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The Age For Austerity? Population Age Structure and Fiscal Multipliers

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Abstract

Advanced economies face two important trends: population aging and rising debt. In the coming years it will be critical to understand how policies undertaken by governments interact with their changing age structures. In a panel of advanced economies, I show that fiscal deficit consolidation multipliers are highly sensitive to changes in demographics. Broadly speaking, these relationships suggest that population age structure may have exerted negative pressure on fiscal multipliers over the period from the 1980s to the mid 2000s. Projecting forward, this effect is less clear. Simple, one variable, controls for population age suggest that multipliers estimated from spending cuts may grow again as countries move from middle to old-aged. However, these are weakly estimated for tax increases. Controlling for movements across the entire age distribution suggests that tax shocks may have stronger state dependence, with mixed implications over the sample period, but uniform pressure on these multipliers toward zero as economies continue to age. These findings give hope that the age for austerity may arrive just in time to deal with looming debts, and suggest that more work to understand the mechanisms behind this relationship will be valuable.

JEL classification codes: E62, H24, H30, H31, J11

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1. Introduction

Advanced economies are getting old. Aging boomers, rising life expectancy, and falling fertility work together to bring an unprecedented change in the population age structures of advanced economies. Just as these demographic tides are rising, policy response the global financial crisis and Covid-19 have seen government debts soar. In this environment it will be critical to understand how government multipliers evolve as economies undergo such a transition. I study the interaction between population age and narratively identified fiscal consolidation shocks in a panel of advanced economies. To do this, I implement a recently proposed Blinder-Oaxaca[1] (BO) decomposition of state dependent effects of fiscal shocks using local projections. This provides a flexible environment to investigate the relationship between aging and fiscal multipliers. I find that these multipliers are highly sensitive to demographic changes. Additionally, demographics seem important not only for the pass through of fiscal shocks to output, but also for their effectiveness at changing government deficits. I show that accounting for these changes has potentially large implications for the size of multipliers, when constructed as the ratio of cumulative change in output relative to deficits.

Why should population age structure be important for fiscal multipliers? Recent work shows that age very plausibly correlates with marginal propensity to consume (MPC), which in turn is important for determining the size of these multipliers. Using Norwegian lottery data Fagereng, Holm, and Natvik (2019) find a negative relationship between MPC and age. Similar negative age relationships arise in Italian data studied by Jappelli and Pistaferri (2014), who find relatively constant MPCs throughout working life, declining in retirement. They show that MPC has a strong negative correlation with cash-on-hand wealth, which can explain a great deal of the observed heterogeneity. Heterogeneous agent life-cycle models generate large changes in cash-on-hand wealth as households age, particularly as they move toward retirement, perhaps motivating a theoretical channel that may link aging to multipliers. Brinca, Holter, Krusell, and Malafry (2016) show that the size of fiscal multipliers in an OLG economy are highly sensitive to the amount of individuals facing liquidity constraints. Other work on aging by Wong (2019) studies the efficacy of monetary policy, showing that younger households more likely face binding borrowing constraints, and respond more to changes in interest rates as a result. This makes monetary policy less effective as populations age. Similar channels are likely possible in the context of household response to fiscal shocks, but this particular mechanism is underexplored in the literature. Basso and Rachedi (2021) study aging and fiscal policy directly and show that

[1]Proposed in the context of macroeconomic impulse response functions by Cloyne, Jordà, and Taylor (2020) using well established methods in the micro literature by Blinder (1973) and Oaxaca (1973).

labor supply differences between broad age groups can account for much of the variation they detect in local fiscal multipliers for the United States.

A large literature emphasizes the state dependence of fiscal multipliers. There is evidence that economies are significantly more responsive to government spending and taxation in recessions than in expansions. While this idea goes back to Keynes, work such as Auerbach and Gorodnichenko (2012)[2] bring it empirical rigor. Ilzetzki, Mendoza, and Végh (2013) show a number of dimensions by which fiscal multipliers are dependent on country characteristics. Of particular relevance to this paper is a phenomenon documented by Perotti (2005), who shows that the effects of fiscal transmission appear to be lower since 1980. A number of potential sources of this structural break have been proposed: changes in monetary policy regimes, changes to the fiscal shocks themselves, and changes in private consumption/savings behavior. Bilbiie, Meier, and Müller (2008) study these mechanisms; they find evidence for all three channels, but suggest that changes in monetary accommodation are likely the most powerful force. Indeed, Cloyne et al. (2020) show that there is strong interaction between narrative fiscal shocks and monetary policy accommodation, using the roughly same data and methodology that I employ here.

I suggest that demographic structure should be added to the list. Monetary accommodation may itself be a channel for aging if demographics are linked with monetary policy effectiveness as in Wong (2019), or if aging shifts equilibrium interest rates, as many[3] have shown. In addition, Bilbiie et al. (2008) suggest that asset participation is quantitatively important, and may alter both the shape and persistence of fiscal transmission. While other factors, such as financial liberalization, may have structurally changed participation, life-cycle profiles in asset demand and participation rates may also play a role.

A small number of recent papers have studied the effects of aging on multipliers directly. Basso and Rachedi (2021) estimate these effects in the context of the United States, making use of the local fiscal shocks of Nakamura and Steinsson (2014). Empirically, they find that young working age individuals increase the size of fiscal spending stimulus. They show in an overlapping generations model that much of the effect can be explained by differential labor adjustment, with young workers having much higher labor supply elasticity. Recent work by Ferraro and Fiori (2020) use narrative tax shocks in the United States to understand differential employment response across the age distribution. The labor response of the young to is almost twice as large as that of older workers, opening a potentially large channel for age to alter the efficacy of policy. Heer and Scharrer (2018) show that the

[2]A large body of work has found evidence in line with this result. See, for example: Jordà and Taylor (2016) and Ramey and Zubairy (2018).

[3]See, for example: Gagnon, Johannsen, and Lopez-Salido (2016) or Eggertsson, Mehrotra, and Robbins (2019)

method of financing fiscal projects interacts with the age distribution, putting a large burden on younger generations when fiscal spending or tax cuts are debt financed.

Most similar to this paper are Honda and Miyamoto (2021) and Miyamoto and Yoshino (2020). They pose a similar question with different identification of fiscal shocks, using the forecast error method of Auerbach and Gorodnichenko (2012), as well as different methods of controlling for population age, with a singular focus on old age dependency ratios. They show that high old age dependency ratios shrink fiscal spending shocks. Moreover, their findings suggest that this relationship is particularly strong during recessions, but not detectable during economic booms. I contribute to their results along a number of dimensions. First my fiscal shocks are narratively identified consolidation shocks, rather than forecast error estimates of fiscal stimulus. I also consider more flexible ways of measuring population changes, allowing that other long run changes in population age structure may be important for fiscal transmission. I will show, consistent with their work, that aging appears to have diminished fiscal shocks. However, my findings also suggest that other age groups (in addition to retirees) may be important for this relationship. Broadly my estimates will suggest a similar result: that aging appears to have had a negative impact on multipliers from 1980 to present. I find that for taxation this effect may continue as populations continue to age, while multipliers on spending cuts may actually grow.

In section 2, I describe the data and estimating equations. In section 3, I present results with two separate demographic controls: the working age population, and a polynomial fit of the entire age distribution. I explore potential channels for demographic pass through to fiscal shocks in section 4, and section 5 concludes.

2. Data and Methods

I use narrative fiscal consolidation shocks from Guajardo, Leigh, and Pescatori (2014), who identify changes in fiscal policy through the study of historical documents in a panel of 17 OECD countries. From the historical record, they establish whether changes in discretionary tax and spending measures are motivated by a response to current economic conditions and forecasts. Unlike similar narrative instruments such as Romer and Romer (2010), who identify shocks that are motivated either to boost long run growth or to address government deficits, Guajardo et al. (2014) shocks focus specifically on policy changes that are motivated to reduce the budget deficit. I will make use of their total consolidation measure, which contains both tax and spending measures, as well as estimates that consider these tax and spending changes separately. All fiscal consolidation shocks are scaled as a percentage of GDP. To provide a rich set of macroeconomic controls, I merge these data with the macrohistory database of Jordà, Schularick, and Taylor (2017). This contains a large number of macroeconomic aggregates I use as controls, and since the additions from Jordà, Knoll, Kuvshinov, Schularick, and Taylor (2019) also contain returns data. Population age structure comes from the Human Mortality Database (2020). I use their population tables by age to generate shares of population across the entire age distribution for each country. From these I will construct my main demographic controls, which I describe in detail below.

The resulting data is a balanced panel of 16 countries from 1978 to 2009. All regressions reported in this paper will be estimated from the 25 year range: 1982 to 2006. This is in part due to the lag structure of my estimating equation, but also to ensure that all local projections (which use forward outcome variables) are estimated on the same sample. While there is not a large difference in estimations if these later years are included, I wish to avoid estimating responses to shocks where some horizons contain the global financial crisis in their estimation, while others do not.

I estimate impulse response functions (IRFs) empirically using the local projection (LP) method of Jordà (2005). To estimate state dependent LPs, I use the Blinder-Oaxaca decomposition proposed in Cloyne et al. (2020). Unlike many previous studies who use split samples to estimate state dependence, this allows for estimation of state dependent effects in an LP framework directly. While this is useful for a number of reasons, one in particular is that continuous controls can be interacted with shocks. The key difference from a standard LP equation is that controls are demeaned, and a set of interactions between treatment variables (here the fiscal shock) and all controls are included. Demeaning allows interpretation of interactions as deviations around a fiscal effect, whose direct coefficient is the average across all states, and comparable to average treatment effects estimated in studies of the shock without state dependent effects. Interaction terms then provide estimates of state dependence. Equation 1 is my estimating equation for the IRFs using this BO decomposition. For exposition, I have split out the demographic controls from the vector of additional controls, $x_{i,t}$, though they are treated identically.

$$\begin{aligned} y_{i,t+h} - y_{i,t-1} = & f_{i,t}\beta^h + (x_{i,t} - \bar{x})\gamma^h + f_{i,t}(x_{i,t} - \bar{x})\theta_x^h \\ & + \left(D_{i,t} - \bar{D}\right)\gamma_D^h + f_{i,t}\left(D_{i,t} - \bar{D}\right)\theta_D^h + \mu_i^h + \mu_t^h + \epsilon_{i,t+h}\ ; \quad \textit{for } h = 0, \ldots, H \end{aligned} \tag{1}$$

In Equation 1, $y_{i,t+h} - y_{i,t-1}$ is the h horizon cumulative change in an outcome variable, y, in country i at time t. The two outcomes I will use calculate fiscal multipliers are the cumulative change in output and government deficits to GDP. The policy shock, $f_{i,t}$ is a fiscal consolidation shock from Guajardo et al. (2014). I will consider the effect of total shocks as well as those for tax increases and spending cuts separately. For all specifications, I include a vector of controls, $x_{i,t}$, which includes two lags of the dependent variable and contemporaneous values plus two lags of: the deficit to GDP ratio, log change in the cpi, log change in real consumption, and change in short term interest rates. Across specifications I will use the same set of $x_{i,t}$ controls.

