Aging Consumers, Competition, and Growth*

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Abstract

Population aging reshapes aggregate demand by changing the age composition of consumers. We study how life-cycle differences in substitution across varieties and shopping behavior affect growth through product-market competition. In a sectoral search model of oligopolistic price competition, the transition from young to middle age weakens competition because demand becomes less elastic, while the transition into retirement strengthens competition because search intensity rises. Using a shift-share IV that combines foreign demographic shifts with sectoral exposure to foreign demand, we identify changes in the age composition of demand. We find that an increase in middle-aged demand raises producer prices and profit shares and lowers output, implying negative co-movement between prices and quantities and suggesting supply-side responses. Embedding this mechanism in a multi-sector general equilibrium model calibrated to the U.S. economy, we show that the demand-composition channel lowers real GDP by about 2 percent in 2019 relative to a counterfactual with fixed 1995 demand shares, with the effect peaking around 2010 and partly reversing thereafter, driven by baby-boomer aging.

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1 Introduction

Advanced economies are undergoing a profound demographic transition, as declining fertility and rising longevity reshape the age distribution of the population. The macroeconomic consequences of this shift have been studied primarily through supply-side channels. A growing literature shows that demographic change affects innovation, productivity, and aggregate output (Maestas et al., 2023; Aksoy et al., 2019; Jones, 2022); alters the incentives to adopt labor-saving technologies and automation (Acemoglu and Restrepo, 2017, 2022; Abeliansky and Prettner, 2023; Abeliansky et al., 2020); and reshapes labor-market outcomes, including employment composition and job polarization (Moreno-Galbis and Sopraseuth, 2014). Yet demographic change not only transforms the economy through the age structure of workers. It also changes the age structure of consumers, and thereby the composition of demand, the intensity of product-market competition, firms' pricing and investment decisions, and ultimately aggregate economic outcomes.

Consumption behavior varies systematically over the life cycle. Young consumers are more willing to substitute across varieties, whereas older consumers are more brand loyal and display lower elasticities of substitution (Lambert-Pandraud et al., 2005; Lambert-Pandraud and Laurent, 2010; Bornstein et al., 2018). Shopping behavior also changes with age because the opportunity cost of time differs across groups. Working-age consumers typically devote less time to shopping and price comparison, whereas retirees can spend more time searching and therefore tend to pay lower transaction prices for a given good (Aguiar and Hurst, 2005, 2007). These life-cycle differences imply that demographic change can alter the competitive environment through the demand side, as shifts in the age composition of consumers change both the elasticity of substitution across varieties and the intensity of search across sellers.

This paper studies how changes in the age composition of demand affect product-market competition and aggregate activity. Our central idea is that demographic shifts operate as competitive demand shocks: by changing the distribution of demand elasticities and the mass of consumers who compare prices, they alter firms' pricing incentives. Unlike a standard demand shifter, which tends to move prices and quantities in the same direction, a demographic reallocation across consumer types can generate a negative co-movement between prices and quantities by changing the intensity of competition. Moreover, because the transition from young to middle age primarily lowers the elasticity of substitution across varieties, whereas the transition from middle age to old age primarily increases search intensity, the competitive effects of aging need not be monotonic over the life cycle.

The theoretical framework is a sector-level model based on Stahl (1989) and Chen and

Zhang (2011) in which a finite number of firms sell the same good, compete in posted prices, and undertake productivity-enhancing investment. Consumers are heterogeneous along two dimensions: search costs and the elasticity of substitution across sectoral goods. We capture this heterogeneity in a parsimonious way by allowing for two search-cost types and two preference types, which together generate four consumer groups. As the age composition of demand shifts across these groups, firms adjust their pricing and productivity-enhancing investment decisions in response.

The mapping from age groups to consumer types is guided by existing micro evidence on shopping behavior and substitution patterns over the life cycle. Young consumers update their baskets more frequently and exhibit higher elasticities of substitution, whereas older consumers are more brand loyal and face less elastic demand. Related evidence from time-use data suggests that young and middle-aged individuals devote less time to shopping and price comparison than older individuals, consistent with a higher opportunity cost of time during working ages. These facts motivate a two-stage representation of demographic change in the model. The transition from young to middle age is captured as a shift toward consumers with lower elasticities of substitution while search costs remain high, whereas the transition from middle age to old age is captured as a shift toward consumers with lower search costs while elasticities remain low.

To isolate variation in the age composition of demand, we use a shift-share IV strategy based on foreign demographic changes. Specifically, we instrument changes in a country–sector's age composition of demand with changes in the age composition of foreign demand, weighted by sectoral exposure to foreign demand along global value chains. To address the concern that demographic change is partly predictable and may therefore be anticipated by firms, we exploit revisions in demographic projections to construct an unexpected component of demographic change. This strategy delivers plausibly exogenous variation in the age structure of demand at the country-sector level.

The empirical results support the view that demographic composition shocks operate as competitive shocks. An increase in the share of middle-aged consumers raises producer prices and profit shares while lowering production. By contrast, increases in the shares of young and old consumers are broadly associated with opposite results. These patterns imply a negative co-movement between producer prices and quantities: when demand shifts toward consumer groups that weaken competition, prices rise while output falls, whereas shifts toward groups that intensify competition lead prices to fall and output to expand. The evidence, therefore, suggests that changes in the age structure of demand are an economically meaningful source

of variation in product-market competition.

To assess the aggregate relevance of the mechanism, we embed the sectoral model into a multi-sector general equilibrium framework. This extension allows changes in product-market competition to propagate beyond a single sector through household expenditure allocation, factor prices, and firms' productivity-enhancing investment decisions. The quantitative model preserves the key sources of household heterogeneity emphasized in the theory, while providing a consistent aggregation of sectoral outcomes into aggregate output, prices, and profits. It therefore allows us to evaluate how the observed demographic transition translates into economy-wide effects.

Calibrated to the U.S. economy, the model reproduces the sign patterns implied by the theory and estimated in the data. In a benchmark exercise that isolates the demand-side channel by holding labor supply fixed, population aging lowers U.S. real GDP by about 2 percent in 2019 relative to a counterfactual with fixed 1995 demand shares. The effect builds up until around 2010 and partly reverses thereafter as the baby-boom cohort moves from middle age into retirement and search intensity rises. These results imply that the demand-composition channel of aging is quantitatively important and helps account for the non-monotonic aggregate effects of demographic change.

The paper makes three contributions. First, it links micro-level heterogeneity in consumer behavior to macroeconomic outcomes. Differences across age groups in elasticities of substitution (Lambert-Pandraud et al., 2005; Lambert-Pandraud and Laurent, 2010; Bornstein et al., 2018) and in search behavior, driven by the opportunity cost of time (Aguiar and Hurst, 2005, 2007), imply that the effects of population aging on competition and growth are non-monotonic over the life cycle.[1] Second, it identifies a novel demand-side channel through which demographic change affects market outcomes. Building on the literature on shopping behavior, goods-market frictions, and consumer inertia (Kaplan and Menzio, 2016; Bethune et al., 2020; Nord, 2022; MacKay and Remer, 2019), we show theoretically that aging demand alters the intensity of competition and document empirically that demographic shifts generate a negative co-movement between producer prices and quantities, consistent with interpreting aging demand as a competition shock rather than a standard demand shock. Third, it quantifies the aggregate importance of this mechanism in a multi-sector general equilibrium model, allowing us to measure the contribution of aging demand to economic growth, in the spirit of recent work on demographic demand composition and the aggregate

[1]The marketing and psychology literature studies additional dimensions of age-specific consumption behavior, including changes in cognitive ability (Gutchess, 2011; Peters, 2011), social networks (East et al., 2014), and the ability to use technology to search for information (Hargittai, 2001).

propagation of sectoral demand shocks (Cravino et al., 2022; Bai et al., 2026).

The rest of the paper is organized as follows. Section 2 presents the sector-level model and derives its implications for prices, quantities, and firm outcomes. Section 3 describes the empirical strategy and reports the main evidence on the effects of demand-side aging on sectoral outcomes. Section 4 embeds the sectoral mechanism into a multi-sector general equilibrium framework and quantifies its aggregate implications. Section 5 concludes.

2 Theoretical framework

We develop a tractable multi-sector model of product-market competition with search frictions. Goods are differentiated across sectors and are imperfect substitutes in final demand, while within each sector a finite number of firms sell the same good and compete in posted prices, as in Stahl (1989) sequential search model. Consumers differ along two dimensions that are central to our mechanism: their search costs and their elasticity of substitution across goods. Firms, in turn, choose both prices and productivity-enhancing investment. Demographic change therefore affects market outcomes through the composition of demand, altering the intensity of competition, firms' pricing decisions, and investment incentives. Because sectors are identical in structure, we present the model for a representative sector.

2.1 Sector-level model

Consumers. Consumers are heterogeneous along two dimensions: search costs and the elasticity of substitution across goods. Let $i \in \{h, l\}$ index search costs, where h denotes high search costs and l low search costs, and let $I \in \{H, L\}$ index the elasticity of substitution, where H denotes high elasticity and L low elasticity. The economy is therefore populated by four consumer types, $(i, I) \in \{(h, H), (h, L), (l, H), (l, L)\}$, with population shares $\lambda^{(i,I)} \in [0, 1]$ satisfying $\sum_i \sum_I \lambda^{(i,I)} = 1$.

Consumers with high search costs observe prices sequentially. The first price observation is free, while each additional observation costs $\nu > 0$. Let z denote the lowest price observed so far. For a consumer of type (h, I), the gain from observing an additional price $p < z$ is

$$CS^{(h,I)}(p; z) \equiv \int_p^z D^{(h,I)}(x)\, dx, \tag{1}$$

where $D^{(h,I)}(\cdot)$ denotes the sector-level demand of type (h, I) consumers and is decreasing

in price.[2] If posted prices are drawn from cumulative distribution F, the expected gain from one more search, conditional on current best price z, is

$$ECS^{(h,I)}(z) \equiv \int_b^z CS^{(h,I)}(p;z)\, dF(p), \tag{2}$$

where b is the lower bound of the price distribution. We define the reservation price $r^{(h,I)}$ by $ECS^{(h,I)}(r^{(h,I)}) = \nu$ whenever a finite solution exists, and set $r^{(h,I)} = +\infty$ otherwise. The optimal stopping rule is standard: a type-(h, I) consumer buys whenever the observed price satisfies $p \leq r^{(h,I)}$ and continues searching otherwise. If all observed prices exceed the reservation price, the consumer buys at the lowest observed price.

Consumers with low search costs face no cost of additional search. They therefore observe all posted prices and buy from the lowest-priced firm in the sector. If firms' posted prices are i.i.d. draws from F, the transaction price faced by low-search consumers is the order statistic $p_{\min} \equiv \min\{p_1, \ldots, p_N\}$, with cumulative distribution $F_{\min}(p) = 1 - (1 - F(p))^N$. Because a positive mass of consumers compares all posted prices, a symmetric pure-strategy equilibrium at the monopoly price cannot be sustained: any firm can profitably undercut by an arbitrarily small amount and capture all low-search consumers. We therefore focus on symmetric mixed-strategy equilibria.

