complementarity. This technology generates age-specific differences in labor demand: experience labor is more complementary to capital than inexperienced labor.[21]

Intermediate producers hire experienced workers at the equilibrium nominal wage W_t^{ex}, inexperienced workers at the equilibrium nominal wage W_t^{in}, and rent capital at the equilibrium nominal gross rate $R_{k,t}$. Firms also face a nominal price rigidity à la Calvo, such that they can reset their prices with a probability $1-\zeta$. This probability is independent and identically distributed across firms, and constant over time. As a result, in each period a fraction ζ of firms cannot reset their prices and maintain the prices of the previous period, whereas the remaining fraction $1-\zeta$ of firms are allowed to set freely their prices. Then, firms decide the optimal amount of capital and labor, as well as the price to set by maximizing the expected stream of dividends discounted with the discount factor of mature individuals.

3.3 Government

In the monetary union there is a government that constitutes of a monetary authority and a fiscal authority. On the monetary side, the government sets the nominal interest rate $R_{n,t}$ following a Taylor rule that reacts to the inflation rate of the monetary union $1+\pi_t^u \equiv \frac{P_{u,t}}{P_{u,t-1}}$, where $P_t^u \equiv N_t P_t + N_t^\star P_t^\star$, and the gap between the output of the monetary union $Y_t^u \equiv Y_t + Y_t^\star$ and the output of an economy with flexible prices $Y_t^{u,F}$

$$\frac{R_{n,t}}{\bar{R}} = \left[\frac{R_{n,t-1}}{\bar{R}}\right]^{\psi_R}\left[(1+\pi_t)^{\psi_\pi}\left(\frac{Y_t^u}{Y_t^{u,F}}\right)^{\psi_Y}\right]^{1-\psi_R} \tag{15}$$

where $\bar{R}$ is the steady-state nominal interest rate, ψ_R denotes the degree of interest rate inertia, and ψ_π and ψ_Y capture the degree at which the nominal interest rates respond to inflation and output gap, respectively.

On the fiscal side, the federal government purchases home goods $G_{H,t}$ and foreign goods $G_{F,t}$, thus government spending is region dependent. The government finances its expenditures with the revenues of a one-period non-contingent

[21]The notion of capital-experience complementarity is related to the capital-skill complementarity emphazised by Krusell et al. (2000) as a rationale for the dynamics of both the supply and the price of skilled labor relative to unskilled labor observed over the last decades.

bond $B_{g,t}$, that yields a nominal gross interest rate $R_{n,t}$, a nominal lump-sum tax levied in the home country T_t and in the foreign country $T_t^\star$, and the proceeds from dividend taxation $\tau_d(D_{m,t} + D^\star_{m,t})$. The empirical exercise assumes that although government spending differs across the regions, taxes are uniformly set in the union. Accordingly, we let per capita lump-sum taxes T_t/N_t and $T_t^\star/N_t^*$ to be the same in both the home and foreign economy. Then, the government budget constraint reads

$$P_{H,t}G_{H,t} + P_{F,t}G_{F,t} + B_{g,t+1} = B_{g,t}R_{n,t} + P_tT_t + P_t^\star T_t^\star + \tau_d(D_{m,t} + D^\star_{m,t}) \quad (16)$$

where $T_t = \int_0^{N_{y,t}} \tau^i_{y,t}\,\mathrm{di} + \int_0^{N_{m,t}} \tau^i_{m,t}\,\mathrm{di} + \int_0^{N_{o,t}} \tau^i_{o,t}\,\mathrm{di}$, and $D_{m,t} = \int_0^{N_{m,t}} d^i_{m,t}\,\mathrm{di}$. Analogous expressions apply for $T_t^\star$ and $D^\star_{m,t}$. However, the progressivity of the U.S. tax system may generate additional heterogeneity across states in the financing of government spending, which is absent in the model. To address this concern, Section E of the Online Appendix presents an extension to the model that replaces lump-sum taxes with a progressive labor income taxation system. Importantly, the implications of this version of the model on the age sensitivity of local multipliers remains largely unchanged.

Government expenditures $G_{H,t}$, and $G_{F,t}$ are exogenous and follow first order autoregressive processes

$$\log G_{H,t} = (1-\rho_G)\log G_{H,SS} + \rho_G \log G_{H,t-1} + \epsilon_{G_H,t}, \quad (17)$$

and

$$\log G_{F,t} = (1-\rho_G)\log G_{F,SS} + \rho_G \log G_{F,t-1} + \epsilon_{G_F,t}, \quad (18)$$

where $G_{H,SS}$ and $G_{F,SS}$ are the steady-state values of government spending in each country, ρ_G denotes the persistence of the processes, $\epsilon_{G_H,t}$ is a spending shock in home goods, and $\epsilon_{G_F,t}$ is a spending shock in foreign goods. These shocks are independent and identically distributed following a Normal distribution $N(0,1)$.