I interpret β^h as the *direct effect* of the policy shock, which is the average effect across all states in the estimation. Each control has a *compositional effect* estimated by γ^h and an *indirect effect* estimated through θ^h. The compositional effect reflects any change in the outcome due to changes in the underlying control set. For example, demographics may have some effect on growth that is unrelated to changes in fiscal shocks. These are estimated through γ^h. My primary object of interest is estimation of θ^h_D, the indirect effect of the fiscal shock dependent on demographic factors.

I consider two methods to control for population age structure. The first is working age population (WAP), defined as the share of the population aged 20-65. This method has the advantage of being simple and easy to interpret. Retirement is likely an important cutoff and this control will capture effects around it. I also wish to have a more flexible approach to population age shares, and thus also divide the population in to J five-year age groups and construct a set of demographic controls using the method proposed in Fair and Dominguez (1991). The idea is to construct a finite set of controls that fit coefficients for the entire age distribution with a K^{th} order polynomial as: $\alpha_j = \sum_k^K \gamma_k j^k$. I construct the following demographic controls:

$$D_{k,i,t} = \left[\sum_j^J (p_{j,i,t} - \bar{p}_t) j^k \right] \tag{2}$$

Where $p_{j,i,t}$ is the share of population in age group j, for country i in time t. As with my other controls these are demeaned to interpret my BO decomposition as described above. I show how these are derived in Appendix A, and that their estimated coefficients in Equation 1 are the γ_k terms of the polynomial for the j specific age effects. I use 15 age groups covering the population share younger than 10 years old, older than 75, and five year intervals between. I set $K = 3$ so that the age specific effects are fitted by a third order polynomial. All population shares are constructed using Human Mortality Database (2020) data on population by age for both sexes.

To get estimates of fiscal multipliers, I not only estimate the change in output in response to a fiscal shock, but also the corresponding change in government deficit. I estimate impulse responses of the cumulative change in both output and government deficits, calculating the multiplier as the ratio of these two changes as in Cloyne et al. (2020). This follows work such as Uhlig (2010), who suggests that multipliers should be the cumulative net-present value ratio of these terms. Ramey (2016) discusses that taking the ratio of these estimated effects is equivalent to the 2SLS method used in Guajardo et al. (2014), where these narrative shocks are used as instruments for change in the cyclically adjusted primary balance. One contribution of my paper is to show that this is not a trivial step in the context of population aging. In some specifications the state dependence of changes in deficits with respect to population age structure will strongly statistically significant, and have quantitatively important effects on the size of multipliers.

I note that the BO methodology used here is not a cure for issues of identification. While the fiscal shock has some claim of exogeneity, underlying demographics do not. In principle, one would need to have an identification strategy for both the fiscal shock as well as for all of the controls to understand the causal effect of indirect transmission of these shocks. This is because any endogeneity that works through these interactive terms could be a threat to causal inference. I caution that lack of strong causal identification should be kept in mind with the results that follow. Nonetheless, the strength and quantitative importance of these empirical relationships are compelling, and should motivate future research into understanding the mechanisms behind them.

3. Population Age Structure and Fiscal Shocks

I now present results from estimating Equation 1 for both demographic specifications. For each fiscal shock, I estimate the impulse response of output and government deficits at four year horizons. I will first consider a simple control for population age structure, using just the working age share of population. If the channel for aging is strictly along a worker/non-worker dimension, it is possible that these estimates will better fit the data than those using the entire age distribution, as the latter will have a harder time capturing a discrete change from one age to the next. As I will show below, when using spending shocks WAP appears to function better, while demographic interactions with tax shocks appear to have important cross-worker variation and are better estimated by my Fair and Dominguez (1991) style controls.

3.1. Fiscal Multipliers and the Working Age Population

I begin by studying interactions between fiscal shocks and the WAP, allowing that the relationship between dependents and those in the workforce may be an important cutoff with respect to how population age structure affects fiscal shocks. These results are reported in Table 1, which contains three separate impulse response functions for each of the two outcomes of interest (output and deficits). These are estimates of IRFs for three fiscal shocks:

total fiscal consolidation, tax hikes, and spending cuts. Total consolidations are simply the combination of spending and tax shocks estimated together. I include the composition effects of the working age population on outcomes directly, as well as their indirect effects coming through the fiscal shocks.

In Table 1, I find direct effects of total consolidations that are largely in line with other research that has used the Guajardo et al. (2014) narrative shocks. The cumulative response of change in log output is quite close to -1, suggesting that a 1% consolidation will reduce output by 1%. The corresponding change in government deficits is close to, but less than one. Multipliers are the ratio between these estimated cumulative changes. Scaling the output effect by the implied change in fiscal deficits is important if the policies do not lead to a one-to-one change in deficits. Here policies were identified as specifically motivated to reduce these deficits, so any variability in their ability to do so is itself a result worth understanding. The average multiplier for a the total consolidations at the four year horizons is 1.26. Splitting these shocks between tax increases and spending cuts, I find that these effects are much larger for tax shocks, with a four year cumulative multiplier of 1.81, and lower (0.39), but insignificant multiplier on spending consolidations. The relative difference between these effects are qualitatively consistent with Guajardo et al. (2014), though both of my responses are smaller than theirs.[4]

The indirect effects of working age population on output through fiscal shocks are strikingly similar across all three specifications in Table 1, though they marginally fail significance tests for the response of output to tax shocks, with a p-value of 0.110. Their positive signs suggest that increasing working age population weakens the effects of fiscal consolidation. One interpretation of this result could be that old and young dependents have relatively inelastic consumption, making their spending (or that of those who support them) less responsive to changes in policy. These dependents may also be much less exposed to these shocks, with income tax shocks falling predominantly on workering age individuals. Of course spending consolidations likely affect both groups, and income tax changes may affect workers based on the dependents they support. These values are large relative to the direct impact of shock itself. For example, a one standard deviation change in WAP (almost 2 percentage points) changes the sign of the response to output for the total consolidation shock.

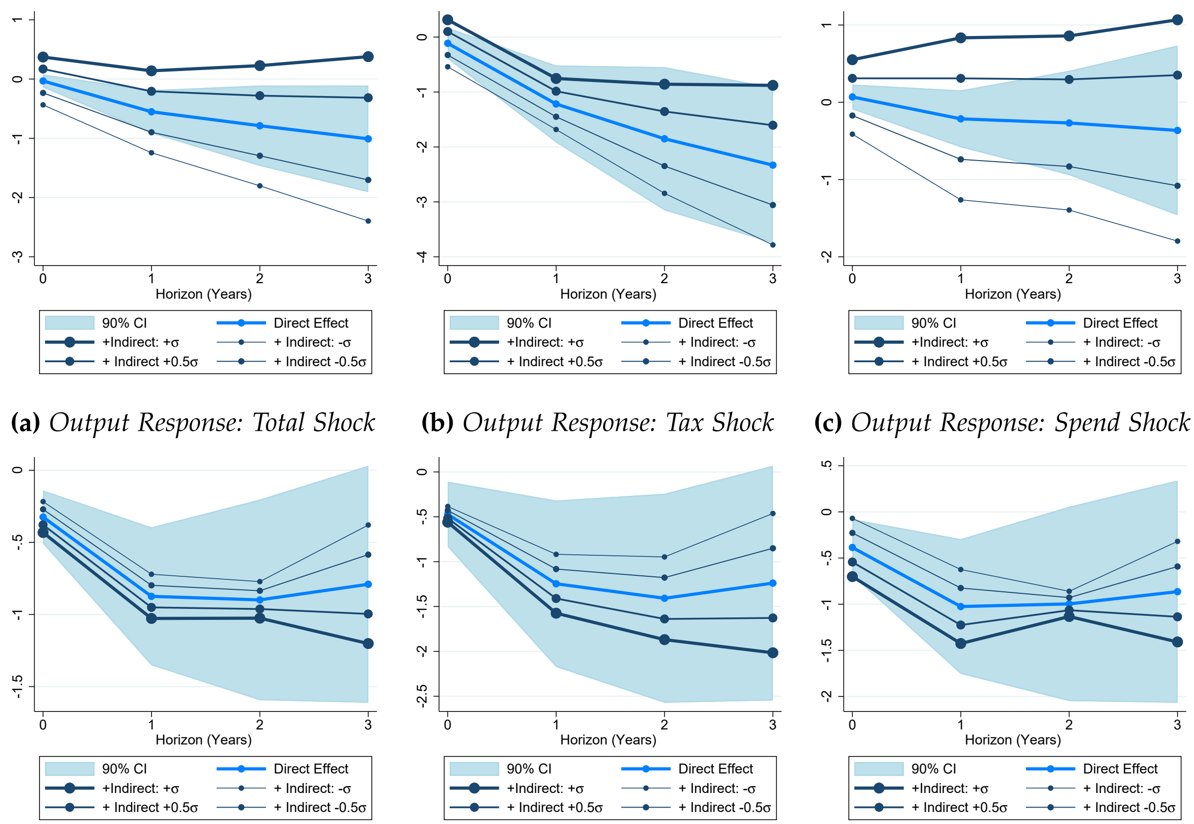
[4]Using a similar specification to theirs by removing interaction terms and working age population brings my estimates closely in line with those in their paper.

Table 1: *Output and Deficit Response : Working Age Population*

	Cumulative IRF: Output				Cumulative IRF: Deficit			
Horizon	0	1	2	3	0	1	2	3
Total	-0.03	-0.55**	-0.79*	-1.01*	-0.33***	-0.88***	-0.91**	-0.80
	(0.06)	(0.21)	(0.39)	(0.51)	(0.11)	(0.28)	(0.40)	(0.47)
WAP	-0.10**	-0.07	-0.19	-0.39	0.18***	0.22**	0.29*	0.45*
	(0.04)	(0.18)	(0.34)	(0.48)	(0.06)	(0.10)	(0.14)	(0.23)
Total× WAP	0.20***	0.35*	0.51*	0.70*	-0.05	-0.07	-0.06	-0.20
	(0.07)	(0.17)	(0.25)	(0.34)	(0.09)	(0.13)	(0.15)	(0.19)
X_i,t	✓	✓	✓	✓	✓	✓	✓	✓
TimeFE	✓	✓	✓	✓	✓	✓	✓	✓
CountryFE	✓	✓	✓	✓	✓	✓	✓	✓
R2	0.82	0.67	0.56	0.52	0.41	0.55	0.59	0.61
N	400	400	400	400	400	400	400	400
Tax	-0.11	-1.22***	-1.84**	-2.31**	-0.48**	-1.27**	-1.43*	-1.28
	(0.16)	(0.41)	(0.75)	(0.81)	(0.22)	(0.54)	(0.68)	(0.79)
WAP	-0.05	0.02	-0.08	-0.25	0.16***	0.21*	0.29*	0.42*
	(0.04)	(0.16)	(0.30)	(0.44)	(0.05)	(0.10)	(0.15)	(0.23)
Tax× WAP	0.21**	0.23	0.50	0.73	-0.03	-0.14	-0.22	-0.36**
	(0.07)	(0.19)	(0.31)	(0.43)	(0.07)	(0.13)	(0.14)	(0.16)
X_i,t	✓	✓	✓	✓	✓	✓	✓	✓
TimeFE	✓	✓	✓	✓	✓	✓	✓	✓
CountryFE	✓	✓	✓	✓	✓	✓	✓	✓
R2	0.82	0.67	0.56	0.53	0.41	0.54	0.58	0.61
N	400	400	400	400	400	400	400	400
Spend	0.07	-0.22	-0.27	-0.36	-0.41**	-1.07**	-1.03	-0.94
	(0.09)	(0.21)	(0.39)	(0.63)	(0.18)	(0.41)	(0.60)	(0.70)
WAP	-0.07	-0.06	-0.11	-0.28	0.20***	0.24**	0.29**	0.43*
	(0.05)	(0.17)	(0.32)	(0.44)	(0.06)	(0.09)	(0.12)	(0.20)
Spend× WAP	0.24***	0.52**	0.57*	0.72*	-0.14	-0.16	-0.04	-0.21
	(0.06)	(0.20)	(0.29)	(0.35)	(0.13)	(0.25)	(0.27)	(0.33)
X_i,t	✓	✓	✓	✓	✓	✓	✓	✓
TimeFE	✓	✓	✓	✓	✓	✓	✓	✓
CountryFE	✓	✓	✓	✓	✓	✓	✓	✓
R2	0.82	0.66	0.55	0.51	0.41	0.54	0.58	0.60
N	400	400	400	400	400	400	400	400

