Population Aging, Regional Integration, and Economic Growth Across U.S. Counties*

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Abstract

This paper examines how the economic effects of population aging vary across space. Using U.S. county data from 2000 to 2020, we estimate the impact of changes in the share of adults aged 60 and older on GDP per capita growth. We instrument for aging using lagged age structure from historic censuses to address endogeneity. We find that a 10 percent increase in the 60+ population share reduces GDP per capita by roughly 4–5 percent, but this average masks substantial spatial heterogeneity. Aging has little measurable effect in large, economically integrated labor markets, while generating sizable growth declines in smaller and more isolated regions. Sectoral analysis reveals contractions in agriculture, construction, and manufacturing alongside expansions in health care and professional services; however, only economically integrated counties appear able to offset sectoral contraction and avoid aggregate losses. These results suggest that the local consequences of demographic aging depend not only on industrial structure but also on regional integration and labor market connectivity.

Keywords: Population aging, Economic Growth, Regional, Urban, Rural, Sectoral, Openness, Commuting
JEL Classification Numbers: J11, J14, O47, R11

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1 Introduction

Economists and demographers have long debated whether aging is a drag on growth or an opportunity to reconfigure economic structures. On one hand, a rising share of older adults may slow economic growth by reducing the labor force participation rate, weakening productivity, and shifting spending away from investment and innovation (Maestas et al., 2023; Eggertsson et al., 2019; Cutler et al., 1990). On the other hand, aging could boost growth through mechanisms such as capital deepening, automation, longer working lives, and the expansion of age-aligned industries like healthcare and professional services (Daniele et al., 2019; Acemoglu and Restrepo, 2017; Feyrer, 2007; Du et al., 2026).

While macroeconomic studies have provided important insights into the national implications of population aging, much less is known about how aging affects local economic growth, where labor markets, industrial composition, and commuting flows vary widely across space. In particular, regions differ substantially in their degree of integration with surrounding labor markets. Counties embedded within larger regional economies can draw workers, capital, and knowledge from nearby areas, while more isolated places rely primarily on their own local population.

These local contexts matter greatly, as the pace and intensity of demographic change differ sharply across regions (Cohen and Greaney, 2023; Takahashi, 2022). Figure 1 illustrates that the share of adults aged 60 and over has increased steadily in both metropolitan and non-metropolitan counties since 1970, with a particularly sharp acceleration since 2000. Figure 2 further highlights the pronounced spatial heterogeneity in the recent pace of population aging across counties, with some counties experiencing increases in the 60+ share exceeding 30 percentage points while others have seen modest declines over the same period. This recent surge underscores how rapidly the aging process has reshaped local population structures. Yet despite this pervasive demographic shift, there remains limited evidence on how population aging influences economic performance across different types of places.

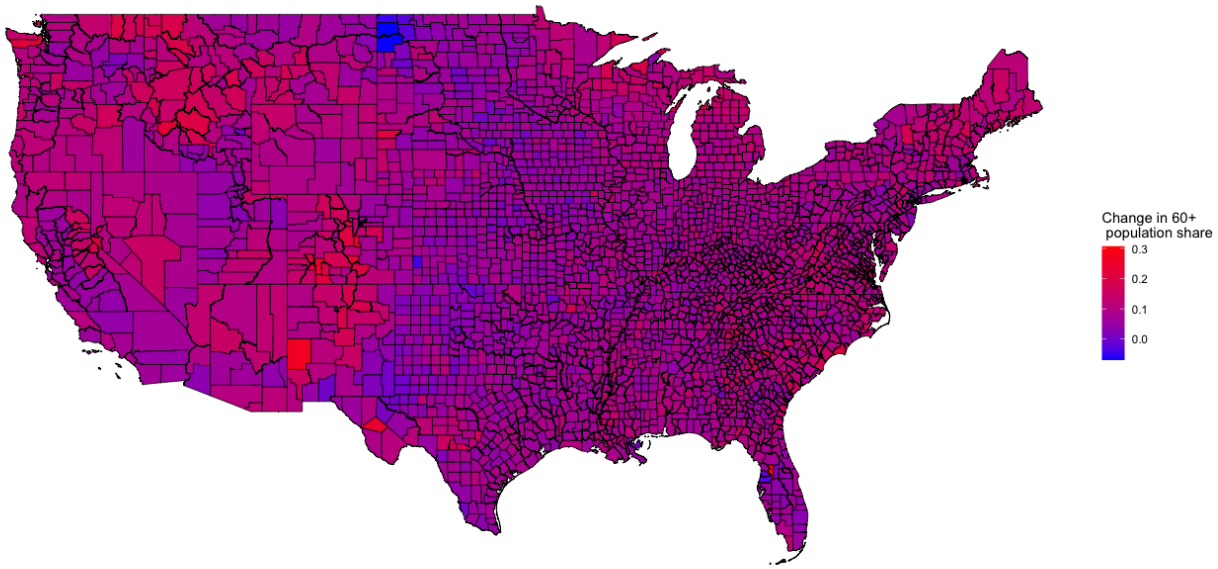
Figure 1: Share of the adult population aged 60+



Notes: Data from decadal censuses. Metro and non-metro defined based on 2023 U.S. Department of Agriculture's Rural-Urban Continuum Codes (RUCCs). Adult population defined as aged 20+.

To estimate the causal impact of population aging on local economic growth, we construct a panel of U.S. counties observed at decadal intervals from 2000 to 2020. Our outcome of interest is the ten-year change in real GDP per capita at the county level, and our key explanatory variable is the change in the share of adults aged 60 and over. However, estimating this relationship using ordinary least squares (OLS) raises important endogeneity concerns. In particular, the timing and magnitude of population aging may be influenced by a county's economic conditions—for example, stronger economies might retain or attract older residents, while economically struggling areas may experience out-migration or mortality that skews the age structure. Additionally, local policy changes or unobserved shocks that affect both demographic change and economic growth could bias OLS estimates.

Figure 2: Change in the Share of 60 + Population: 2000 - 2020



Notes: The data are the change in population over 60 divided by the adult population defined as aged 20+ between 2000 and 2020.

To address these challenges, our identification strategy follows a growing literature that uses lagged demographic variables as instruments for current population structure, including studies of aging at national and regional levels (e.g., Maestas et al., 2023; Daniele et al., 2019; Böhm and Siegel, 2021; Zhang et al., 2015). We implement an instrumental variables (IV) strategy that is conceptually similar to a shift-share design while also controlling for several different types of unobserved heterogeneity. Specifically, we instrument for the decadal change in the 60+ population share using age structure data from 10, 20, and 30 years prior, combined with *national* cohort survival rates. Lagged age structure acts as a source of exogenous variation in recent changes to the older adult share. Using multiple lag lengths allows us both to assess robustness and to evaluate the plausibility of the exclusion restriction across instruments with different historical distance.

We combine this IV strategy with first differencing at decadal intervals and state fixed effects to control for unobserved heterogeneity. First differencing removes time-invariant county characteristics—making the specification analogous to a county fixed effects model—while state fixed effects absorb broader regional trend differences.[1] We further show that our results are robust to the inclusion of state-by-decade fixed effects, which account for regional economic shocks and state-specific growth trends that may be correlated with population aging.

The identifying assumption is that, conditional on these controls, historical age structure affects current economic growth only through its impact on recent population aging, and not through independent channels. This assumption becomes more plausible when using longer lags and richer controls for unob-

[1]While our empirical models include three time periods, it is useful to note that first differencing and a county fixed effect are equivalent in panel models with two periods.

served heterogeneity, as these reduce the likelihood that historical demographic composition is correlated with current unobserved economic shocks. To further assess this assumption, we conduct placebo tests analogous to pre-trend tests in a difference-in-differences framework. Specifically, we examine whether predicted aging for a future period is associated with economic growth in a prior decade. The placebo test provides reassuring evidence that the instrument is not proxying for persistent local economic conditions, as predicted future aging does not explain pre-period economic growth once contemporaneous aging and county type are accounted for.

Across all specifications, the instruments are strong and yield broadly consistent results, increasing confidence in the validity of our approach. Importantly, our strategy isolates variation in aging driven by long-run demographic momentum—such as cohort aging and mortality—rather than short-term migration flows or local economic sorting. In this sense, our estimates capture the impact of underlying demographic change on economic performance, rather than changes in age structure driven by selective in- or out-migration. This distinction is particularly relevant for policymakers, as it highlights the structural economic implications of aging populations rather than more transient, mobility-driven shifts.

Our baseline estimates using a 10-year lag instrument suggest that a 10 percent increase in the 60+ share reduces county GDP per capita by approximately 4.5 percent. These effects are substantially larger in non-metropolitan counties, where the same demographic shift is associated with a 5.3 percent decline in GDP per capita. In contrast, the estimated effect in metropolitan counties is smaller—about 1.7 percent with the 10-year lag—and becomes statistically insignificant at longer lags. These findings point to a meaningful economic burden of population aging in certain communities—particularly in rural and economically isolated places.

