

Demographic Change and Housing Transactions in Türkiye: A Spatial Durbin Analysis of Segment-Specific Demand and Regional Spillovers

Kerem Yavuz ARSLANLI

arslanli@itu.edu.tr

Istanbul Technical University

Research Article

Keywords: Housing demand, Demographic change, Population aging, Spatial Durbin model, Regional spillovers, Türkiye

Posted Date: October 23rd, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10107757/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Demographic change is reshaping housing demand worldwide, yet most evidence concerns house prices in high-income countries and pays little attention to transaction activity, to heterogeneity across financing segments, or to how demographic forces spill across regional housing markets. We address these gaps using the 81 provinces of Türkiye over 2014–2024, distinguishing mortgage-financed from cash purchases. Province-level transaction records are combined with district-level demographic data harmonized to a time-consistent boundary set, and analyzed with a spatial Durbin panel with two-way fixed effects, selected through a formal test-down procedure and identified with a shift-share (Bartik) control function. We find strong spatial dependence in sales greatest in the mortgage segment and a large, causally robust effect of the young-adult population share that operates mainly through cross-province spillovers (about three-quarters of the total effect). Segment heterogeneity is pronounced: mortgaged sales respond to young-adult demand, household formation and mortgage-rate exposure, whereas cash sales are depressed by inflation exposure in older provinces. The findings imply that housing-supply planning, demographic monitoring and mortgage-market policy should be coordinated at a regional rather than purely local scale.

JEL Classification R21 · R31 · J11 · C21

1. Introduction

Demographic change has become one of the most consequential long-run forces acting on housing markets. Population aging, declining fertility and shifting patterns of household formation alter both the level and the composition of housing demand, with implications for prices, construction, mobility and the spatial distribution of urban growth. The seminal contributions of Mankiw and Weil (1989) and, more recently, Takáts (2012) established that cohort size and age structure exert first-order effects on real house prices, and a substantial literature has since refined these results across countries and housing segments (Hiller & Lerbs, 2016; Cheung, 2024). Yet the bulk of this evidence concerns house prices in high-income economies, leaving three dimensions comparatively underexplored.

The first is transaction activity. Sales volumes measure market liquidity and the realization of moves information distinct from, and not reducible to, price levels. Demographic shifts that change who wants to move, and whether they can finance a move, may register in volumes well before they register cleanly in prices, particularly where prices are buffeted by macro-financial shocks. The second is heterogeneity across financing segments. Mortgage-financed and cash purchases are made by different populations credit-reliant, typically younger first-time buyers on one side; older, wealthier or investment-motivated buyers on the other so a given demographic shift need not move the two segments in the same direction. Pooling them obscures precisely the channels through which demography operates. The third is the spatial dimension. Housing markets are interconnected through migration, search behavior and the regional formation of expectations, so the demographic conditions of one area may influence

transactions in its neighbors. Spatial econometric tools make such spillovers estimable (Anselin, 1988; LeSage & Pace, 2009; Elhorst, 2014), but demographic spillovers in particular are rarely quantified.

Türkiye offers an unusually informative setting in which to examine all three. It combines a still-young but rapidly aging population with pronounced regional demographic disparities; it experienced acute macro-financial volatility over our sample high and rising inflation, sharp swings in mortgage rates, and a collapse in the share of transactions that were mortgage-financed; and, crucially for empirical work, it provides fine-grained district-level demographic data alongside provincial transaction records. These features let us separate demographic demand from the macro-financial environment and observe how each financing segment responds.

We assemble a balanced panel of 81 provinces over 2014–2024 and estimate a spatial Durbin model (SDM) with two-way fixed effects, modeling total, mortgaged and cash transactions. The specification is chosen through a general-to-specific test-down against spatial autoregressive and spatial error alternatives, and the demographic channel is identified using a shift-share instrument national age-cohort growth interacted with each province's predetermined age structure implemented as a control function within the spatial likelihood. We summarize results through the direct, indirect and total effect decomposition that the spatial multiplier requires.

Four findings stand out. First, spatial dependence in transactions is strong and is largest in the mortgage segment. Second, the young-adult population share exerts a large and statistically robust effect that operates mainly through cross-province spillovers: roughly three-quarters of the total effect is indirect, arising from neighboring provinces' demographics. Third, instrumenting the young-adult share strengthens rather than weakens this effect, indicating that ordinary estimates are attenuated and the relationship is causal. Fourth, the segments diverge sharply mortgaged sales track young-adult demand, household formation and mortgage-rate exposure, while cash sales are depressed by inflation exposure concentrated in older provinces.

The paper contributes to housing and regional research in four ways. It shifts attention from prices to transaction volumes and market liquidity; it documents segment-specific demographic demand by financing type; it quantifies demographic spillovers explicitly using an SDM with a full effects decomposition; and it provides causal identification through a Bartik control function, supported by a harmonized district demographic dataset and a novel measure of within-province demographic dispersion. For policy and planning the core concerns of this journal's readership the results indicate that the regional scale, not the individual locality, is the relevant unit for anticipating demographic housing demand and for designing supply and mortgage-market responses.

2. Literature review

This study sits at the intersection of three bodies of research: the demographic determinants of housing demand, the price–volume and liquidity behaviour of housing markets, and the spatial dependence and

diffusion of outcomes across regional housing markets. We review each strand in turn, then the Turkish evidence, and conclude by locating the contribution of this paper.

2.1 Demographic change and housing demand

The analytical starting point is the life-cycle model of housing consumption, in which demand is shaped by household characteristics and evolves over the life course rising as young adults form households and acquire homes, and easing in later life (Lancaster, 1966; DiPasquale & Wheaton, 1994). Aggregated across a population, shifts in age structure therefore move housing demand. The seminal statement is Mankiw and Weil (1989), who linked cohort size to housing demand and forecast that the ageing of the baby-boom generation would depress real house prices; Engelhardt and Poterba (1991) found weaker effects in Canadian data, opening a long debate about magnitude. Using a panel of OECD economies, Takáts (2012) provided influential evidence that population ageing exerts downward pressure on real house prices over multi-decade horizons. Subsequent work has refined and qualified this result: Heo (2022) shows the negative effect is concentrated among the “old-old” (roughly 75+) rather than the newly retired, while Eichholtz and Lindenthal (2014), using household-level English data, find that housing demand rises with age and human capital before declining only modestly after retirement.

A smaller set of studies moves from national aggregates to spatial and sub-national units. Hiller and Lerbs (2016), in a mixed-regressive spatial panel of German cities, document that ageing depresses owner-occupied price growth but is heterogeneous across housing segments negative for condominiums and single-family homes, positive for rents establishing that demographic effects differ by segment. Monnet and Wolf (2017) connect demographic cycles, migration and residential investment, and Miles (2012) emphasises the interaction of population density with prices and mortgage design. Evidence from fast-ageing Asian economies broadly corroborates the demographic channel: Park et al. (2017) for Korea and Wang, Hui, and Sun (2018) for Chinese cities link dependency ratios and mobility to real estate prices, while Cheung (2024) models ageing-related risks in long-run house-price dynamics. Two features of this literature motivate our design. First, it concentrates on prices and, predominantly, on the ageing side of demographic change, leaving the young-adult and household-formation channel and the response of transaction activity comparatively underexplored. Second, where heterogeneity is examined it is by housing type rather than by financing channel, although the two are tightly linked through the life cycle.