Firms. In each sector, a finite number $N \geq 2$ of ex-ante identical firms choose posted prices and productivity-enhancing investment. Production uses labor according to

$$y^{sup.}(a) = (\bar{a} - a)^{-1}\ell, \tag{3}$$

where $y^{sup.}$ denotes output, ℓ labor input, and $a \in [0, \bar{a})$ is firm-level investment. A higher value of a raises productivity by lowering the amount of labor required to produce a given level of output. Equation (3) implies labor demand $\ell = y^{sup.}(\bar{a} - a)$, so total variable cost is $w\, y^{sup.}(\bar{a} - a)$ and marginal cost is $m(a) \equiv w(\bar{a} - a)$, where w denotes the wage. We assume a quadratic investment cost, $z(a) = a^2/2$, which implies diminishing returns to productivity-enhancing investment and keeps the firm's problem tractable.

Expected demand and firm problem. Given the search structure above, a firm posting price p faces two sources of demand. In symmetric equilibrium, consumers with high search costs generate a demand component that is split evenly across firms, while consumers with

[2] The sector-level demand functions are micro-founded in the general-equilibrium environment below.

low search costs buy from the lowest-priced firm. Expected demand is therefore

$$\mathbb{E}\{y^{dem.}(p)\} = \frac{1}{N}\sum_{I}\lambda^{(h,I)}D^{(h,I)}(p) + [1-F(p)]^{N-1}\sum_{I}\lambda^{(l,I)}D^{(l,I)}(p). \tag{4}$$

The first term captures demand from high-search consumers, while the second captures demand from low-search consumers. The probability that a firm charging price p is the lowest-priced seller is $[1-F(p)]^{N-1}$.

Given the equilibrium price distribution F, a firm choosing posted price p and investment a solves

$$\max_{\{a,p\}}\left\{\mathbb{E}\{y^{dem.}(p)\}\big(p-m(a)\big)-z(a)\right\}. \tag{5}$$

The first-order condition with respect to investment is

$$z'(a(p)) = w\,\mathbb{E}\{y^{dem.}(p)\}, \tag{6}$$

so firms invest more when expected demand is higher.

Equilibrium. Following Chen and Zhang (2011), we restrict attention to symmetric mixed-strategy equilibria. A symmetric equilibrium is a collection $\{F(p), a(p), r^{(h,H)}, r^{(h,L)}\}$, where $F(p)$ is the equilibrium distribution of posted prices, $a(p)$ is the investment choice associated with price p, and $r^{(h,H)}$ and $r^{(h,L)}$ are the reservation prices of high-search consumers. Given these objects, firms optimize, high-search consumers search sequentially according to their stopping rule, and low-search consumers buy from the lowest-priced firm.

The game admits no pure-strategy equilibrium. If a positive mass of firms were to set the same price, any one of them could profitably undercut by an arbitrarily small amount and capture all low-search consumers. Hence the equilibrium price distribution is atomless over its support.

Under a condition ruling out profitable deviations that target only the consumer group with the higher reservation price, the upper bound of the support is

$$\bar{r} \equiv \min\{r^{(h,H)}, r^{(h,L)}, p^{mon.}\}, \tag{7}$$

so equilibrium prices cannot exceed the lower of the two reservation prices among high-search consumers, unless the monopoly price binds first. The formal condition and proof are reported in Appendix A.1.

Define per-consumer revenue by $R^{(i,I)}(p) \equiv D^{(i,I)}(p)\big(p - m(a(p))\big)$. At the upper bound $\bar{r}$, a firm attracts no low-search consumers, since $F(\bar{r}) = 1$. Expected profits at $\bar{r}$ are therefore

$$\mathbb{E}\{\pi(\bar{r}, F)\} = \frac{1}{N} \sum_I \lambda^{(h,I)} R^{(h,I)}(\bar{r}) - z(a(\bar{r})). \tag{8}$$

Since all prices in the support of a mixed-strategy equilibrium must yield the same expected profit, the equilibrium price distribution satisfies

$$F(p) = 1 - \left[\frac{\frac{1}{N} \sum_I \lambda^{(h,I)} \left(R^{(h,I)}(\bar{r}) - R^{(h,I)}(p) \right) + z(a(p)) - z(a(\bar{r}))}{\sum_I \lambda^{(l,I)} R^{(l,I)}(p)} \right]^{\frac{1}{N-1}}. \tag{9}$$

For high-search consumers, reservation prices are determined by indifference between buying and continuing to search. For any finite interior reservation price,

$$\int_b^{r^{(h,I)}} \left[\int_p^{r^{(h,I)}} D^{(h,I)}(x)\, dx \right] dF(p) = \nu, \qquad I \in \{H, L\}. \tag{10}$$

If no finite solution exists, we set $r^{(h,I)} = +\infty$.

Pricing condition and two margins of competition. Using (4), the firm's optimal pricing condition can be written as

$$\begin{aligned} 0 = \Bigg[& \underbrace{\frac{1}{N} \sum_I \lambda^{(h,I)} D^{(h,I)\prime}(p) + [1 - F(p)]^{N-1} \sum_I \lambda^{(l,I)} D^{(l,I)\prime}(p)}_{\mathcal{I}(p)\text{: intensive margin}} \\ & \underbrace{- (N-1) f(p) [1 - F(p)]^{N-2} \sum_I \lambda^{(l,I)} D^{(l,I)}(p)}_{\mathcal{E}(p)\text{: extensive margin}} \Bigg] \big(p - m(a(p))\big) + \mathbb{E}\{y^{dem.}(p)\}, \end{aligned} \tag{11}$$

where $f(p)$ denotes the density associated with $F(p)$. Equation (11) makes clear that competition operates through two margins. The intensive margin, $\mathcal{I}(p)$, captures how all consumers discipline prices through the slope of their demand. The extensive margin, $\mathcal{E}(p)$, captures the additional incentive to undercut that arises because low-search consumers compare posted prices and reallocate toward the lowest-priced firm. High-search consumers contribute only to the intensive margin, whereas low-search consumers contribute to both.

2.2 Aging demand in theory

We interpret aging as a gradual reallocation of the population across consumer types. Evidence points to two life cycle patterns: (i) young to middle aged consumers become less willing to substitute across varieties while remaining relatively time constrained in shopping; (ii) middle to old consumers devote more time to price comparison, holding their lower elasticity fixed. We map young consumers to (h, H), middle-aged to (h, L), and old to (l, L), so aging traces two transitions: $(h, H) \to (h, L)$ and $(h, L) \to (l, L)$.

Recall the equilibrium price CDF: $F(p) = 1 - \Theta(p; \lambda)^{1/(N-1)}$. We define the *competition index*

$$\Theta(p; \lambda) \equiv \frac{B(p)}{C(p)}, \tag{12}$$

where $B(p)$ is the opportunity cost of undercutting, namely the revenue a firm forgoes on captive high search consumers when it cuts price from $\bar{r}$ to p, and $C(p)$ is the prize from being the lowest priced firm, namely the revenue gained from low search consumers who always buy the cheapest option. We call Θ a competition index because it is a sufficient statistic for the equilibrium price distribution: a higher Θ means undercutting is expensive relative to its reward, so firms post higher prices (F shifts down, prices rise in FOSD), while a lower Θ means the prize dominates the cost, intensifying price competition (F shifts up, prices fall).

The propositions below are local comparative statics holding $\bar{r}$ and $z(\cdot)$ fixed. Feedback through the endogenous reservation price and investment cost is small and does not reverse any sign prediction; we verify this formally in the appendix and numerically ex post in the full general equilibrium. For notation, $\Delta R^I(p) \equiv R^I(\bar{r}) - R^I(p)$ is the per-consumer revenue forgone by undercutting from $\bar{r}$ to p.

Proposition 2.1 (Young to middle-aged: $(h, H) \to (h, L)$)**.** *A local reallocation from (h, H) to (h, L) raises prices in FOSD if*

$$\Delta R^L(p) > \Delta R^H(p) \qquad \forall p \in (b, \bar{r}). \tag{13}$$

Under this condition: (a) both $E[p]$ and $E[p_{\min}]$ increase; (b) sectoral quantity falls when the price induced demand contraction dominates the composition effect; (c) the sectoral profit share rises.

Intuition. Lower elasticity raises the revenue sacrificed by undercutting (B rises), while

the prize C is unchanged. The competition index increases and firms post higher prices. See Appendix B.5 for the proof.

Proposition 2.2 (Middle-aged to old: $(h, L) \to (l, L)$)**.** *A local reallocation from (h, L) to (l, L) lowers prices in FOSD under*

$$\Delta R^L(p) \geq 0 \qquad \forall p \in (b, \bar{r}). \tag{14}$$

Under this condition: (a) both $E[p]$ and $E[p_{\min}]$ fall; (b) sectoral quantity rises; (c) the sectoral profit share falls.

Intuition. The pool of low search shoppers grows (C rises) while captive high search mass shrinks (B falls). The competition index falls and firms undercut more aggressively. See Appendix B.7.

Corollary 2.2.1 (Isoelastic demand)**.** *Under $D^I(p) = \kappa_I p^{-\sigma_I}$ with $\sigma_H > \sigma_L > 1$ and $M(p) = p - m$, Condition (13) holds iff $\bar{r} \leq \frac{\sigma_H}{\sigma_H - 1} m$, and Condition (14) holds iff $\bar{r} \leq \frac{\sigma_L}{\sigma_L - 1} m$. Both are satisfied whenever market power is moderate ($\bar{r}$ close to m); we verify these conditions numerically ex post.*

Population aging thus has *non-monotonic* effects on competition: the Y→M transition weakens competition (higher prices, lower output) while the M→O transition strengthens it (lower prices, higher output). The comparative statics deliver three testable sign restrictions. First, sectors with greater reweighting toward middle-aged consumers should exhibit higher prices, lower output, and higher markups. Second, sectors with greater reweighting toward old consumers should exhibit the opposite pattern. Third, the model predicts negative price-quantity comovement under the middle age channel, a signature unique to the search competition mechanism. We exploit cross-sector variation in exposure to foreign demographic changes to test these restrictions empirically. Appendix B.9 discusses additional implications, including the model's predictions for price dispersion and the mapping from firm-level to sector-level comparative statics.

3 Empirical analysis

This section provides empirical evidence on the demand-side effects of aging on sectoral aggregates. Guided by the theory, we ask whether sectors that experience a larger increase in the share of middle-aged consumers—defined as ages 45–64—display higher producer prices

and profitability and lower real activity. Because sector-level markups are not directly observed in our data, we proxy profitability with the sectoral profit share, which is a monotone indicator of markup variation under standard accounting (holding factor shares and technology fixed).

Identifying this demand-side channel with domestic demographics is challenging: changes in the age structure of the domestic population simultaneously affect labor supply, savings, and other aggregate conditions that can move prices and quantities through the cost side. We therefore isolate a demand-driven source of variation by exploiting cross-sector differences in exposure to foreign markets. The empirical strategy is a shift-share IV that instruments the change in the age composition of demand with predetermined export exposure to destination countries interacted with destination-specific demographic changes. Intuitively, foreign demographic shifts reweight the demand faced by a sector through exports while leaving the domestic population composition unchanged.