To better understand why the effects of aging vary across space, we examine several forms of heterogeneity. First, we show that the negative effect of aging is not strictly monotonic with rurality. Rather, it is particularly acute in non-metropolitan counties that are geographically or economically disconnected from larger labor markets—those with weak commuting ties to surrounding areas. For instance, isolated non-metro counties experience significantly larger growth penalties from aging than similarly sized non-metro counties located adjacent to metropolitan cores. This suggests that spatial integration, not just rural status or population size, plays a critical role in mediating the economic consequences of demographic change.

We also examine the sectoral composition of local economies to better understand the mechanisms through which aging shapes economic performance. Using industry-specific GDP per capita as the outcome, we find that population aging is associated with significant output declines in several core sectors, including agriculture, construction, mining, trade and transportation, manufacturing, and government. These industries tend to rely more heavily on physical labor or are tied to goods production and public provision—making them especially vulnerable to a shrinking working-age population and potential declines in local demand. Importantly, these sectoral contractions are not offset by growth in areas like leisure and hospitality, which show no significant relationship with aging. At the same time, we observe positive effects of aging on output in health care, education, and professional services—sectors that either directly serve older populations or reflect broader shifts toward service- and knowledge-based economies. When we disaggregate results by metropolitan status, we find that non-metro counties experience significantly larger declines in labor-intensive sectors, including a meaningful contraction in manufacturing, whereas metro counties appear more insulated—potentially due to greater capital intensity, automation, or industrial diversification.

We then explore the role of economic openness, measured by the share of the local workforce that commutes in from other counties. Across all counties, the interaction between aging and commuting openness is large and significantly positive, suggesting that more open counties are better positioned to absorb the structural shocks associated with aging. These mitigating effects are especially strong in

non-metro areas. We also show that the industry-specific effects of aging differ depending on openness. For example, aging is associated with increased employment in healthcare and professional services only in counties that are economically open—suggesting that integration with surrounding regions may be essential for translating demographic change into growth opportunities.

This paper contributes and extends several strands of literature. First, it contributes to a growing body of research on population aging and economic performance. Much of this literature uses macroeconomic empirical strategies such as structural models (Jones, 2023; Basso and Jimeno, 2021), cross-country regressions (Kotschy and Bloom, 2023; Eggertsson et al., 2019; Bloom et al., 2010; Feyrer, 2008, 2007), or vector autoregression models (Aksoy et al., 2019) and highlights the potential for "demographic drag." Similar to Maestas et al. (2023) who uses variation across U.S. states, we contribute to this broad literature by leveraging variation at the county-level to provide new causal evidence on how population aging affects local economic growth. This allows us to both use quasi-experimental variation by using the lagged age structure as an instrument as well as control for both local time-invariant and shared macro shocks. In addition, by using local measures of growth and decomposing the impact of aging by industry, we provide insights that are directly applicable to local policymakers. This complements existing studies that highlight the link between industrial composition and local vulnerability to shocks (Hartal et al., 2023; Ženka et al., 2019; Brown and Greenbaum, 2017; Fratesi and Rodríguez-Pose, 2016).

We also contribute to the literature by documenting that the consequences from aging on economic growth are heterogeneous across space. Specifically, aging generates large and robust reductions in growth in non-metropolitan counties, but much smaller and often statistically insignificant effects in metropolitan areas. This spatial heterogeneity is masked at the state and national level. Furthermore, we show that labor-market openness is a potential key local mitigating mechanism. Counties with stronger commuting inflows experience substantially smaller growth penalties from aging. This buffering effect is more pronounced in non-metro areas. This pattern is consistent with theoretical models in which demographic change interacts with economic integration to reshape agglomeration forces (Grafeneder-Weissteiner and Prettner, 2013). Our findings therefore link demographic change directly to the spatial structure of labor markets, complementing research that emphasizes the role of regional integration and inter-jurisdictional linkages in mediating adjustment to shocks (Feng et al., 2023; Adao et al., 2019; Diodato and Weterings, 2015; Martin, 2012; Partridge et al., 2010). Our results are also consistent with evidence that demographic shocks impose larger economic costs in lagging or low-capacity regions, where limited connectivity and weaker institutional or market integration constrain local adaptation (Daniele et al., 2019; Aiyar and Ebeke, 2017).

2 Data

Our analysis draws on several sources of county-level data from 2000 to 2020 to construct measures of economic performance, demographic change, and commuting patterns across U.S. counties. The primary source for economic data is the Bureau of Economic Analysis (BEA), which provides annual estimates of real Gross Domestic Product (GDP) by industry at the county level (U.S. Bureau of Economic Analysis, 2023). Because county-level GDP estimates begin in 2001, our baseline growth measures use GDP per capita from 2001 to 2010 and from 2010 to 2019. Throughout the paper, we refer to these as "decadal" changes for simplicity, though the economic data span 2001–2010 and 2010–2019.[2]

Industry-level GDP is aggregated into 11 categories: manufacturing, agriculture and forestry, mining, construction, health care, educational services, professional and business services, leisure and hospitality,

[2]Using 2001–2010 and 2010–2019 ensures consistent interval lengths for GDP growth. We also use 2019 rather than 2020 GDP in our baseline estimates to avoid distortions associated with the COVID-19 pandemic. Results using 2020 GDP are presented as a robustness check.

other services, government, and trade and transportation. This industry breakdown allows us to explore sector-specific patterns of economic change in response to demographic aging.

To mitigate the influence of extreme outliers—particularly in sparsely populated counties with volatile growth rates—we winsorize growth in GDP per capita at the 1st and 99th percentiles. We assess robustness by replicating results using the raw, untransformed data and by testing alternative outlier-handling approaches.

Demographic data, including age-specific population counts, are obtained from the decennial U.S. Census through IPUMS (Schroeder et al., 2025). Because these data come directly from the decennial Census, our demographic measures reflect changes from 2000 to 2010 and from 2010 to 2020. We use county-level counts by single-year age bins to construct measures of aging and to build lagged instruments for our instrumental variables strategy. Adult population is defined as individuals aged 20 and older.

We define metro and non-metro counties based on the 2023 U.S. Department of Agriculture's Rural-Urban Continuum Codes (RUCC) (U.S. Department of Agriculture, Economic Research Service, 2023). Counties coded RUCC 1 through 3 are classified as metro, while those coded 4 through 9 are considered non-metro (Table 1). Non-metro counties are also divided based on adjacency to a metro area.[3] We examine results by each RUCC code in addition to aggregated metro and non-metro areas.

Table 1: Rural-Urban Continuum Codes (RUCC) Definitions

Code	Description
Metro counties:	
1	Counties in metro areas of 1 million population or more
2	Counties in metro areas of 250,000 to 1 million population
3	Counties in metro areas of fewer than 250,000 population
Non-metro counties:	
4	Urban population of 20,000 or more, adjacent to a metro area
5	Urban population of 20,000 or more, not adjacent to a metro area
6	Urban population of 5,000 to 20,000, adjacent to a metro area
7	Urban population of 5,000 to 20,000, not adjacent to a metro area
8	Urban population of fewer than 5,000, adjacent to a metro area
9	Urban population of fewer than 5,000, not adjacent to a metro area

Source: USDA, Economic Research Service using data from the Office of Management and Budget and U.S. Department of Commerce, Bureau of the Census.

Commuting patterns are captured by a measure of economic openness at the county level, defined as the share of workers employed in a county who reside outside of it. This variable, derived from the American Community Survey (ACS) for 2006-2010, is taken directly from Monte et al. (2018a), who provide a processed version of the commuting flow data in their replication materials (Monte et al., 2018b). We use this measure to evaluate whether more economically open counties are more resilient to the effects of demographic aging.

3 Empirical Strategy

3.1 Model Specification

We estimate the impact of demographic aging on local economic growth using a panel of U.S. counties observed at decadal intervals from 2000 to 2020. Our primary outcome is the decadal growth rate of real

[3] Adjacency is defined as physically adjoined to one or more metro areas and at least 2 percent of employed labor force commuting to central metro counties.

GDP per capita. The baseline estimating equation is:

$$\text{Growth}_{cst} = \beta \cdot \text{Aging}_{cst} + \mu_s + \tau_t + \varepsilon_{cst} \tag{1}$$

where Growth_{cst} denotes the change in the natural logarithm of real GDP per capita in county c, state s, between time t and $t-10$:

$$\text{Growth}_{cst} = \ln\left(\frac{\text{GDP}_{cs,t}}{\text{Pop}_{cs,t}}\right) - \ln\left(\frac{\text{GDP}_{cs,t-10}}{\text{Pop}_{cs,t-10}}\right) \tag{2}$$

Our key explanatory variable is the decadal change in the old-age share:

$$\text{Aging}_{cst} = \ln\left(\frac{\text{Old}_{cs,t}}{\text{Adults}_{cs,t}}\right) - \ln\left(\frac{\text{Old}_{cs,t-10}}{\text{Adults}_{cs,t-10}}\right) \tag{3}$$

where $\text{Old}_{cs,t}$ is the number of individuals aged 60 and older in county c at time t, and $\text{Adults}_{cs,t}$ is the total adult population (aged 20+) in that county and year. μ_s captures state fixed effects, τ_t denotes decade fixed effects, and ε_{cst} is the error term. We cluster standard errors by state and estimate the model separately for metro and non-metro counties to examine heterogeneous effects. Because the outcome and aging variables are measured in decade differences, identification comes from cross-county variation in changes in the age structure over time, conditional on state and decade fixed effects. Note that the specification implicitly differences out time-invariant county characteristics.