Table reports separate estimations for IRFs of three fiscal shocks on two outcomes. Standard errors in parenthesis and clustered at the country level. $*p < 0.10, **p < 0.05, ***p < 0.01$. $X_{i,t}$ includes two lags of the dependent variable as well as contemporaneous values and two lags of all controls and their interactions with policy shocks.

Figure 1: *BO Decomposition: Output and Deficit Shocks with Changing WAP*



(a) *Output Response: Total Shock* **(b)** *Output Response: Tax Shock* **(c)** *Output Response: Spend Shock*

(d) *Deficit Response: Total Shock* **(e)** *Deficit Response: Tax Shock* **(f)** *Deficit Response: Spend Shock*

Direct effect shows point estimates of average fiscal shock. Indirect effect reflects changes in the working age population.

Turning to the effect of demographics on deficits, the only significant interaction coefficient is for tax shocks at the full four year horizon. A negative sign suggests that increases in taxes will have a stronger effect on deficits when the working age population is high. This is an intuitive result considering that most tax burden falls on this part of the population. With more workers, a particular tax change will have larger impacts on fiscal deficits. This implies that a higher working age population shrinks tax multipliers in two ways: decreasing the pass through to output and increasing the response of the deficit. One distinct advantage of estimating state dependence in this way is that I can now show quantitatively, the conditional impulse response function when the age structure shifts. These impulse response functions are visualized in Figure 1, for all three shocks. Each plot also shows the conditional IRF when WAP is +/- one and one-half standard deviations around its sample mean.

What do these results mean for advanced economies? All countries in my sample have undergone some degree of population aging, with varying sized baby boomer cohorts moving through the population. These cohorts, along with other demographic forces are such that WAPs have only recently begun to fall for most of the countries in the sample, with flat or rising WAP over most of the period. Thus for most countries, these results imply stronger fiscal effects in the 1980s and early 1990s, with a weakening as WAP peaks sometime in the 2000s.[5] The boomer cohort began leaving the workforce in roughly 2010. Projecting forward to their continual exit, WAP will begin to fall dramatically, with little room for recovery as slower moving forces of longevity and fertility imply larger shares of retirees with relatively few workers supporting them. According to these estimates this would mean a rebounding of the fiscal multiplier as working age cohorts shrink relative to this old age group.

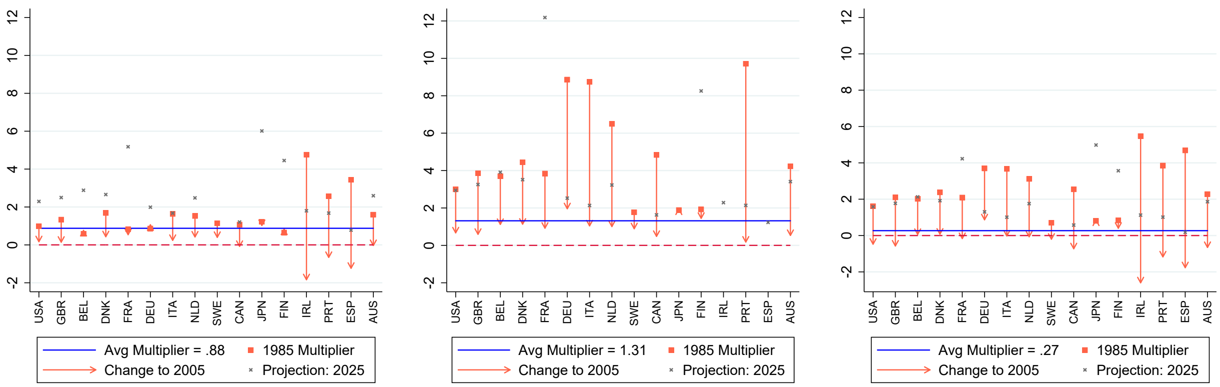
I visualize the quantitative size of state dependence on these multipliers for all of the countries in my sample in Figure 2. I report the multiplier for the three year ($h = 2$) horizon, as estimates for the shock's direct effect on government deficit become imprecisely measured at longer horizons. I choose two in-sample estimates near the start and end of my sample (1985 and 2005) as well as one out-of-sample prediction for changing demographics in 2025. Occasionally because the state dependent estimate for the change in fiscal deficit becomes close to zero, these point estimates become quite large and unstable. I omit any multipliers above 15 for clarity.[6] It is worth noting that the responses of each effect individually (ie: those in Figure 1) are by definition symmetric around the average effect. This may not be the case in the state dependent multipliers of Figure 2. For one, this is because I am plotting specific values from the data (rather than symmetric deviations). Additionally, the deficit and output effects need not work in the same direction.

The interpretation of state dependent effects across all three shocks in Figure 2 is clear. Over the period from the mid 1980s to early 2000s there was downward pressure on consolidation multipliers. However, unlike the predictions of Honda and Miyamoto (2021), these suggest that multipliers may be larger as economies continue to age. This may be due to differences in the shocks studied as they focus on fiscal stimulus, while I only study consolidations here. To understand if this is the case, I use a measure of old age dependency ratio equivalent to theirs, and repeat this exercise in Table 7 in Appendix D. In line with their results these specifications suggest that the old age dependency ratio should decrease the absolute value of output responses (positive interaction), while increasing the effect of shocks on deficits (negative). These effects are not as precisely estimated as those

[5]Some countries in this sample, notably Japan see a peak in WAP much closer to the start of the sample.

[6]The biggest culprit in this regard is Ireland, which saw a more than ten percentage point increase in their working age population. This is due to both higher fertility rates than most countries in the study, and a huge reversal from outward to inward migration over the Celtic tiger period.

Figure 2: *State Dependent Fiscal Multipliers at $h = 2$*



(a) *Total Shock* **(b)** *Tax Shock* **(c)** *Spend Shock*

Conditional multipliers calculated using demographic values in each country year for their effect on both output and deficits.

using WAP, but the difference in implications projecting forward is worth exploring further. I take the discrepancy as some evidence that more flexible estimators may be useful for identifying what parts of the age distribution are most important, as I will explore in the next section.

3.2. Fiscal Multipliers: Using the Full Age Distribution

The results above force demographics to operate along very narrow lines. Only differences that matter for young and old relative to working can create variation in the above estimates. Additionally, young and old dependents are forced to have symmetric effects. I now turn to a more flexible approach to controlling for the age distribution, to allow the data to speak for itself as to where important cutoffs lie. As outlined above this involves fitting population share coefficients across the entire age distribution using an approach pioneered in Fair and Dominguez (1991). I will report estimates for tax shocks here, reserving those from total and spending consolidation for Appendix B, as their state dependent effects are generally insignificant.[7] In Table 2, I show estimates for Equation 1 using the three Fair and Dominguez (1991) style demographic variables to control for population age structure.

[7] With the exception of one horizon for each outcome, no individual coefficient is significant. For a number they are jointly significant.

Table 2: *Output and Deficit Response to Tax Shocks: Full Age Distribution*

	Cumulative IRF, Output				Cumulative IRF, Deficit			
	0	1	2	3	0	1	2	3
Tax	-0.16	-1.60***	-2.53***	-3.04***	-0.33	-0.67*	-0.58	-0.25
	(0.15)	(0.48)	(0.77)	(0.84)	(0.22)	(0.38)	(0.45)	(0.58)
D1	-0.05	-0.11	-0.34	-0.53	0.23***	0.40***	0.62**	0.83**
	(0.05)	(0.13)	(0.23)	(0.33)	(0.07)	(0.13)	(0.23)	(0.31)
D2	0.09	0.23	0.61	0.88	-0.36**	-0.69**	-1.05**	-1.36**
	(0.09)	(0.25)	(0.42)	(0.61)	(0.13)	(0.24)	(0.42)	(0.57)
D3	-0.05	-0.12	-0.29	-0.42	0.14**	0.29**	0.44**	0.56**
	(0.04)	(0.12)	(0.20)	(0.29)	(0.06)	(0.11)	(0.19)	(0.26)
Tax× D1	0.05	0.60**	1.10**	1.18**	-0.02	-0.54**	-0.84***	-1.02***
	(0.13)	(0.27)	(0.46)	(0.52)	(0.11)	(0.25)	(0.28)	(0.34)
Tax× D2	-0.07	-1.04*	-1.86**	-1.94*	0.08	1.05**	1.55***	1.86***
	(0.24)	(0.51)	(0.85)	(0.98)	(0.20)	(0.40)	(0.47)	(0.58)
Tax× D3	0.03	0.48*	0.84*	0.86*	-0.05	-0.51**	-0.74***	-0.88***
	(0.11)	(0.25)	(0.40)	(0.47)	(0.09)	(0.18)	(0.22)	(0.27)
X_i,t	✓	✓	✓	✓	✓	✓	✓	✓
TimeFE	✓	✓	✓	✓	✓	✓	✓	✓
CountryFE	✓	✓	✓	✓	✓	✓	✓	✓
R2	0.82	0.68	0.59	0.56	0.42	0.56	0.62	0.64
N	400	400	400	400	400	400	400	400

Table reports estimations for IRFs of tax shocks on two outcomes. Standard errors in parenthesis and clustered at the country level. $*p < 0.10, **p < 0.05, ***p < 0.01$. $X_{i,t}$ includes two lags of the dependent variable as well as contemporaneous values and two lags of all controls and their interactions with policy shocks.