2.2 From prices to transactions: liquidity, credit constraints and buyer types

Transaction volumes convey information distinct from price levels, and a well-developed theory explains why they should respond to demographic and credit forces. Stein (1995) shows that minimum down-payment requirements generate a positive price–volume correlation: because home equity finances the down-payment on a subsequent purchase, a negative price shock erodes equity across many owners simultaneously and suppresses trading. Ortalo-Magné and Rady (1999, 2006) embed this logic in

dynamic and overlapping-generations frameworks in which income shocks and credit constraints binding most tightly for young, first-time buyers drive both prices and volumes, and in which “starter” and “trade-up” segments respond differently. Complementary behavioural accounts emphasise nominal loss aversion in seller behaviour (Genesove & Mayer, 2001). Empirically, the price–volume relationship has been documented across markets and tested against competing theories (Leung & Feng, 2005; de Wit, Englund, & Francke, 2013), and Tsai (2014) shows that ripple effects operate in trading volume as well as in prices. This literature directly motivates two design choices in the present paper: modelling transaction volumes as the outcome, and distinguishing the mortgage-financed segment where credit constraints and young first-time buyers dominate from cash purchases. Yet the specifically demographic drivers of transaction volume, and their variation across financing segments, remain little studied.

2.3 Spatial dependence and spillovers in housing markets

Housing markets are spatially interconnected through migration, buyer search across adjacent areas, equity transfer and the regional formation of expectations. Meen (1999) formalised the “ripple effect,” attributing inter-regional house-price co-movement to migration, spatial arbitrage and equity transfer, and Holly, Pesaran, and Yamagata (2011) traced the spatial and temporal diffusion of UK house prices. The modern toolkit for such questions is spatial econometrics (Anselin, 1988; LeSage & Pace, 2009; Elhorst, 2014), with maximum-likelihood and instrumental-variable estimators for spatial panels with fixed effects (Kelejian & Prucha, 1998; Lee & Yu, 2010). The spatial Durbin model is widely used to study spillovers because it admits both an endogenous spatial lag of the outcome and spatial lags of the covariates, and because the LeSage–Pace decomposition separates own-area (direct) from neighbour (indirect) effects. Applications include Gong, Hu, and Boelhouwer (2016) on convergence and diffusion in Chinese housing markets, Tsai and Chiang (2019) on exuberance and spillovers across Chinese tiers, and Vizek, Stojčić, and Mikulić (2023) on tourism-driven price spillovers in Croatia. Despite this maturity, spatial analyses overwhelmingly target prices; the spillover of demographic conditions whereby a neighbour’s age structure influences local outcomes is rarely quantified, and almost never for transaction volumes disaggregated by financing segment.

2.4 The Turkish housing market

Research on Türkiye has concentrated on price dynamics, fundamentals and bubble detection. Coşkun and Jadevicius (2017) and Coşkun, Seven, Ertuğrul, and Alp (2020) find evidence of overvaluation but not of a clear-cut bubble, and identify cointegration among house prices, rents, construction costs and the real mortgage rate; they also stress that, amid persistent inflation and exchange-rate shocks, Turkish households treat housing as a store of value an interpretation directly relevant to the cash segment in our analysis. At the intra-urban scale, Özsoy and Şahin (2022) estimate quantile hedonic models for İzmir, and Sayın, Elburz, and Duran (2022) apply spatial panel and geographically weighted regressions to İzmir neighbourhoods, finding that structural, locational, demographic and macroeconomic factors all matter and that house prices exhibit strong spatial dependence and positive spillovers. The latter is the closest methodological precedent to the present study, but it is confined to a single city, to neighbourhood prices, and to a short window. The national statistical infrastructure readily supports a

provincial-scale spatial analysis: TURKSTAT reports house-sales counts by province and financing type and, through the address-based population registration system, district-level population by age and sex (TURKSTAT, 2024a, 2024b). To our knowledge, no study analyses demographic change and housing transactions at the national, provincial scale for Türkiye within an explicitly spatial framework.

2.5 Research gap and contribution

Taken together, these literatures leave a clear opening. The demographic-housing literature is largely about prices, aggregate units and ageing; the price–volume literature establishes that volumes and financing segments respond to demographic and credit forces but rarely measures the demographic drivers directly; and the spatial literature models price spillovers but seldom demographic ones. This paper joins the three. It models transaction volumes rather than prices; it separates mortgage-financed from cash purchases, mapping the life-cycle distinction between credit-reliant young buyers and older or investment-motivated buyers onto observable segments; it quantifies demographic spillovers explicitly through a spatial Durbin panel with a full direct–indirect–total effects decomposition; and it identifies the young-adult channel causally with a shift-share (Bartik) control function (Goldsmith-Pinkham, Sorkin, & Swift, 2020; Borusyak, Hull, & Jaravel, 2022). In doing so it extends the segment heterogeneity of Hiller and Lerbs (2016) and the ripple logic of Meen (1999) to demographic spillovers, connects the credit-constraint volume theory of Stein (1995) and Ortalo-Magné and Rady (2006) to demographic change by segment, and provides the first national, provincial-scale spatial analysis of demographic change and housing transactions for Türkiye.

3. Data and variables

3.1 Institutional context: the Turkish housing market, 2014–2024

Several features of the Turkish setting over our sample period shape both the data and their interpretation. Türkiye recorded some of the fastest nominal house-price growth in the OECD during the 2010s, against a macro-financial backdrop of high and accelerating inflation, sustained lira depreciation, and volatile policy and mortgage interest rates. In this environment housing came to function in part as a store of value, with households treating property as a hedge against the erosion of purchasing power (Coşkun, Seven, Ertuğrul, & Alp, 2020). A direct consequence visible in our data is the collapse of mortgage finance: the share of transactions that were mortgage-financed fell from roughly 29% in 2014 to about 9% by 2024 as borrowing costs rose (Fig. 2), shifting the market toward cash purchases.

Foreign demand became a non-trivial and spatially concentrated force. A citizenship-by-investment programme tied to residential property, introduced in 2017 and made markedly more accessible in 2018, channelled substantial foreign purchasing mainly from neighbouring and Gulf countries into a small set of coastal and metropolitan provinces such as Istanbul, Antalya and Mersin (Polat, 2019). This connects the Turkish case to a broader literature on how immigration and cross-border capital flows capitalise into

housing markets (Larkin et al., 2019; Pavlov & Somerville, 2020), and motivates our controlling for the foreign-buyer channel so that it does not contaminate the demographic estimates. Administrative geography also changed: Law No. 6360, enacted in 2012 and effective from the 2014 local elections, converted fourteen further provinces (those exceeding 750,000 residents) into metropolitan municipalities and redrew their sub-provincial district boundaries, raising the number of metropolitan provinces from sixteen to thirty (Law No. 6360, 2012) the reason we harmonise district boundaries to a time-consistent set (Section 3.4).

Finally, the country's demographic geography is highly uneven. The young-adult population share is highest in the south-east (for example Hakkâri and Şırnak) and lowest in the ageing Black Sea north and interior (for example Sinop), with the old-age dependency ratio displaying the mirror-image pattern; mortgage reliance is correspondingly lower in the youngest, lower-income south-eastern provinces (Fig. 1). Two shocks bound the period: a large temporary-protection (refugee) population concentrated in border provinces, which the address-based population register (ADNKS) may incompletely capture, and the February 2023 earthquakes, which delivered a simultaneous housing-and-population shock to eleven south-eastern provinces near the end of the window. We return to both in the limitations.