To address endogeneity in the relationship between local aging and growth—particularly through selective migration[4]—we adopt an instrumental variables (IV) strategy that projects aging using lagged age structures and national survival rates. This approach is conceptually similar to a shift-share design: local age cohorts from earlier periods (the "shares") are combined with national age-specific survival rates (the "shifters") to form predicted population aging that is plausibly exogenous to local economic shocks (Borusyak et al., 2025). Identification relies on the assumption that historical cohort sizes within a county are predetermined with respect to future local economic shocks, so that predicted aging reflects demographic momentum rather than endogenous responses of population structure to local economic conditions.

For each decade t and lag length $x \in \{10, 20, 30\}$, we use population data from time $t-x$ to predict the number of older and adult residents in future periods.[5] These are constructed as follows:

$$\widehat{\text{Old}}_{cs,t} = \sum_{j \geq 60-x} \text{Pop}_{jcs,t-x} \times \left(\frac{\text{Pop}_{j+x,t}}{\text{Pop}_{j,t-x}}\right) \tag{4}$$

$$\widehat{\text{Old}}_{cs,t-10} = \sum_{j \geq 60-x-10} \text{Pop}_{jcs,t-x} \times \left(\frac{\text{Pop}_{j+x-10,t-10}}{\text{Pop}_{j,t-x}}\right) \tag{5}$$

$$\widehat{\text{Adults}}_{cs,t} = \sum_{j \geq 20-x} \text{Pop}_{jcs,t-x} \times \left(\frac{\text{Pop}_{j+x,t}}{\text{Pop}_{j,t-x}}\right) \tag{6}$$

$$\widehat{\text{Adults}}_{cs,t-10} = \sum_{j \geq 20-x-10} \text{Pop}_{jcs,t-x} \times \left(\frac{\text{Pop}_{j+x-10,t-10}}{\text{Pop}_{j,t-x}}\right) \tag{7}$$

In these expressions, $\text{Pop}_{jcs,t-x}$ is the number of residents in county c, state s, aged j in year $t-x$ and $\frac{\text{Pop}_{j+x,t}}{\text{Pop}_{j,t-x}}$ is the national cohort survival rate for people of age j at time $t-x$ surviving to age $j+x$ at

[4] E.g. empirical evidence that aging individuals tend to locate in places with attractive consumer amenities (Chen and Rosenthal, 2008).

[5] For the 30-year lag ($x = 30$), we are unable to predict the population aged 20–30 in time t using data from $t-x$ since those individuals were not yet born. We therefore set their predicted counts to zero.

time t.

This approach assumes that future changes in local age structure are substantially driven by demographic momentum—the aging of existing cohorts—rather than only by local economic shocks that selectively attract or repel specific age groups. By applying *national* survival rates, we strip out the influence of local health systems, migration patterns, and labor market conditions, ensuring the instrument reflects aging from cohort size, not endogenous local responses.

To construct the predicted aging rate, we take:

$$\text{PredAging}_{cst} = \ln\left(\frac{\widehat{\text{Old}}_{cs,t}}{\widehat{\text{Adults}}_{cs,t}}\right) - \ln\left(\frac{\widehat{\text{Old}}_{cs,t-10}}{\widehat{\text{Adults}}_{cs,t-10}}\right) \tag{8}$$

The two-stage least squares (2SLS) model is then estimated as follows:

First Stage:

$$\text{Aging}_{cst} = \pi \cdot \text{PredAging}_{cst} + \mu_s + \tau_t + \nu_{cst} \tag{9}$$

Second Stage:

$$\text{Growth}_{cst} = \beta \cdot \widehat{\text{Aging}}_{cst} + \mu_s + \tau_t + \varepsilon_{cst} \tag{10}$$

We estimate the model using separate instruments for 10-, 20-, and 30-year lags to test robustness and explore how the strength and validity of the instrument evolve with historical distance. Longer lags offer stronger exclusion assumptions but may reduce predictive power.

3.2 Industry-Level Decomposition

To investigate how aging influences economic structure, we disaggregate GDP per capita by industry using BEA county-level GDP-by-industry data. We group industries into eleven sectors: manufacturing, agriculture/forestry, mining, construction, health care, educational services, professional/business services, leisure and hospitality, other services, government, and trade/transportation. This decomposition helps identify whether certain sectors are more or less impacted by demographic shifts.

3.3 Commuting Flow Interaction

We also explore whether counties more integrated into regional labor markets are better able to absorb demographic shocks. Following Monte et al. (2018a), we use an "openness" measure based on county-to-county worker flows from the 2006-2010 ACS:

$$\text{Openness}_c = \frac{\text{Nonresident Workers}_c}{\text{Total Jobs}_c} \tag{11}$$

This reflects the share of workers employed in county c who reside outside of it. We interact this measure with the aging variable to test whether more economically open counties are more resilient to aging:

$$\text{Growth}_{cst} = \beta_1 \cdot \text{Aging}_{cst} + \beta_2 \cdot (\text{Aging}_{cst} \times \text{Openness}_c) + \mu_s + \tau_t + \varepsilon_{cst} \tag{12}$$

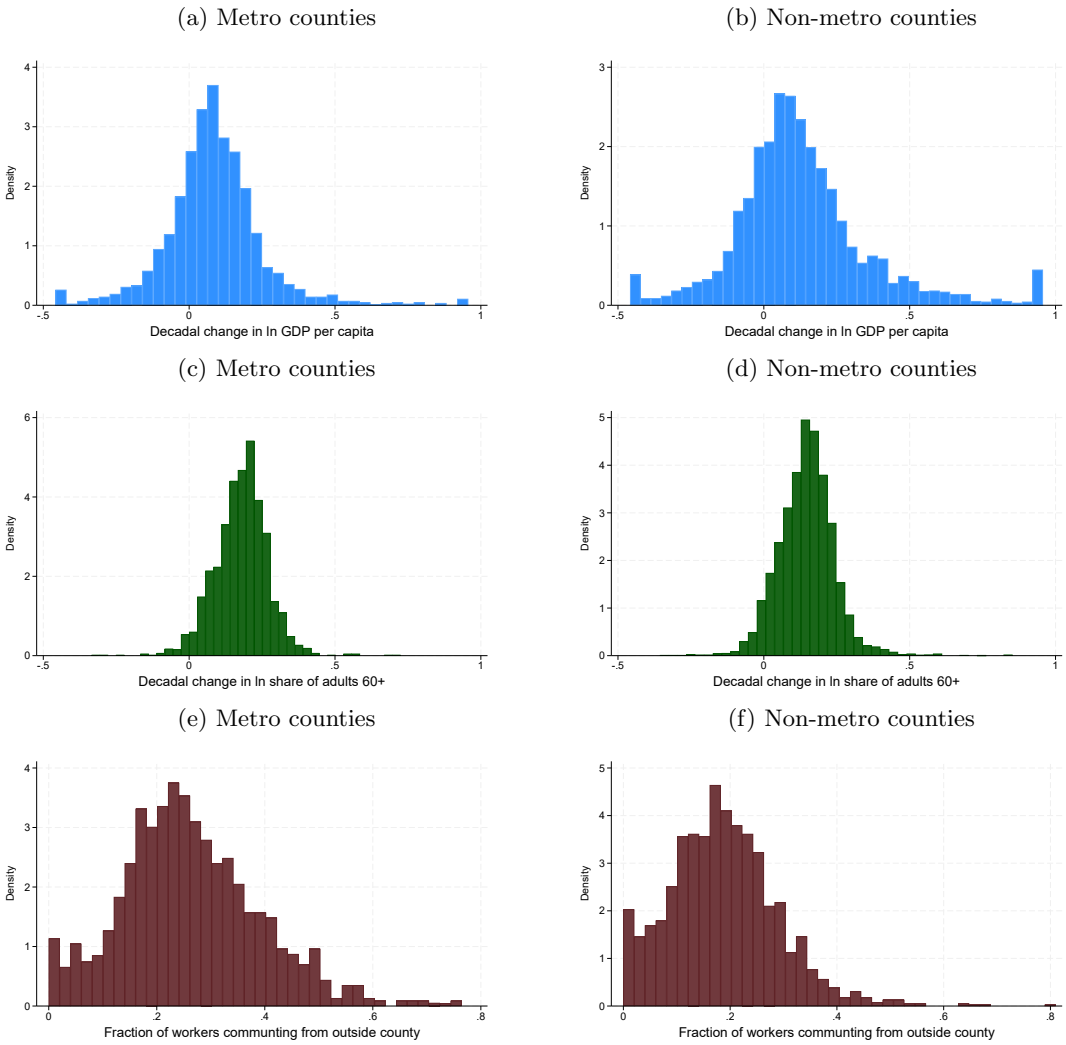
Under this specification, β_1 captures the effect of aging in completely closed counties, while β_2 measures how this effect changes as counties become more integrated into regional labor markets. We estimate this model using the same 2SLS approach outlined above.

