Baby Booms and Asset Booms: Demographic Change and the Housing Market

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Abstract

How do demographic changes affect asset prices? Based on centuries of data, this paper shows that demographic changes are a key and predictable determinant of house prices. A one percentage point increase in the current birth rate increases house prices about 25-30 years later by 4 to 5%. Using individual data on housing decisions, transactions and portfolios we argue this is driven by strongly age-dependent demand for home-ownership and the limited response of investors to such shocks. Correspondingly, we find large impacts of past birth rates on rent-price ratios, but negligible impacts on rent prices, bond yields, and dividend yields.

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1 Introduction

Countries across the world differ significantly in their population structures, reflecting structural differences in fertility and life expectancy as well as transitory shocks to birth rates. These transitory shocks extend beyond the post-war baby boom. For example, the United States currently has a large cohort around age 30, which outnumbers the cohort around age 50 by a ratio of 12 to 10. In this paper, we investigate the impact of such demographic shifts on asset prices, focusing specifically on the housing market. We show that demographic shifts can explain a large fraction of the variation in house prices and rent-price ratios in the past centuries. Birth rate shocks predict large house price increases at the time a cohort enters its prime home-buying years, and large decreases when a cohort exits home-ownership at old ages or after death. Using micro-level investment data, we argue that these price effects are housing-specific and driven by the fact that other housing investors absorb excess demand or supply caused by demographic shocks to housing investments only to a limited extent. Correspondingly, lagged birth rates generally have small and insignificant effects on the yields of other assets and on rent prices.

We introduce a novel historical approach to empirically identify the impact of demographic shocks on asset prices. Measuring reduced-form effects of demographic changes has been challenging since the onset of the literature (e.g. Mankiw and Weil, 1989; Poterba, 2001) and most papers have therefore relied on theoretical models. At aggregate levels, demographic trends tend to be very gradual, implying one needs long-horizon data to study its impact. However, over longer horizons countries have typically experienced demographic transitions that closely link to economic development, making it very difficult to separate economic shifts from demographic shocks. While there exist differences in demographic structure in the cross-section, these are highly endogenous, for example because young individuals migrate to areas with the most economic opportunities.

Our approach uses newly-constructed long-run time series of demographic rates and asset returns, combined with historical micro-data on housing and investment decisions. We study the period between the 16th century and the start of the demographic transition in the 19th century, based mainly on data from Amsterdam, but also from Paris (rents only). For these two cities, enough data survived to construct long time series. We focus on the period before the demographic transition, because there were no structural trends in fertility, life expectancy and economic growth during that period, implying that birth cohorts did not differ systematically in the demographic and economic prospects they faced.

Because contemporaneous changes in the demographic structure correlate with economic outcomes, our identification uses lagged birth rates, and tests for a relation with price or yield changes decades later. While economic changes decades ago are unlikely to still affect price changes today, the relationship between lagged birth rates and the housing market is natural due to the strong age patterns in housing consumption and investment. Although our historical setting helps with identification, it raises the question how these results generalize to modern markets. We argue that they do and provide suggestive empirical evidence that the same relationships likely still hold in modern OECD countries.

We start the paper by providing stylized facts on age-patterns in housing consumption and investment today and in history, and show how demographic rates have changed over time. These stylized facts show that both today and in history the largest increases in housing demand occur around 20-25 years after birth. However, the impact of a given shock to birth rates is twice as large today: before the demographic transition, only half of children would reach the ages at which they typically start renting a house or could look for owner-occupied housing. Price impacts are likely thus larger in modern demographic regimes. For older ages, reductions in consumption demand due to downsizing and mortality have smaller effects, because these are more gradual both in the modern and historical regime. In terms of housing investment, home purchases peak at similar ages today (around age 30), but housing sales historically concentrate at earlier ages given changes in life expectancy. These age peaks in housing purchases and sales are distinct from the more gradual age patterns in demand for housing consumption.

Our paper highlights that the impact of demographic shocks on house prices and rent-price ratios differs substantially from that on rent and other asset prices. In most asset pricing theories, the impact of demographic structure on asset prices is primarily driven by its general-equilibrium impact on interest rates and risk premia. The housing literature focuses on age-dependence in housing demand. We argue that large impacts on house prices and rent-price ratios in demand could be driven by a different mechanism: the strong age-dependence of investments in owner-occupied housing and the limited response of other housing investors to these shocks.

To understand why, consider a large birth cohort reaching adulthood. Based on our stylized facts, total housing demand of this cohort will rise substantially in their late teens and early twenties, with growth tapering off at older ages. Because young adults typically start their housing career by renting, most of this demand will clear in the rental market. In the rental market, new contracts are signed very frequently and permanent contracts typically include rent indexation clauses, so this shock will affect the rental prices and corresponding housing consumption decisions of all households. Rent prices will decrease depending on demand and supply elasticities. If investors price homes based on discounted future rents, house prices might increase at the same time as rent prices or even earlier if investors anticipate the demand shock.