3.2 Data sources and coverage

The analysis draws on three sources. House-sales data are official provincial transaction counts for each of Türkiye's 81 provinces (il) over 2014–2024, disaggregated by financing type into mortgaged and non-mortgaged ("cash/other") sales (TURKSTAT, 2024a). Demographic data are district-level (ilçe) full age-by-sex population counts, household counts and dependency ratios spanning 2007–2025, drawn from the address-based population registration system (ADNKS), TURKSTAT's de jure register that records each resident at their registered place of usual residence as of 31 December each year (TURKSTAT, 2024b). These provide a seven-year pre-sample window used to construct predetermined and instrumental variables. District geometries are taken from an official boundary shapefile, from which province polygons and the spatial weights matrix are derived. After merging, the estimation sample is a balanced panel of 81 provinces over 11 years (891 province-year observations).

3.3 Dependent variables

We model three outcomes, each in natural logarithms: total transactions, mortgaged transactions, and cash/other transactions. The segmentation is central to our design. Mortgaged purchases are dominated by credit-constrained, typically younger first-time buyers, whereas cash purchases reflect wealthier and older households and investment or inflation-hedging motives. The two segments are therefore expected to respond to different demographic and macro-financial forces a hypothesis the spatial model allows us to test directly.

3.4 Demographic and control variables

From the district data we construct, at the province-year level: the young-adult population share (ages 20–34, the prime household-formation and first-time-buyer cohort); the change in the old-age

dependency ratio; the household-formation rate (annual growth in household counts); and a measure of within-province demographic heterogeneity the population-weighted coefficient of variation of district-level old-age dependency, which we term aging dispersion. Because the metropolitan reform created and reorganised districts during 2007–2013 (predating the sales window; Law No. 6360, 2012), the dispersion measure is computed on a time-consistent set of 970 districts present in every year 2014–2024, retaining 99.9% of population and holding each province’s district count fixed; movements therefore reflect genuine intra-provincial demographic divergence rather than boundary change. Two macro-financial controls national mortgage rate and inflation are constant across provinces within each year and are absorbed by year fixed effects; they enter instead as province-exposure interactions with predetermined 2007 age shares, which vary across province-years and survive the fixed effects.

Table 1
Descriptive statistics

Variable	Mean	SD	Min	Max
Total sales (count)	18,104.6	35,201.8	140.0	312,109.0
Mortgaged sales	4,578.9	10,830.5	9.0	118,264.0
Cash/other sales	13,525.7	25,437.2	120.0	242,612.0
Old-age dependency ratio (%)	15.8	5.4	4.6	32.5
Young-adult share (%)	23.1	2.5	18.0	34.7
Aging dispersion (CV)	0.4	0.1	0.1	0.7
Household formation (%)	2.5	1.7	-11.9	15.3
Inflation (%)	22.1	20.0	7.6	74.1
Mortgage rate (%)	18.9	9.0	11.9	42.8
<i>Note. Province-year observations, N = 891 (81 provinces × 11 years, 2014–2024). Sales in transaction counts; aging dispersion is the population-weighted coefficient of variation of district old-age dependency.</i>				

3.5 Spatial weights

Spatial dependence is modeled with a row-standardized 81×81 contiguity matrix W. Province polygons are obtained by dissolving the district shapefile, and the baseline W encodes queen (shared-border) contiguity; every province has between one and nine neighbors (mean 4.9), with no islands. A five-nearest-neighbor (KNN-5) matrix based on province centroids is used to assess robustness to the weights specification.

4. Empirical strategy

4.1 Spatial Durbin specification

For segment s , province i and year t , we estimate a spatial Durbin model (SDM) with two-way fixed effects:

$$\ln \text{Sales}_{i,t} = \rho \sum_j w_{ij} \ln \text{Sales}_{j,t} + X_{i,t} \beta + (\sum_j w_{ij} X_{j,t}) \theta + \mu_i + \lambda_t + \varepsilon_{i,t}$$

Here ρ is the spatial autoregressive parameter on the spatially lagged dependent variable, X collects the demographic regressors and the macro-exposure interactions, WX are their spatial lags (the Durbin terms with coefficients θ), and μ_i and λ_t are province and year fixed effects that absorb, respectively, time-invariant provincial heterogeneity (geography, fixed amenities, long-run market size) and common national shocks (the policy-rate cycle, nationwide inflation, the pandemic, and the aggregate component of the 2023 earthquake year). We adopt the SDM as the general starting point on the recommendation of LeSage and Pace (2009): it nests the spatial autoregressive (SAR), spatial error (SEM) and spatially-lagged- X (SLX) models, and unlike the simpler alternatives omitting relevant spatial lags of the covariates biases the remaining coefficients, whereas including unnecessary ones does not. Estimating the general model and testing downward (Section 4.4) is therefore the conservative strategy. Solving the system gives the reduced form, $\ln \text{Sales} = (I - \rho W)^{-1}(X\beta + WX\theta + \text{fixed effects} + \varepsilon)$, in which the spatial multiplier $(I - \rho W)^{-1}$ transmits any local shock throughout the connected system the feature that gives rise to the spillover effects reported below.

A simultaneity concern attaches to the demographic regressors: young adults may relocate toward provinces with buoyant housing markets, so a contemporaneous age structure could be jointly determined with sales. We mitigate this in two ways. The structural demographic variables are constructed in predetermined form from the 2007–2013 pre-sample lagged growth rates and initial conditions that precede the outcomes they explain and the young-adult channel is additionally identified with an external instrument (Section 4.6). The macro controls (mortgage rate, inflation) are national series and are absorbed by λ_t ; they re-enter only as interactions with predetermined 2007 age shares, which vary across province-years and therefore survive the fixed effects.

4.2 Estimation: within transformation and bias correction

The model is estimated by maximum likelihood. Because the panel is balanced, the two-way fixed effects are removed exactly by a within (double-demeaning) transformation of the dependent variable, the regressors, and their spatial lags, after which the concentrated log-likelihood is maximized over ρ . The likelihood includes the Jacobian term $T \cdot \ln|I - \rho W|$, evaluated by the log-determinant of $(I - \rho W)$ over the admissible range of ρ implied by the eigenvalues of W ; coefficient standard errors are obtained from the analytic information matrix. With fixed effects estimated jointly, spatial panel estimators carry an incidental-parameters (Nickell-type) bias of order $1/T$ (Lee & Yu, 2010); with $T = 11$ this bias is modest for the static specification we adopt, and we treat a dynamic spatial panel which would require the Lee–Yu bias correction as an extension rather than the baseline. As a complementary check, the non-spatial two-way fixed-effects baseline is estimated with province-clustered standard errors, and inference on the spatial effects (Section 4.5) is based on simulation rather than on the coefficients alone.

4.3 Exogeneity of the spatial weights

A recurring critique of spatial models concerns the endogeneity of the weights matrix when W is built from economic flows (for example migration or trade) that respond to the outcome. We avoid this by defining W from fixed administrative geography: the row-standardized queen-contiguity matrix of the 81 provinces is time-invariant, predetermined, and not a function of housing sales, so the principal source of weights endogeneity does not arise. We deliberately do not use a migration-based or price-similarity-based W , precisely because such matrices would be jointly determined with the housing market. To ensure that results are not artefacts of one connectivity definition, all effects are re-estimated under a five-nearest-neighbour matrix (Section 5.5); the substantive conclusions are unchanged.

4.4 Model selection

We follow the general-to-specific ("test-down") procedure of Elhorst (2014). The SDM reduces to SAR when $\theta = 0$ and to SEM under the common-factor restriction $\theta = -\rho\beta$. We test SDM against SAR with a likelihood-ratio test and against SEM with a Wald test of the (non-linear) common-factor restriction, evaluated using the joint covariance of (ρ, β, θ) . The SDM is retained only where both restrictions are rejected; as Section 5.1 reports, they are rejected decisively for all three segments, so the Durbin terms the demographic spillovers are statistically warranted rather than imposed.