4 Results

4.1 Descriptive Statistics

We begin by exploring the distributional properties of our main variables across metro and non-metro counties, presented in Figure 3. Panels A through F show histogram plots of three variables: decadal growth in log real GDP per capita, decadal change in the log share of adults aged 60 and older (our aging measure), and the share of jobs held by non-residents (our measure of local labor market openness).

Figure 3: Distribution of main variables



Notes: Figures show pooled decadal changes (2000-2010 and 2010-2020) in each variable. Metro and non-metro counties are defined by the 2023 Rural-Urban Continuum Codes.

Panel A shows the distribution of decadal GDP per capita growth for metro counties, while Panel B shows the same for non-metro counties. Metro counties exhibit a slightly tighter distribution, suggesting fewer instances of very high or very low growth. In contrast, non-metro counties have a wider distribution with more pronounced skewness in both tails, indicating greater variability in economic performance. The effects of Winsorizing at the 1st and 99th percentiles are most visible at the extremes in non-metro counties.

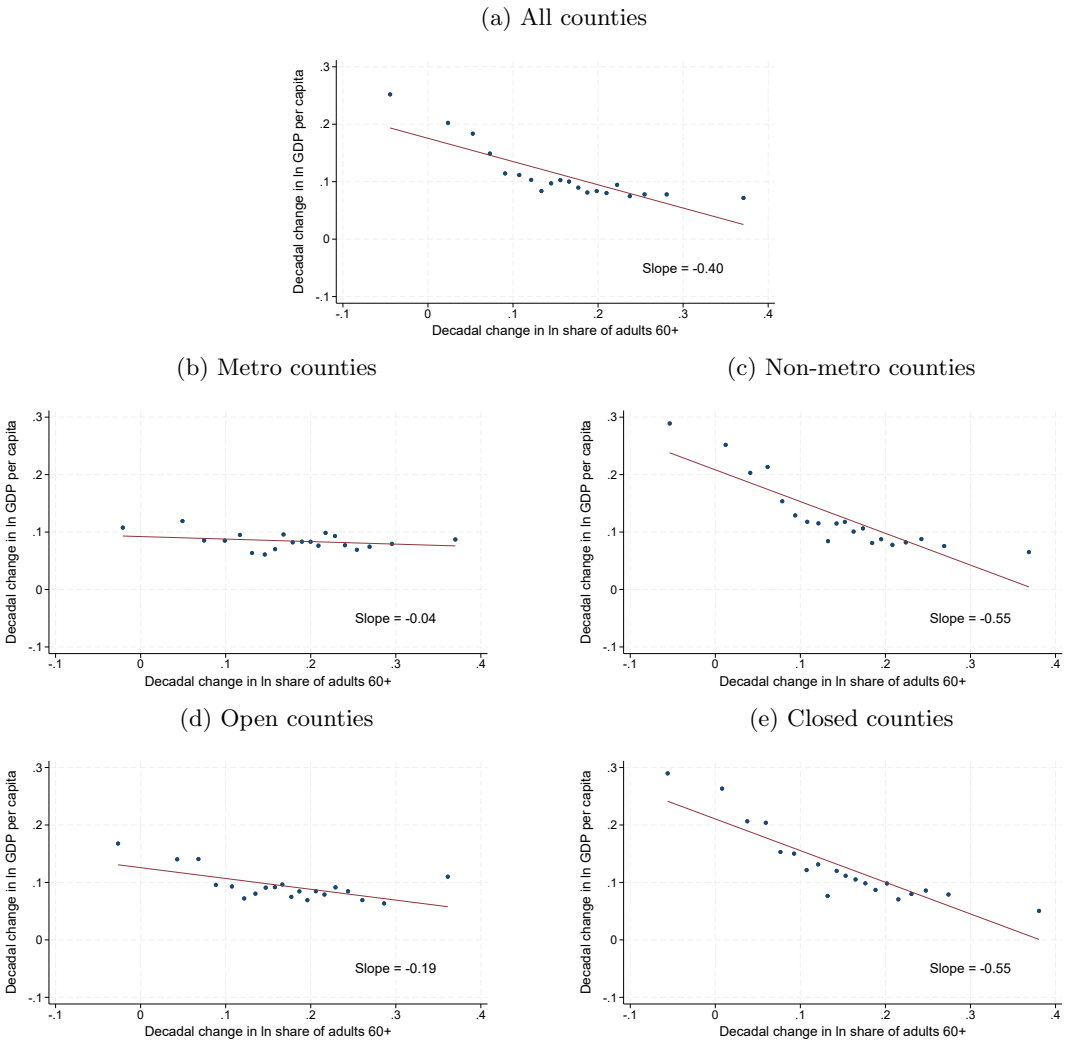
Panels C and D depict the distribution of decadal aging rates—the change in the log share of adults aged 60 and older. The two county types exhibit broadly similar patterns, though again the distribution is slightly tighter in metro counties. Aging varies substantially across both metro and non-metro counties,

with neither group dominating the distribution, reinforcing the idea that rapid population aging is not exclusively a rural phenomenon.

Panels E and F display the distribution of commuting-based openness. While the average level of openness is higher in metro counties, the distributions overlap considerably. Some metro counties remain highly self-contained, while some non-metro counties are quite open. The non-metro distribution is more right-skewed, indicating that a small subset of non-metro counties has particularly high inflows of non-resident workers.

Figure 4 turns to the raw correlation between aging and economic growth. Each panel displays a binned scatter plot in which counties are grouped into quintiles based on the decadal change in the log share of adults 60 and older, and the average growth rate is plotted for each bin. The fitted line represents the unweighted linear correlation.

Figure 4: Correlation between population aging and economic growth across counties



Notes: Binned scatter plots showing the average decadal change in ln GDP per capita for each quintile of decadal change in ln share of adults aged 60+. Regression line is the unweighted correlation in underlying data. Open/closed counties defined as above/below the median of the openness variable. Metro and non-metro counties are defined by the 2023 Rural-Urban Continuum Codes.

Panel A shows a clear negative correlation across all counties, with a slope of approximately –0.40. Panels B and C break this down by metro status. In metro counties, the slope is much flatter (–0.04) and statistically indistinguishable from zero, suggesting no meaningful correlation between aging and economic growth. In contrast, non-metro counties show a substantially steeper negative slope (–0.55),

consistent with greater vulnerability to aging-related slowdowns.

Panels D and E divide counties based on whether their openness measure is above or below the median. For counties with below-median openness (Panel D), the slope is strongly negative (–0.55), nearly identical to the non-metro pattern. In contrast, for more open counties (Panel E), the slope is noticeably flatter at –0.19. This suggests that more economically integrated counties may be better able to mitigate the adverse effects of population aging on economic performance, possibly by drawing in younger or more productive labor from surrounding areas.

Taken together, these descriptive patterns point to substantial heterogeneity in how population aging manifests across place. While aging is widespread, its implications for growth appear contingent on both county type and the degree of regional labor market integration. These insights motivate the formal econometric analyses in the sections that follow.

4.2 Aggregate Effects of Aging on Economic Growth

We next estimate the average relationship between demographic aging and local economic growth using our instrumental variables approach. Table 2 presents results from 2SLS regressions of decadal real GDP per capita growth on the change in the share of adults aged 60 and older. Each column uses a different lag length (10, 20, and 30 years) for constructing the predicted aging instrument based on historical age distributions.

Table 2: Aging and economic growth by instrument lag and county type

	All Counties			**Metro**			**Non-Metro**		
	10-year	20-year	30-year	10-year	20-year	30-year	10-year	20-year	30-year
Aging	-0.451***	-0.438***	-0.435***	-0.179**	-0.080	-0.032	-0.532***	-0.591***	-0.629***
	(0.109)	(0.113)	(0.128)	(0.078)	(0.092)	(0.115)	(0.161)	(0.165)	(0.165)
N	6,143	6,139	6,130	2,283	2,281	2,280	3,860	3,858	3,850
F	677.53	404.97	185.36	888.22	407.89	125.20	311.50	201.28	78.44

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors clustered at the state level. Metro and non-metro counties are defined by the 2023 Rural-Urban Continuum Codes.

When all counties are pooled together, we find a strong and statistically significant negative relationship between population aging and economic growth. The estimated coefficients range from -0.43 to -0.45, depending on the lag used. For example, using the 10-year lag (Column 1), the point estimate implies a 10 percent increase in the share of adults over 60 is associated with a 4.5 percent decline in real GDP per capita. The results are quite stable across specifications and robust to the choice of lag length, suggesting the effect is not sensitive to the particular age distribution vintage used for instrument construction.