3.1 Data

To recover a measure of the exposure of the domestic economy to foreign demand, we use the World Input-Output Database (Timmer et al., 2015) which provides sector-level statistics on value-added, hours worked, price deflator, and input-output tables with information on trade links at the country-sector level. The WIOD covers the 27 European Union countries, 13 other major economies in the world for the period 1995-2009, and estimates for the rest of the world.[3] The dataset provides information over 35 sectors. The structure of the input-output tables is represented in Figure (1).[4] Using the input-output tables allows us to capture the interdependence coming from the integrated production structure of the world's economies.

To recover the demographic variables, we use the World Population Prospects (WPP, 1996, and 2019 revisions) United Nations (2022), providing estimates and projections in 1996 and 2019 of the age composition of the population in the past, current, and future

[3]Besides the 27 European Union countries, the WIOD dataset contains information on Australia, Brazil, Canada, China, Indonesia, India, Japan, South Korea, Mexico, Russia, Turkey, Taiwan, and the United States.

[4]Rows represent the country-sector supplying the input, while the columns the country-sector buying the inputs to be used in the production process. Each cell represents the amount traded in terms of value-added. The columns "Final use" and "Total use" represent the amount produced by each country-sector which is consumed by each country and the total output of the country-sector respectively. Several variables compose the "Final use" columns (i.e. "Final consumption expenditure by households", "Final consumption expenditure by non-profit organizations serving households (NPISH)", "Final consumption expenditure by the government", "Gross fixed capital formation", "Changes in inventories and valuables"). Coherently with the scope of our analysis, we consider only the "Final consumption expenditure by households" variable.

Figure (1) The structure of a world input-output table

			Input use & value added							Final use			Total use
			Country 1			⋯	Country J			Country 1	⋯	Country J	
			Industry 1	⋯	Industry S	⋯	Industry 1	⋯	Industry S				
Intermediate inputs supplied	Country 1	Industry 1	Z_{11}^{11}	⋯	Z_{11}^{1S}	⋯	Z_{1J}^{11}	⋯	Z_{1J}^{1S}	F_{11}^{1}	⋯	F_{1J}^{1}	Y_1^1
		⋯	⋯	Z_{11}^{rs}	⋯	⋯	⋯	Z_{1J}^{rs}	⋯	⋯	⋯	⋯	⋯
		Industry S	Z_{11}^{S1}	⋯	Z_{11}^{SS}	⋯	Z_{1J}^{S1}	⋯	Z_{1J}^{SS}	F_{11}^{S}	⋯	F_{1J}^{S}	Y_1^S
	⋯	⋯	⋯	⋯	⋯	Z_{ij}^{rs}	⋯	⋯	⋯	⋯	F_{ij}^{r}	⋯	Y_i^r
	Country J	Industry 1	Z_{J1}^{11}	⋯	Z_{J1}^{1S}	⋯	Z_{JJ}^{11}	⋯	Z_{JJ}^{1S}	F_{J1}^{1}	⋯	F_{JJ}^{1}	Y_J^1
		⋯	⋯	Z_{J1}^{rs}	⋯	⋯	⋯	Z_{JJ}^{rs}	⋯	⋯	⋯	⋯	⋯
		Industry S	Z_{J1}^{S1}	⋯	Z_{J1}^{SS}	⋯	Z_{JJ}^{S1}	⋯	Z_{JJ}^{SS}	F_{J1}^{S}	⋯	F_{JJ}^{S}	Y_J^S
Value added			VA_1^1	⋯	VA_1^S	VA_j^s	VA_J^1	⋯	VA_J^S				
Gross output			Y_1^1	⋯	Y_1^S	Y_j^s	Y_J^1	⋯	Y_J^S	⋯			

Source: World Input-Output Database

years. We use these datasets to recover measures of the actual demographic change and of the unexpected demographic changes.

3.2 Identification of middle-aged consumers

We now present the OLS baseline model and highlight the caveats of this approach. We then present the shift-share IV identification approach addressing these caveats.

OLS model To estimate the effect of a change in the share of middle-aged consumers on sector aggregate price, production output, and profits, we use the following long-difference fixed-effect model specification similar to Acemoglu and Restrepo (2022):

$$\Delta \log Y_i^s = \beta_0 + \beta_1 \cdot \Delta MiddleAgeConsumers_i^s + \beta_2 \cdot ForeignExposure_i^s + \gamma_i + \gamma_s + \epsilon_i^s, \quad (15)$$

The left-hand side variables are, in turn, the log difference in prices, production output, and profit shares between 1996 and 2006 in sector s, country i.[5] We use the sector-specific value-added price deflator as a proxy for the average price, which measures prices from the producers' side and, thus, contrary to the consumer price index (CPI), does not depend on the basket of goods and services purchased by consumers. As a proxy for production output, we use real value-added. Finally, as a proxy for profits, we use the profit shares estimated as in Van Vlokhoven (2024).

[5]We consider the longest available period in the WIOD 2013 release excluding the recession years from 2007 on; we consider 1996 instead of 1995 (the first year available in the WIOD 2013 release) to consistently define the dependent variables across the different models as the UN WPP was published in 1996 but not in 1995.

The regressor of interest is the change in the share of middle-aged consumers at the country-sector level, and it is defined as the change between 1996 and 2006 of the country-level middle-aged share (population aged 45-64 relative to total population aged 25-79) weighted by the exposure of each country-sector to each country's demand:

(16)
$$\Delta MiddleAgeConsumers_i^s = \sum_j \xi_{i,j,2006}^s \cdot MiddleAge_{j,2006} - \sum_j \xi_{i,j,1996}^s \cdot MiddleAge_{j,1996},$$

where $\xi_{i,j,t}^s$ is a measure of the exposure of sector s in country i to the demand of country j in period t. We define the exposure share as in Ferrari (2023):

$$\xi_{i,j}^s \equiv \frac{F_{i,j}^s \; + \; \sum_r \sum_k \; a_{i,k}^{s,r} \; F_{k,j}^r \; + \; \sum_r \sum_k \sum_g \sum_m \; a_{i,k}^{s,r} \; a_{k,m}^{r,g} \; F_{m,j}^g + ...}{Y_i^s}, \tag{17}$$

The first term in the numerator, $F_{i,j}^s$, represents the output produced by sector s in country i which is directly sold for consumption in country j; the second term represents the fraction of output produced by sector s in country i sold to any producer r in any country k which is then consumed in country j. The same logic applies to higher-order terms.[6] The exposure shares in (17) capture the interconnection of global trade, allowing us to track intermediate trades from the initial producer to the final consumer, including both direct and indirect sales.[7]

To control for the heterogeneous exposure of sectors to foreign demand, we include in the regression the exposure to foreign demand ($ForeignExposure_i^s$) at the initial period (1996) defined as the sum of the exposure of each country-sector relative to foreign countries, i.e., $\sum_{j \neq i} \xi_{i,j,1996}^s$. Furthermore, to control for sector-specific and country-specific trends, we include country and sector dummies (γ_i and γ_s respectively).[8]

[6] We compute the exposure of each sector s in country i to country j making use of the Leontief inverse matrix $(I - A)^{-1}$. We retrieve the Leontief inverse matrix from the Leontief input-output model relating production (Y) with final demand ($F \equiv [\sum_j F_{i,j}^s]$): $Y = AY + F$, where $A \equiv [a_{i,j}^{s,r}] \equiv [Z_{i,j}^{s,r}/Y_i^s]$ is the input-output matrix. The Leontief inverse matrix relates the exposure share matrix $[\xi_{i,j}^s]$ to the final demand matrix $[f_{i,j}^s] \equiv [F_{i,j}^s/Y_i^s]$ that shows the amount of output produced by sector s in country i consumed or invested in country j as a share of the total output produced by sector s in country i. We, therefore, estimate the exposure share matrix as $[\xi_{i,j}^s] = (I - A)^{-1} \cdot [f_{i,j}^s]$.

[7] Consider, for example, a German car producer using tires produced in Italy. Assume that the German producer sells its cars in France. By only considering the direct sale, we would not capture the exposure of the Italian tire producer to French demand. This simple example shows, particularly for very interconnected countries, the necessity of taking into account also indirect sales to retrieve the correct measure of final demand exposure.

[8] In this context, it is relevant to control for sector-specific trends as young, middle-aged, and old consumers might differ in their consumption basket due to heterogeneity in preference for goods. Think, for instance, of elderly consumers who on average consume more health services than young and middle-aged consumers.

Shift-share IV model Since changes in the middle-aged consumers are correlated with the change in the middle-aged workers, which is likely to affect the sectors' aggregates of interest (price and production output), we implement a shift-share IV identification approach and instrument the change in the age composition of demand with foreign demographics weighted by the exposure of the domestic economy to foreign demand. We exploit the wedge between the age composition of consumers (which depends on both the domestic and the foreign demands) and the age composition of the domestic population. This allows us to disentangle the effect coming from the demand side of the economy (i.e., the change in the share of middle-aged consumers) from other direct effects going through the labor market and other domestic channels. We, therefore, estimate the following first-stage model:

$$\Delta MiddleAgeConsumers_i^s = \alpha_0 + \alpha_1 \cdot \Delta ForeignMiddleAgeConsumers_i^s + \\ + \alpha_2 \cdot ForeignExposure_i^s + \gamma_i + \gamma_s + \nu_i^s, \tag{18}$$

where $\Delta ForeignMiddleAgeConsumers_i^s$ is the shift-share instrument defined as a measure of demographic change (shift) weighted by the exposure of each country-sector to foreign demand (share):

$$\Delta ForeignMiddleAgeConsumers_i^s \equiv \sum_{j \neq i} \xi_{i,j,1996}^s \cdot DemographicShift_{j,1996}. \tag{19}$$

We follow the methodology described in Borusyak et al. (2022), Adão et al. (2019), and Goldsmith-Pinkham et al. (2020), which requires either exogenous shares (the exposure to foreign demand) or exogenous shifts (the change in foreign demographics). Since the exposure to foreign demand is potentially endogenous as firms choose the sectors and the countries to trade with, we identify exogenous shifts, hence, exogeneity of foreign demographics relative to domestic price, production, and profits. To ensure the exogeneity of the instrument relative to the dependent variables, we then require the independence of the exogenous shifts relative to the shares. To ensure that the shifts and the shares are independent one another, as it is standard in the shift-share literature, we use lagged values of the shares shielding the results from contemporaneous co-movements of the shifts and the shares. However, in our framework, this strategy might not be enough to guarantee the independence between

In the case in which the growth rates of prices and production in this sector differ relative to the growth rates in other sectors, a higher share of old consumers would affect the price and production growth rates through a change in the sector composition of demand. Controlling for sector-fixed effects, we account for the changes in consumption patterns across age categories affecting the allocation of demand across sectors.