4.5 Effects decomposition

Because the spatial multiplier propagates shocks across provinces, the SDM coefficients are not marginal effects and should not be interpreted as such (LeSage & Pace, 2009). For each regressor k the matrix of partial derivatives is $(I - \rho W)^{-1}(\beta_k I + \theta_k W)$; we summarize it as the average direct effect (the mean diagonal element, i.e. the own-province response including feedback loops through neighbours), the average total effect (the mean row sum), and the indirect or spillover effect (their difference). Inference on these scalar summaries uses Monte Carlo simulation: we take 3,000 draws from the estimated asymptotic distribution of the parameters, compute the effects for each draw, and report simulation standard errors and significance from the resulting empirical distribution.

4.6 Identification: a shift-share control function

Predetermination reduces but does not eliminate the endogeneity of the young-adult share, which could still correlate with persistent unobserved local demand shocks. We therefore instrument it with a shift-share (Bartik) instrument that isolates the component of the share driven by the national demographic wave rather than by local housing conditions: for each province-year we combine national age-cohort growth (the shocks) with the province's frozen 2007 age composition (the shares), yielding a predicted young-adult share. The instrument admits the two complementary identifying interpretations now standard in this literature. Under the shares view (Goldsmith-Pinkham, Sorkin, & Swift, 2020), identification requires the 2007 age composition to be uncorrelated with subsequent province-specific sales shocks; this is plausible because the composition is fixed seven years before the estimation window and well before the housing boom, and because province fixed effects absorb any time-invariant

association between initial composition and the level of sales. Under the shocks view (Borusyak, Hull, & Jaravel, 2022), identification requires the national cohort-growth rates to be as-good-as-randomly distributed across provinces; this is plausible because national age-structure evolution is a slow, predetermined product of past fertility and mortality that is exogenous to any individual province's housing market. The exclusion restriction is that the instrument affects sales only through the young-adult share, conditional on the fixed effects and controls; the chief residual threat that the 2007 composition proxies for differential local growth trends is mitigated by the province and year fixed effects, though we acknowledge it cannot be ruled out entirely.

Implementation uses a control function within the spatial likelihood. Because the spatial lag of an endogenous regressor is itself endogenous, we instrument both the young-adult share and its spatial lag, using the Bartik instrument and its spatial lag as excluded instruments; the first-stage residuals for both are then included as control-function terms in the SDM, where a non-zero coefficient on a residual is a direct test of endogeneity. First-stage strength is assessed with the excluded-instrument F-statistics, and standard errors for the control-function effects are obtained from a province block-bootstrap that resamples entire provincial time series. We note one limitation of this resampling scheme: by drawing provinces with replacement it does not perfectly preserve the cross-sectional spatial dependence structure, so the block-bootstrap standard errors on the instrumented effects should be read as approximate.

5. Results

5.1 Spatial diagnostics and model selection

Global Moran's I on log total sales averages 0.33 across years (range 0.26–0.39), indicating pronounced and stable spatial clustering. The estimated spatial parameter ρ is positive and highly significant in every segment (Table 2), and is largest for mortgaged sales ($\rho = 0.53$), consistent with credit-market conditions and buyer search spilling across provincial borders. The test-down procedure is decisive: the SDM is preferred to SAR (likelihood-ratio tests, all $p < 0.001$) and to SEM (common-factor Wald tests, all $p < 10^{-7}$) for all three outcomes, confirming that demographic spillovers are substantive rather than a nuisance error process.

5.2 Main estimates

Table 2 reports the SDM coefficients. The young-adult share enters positively and significantly in all segments, and its spatial lag is also positive and significant, the first indication that demographic demand crosses borders. The macro-exposure interactions separate the segments as hypothesized: mortgage-rate exposure raises mortgaged sales in younger provinces, while inflation exposure depresses cash sales in older provinces.

Table 2
Spatial Durbin model estimates by market segment

Spatial lag (p)	Total	Mortgaged	Cash/other
	0.287***	0.531***	0.174***
	(0.045)	(0.036)	(0.048)
Young-adult share	0.032***	0.052***	0.026**
	(0.010)	(0.012)	(0.010)
Δ Old-age dependency	0.011	0.025	0.007
	(0.019)	(0.024)	(0.020)
Aging dispersion	0.517**	0.049	0.525**
	(0.242)	(0.297)	(0.249)
Household formation	0.005	0.012**	0.006
	(0.004)	(0.005)	(0.004)
Mortgage rate × young (2007)	0.000	0.001**	0.000
	(0.000)	(0.000)	(0.000)
Inflation × elderly (2007)	-0.001***	-0.000	-0.001***
	(0.000)	(0.000)	(0.000)
W·Young-adult share	0.087***	0.054***	0.102***
	(0.017)	(0.020)	(0.017)
W·Δ Old-age dependency	0.032	0.005	0.032
	(0.033)	(0.040)	(0.034)
W·Aging dispersion	-0.423	1.754***	-0.733
	(0.510)	(0.623)	(0.524)
W·Household formation	0.002	0.002	0.004
	(0.008)	(0.010)	(0.008)
Log-likelihood	483.4	276.4	463.8
LR test vs SAR	27.3***	19.7***	36.2***
Wald test vs SEM	41.1***	37.1***	45.7***

*Note. ML spatial Durbin estimates; dependent variable $\ln(\text{sales})$. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Province and year fixed effects included.*

Spatial lag (ρ)	Total	Mortgaged	Cash/other
	0.287***	0.531***	0.174***
	(0.045)	(0.036)	(0.048)
Observations	891	891	891
<i>Note. ML spatial Durbin estimates; dependent variable $\ln(\text{sales})$. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Province and year fixed effects included.</i>			

5.3 Direct, indirect and total effects

Table 3 and Fig. 3 present the effects decomposition. The young-adult result is the central finding: a one-percentage-point higher young-adult share raises total sales by about 0.17 log points and mortgaged sales by 0.23, with roughly three-quarters of each total arising from indirect spillovers from neighboring provinces. Household formation lifts own-province mortgaged sales. Aging dispersion has a robust positive direct effect on total and cash sales; its spillover onto mortgaged sales is large but, as Section 5.5 shows, sensitive to specification.

Table 3
Direct, indirect and total effects

Young-adult share		Total	Mortgaged	Cash/other
	Direct	0.039*** (0.010)	0.065*** (0.012)	0.030*** (0.010)
	Indirect	0.129*** (0.019)	0.163*** (0.033)	0.125*** (0.017)
	Total	0.168*** (0.019)	0.227*** (0.036)	0.156*** (0.017)
Aging dispersion	Direct	0.500** (0.241)	0.322 (0.319)	0.496** (0.251)
	Indirect	-0.350 (0.681)	3.563*** (1.270)	-0.730 (0.621)
	Total	0.150 (0.763)	3.885*** (1.432)	-0.234 (0.683)
Household formation	Direct	0.006 (0.004)	0.013** (0.006)	0.006 (0.004)
	Indirect	0.005 (0.010)	0.016 (0.018)	0.006 (0.009)
	Total	0.010 (0.011)	0.029 (0.021)	0.012 (0.010)
<p><i>Note. LeSage–Pace effects from the SDM; Monte Carlo standard errors (3,000 draws) in parentheses.</i> *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.</p>				

5.4 Causal identification

Table 4 reports the Bartik control-function results. The instrument is strong, with first-stage F-statistics of 88 for the young-adult share and 355 for its spatial lag, far above conventional weak-instrument thresholds. Instrumenting raises the young-adult coefficient in every segment (for example, from 0.032 to 0.178 for total sales), indicating that ordinary estimates are attenuated rather than inflated by reverse causality. The control-function total effect is significant for total and cash sales and positive though less precise for the noisier mortgaged segment.