All models include state and decade fixed effects to account for regional macroeconomic conditions and time-specific shocks. Standard errors are clustered at the state level to account for spatial correlation in aging trends and policy environments. First-stage F-statistics (reported at the bottom of the table) indicate strong instrument relevance, especially for the 10- and 20-year lags. Taken together, these results suggest that population aging has had a sizable and robust negative effect on economic growth across U.S. counties between 2000 and 2020.

To better understand how local context moderates the relationship between aging and economic performance, Table 2 disaggregates the estimates by metro and non-metro counties. Confirming our descriptive results, we find that the negative effects of aging on growth are highly concentrated in non-metro areas.

For metro counties, the estimated coefficients are small and statistically indistinguishable from zero

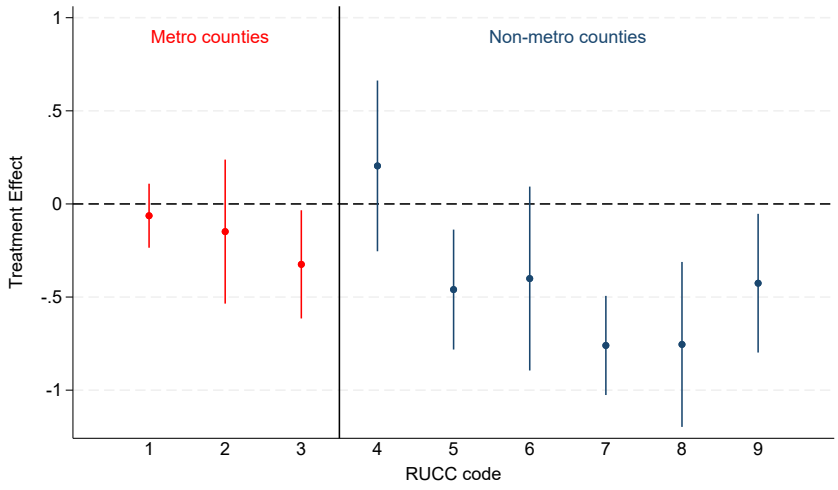
across all but the 10-year lag. This suggests that aging does not, on average, impede economic growth in urban areas. In contrast, for non-metro counties, the effects are large, negative, and statistically significant. The point estimates range from -0.53 to -0.62, implying that a 10 percent increase in the share of older adults is associated with roughly a 6 percent decline in GDP per capita over a decade.

These findings point to important regional disparities in the capacity to adapt to demographic change. While urban counties may mitigate the economic impact of aging through agglomeration economies, labor market flexibility, and access to capital, rural and small-town areas appear much more vulnerable to the structural headwinds posed by population aging.

This divergence also helps reconcile the relatively modest aggregate effects seen in pooled specifications: when metro and non-metro areas are combined, the negative effects in non-metro regions are partially offset by the near-zero effects in urban counties. In subsequent sections, we explore the mechanisms behind this heterogeneity, focusing on differences in industry composition and commuting patterns.

To further explore heterogeneity across the rural-urban spectrum, Figure 5 plots the estimated effects of aging on economic growth separately for each of the nine Rural-Urban Continuum Codes (RUCCs), using the 10-year lag instrument. While the overall pattern suggests larger negative effects in more rural areas, the relationship is not perfectly monotonic. Notably, the negative effect is statistically significant for RUCC 3 counties—metro areas with fewer than 250,000 people—but this result does not persist across all lag specifications (see results in appendix Table 8). Interestingly, RUCC 4 counties, which are non-metro but have urban populations over 20,000 and are adjacent to metro areas, show no statistically significant effect. In contrast, starting with RUCC 5 counties, which are similarly urban in population but not adjacent to a metro area, the effects become large, negative, and statistically significant, and remain so across RUCC codes 5 through 9.

Figure 5: Aging and economic growth by rural-urban continuum codes (RUCCs)



Notes: Results using 10 year lag instrument and robust standard errors clustered at the state level.

This sharp break between codes 4 and 5—despite similar population profiles—highlights the potential importance of economic connectedness and spatial integration. Consider two illustrative cases in Colorado: Fremont County (RUCC 4), anchored by the city of Cañon City, lies just southwest of Colorado Springs and is closely tied to that metro area's labor market through commuting and service spillovers. In contrast, Montrose County (RUCC 5) is a similarly sized urban county on Colorado's Western Slope, geographically distant from major metro areas. Despite similar urban scale, the economic insulation of Montrose may leave it more vulnerable to the growth challenges posed by population aging.

A similar, though somewhat less stark, pattern emerges when comparing RUCC codes 6 and 7. Both contain counties with urban populations between 5,000 and 20,000, but RUCC 6 counties are adjacent to metro areas while RUCC 7 counties are not. Consistent with the broader trend, we observe that aging has a more negative economic impact in RUCC 7 counties, suggesting that even among smaller urban areas, proximity to a metro region may buffer the local economy against the adverse effects of aging.

This pattern supports the idea that openness to economic flows—whether through commuting, trade, or institutional ties—may mediate the local impact of aging. We explore this theme more directly below by examining how commuting patterns affect vulnerability to demographic shifts. For now, the results reinforce the idea that economic geography—not just rurality per se—plays a crucial role in shaping counties' ability to withstand the economic effects of an aging population.

4.3 Sectoral Decomposition

To better understand the sectoral channels through which demographic aging affects local economic performance, we estimate separate IV models using real GDP per capita by industry as the outcome. Table 3 presents estimated coefficients for eleven major industry sectors, disaggregated by all counties, metro counties, and non-metro counties.

Table 3: Aging and economic growth by industry and county type

Industry	**All Counties**	**Metro**	**Non-Metro**
Agriculture, forestry, fishing and hunting	-2.619***	-2.183***	-3.027***
	(0.557)	(0.511)	(0.867)
Construction	-1.283***	-0.948***	-1.442***
	(0.189)	(0.166)	(0.251)
Educational Services	0.792**	0.678**	0.844
	(0.331)	(0.290)	(0.562)
Government	-0.205***	-0.207***	-0.117**
	(0.039)	(0.038)	(0.050)
Health Care and Social Assistance	0.356***	0.333***	0.344***
	(0.063)	(0.076)	(0.109)
Leisure and Hospitality	-0.008	-0.073	0.020
	(0.064)	(0.129)	(0.099)
Manufacturing	-0.378**	0.226	-0.679***
	(0.160)	(0.176)	(0.229)
Mining, quarrying, and oil and gas extraction	-0.841*	-0.514	-0.512
	(0.445)	(0.474)	(0.574)
Other services	-0.102*	-0.017	-0.093
	(0.059)	(0.063)	(0.107)
Professional and Business Services	0.370**	0.346**	0.080
	(0.186)	(0.142)	(0.251)
Trade and Transportation	-0.385***	-0.185	-0.290*
	(0.107)	(0.141)	(0.160)

Notes: Results using 10 year lag instrument. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors clustered at the state level. Outcomes windsorized at the 1% level within each industry. Metro and non-metro counties are defined by the 2023 Rural-Urban Continuum Codes.

Across all counties, aging is associated with significant declines in several key sectors. The largest negative effect is observed in agriculture and forestry, followed by construction, mining and oil extraction, trade and transportation, manufacturing, and government. These sectors are generally more labor-intensive or tied to physical production, and may be more vulnerable to reductions in local working-age

populations or declines in demand stemming from aging populations. Notably, these declines are not offset by losses in leisure and hospitality or other services, where the estimated effects are small.

At the same time, we find that aging is associated with increases in per capita output in health care, educational services, and professional and business services. These sectors are either directly linked to population aging—such as increased demand for health care—or may reflect structural shifts in local economies toward service-oriented and knowledge-based industries.

When disaggregating by metro status, several patterns emerge. First, the overall direction of effects is broadly similar between metro and non-metro areas, but the magnitudes differ. In metro counties, the declines in agriculture, construction, and trade and transportation are smaller. The negative effect on manufacturing disappears entirely—indeed, the coefficient for manufacturing turns slightly positive, although it remains statistically insignificant.

In contrast, non-metro counties experience stronger negative effects in these same sectors, especially in agriculture, construction, and manufacturing. The estimated decline in manufacturing output per capita in non-metro areas is statistically significant and substantially larger than in metro areas. This divergence suggests that metro counties may be better positioned to adapt manufacturing processes to accommodate an aging workforce—possibly through greater automation, capital substitution, or more diversified industrial bases. In non-metro regions, by contrast, manufacturing may remain more reliant on manual labor or be more exposed to population loss, reducing local production capacity and demand.

The positive effects of aging on health care, educational, and professional services are present in both metro and non-metro counties, though the effect on professional services is smaller in magnitude in the latter. This may reflect differences in the availability or scale of these services, as well as limited workforce pipelines in rural areas.