A few years later, this large birth cohort will have saved some funds and start to settle: the typical period to look for owner-occupied housing. Both in modern countries and in historical Amsterdam individuals typically purchase their first house around age 30 and exit only when they reach old ages or after death. In the housing market, only a small fraction of properties trades hands every year, so the arrival of a large cohort of prospective home-buyers will increase the number of searching buyers significantly relative to the number of properties for sale. If searching households hold strong preferences for home-ownership at this stage in their life, they might significantly bid up prices. In line with this narrative, media have linked recent increases in house prices to the fact that the large millennial cohort has reached its prime home-buying years.[1] Any such price impact will depend on the behavior of other investors. If prices increase, they might put additional properties on the market until prices again equal discounted rents. However, if markets are segmented, investors and incumbent home-owners might not put extra properties up for sale.

These considerations are likely less important for other assets, which are less lumpy and more liquid, allowing investment and divestment to be spread more gradually over the life cycle. If households exit the owner-occupied market, for example by moving to an old-age rental home or after death, this might likewise result in price declines if deep-pocketed investors or prospective home-buyers are unwilling to absorb this supply.

Based on this framework, a limited response of investors from other age cohorts to demographic demand shocks for housing investments might cause house prices to change significantly, even if aggregate housing consumption and corresponding rental prices change by a small amount. Greenwald and Guren (2021) have formalized this intuition for the case of credit shocks, arguing that the limited response of deep-pocketed investors to credit shocks was a key driver of their large effects on house prices and price-rent ratios around 2008. When applied to demographic demand shocks, such a model could form a natural micro-foundation for the effects we find in this paper.

For our main analysis, we focus on identifying the relation between current changes in rents, house prices and rent-price ratios and various lags of birth rates, ranging from 15 to 75 years ago. Our central identifying assumption is that historical birth rates predict current housing and asset demand, but are not significantly related to unobserved economic variables that could be correlated with current housing and asset demand. We can control directly for a basic set of other economic and demographic variables.

We find changes in the demographic structure generally have negligible impacts on rent prices. While the coefficients we find are in line with housing demand shocks in

[1]For example: "Millenials are Supercharging the Housing Market," *Wall Street Journal*, December 2021.

the simple model, being positive for young cohorts and negative for old cohorts, they are small and mostly insignificant. However, we find statistically significant impacts of changes in the demographic structure on house prices and rent-price ratios in Amsterdam. A one percentage point increase in birth rates about 25 years ago, increases current house prices and reduces rent-price ratios by about 4%. We find opposite effects for cohorts born around 60 years ago: increases in birth rates 60 years ago increase current rent-price ratios and decrease house prices by almost 5%. The timing of both effects corresponds exactly with the ages at which net housing purchases and sales start increasing significantly. We find no significant impact for birth rate lags corresponding to cohorts in their late thirties to fifties. These results change little when we control for contemporaneous changes in demographic rates and economic conditions, nor when we add lagged control variables. This suggests that our findings are not driven by the correlation of historical fertility shocks with other economic factors affecting current house or rent prices.

In aggregate, demographic changes are a key determinant of house prices and rent-price ratios, and also result in economically significant predictability. A simple predictive regression that uses only the five-year birth rate 25 and 60 years ago as explanatory variables, explains respectively 13% and 18% of current five-year changes in house price and rent-price ratios. This result is particularly striking given that lagged fertility is a relatively noisy measure in the period we study: on average, half of the newborns would not reach adulthood.

The timing and magnitude of the effects on house prices and rent-price ratios that we find are in line with our mechanism of age-specific shocks to the demand for home-ownership coupled with a limited response in the number of homes for sale. In the second part of the paper, we explore this mechanism in more detail and discuss external validity.

We start by examining whether the impact of lagged birth rates on asset prices is housing-specific, as the mechanism suggests, or also exists for other assets. In the latter case, the impact could also be driven by broader effects of demographic shocks on interest rates and risk premia. We focus on the impact on bond and dividend yields and show that lagged fertility has economically much smaller and statistically less significant effects on bond and dividend yields. For fertility lags corresponding to young cohorts, the effects on bond yields have also an opposite sign, which might reflect the tendency of the young to invest more in risky assets. At old ages, all coefficients are positive, but they are again smaller and statistically less significant for bond and dividend yields. In line with the pattern in housing sales, this is likely driven by heirs selling financial assets after death. In short, demographic shocks might indeed have an impact on interest rates and risk premia, but these cannot explain the large impact on house prices and rent-price ratios.

Next, we study whether the age-specific role of housing is also confirmed in investment portfolios. We link marriage certificates to asset portfolios at death for individuals that died in Amsterdam between 1688 and 1780. Death typically came suddenly and continuously during the time period we study, implying we can compare individuals that died at different ages, approximated by the number of years since marriage. We show that individuals that died shortly after marriage possessed a relatively larger fraction of their wealth in real estate compared to individuals that were old. These results are exactly opposite for bonds, as individuals typically saved their remaining wealth in government bonds or other debt assets. Alike today, large equity holdings were only found in the portfolios of the wealthy but we have too few data points to study this in more detail.