Table 4
Bartik control-function identification

Young-adult coef. (naive SDM)	Total	Mortgaged	Cash/other
	0.032	0.052	0.026
Young-adult coef. (CF-corrected)	0.178	0.234	0.144
CF total effect	0.316	0.292	0.287
Block-bootstrap SE	(0.118)	(0.182)	(0.102)
p-value	0.007	0.108	0.005
<i>Note. Shift-share (Bartik) instrument: national age-cohort growth $\times$ province 2007 age composition. Young-adult share and its spatial lag are both instrumented. Block-bootstrap standard errors (200 replications).</i>			

5.5 Robustness to spatial weights

Table 5 and Fig. 4 re-estimate the effects under KNN-5 weights. The young-adult effects direct, indirect and total are stable in magnitude and significance across both weighting schemes in every segment, as is p. The aging-dispersion direct effect is likewise robust. The dispersion spillover, by contrast, weakens under KNN-5 and in some segments changes sign, so we treat it as suggestive rather than confirmed.

Table 5
Effect robustness: queen contiguity vs. KNN-5

Young-adult share		Total	Mortgaged	Cash/other
	Direct	0.039*** / 0.038***	0.064*** / 0.059***	0.030*** / 0.032***
	Indirect	0.129*** / 0.121***	0.162*** / 0.172***	0.126*** / 0.112***
	Total	0.168*** / 0.159***	0.227*** / 0.231***	0.156*** / 0.144***
Aging dispersion	Direct	0.500** / 0.579**	0.325nan / 0.378nan	0.499** / 0.547**
	Indirect	-0.350nan / -1.461**	3.512*** / 2.271*	-0.756nan / -1.461**
	Total	0.150nan / -0.881nan	3.837*** / 2.649*	-0.257nan / -0.914nan
<i>Note. Each cell reports the queen-contiguity estimate / KNN-5 estimate. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$ from Monte Carlo standard errors.</i>				

6. Discussion

6.1 Demographic demand and the primacy of spillovers

The central result that the young-adult share raises transactions chiefly through cross-province spillovers, with the indirect effect roughly three times the direct one recasts demographic housing demand as a regional rather than a local phenomenon. It is the demographic analogue of the price "ripple effect" that Meen (1999) attributed to migration, spatial arbitrage and equity transfer, and of the spatial-temporal diffusion documented by Holly, Pesaran, and Yamagata (2011): here it is a neighbour's age structure, not a neighbour's past prices, that propagates. The finding also complements rather than contradicts the aging-and-prices literature. Where Mankiw and Weil (1989) and Takáts (2012) show that aging depresses real prices, our evidence shows that a large young cohort sustains transaction activity and does so across a region so the demographic forces visible in prices and in volumes are two faces of the same life-cycle mechanism (DiPasquale & Wheaton, 1994). That the largest spatial parameter appears in the mortgage segment ($\rho = 0.53$) is consistent with integrated regional credit and search markets in which financing conditions and buyer flows cross provincial lines.

Two aspects of this result are genuinely surprising. First, the dominance of the spillover over the own-province effect is larger than the housing-demography literature, which is overwhelmingly estimated on aggregate or own-area data, would lead one to expect; it implies that province-by-province demand models materially understate how demographic change is transmitted. Second, instrumenting the young-adult share with the shift-share instrument increases the coefficient rather than shrinking it. The naive expectation that young adults move toward booming markets, inflating ordinary estimates is not borne out; instead the ordinary estimates are attenuated. Plausible explanations are classical measurement error in the share and a degree of negative selection, whereby rising prices in the most active markets price out younger renters, both of which bias the uninstrumented coefficient toward zero. Either way, the causal demographic effect is stronger, not weaker, than it first appears, which is reassuring for the substantive claim and unusual enough to merit emphasis.

6.2 Segment heterogeneity: credit access versus the inflation hedge

Separating financing segments uncovers two distinct mechanisms that a pooled model would blur. Mortgage-financed transactions respond to the young-adult share, to household formation, and to mortgage-rate exposure concentrated in younger provinces. This is precisely the configuration predicted by the credit-constraint theory of housing turnover: Stein (1995) and Ortalo-Magné and Rady (1999, 2006) show that down-payment and credit constraints bind most tightly on young, first-time buyers, so the segment where they dominate is the segment most sensitive to demographic demand and to the cost of credit. Our results give that theory a spatial dimension the young-buyer credit channel is regionally amplified and extend the segment heterogeneity that Hiller and Lerbs (2016) found across housing types to a split by financing type.

Cash transactions behave differently: they are depressed by inflation exposure in older provinces. The store-of-value interpretation of Turkish housing (Coşkun et al., 2020) might suggest the opposite that inflation drives flight into property so the negative sign is the second surprise of the paper and warrants

careful reading. The most coherent interpretation is that, in older provinces, sustained inflation erodes the real value of fixed and pension incomes and the liquid savings from which cash purchases are funded, and may encourage incumbent older owners to hold rather than transact; these liquidity and life-cycle forces appear to outweigh any hedging motive in the cash segment. The contrast with the mortgage segment, where inflation/rate exposure operates through younger first-time buyers, reinforces the case for modelling the two segments separately.

6.3 Within-province dispersion: a tentative result

The aging-dispersion measure adds a further, more tentative, insight: a province's own transaction activity rises with the internal heterogeneity of its district age structure, suggesting that demand is shaped by sub-provincial composition and not only by the provincial average. This is consistent with the aggregation-bias concerns that motivated city-level and disaggregated demographic studies (Hiller & Lerbs, 2016). The corresponding spillover, however, is sensitive to the spatial-weights specification, weakening and in places reversing under nearest-neighbour weights. We therefore treat the dispersion direct effect as a credible secondary finding and the dispersion spillover as a hypothesis for future work rather than an established result. An honest robustness analysis forces and that we think strengthens, rather than weakens, the paper's claims.

6.4 Implications for planning and housing policy

The results carry concrete implications for the planning and policy audience this journal serves. Most directly, because demographic housing demand diffuses across provincial borders, the relevant unit for anticipating and provisioning that demand is the functional region, not the individual province. Land release, infrastructure and housing-supply planning organised strictly within administrative provincial boundaries will systematically under-provide where a province sits beside young, fast-growing neighbours, and over-provide where it does not. This argues for inter-provincial or metropolitan-regional coordination of supply planning and for demographic-demand projections built at the district scale data that, as our harmonised dataset shows, the national statistical system already supports.

For mortgage policy the segment results are equally concrete. Because the young-adult demand channel works mainly through the mortgage segment and largely through spillovers, instruments that ease first-time purchase targeted low-rate mortgage lines, guarantees, or down-payment assistance for younger households would have effects that extend well beyond the locality in which they are deployed; conversely, mortgage-rate shocks transmit regionally and not just locally. The cash segment calls for a different lever: in older, inflation-exposed provinces, transaction activity is governed less by housing-specific policy than by macro-financial stability, so price stabilisation and the protection of real incomes are, in effect, housing-market policy for those provinces. The broader lesson is that uniform national housing and mortgage policies will have uneven, regionally amplified effects, and that targeting by segment and by demographic region would make them more effective and more equitable.