There are a few interesting changes relative to estimates of the tax shock using WAP. First is that the direct output response to the shock is about a third larger than in Table 1. Perhaps most notable is the response of the cumulative deficit. Where the prior specification saw large composition effects from demographics, but little evidence for indirect effects, here these interactions are substantial. Additionally, the direct effect of taxes on deficits moves in the expected direction in the first two years, but then starts to shrink. It appears that at longer horizons the indirect effects of taxes through demographics dominate. All three of these new controls are strongly significant for deficits, with indirect effects significant at all horizons greater than the initial year of the shock for both outcomes. This will clearly have large implications on multipliers, as the ratio of these two terms.

A drawback of this approach to controlling for age is that these coefficients are not easy to interpret themselves. Since they are weights on the polynomial fitting of the age distribution, this means that there is enough variation in effect across ages to justify all three terms. A third order polynomial allows for up to two turning points in the coefficients across ages, which will be easily seen below. The significance of these coefficients are much stronger than those when only WAP was used, suggesting that important variation was missed by the single control for demographics.

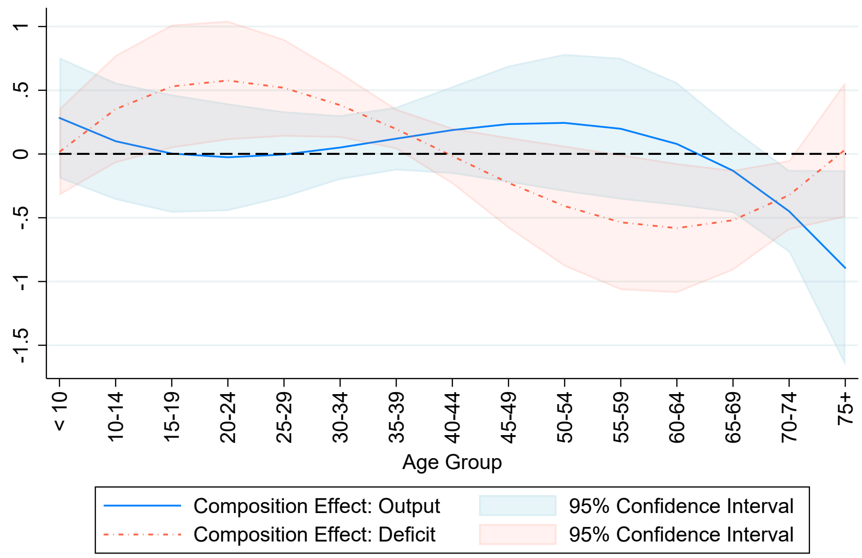
For IRFs using the total fiscal shock and spending cuts, WAP is significant while these population interactions are not. These are reported in Table 5 , in Appendix B. This is useful for understanding how tax increases may differ from spending cuts. Tax shocks may have important variation either across the life-cycle or between old and young dependents that weakened results in the WAP specification. Further, working age cutoffs may have been a useful distinction capturing some variation in the spending shock. The Fair and Dominguez (1991) controls can in principle replicate something like a working life cutoff, and I show in Appendix B that something resembling this is the case. However, the requirement of smooth transitions between age groups could weaken the model fit, if a sharp cutoff at particular ages is indeed the correct specification.

To better unpack this result, I now back out the age specific coefficients α_j using the estimates from Table 2. These are by assumption: $\alpha_j = \sum_{k=0}^{K} \gamma_k j^k$, where γ_k is given by the estimates of $\gamma_{k,D}^{h}$ from Equation 1. These are calculated with standard errors from the delta method using the coefficients in Table 2. These are the direct (compositional) effects of population aging, but the indirect effects are calculated in the same way using $\theta_{k,D}^{h}$, and scaled by a fixed value of the fiscal shock.

Figure 3 gives the five-year age specific values for the composition effect of aging for both the output and deficit responses to tax shocks, at a three year ($h = 2$) horizon. These are the estimated effect of demographics on output and deficits directly. While the coefficients on output in Table 2 are not individually significant, they are jointly significant, and it's clear that a few ages have estimates that are different from zero here. In particular, the estimated effect of retirees on growth is negative. Deficits have a positive estimated coefficient early in working life and negative later, with aging having quite a strong direct effect on deficits. I include these point estimates for context, and to help understand similar figures for indirect effects.

My key outcome of interest is the interaction between demographics and the fiscal tax shock. I report the estimates of their age specific coefficient for both output and deficits in Figure 4. These figures, unlike the composition effect are dependent on a particular value of the tax shock, as they are zero when the fiscal shock is not present. I report these for a 1 percent increase in tax relative to GDP. To help understand quantitatively what these figures mean, I also include the demeaned values of the population age shares in the United States

Figure 3: *Population Aging: Composition Effect at $h = 2$*

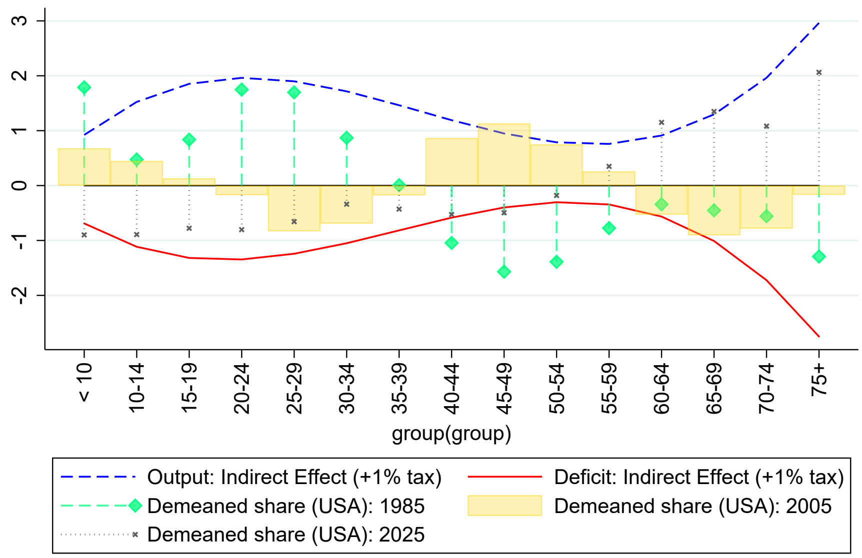


for the same years as the conditional IRFs above. Demeaned values of population shares always sum to zero, so while the output indirect effect coefficients are always positive (and deficit all negative), it does not mean that the demographic effect must itself be positive as it depends on where the negative/positive demographic weights fall.

To further build intuition for Figure 4, I calculate the state dependent contributions of population age structure to output and deficits for the United States, and their implied multipliers in Table 3. The demographic effect is simply the sum of interaction terms (θ_D) from Table 2 multiplied by the constructed demographic variables. This is by definition equal to the sum of all five year coefficients (α_j), graphed in Figure 4, times the corresponding demeaned five year population share. This table puts numbers to the story that one can tell from looking at the movement of age shares in Figure 4. In 1985 large population pressure in young working ages shrinks the absolute size of the output response, as this group has a relatively large, positive, indirect effect. The corresponding negative population weights are concentrated in late career, where this effect is at its lowest. This is offset slightly by a relatively small share of old age retirees. The net result is a positive, 1.84, contribution to the effect of the tax shock, making it much smaller in absolute value than its -2.53 average at this horizon. Meanwhile, this large share of young workers (and dependents) have a relatively large negative effect reinforcing the contraction of the deficit. These results together suggest that demographics decrease the multiplier substantially.

Boomers move to late career working age in 2005, where their estimated impact on deficits shrink substantially. The result is a much larger impact on output, but a large contraction in their impact on the deficit. In fact, the sign of this effect changes, with

Figure 4: *Indirect Effects at $h = 2$ by Age and USA Population Shares*



increasing taxes having a positive predicted impact on deficits. So while demographics push the effect of output far above its mean, making tax increases strongly contractionary, the multiplier becomes negative. One could perhaps interpret underlying demographics as changing where the economy falls on a Laffer curve, with having most shares concentrated in 40-60 age groups pushing the economy to the downward sloping portion. The point estimates for old age retrees is strongly positive for output (shrinking its effect) and negative for deficits (reinforcing the average effect), such that predicted multipliers shrink to near zero as aging continues.

Table 3: *State Dependent Multipliers: the United States $h = 2$*

	Sample Average	USA 1985	USA 2005	USA 2025
Output Response				
β_{Tax}	-2.53	-2.53	-2.53	-2.53
$\sum_j \hat{\alpha}_j (p_{i,j} - \bar{p}) \equiv \sum_k \hat{\gamma}_{k,D} D_{k,i,j}$	0	1.84	-2.63	2.40
Δ Output	-2.53	-0.69	-5.16	-0.13
Deficit Response				
β_{Tax}	-0.58	-0.58	-0.58	-0.58
$\sum_j \hat{\alpha}_j (p_{i,j} - \bar{p}) \equiv \sum_k \hat{\gamma}_{k,D} D_{k,i,j}$	0	-1.07	2.71	-3.86
Δ Deficit	-0.58	-1.65	2.13	-4.44
Multiplier	4.36	0.42	-2.42	0.03

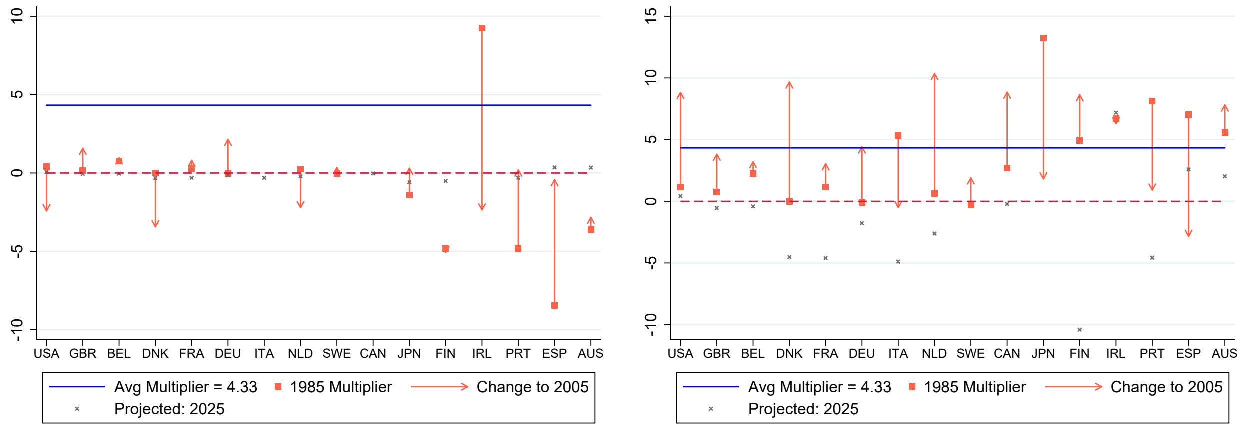
The exercise from Table 3 can be repeated for all countries in the sample, with results shown in Figure 5a. As with estimates from Figure 2, I exclude from this figure extreme values that arise predominantly from values of the deficit response very close to zero. The first thing that becomes apparent in the exercise in Figure 5a is that while the estimate for multipliers for this specification is on average quite large (> 4), the demographic impact on fiscal deficits almost always works to make the state dependent multiplier small. The relatively young and old economies of 1985 and 2025 respectively see weaker output responses due to demographics and stronger deficit responses. Since these *both* work to shrink multipliers, effects are generally much smaller in absolute value than the average effect. While the middle aged economies of 2005 see output effects of these tax shocks strongly reinforced, the effect on deficit is weakened, often reversing the sign of the multiplier entirely. As we move to a world of high concentration of populations in old age retirees the large negative effects on deficits and large positive effects on output response tends to push all conditional multipliers toward zero.