Overall, these results indicate that the economic impact of aging is mediated by the industrial structure of local economies. While some service sectors expand in response to demographic change, many goods-producing and public-facing sectors contract, particularly in non-metro areas. The ability of metro regions to absorb structural change—especially in manufacturing—may offer partial insulation from the economic consequences of aging.

4.4 Commuting Openness

We next examine whether a county's economic openness—measured as the share of workers commuting in from other counties—shapes its vulnerability to demographic aging. This builds on prior findings by probing whether spatial labor market integration buffers the local economy from the adverse effects of aging.

Table 4 reports results from our baseline 2SLS specification, now including an interaction between the change in the older adult share and county openness. Each panel presents estimates separately for all counties, metro counties, and non-metro counties, across the 10-, 20-, and 30-year instrument lags.

Table 4: Aging and economic growth by commuting openness

	All Counties			**Metro**			**Non-Metro**		
	10-year	20-year	30-year	10-year	20-year	30-year	10-year	20-year	30-year
Aging	-0.686***	-0.743***	-0.637***	-0.287**	-0.236*	-0.199*	-0.749***	-0.826***	-0.754***
	(0.162)	(0.166)	(0.145)	(0.126)	(0.131)	(0.111)	(0.194)	(0.210)	(0.196)
Aging × Open	0.775***	0.936***	0.625***	0.272	0.390	0.427**	1.103***	1.162***	0.631**
	(0.255)	(0.280)	(0.199)	(0.218)	(0.252)	(0.202)	(0.390)	(0.398)	(0.264)

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors clustered at the state level. Metro and non-metro counties are defined by the 2023 Rural-Urban Continuum Codes.

Across all counties, the results show a consistent and significant moderating effect of openness. The

main effect of aging remains strongly negative—ranging from −0.68 to −0.74—reflecting the impact in counties with very low openness (i.e., where few workers commute in from outside). However, the interaction term between aging and openness is positive and statistically significant across all three lags, ranging from 0.62 to 0.93. This pattern indicates that the economic impact of aging is substantially mitigated in counties that are more integrated into regional labor markets.

The effects are particularly pronounced in non-metro counties. For instance, under the 10-year lag specification, the baseline effect of aging is −0.74, but the interaction coefficient is a sizable 1.10, suggesting that in non-metro counties with high openness, the negative effect of aging can be nearly neutralized or even reversed. This reinforces the idea that rural areas connected to broader regional economies are more resilient in the face of demographic aging.

Interestingly, metro counties also exhibit a negative main effect of aging, and while the interaction term is not always statistically significant, it remains consistently positive and sizable. This suggests that even in urban areas, a lack of labor market integration may heighten the economic risks of aging, while spatially open metro counties are better able to absorb demographic shifts.

Figure 6 visualizes these patterns by plotting the estimated marginal effect of aging on GDP per capita growth as a function of commuting openness (appendix Figure 7 plots results separately for metro and non-metro counties). At zero openness, the effect is strongly negative—around −0.7. As openness increases, the marginal effect becomes progressively less negative, approaching −0.2 around an openness level of 0.6. This gradient reinforces the interpretation that spatial integration is a key mediating mechanism.

Figure 6: Average marginal effects by commuting openness



Notes: Results using all counties and 10 year lag. Robust standard errors clustered at the state level.

Taken together, these results suggest that economic openness—via commuting flows—offers counties an important buffer against the economic drag associated with population aging. Openness may allow firms to draw on a wider labor pool, offsetting local aging pressures, and may also facilitate knowledge spillovers and market access that strengthen local resilience.

In combination with our earlier RUCC code analysis, these findings underscore the importance of geography and connectivity. The stark contrast between RUCC codes 4 and 5, and between codes 6 and 7, is echoed here: counties with similar urban scale but differing levels of spatial integration exhibit divergent responses to aging.

These results suggest that commuting openness plays an important role in mediating the economic consequences of demographic aging. To further explore how this relationship varies by economic structure, appendix Table 9 presents industry-specific regressions that interact aging with commuting open-

ness. Although the interaction terms are generally noisy, a few notable patterns emerge in the pooled county results. Specifically, we find statistically significant positive interactions in four sectors: construction, mining, healthcare, and professional and business services. The first two—construction and mining—are industries that exhibit negative growth effects from aging in our earlier decomposition. In these cases, greater openness appears to partially mitigate the sectoral decline associated with an aging population, perhaps by enabling labor or capital inflows from surrounding areas.

In contrast, the positive interactions in healthcare and professional services reflect a somewhat different pattern. These industries show positive baseline effects from aging in pooled regressions, but the interaction analysis reveals that these gains accrue only in counties with higher levels of openness. In other words, more isolated counties do not experience the same upside in healthcare or professional/business growth that more economically integrated counties do. This implies that openness is not merely a buffer against decline, but may be a prerequisite for reaping the potential benefits of demographic change in certain service-oriented sectors. Together, these results reinforce the idea that economic openness shapes not only the magnitude but also the composition of local economic responses to aging.

4.5 Robustness Checks

To assess the stability of our findings, Table 5 presents results from a series of robustness checks. Each row corresponds to a different specification, with estimates shown separately for all counties, metro counties, and non-metro counties. For ease of comparison, the first row replicates our baseline results, which use unweighted 2SLS estimates of decadal GDP per capita growth on instrumented changes in the 60+ population share, with controls for state and decade fixed effects and standard errors clustered at the state level. The remaining rows explore alternative modeling choices and data definitions. Broadly, our conclusions hold across specifications, especially for non-metro counties, though several patterns merit closer discussion.

4.5.1 Population-Weighted Estimates

The second row of Table 5 introduces population weights to account for county size. While our baseline specifications are intentionally unweighted to focus on place-level effects rather than population-aggregated impacts, it is informative to examine how results vary when giving larger counties more influence. We use county population in 2000 as our weights.

Population weighting has the largest impact of any robustness check. For results pooled across all counties, the estimates become slightly positive and statistically insignificant. Among metro counties, we even observe a positive and statistically significant association between aging and growth for the 20 and 30-year lags (e.g., a coefficient of 0.21 for the 20-year lag). In contrast, the results for non-metro counties remain large, negative, and highly significant, with magnitudes very similar to baseline (e.g., -0.54 for the 10-year lag). These findings underscore that the growth penalty of aging is concentrated in smaller, more rural places.

4.5.2 Handling of Outliers

The next set of rows assess whether our findings are driven by extreme values in the outcome variable. Our baseline results Winsorize the top and bottom 1% of economic growth changes. When we remove this Winsorization and instead use the raw, untrimmed data, we observe only minor differences in coefficient estimates across all county types, with some decline noted for non-metro counties (e.g., the 10-year lag estimates falls from -0.53 to -0.41). Expanding the trimming to the top and bottom 5% of values similarly results in minimal changes, suggesting that our findings are not sensitive to the specific

Table 5: Aging and economic growth robustness results

	All Counties			Metro			Non-Metro		
	10-year	20-year	30-year	10-year	20-year	30-year	10-year	20-year	30-year
Baseline	-0.451***	-0.438***	-0.435***	-0.179**	-0.080	-0.032	-0.532***	-0.591***	-0.629***
	(0.109)	(0.113)	(0.128)	(0.078)	(0.092)	(0.115)	(0.161)	(0.165)	(0.165)
Weighted	0.014	0.065	0.126	0.162	0.219**	0.285**	-0.540***	-0.611***	-0.526***
	(0.094)	(0.083)	(0.103)	(0.106)	(0.088)	(0.120)	(0.119)	(0.123)	(0.110)
No Windsorize	-0.413***	-0.419***	-0.433***	-0.190**	-0.094	-0.037	-0.419*	-0.489**	-0.561***
	(0.134)	(0.126)	(0.136)	(0.091)	(0.107)	(0.123)	(0.242)	(0.235)	(0.206)
Windsorize at 5%	-0.406***	-0.416***	-0.410***	-0.145**	-0.078	-0.059	-0.502***	-0.593***	-0.606***
	(0.089)	(0.092)	(0.100)	(0.058)	(0.063)	(0.076)	(0.122)	(0.131)	(0.130)
No Outliers	-0.474***	-0.455***	-0.458***	-0.171***	-0.089	-0.059	-0.602***	-0.655***	-0.695***
	(0.095)	(0.102)	(0.118)	(0.063)	(0.074)	(0.104)	(0.126)	(0.136)	(0.140)
State × Year	-0.309***	-0.310***	-0.367***	-0.116	-0.034	0.009	-0.322**	-0.378***	-0.513***
	(0.084)	(0.093)	(0.116)	(0.081)	(0.101)	(0.124)	(0.133)	(0.126)	(0.127)
2020	-0.447***	-0.427***	-0.441***	-0.189**	-0.076	-0.030	-0.522***	-0.585***	-0.654***
	(0.105)	(0.111)	(0.132)	(0.079)	(0.089)	(0.117)	(0.153)	(0.156)	(0.162)
Age controls	-0.372***	-0.302***	-0.396***	-0.201**	-0.008	-0.132	-0.363**	-0.356**	-0.507***
	(0.094)	(0.096)	(0.112)	(0.091)	(0.103)	(0.171)	(0.158)	(0.147)	(0.154)

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors clustered at the state level. Baseline results are unweighted and use outcome variable windsorized at 1%. "Weighted" includes 2000 population as observation weights. "No Windsorize" uses the raw unwindsorized outcome data. "Windsorize at 5%" windsorizes the outcome at 5%. "No outliers" drops outliers at the 1% level instead of windsorizing. "State x Year" adds a state by year interaction term to the baseline specification. "2020" uses 2020 GDP data in place of 2019. "Age Controls" includes the share of adult population that is aged 30-39, 40-49, and 50-59. IV for these age groups are constructed analogously to our baseline IV. Age group 30-39 is excluded from the 30-year lag estimates as the IV is not available. Metro and non-metro counties are defined by the 2023 Rural-Urban Continuum Codes.

trimming threshold. As a final check, we also test an alternative strategy of dropping outlier observations entirely—those in the top and bottom 1% of the distributions—rather than recoding them. While this yields slightly more negative coefficients for non-metro counties, the changes are relatively small, and the overall patterns remain robust. Together, these checks indicate that outliers are not driving the estimated relationship between aging and growth.