We assume that the government follows a fiscal rule which determines the response of debt and tax to the exogenous changes in government spending:

$$\frac{\widehat{B}_{g,t+1}}{Y^u_{SS}} = \rho_{bg}\frac{\widehat{B}_{g,t}}{Y^u_{SS}} + \phi_G\frac{\widehat{P_{H,t}G_{H,t}}}{Y^u_{SS}} + \phi_G\frac{\widehat{P_{F,t}G_{F,t}}}{Y^u_{SS}} + \phi_T\frac{\widehat{P_tT_t}}{Y^u_{SS}} + \phi_T\frac{\widehat{P_t^\star T_t^\star}}{Y^u_{SS}} \quad (19)$$

where Y^u_{SS} denotes the steady-state value of the output of the monetary union, and $\hat{Z}_t \equiv Z_t - Z_{SS}$ denotes the absolute deviation from steady-state. The parameters ρ_{bg}, ϕ_G, and ϕ_T control to what extent debt and tax finance an increase in government spending and how long the government takes to raise taxes to bring government debt back to the steady state level. For instance, when $\phi_G = 0$, $\rho_{bg} = 0$, and $\phi_T = 0$, spending is fully financed through taxes. As ϕ_G and ρ_{bg} increase, government spending becomes partially financed through debt. As ϕ_T increases, debt levels above steady-state trigger tax adjustments.[22]

[22] Given the non-Ricardian behavior of the agents in this life-cycle economy, national fiscal multipliers tend to be higher when spending is financed relatively more by debt and less by taxes. Local fiscal multipliers are significantly less sensitive to the characteristics of the fiscal rule since the tax burden falls over the entire union.

3.4 Closing the Model

Our setup allows us to derive optimal policies for each individual that can be aggregated linearly within each age-group. For instance, we can define total young consumption, mature consumption, and old consumption of goods produced in the home economy as

$$C_{H,y,t} = \int_0^{N_{y,t}} c^i_{H,y,t}\,\text{di}, \quad C_{H,m,t} = \int_0^{N_{m,t}} c^i_{H,m,t}\,\text{di}, \quad \text{and} \quad C_{H,o,t} = \int_0^{N_{o,t}} c^i_{H,o,t}\,\text{di},$$

such that the overall total consumption equals $C_{H,t} = C_{H,y,t}+C_{H,m,t}+C_{H,o,t}$. The same applies to all the variables of the model. Section C of the Online Appendix shows that the life-cycle setup of the model allows for a simple linear aggregation within age groups.

Bonds move freely across countries, and the clearing of the market implies that the supply of government bonds equals the sum of individual positions across countries, that is $B_{g,t} = B_t+B^\star_t = B_{y,t}+B_{m,t}+B_{o,t}+B^\star_{y,t}+B^\star_{m,t}+B^\star_{o,t}$. Instead, we assume that labor and physical capital are immobile.[23] The clearing of the rental markets of capital implies $K_t = K_{y,t}+K_{m,t}+K_{o,t}$ and $K^\star_t = K^\star_{y,t}+K^\star_{m,t}+K^\star_{o,t}$. The labor markets clear when $L_{in,t} = \xi_y L_{y,t}$, $L_{ex,t} = \xi_m L_{m,t}+\xi_o L_{o,t}$ and $L^\star_{in,t} = \xi_y L^\star_{y,t}$, $L^\star_{ext,t} = \xi_m L^\star_{m,t} + \xi_o L^\star_{o,t}$. As such $W_{y,t} = W^{in}_t$ and $W_{m,t} = W_{o,t} = W^{ex}_t$.

Then, the resource constraint of the home economy posits that output is split into the consumption of the home goods of the households of both countries, the investment of both countries, and the goods purchased by the government, net of the adjustment costs of capital $Y_t = C_{H,t} + C^\star_{H,t} + G_{H,t} + X_{H,t} + X^\star_{H,t} - \varphi_t$, where φ_t denotes the sum of the adjustment costs bore by all agents in the home economy. Similarly, for the foreign economy we have that $Y^\star_t = C_{F,t} + C^\star_{F,t} + G_{F,t} + X_{F,t} + X^\star_{F,t} - \varphi^\star_t$.

4 Quantitative Analysis

4.1 Calibration

In the calibration exercise, we discipline the life-cycle dynamics by matching some salient facts on the demographics of the U.S. population and the life-cycle pattern of labor income. Throughout the calibration, we set one period of the model to correspond to one quarter.

The calibration of the set of parameters that govern the demographic and life-cycle structure of the model is reported in Tables D.1 and D.2 in Section D of the Online Appendix. We first set the size of the home economy to $N/N^u = 0.02$, which is the average size of a U.S. state. We define young households as the

[23] In the empirical analysis we instrument of the share of young people with lagged birth rates to wash out the effect of migration on local fiscal multipliers. Accordingly, we set that labor is immobile in the model. When we do not control for migration flows in the data, the age sensitivity of local fiscal multipliers is even larger.

individuals between 20 and 29 years old, mature households are the individuals between 30 and 64 years old, and old households are the individuals above 65 years old. Then, we define the parameters that control the law of motion of age group populations to match the average share of young people in total population between 1967 and 2015, the average share of old people in total population between 1967 and 2015, the average number of years that an individual spends as young (10 years), the average number of years that an individual spends as mature (35 years). Matching these moments yields a birth rate of new young agents of $\omega_n = 0.0274$, a probability of the transition from young to mature of $1 - \omega_y = 0.0250$, a probability of the transition from mature to old of $1 - \omega_m = 0.0071$, and a death probability for an old agent of $1 - \omega_o = 0.0274$.