We also look at measures of turnover and show that lagged birth rates do not predict an increase in the number of sales for lags corresponding to cohorts of prospective home-buyers despite the increase in prices and searching home-buyers. This suggests the response in the number of homes for sale is indeed limited. We do find an increase in sales for lags corresponding to old ages, indicating that heirs or older individuals do put their properties on the market and end up selling at lower prices.

In the final part of the paper, we return to the external validity of our findings. A key finding in our paper is the disparate effect of demographic shocks on rent and house prices. The frictions driving this segmentation might be related to the specific characteristics of the housing market we study. We argue this is unlikely to be the case. Transaction costs and fiscal wedges between home-ownership and tenancy were low compared to modern markets. Housing markets were also not any less liquid than modern housing markets, while home-ownership rates in historical Amsterdam were not very different from those in modern Amsterdam or other large cities. Our estimates thus constitute a lower bound.

Lastly, we use house prices and demographic data from a panel of OECD countries to show that the empirical relationships we document in our historical time period also appear in more recent data. Although limitations imply that we cannot identify these effects as precisely as in the historical period, we find that the lagged population share of children predicts increasing house prices and decreasing rent-price ratios when this cohort enters its home-buying years, while there is no significant effect on rents.

1.1 Related literature and contribution

Our findings link and contribute to existing work in both finance and urban economics. First, our paper relates to the literature investigating the link between demographic changes on asset prices. A large stream of theoretical papers uses overlapping-generations models to calibrate the impact of demographic shocks on interest rates or asset prices (e.g Abel, 2001, 2003; Geanakoplos et al., 2004; Carvalho et al., 2016; Eggertsson et al., 2019; Leombroni et al., 2020; Gagnon et al., 2021; Auclert et al., 2021; Kopecky and Taylor, 2020). In line with our empirical approach, these papers generally assume demographic shifts to originate from shocks to birth rates. Although there is no strong consensus from this literature, results generally point to large young cohorts having positive impacts on risky asset prices, while large old cohorts will depress interest rates an increase risk premia.

Most theoretical papers do not explicitly consider housing, the main investment asset for households. Housing is lumpy and illiquid, and net buying or selling correlates more strongly with age than investments in other assets. Accordingly, the large impact of demographics on house prices and rent-price ratios is likely specific to the housing market and we do not find strong empirical evidence for such effects in other assets. Leombroni et al. (2020) consider housing in the context of an overlapping-generations model, exploring the role of the baby boom generation and high inflation in asset price dynamics in the 1970s. They show that the market entry of baby boomers lowered the saving rate, caused a portfolio shift towards housing and a corresponding boom in house prices. Their model features frictionless rental markets where house prices equate the present value of discounted rents.

Our empirical estimates indicate that housing market frictions might be a major driver of the impact of demographic shocks on house prices and rent-price dynamics. While developing a model including such frictions is beyond the scope of this paper, this mechanism closely aligns with the work of Greenwald and Guren (2021) on credit shocks. In their model, the housing market impact of these shocks depends on the degree to which deep-pocketed landlords are willing to soak up credit-driven excess demand. In line with our empirical evidence for demographic shocks, their calibration points to sizeable market segmentation and thus a large impact of demand shocks on house prices and rent-price ratios.

Relative to the theoretical literature, our key contribution is to develop empirical estimates of the impact of demographic shocks on asset prices, specifically highlighting the role of housing assets and their special characteristics. Various existing papers have studied the empirical link between demographics and asset prices, but results are mixed. Poterba (2001, 2004) generally found limited support that demographic shifts affect aggregate asset prices, while Favero et al. (2011) find that the middle-aged to young ratio does predict dividend-price ratios. At individual stock level, DellaVigna and Pollet (2007) find that demographics predict stock returns in industries with age-dependent demand. Similar shifts also affect capital budgeting decisions and cash holdings (DellaVigna and Pollet, 2013; Cunha and Pollet, 2020).

Our historical approach allows to identify the empirical effects of demographic shocks on asset prices more precisely and to also examine predictability over long horizons. We also focus primarily on housing instead of bonds or equities, and build on existing literature that started with Mankiw and Weil (1989) and extends until today (e.g. Engelhardt and Poterba, 1991; Green and Hendershott, 1996; Takáts, 2012; Green and Lee, 2016; Hiller and Lerbs, 2016; Gong and Yao, 2022). These papers establish how observed housing consumption demand varies with age and assess how changes in this demographic demand affect housing costs. The findings have resulted in limited consensus, given the difficulty of accurately separating effects of cohort sizes from other economic conditions. Our empirical identification strategy aims to overcome this limitation.

The aforementioned papers have also not considered the possibility of segmentation between the rental market and housing market. Our price effects suggest such segmentation is significant, and imply that house price effects are primarily driven by the strongly age-dependent net entry and exit into home-ownership instead of general life-cycle patterns in housing consumption, as asserted in earlier papers.

2 Data

2.1 Demographic Data

We combine archival sources and published studies to construct annual time series of demographic variables in Amsterdam and Paris. The key variable of interest is the birth rate, and time series of mortality, migration and marriage rates will be applied as control variables in our main analysis. For Amsterdam, we also employ marriage data to link the age of a person, approximated by the number of years since marriage, to their portfolio composition and housing market activity.