4.5.3 State-by-Decade Interactions

We next allow for more flexible controls for regional economic shocks by interacting state fixed effects with decade indicators. This controls for potential state-specific time trends in economic growth that may be correlated with aging. This reduces the magnitude of our estimated coefficients somewhat. For example, the 10-year lag coefficient for all counties drops from -0.45 to -0.30. However, the signs and significance of the coefficients are largely preserved, especially in non-metro counties. These results suggest that state-level shocks are not confounding our core findings.

4.5.4 Using 2020 GDP Data

Our baseline growth measures rely on 2019 GDP data to avoid potential distortions from the COVID-19 pandemic. As a final check, we re-estimate our models using 2020 GDP data as the endpoint for the final decade. This change has only minor effects on the results. For all counties and metro counties, the estimates remain within the range of baseline values. In non-metro counties, the coefficients become slightly more negative but still highly significant. This confirms that our results are not driven by the choice to exclude 2020.

4.5.5 Controlling for Younger Age Groups

As an additional robustness check, we account for potential confounding effects arising from changes in other age groups. In particular, shifts in the share of adults aged 60 and over may be systematically correlated with changes in the relative size of prime-age and near-retirement cohorts, creating potential omitted variable bias if these demographic shifts independently influence local economic growth. To address this concern, we augment our baseline specification by including changes in the shares of individuals aged 30–39, 40–49, and 50–59. Consistent with our identification strategy, we instrument for these cohort shares using lagged age structure in the same manner as for the 60+ population share.

Including these additional demographic controls modestly attenuates the magnitude of the estimated aging effect. The coefficients for all counties combined and for non-metro counties become somewhat less negative relative to the baseline specification. However, the estimates remain economically large and statistically significant across instrument lags. These results suggest that while shifts in adjacent age cohorts partially account for local growth dynamics, the negative growth effects associated with population aging are not simply driven by correlated changes in other working-age groups. Rather, the aging effect appears robust to controlling for broader demographic restructuring within counties.

4.5.6 Commuting Zone

As an additional robustness check, we aggregate the analysis to the commuting zone (CZ) level, which more closely approximates integrated labor market areas. This specification addresses concerns that county boundaries may fragment economically connected regions and allows us to test whether the results persist when using a broader geographic unit. A shown in Table 6, re-estimating our baseline IV specification at the CZ level yields results that are similar to the county-level estimates. Across all CZs, the estimated coefficients on aging remain negative and statistically significant across all instrument lags, with point estimates close to -0.5. This magnitude is near our baseline county results (≈ -0.44), suggesting that the negative growth effects of demographic aging are not an artifact of county-level boundary definitions.

Table 6: Aging and economic growth at the commuting zone level

	All Commuting Zones			**Population >250k**			**Population <250k**		
	10-year	20-year	30-year	10-year	20-year	30-year	10-year	20-year	30-year
Aging	-0.588***	-0.559***	-0.405***	-0.113	0.070	0.134	-0.573***	-0.537***	-0.410***
	(0.131)	(0.125)	(0.121)	(0.116)	(0.123)	(0.137)	(0.145)	(0.141)	(0.150)
N	1,153	1,150	1,146	432	432	432	721	718	714
F	181.41	729.79	278.02	246.10	204.87	156.62	115.62	431.46	171.93

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors clustered at the commuting zone level. Split based on 2000 population.

We further explore heterogeneity by splitting CZs based on baseline population size in 2000, using a threshold of 250,000 residents to distinguish larger and smaller labor markets.[6] Among smaller CZs, the estimated effects of aging remain large, negative, and statistically significant across instrument lags, with magnitudes comparable to the pooled CZ results. In contrast, the coefficients for larger CZs are small and statistically insignificant. These findings mirror our earlier metro/non-metro comparisons and reinforce the conclusion that demographic aging imposes more severe growth penalties in smaller and less economically thick labor markets. Together, the CZ-level results strengthen the interpretation that local economic scale and integration capacity play central roles in shaping resilience to demographic change.

[6]This population split for commuting zones mimics the ratio of metro to non-metro counties. Specifically, our baseline result has 37% metro counties (2,283/6143) and the commuting zone population cutoff yields 37% of commuting zones above 250,000 people.

5 Placebo tests

A central identifying assumption of our empirical strategy is that predicted aging—constructed using lagged age structures and national survival rates—captures demographic momentum rather than persistent local economic conditions. A potential concern is that the instrument may proxy for long-run county characteristics, such as structural decline or limited economic dynamism, which could independently influence growth outcomes.

To assess this concern, we conduct a placebo test that examines whether predicted aging for a future period is associated with economic growth in a prior decade. Specifically, we test whether predicted changes in the older population share between 2010 and 2020 are correlated with GDP per capita growth between 2000 and 2010.[7] If the instrument were capturing persistent local economic conditions rather than future demographic change, it would be expected to predict earlier growth outcomes as well. Because predicted aging is constructed from historical age structure, it is naturally correlated with earlier demographic trends. As a result, any unconditional relationship with prior economic growth may reflect the persistence of demographic change rather than a violation of the exclusion restriction. We therefore focus on whether predicted future aging has explanatory power for prior growth conditional on contemporaneous aging and county type.[8]

Table 7 presents the results. For each lag specification (10-, 20-, and 30-year), we estimate OLS regressions of 2000–2010 growth on both actual aging during 2000–2010 and predicted aging for 2010–2020. All specifications include state fixed effects and RUCC fixed effects to account for broad differences in regional economic structure and county type. We report results for the full sample, as well as separately for metropolitan and non-metropolitan counties.

Table 7: Aging and economic growth placebo results

	All Counties			**Metro**			**Non-Metro**		
	10-year	20-year	30-year	10-year	20-year	30-year	10-year	20-year	30-year
Current Aging	-0.164*	-0.173*	-0.179**	0.119	0.145*	0.064	-0.346***	-0.361***	-0.339***
	(0.089)	(0.087)	(0.072)	(0.093)	(0.078)	(0.059)	(0.081)	(0.087)	(0.080)
Future PredAging	-0.060	-0.031	0.010	-0.136	-0.152	0.064	-0.035	-0.006	-0.053
	(0.075)	(0.064)	(0.081)	(0.149)	(0.137)	(0.155)	(0.100)	(0.114)	(0.080)

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors clustered at the state level. Current aging is the actual change in 60+ share between 2000 and 2010. Future PredAging is the predicted change in 60+ share between 2010 and 2020 based on 10-, 20-, and 30-year lagged instruments. Regressions include state and RUCC fixed effects.

Across all specifications, actual aging during 2000–2010 is negatively and statistically significant in the full sample and in non-metropolitan counties, consistent with our baseline findings. In contrast, predicted aging for 2010–2020 is uniformly small in magnitude and statistically insignificant across all samples and lag structures. Taken together, these results provide support for the exclusion restriction underlying our instrumental variables strategy. Once contemporaneous aging and broad county characteristics are accounted for, predicted future aging does not explain earlier economic growth, suggesting that the instrument is not simply proxying for persistent local economic decline.

6 Discussion and Conclusion

Our findings highlight the unequal economic consequences of demographic aging across U.S. counties, emphasizing the role of regional integration and industrial composition in mediating local declines in

[7] We focus on 2000–2010 because county-level GDP data are only available beginning in 2001, preventing construction of earlier economic growth measures.

[8] Results are similar when conditioning on baseline demographic structure using 2000 age shares instead of contemporaneous aging from 2000 to 2010; coefficients on predicted future aging remain largely statistically insignificant across specifications.

economic growth. While aging poses challenges to growth, especially in non-metro and economically isolated places, its impacts are not uniform. The local context—shaped by commuting patterns, sectoral specialization, and spatial connectivity—fundamentally determines whether aging becomes a drag on growth. From a spatial economic perspective, this suggests that demographic shocks interact with the structure of regional labor markets: counties embedded in larger, economically integrated regions can draw on broader labor pools and adapt more easily, while more isolated places must adjust largely through their own local demographic and industrial change.