I show what happens if I still adjust by average deficit, but allow only for state dependent effects on output in Figure 5b. This is useful as it shows just the output response of multipliers to aging. For many countries multipliers would then appear to have increased over the sample, due similar dynamics described for the United States above. This underlines an important implication for these multipliers in general, which is that demographics increases output sensitivity to tax shocks over this sample. The response of multipliers in Figure 5a is strongly driven by the demographic interaction with deficits, something which was not true in the prior section using WAP. However, the implications going forward are identical for both figures as countries in this sample age. By 2025 this output effect itself has gone to zero, or even turned negative. Projecting further still would imply near zero output effects as the population weight of the oldest age groups grow substantially.

What do the results in Figure 5 suggest? Not only is aging potentially quite important for the pass through of fiscal tax shocks to output, but also incredibly important for deficits. Understanding how both series respond will be crucial to understand the effects of fiscal consolidation going forward. There is evidence from these empirical correlations that there may be strong downward pressure on multipliers arising from tax shocks in the future. Any research trying to understand the role of fiscal consolidations should consider that policy changes may have drastically different efficacy as underlying demographics change. While the picture for tax consolidations using these estimates is less clear looking back in-sample than those using WAP, the implication old age economies is fairly clear. Tax multipliers may face demographic pressure toward zero.

This result may be welcome news to policy makers. Returning to the decomposition

Figure 5: *Tax Multipliers with Changing Country Demographics: $h = 2$*



(a) *State Dependent Response: Output and Deficit* **(b)** *State Dependent Output, Average Deficit Response*

in Table 3, suppose that in the United States, pressure mounts to finance debt through austerity. While average multipliers I estimate would suggest that this is incredibly painful, factoring in the demographic impact on these suggests that the output impact of a tax increase would be blunted, while relatively small changes may have outsized effects on deficit reduction. Conversely, tax cuts may have little impact while being quite hard to finance due to their small impact on the deficit.

Notably, these effects are not obviously present in fiscal spending consolidations when controlling for the full age distribution in this way. In Appendix B, I show that these coefficients are much less significant, and that their implied age profile suggests that the model may be poorly attempting to approximate something similar to a worker/dependent cutoff. For that reason I interpret the WAP estimates for demographic effects on spending shocks as more relevant, while the Fair and Dominguez (1991) specification is more appropriate for tax shocks. This itself is an intriguing result, as it suggests that the mechanisms that operate may be quite different depending on the type of fiscal consolidation. From a policy perspective it suggests that these tax multipliers, which may have been small or even expansionary due to past demographics, may be close to zero as boomers fully retire. Meanwhile the suggestive evidence for spending multipliers in Figure 2c implies that these were low in the recent past, but may grow in the future. Further investigation into the difference of these tools under aging will be needed to fully understand these mechanisms, as the implications for fiscal consolidations in the future will be important to understand.

4. Exploring Potential Channels: Response of Consumption, Investment, and Hours Worked

I now explore the potential channels that may be important for the interaction of output and population age structure. To do so, I estimate impulse responses as above for the log changes in: real consumption, real investment, and total hours worked.[8] The hope is to understand whether aging affects the pass through of policy to consumption/savings and labor supply channels.

Results for these impulse response functions are shown in Table 4. I report only the specifications using the full age distribution here to conserve space, also omitting composition effects, but I report results using the WAP in Appendix C. While direct effects are similar in both specifications, few of the interactions with WAP are significant. As will be clear below this is likely due to important variation happening across the age distribution which would make any effect for WAP difficult to detect.

Looking at the results from tax shocks, signs of the direct effect for taxation are the expected negative and are significant. Magnitudes are intuitive with standard macro facts: investment responds more than consumption, while labor response is slightly weaker. Consistent with findings on output above, spending shocks have little statistical significance. There is a large degree of age dependence with some significance on all three outcomes under the tax shock, with consumption and investment showing much stronger significance. Tax shocks are much less strongly estimated for hours worked, suggesting perhaps that the channel is stronger with consumption and investment responses in the presence of tax shocks.

With the spending consolidation, there are some weak age effects of the shock in short horizons, with working hours the only large and persistent interaction. While the effect of spending consolidations directly on hours is not precisely estimated, it's not entirely clear what the sign should be. A positive response would be sensible if reductions in spending, for example on social welfare programs, encourages individuals to work more, while a negative response may imply that effects coming through output reductions affect employment negatively. Notably, while the interaction coefficients are difficult to interpret directly, it is clear that these effects are rather different than those for taxation as the signs of the interaction coefficients for D1-D3 follow a different pattern between these specifications.

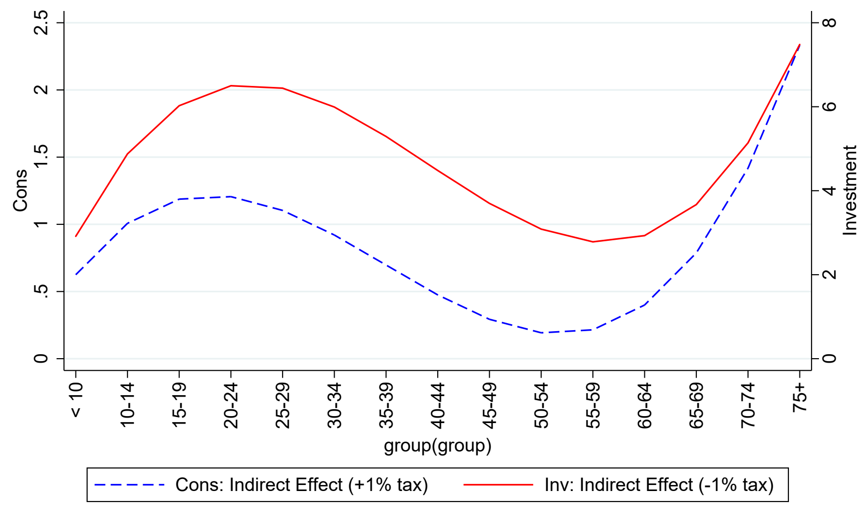
[8] Hours worked is the only variable not present in the Jordà et al. (2017) and come from OECD (2021).

Table 4: *Consumption, Investment, Hours Impulse Response Functions*

	Cumulative IRF (Tax Shock)					Cumulative IRF (Spend Shock)			
	0	1	2	3		0	1	2	3
Consumption									
Tax	0.08	-0.96***	-1.66**	-2.30***	Spend	-0.00	-0.06	-0.33	-0.68
	(0.22)	(0.31)	(0.58)	(0.73)		(0.07)	(0.23)	(0.49)	(0.71)
Tax× D1	-0.01	0.38	0.76*	0.96**	Spend× D1	-0.10*	-0.07	0.04	0.08
	(0.13)	(0.22)	(0.36)	(0.39)		(0.06)	(0.14)	(0.22)	(0.26)
Tax× D2	0.04	-0.73*	-1.42**	-1.75**	Spend× D2	0.12	0.06	-0.10	-0.13
	(0.23)	(0.38)	(0.62)	(0.70)		(0.10)	(0.25)	(0.40)	(0.46)
Tax× D3	-0.02	0.35*	0.68**	0.83**	Spend× D3	-0.04	-0.02	0.06	0.06
	(0.11)	(0.17)	(0.29)	(0.33)		(0.05)	(0.12)	(0.19)	(0.22)
R2	0.82	0.72	0.63	0.58		0.82	0.72	0.62	0.57
N	400	400	400	400		400	400	400	400
Investment									
Tax	-1.83**	-4.00***	-6.06***	-8.86***	Spend	-0.54	-0.34	0.51	0.32
	(0.66)	(1.04)	(1.84)	(2.62)		(0.57)	(0.87)	(1.16)	(1.49)
Tax× D1	0.94	2.51**	3.44**	3.97**	Spend× D1	0.71	0.60	0.02	-0.55
	(0.57)	(0.96)	(1.43)	(1.62)		(0.46)	(0.58)	(0.57)	(0.69)
Tax× D2	-1.68	-4.21**	-5.47*	-6.45**	Spend× D2	-1.25*	-1.33	-0.52	0.57
	(1.02)	(1.71)	(2.57)	(2.92)		(0.68)	(0.89)	(0.97)	(1.25)
Tax× D3	0.78	1.88**	2.34*	2.80*	Spend× D3	0.58*	0.69*	0.37	-0.15
	(0.48)	(0.80)	(1.21)	(1.38)		(0.29)	(0.39)	(0.44)	(0.60)
R2	0.76	0.77	0.73	0.69		0.76	0.77	0.71	0.68
N	400	400	400	400		400	400	400	400
Hours									
Tax	-0.15	-0.33	-0.72*	-0.78**	Spend	-0.00	-0.19	-0.23	-0.21
	(0.20)	(0.34)	(0.35)	(0.35)		(0.10)	(0.16)	(0.23)	(0.23)
Tax× D1	0.07	0.30*	0.35*	0.16	Spend× D1	-0.07	-0.21	-0.32*	-0.38*
	(0.10)	(0.17)	(0.20)	(0.25)		(0.07)	(0.14)	(0.17)	(0.19)
Tax× D2	-0.13	-0.50*	-0.60*	-0.33	Spend× D2	0.10	0.28	0.48*	0.60**
	(0.17)	(0.28)	(0.33)	(0.43)		(0.10)	(0.21)	(0.24)	(0.28)
Tax× D3	0.06	0.22	0.27*	0.16	Spend× D3	-0.03	-0.10	-0.19*	-0.25**
	(0.08)	(0.13)	(0.15)	(0.20)		(0.04)	(0.09)	(0.10)	(0.11)
R2	0.27	0.27	0.31	0.32		0.28	0.28	0.33	0.34
N	366	366	366	366		366	366	366	366

Control set same as above including two lags of the dependent variable as well as contemporaneous values and two lags of all controls and their interactions with policy shocks. Year and country fixed effects included. $*p < 0.10, **p < 0.05, ***p < 0.01$. D2 and D3 scaled by 10 and 100 respectively for readability. Effects of population structure on outcomes directly are omitted for space.