We define the relative disutility of working for mature households such that their steady-state hours worked equal 0.35. This condition yields $\chi_m = 131.9$. Then, we define the relative disutility of working for young and old households such that their hours worked equal 0.324 and 0.08, respectively. These moments are derived by multiplying the steady-state hours worked by mature households with the employment rate of either young or old households relative to the employment rate of the mature.[24] These conditions yield the values of $\chi_y = 2.4$ and $\chi_o = 14.5$.

The parameters of the production that control the complementarity between inexperienced labor, experienced labor, and capital, σ and κ, are disciplined with the empirical evidence of Jaimovich et al. (2013). These authors estimate these parameters using CPS data, and find that $\sigma = 0.7$ and $\kappa = 0.2$. These values imply that experienced labor is much more complementary to capital than inexperienced labor. Then, we calibrate jointly the remaining parameters of the production function α and μ with the parameters that govern the efficiency unit of hours across age groups ξ_y, ξ_m, and ξ_o, to match the life-cycle dynamics of labor earnings and the share of capital in the production function. Namely, we want to match three targets: the share of labor in the production function of 0.67, the fact that the hourly wage of individuals between 20 and 29 years equals on average 71% of the hourly wage of individuals between 30 and 64 years, and the fact that the hourly wage of individuals above 65 years equals on average 72% of the hourly wage of individuals between 30 and 64 years. Accordingly, we need three parameters. Hence, we first normalize the efficiency unit of hours of young and mature agents and set $\xi_y = \xi_m = 1$. Then, we set $\mu = 0.36$, $\alpha = 0.27$, and $\xi_o = 0.72$.[25]

[24] The average employment rate of young individuals between 1970 and 2015 equals 69.3%. The employment rate of mature individuals equals 72.2%. The employment rate of old individuals equals 13.7%.

[25] This calibration choice is motivated by the fact that, given the values of σ and κ, the parameters α and μ pin down the share of capital in the production function and the ratio between the hourly wage of young inexperienced workers vis-à-vis older experienced workers. Then, the parameter ξ_o pins down the hourly wage of old workers vis-à-vis mature workers. In the quantitative analysis we quantify the role of the age-specific labor demand through the experience-capital complementarity by computing the local fiscal multipliers in an economy with a standard Cobb-Douglas production function in labor and capital, such as $Y_t = L_t^{1-\alpha} K_t^{\alpha}$. In this case, inexperienced and experienced labor are perfect substitutes and there is a unique equilibrium wage. This economy is calibrated such as $\alpha = 0.33$ to match the share of capital in the

Since we assume that mature households own the firms and receive all the dividends, the proportional tax on dividends aims at re-distributing dividend proceeds across households of all ages. According to the 2013 Survey of Consumer Finance (SCF), individuals between 30 and 65 years old receive around 60% of the entire business income of the economy. We match this statistics by setting the dividend tax to $\tau_d = 0.9394$. Importantly, the calibration of the dividend tax rate jointly with that of hours and wages implies lifecycle profiles of consumption and wealth which are consistent with the data.[26]

The literature on fiscal multipliers emphasizes the role of the labor supply elasticity in the determination of the magnitude of the response of output to government spending shocks (Woodford, 2011). Moreover, the variation of the labor supply elasticity over the lifecycle is one of the mechanisms through which the model rationalizes the age-sensitivity of fiscal multipliers. Accordingly, we opt for a conservative approach by disciplining the values of the labor supply elasticity with the evidence on the micro elasticity provided by the literature. However, a complete characterization of demographic composition of labor supply is key to correctly map the micro labor supply elasticities into a macro elasticity (Browning et al., 1999). For this reason, the focus of the empirical analysis on the white male population allows us to calibrate the labor supply elasticities with the ultimate aim of isolating the role of the change in the age structure of the homogenous population of white males. In this way, we do not need to complicate further the structure of the model by incorporating – and endogenizing – other relevant secular changes in the demographic structure of the population, such as the rise in female labor participation.

The meta-analysis of quasi-experimental studies carried out by Chetty et al. (2013) computes a mean of the intensive margin Frisch elasticity of 0.54. These studies tend to focus on groups with weak attachment to the labor force, such as single mothers or workers near retirement. Since we are after the elasticity of white male workers, which feature a much lower elasticity than the rest of the workers, we set the labor supply elasticities across age groups such as its average value is 0.4, which is slightly below the average of the Frisch elasticity estimates and slightly above the average of the Hicksian elasticity estimates in Chetty et al. (2013).

Then, we calibrate of mature workers to $\nu_m = 0.2$, consistently with the fact that the elasticity of prime-age workers lies at the lower end of the micro elasticity estimated in the literature. The labor supply elasticity of old workers is set following Rogerson and Wallenius (2013), who point out that only elasticities above 0.75 can rationalize the observed retirement behavior from full-work.

production function, and the life-cycle dynamics of labor earnings is matched by setting $\xi_m = 1$, $\xi_y = 0.71$, and $\xi_o = 0.72$.

[26]The ratios of consumption of young-to-mature people and old-to-mature people in the model are respectively 0.58 and 0.64. In 2014 PSID data, these ratios are 0.58 and 0.71 (Aksoy et al., 2020). In the model, the values for wealth of the three age groups (normalized by the average wealth across all age groups) equal respectively 0, 1.30, and 1.33. In 2013 SCF data, these values are 0.09, 1.00, and 1.57 (Kuhn and Ríos-Rull, 2016).