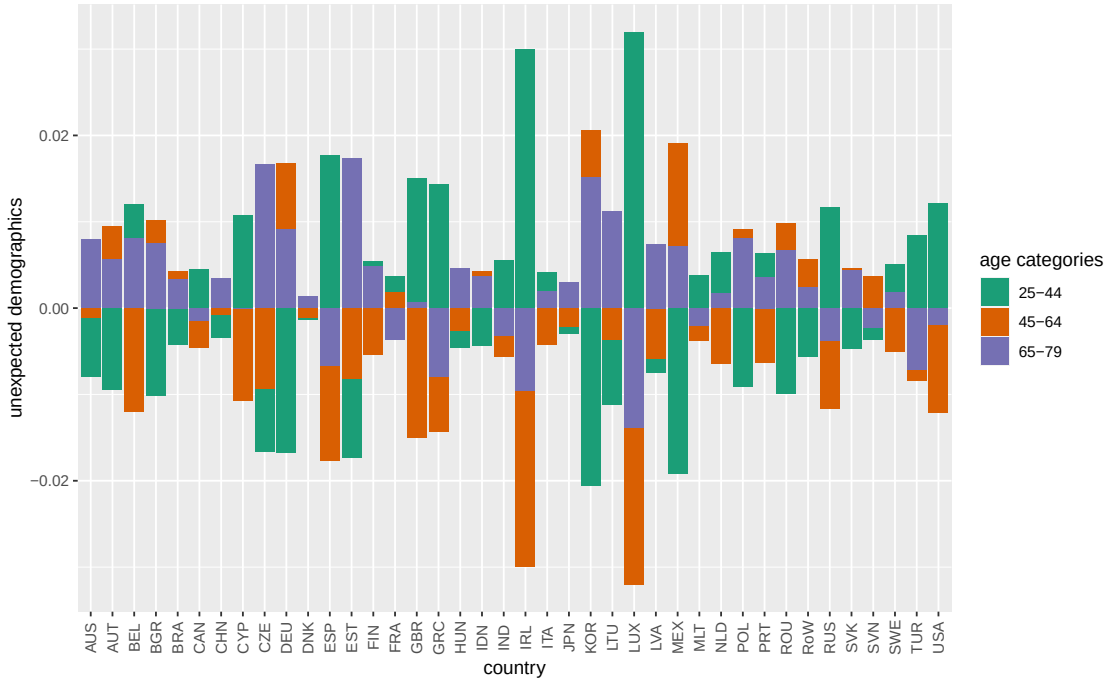


Figure (2) Unexpected demographic changes aggregated in three age categories.

Notes: this figure shows the prediction revisions for the year 2006 between 1996 and 2006. For each age category we compute its share in the total population between 25 and 79 years old. The prediction revisions are computed according to equation (20) from different vintages of the UN World Population Prospects.

the shifts and the shares as demographic changes are highly predictable. Demographic expectations, indeed, could still affect the lagged exposure shares. We, therefore, build a measure of unexpected demographic change using the error in forecasts in 1996 regarding the 2006 demographic composition of countries:

$$DemographicShift_{j,1996} \equiv age_{j,2006} - \mathbb{E}_{1996}\left(age_{j,2006}\right). \tag{20}$$

By fixing exposure shares at the initial period and considering the error in expectations in 1996 regarding demographics in 2006, we ensure that the demographic shifts are unexpected and, therefore, uncorrelated with the exposure shares. Figure 2 shows that there are large variations in prediction errors in demographics across countries and age categories (middle-aged, in particular), guaranteeing enough variation to perform the empirical estimation.

Since sectors selling to the same foreign countries are exposed to the same shocks, we cluster standard errors by the main exposure country (i.e., the country's final demand to which each country-sector sells the highest share of its value-added). Our clustering partly mitigates concerns related to this correlation. Finally, we weight observations by the value added of each country–sector pair, consistent with aggregation to the macro level.

3.3 Results

Table 1 summarizes the main empirical results. For each outcome — prices, production, and profits — odd-numbered columns report OLS estimates from (14) and even-numbered columns report shift-share IV estimates based on the first stage (17) and instrument (18).

Table (1) Demand-Composition Aging and Sectoral Outcomes

	Δ log Price		Δ log Production		Δ log Profit	
	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Middle-aged (45–64)	3.162	10.212	−3.143	−8.308	18.744	46.099
	(0.750)	(4.440)	(0.901)	(2.878)	(3.181)	(21.020)
Initial foreign exposure	✓	✓	✓	✓	✓	✓
Country fixed effects	✓	✓	✓	✓	✓	✓
Sector fixed effects	✓	✓	✓	✓	✓	✓
Observations	1,353	1,353	1,353	1,353	917	917
R^2	0.885	0.877	0.582	0.571	0.297	0.236
KP F-stat		5.1		5.1		5.1

Notes: This table reports OLS and shift-share IV estimates of the effect of changes in the share of middle-aged consumers (aged 45–64, relative to the population aged 25–79) on sectoral outcomes over the period 1996–2006. The instrument is the unexpected change in foreign middle-aged shares, weighted by initial sectoral exposure to foreign demand. The Kleibergen-Paap F-statistic tests the strength of the first stage. Standard errors, clustered by main exposure country, are reported in parentheses. Observations are weighted by country–sector value added.

An increase in the share of middle-aged consumers raises producer prices and profit shares while lowering production. The shift-share IV model estimates imply that in the period considered (1996-2006), a standard deviation increase in the share of middle-aged (2.21%) leads to a yearly 2.28% increase in prices, a 1.82% reduction in production output, and a 10.71% increase in profits.[9]

Standard demand shocks typically generate a positive co-movement between prices and quantities. In contrast, the increase in the middle-aged share raises prices while lowering production, implying a negative co-movement. This pattern is consistent with a change in the intensity of product-market competition rather than a shift in the level of demand: the accompanying rise in profit shares confirms that firms' pricing power increases, prompting

[9]The average annual changes are computed as follows: $100 \times [1 + \%\Delta y/100]^{\frac{1}{2006-1996}} - 100$, where $\%\Delta y$ is the cumulative percentage change in price (over the period 1996-2006), i.e., $\%\Delta y = 100 \cdot (e^{\hat{\beta}_1 \cdot \Delta x} - 1)$, and $\hat{\beta}_1$ is the coefficient estimates for the IV model specification for prices and production in Table (1), and Δx is set to be equal to one standard deviation in the domestic change between 1996 and 2006 of the share of the age category analyzed.

a supply-side adjustment in both pricing and production. These findings align with the model: middle-aged consumers combine high search costs with low elasticity of substitution, weakening both the price-comparison and the variety-switching channels of competition.

Robustness Results are robust to a wide range of checks. When repeating the analysis for young (25–44) and old (65–79) consumers instead of middle-aged agents, the results are qualitatively opposite: both young and old are generally associated with lower prices, higher production, and lower profits. The findings are also robust to alternative age definitions, different expectation horizons used to construct unexpected demographic shifts, the use of actual (rather than unexpected) demographic changes, and alternative instruments based on lagged fertility rates, controlling for migration-driven demographic changes. All robustness checks are reported in the Appendix.

4 Quantitative analysis

The reduced-form evidence supports the model's central mechanism: changes in the demographic composition of demand generate a negative co-movement between prices and quantities and a systematic response of the sectoral profit share, consistent with interpreting those changes as competitive demand shocks. This section quantifies the aggregate importance of that mechanism by mapping the sector-level channel into an aggregate counterfactual.

To do so, we embed the sector block into a simple multi-sector general equilibrium environment. The quantitative model preserves the two key sources of household heterogeneity emphasized in the theory: age groups differ in search intensity and in elasticity of substitution across goods. Young and middle-aged consumers observe one random price in each sector, but young consumers are more price sensitive and therefore substitute more strongly away from expensive goods. Old consumers instead purchase at the lowest price in each sector, but substitute relatively less across sectors than young consumers because their elasticity of substitution is lower.

As the population ages, the composition of demand shifts across these groups, changing the intensity of product-market competition, firms' pricing decisions, and productivity-enhancing investment. In the benchmark exercise, we hold labor supply fixed to isolate the demand-side effect of aging, and we assume that income is independent of age so as to abstract from income-composition effects on demand. Full details of the quantitative environment are reported in Appendix D.

The quantitative analysis proceeds in two steps. We first calibrate the model to the U.S. economy using a small set of moments chosen to discipline the margins that are central to the mechanism: search intensity, price competition, and productivity-enhancing investment. The goal of the calibration is not to provide a full quantitative account of the U.S. economy, but to obtain a parsimonious benchmark for measuring the aggregate relevance of the demand-composition channel. We then use the calibrated model, first to compare sector-level and general-equilibrium responses to demographic reallocations, and then to quantify the aggregate implications of the observed evolution of demographic shares in the United States.

4.1 Calibration

We calibrate the model to the U.S. economy in 1995 and then hold the structural parameters fixed while feeding the model the observed evolution of demographic shares over time. The 1995 baseline aligns with the start of the sample used in the empirical analysis and with the initial year of the aggregate markup series in De Loecker and Eeckhout (2020). This provides a transparent benchmark for quantifying the aggregate effects of the subsequent demographic transition.

We discipline age-specific elasticities of substitution in two steps. First, we use the evidence in Curtis et al. (2025) to pin down relative life-cycle differences in substitution patterns. Because their estimates are obtained in a retail setting, we use them to discipline the *wedge* between young consumers and older consumers rather than the overall level of the elasticity. Specifically, we use their estimates to pin down the ratio between the elasticity of young consumers and that of older consumers, and, consistent with empirical evidence, we impose $\sigma^M = \sigma^O$. Second, we choose the level of the elasticities so that the population-weighted average elasticity equals $\bar{\sigma} = 2.9$, following Broda and Weinstein (2006). Under 1995 population shares, this implies $\sigma^Y \approx 3.12$ and $\sigma^M = \sigma^O \approx 2.66$.[10] Demographic shares are taken from the UN World Population Prospects.

The remaining parameters $\theta = (\bar{a}, \nu, N)$ are calibrated internally. Each of these parameters governs a distinct margin of the model. The number of firms, N, controls the extent of price dispersion and the gains from undercutting shoppers, and therefore disci-

[10]The higher elasticity of substitution of young relative to middle-aged consumers implies that the reservation price of the middle-aged is higher than the reservation price of the young. The intuition runs as follows: since young consumers have a higher elasticity of substitution, they can more easily substitute away from goods for which they observe a relatively high price, leading to a lower reservation price with respect to middle-aged. Therefore, in accordance with Lemma **??** in the calibration, we use the reservation price of the young as the upper bound of the price distribution.

plines the strength of price competition. The investment parameter, $\bar{a}$, governs the strength of the productivity-enhancing investment margin. The search-cost parameter, ν, governs the severity of search frictions and therefore the equilibrium level of market power. We identify these parameters using three moments chosen to discipline those margins directly. First, we target the young-old paid-price gap from Aguiar and Hurst (2007), which disciplines within-sector price dispersion. Second, we target innovation intensity, measured as investment relative to labor expenses, which disciplines the investment margin. Third, we target the aggregate markup in 1995 from De Loecker and Eeckhout (2020), which disciplines the overall degree of market power. Table 2 reports the calibration targets and fit. Finally, to isolate the demand-side competition channel, the benchmark calibration imposes equal per-capita expenditures across cohorts, so that expenditure shares coincide with population shares.