These findings are also informative for an international readership. They suggest that in fast-growing, demographically heterogeneous and macro-financially volatile economies, the segment of the market

and the spatial scale of analysis materially change the conclusions one would draw from aggregate, price-only studies and that the regional transmission of young-adult demand may be a general feature of such settings, testable wherever comparable sub-national demographic and transaction data exist.

7. Conclusions

Using a harmonized province-by-year panel for Türkiye over 2014–2024 and a spatial Durbin model with Bartik-based identification, we show that demographic change shapes housing transactions through channels that are segment-specific and substantially regional. The young-adult population share raises sales especially mortgage-financed sales mainly through cross-province spillovers, a result robust to alternative spatial weights and strengthened under instrumentation. Mortgaged and cash segments respond to distinct demographic and macro-financial forces, and within-province demographic dispersion contributes to local transaction activity.

Several limitations qualify these conclusions and point to future work. The analysis uses provincial transaction counts; extending it to micro-level transactions and to prices would allow welfare and affordability questions to be addressed directly. The dispersion spillover is specification-sensitive and warrants further scrutiny, ideally with a longer harmonized boundary history. Two Türkiye-specific shocks bound the inference: the population register may understate the population of provinces hosting large temporary-protection (refugee) communities, and the February 2023 earthquakes delivered a simultaneous housing-and-population shock to several provinces at the end of the window; both deserve explicit treatment in extensions. Finally, comparative analysis across countries would test whether the regional-spillover character of young-adult demand generalizes beyond the Turkish case. Despite these caveats, the core implication is robust: the regional scale, and the financing segment, belong at the center of how demographic change in housing demand is analyzed and governed.

Declarations

Competing interests.

The authors have no competing interests to declare that are relevant to the content of this article.

Ethics approval.

Not applicable; the study uses aggregate, publicly sourced administrative data.

Funding.

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Author Contribution

K.Y.A. is the sole author of this manuscript. K.Y.A. conceived and designed the study, assembled and harmonized the data, developed the spatial econometric methodology and implemented the estimation, conducted the formal analysis, prepared all tables and figures, and wrote and revised the manuscript. The author read and approved the final manuscript.

Data availability.

The house-sales and demographic data are derived from official Turkish statistical sources (TURKSTAT/TUIK) and an official district boundary shapefile. The harmonized analysis panel and estimation code are available from the corresponding author on reasonable request.

References

1. Anselin, L. (1988). *Spatial econometrics: Methods and models*. Kluwer Academic.
2. Borusyak, K., Hull, P., & Jaravel, X. (2022). Quasi-experimental shift-share research designs. *The Review of Economic Studies*, 89(1), 181–213.
3. Cheung, W. M. (2024). Cointegrations in house price dynamics and ageing population risks. *PLOS ONE*, 19(2), e0296991.
4. Coşkun, Y., & Jadevicius, A. (2017). Is there a housing bubble in Turkey? *Real Estate Management and Valuation*, 25(1), 48–73.
5. Coşkun, Y., Seven, Ü., Ertuğrul, H. M., & Alp, A. (2020). Housing price dynamics and bubble risk: The case of Turkey. *Housing Studies*, 35(1), 50–86.
6. de Wit, E. R., Englund, P., & Francke, M. K. (2013). Price and transaction volume in the Dutch housing market. *Regional Science and Urban Economics*, 43(2), 220–241.
7. DiPasquale, D., & Wheaton, W. C. (1994). Housing market dynamics and the future of housing prices. *Journal of Urban Economics*, 35(1), 1–27.
8. Eichholtz, P., & Lindenthal, T. (2014). Demographics, human capital, and the demand for housing. *Journal of Housing Economics*, 26, 19–32.
9. Elhorst, J. P. (2014). *Spatial econometrics: From cross-sectional data to spatial panels*. Springer.
10. Engelhardt, G. V., & Poterba, J. M. (1991). House prices and demographic change: Canadian evidence. *Regional Science and Urban Economics*, 21(4), 539–546.
11. Genesove, D., & Mayer, C. (2001). Loss aversion and seller behavior: Evidence from the housing market. *The Quarterly Journal of Economics*, 116(4), 1233–1260.
12. Goldsmith-Pinkham, P., Sorkin, I., & Swift, H. (2020). Bartik instruments: What, when, why, and how. *American Economic Review*, 110(8), 2586–2624.

13. Gong, Y., Hu, J., & Boelhouwer, P. J. (2016). Spatial interrelations of Chinese housing markets: Spatial causality, convergence and diffusion. *Regional Science and Urban Economics*, 59, 103–117.
14. Heo, Y. J. (2022). Population aging and house prices: Who are we calling old? *The Journal of the Economics of Ageing*, 23, 100417.
15. Hiller, N., & Lerbs, O. W. (2016). Aging and urban house prices. *Regional Science and Urban Economics*, 60, 276–291.
16. Holly, S., Pesaran, M. H., & Yamagata, T. (2011). The spatial and temporal diffusion of house prices in the UK. *Journal of Urban Economics*, 69(1), 2–23.
17. Kelejian, H. H., & Prucha, I. R. (1998). A generalized spatial two-stage least squares procedure for estimating a spatial autoregressive model with autoregressive disturbances. *The Journal of Real Estate Finance and Economics*, 17(1), 99–121.
18. Lancaster, K. J. (1966). A new approach to consumer theory. *Journal of Political Economy*, 74(2), 132–157.
19. Larkin, M. P., Askarov, Z., Doucouliagos, H., Dubelaar, C., Klona, M., Newton, J., Stanley, T. D., & Vocino, A. (2019). Do house prices ride the wave of immigration? *Journal of Housing Economics*, 46, 101630.
20. Law No (6360). (2012). On the establishment of fourteen metropolitan municipalities and twenty-seven districts and amendments to certain laws and decree laws [Resmî Gazete No. 28489, 6 December 2012]. Ankara.
21. Lee, L. F., & Yu, J. (2010). Estimation of spatial autoregressive panel data models with fixed effects. *Journal of Econometrics*, 154(2), 165–185.
22. LeSage, J., & Pace, R. K. (2009). *Introduction to spatial econometrics*. CRC.
23. Leung, C. K. Y., & Feng, D. (2005). What drives the property price–trading volume correlation? Evidence from a commercial real estate market. *The Journal of Real Estate Finance and Economics*, 31(2), 241–255.
24. Mankiw, N. G., & Weil, D. N. (1989). The baby boom, the baby bust, and the housing market. *Regional Science and Urban Economics*, 19(2), 235–258.
25. Meen, G. (1999). Regional house prices and the ripple effect: A new interpretation. *Housing Studies*, 14(6), 733–753.
26. Miles, D. (2012). Population density, house prices and mortgage design. *Scottish Journal of Political Economy*, 59(5), 444–466.
27. Monnet, E., & Wolf, C. (2017). Demographic cycles, migration and housing investment. *Journal of Housing Economics*, 38, 38–49.
28. Ortalo-Magné, F., & Rady, S. (1999). Boom in, bust out: Young households and the housing price cycle. *European Economic Review*, 43(4–6), 755–766.
29. Pavlov, A., & Somerville, T. (2020). Immigration, capital flows and housing prices. *Real Estate Economics*, 48(3), 915–949.