Figure 6: *Age Shares Indirect Effects on Tax Shocks at $h = 2$ by Age*

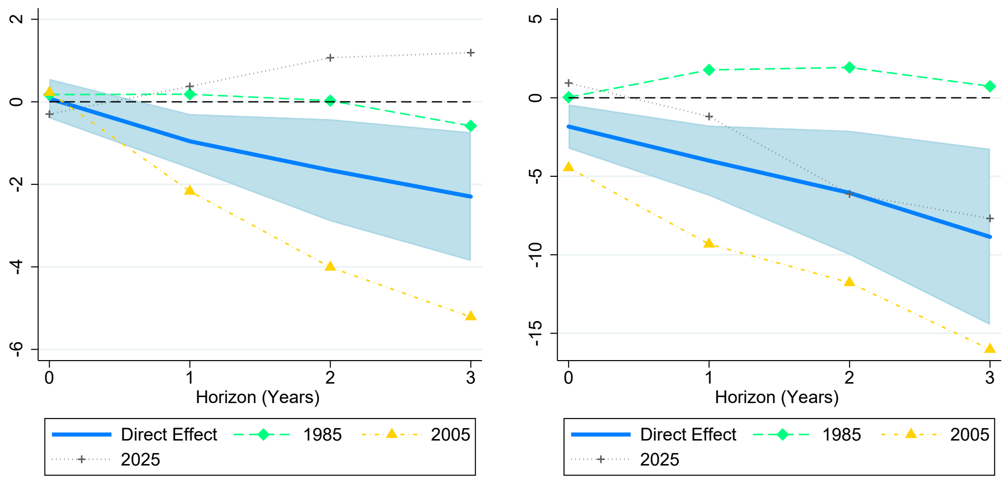


I plot the indirect effects across the age distribution for consumption and investment responses to tax shocks in Figure 6 for the three[9] year horizon ($h = 2$). While the level values are quite different, the relative change by age groups follow similar patterns, with one notable difference being stronger relative increases in old age for consumption. These shapes are nearly identical to those in Figure 4 for output. Considering the same logic above, and again using the United States data on ages plotted in in Figure 4, it is possible to see how each age group affects pass through of tax shocks. In 1985 the United States has above average shares of all age groups under 40, with particularly large shares of individuals in their 20s. Coefficients for these ages are relatively large and positive, and negative weights are mostly concentrated in late career where coefficients are small. This implies that there will be strong positive pressure mitigating the negative effects of tax hikes when the population is distributed as in this period. In 2005, when these young workers are scarce and mid-late career workers have much larger population shares, this flips, allowing negative responses to tax increases to grow in absolute value. Eventually the large coefficients in old age will bring these effects back down, with consumption having particularly strong impact.

I graph the conditional impulse responses for the United States for 1985, 2005, and 2025 in Figure 7. These feed the empirical values for D1-D3 into the estimations for tax shocks on consumption and investment in Table 4. The resulting conditional impulse responses suggest that consumption and investment respond quite similarly to output, following the intuition outlined above. Young populations shrink the effect, with estimated

[9]These results look quite similar at the full horizon, but this is chosen to keep results consistent across all specifications both above and below, where occasionally the full four year horizon is insignificant.

Figure 7: *Consumption, Investment: Conditional IRFs United States*

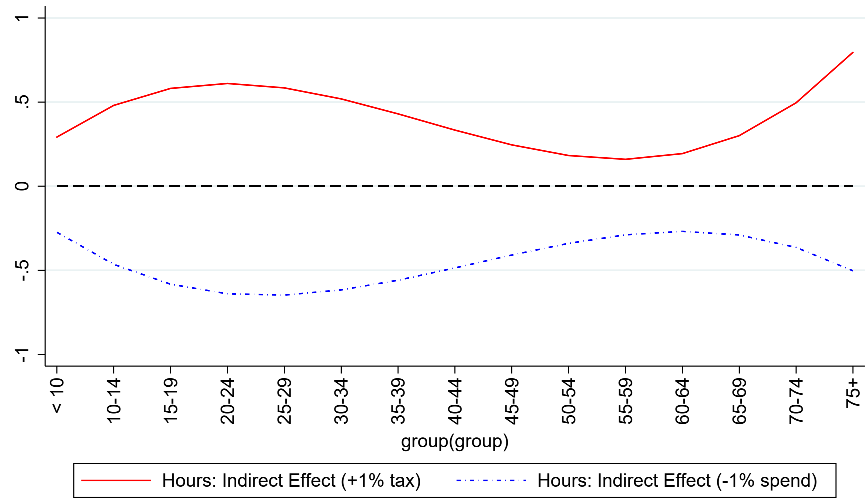


(a) *Consumption Response: Tax Shock* **(b)** *Investment Response: Tax Shock*

Direct effect shows point estimates of average fiscal shock. Conditional IRFs adjusted for indirect effect through aging using Fair and Dominguez (1991) controls for age distribution in the specified year.

coefficients for both consumption and investment close to zero in 1985, while the middle-aged population in 2005 strongly reinforces the effect. This may be due to later career workers being more strongly impacted by the tax, but also may be due to changes in household MPC over the life-cycle. Fernández-Villaverde and Krueger (2007) show a hump-shaped consumption profile with age. Perhaps life-cycle models, which could likely capture such an age relationship will shed light on mechanisms that can explain why young workers and old retirees are weakening tax shocks in this way. While it is intuitive that these households may be less exposed to these shocks, one might expect that they are more income constrained and therefore react more strongly as estimated in work such as Basso and Rachedi (2021) and Ferraro and Fiori (2020). Understanding how household decisions aggregate under plausible tax changes may help unpack discrepancies between those results and what I find here. If part of the story is that income taxes are driving these, it would also be useful to understand how other forms of taxation may alter this result. Recent work by Nguyen, Onnis, and Rossi (2021) shows that consumption taxes have much lower impact than income. This result may be in part due to consumption taxes having different effects across age relative to income. Studying the effects of aging across different classifications of taxation may yield further insight, as one would expect retirees and lower age workers to bear a much greater share of this consumption tax burden relative to income.

Figure 8: *Indirect Effects at $h = 2$ by Age: Hours*

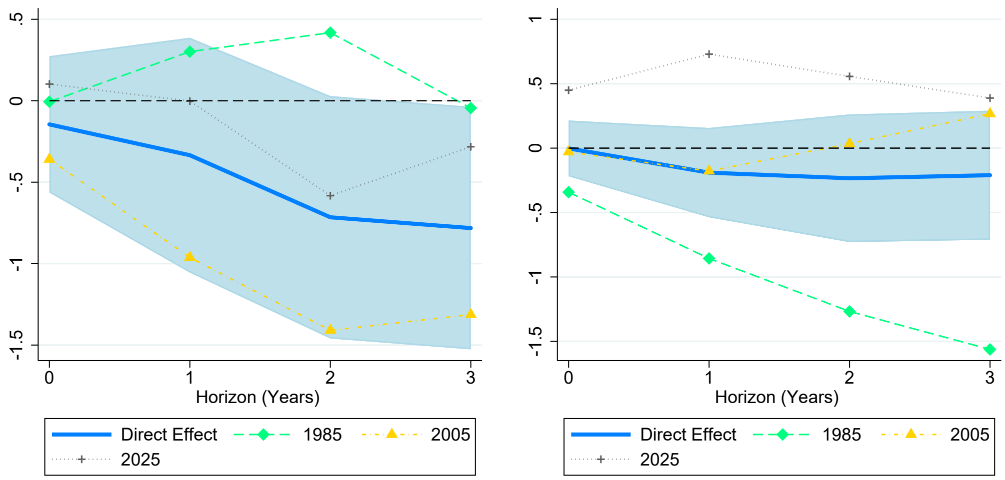


In Figure 8, I show the age specific effect at a three year ($h = 2$) horizon for hours worked across the tax and spending specification. Interaction coefficients between population age structure and fiscal shocks are significant for both specifications at this horizon. The response to a tax shock is more or less in line with the effects estimated for consumption and investment, response to spending shocks are inverted. For spending shocks, large positive deviations in young workers will reinforce the negative estimated effect of spending, making contractions in labor supply larger. This is mitigated by mid-to-late career workers. While the direct effect of spending shocks are imprecisely estimated, this suggests that when populations are very young they are more likely to have large impacts of spending shocks on employment, while this effect disappears, and even reverses signs with more mature workers and retirees.

In Figure 9, I plot the conditional IRFs for hours in the United States to both tax and spending shocks. As discussed above the effects are flip-flopped between taxation and spending, with tax consolidations having stronger impacts in 2005, as they do with consumption and investment, and spending shocks having stronger impact in 1985. This tax effect is notably the opposite of the findings of Ferraro and Fiori (2020), who show that the effects of tax cuts on employment will shrink as economies age. While I estimate that this will happen with increasing retirees, they find a peak effect in the mid-1970s, where my estimated impact would be quite weak.

It is difficult to read too deeply into these patterns as many plausible mechanisms may be important for aging effects, but broadly speaking I see two important takeaways. The demographics of tax shocks appear to work strongly through consumption and investment responses, with fairly weak response on hours. Young and old populations have mitigated

Figure 9: *Hours Worked: Conditional IRFs United States*



(a) *Hours Worked Response: Tax Shock* **(b)** *Hours Worked Response: Spending Shock*

Direct effect shows point estimates of average fiscal shock. Conditional IRFs adjusted for indirect effect through aging using Fair and Dominguez (1991) controls for age distribution in the specified year.

effects on these tax increases, while middle aged economies see the shocks reduce both consumption and investment dramatically. Spending cuts, conversely, appear to induce large reductions in hours worked for young economies, while having little, or even positive effects in middle and old aged economies. Spending consolidations appear to have little effect on consumption behavior that is related to demographics, and small transitory effects on investment.

5. Conclusions

With public debts reaching their highest levels since world war II, and populations rapidly aging, it is important to understand the effect that age structures will have on fiscal decisions going forward. This paper provides context for understanding how age structure is related to the efficacy of fiscal shocks in a recent panel of advanced economies. I find strong empirical evidence of such state dependence. Using narratively estimated fiscal consolidation shocks, a flexible methodology for state dependence, and controlling for population structure, it appears that demographics may have had a negative impact on fiscal spending multipliers over the last thirty years. Tax shocks appear to have much more life-cycle variation, which strongly affects the response of both output and deficits to shocks. Multipliers of changes in tax policy may be shrinking substantially as populations continue to age, while spending multipliers may rise.

What takeaways are there for policy makers? For one, output responses to tax shocks look much stronger with middle-aged economies, as many advanced economies were in the mid-2000s, and much weaker in the relatively young and old economies of 1985 and 2025 respectively. These output responses to tax shocks appear to come predominantly through consumption and investment responses that are much stronger when there are larges shares of the population aged 45-65. However, middle aged economies have much stronger deficit responses such that an appropriately defined multiplier appears to have been either small or negative in the recent past. Response to spending cuts may move in the opposite direction if it is more closely linked to working age population, which for many advanced economies will fall rapidly. If so there may be pressure for spending consolidation multipliers to rise, making them more costly to implement than tax increases.