We find robust evidence that increases in the older population share significantly depress per capita GDP growth at the county level. A 10 percent increase in the 60+ share reduces GDP per capita by about 4.5 percent on average, with larger effects in non-metro counties. This growth penalty reflects sectoral contractions in agriculture, construction, and manufacturing, particularly in rural areas where these industries play a larger economic role and local labor markets are less adaptable. In contrast, metro counties—especially those with more diversified economies—appear better positioned to offset aging-related slowdowns through growth in health care and professional services and the partial resilience of manufacturing sectors. These patterns are consistent with the idea that larger and more diversified regional economies have greater capacity to reallocate labor and capital across sectors when demographic pressures emerge.

A key insight from our analysis is that regional integration—measured by commuting flows and adjacency to metro areas—mitigates the negative economic consequences of aging. Counties with stronger commuting ties to neighboring regions experience less severe declines in output, suggesting that economic connectedness allows for greater labor market pooling, spillover demand, and access to service infrastructure. This aligns with theoretical expectations that open, integrated regions can better absorb demographic shocks by reallocating labor and capital more efficiently. In practice, commuting integration effectively expands the functional labor market available to firms, enabling them to draw workers from surrounding areas even as the local population ages.

Our industry-specific results further support this interpretation. While aging is associated with expansion in health care and professional services sectors across the board, these effects are more economically meaningful in integrated counties. In disconnected rural areas, growth in age-aligned services is often insufficient to offset broader sectoral contraction, pointing to limits in adaptive capacity where institutions, infrastructure, or workforce pipelines are weak. In these places, demographic aging may reinforce existing structural challenges, accelerating declines in industries that rely heavily on local labor supply or local demand.

Much of the policy debate around population aging has focused on national-level levers, such as the retirement age, immigration, and fertility incentives. However, from a local policy perspective, our results underscore the importance of targeted strategies to bolster economic resilience in aging, non-integrated regions. Investments in transportation infrastructure, broadband connectivity, and workforce development could help strengthen ties to larger labor markets and expand local capacity to attract or grow service-based industries. Regional planning efforts that promote integration may therefore not only support short-term labor mobility, but also foster long-run adaptability to demographic change. More broadly, these results suggest that demographic aging may contribute to widening regional economic disparities if economically isolated areas lack the connectivity needed to adjust.

More broadly, our findings contribute to a growing literature examining how demographic change interacts with spatial economic structure. While previous work has documented the aggregate effects of population aging on productivity and labor supply (e.g., Maestas et al. (2023)), our results show that these effects vary substantially across local labor markets. In particular, the ability of counties to draw workers from surrounding areas appears to play a central role in determining whether aging translates into slower economic growth. This highlights the importance of regional labor market integration as

a mechanism through which local economies adjust to demographic shocks. By emphasizing spatial heterogeneity and commuting-based integration, our analysis complements national-level studies and provides new evidence on how demographic change interacts with the geographic organization of economic activity.

Our study has limitations that suggest directions for future research. First, because our approach instruments for aging using lagged age shares, it estimates the impact of demographic momentum rather than aging driven by recent migration. That is, our results capture the effects of aging due to underlying cohort aging and long-run settlement patterns, not selective in- or out-migration of older or younger populations. Second, while we emphasize regional integration through commuting flows, other dimensions, such as institutional collaboration, trade linkages, or governance structure may also shape resilience to aging. Future work could incorporate these additional channels. Lastly, while we focus on economic growth, aging may affect other dimensions of well-being, such as health outcomes, inequality, or civic engagement that merit further attention. Additional research using firm- or worker-level data could also help clarify the mechanisms through which demographic change affects productivity, labor demand, and industrial structure across regions.

In sum, the economic effects of aging are not only a function of who lives where, but also of how places are connected and how they adapt. Regions that are economically integrated appear better positioned to absorb demographic shocks, while smaller and more isolated counties face greater structural adjustment pressures. As the U.S. continues to age, understanding these spatial dynamics will be essential for designing place-based policies that promote equitable and sustainable growth.

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7 Appendix

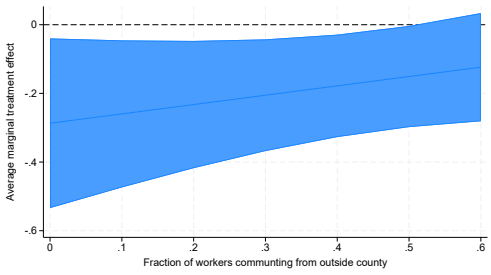
Table 8: Aging and economic growth by rural-urban continuum codes (RUCCs)

RUCC	10-year	20-year	30-year
1	-0.063	0.059	0.037
	(0.088)	(0.075)	(0.084)
2	-0.149	-0.059	0.058
	(0.197)	(0.224)	(0.278)
3	-0.325**	-0.252	-0.161
	(0.148)	(0.168)	(0.324)
4	0.204	0.027	-0.033
	(0.234)	(0.178)	(0.162)
5	-0.460***	-0.436**	-0.429**
	(0.164)	(0.185)	(0.167)
6	-0.401	-0.524*	-0.372
	(0.252)	(0.280)	(0.319)
7	-0.760***	-0.746***	-0.602***
	(0.136)	(0.127)	(0.171)
8	-0.754***	-0.490	-0.417
	(0.226)	(0.348)	(0.334)
9	-0.426**	-0.338	-0.586**
	(0.190)	(0.212)	(0.238)

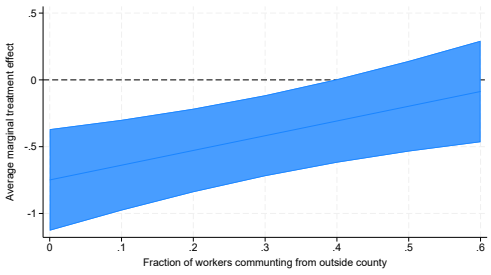
Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors clustered at the state level.

Figure 7: Average marginal effects by commuting openness

(a) Metro counties



(b) Non-metro counties



Notes: Results using 10 year lag instrument. Robust standard errors clustered at the state level.

Table 9: Aging and economic growth by industry and commuting openness

Industry	**All Counties**	**Metro**	**Non-Metro**
Agriculture, forestry, fishing and hunting	-2.787***	-2.054**	-3.335***
	(0.886)	(0.997)	(1.085)
Agriculture, forestry, fishing and hunting × Open	0.560	-0.354	1.471
	(1.489)	(1.767)	(2.549)
Construction	-1.884***	-1.247***	-1.820***
	(0.298)	(0.247)	(0.373)
Construction × Open	1.909***	0.747*	1.992**
	(0.529)	(0.414)	(0.943)
Educational Services	0.958**	0.551	1.443**
	(0.465)	(0.347)	(0.726)
Educational Services × Open	-0.566	0.332	-3.306
	(0.728)	(0.566)	(2.038)
Government	-0.221***	-0.242***	-0.185***
	(0.048)	(0.061)	(0.056)
Government × Open	0.050	0.087	0.348*
	(0.125)	(0.130)	(0.196)
Health Care and Social Assistance	0.167*	0.152*	0.163
	(0.094)	(0.082)	(0.167)
Health Care and Social Assistance × Open	0.634***	0.473*	1.012
	(0.235)	(0.262)	(0.654)
Leisure and Hospitality	0.055	-0.075	0.152
	(0.080)	(0.146)	(0.120)
Leisure and Hospitality × Open	-0.209	0.005	-0.744**
	(0.167)	(0.187)	(0.343)
Manufacturing	-0.554**	0.190	-0.885***
	(0.247)	(0.237)	(0.310)
Manufacturing × Open	0.578	0.094	1.058
	(0.468)	(0.403)	(0.773)
Mining, quarrying, and oil and gas extraction	-1.653***	-1.363***	-1.166
	(0.586)	(0.450)	(0.739)
Mining, quarrying, and oil and gas extraction × Open	2.726***	2.197**	3.380
	(0.801)	(1.031)	(2.643)
Other services	-0.152	0.026	-0.225
	(0.103)	(0.076)	(0.157)
Other services × Open	0.163	-0.108	0.750*
	(0.183)	(0.126)	(0.404)
Professional and Business Services	0.079	0.332**	0.089
	(0.231)	(0.166)	(0.262)
Professional and Business Services × Open	0.962**	0.035	-0.047
	(0.411)	(0.502)	(0.562)
Trade and Transportation	-0.364**	-0.229	-0.183
	(0.163)	(0.218)	(0.194)
Trade and Transportation × Open	-0.071	0.113	-0.572
	(0.306)	(0.366)	(0.579)

Notes: Results using 10 year lag instrument. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors clustered at the state level.