Table (2) Calibration targets and baseline fit

Moment	Source	Target	Model	Parameter
Price gap (Y/O, tx log −1)	Aguiar and Hurst (2007)	0.0400	0.0403	$N = 3.2867$
Inv./labor	U.S. NIPA/BLS	0.0329	0.0322	$\bar{a} = 1.2474$
Markup (1995)	De Loecker and Eeckhout (2020)	1.3775	1.3422	$\nu = 2.5317$
Objective $\mathcal{L}$		0.01985		

Notes: The table reports the three internally targeted moments and the corresponding model fit. See Appendix E for details.

4.2 Aggregate implications of the demand-side aging channel

We now use the calibrated model to quantify the aggregate importance of the demand-side aging channel. The model is solved every five years from 1995 to 2020, treating each year as a separate stationary equilibrium. This comparative-static approach is well suited to our setting, both because the empirical analysis is based on long differences and because the mechanism of interest operates statically through price competition and productivity-enhancing investment.

From sector-level effects to aggregate effects. Table 3 reports the effects of the two demographic transitions emphasized in the model. A shift from young to middle-aged consumers ($Y \to M$) raises average paid prices and lowers output, whereas a shift from middle-aged to old consumers ($M \to O$) lowers prices and raises output, both in the sector

partial equilibrium model and in the multi-sector general equilibrium model. The two demographic transitions, however, operate through different channels. The transition $Y \to M$, or $(h, H) \to (h, L)$, lowers substitutability across varieties, reduces competition, and raises prices. By contrast, the transition $M \to O$, or $(h, L) \to (l, L)$, increases the mass of consumers with low search costs, strengthens competition, and pushes prices down.

Table 3 also clarifies the distinction between sector-level effects and the aggregate counterfactuals studied below. The shift-share specification in Section 3 identifies sector-country variation in demand composition similarly to the sector partial equilibrium analysis: foreign demographic shifts affect the age composition of buyers faced by a given sector while leaving other sectors largely unaffected.

In the sector partial equilibrium model, a $Y \to M$ transition acts as a sector-specific shock: prices rise in the affected sector, and part of the decline in its demand is absorbed by expenditure reallocation toward other sectors. Sectoral quantity therefore falls, but aggregate quantity need not move much. By contrast, in the multi-sector general-equilibrium exercise, the same demographic transition occurs in all sectors simultaneously. Prices rise in every sector, so consumers can no longer reallocate expenditure toward unaffected sectors. The decline in demand therefore translates into a fall in aggregate quantity and productivity-enhancing investment. Lower investment reduces productivity and profits. This is why the profit-share response under $Y \to M$ changes sign: in general equilibrium, profitability depends not only on markups but also on economy-wide adjustments in output, investment, and productivity.

Table (3) Local comparative statics under 1pp demographic shocks

Shock	Framework	Δ Avg. paid price (%)	Δ Quantity (%)	Δ Profit share (%)
Y→M	Sector partial	+2.025	-6.905	+0.723
Y→M	GE	+1.968	-7.843	-0.193
M→O	Sector partial	-0.322	+0.516	-0.795
M→O	GE	-0.622	+0.817	-1.744

Notes: "Avg. paid price" is the demand-weighted mean transaction price. "Quantity" is aggregate production. "Profit share" is profits as a share of sectoral revenue.

The results highlight two broader lessons. First, under the $Y \to M$ transition, general equilibrium leaves the price response almost unchanged but strengthens the decline in quantity. This reflects the fact that, once all sectors are simultaneously affected, the fall in demand can no longer be absorbed through reallocation toward unaffected sectors. Second, under the $M \to O$ transition, general equilibrium amplifies both the decline in prices and the increase in quantity. When competition increases economy-wide, aggregate demand increases rather than just reallocating expenditure across sectors.

Aging consumers in the United States. We now quantify the mechanism along the observed U.S. demographic transition. We focus on the United States because it is closer to a closed economy, so a domestic demographic counterfactual is less affected by simultaneous foreign demand shifts. Figure 3 reports the demographic paths used in the quantitative exercise. Up to around 2010, the share of young consumers declines while the share of middle-aged consumers rises, with the old share remaining relatively stable. This phase corresponds closely to the $Y \to M$ transition emphasized in the model. After 2010, the middle-aged share declines and the old share rises, while the young share remains broadly stable. This phase corresponds to the $M \to O$ transition. Together, these paths reflect the aging of the baby-boomer generation.

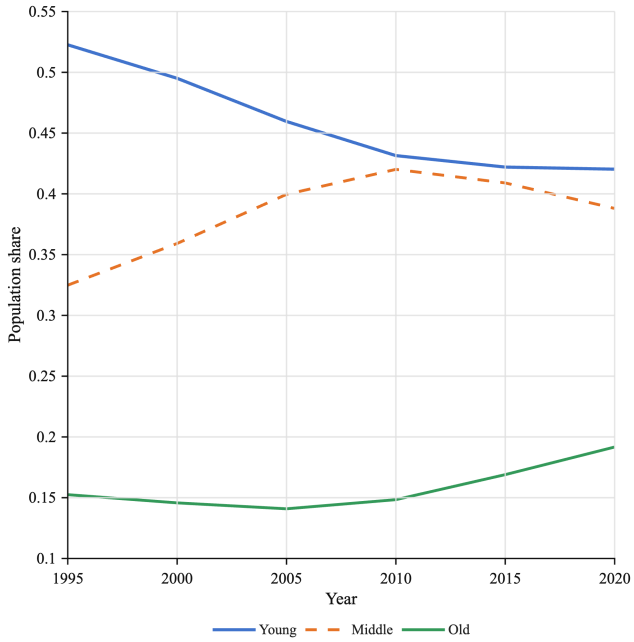


Figure (3) **Exogenous paths used in the quantitative exercise**

Notes: The figure reports cohort population shares from UN-WPP for 1995–2020.

In the benchmark exercise, we isolate the demand-side channel by holding aggregate labor supply fixed at its 1995 level. We now allow for demographic-driven changes in aggregate labor supply, assuming that only young and middle-aged agents work while the old are retired.[11] Figure 4 reports the paths of aggregate production, prices, and profits when labor supply is allowed to vary with demographics and age-specific participation rates (solid red lines), and decomposes the total effect into its demand-side (dashed blue lines) and supply-side (dotted green lines) components.

The demand-side channel of aging exerts a sizable negative effect on aggregate output

[11] As in the benchmark exercise, we keep income constant across generations.

(Panel a). As the middle-aged share rises after 1995, the effect becomes negative; it then partly reverses as the baby-boomer cohort moves from middle age into old age. The aggregate effect of aging through the demand side is therefore non-monotonic. Quantitatively, the model implies that U.S. real GDP remains roughly 2 percent below a counterfactual path with fixed 1995 demographics for most of the period considered. This demand-side effect is comparable in magnitude to the supply-side channel, which reaches a peak positive effect of about 3 percent relative to 1995 around 2005.

The decomposition also shows that the demand-side channel accounts for most of the change in average prices (Panel b), while the supply-side contribution is small. Aggregate profits, by contrast, are initially shaped by both channels, but the demand-side channel becomes dominant from around 2010 onward (Panel c), as the baby-boomer generation transitions from middle age into old age.

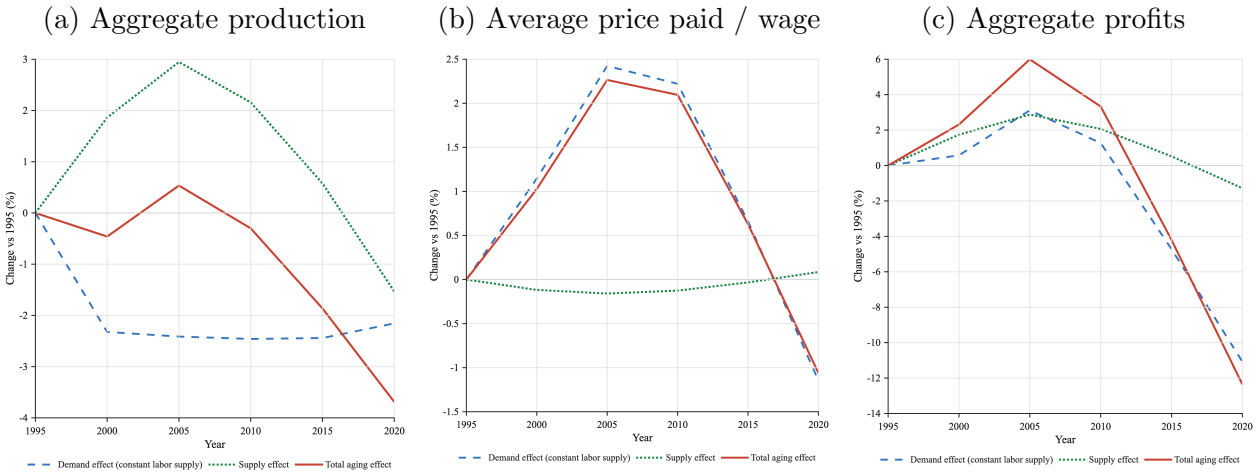


Figure (4) **Demand-side versus supply-side effects of aging**

Notes: In each panel, the total effect (solid red) equals the demand-side effect (dashed blue, constant labor supply) plus the additional supply-side effect (dotted green). Panel B reports the paid-price index normalized by the wage, $E_\omega[p]/w$. All series are expressed as deviations from 1995.

The decomposition shows that the demand-side channel is quantitatively important, accounting for a substantial share of the full effect in most years. In this sense, the standard view of aging as primarily a labor-supply shock misses an important part of its aggregate consequences.

5 Conclusion

This paper studies how population aging affects product-market competition through the demand side. We build a tractable model of search in goods markets in which consumers

are heterogeneous along two dimensions: (i) their elasticity of substitution across goods and (ii) their search costs, and thus their propensity to compare prices. We discipline the model using micro evidence and interpret the aging process as a two-stage reallocation of demand: as consumers move from young to middle age, demand becomes less elastic; as they move from middle age into retirement, search intensity rises and prices fall. This micro-to-macro mapping allows us to interpret demographic change as a competitive shock rather than as a standard demand shift.

A shift in demand toward middle-aged consumers, who have high search costs and low elasticity of substitution, weakens competition. In the model, this raises prices, lowers output, and reduces productivity-enhancing investment, thereby lowering productivity. By contrast, shifts toward young or old consumers strengthen competition, due respectively to higher demand elasticity and lower search costs, leading to lower prices and higher output.

We test these predictions using a country–sector panel and a shift-share design that identifies demand-driven demographic changes through foreign demographics. The evidence supports the competitive-shock interpretation: increases in the share of middle-aged demand are associated with higher prices, lower output, and higher profits. The implied negative co-movement of prices and quantities is difficult to reconcile with a standard demand shift, but arises naturally when demographic change affects the intensity of competition and induces firms to adjust prices, production, and investment.

Finally, we embed the sector block in a multi-sector general equilibrium framework and use it to quantify the aggregate implications of the mechanism. The calibrated model implies that the demand-composition channel of aging lowers U.S. real GDP relative to a counterfactual with fixed 1995 demand shares, with the effect partly reversing as the baby-boom cohort transitions into retirement. Population aging therefore affects the macroeconomy not only through labor supply, but also through the composition of demand and the intensity of product-market competition.