It is important to keep in mind that while the narratively identified fiscal shocks can make some claim toward being well identified, underlying population age structure likely cannot, and that more work should be done to try to understand the potential mechanisms at play here. Additionally, it is likely that not all tax and spending related shocks interact with age structure in the same way. The deficit driven consolidations studied here may interact differently with age than other types of tax shocks. Even among consolidation measures, consumption taxes, shown to have weaker effects in general than income taxes by Nguyen et al. (2021), may interact differently with age than those on income tax, while spending shocks that affect investment may work differently than those aimed at providing government services. More work can be done to understand these mechanisms in the macro data by continuing to classify fiscal shocks. Models that have been used widely to understand the life cycle implications of a number of macroeconomic trends should be turned toward this question of fiscal shocks to uncover specific mechanisms that in turn can be tested in micro data.

This paper, along with existing estimates using fiscal stimulus by Honda and Miyamoto (2021), suggests that governments will see an important tool weaken as economies age. However if true, these estimates paint a favorable portrait for government's ability to pay down debts, which at present are extremely high. If policy makers are able to finance deficit reductions without a large economic contract the age for austerity may arrive just in time.

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A. Construction of Demographic Controls

My estimates for effects across the entire age distribution use a methodology first proposed in Fair and Dominguez (1991). Suppose one wanted to estimate the following relationship:

$$y_{i,t} = X_{i,t}\beta + \sum_{j}^{J} \alpha_j p_{j,i,t} + \mu_i + \nu + \epsilon_{i,t} \tag{3}$$

Where $y_{i,t}$ is any outcome of interest, $X_{i,t}$ is an arbitrary vector of controls, $\epsilon_{i,t}$ is error, μ_i country fixed effects, and ν a constant. The variables $p_{j,i,t}$ are shares of the population, divided into J bins. This is inestimable due to the perfect colinearity of the population shares $p_{j,i,t}$. Additionally while one would prefer to take a granular approach to modeling population shares (allowing for a large number of, J, groups), these shares are highly colinear with one another, more so as their number increases. Finally in smaller samples it may be undesirable to fit such a large number of coefficients, particularly as in my case when interaction terms would also be needed. Fair and Dominguez (1991) proceeds by making the following two assumptions:

1. Letting α_j be the be the coefficient on population share $p_{j,i,t}$ of age group j in country i and time t. Assume that all of the effects of these coefficients across the age distribution sum to zero. In other words:

$$\sum_{j}^{J} \alpha_j = 0$$

2. Assume that the age coefficients α_j can be fitted with a K order polynomial. In other words:

$$\alpha_j = \sum_{k}^{K} \gamma_k j^k \tag{4}$$

All three problems are addressed. First it transforms the problem of estimating J coefficients into one of estimating K, as I will show in a moment. Second, the assumption that all age effects, α_j, sum to zero makes them jointly estimable, without having to drop the regression constant. Finally, by forcing the age effects to lie on a polynomial, the model requires that there be relatively smooth transitions from the effect of one age group to another. If one were to take only the first assumption (or omit the constant of the regression) it would be possible to estimate the effects in Equation 3. The results of such estimations when using five or ten year population age groups often lead to highly unstable coefficients that alternate signs quickly from one age group to the next. This is due to the high degree of colinearity between one age group and those immediately around it, a problem which increases in J.

To see how this methodology works. Substitute α_j into Equation 3. I will assume in what follows a third order polynomial for exposition. This yields:

$$y_{i,t} = X_{i,t}\beta + \sum_{j}^{J} \left[(\gamma_0 + \gamma_1 j + \gamma_2 j^2 + \gamma_3 j^3) p_{j,i,t} \right] + \mu_i + \nu + \epsilon_{i,t} \tag{5}$$

The summing over both sides of Equation 4, and using the assumption that the sum of α_j must be zero, it can easily be shown that γ_0 is equal to:

$$\gamma_0 = -\frac{1}{J} \left[\gamma_1 \sum_j j + \gamma_2 \sum_j j^2 + \gamma_3 \sum_j j^3 \right]$$

Thus far I have followed exactly the methodology of Fair and Dominguez (1991). From here one simply plugs the above expression for γ_0 into Equation 5, and given the fact that the first term, $\sum_j \gamma_0 p_{j,i,t} = \gamma_0$ by the fact that the population parameters sum to one, then this can be rearranged as:

$$y_{i,t} = X_{i,t}\beta + \gamma_1 \sum_{j}^{J} \left(p_{j,i,t} j - \frac{\sum j}{J} \right) + \gamma_2 \sum_{j}^{J} \left(p_{j,i,t} j^2 - \frac{\sum j^2}{J} \right) + \gamma_3 \sum_{j}^{J} \left(p_{j,i,t} j^3 - \frac{\sum j^3}{J} \right) + \mu_i + \nu + \epsilon_{i,t} \tag{6}$$

With the terms in parenthesis being the demographic variables. Because I wanted my estimates to follow the demeaned structure and interpretability of for the Blinder-Oaxaca decomposition. I opt instead to estimate:

$$y_{i,t} = X_{i,t}\beta + \sum_{j}^{J} \alpha_j (p_{j,i,t} - \bar{p}_{j,t}) + \mu_i + \nu + \epsilon_{i,t} \tag{7}$$

The first few steps are exactly the same so I don't replicate them here. The problem however is just to rearrange terms slightly differently in order to construct the correct demographic variables for estimation. This simplifies to:

$$Dk_{i,t} = \left[\sum_{j}^{J} (p_{j,i,t} - \bar{p}_{i,t}) j^k - \sum_{j}^{J} j^k \sum_{j}^{J} (p_{j,i,t} - \bar{p}_{i,t}) \right] \tag{8}$$

But only this first term is needed given that $\sum_j \gamma_0 (p_{j,i,t} - \bar{p}_{j,t}) = 0$, and not γ_0 as before. So rather the estimation becomes

$$y_{i,t} = X_{i,t}\beta + \gamma_1 \sum_j^J (p_{j,i,t} - \bar{p}_{j,t}) j + \gamma_2 \sum_j^J (p_{j,i,t} - \bar{p}_{j,t}) j^2 + \gamma_3 \sum_j^J (p_{j,i,t} - \bar{p}_{j,t}) j^3 + \mu_i + \nu + \epsilon_{i,t} \tag{9}$$

Where these $\sum_j (p_{j,i,t} - \bar{p}_{j,t}) j^k$ terms are the demographic controls used in the estimations in the paper.

B. Total and Spending Shocks with Fair and Dominguez (1991) Style Controls

Here I present the regression estimates for total and spending fiscal consolidation shocks when using the full age distribution as controls. While these results are mostly insignificant, they still give some useful context for how tax and spending shocks are affected differently.

In Table 5, I report the equivalent estimations to Table 2 from the text using instead the total consolidation, and spending cut shocks. As with the results from taxes the direct effect of fiscal multipliers are actually stronger in these results, with output effects greater than one for total consolidations and implied multipliers of 2.27 and 0.45 for total and spending consolidations respectively. While composition effects of aging are present for deficits, as with taxes, the interaction effects are rather weak. For a the first few horizons, spending shocks have some significant interaction effects on output with demographics, while for the last they have significant impact on deficits. Total consolidation shocks are jointly significant in their effect on output, but are weakly estimated in general.

Plotting the age specific coefficients for these interaction effects is informative when compared to those for taxation. I plot these for both total and spending shocks in Figure 10. I use the horizons where responses to output are most significant for these: the third and first year of the shock respectively. Figure 10a looks somewhat similar to the tax indirect effects plotted in Figure 4. This shouldn't be completely surprising as those tax effects where much more strongly significant that spending and are present here. Though there are some key differences the relative changes in both output and deficit are similar.

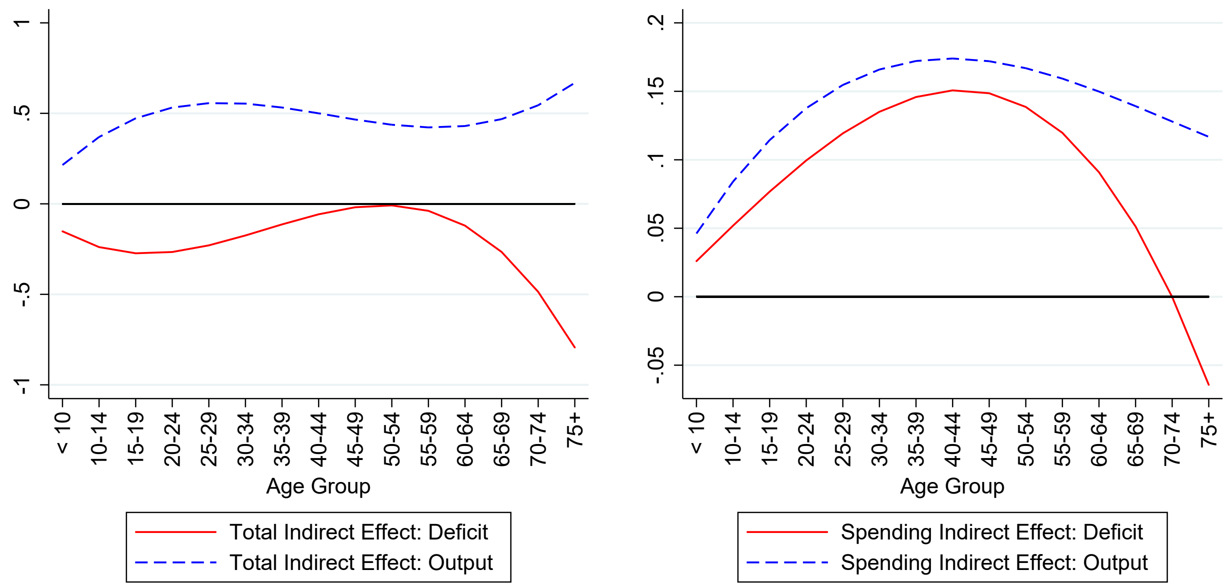
Turning to spending indirect effects in Figure 10b gives a parabolic figure that peaks around mid career. This is similar if plotted for other horizons, but is a significant effect in the year of the shock, $h = 0$. What this suggests is that for spending related consolidations, something similar to the working age population is likely a better fit of that data, as this parabolic shape is more or less as close as the polynomial fitting can get to generating something similar.