For Amsterdam, we use archival civil registers on all individual births, marriages, and deaths in the period before 1810. These have been digitized by the Amsterdam City Archives (ACA), available from 1554 (deaths) and 1565 (births, marriages).[2] Records of births and deaths are organized by parish or cemetery, and some of the records are missing, in particular in the early part of the sample. In those periods, we estimate

[2]Source: ACA inv. nr. 5001 and inv. nr. 5009.

demographic rates based on data from parishes that are consistently available. This is comparable to other studies (e.g. Curtis, 2016) and is explained in more detail in Internet Appendix A.

After 1810 aggregate numbers of births, deaths, and marriages are supplied by the Gemeente Amsterdam (1923) and the yearbooks of the Amsterdam Statistical Office (Gemeente Amsterdam, 2019). These same sources also provide population and migration estimates after 1850. For the period before 1850, we use population numbers from Nusteling (1985) and Van Leeuwen and Oeppen (1993) that are available at five-year intervals. To transform these to annual numbers, we use actual birth and mortality data, while interpolating the implied migration estimates from the population series. Because population series might contain error, we also constructed a normalized series of migration based on purchases of citizenship and registration in the protestant church, which we explain in Internet Appendix A.

For Parisian demographic data, we rely on a multitude of publications on annual numbers of births, deaths and marriages, from Biraben and Blanchet (1999) and Charlot and Dupâquier (1967) together with the Annuaire Statistique de la Ville de Paris, available from 1880 to 1967 (Mairie de Paris, 1967). For the remainder, we use data published by INSEE, the French Statistical Office. We transform these to crude birth, marriage and death rates, based on population numbers of Biraben and Blanchet (1999) for the pre-revolution period, and data from INSEE and the Parisian Annuaires from the Revolution onwards. For Paris, we have no information on migration.

2.2 Housing Market Data

For the housing market, we combine several datasets of individual Amsterdam transaction prices. For the period between the 1600s and 1810, we make use of the database in Korevaar (2022), which covers all housing transactions in Amsterdam between 1700 and 1810, and the majority of housing transactions in the 17^{th} century. We combine the repeat-sales pairs in his database with 5,269 repeat-sales prices of properties along the

Herengracht, Amsterdam's most expensive canal, from Eichholtz (1997). This dataset extends from the 17th century until 1976. For the period 1840–1979, we have additional transaction data from property auctions from Eichholtz et al. (2021).

We combine the observations from all data sources to estimate a repeat-sales index using the methodology of Francke (2010), spanning the period 1625–1979. This method avoids excessive noise in periods with a low number of observations (between 1810 and 1840, and between 1625 and 1637), and is consistent with the rent indices that are based on the same method.[3]

For indices of rent prices, wages, and consumer prices, we use existing indices as reported in Eichholtz et al. (2020), which cover the period from 1500-present for Paris and from 1550-present for Amsterdam. Last, we combine various series of bond yields to construct a series of interest rates for Amsterdam spanning from 1586 to the present. Until 1795 we use data from Gelderblom and Jonker (2011) on the yields on Holland bonds, the most important public debt instrument in the Dutch Republic. Between 1795-1807, we use data on bond prices (and the implied yields) from the Maandelykse Nederlandsche Mercurius, which published price lists of bonds from the 1790s onwards. After 1814 we use the long-term (10-year) Dutch bond-yield. To interpolate between 1807-1814, we use observations from Wilson (1941). To compare developments in housing yields and bond yields with other asset yields, we also use the series of dividend yields for the Dutch East India Company from Golez and Koudijs (2017), the main asset on the Amsterdam equity market in the period we study, covering the period from 1629 until 1782.

Descriptive statistics on each of the variables that we introduced in this section are reported in Table 1. The statistics on rent prices, house prices, wages, and consumer prices all refer to annual log-differences. Note that inflation was limited in this period, except in the late 16th century. Mortality, nuptiality, birth rates, and implied migration reflect percentage shares of the total population. For reference, we have also included statistics on annual population changes in the table, but we should note that these are

[3]For more information on the data and the index construction, we refer to the individual papers.

based on interpolated estimates from various studies, such that their annual standard deviation likely underestimates the true standard deviation.

[Place Table 1 about here]

3 Stylized facts

Before moving on to the main empirical analysis of the paper, we present four key stylized facts about demographics and the age-dependence of demand for rental and owner-occupied housing. We will outline each of these stylized facts and the empirical basis for them in both contemporary and historical data. We then use these stylized facts to motivate a basic framework that illustrates the extent to which the effect of demographic shocks today may differ from those in the past and the extent to which the effect on rents and house prices may differ.