30. Ortalo-Magné, F., & Rady, S. (2006). Housing market dynamics: On the contribution of income shocks and credit constraints. *The Review of Economic Studies*, 73(2), 459–485.
31. Özsoy, O., & Şahin, H. (2022). Factors affecting housing prices in Izmir, Turkey: A quantile regression approach. *International Journal of Housing Markets and Analysis*, 15(1), 145–164.
32. Polat, Z. A. (2019). Legal, economic, geographical and demographic analysis of the acquisition of real estate by foreigners in Turkey. *Land Use Policy*, 85, 207–217.
33. Park, S., et al. (2017). The dynamic effect of population ageing on house prices: Evidence from Korea. *Pacific Rim Property Research Journal*, 23(2), 195–212.
34. Sayın, Z. M., Elburz, Z., & Duran, H. E. (2022). Analyzing housing price determinants in Izmir using spatial models. *Habitat International*, 130, 102712.
35. Stein, J. C. (1995). Prices and trading volume in the housing market: A model with down-payment effects. *The Quarterly Journal of Economics*, 110(2), 379–406.
36. Takáts, E. (2012). Aging and house prices. *Journal of Housing Economics*, 21(2), 131–141.
37. Tsai, I. C. (2014). Ripple effect in house prices and trading volume in the UK housing market: New viewpoint and evidence. *Economic Modelling*, 40, 68–75.
38. Tsai, I. C., & Chiang, S. H. (2019). Exuberance and spillovers in housing markets: Evidence from first- and second-tier cities in China. *Regional Science and Urban Economics*, 77, 75–86.
39. Turkish Statistical Institute (TURKSTAT). (2024a). *House sales statistics*. Turkish Statistical Institute. <https://data.tuik.gov.tr>
40. Turkish Statistical Institute (TURKSTAT). (2024b). *The results of the address-based population registration system*. Turkish Statistical Institute. <https://data.tuik.gov.tr>
41. Vizek, M., Stojčić, N., & Mikulić, J. (2023). Spatial spillovers of tourism activity on housing prices: The case of Croatia. *Tourism Economics*, 29(5), 1376–1390.
42. Wang, X., Hui, E. C. M., & Sun, J. (2018). Population aging, mobility, and real estate price: Evidence from cities in China. *Sustainability*, 10(9), 3140.

Figures

Figure 1. The geography of demographic structure and mortgage finance across Turkish provinces (2014-2024 averages, 81 provinces)

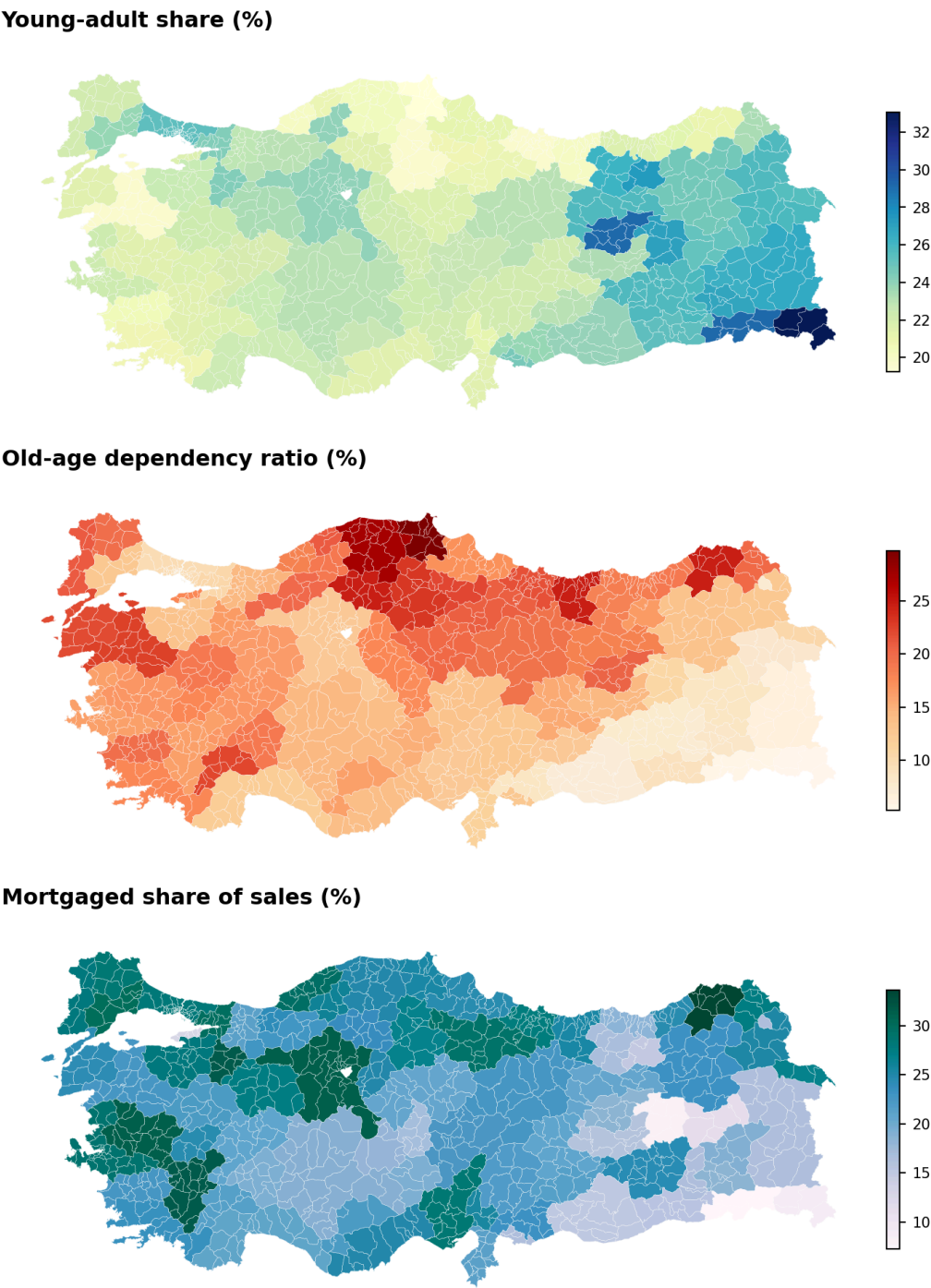


Figure 1

The geography of demographic structure and mortgage finance across the 81 provinces (2014–2024 averages): young-adult share, old-age dependency ratio, and mortgaged share of sales.