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A Model Appendix

A.1 Upper support of the price distribution

Lemma A.1. *Given the equilibrium price distribution F, suppose that*

$$\text{(A1)} \qquad \begin{cases} \mathbb{E}\{\pi(p,F)\} > \dfrac{\lambda^{(h,H)}}{N} R^{(h,H)}(\hat{p}) - z(a(\hat{p})) & \text{if } r^{(h,L)} \leq r^{(h,H)}, \\ \mathbb{E}\{\pi(p,F)\} > \dfrac{\lambda^{(h,L)}}{N} R^{(h,L)}(\hat{p}) - z(a(\hat{p})) & \text{if } r^{(h,L)} > r^{(h,H)}, \end{cases}$$

for all

$$\text{(A2)} \qquad \hat{p} \in (\min\{r^{(h,L)}, r^{(h,H)}\}, \max\{r^{(h,L)}, r^{(h,H)}\}],$$

where

$$\text{(A3)} \qquad R^{(h,I)}(p) \equiv D^{(h,I)}(p)\big(p - m(a(p))\big).$$

Then the upper bound of the support of the equilibrium price distribution is

$$\text{(A4)} \qquad \bar{r} \equiv \min\{r^{(h,L)}, r^{(h,H)}, p^{mon.}\},$$

where $p^{mon.}$ denotes the monopoly price.

Proof. Take first the case $r^{(h,L)} \leq r^{(h,H)}$. Any firm posting a price

$$\text{(A5)} \qquad \hat{p} \in (r^{(h,L)}, r^{(h,H)}]$$

cannot sell to type-(h,L) consumers, since $\hat{p} > r^{(h,L)}$. Hence such a deviation can at most target type-(h,H) consumers among the high-search groups, yielding payoff

$$\text{(A6)} \qquad \frac{\lambda^{(h,H)}}{N} R^{(h,H)}(\hat{p}) - z(a(\hat{p})).$$

By condition (A1), this payoff is strictly below equilibrium expected profits, so no such price can lie in the support.

The argument is symmetric when $r^{(h,L)} > r^{(h,H)}$. Any price

$$\text{(A7)} \qquad \hat{p} \in (r^{(h,H)}, r^{(h,L)}]$$

can at most target type-(h, L) consumers among the high-search groups, yielding payoff

$$\frac{\lambda^{(h,L)}}{N} R^{(h,L)}(\hat{p}) - z(a(\hat{p})). \tag{A8}$$

Again, (A1) implies that such a deviation is unprofitable.

Therefore, no equilibrium price can lie strictly between the two reservation prices. Since prices above $p^{mon.}$ are never optimal, the upper bound of the support is given by (A4). □

A.2 Derivation of the pricing condition

Firm profits are

$$\pi(p, a) = \mathbb{E}\{y^{dem.}(p)\}\big(p - m(a)\big) - z(a). \tag{A9}$$

Differentiating (A9) with respect to price and applying the envelope theorem yields

$$0 = \frac{d\,\mathbb{E}\{y^{dem.}(p)\}}{dp}\big(p - m(a(p))\big) + \mathbb{E}\{y^{dem.}(p)\}. \tag{A10}$$

Using (4),

$$\mathbb{E}\{y^{dem.}(p)\} = \frac{1}{N}\sum_I \lambda^{(h,I)} D^{(h,I)}(p) + [1 - F(p)]^{N-1} \sum_I \lambda^{(l,I)} D^{(l,I)}(p), \tag{A11}$$

its derivative is

$$\begin{aligned} \frac{d\,\mathbb{E}\{y^{dem.}(p)\}}{dp} = \frac{1}{N}\sum_I \lambda^{(h,I)} D^{(h,I)\prime}(p) + [1 - F(p)]^{N-1} \sum_I \lambda^{(l,I)} D^{(l,I)\prime}(p) \\ - (N-1) f(p) \, [1 - F(p)]^{N-2} \sum_I \lambda^{(l,I)} D^{(l,I)}(p), \end{aligned} \tag{A12}$$

where $f(p)$ denotes the density associated with $F(p)$.

Substituting (A12) into (A10) gives

(A13)
$$0 = \Bigg[\underbrace{\frac{1}{N}\sum_I \lambda^{(h,I)} D^{(h,I)\prime}(p) + [1-F(p)]^{N-1} \sum_I \lambda^{(l,I)} D^{(l,I)\prime}(p)}_{\mathcal{I}(p)} - \underbrace{(N-1) f(p) [1-F(p)]^{N-2} \sum_I \lambda^{(l,I)} D^{(l,I)}(p)}_{\mathcal{E}(p)} \Bigg] \big(p - m(a(p))\big) + \mathbb{E}\{y^{dem.}(p)\},$$

which is the pricing condition reported in the text.

B Comparative statics with four consumer types

This appendix derives a convenient closed-form representation of the equilibrium price cumulative distribution function (CDF) and proves Propositions 2.1 and 2.2. The guiding idea is to separate two margins of competition: (i) an *intensive* margin pinned down by the curvature of demand and firms' margin choice, and (ii) an *extensive* margin driven by competition for low search consumers (who purchase from the lowest-priced firm). Composition changes shift the relative strength of these margins and therefore the equilibrium price distribution.

Throughout, we consider local composition changes around an interior symmetric mixed-strategy equilibrium with atomless $F(\cdot)$ on a common support $[b, \bar{r}]$. We take $\bar{r}$ as locally fixed and verify this maintained restriction numerically ex post.

B.1 Equilibrium price CDF and the competition index

Let the endogenous per unit margin be $M(p) \equiv p - m(a(p))$ and define, for $I \in \{H, L\}$,

(A14)
$$R^I(p) \equiv D^I(p) M(p), \quad \Delta R^I(p) \equiv R^I(\bar{r}) - R^I(p), \quad \Delta z(p) \equiv z(a(\bar{r})) - z(a(p)).$$

Here $R^I(p)$ is per consumer revenue from a type-I buyer at price p, $\Delta R^I(p)$ is the per consumer revenue lost when cutting price from $\bar{r}$ to p, and $\Delta z(p)$ is the incremental investment cost of charging p rather than $\bar{r}$.

Using the equilibrium indifference condition that profits at any $p \in [b, \bar{r}]$ equal profits at

$\bar{r}$, we derive

$$(1 - F(p))^{N-1} = \frac{B(p)}{C(p)}, \tag{A15}$$

where

$$B(p) \equiv \frac{\lambda^{(h,H)}}{N}\Delta R^H(p) + \frac{\lambda^{(h,L)}}{N}\Delta R^L(p) + \Delta z(p), \tag{A16}$$

$$C(p) \equiv \lambda^{(l,H)} R^H(p) + \lambda^{(l,L)} R^L(p). \tag{A17}$$

Thus

$$F(p) = 1 - \left[\frac{B(p)}{C(p)}\right]^{\frac{1}{N-1}}, \quad p \in [b, \bar{r}]. \tag{A18}$$

The decomposition above is central to understanding the comparative statics. $C(p)$ is the *prize of being the lowest priced firm*: it aggregates revenues from low search consumers and scales the extensive margin incentive to undercut. $B(p)$ is the *opportunity cost of lowering price*: it is the profit lost on captive high search demand plus any additional investment cost induced by lower prices. A composition change that raises $B(p)/C(p)$ pointwise reduces $F(p)$ pointwise, shifting posted prices upward in first-order stochastic dominance.

B.2 Feedback stability

Propositions 2.1–2.2 hold $\bar{r}$ and $z(\cdot)$ fixed. Two feedback channels arise in the full equilibrium. First, a *reservation price* channel: by the envelope theorem on the consumer's stopping problem, the elasticity of $\bar{r}$ with respect to $E[p]$ is $\eta_r \approx 0.05$ at baseline parameters. This feedback is destabilizing (it partially offsets the direct price effect through ΔR^I) but small: a 10% change in expected prices shifts $\bar{r}$ by only 0.5%. Second, an *investment cost* channel: lower prices raise expected demand and thus $z(a(p))$, increasing $B(p)$. This is stabilizing with elasticity $\eta_z \approx -0.03$. The net feedback shifts $E[p]$ by at most $|\eta_r + \eta_z|/(1 - |\eta_r + \eta_z|) < 5\%$ of the direct effect and does not reverse any sign prediction. We confirm this by recomputing the full fixed point under each demographic perturbation in the quantitative analysis.

B.3 FOSD lemma for transaction prices

Lemma B.1. *Let τ be a scalar parameter. Suppose that for all $p \in (b, \bar{r})$, $\frac{dF(p)}{d\tau} < 0$. Then (i) $\frac{d}{d\tau}E[p] > 0$ for $p \sim F$, (ii) $\frac{d}{d\tau}E[p_{\min}] > 0$ for $p_{\min}$ the minimum of N i.i.d. draws from F, and*

(iii) for any differentiable strictly decreasing function g, $\frac{d}{d\tau}E[g(p)] < 0$ and $\frac{d}{d\tau}E[g(p_{\min})] < 0$.

Proof. The hypothesis $\frac{dF}{d\tau} < 0$ means that for any cutoff p, fewer firms post prices below p when τ increases—exactly a first-order stochastic dominance upward shift. An upward shift raises the mean of an increasing statistic (prices) and lowers the mean of a decreasing statistic (demands).

(i) Since $p \in [b, \bar{r}]$,

$$E[p] = b + \int_b^{\bar{r}} (1 - F(t))dt \quad \Rightarrow \quad \frac{d}{d\tau}E[p] = -\int_b^{\bar{r}} \frac{dF(t)}{d\tau}dt > 0. \tag{A19}$$

(ii) Since $F_{\min}(p) = 1 - (1 - F(p))^N$, we have $\frac{dF_{\min}(p)}{d\tau} = N(1 - F(p))^{N-1}\frac{dF(p)}{d\tau} < 0$. The same tail representation yields $\frac{d}{d\tau}E[p_{\min}] > 0$.

(iii) Integration by parts gives $E[g(p)] = g(\bar{r}) - \int_b^{\bar{r}} g'(t)F(t)dt$. Differentiating yields $\frac{d}{d\tau}E[g(p)] = -\int_b^{\bar{r}} g'(t)\frac{dF(t)}{d\tau}dt < 0$ since $g'(t) < 0$ and $\frac{dF(t)}{d\tau} < 0$. The argument for $g(p_{\min})$ is identical. □

B.4 Young to middle aged transition: Y→M

Let $\tau_{YM} \geq 0$ parameterize a local reallocation from young to middle aged consumers:

$$\lambda^{(h,H)}(\tau_{YM}) = \lambda_0^{(h,H)} - \tau_{YM}, \quad \lambda^{(h,L)}(\tau_{YM}) = \lambda_0^{(h,L)} + \tau_{YM}, \tag{A20}$$

with $\lambda^{(l,H)}$ and $\lambda^{(l,L)}$ fixed. High search mass is constant; only the elasticity composition within high search consumers changes.