Stylized fact 1*: Housing demand is negligible in childhood, increases significantly in early adulthood and then gradually tapers off towards older ages.*

Establishing the extent to which housing consumption demand varies by age has been the subject of much debate in the literature (e.g. Mankiw and Weil, 1989; Green and Hendershott, 1996; Eichholtz and Lindenthal, 2014; Green and Lee, 2016). Mankiw and Weil (1989) assume the housing demand of a household equates to the summed housing demand of each of its members, where the housing demand depends entirely on age. To estimate this, Mankiw and Weil used census data and regressed the dollar value of all properties in the census on age dummy variables. Their analysis concluded that the demand for housing increases rapidly for people in their twenties or early thirties, but decreases as one gets older.

In Figure 1, we replicate this analysis for historical Amsterdam by linking the individuals in the 1851 census to the rental values of the properties in which they lived. The age pattern that we find is very similar to that of Mankiw and Weil, with negligible demand for housing by children, a rapidly increasing demand for housing in the late teens and early twenties, and then a gradual decline in older age. Housing demand seems to increase and peak slightly earlier in historic Amsterdam than in the United States, which is probably because people in Amsterdam left their parental homes early and typically lived independently until they got married.

[Place Figure 1 about here]

As later studies have noted, while the rise in housing consumption demand in early adulthood is a robust feature of the data, the extent to which housing demand reduces at older ages has been subject to much more debate and is quite sensitive to the specification of the data. This also holds in the Amsterdam data.

Stylized fact 2: *Home purchases relative to home sales increase the most among people in their twenties and thirties, while home sales relative to home purchases are highest at older ages.*

In Table 2, we provide some basic statistics on the demographic patterns in home buying and selling, both for modern data and using data from 18$^{\text{th}}$-century Amsterdam. For historic Amsterdam, we do not have information on age, but we link sales records to marriage records for individuals with unique names and list the number of years since their first marriage. We explain this procedure in Internet Appendix B and show the distribution of house purchases and sales as a function of years since marriage in Figure 2. The average age at first marriage in Amsterdam was 27 years and similar for grooms and brides, with most people marrying before age 30. We highlight both young-age transactions and old-age transactions. Because our data does not allow to compute sales at individual ages, we report results for comparable age ranges.

[Place Table 2 about here]

[Place Figure 2 about here]

In all three societies (Amsterdam, the Netherlands, and the United States), we see that about half of the purchases occur by people in their late twenties, thirties, and early forties, or in the first twenty years after marriage. The number of sales executed in this age bracket is similar, with the buyer-seller ratio around 2. The opposite pattern is apparent for persons of older age, who account for a relatively large share of sales and are much less likely to buy. The buyer-seller ratio is around 0.7-0.75 in the US and around 0.5–0.6 in 18th-century Amsterdam.

While these age patterns reflect averages and likely vary endogenously with economic and demographic conditions, it seems generally true that most of the increase in home-buying activity occurs in the 25-35 age group. The peak in sales activity in Amsterdam is around 35 years after marriage (young sixties), similar to the pattern in the US, where the baby-boom generation is currently the generation selling most actively. The peak ages at which individuals sell may be more sensitive to changes in the demographic regime and we will present two stylized facts about this below.

Note that these concentrations in purchase and sale activity are distinct from the more gradual changes in demand for housing space that we documented in Figure 1, which correlated only weakly. They thus reflect primarily a change in housing investment, such as the move from a rental house to an owner-occupied house or the sale of a house after death.

One might wonder why the stylized facts about the sales market do not differ much in the historical data compared to modern findings, despite large differences in birth and survival rates. As for the sales market, homes were bought and sold only by the group of individuals who survived until the age at which they were able to buy or sell real estate and had sufficient wealth to do so. This implies that life expectancy conditional on purchasing a house was much higher than life expectancy in general. Second, some sales were conducted by heirs, who may not have sold the property immediately after death, but rented it out for some time.

Stylized fact 3: *Birth rates in Western Europe were high and volatile until the 19th century and reduced to modern levels during the 19th and 20th century.*

In order to understand the long-term evolution of birth rates, Figure 3 shows the evolution of birth rates for Amsterdam and Paris on an annual basis (Figure 3a) and for five-year periods (Figure 3b), which will be the main frequency of analysis in this paper.

[Place Figure 3 about here]

In the figure we can distinguish two periods. Until the 19th century birth rates were high and fluctuated substantially. After the start of the demographic transition, birth rates gradually started to decline to the low levels that are observed today. The main break in this trend was the baby boom after World War II, nowadays a large but transient driver of population aging.

We focus in this paper entirely on the period before the demographic transition. The most important reason is that the meaning of a given level of birth rates changes continuously when the demographic regime is changing. For example, five-year birth rates peaked around 10% during the baby boom after World War II, equivalent to the values reached during the large baby-bust in Amsterdam and Paris history in the late-16th century. A second reason is that rent prices were strictly controlled for a large part of the 20th-century in both Paris and Amsterdam. These controls appear to have had a very large impact on the evolution of prices and returns (Eichholtz et al., 2021), implying we cannot treat these prices as the market equilibrium of supply and demand factors.

As evident from Figure 3, the demographic transition in Paris happened earlier than in Amsterdam. To be conservative in our analysis, we will only include data up to the final birth rate peak. In Paris, the final birth rate peak occurs in 1831 and in Amsterdam in 1884. This means that we have about three centuries of data left in our sample for both cities, as Paris rent data starts slightly earlier. During this period, five-year birth rates fluctuated substantially with a standard deviation of 1.5%. For reference, birth rates in Amsterdam and Paris rose by around 3 percentage points during the post-war baby boom before reverting.