Figure 3. Population aging and the collapse of mortgaged sales, 2014-2024

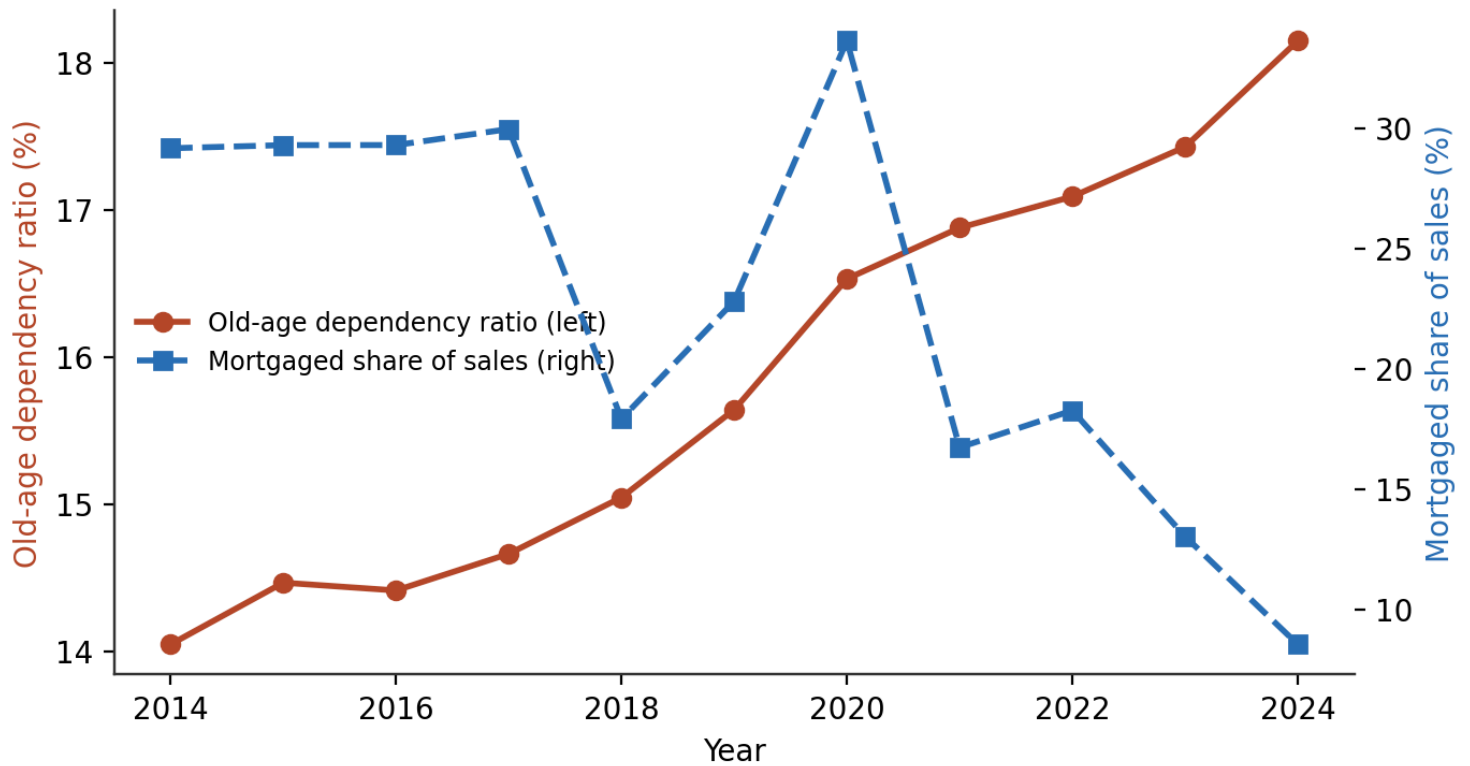


Figure 2

Population aging and the decline of mortgage-financed sales, 2014–2024 (province means).

Figure 1. Decomposed effects of young-adult share on house sales, by market segment

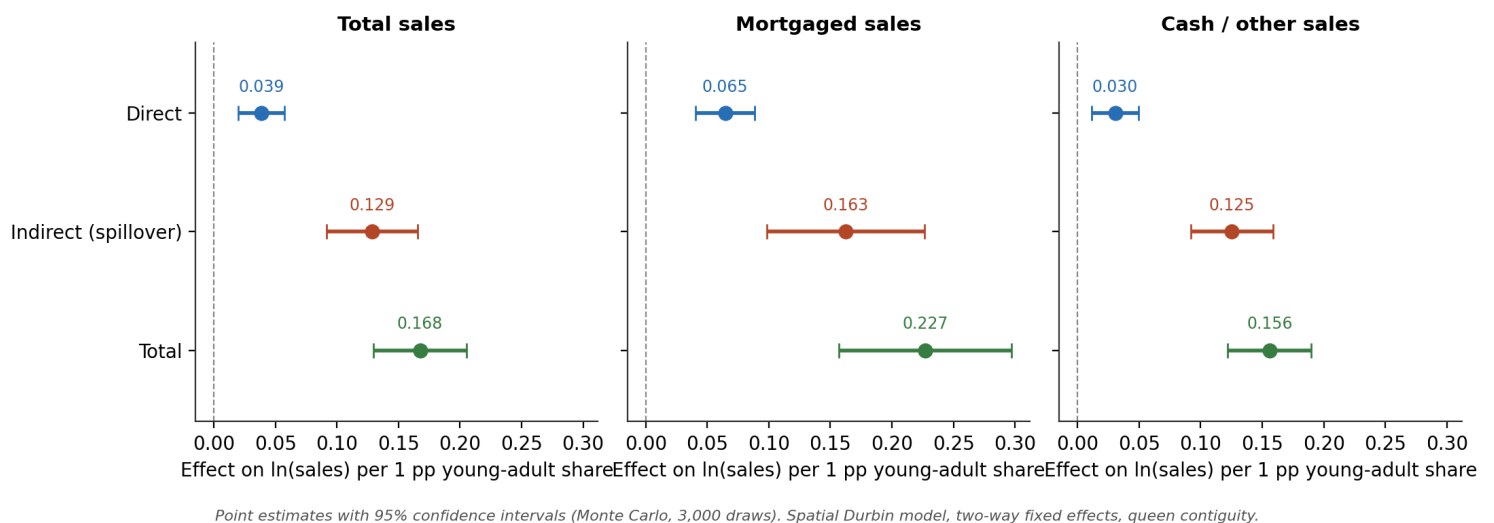


Figure 3

Decomposed effects of young-adult share by market segment, with 95% confidence intervals.

Figure 2. Robustness of young-adult effects to spatial weights specification

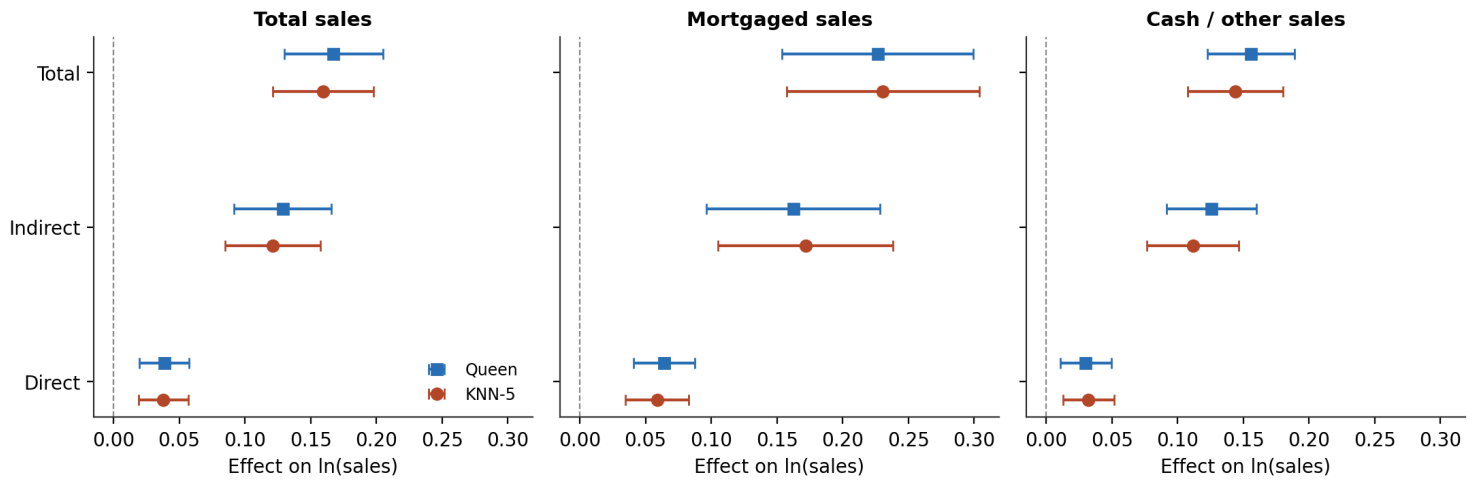


Figure 4

Young-adult effects under alternative spatial weights, with 95% confidence intervals.