B.5 Proof of Proposition 2.1

Proof. **Part (a): Posted prices shift upward in FOSD.**

Under the Y→M perturbation, $B(p)$ and $C(p)$ become

$$B(p) = \frac{\lambda_0^{(h,H)} - \tau_{YM}}{N}\Delta R^H(p) + \frac{\lambda_0^{(h,L)} + \tau_{YM}}{N}\Delta R^L(p) + \Delta z(p), \quad C(p) = \lambda^{(l,H)}R^H(p) + \lambda^{(l,L)}R^L(p). \tag{A21}$$

Therefore, for any $p \in (b, \bar{r})$,

$$\frac{d}{d\tau_{YM}} \log\left(\frac{B(p)}{C(p)}\right) = \frac{1}{NB(p)}\Big(\Delta R^L(p) - \Delta R^H(p)\Big). \tag{A22}$$

Plugging into the CDF formula yields

$$\frac{dF(p)}{d\tau_{YM}} = -\frac{1}{N-1}\left[\frac{B(p)}{C(p)}\right]^{\frac{1}{N-1}} \frac{d}{d\tau_{YM}} \log\left(\frac{B(p)}{C(p)}\right). \tag{A23}$$

If Condition (13) holds pointwise, then $\frac{dF(p)}{d\tau_{YM}} < 0$ for all $p \in (b, \bar{r})$. This is a downward shift in the CDF, i.e., prices rise in FOSD. By Lemma B.1(i) and (ii), both $E[p]$ and $E[p_{\min}]$ increase.

Part (b): Quantity falls.

Define sectoral quantity as

$$Q = \lambda^{(h,H)} E[D^H(p)] + \lambda^{(h,L)} E[D^L(p)] + \lambda^{(l,H)} E[D^H(p_{\min})] + \lambda^{(l,L)} E[D^L(p_{\min})]. \tag{A24}$$

Differentiating with respect to τ_{YM} yields

$$\frac{dQ}{d\tau_{YM}} = \underbrace{E[D^L(p)] - E[D^H(p)]}_{\text{composition effect}} + \underbrace{\sum_{(i,j)} \lambda^{(i,j)} \frac{d}{d\tau_{YM}} E[D^j(p_i)]}_{\text{price-induced effect}}. \tag{A25}$$

If $D^H(\cdot)$ and $D^L(\cdot)$ are strictly decreasing, Lemma B.1(iii) implies that each expected-demand term decreases with τ_{YM} via the induced price rise. When the price induced contraction dominates the composition effect (smaller expected demands for type L relative to type H), sectoral quantity falls.

Part (c): Profit share rises.

The per unit markup is $M(p) = p - m(a(p))$. The FOSD upward shift raises $E[M(p)]$ directly through higher prices. Investment adoption $a(p)$ adjusts through the stabilizing channel (Appendix B.2), raising $m(a(p))$ by at most 3% of the price increase, so the net markup effect is positive. Meanwhile, the quantity contraction from Part (b) is smaller in proportional terms than the markup expansion (since demand elasticities $\sigma_I > 1$ imply that revenue $R^I(p) = D^I(p)M(p)$ is increasing in p near baseline). Hence the sectoral profit share (markup times quantity share) rises. □

B.6 Middle to old transition: M→O

Let $\tau_{MO} \geq 0$ parameterize a local reallocation from middle aged to old consumers:

$$\lambda^{(h,L)}(\tau_{MO}) = \lambda_0^{(h,L)} - \tau_{MO}, \quad \lambda^{(l,L)}(\tau_{MO}) = \lambda_0^{(l,L)} + \tau_{MO}, \tag{A26}$$

with $\lambda^{(h,H)}$ and $\lambda^{(l,H)}$ fixed.

B.7 Proof of Proposition 2.2

Proof. **Part (a): Posted prices shift downward in FOSD.**

Under the M→O perturbation,

(A27)
$$B(p) = \frac{\lambda_0^{(h,H)}}{N}\Delta R^H(p) + \frac{\lambda_0^{(h,L)} - \tau_{MO}}{N}\Delta R^L(p) + \Delta z(p), \quad C(p) = \lambda_0^{(l,H)} R^H(p) + (\lambda_0^{(l,L)} + \tau_{MO}) R^L(p).$$

Therefore,

(A28)
$$\frac{dB(p)}{d\tau_{MO}} = -\frac{1}{N}\Delta R^L(p), \quad \frac{dC(p)}{d\tau_{MO}} = R^L(p),$$

and

(A29)
$$\frac{d}{d\tau_{MO}} \log\left(\frac{B(p)}{C(p)}\right) = -\frac{\Delta R^L(p)}{NB(p)} - \frac{R^L(p)}{C(p)} < 0$$

under $\Delta R^L(p) \geq 0$ and $R^L(p) > 0$ on $(b, \bar{r})$.

Using the CDF formula,

(A30)
$$\frac{dF(p)}{d\tau_{MO}} = -\frac{1}{N-1}\left[\frac{B(p)}{C(p)}\right]^{\frac{1}{N-1}} \frac{d}{d\tau_{MO}} \log\left(\frac{B(p)}{C(p)}\right) > 0.$$

This is an upward shift in the CDF, i.e., prices fall in FOSD. By Lemma B.1(i) and (ii), both $E[p]$ and $E[p_{\min}]$ decrease.

Part (b): Quantity rises.

Differentiating Q with respect to τ_{MO},

(A31)
$$\frac{dQ}{d\tau_{MO}} = \underbrace{E[D^L(p_{\min})] - E[D^L(p)]}_{\text{composition effect}} + \underbrace{\sum_{(i,j)} \lambda^{(i,j)} \frac{d}{d\tau_{MO}} E[D^j(p_i)]}_{\text{price-induced effect}}.$$

The composition term is weakly positive because $p_{\min} \leq p$ implies $E[D^L(p_{\min})] \geq E[D^L(p)]$ when D^L is decreasing. The price induced term is also weakly positive since the upward CDF shift (downward price shift) raises expected demands for all types. Thus $dQ/d\tau_{MO} > 0$ when demands are strictly decreasing.

Part (c): Profit share falls.

The FOSD downward shift in prices lowers $E[M(p)]$ directly. The quantity expansion from Part (b) operates primarily through the extensive margin (more consumers observe $p_{\min}$) rather than through higher per unit margins. Since the markup contraction is proportionally larger than any volume gain (demand increases along the extensive margin, not through higher revenue per unit), the sectoral profit share falls. □

B.8 Isoelastic characterization

Assume isoelastic demand $D^I(p) = \kappa_I p^{-\sigma_I}$ with $\sigma_H > \sigma_L > 1$, and locally constant margin $M(p) = p - m$. Then

$$R^I(p) = \kappa_I (p - m) p^{-\sigma_I}. \tag{A32}$$

The Y→M condition $\Delta R^L(p) > \Delta R^H(p)$ becomes

$$R^L(\bar{r}) - R^L(p) > R^H(\bar{r}) - R^H(p), \tag{A33}$$

or equivalently, $g(p) > g(\bar{r})$ where

$$g(p) \equiv R^L(p) - R^H(p) = \kappa(p - m)(p^{-\sigma_L} - p^{-\sigma_H}). \tag{A34}$$

For $p > 1$ and $\sigma_H > \sigma_L$, we have $p^{-\sigma_L} > p^{-\sigma_H}$, so $g(p) > 0$ in the interior of the support. The condition $g(p) > g(\bar{r})$ (equivalently, $\Delta R^L(p) > \Delta R^H(p)$) holds when g is decreasing on part of the support, which requires $\bar{r}$ to be below the turning point $p^\star$ of g.

The M→O condition $\Delta R^L(p) \geq 0$ requires that $R^L(p)$ is non-decreasing on $[b, \bar{r}]$. Taking the derivative,

$$\frac{dR^L}{dp} \propto \sigma_L m - (\sigma_L - 1)p. \tag{A35}$$

Hence $R^L(p)$ is increasing when $\bar{r} \leq \frac{\sigma_L}{\sigma_L - 1} m$, ensuring $\Delta R^L(p) \geq 0$ on $(b, \bar{r})$.

For calibrated parameters $\sigma_H \approx 3.12$, $\sigma_L \approx 2.66$, $m \approx 1.25$, we have $\frac{\sigma_L}{\sigma_L - 1} m \approx 2.8$. Since the reservation price $\bar{r} \lesssim 2.1$ in equilibrium, both conditions are satisfied. We verify these conditions numerically ex post under the full demographic transition.

B.9 Discussion of comparative statics

Theory to data mapping. The model features N symmetric firms competing for a single product, while the empirical analysis uses sector level data with many heterogeneous firms. The relevant mapping is to the *sector-average* pricing distribution: because the equilibrium is symmetric across firms and composition shifts affect all firms proportionally through the common λ, firm level comparative statics aggregate to sector level predictions with the same sign. The shift-share IV identifies precisely this sector level response, making the mapping direct.

Mechanism detail: profit share. In Proposition 2.1, the profit share rises because the per unit markup $M(p) = p - m(a(p))$ increases with the FOSD upward shift in prices, while adoption costs adjust only through the stabilizing investment channel (at most 3% of the price change). In Proposition 2.2, the profit share falls because the markup declines with lower prices, and the quantity expansion operates through the extensive margin (more consumers observe $p_{\min}$) rather than through higher per unit revenue.

Price dispersion diagnostic. The FOSD shifts also have implications for the shape of the price distribution. Under Y→M, the lower tail compresses (fewer ultra-low prices) and the upper tail fattens; under M→O, the reverse occurs. These patterns are qualitatively unique to a search model: standard Bertrand or monopolistic competition without search frictions does not generate non-monotonic dispersion responses to demographic shifts. We note this as a qualitative implication rather than a sharp empirical test, since measuring within sector price dispersion at the required granularity is beyond the scope of our data.

C Empirical appendix

Table 4 shows the estimated results for young, middle-aged, and old agents. Further, we perform a series of robustness checks focusing on the middle-aged category. We consider alternative definitions of the middle-aged category by changing the thresholds considered. We, therefore, alternatively define middle-aged as the share of the population aged 45-59, 40-64, and 40-59 (45-64 in the baseline model). Table (5) rows (2)-(4) shows that results are fully consistent across the different definitions of middle-aged consumers and quantitatively similar to the baseline results (row 1).

We also consider a change in expectations between 1996 and 2006 regarding demography

Table (4) Effect of the age composition of consumers on sectoral outcomes

	Δ log Price			Δ log Production			Δ log Profit		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: OLS									
Δ Young (25–44)	1.034			0.029			1.171		
	(0.670)			(0.804)			(3.046)		
Δ Middle-aged (45–64)		3.162			−3.143			18.744	
		(0.750)			(0.901)			(3.181)	
Δ Old (65–79)			−4.437			0.838			−31.190
			(0.939)			(1.135)			(3.984)
Initial foreign exposure	✓	✓	✓	✓	✓	✓	✓	✓	✓
Country fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sector fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	1,353	1,353	1,353	1,353	1,353	1,353	917	917	917
R^2	0.884	0.885	0.885	0.578	0.582	0.578	0.269	0.297	0.318
Panel B: Shift-share IV									
Δ Young (25–44)	−12.859			12.395			−109.172		
	(14.195)			(6.920)			(181.879)		
Δ Middle-aged (45–64)		10.212			−8.308			46.099	
		(4.440)			(2.878)			(21.020)	
Δ Old (65–79)			−14.597			19.627			−49.142
			(8.571)			(20.029)			(8.965)
Initial foreign exposure	✓	✓	✓	✓	✓	✓	✓	✓	✓
Country fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sector fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	1,353	1,353	1,353	1,353	1,353	1,353	917	917	917
R^2	0.845	0.877	0.875	0.500	0.571	0.487	−0.870	0.236	0.302

Notes: This table reports OLS (Panel A) and shift-share IV (Panel B) estimates of the effect of changes in the age composition of consumers on sectoral outcomes over the period 1996–2006. Each column includes a single age-group regressor. Age shares are defined relative to the population aged 25–79. The instrument is the unexpected change in the corresponding foreign age share, weighted by initial sectoral exposure to foreign demand. Standard errors, clustered by main exposure country, are reported in parentheses. Observations are weighted by country–sector value added.