Accordingly, we calibrate the elasticity of old workers to $\nu_o = 0.75$. Finally, we calibrate the elasticity of young workers such that the weighted-average elasticity of the economy equals 0.4. This procedure yields an elasticity of young workers of $\nu_y = 0.71$, which is slightly lower than the elasticity of old workers. Interestingly, this relative ranking between elasticities across age groups is consistent with the evidence of Ríos-Rull (1996) and Jaimovich and Siu (2009), which document that the volatility of hours and wages is u-shaped over the life-cycle, and highest for old workers.[27]

The calibration of the set of parameters of the New Keynesian structure of the model is reported in Table D.3 in Appendix D. We set the time discount factor to $\beta = 0.995$, whereas we fix $\eta = -9$ so that the elasticity of intertemporal substitution is 0.1, consistently with the estimates of Hall (1988).

The capital depreciation rate is set to the standard value of $\delta = 0.025$, which implies a 10% annual depreciation rate. Instead, for the capital adjustment costs we do the following. First, we posit that the adjustment costs for an individual i in the age group z at time t equal $\varphi^i_{z,t+1} = \frac{\varphi}{2}\left(\frac{k^i_{z,t+1}}{k^i_{z,t}} - \vartheta_z\right)^2 k^i_{z,t}$. The parameter ϑ_z captures the life-cycle dynamics of capital accumulation and it is pinned down such that no adjustment cost is paid at steady-state. In the baseline calibration, young households do not own capital and therefore do not bear adjustment costs. The average quarterly capital accumulation rate for mature households is 0.72%, which implies $\vartheta_m = 1.0072$, whereas old households on average deplete capital, and they do so at a quarterly rate of -0.12%, such that $\vartheta_o = 0.9988$. Then, we set $\varphi = 200$ such that the response of investment to a government spending shock bottoms after 8 quarters, in line with the empirical evidence of Blanchard and Perotti (2002).

We set the elasticity of substitution across varieties to $\epsilon = 9$, which implies a markup of 12.5%, in the ball park of the estimates used in the literature of New Keynesian models. The Calvo price parameter is set to $\zeta = 0.75$, which implies that on average firms adjust their prices every 12 months. Regarding the consumption and investment bundles, we follow Nakamura and Steinsson (2014a): we set the home bias to $\lambda = 0.69$ and the elasticity of substitution across home and foreign consumption goods to $\psi_c = 2$. Finally, we impose that the elasticity of substitution across investment goods equals the one of consumption goods, that is, $\psi_i = \psi_c$.

The ratio of steady-state value government spending (both in the home and foreign economy) to output is set to 0.204. This value coincides with the average ratio of total government spending to output observed in the data from 1960 to 2016. To calibrate the persistence of the government spending shock, we follow the approach by Nakamura and Steinsson (2014a) and estimate the quarterly

[27] Our calibration choice for the labor supply elasticity across age groups is consistent with Jaimovich and Siu (2009), Rogerson and Wallenius (2013), Janiak and Monteiro (2016), and Peterman (2016), who find that young and old individuals have higher labor supply elasticities than mature individuals. Although we cannot discount the possibility that the labor supply elasticity changes with population aging, throughout the paper we assess the effect of aging conditional on a constant labor supply elasticity over time.

persistence of military spending using annual data through a simulated method of moments approach. This procedure yields a value of $\rho_G = 0.953$.[28] Finally, we calibrate the fiscal rule parameters. We calibrate the three parameters ρ_{bg}, ϕ_G, and ϕ_T to match the inertia observed in the data in the response of government debt to a government spending shock. First, we posit that following a government spending shock the ratio of government deficit to debt issuance is u-shaped, with a trough after 6 quarters. Second, throughout the first 8 quarters, new debt issuance covers on average around 90% of the total deficit. Third, after the trough, debt issuance starts decreasing and from the 20^{th} quarter onwards, government debt is progressively repaid through increases in lump-sum taxation. This procedure yields the following parameters: $\rho_{bg} = 0.95$, $\phi_G = 4.5$, and $\phi_T = 0.01$.

We set the Taylor rule parameters following the estimates of Clarida et al. (2000): the inertia parameter equals $\psi_R = 0.8$, the degree of response to the inflation rate is $\psi_\pi = 1.5$, and the degree of response to the output gap is $\psi_Y = 0.2$.

4.2 Demographics and Local Fiscal Multipliers

What is the effect of a change in the age structure of the economy on the size of local fiscal multipliers in the model? We address this question by replicating the same empirical analysis carried out in Section 2 with the simulated data of our model. In the simulation, we consider the effect of federally-financed increases in (wasteful) government spending in each of the two economies: we shock the economy with innovations to government spending in home goods $G_{H,t}$ and innovations to government spending in foreign goods $G_{F,t}$. These purchases are financed at the federal level, partially through bonds and partially through lump-sum taxes on all the households of the monetary union.