Table 5: *Output and Deficit Response : Fair and Dominguez (1991) Style Population Controls*

	Cumulative IRF, Output				Cumulative IRF, Deficit			
	0	1	2	3	0	1	2	3
Total	-0.10	-0.76***	-1.12***	-1.34***	-0.34**	-0.80***	-0.72**	-0.59*
	(0.07)	(0.19)	(0.34)	(0.45)	(0.13)	(0.25)	(0.30)	(0.29)
D1	-0.07	-0.12	-0.33	-0.47	0.23***	0.39**	0.59**	0.71**
	(0.05)	(0.13)	(0.25)	(0.38)	(0.07)	(0.14)	(0.23)	(0.30)
D2	0.10	0.21	0.54	0.73	-0.36***	-0.69**	-1.01**	-1.17*
	(0.09)	(0.23)	(0.43)	(0.66)	(0.11)	(0.26)	(0.44)	(0.57)
D3	-0.05	-0.11	-0.26	-0.34	0.14**	0.29**	0.43**	0.48*
	(0.04)	(0.11)	(0.20)	(0.30)	(0.05)	(0.12)	(0.20)	(0.26)
Total× D1	0.05	0.23	0.35	0.28	0.04	-0.05	-0.10	0.04
	(0.04)	(0.13)	(0.21)	(0.22)	(0.06)	(0.12)	(0.15)	(0.19)
Total× D2	-0.05	-0.30	-0.48	-0.29	-0.05	0.13	0.25	0.04
	(0.07)	(0.23)	(0.36)	(0.39)	(0.11)	(0.20)	(0.24)	(0.29)
Total× D3	0.01	0.11	0.19	0.09	0.02	-0.08	-0.14	-0.06
	(0.03)	(0.11)	(0.17)	(0.19)	(0.05)	(0.09)	(0.11)	(0.12)
R2	0.82	0.68	0.58	0.56	0.42	0.57	0.62	0.65
N	400	400	400	400	400	400	400	400
Spend	-0.06	-0.55***	-0.56	-0.62	-0.45**	-1.19***	-1.26**	-1.38***
	(0.08)	(0.16)	(0.33)	(0.51)	(0.16)	(0.30)	(0.44)	(0.43)
D1	-0.06	-0.08	-0.21	-0.32	0.24***	0.40**	0.56**	0.63**
	(0.06)	(0.15)	(0.28)	(0.39)	(0.07)	(0.15)	(0.23)	(0.28)
D2	0.11	0.16	0.40	0.54	-0.38***	-0.67**	-0.95**	-1.05*
	(0.11)	(0.26)	(0.47)	(0.68)	(0.12)	(0.27)	(0.42)	(0.55)
D3	-0.05	-0.09	-0.21	-0.28	0.15***	0.28**	0.40*	0.43
	(0.05)	(0.12)	(0.21)	(0.30)	(0.05)	(0.12)	(0.19)	(0.25)
Spend× D1	0.10*	0.24	0.18	0.00	0.04	0.07	0.12	0.42**
	(0.06)	(0.14)	(0.18)	(0.18)	(0.07)	(0.12)	(0.16)	(0.19)
Spend× D2	-0.11	-0.27	-0.19	0.15	-0.06	-0.03	-0.03	-0.44
	(0.09)	(0.23)	(0.29)	(0.29)	(0.13)	(0.20)	(0.26)	(0.30)
Spend× D3	0.04	0.09	0.06	-0.10	0.02	-0.02	-0.05	0.10
	(0.04)	(0.11)	(0.13)	(0.14)	(0.06)	(0.09)	(0.11)	(0.13)
R2	0.82	0.67	0.56	0.54	0.42	0.56	0.62	0.66
N	400	400	400	400	400	400	400	400

Table reports estimations for IRFs by local projections of total consolidation shock and spending cut shocks on two outcomes. All regressions contain full set of controls described above as well as country and time fixed effects. Standard errors in parenthesis and clustered at the country level. $*p < 0.10, **p < 0.05, ***p < 0.01$. $X_{i,t}$ includes two lags of the dependent variable as well as contemporaneous values and two lags of all controls and their interactions with policy shocks.

Figure 10: *Indirect Effects of Aging on Deficits and Output*



(a) *Total Consolidation Shocks:* $h = 2$

(b) *Spending Consolidation Shocks:* $h = 0$

While I take Figure 10 as some suggestive evidence that WAP is more appropriate than a polynomial fit of the age distribution for spending shocks, more research into this mechanism would be useful. Using polynomial fits it appears that hours worked may be an important channel for an effect of spending shocks, with very young and old age groups decreasing the sensitivity of hours to spending shocks. This might support the idea that the working age cutoff is an important one. However, in Appendix C such effects are weakly detected when WAP is used. Better understanding the micro channels, either through the lens of a theoretical model, or through micro level data will be crucial in interpreting the differences between how these shocks appear to transmit at a macro level.

C. Consumption, Investment, and Hours and Working Age Population

Here I present IRFs for consumption, investment, and hours worked with demographics controlled by the WAP. As mentioned in the main text there is little in the way of state dependence here, which is somewhat puzzling in the case of spending shocks where WAP is significant and the Fair and Dominguez (1991) variables are not. Consumption has some effects in the first years after the shock, while hours respond at longer horizons, but only weakly.[10] The sign is hard to interpret, more workers weakening the effect on hours, this may be due to the effect being strongest among workers nearest the worker/non-worker cutoffs. For example workers early in career may be more likely to be induced to reduce work and acquire skills through college, while workers near retirement may be more compelled to stop working or reduce their work efforts. While the working age population cutoff may be important for this channel, it may not represent uniform effects across work life, and therefore is better fit by the polynomial in Figure 8.

[10]The p-value at the full four year horizon is 0.16.

Table 6: *Consumption, Investment, Hours Impulse Response Functions*

	Cumulative IRF (Tax Shock)					Cumulative IRF (Spend Shock)			
	0	1	2	3		0	1	2	3
Consumption									
Tax	0.03	-0.76*	-1.24*	-1.74**	Spend	-0.14	-0.17	-0.35	-0.63
	(0.19)	(0.40)	(0.66)	(0.77)		(0.10)	(0.26)	(0.50)	(0.71)
Tax× WAP	-0.04	-0.28	-0.13	0.07	Spend× WAP	-0.26***	-0.31**	-0.16	0.06
	(0.06)	(0.17)†	(0.26)	(0.39)		(0.04)	(0.14)	(0.24)	(0.25)
R2	0.82	0.72	0.62	0.57		0.82	0.72	0.62	0.56
N	400	400	400	400		400	400	400	400
Investment									
Tax	-1.36	-2.96	-4.80*	-7.11**	Spend	-0.32	-0.52	-0.24	-0.72
	(0.90)	(1.71)	(2.49)	(3.18)		(0.60)	(0.93)	(1.36)	(1.84)
Tax× WAP	-0.14	-0.11	0.26	0.09	Spend× WAP	-0.28	-1.09	-1.70	-1.09
	(0.15)	(0.42)	(0.80)	(0.71)		(0.49)	(0.64)†	(0.99)†	(1.15)
R2	0.76	0.76	0.71	0.68		0.75	0.76	0.71	0.68
N	400	400	400	400		400	400	400	400
Hours									
Tax	-0.14	-0.24	-0.59*	-0.69**	Spend	-0.07	-0.35	-0.42	-0.34
	(0.16)	(0.29)	(0.33)	(0.31)		(0.12)	(0.21)	(0.25)	(0.22)
Tax× WAP	-0.00	0.09	-0.02	-0.09	Spend× WAP	0.05	0.06	0.16	0.37
	(0.08)	(0.12)	(0.15)	(0.22)		(0.07)	(0.15)	(0.23)	(0.26)†
R2	0.27	0.26	0.30	0.32		0.27	0.27	0.31	0.33
N	366	366	366	366		366	366	366	366

Control set same as above including two lags of the dependent variable as well as contemporaneous values and two lags of all controls and their interactions with policy shocks. Year and country fixed effects included. $\dagger p < 0.20, *p < 0.10, **p < 0.05, ***p < 0.01$.

D. Estimates Using the Old Age Population Share

Honda and Miyamoto (2021) use old age dependency ratios in their estimations. Though they use a different identification of fiscal shocks, it is worthwhile to show that I can replicate their effects. In Table 7, I show estimates for four year impulse response functions for output and deficits for all three narrative consolidation shocks (Total, Tax, and Spending), but unlike above, I use old age dependency ratios to control for population age structure. Consistent with their broad finding I estimate positive interactions for each of these shocks, suggesting that aging decreases the size of fiscal multipliers. Their work does not report effects of fiscal deficits and instead adjust their output variable (scaling by previous year GDP) in an attempt to correctly arrive at fiscal multipliers, so while I find a large amount of state dependence of deficits, with old ages increasing the negative responses of all consolidation shocks, I cannot directly compare to theirs. In either case this would reinforce the shrinking of the multiplier effect as found in this paper.

Table 7: *Output and Deficit Response and the Old-Age Dependency Ratio*

	Cumulative IRF: Output				Cumulative IRF Deficit			
	0	1	2	3	0	1	2	3
Total	-0.06	-0.63**	-0.91**	-1.17**	-0.32**	-0.80***	-0.73**	-0.50
	(0.10)	(0.22)	(0.38)	(0.53)	(0.12)	(0.25)	(0.30)	(0.29)
OldAge	-0.08**	-0.31***	-0.54***	-0.78***	-0.14***	-0.19**	-0.25**	-0.25
	(0.03)	(0.05)	(0.10)	(0.14)	(0.03)	(0.08)	(0.11)	(0.15)
Total× OldAge	0.05*	0.11	0.18*	0.21*	0.00	-0.08	-0.21***	-0.36***
	(0.03)	(0.07)	(0.09)	(0.11)	(0.03)	(0.05)	(0.06)	(0.09)
R2	0.82	0.67	0.57	0.55	0.43	0.57	0.63	0.65
N	400	400	400	400	400	400	400	400
Tax	-0.19	-1.32***	-2.01**	-2.53***	-0.41**	-1.05**	-1.10*	-0.85
	(0.17)	(0.39)	(0.73)	(0.84)	(0.17)	(0.43)	(0.56)	(0.68)
OldAge	-0.07**	-0.28***	-0.50***	-0.73***	-0.13***	-0.19**	-0.28**	-0.30*
	(0.03)	(0.06)	(0.10)	(0.16)	(0.03)	(0.07)	(0.10)	(0.15)
Tax× OldAge	0.10*	0.20*	0.30	0.37	-0.07	-0.24*	-0.34**	-0.45**
	(0.05)	(0.11)	(0.18)	(0.21)	(0.07)	(0.12)	(0.14)	(0.18)
R2	0.82	0.68	0.58	0.55	0.42	0.56	0.62	0.63
N	400	400	400	400	400	400	400	400
Spend	0.02	-0.36*	-0.44	-0.63	-0.37**	-1.05***	-1.04**	-0.94**
	(0.10)	(0.20)	(0.34)	(0.54)	(0.17)	(0.32)	(0.42)	(0.42)
OldAge	-0.07**	-0.30***	-0.53***	-0.76***	-0.14***	-0.20**	-0.25**	-0.24
	(0.03)	(0.05)	(0.10)	(0.15)	(0.03)	(0.08)	(0.11)	(0.15)
Spend× OldAge	0.04	0.08	0.16	0.16	0.01	-0.13**	-0.32***	-0.57***
	(0.04)	(0.10)	(0.11)	(0.15)	(0.05)	(0.06)	(0.08)	(0.12)
R2	0.81	0.67	0.56	0.54	0.42	0.56	0.62	0.65
N	400	400	400	400	400	400	400	400

Control set same as above including two lags of the dependent variable as well as contemporaneous values and two lags of all controls and their interactions with policy shocks. Year and country fixed effects included. $*p < 0.10, **p < 0.05, ***p < 0.01$.