Table (5) Robustness checks for middle-aged consumers

		Δ log Price	Δ log Production	Δ log Profit
Panel A: Alternative age definitions				
(1)	Δ Middle-aged (45–64) Unexpected demographics, $t = 2006$	10.212 (4.440)	−8.308 (2.878)	46.099 (21.020)
(2)	Δ Middle-aged (45–59) Unexpected demographics, $t = 2006$	12.668 (4.053)	−9.952 (4.355)	50.313 (13.554)
(3)	Δ Middle-aged (40–64) Unexpected demographics, $t = 2006$	12.790 (3.029)	−8.805 (4.718)	52.913 (11.077)
(4)	Δ Middle-aged (40–59) Unexpected demographics, $t = 2006$	12.636 (2.484)	−7.706 (5.629)	46.273 (3.944)
Panel B: Alternative expectation horizons				
(5)	Δ Middle-aged (45–64) Unexpected demographics, $t = 2010$	9.279 (4.095)	−7.849 (2.252)	43.359 (19.434)
(6)	Δ Middle-aged (45–64) Unexpected demographics, $t = 2015$	9.615 (4.056)	−7.249 (2.096)	47.258 (19.613)
(7)	Δ Middle-aged (45–64) Unexpected demographics, $t = 2020$	7.511 (3.096)	−5.340 (1.496)	42.963 (13.481)
Panel C: Alternative instruments				
(8)	Δ Middle-aged (45–64) Actual demographics, $t = 2006$	4.247 (2.895)	−3.647 (2.545)	21.105 (12.123)
(9)	Δ Middle-aged (45–64) Lagged fertility rates, $t = 2006$	2.335 (0.923)	−2.122 (1.381)	20.401 (6.386)

Notes: This table reports shift-share IV estimates for the middle-aged regressor under alternative specifications. Row (1) is the baseline. Panel A varies the age definition of the middle-aged group. Panel B varies the forecast horizon t used to construct the unexpected demographic shift in equation (A36). Panel C uses alternative instruments: row (8) uses actual demographic changes as in equation (A37); row (9) uses lagged fertility rates as in equation (A38). All specifications include initial foreign exposure, country fixed effects, and sector fixed effects. Standard errors, clustered by main exposure country, are reported in parentheses. Observations are weighted by country–sector value added.

in year $t \in \{2010, 2015, 2020\}$ ($t = 2006$ in the baseline model). We, therefore, define the instrumental variable as:

$$\Delta ForeignAgeDemand_i^s \equiv \sum_{j \neq i} \xi_{i,j,1996}^s \cdot \left[\mathbb{E}_{2006}\left(age_{j,t}\right) - \mathbb{E}_{1996}\left(age_{j,t}\right)\right]. \tag{A36}$$

Table (5) rows (5)-(7) shows that the results obtained considering the change in expectations with respect to future demographics are qualitatively and quantitatively consistent with the results of the baseline shift-share IV model.

A potential concern of our baseline model is that the demographic variable can be affected by immigration. Since economic reasons are often at the base of the decision to migrate, the age variable might be partially endogenous in the context of our baseline model specification. Moreover, in the case in which immigrants have different purchasing behaviors with respect to the native population, our results might partially capture the effect of immigration rather than age. While in the baseline model, we do not directly account for these issues, we can analyze the relevance of these potential effects by comparing the model estimates of a model in which we control for immigration and a model in which we do not control for it. We consider the actual demographic change between 1996 and 2006 as a proxy of the demographic shift that captures both the effect of native demographic change and immigration. We, therefore, define the instrumental variable as:

$$\Delta ForeignAgeDemand_i^s \equiv \sum_{j \neq i} \xi_{i,j,1996}^s \cdot \left[age_{j,2006} - age_{j,1996}\right]. \tag{A37}$$

To control for the effect of immigration on age, we use lagged fertility rates weighted by the exposure shares which allows us to identify the native demographic component that explains the demographic shift. We, therefore, estimate the following first-stage model:

$$\Delta AgeDemand_i^s = \alpha_0 + \sum_x \alpha_x \sum_{j \neq i} \xi_{i,j,1996}^s \cdot fert_{j,2006-x} + \Gamma_i^s + \nu_i^s, \tag{A38}$$

where $fert_{j,2006-x}$ is the fertility rate in country j in year $2006-x$, with $x \in \{20, 25, 30, 35, 40, 45, 50, 55\}$ and Γ_i^s are the same controls as in the baseline model. Table (5) shows that the point estimates between the model using actual demographic change (row 8) and the model controlling for immigration (row 9) are not significantly different suggesting that the effect of immigration is marginal.

D General equilibrium environment

The economy features a unit measure of sectors indexed by $s \in [0,1]$. In each sector, $N \geq 2$ ex-ante identical firms compete in prices and choose productivity-enhancing investment as in Section 1. Sectors are symmetric, so equilibrium strategies are identical across sectors, but they differ ex-post after uncertainty is resolved.

Model outcomes and data counterparts. To facilitate the link to Section 2, we report three sector-level outcomes that correspond closely to the empirical objects: (i) a demand-weighted average transaction price (the model analogue of the sectoral price deflator), (ii) sectoral output (real value added in the data), and (iii) the *profit share*, defined as operating profits divided by revenue. The model also produces an implicit markup, which we use for calibration against aggregate evidence, but the empirical analysis focuses on the profit share as the observable proxy for profitability and competitive pressure.

Households, search, and transaction prices. There are three age groups $i \in \{Y, M, O\}$ with population shares λ^i. Within each sector, young and middle-aged consumers are "non-shoppers" who sample one posted price (high search costs), while old consumers are "shoppers" who sample all posted prices (low search costs) and purchase at the lowest observed price.[12] Let $F(\cdot)$ denote the equilibrium distribution of posted prices in a representative sector. Then the transaction-price CDF faced by young and middle-aged consumers coincides with $F(\cdot)$, while the transaction-price CDF faced by old consumers is the distribution of the minimum of N i.i.d. draws from F,

$$F^O(p) = 1 - (1 - F(p))^N . \tag{A39}$$

Preferences and sectoral demands. Each cohort derives utility from a CES aggregate of sectoral consumption and is linear in the aggregate:

$$\max_{\{c_s^i\}} \; C^i \equiv \left[\int_0^1 (c_s^i)^{\frac{\sigma_i - 1}{\sigma_i}} \, ds \right]^{\frac{\sigma_i}{\sigma_i - 1}} , \tag{A40}$$

subject to

$$I^i = \widetilde{P}^i \, C^i. \tag{A41}$$

[12] This mapping corresponds to the reduced-form representation in Section 1.A: $Y \equiv (h, H)$, $M \equiv (h, L)$, $O \equiv (l, L)$, with $\lambda(l, H) = 0$ in the quantitative implementation.

Here σ_i is the age-specific elasticity of substitution across sectors, and $\widetilde{P}^i$ is the cohort-specific (normalized) price index.[13] Independent of the age category, each agent receives the same income, which is given wages plus profits net of investment costs.

Standard CES demand yields

$$c_s^i = C^i \left(\frac{\widetilde{p}_s^i}{\widetilde{P}^i} \right)^{-\sigma_i} = C^i (\widetilde{P}^i)^{\sigma_i} (\widetilde{p}_s^i)^{-\sigma_i}. \tag{A42}$$

In the sector block, c_s^i pins down the cohort-specific demand curve that enters firms' price and investment incentives.

Aggregation and factor-market clearing. Market clearing in each sector implies that aggregate output equals the integral of sectoral demands,

$$Q = \int_0^1 \sum_i \lambda^i c_s^i \, ds = \sum_i \lambda^i C^i (\widetilde{P}^i)^{\sigma_i} \int_0^1 (\widetilde{p}_s^i)^{-\sigma_i} \, ds. \tag{A43}$$

Under sector symmetry, the distribution of transaction prices faced by cohort i is the same in every sector. Hence $\int_0^1 (\widetilde{p}_s^i)^{-\sigma_i} \, ds = \mathbb{E}[(\widetilde{p}^i)^{-\sigma_i}]$, where the expectation is taken with respect to the cohort-specific transaction-price distribution (F for $i \in \{Y, M\}$ and F^O for $i = O$).

Given the production technology in Section 1, the unit labor requirement at a firm that posts price p is $\bar{a} - a(p)$. Aggregating across firms and sectors yields aggregate labor demand

$$ALD = \sum_i \lambda^i C^i (\widetilde{P}^i)^{\sigma_i} \mathbb{E}\left[(\widetilde{p}^i)^{-\sigma_i} \left(\bar{a} - a(p) \right) \right]. \tag{A44}$$

In the *demand-channel* experiments below, aggregate labor supply is fixed at $ALS = 1$ so that the wage adjusts to clear the labor market, $ALD = ALS$. In the *full-channels* experiments, labor supply shifts with age-specific participation rates, which activates the standard supply-side aging mechanism.

[13] Following Ghironi and Melitz (2005), we normalize by the economy-wide average price. Formally, $\widetilde{p}_s^i \equiv p_s^i / P_{\text{AVR}}$, $\widetilde{P}^i \equiv P^i / P_{\text{AVR}}$, with $P^i \equiv \left[\int_0^1 (p_s^i)^{1-\sigma_i} \, ds \right]^{\frac{1}{1-\sigma_i}}$ and $P_{\text{AVR}} \equiv \sum_i \lambda^i P^i$.

E Calibration details

The objective function is $\mathcal{L}(\theta) = \sqrt{\frac{1}{3}\sum_{k=1}^{3}\left(\frac{m_k^{\text{model}}(\theta)}{m_k^{\text{data}}} - 1\right)^2}$. We minimize $\mathcal{L}(\theta)$ over $\bar{a} \in [1.00, 5.00]$, $\nu \in [0.30, 3.50]$, and $N \in [2.00, 28.00]$ using bounded derivative-free search. To match the Aguiar–Hurst moment, the model counterpart is the demand-weighted transaction log-price ratio $m_1^{\text{model}} = \exp(\mathbb{E}_{\omega_Y}[\log p] - \mathbb{E}_{\omega_O}[\log p]) - 1$, where $\omega_i(p) = \frac{p^{-\sigma_i} f_i(p)}{\int p^{-\sigma_i} f_i(p)\, dp}$, and f_i denotes the cohort-specific transaction-price density implied by the equilibrium price distribution.