Stylized fact 4*: There were no clear trends in survival rates until the late 19th century.*

Afterward, life expectancy rose significantly.

Beyond the *level* change in birth rates since the demographic transition, the meaning of a given birth rate shock has been changing over time and continues to do so. Figure 4 reports estimates of the evolution of survival rates in Amsterdam and The Netherlands over time. Estimates for 1586 and 1670 are based on data from life annuities reported in (Alter, 1983), with later data from Statistics Netherlands.

[Place Figure 4 about here]

Since the late 19$^{\text{th}}$ century, life expectancy has continuously been increasing. These increases in longevity partially affect the housing market impact of a birth cohort of a given size: individuals born at time t can only buy or rent housing x years late if they are still alive at time t+x. For example, the potential negative effect of a comparatively small birth cohort entering the housing market might be offset by the fact that increased longevity implies an older birth cohort will demand housing for longer periods of time.

An advantage of our focus on the period before the late 19$^{\text{th}}$ century is that both birth and survival rates were stable over time. Figure 4 shows that survival rates look very similar in 1586, 1670 and 1850. Although epidemics or other events likely impacted the survival changes of certain cohorts, we do not see large differences in the aggregate. The absence of a trend in birth and survival rates helps us to make internally valid point estimates of the impact of demographic factors on house and rent prices. At the same time it implies that we cannot extrapolate them directly to other demographic regimes.

Stylized fact 5*: The impact of birth rate shocks on housing demand is largest when the birth cohort reaches early adulthood both in historical and modern contexts. Due to child mortality, the impact is twice as large today.*

Total housing consumption demand in society equals the summed demand of all individuals in that society. If we normalize the size of birth cohorts to one, total housing demand in society is given by the sum of the survival probabilities s_t of each cohort multiplied by the housing demand h_t at each age: $\sum_{t=0}^{99}(s_t \times h_t)$ (assuming life-expectancy is limited to 99).

Using the earlier stylized facts on survival rates and estimated housing demand by age, we consider the impact of a one percentage point shock in the birth rate on housing demand in different demographic regimes, using different housing demand estimates. We use both the 1850 and 2021 survival rate rates, where the former is representative of the period until the mid-19$^{\text{th}}$ century. For estimates of housing demand by age, we use the estimates based on the 1850 Amsterdam housing census, the Mankiw-Weil estimates from the 1970 US housing census, as well as a modified set of estimates that uses Mankiw-Weil 1970 estimates until the peak at age 35, and assumes housing demand is flat afterward.

[Place Figure 5 about here]

Figure 5 presents the results. In panel 5a we report the impact on total housing demand of the one percent shock over time. In panel 5b we report five-year changes in total housing demand due to the shock, which will be the main horizon of analysis for the empirical part of this paper.

The shock to housing demand is greatest once a cohort is in its early twenties, because during this period housing demand rises rapidly in a short period. Because survival rates at older ages do not decline very rapidly, demand reversals at later ages are comparatively small, even with a medium-term horizon of about five years. The effect on housing demand for cohorts in their early twenties is about twice as large in the modern demographic regime, since only half of newborns would reach adulthood in the historical period. Given lower survival rates, these differences become larger at older ages, but they are less economically significant because housing demand does not change much during these periods. Different modeling assumptions on the age-dependence of housing demand have a comparatively small impact on the magnitude of the demand shocks suggesting they are an unlikely driver of differential price effects across contexts.

Note that if these demand shocks have effects on rent prices that are not fully anticipated at birth of the large cohort, than discounted rents should rise primarily by the time these shocks realize around age 20.

3.1 A basic framework

The set of stylized facts shows how demand for housing services and home-ownership varies with age, both in the modern and demographic regimes. In this section, we introduce a basic framework to understand how such demographics-driven demand shock might affect both house price and rental prices. We focus particularly on mechanisms that might result in differential rent and house price developments, which have not been studied in previous literature on demographic shocks.

3.1.1 Rental market

Since both historical Amsterdam and Paris as well as most modern urban markets have liquid rental markets, we assume that rent prices accurately reflect the household's cost of housing consumption and the imputed rent for home-owners. Alike today, home-ownership was relatively lower in cities. In Amsterdam, the rate fluctuated over time, from less than 10 percent at the end of the 19th century to more than 30 percent in the 16th and 21st centuries.[4] To what extent demographic demand shocks result in changing rental prices, depends on the respective price elasticities of demand and supply. We cannot directly observe these elasticities and they also vary over longer horizons. In Internet Appendix C, we provide a descriptive discussion of housing supply elasticities in our context. The general conclusion is that supply was relatively elastic unless large migration-driven demand shocks called for significant planned urban expansions.

3.1.2 Housing market

The bigger question is how demographics-driven demand shocks influence house prices. We distinguish two different perspectives.