We proceed in two steps. In the first one, we estimate the local output fiscal multiplier in a model in which both economies are symmetric in the shares of population across age groups, which are calibrated to average values observed between 1967 and 2015. To do so, we estimate the following panel regression:

$$\frac{Y_{i,t} - Y_{i,t-2}}{Y_{i,t-2}} = \alpha_i + \delta_t + \beta \frac{G_{i,t} - G_{i,t-2}}{Y_{i,t-2}} + \epsilon_{i,t}, \qquad i \equiv \{H, F\}.$$

This first step yields the model counterpart of the coefficient β of the regression (1), that is, the size of local multipliers for a state with an average share of young people in total population. In the second step, we change the age structure of the home economy by increasing the share of young people by 1%. Then, we estimate again the local fiscal multiplier as before. The difference in the size of

[28] The simulated method of moments yields a value slightly higher than the 0.933 estimated by Nakamura and Steinsson (2014a), pointing out to the fact that the extra 10 years of national military in our sample from 2006 to 2015 drive the upward revision of the autoregressive coefficient. Nevertheless, varying the autoregressive coefficient of military spending has negligible effects on age sensitivity of local fiscal multipliers generated by our model.

the local output fiscal multiplier between the second and the first step yields the model counterpart of the coefficient γ of the regression (1), which defines how local multipliers vary with the age structure of an economy.

Table 3 reports the results of this exercise. In the data, the local output fiscal multiplier for a U.S. state with an average share of young people in total population is 1.51. A 1% increase in the share of young people raises the multiplier by 3.1%, up to 1.56. In the model, the local output fiscal multiplier for a U.S. state with an average share of young people in total population is 1.46. A 1% increase in the share of young people raises the multiplier by 2.7%, up to 1.50. Hence, the model matches almost entirely the size of the local fiscal multiplier and explains 87% of the link between fiscal multipliers and demographics.

Table 3: Local Output Fiscal Multiplier - Data vs. Model

		Data	Model
Average Local Output Fiscal Multiplier	β	1.511	1.463
Sensitivity of Local Output Fiscal Multiplier with States' Age Structure	γ	0.047	0.039
Δ Local Output Fiscal Multiplier of 1% Increase in Share Young People	γ/β	3.1%	2.7%

This table reports the results of the estimation of the local output fiscal multiplier in the data and in the model. The first row reports the estimated value of the local output fiscal multiplier for a U.S. state with an average share of young people in total population. The second row reports how a 1% increase in the share of young people rises the size of the local output fiscal multiplier. The last row computes the age sensitivity of local output fiscal multiplier.

What is the contribution of the different channels of the model to the quantitative implications on the age sensitivity of the local fiscal multiplier? On the one hand, the model features two mechanisms that generate a higher response of the labor of young workers vis-à-vis older workers: the age-specific differences in labor supply and labor demand. The differences in labor supply consist in the fact that the labor supply elasticities vary exogenously across age groups, such as the elasticity of young and old workers is larger than the one of mature workers. The differences in labor demand hinge on the capital-experience complementarity embedded in the production function we consider, such as the demand of experienced labor (i.e., the labor of mature and old workers) is relatively more tied to the stock of capital, and thus fluctuates less over the cycle. On the other hand, the model features two forms of credit market imperfections - the incomplete asset markets and ad-hoc borrowing constraint - that raise the marginal propensity to consume of all households, and especially that of young individuals.

To disentangle the contribution of all these channels, we compare the results of the baseline model with implications of three counterfactual economies, which isolate the quantitative relevance of each channel by eliminating each time a feature of the model in a sequential and cumulative way. The first counterfactual economy, the "Constant Labor Supply Elasticity", refers to a version of the baseline model which abstracts from the age-differences in the labor supply elasticity: the elasticity is kept constant across the three age groups and equals the weighted average value of the baseline economy, that is, $\nu_y = \nu_m = \nu_o = 0.4$. The second counterfactual economy, the "No Capital Experience Complementarity", uses as a starting point the previous economy in which there is no differences in labour supply, and eliminates the age-differences in labor demand, by considering a standard Cobb-Douglas in capital and labor. In this economy, the labor of inexperienced young workers is a perfect substitute to the labor of older experienced workers. Finally, the "No Borrowing Constraint" economy uses the previous economy as a starting point and eliminates the ad-hoc constraint, so that young households can borrow within an environment without differences in labour demand and supply. In this economy, the only form of credit market imperfections is given by the incomplete asset markets. Table 4 reports the age sensitivity of the local fiscal multipliers in all these specifications.

Table 4: Age Sensitivity of Local Output Fiscal Multiplier - Channels

	Data	Baseline	Constant Labor Supply Elasticity	No Capital Experience Complementarity	No Borrowing Constraint
Δ Local Output Fiscal Multiplier of 1% Increase in Share Young People	3.1%	2.7%	2.5%	1.6%	0.8%

This table reports the results of the age sensitivity of local output fiscal multiplier in the data, in the "Baseline" mode, and in a series counterfactual economies, which sequentially eliminates mechanisms of the "Baseline" model. The "Constant Labor Supply Elasticity" economy eliminates the variation in the elasticity of labor supply across age groups, the "No Capital Experience Complementarity" eliminates the differences in the complementarity of young and older labor with respect to capital, and considers a standard Cobb-Douglas production function in labor and capital, and the "No Borrowing Constraint" economy eliminates the ad-hoc borrowing constraint on household' bond-holdings.