[4] Home-ownership was much higher in rural and less expensive areas; it reached close to 100% in rural areas 30 kilometers out of the city (Zuijderduijn, 2009).

From an asset-pricing point of view, the price of a house equals the discounted value of the expected rental cash flows. This gives two channels for a price effect. First, house prices could increase to the extent that demographics-driven demand shocks increase future rents. If investors do not have any foresight on such shocks, we expect the impact on house prices to be the same as those on rental prices. Following Figure 5a, most of this shock will materialize when a cohort reaches its early twenties. If investors anticipate expected rental growth, house prices might increase even before any rental price growth materializes. In the stock market, DellaVigna and Pollet (2007) found limited evidence that investors anticipate demographic demand shocks. Eichholtz et al. (2020) use the rent data from Paris to identify that the market has some knowledge of future rents.

The second channel is that changes in demographic structure might have general equilibrium effects on interest rates and risk premia, in line with the wider life-cycle literature. If we consider a house a risky asset for which the young have more demand, we would expect decreasing discount rates and increasing prices in young populations and the opposite effect for older populations. To test for such discount rate effects, we will compare yield developments in housing assets to equities and bonds.

From the point of view of a (prospective) owner-occupier, individuals typically start to look for owner-occupied housing by the time they settle down, in line with common preferences for home-ownership when holding periods are longer. This translates into a large increase in net housing purchases from the mid-twenties onwards (after marriage in Amsterdam, see Figure 2). A comparable increase is observed in most modern societies. Given preference heterogeneity for home-ownership and financial constraints, not every household will become a homeowner, but home-ownership generally is positively related to income and age (Goodman and Mayer, 2018). Conversely, net exit from home-ownership happens at older ages or when the heirs sell the property after death, as people typically stay home-owner once they have bought their first house.

In short, there are two very distinct shocks in the demand of households for home-ownership: one large positive shock when entering, typically in the late twenties, and one large negative shock when exiting home-ownership at old ages or after death. These shocks are distinct from the asset-pricing point of view, where demographics-driven shocks to housing investment are limited to the extent that demographic changes move general risk preferences and total housing demand of an entire population.

To understand how this might affect prices, we consider two cases. Our intuition closely follows the insights of Greenwald and Guren (2021), who build a formal model to understand the impact of credit shocks on the housing market. In their model, the price impact of a credit shock depends on market segmentation. If the credit shock does not result in an increase in the number of properties available for sale, households will use the extra credit to bid-up home prices, resulting in a large increase in house prices relative to rents. Whether this happens depends on the behavior of landlords: if house prices increase above discounted rents, landlords might put their properties on the market and sell them to owner-occupiers until prices again equate discounted rents. Their calibration exercise suggests that modern US markets have significant segmentation, implying a limited supply response of landlords to large housing shocks.

In our paper, the shock is a large cohort of young adults reaching the age at which households typically start searching for owner-occupied housing. Searching home-buyers might bid up prices if the number of homes for sale does not increase, implying properties will be bought by the households with fewest financial constraints and the strongest preferences for home-ownership (*Case 1*). In this case, we would expect large increases in house prices and price-rent ratios when a large cohort enters its prime home-buying years. The opposite phenomenon might happen if a large cohort of people reaches old ages and passes away, implying they or their heirs put a large amount of properties for sale. Absent extra buyers, these properties will not sell quickly and prices will fall.

These price effects will be muted if landlords or any other investors soak-up any excess demand or supply from the market until house prices again equate discounted rents (*Case 2*). In that case, any price effects of demographic shocks will be limited to changes in rental prices and aggregate discount rates. Note that the distinction between

Case 1 and Case 2 does not depend on a supply response, since that would reduce both rent prices and house prices.

4 Analysis

This section analyzes the impact of the demographic structure on rent and house prices. In our main analysis, we focus on predicting changes in house and rent prices with historical birth rates. The idea here is that a large number of babies today implies there will be a large cohort of x-year olds x years from now.

The benefit of this approach is that it enables us to test for actual predictability and circumvents the issue that the demographic structure is endogenous due to migration. Alike modern cities, both Paris and Amsterdam depended highly on migration for growth and most of these migrants were young adults. Migration flows were dependent on the economic opportunities within a city, and those opportunities themselves also affected housing costs.

Clearly, birth rates themselves are not exogenous. In fact, there exists extensive literature that aims to explain fluctuations in birth rates in the period before the demographic transition. The key finding is that birth rates are endogenous in the short-term and primarily related to food prices, real wages and mortality (e.g Galloway, 1988; Bailey and Chambers, 1998; Crafts and Mills, 2009), largely in line with the Malthusian mechanism. This is also visible in extreme events. For example, Parisian birth rates reached a low point after the Siege of Paris (1590) which resulted in high prices and mortality. There is likely also a weaker role for weather conditions (Galloway, 1994). At five-year level, we find strong contemporaneous correlations between birth rates and other demographic and economic outcomes in the data.