The age-specific components that generate a differential response of labor across age groups account overall for 40% of the link between demographics and local multipliers, as the age sensitivity in the economy with a constant labor supply elasticity across age groups and no capital-experience complementarity drops from 2.7% to 1.6%. To validate this implication, in Section A.7 of the Online Appendix we use CPS data to derive measures of labor earnings, hours worked, and hourly wages for young workers and older workers (i.e., any worker above 30 years old). Then, we estimate the local multiplier for each of these labor market variables, and find that the labor earnings, hours, and hourly wages of young workers react relatively more following a government spending shock. These results are consistent with the empirical evidence at the national level on the labor market response to tax shocks reported in Ferraro and Fiori (2020), and more generally in line with the evidence on the relatively higher volatility of labor market outcomes of young workers over the business cycle (e.g., Ríos-Rull, 1996; Jaimovich and Siu, 2009).

Importantly, we can disentangle the role of labor supply and labor demand, and isolate in which side of the labor market the age-differences matter more in explaining the age sensitivity of local multipliers. We find that age-specific differences in labor demand account for 33% of the link between demographics and local multipliers, whereas labor supply motives account for only 7% of the age sensitivity. This result is consistent with the findings of Jaimovich et al. (2013), who point out that the age-specific differences in labor supply cannot simultaneously account for the high volatility of hours and wages of young workers, whereas the age-specific differences in labor demand can.

Credit market imperfections account for 60% of the age sensitivity of the local multipliers. The relevance of the ad-hoc borrowing constraint and the role of incomplete credit markets in this sensitivity is roughly the same. Indeed, when we eliminate the ad-hoc constraint, the age sensitivity drops from 1.6% to 0.8%. The relevance of credit market imperfections holds even in a version of the model in which the young is divided in two groups, one facing a borrowing constraint on bond-holdings and the other one that can freely borrow. When we calibrate the share of borrowing constrained young individuals to 40%, which is the fraction of hand-to-mouth households aged between 20 and 29 in the U.S. as computed by Kaplan et al. (2014), then the age sensitivity equals 1.1%.

Although these findings confirm the key role of the fraction of hand-to-mouth households to understand the effectiveness of fiscal policy discussed by Galí et al. (2007) and Kaplan and Violante (2014), they highlight that even in the absence of the ad-hoc borrowing constraint, the lack of complete markets in a life-cycle setting can still generate local multipliers that depend on the age structure of the population. The relevance of credit market imperfections is also consistent with the findings of Demyanyk et al. (2019), who document that the level of local multipliers depend on households' debt positions and marginal propensities to consume.

The relevance of incomplete markets - above and beyond the fraction of borrowing constrained agents - for the size of fiscal multipliers is also highlighted by Brinca et al. (2016) and Ferriere and Navarro (2017). In these papers, markets are incomplete because the idiosyncratic labor income risk is uninsurable and there is no state-contingent bonds. In our environment the lack of complete markets is also rooted in the overlapping generations structure of the model. In equilibrium, given the interest rate and the amount of bonds traded, young agents cannot borrow sufficiently to smooth consumption in the face of a hump-shaped

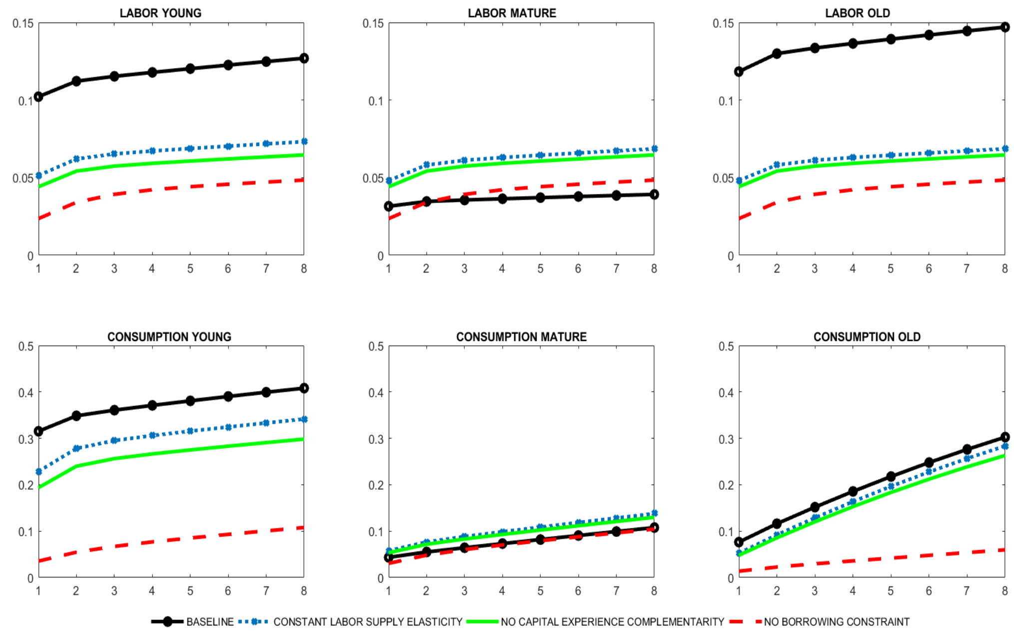

Figure 1: Consumption and labor cumulative responses by age groups.
The figure plots the cumulative responses of individual labor (upper panel) and consumption (lower panel) by age groups over eight quarters after the realization of the government spending shock. In each plot we report the cumulative responses under four different scenarios. The squared line corresponds to the "Baseline" economy. The crossed line corresponds to the "Constant Labor Supply Elasticity" economy. The continuous line corresponds to the "No Capital Experience Complementarity" economy. The dashed line corresponds to the "No Borrowing Constraint" economy.

labor income dynamics over the life-cycle.[29] As a result, the marginal propensity to consume of young households is above the one of mature households, as it is in the data. Hence, an economy with relatively more young households features a stronger demand channel.

To shed further light on the contribution of each age group on the age-sensitivity of local fiscal multipliers, we report in Figure 1 the individual cumulative labor and consumption responses across the three different age groups in the baseline model and in all the counterfactual economies.

The figure shows that following a government spending shock the responses of young and old households labor are on impact four times larger than the response of labor of mature households. These dynamics are driven by both the age-specific labor supply elasticities and the capital-experience complementarity. Since we consider a utility function with no wealth effect on labor supply, the absence of these two features makes the responses of labor across age groups to

[29]The inability to trade bonds/write contracts with the agents that are unborn prevents the (current) young agents from accessing additional asset markets to perfectly smooth consumption.

coincide, as in the case of the labor responses of the "No Capital Experience Complementarity" economy.

Not only the response of labor, but also the one of consumption displays sizable differences across age groups. Although consumption always rise following a government spending shock due to the complementarity between consumption and leisure in the utility function, the response of the young households is the largest one, even in the case we consider an economy without age-specific differences in labor supply and demand, and also without the ad-hoc borrowing constraint. The rationale of this finding is twofold. First, although old households have a high marginal propensity to consume, they account for a low fraction of the labor force, and therefore they experience a mild positive income effect, which then translates into a relatively low consumption response.[30] Second, young households have a higher marginal propensity to consume than mature workers, which is consistent with the evidence of the literature on the response of age-group consumption to tax changes. Although Johnson et al. (2006), Agarwal et al. (2007), Anderson et al. (2016) use different approaches to identify the consumption response to tax shocks, they all conclude that young households display a much larger consumption response than prime-age individuals.

4.3 Population Aging and National Fiscal Multipliers

Since our theoretical model accounts for general equilibrium forces and is also consistent with the empirical evidence on local multipliers, it represents an ideal laboratory to study how demographics shape the size of national government spending multipliers. This section employs the model to bridge the evidence on local multipliers with the analysis on national multipliers, and evaluate whether the link between demographics and multipliers persist also at the national level. Then, we use the model to look at the implications of the progressive aging of the U.S. population on the evolution of national fiscal multipliers over the recent decades.

To do so, we estimate national multipliers in the following exercise. We consider a symmetric increase in government spending in both the home and the foreign economy. Similarly to our definition of national output Y_t^U, we define national government spending as sum of government spending in the home economy and government spending in the foreign economy, that is, $G_t^u = G_{H,t} + G_{F,t}$. Hence, now we consider an increase in national (wasteful) government spending which is financed by all the individuals in the monetary union. We estimate the national output multiplier β_N as

$$\frac{Y_t^u - Y_{t-2}^u}{Y_{t-2}^u} = \beta_N \frac{G_t^u - G_{t-2}^u}{Y_{t-2}} + \epsilon_t.$$

[30]The dynamics of the response of consumption over the life-cycle is due to the fact that the response of income of old workers in absolute per capita terms is a fourth of the similar change in income associated to young workers.

Table 5: National Fiscal Multipliers

	Output	Consumption	Investment	Employment
Avg. National Fiscal Multiplier	0.82	0.61	-0.79	1.32
Δ National Fiscal Multiplier of 1% Increase in Share Young People	1.1%	1.8%	0.2%	1.0%

This table reports the results of the estimation of the national fiscal multipliers in the model. We consider the two-year output fiscal multiplier, the two-year output consumption fiscal multiplier, the two-year investment fiscal multiplier, and the two-year employment fiscal multiplier. The first row reports the estimated value of the national fiscal multipliers. The second row computes the age sensitivity of national fiscal multipliers.

Again, we proceed in two steps. First, we estimate β_N by running the regression on the simulated data from the model which is calibrated to the average population shares observed in the U.S. between 1967 and 2015. Then, we change the age structure of the economy by increasing the share of young people in the overall union by 1% and estimate again β_N. The difference between the estimates of the second and the first step yields the age sensitivity of national output fiscal multipliers. Following the same procedure, we also estimate the age sensitivity of the national consumption, investment, and employment fiscal multiplier.

Table 5 reports the results of this exercise. In the model the national output fiscal multiplier associated with the average population shares observed over the recent decades is 0.82, and a 1% increase in the share of young people raises the multiplier by 1.1%.[31] A similar change in the age structure of the population raises also the consumption multiplier by 1.8% and the employment multiplier by 1%. Instead, the investment multiplier barely changes following an increase in the share of young people.

Although the age sensitivity is lower than for the case of local multipliers, it is still highly economically significant: changes in the age structure of an economy affect fiscal multipliers also at the national level. In Section B of the Online Appendix we validate the prediction of the model on the link between demographics and national fiscal multipliers. We estimate a SVAR on both a panel of developed countries and a panel of developing countries and identify government spending shock with a Choleski ordering à la Blanchard and Perotti (2002). In

[31]Nakamura and Steinsson (2014a) show that the mapping from local multipliers to national multiplier depend crucially on the monetary policy stance. Yet, although different monetary policy rules affect substantially the level of the national multiplier, they barely change its age sensitivity. For instance, if we consider a hawkish monetary policy and increase the parameter that in the Taylor rule controls the response of the nominal interest rate to changes in inflation, ψ_π, from 1.5 to 5, then the output national multiplier drops to 0.2, whereas the age sensitivity keeps being 1.1%. Hence, all the results that follow should be interpreted more in terms of the sensitivity of the national fiscal multiplier to changes in the age structure of the population, rather than looking at the level of multipliers per se.

either case, we show that the long-run national output fiscal multiplier is indeed larger in countries with higher shares of young people in total population.

Since the model predicts that also national fiscal multipliers depend on the age structure of the population, we can now evaluate how the effectiveness of government spending has been shaped by the dramatic changes in the demographic structure of the U.S. population over the recent decades. Indeed, the onset of the baby boomers raised the share of young people by 22% between 1967 and 1980. From 1980 to 2015, the U.S. population has progressively shifted towards older ages, with the share of young people shrinking by 30%.

We measure the implications of the U.S. population aging on the effects of government spending by feeding the model with the entire path of population shares observed from 1967 until 2015, and then compute national fiscal multipliers through the lenses of the model. This exercise has to be evaluated with an important caveat. In this exercise, we only change the age structure of the model to isolate the role of the demographic transition on the size of fiscal multipliers. All the other features of the model are kept constant, e.g., the monetary policy stance and the degree of credit market imperfections. Although in our model changes in the demographic structure generate endogenous variation in the degree of credit market imperfections, we acknowledge that this pattern captures only a fraction of process of financial development of U.S. credit markets.

Figure 2 shows the results of this exercise for the output fiscal multiplier. The output fiscal multiplier was 0.87 in 1970 and increased up to 1.04 in 1980, when the effect of the baby boom on the share of young people was the greatest. As the share of young people progressively shrinks, the multiplier starts decreasing, drops below 1 in 1985, and reaches a value of 0.65 in 2015. Hence, the model predicts that over the last forty years the size of the output fiscal multipliers went down by 38%.

These results are consistent with the evidence of Blanchard and Perotti (2002) on the reduction of the size of U.S. fiscal multipliers over time. These papers show that fiscal multipliers in the recent decades are smaller than what they used to be during the 1960s and 1970s. Our model provides a rationale of this empirical finding, by linking the aging of the U.S. population to the observed reduction in the effectiveness of fiscal policy.

Although over the recent decades the age structure of the U.S. population has already experienced a remarkable shift towards older ages, the population aging is not expected to decelerate. The United Nations project that by 2100 the share of old people will be around 30% and the share of young people will drop a further 26% from 2015 to 2100. To assess the implications of these changes, we feed our model with the projected shares of young, mature, and old people in the U.S. population in 2100, and compute the output fiscal multiplier. The model predicts that in 2100 the output fiscal multiplier will equal 0.55. Hence, in 2100 the output fiscal multiplier will be 48% lower than in 1980, and 15% lower than in 2015.

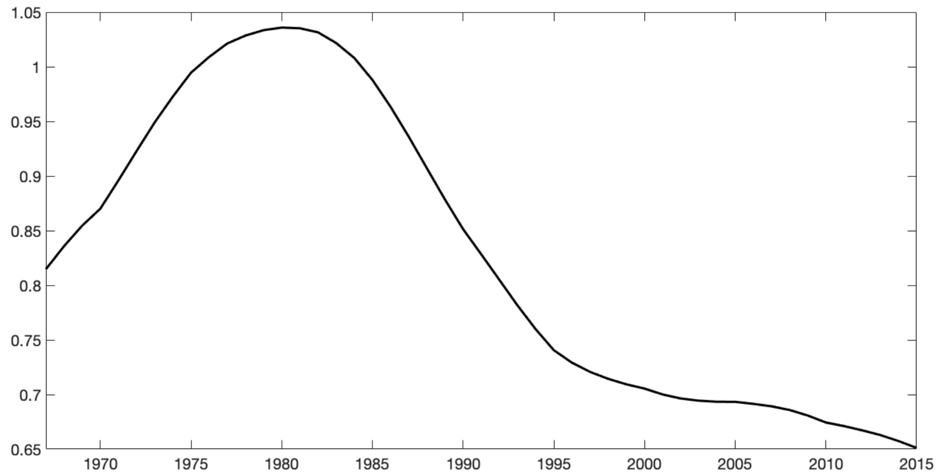

Figure 2: Fiscal multipliers from 1967 until 2015.
This graph reports the two-year national output fiscal multipliers in a sequence of versions of the baseline model, which are calibrated to the changes in the population shares observed in the U.S. from 1967 to 2015.

5 Conclusion

The output effects of government consumption spending depend on the age structure of the population, such that fiscal multipliers are larger in economies with higher shares of young people in total population. Our model predicts that in U.S. over the future decades fiscal policy would become a relatively less effective tool for spurring economy activity. Since most economies are experiencing a similar process of population aging, our results suggest that the reduction in the effectiveness of fiscal policy is a global phenomenon. This result has to be interpreted with two caveats. First, our analysis refers to the effectiveness of fiscal policy in normal times, abstracting from cases in which there is slack in the economy or the stance of monetary policy changes. Second, although fiscal policy - intended in the classical form of purchasing goods from the private sector - becomes less effective in spurring economic activity due to population aging, fiscal interventions targeted to specific age groups could be still highly expansionary. To this end, a new class of model as ours could be used as a laboratory to design and evaluate the effects of such policies.

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