The key identifying assumption in our analysis is that any effects from *past* shocks to birth rates on current house prices or rents operate through their impact on current demographic demand for housing. Based on the stylized facts we have established in

Section 3, such a relationship is intuitive: once babies grow up, they will need a house to live in and start investing in housing markets. While current changes in demographic rates, weather patterns, wages or consumer prices may strongly affect current birth rates, it seems less plausible they have a significant impact on changes in economic conditions and the housing market decades later. However, we will explicitly test for this by testing whether the inclusion of lagged control variables impacts our results.

More specifically, to estimate the impact of the demographic structure on prices and rents, we estimate the following model:

$$y_t - y_{t-5} = \alpha + x'_{t-lag}\beta + z'_t\gamma + \varepsilon_t, \tag{1}$$

where y is a vector of (i) rent price indices, (ii) house price indices, or (iii) rent-price ratios (in logs).[5]

We use five-year log changes to filter out noise and because changes in demographic structure are slow. A five-year period draws a good balance between picking up actual changes in demographic structure and statistical power.[6] To account for serial correlation introduced by overlapping observations, we compute Newey-West standard errors using a lag length of five (as we take five-year differences). We will use these in all other estimation results we present in this section.

The vector x_t contains the key lagged independent variable of interest, the total five-year lagged birth rate ($\sum_{j=t-4}^{t} B_{j-lag}$). In later specifications, we will also include lagged control variables. We will use various lag lengths, ranging from 15 to 70 years. Five-year birth rates 15 years ago correspond to birth cohorts that are between 15 and 19 years old. We start at 15 years old, since children typically started moving out of their parental houses from this age onward (Figure 1). We do not extend beyond 70 years old, because

[5] We did also include a lagged dependent variable, $y_{t-5} - y_{t-10}$, however the corresponding coefficient is close to zero, and statistically not different from zero, therefore we excluded the lagged dependent variable in all specifications.

[6] Our results are not sensitive to the specific horizon; we obtain similar results when using 3 or 10 year changes; results available upon request.

very few newborns would reach such an age.

We will estimate Eq. (1) both excluding and including the following demographic and economic control variables in z_t and their lags in x_{t-lag}: Five-year birth rates (B), nuptiality (N), mortality (M), migration (Mi), and five-year log changes in wages (w) and consumer prices (p):

$$z_t' = (\sum_{j=t-4}^{t} B_j, \sum_{j=t-4}^{t} N_j, \sum_{j=t-4}^{t} M_j, \sum_{j=t-4}^{t} Mi_j, w_t - w_{t-5}, p_t - p_{t-5}).$$

We should note that our control for mortality has a slightly different meaning in the historical demographic regime. In modern demographic regimes, mortality closely coincides with exit from the property market at old ages. In the historical regime, mortality shocks predominantly affect children with remaining mortality more equally spread across age groups.

Finally, we use changes rather than levels for all non-demographic variables, because we could not consequently reject the presence of a unit root.[7] This also avoids sensitivity of our rent-price ratio to any measurement error, which might accumulate over time when using levels (Eichholtz et al., 2021). All economic variables are using nominal changes as structural inflation was limited in this period. In Internet Appendix Figure D.1 we show results are unchanged when using real changes.

4.1 Results

Figure 6 presents estimated lagged birth rate coefficients and corresponding 95% confidence intervals for different lag lengths and for each of the four dependent variables: Amsterdam rent growth (panel 6a), Paris rent growth (panel 6b) and Amsterdam growth in house prices and rent-price ratios (panel 6c and 6d).[8] Every point on these lines repre-

[7] We tested for the null of a unit root using ADF-tests, KPSS-tests and DF-GLS tests. In most cases all tests give the same results; we take first differences in case one of the tests indicates the presence of a unit root. All variables are stationary in first differences.

[8] As a robustness check, Figures D.2 and D.3 in the Internet Appendix report coefficients and 95% confidence intervals based on the average coefficient and standard error from five non-overlapping regres-

sents a different regression with the birth rate lags varying across regressions. For clarity, a birth rate lag of 20 corresponds to the birth rate 20-24 years ago. We report estimates both without control variables to test for pure time-series predictability of that particular lag, while the estimates including controls adjust for contemporaneous changes in economic and demographic variables that might also affect housing demand.

[Place Figure 6 about here]

Starting with the rental regressions in the two top panels, there appears no evidence for pure time-series predictability of housing rents with lagged fertility levels. When adding contemporaneous controls, we find a weakly significant positive relationship between lagged fertility and rental prices for some lags. A one percentage point increase in the five-year birth rate 21-years ago, corresponding to babies born 21 to 25 years ago, results in a five-year rental price growth of 1.4 percent in Amsterdam and about 2 percent in Paris. Birth rates 55 to 59 years ago result in a negative five-year rental price growth of 1.8 percent in Paris and about 1.0 percent in Amsterdam. For reference, a one standard deviation change in birth rates is 1.4% in Amsterdam and 3.4% in Paris (due to the large volatility around 1590), while five-year rent price volatility is 10% and 17% respectively. In short, while the evolution of the coefficient across age lags is consistent with the pattern in Figure 5b, there generally is limited evidence that demographic demand is a significant contributor of rental price growth.

We document much more sizeable and consistent effects for changes in house prices and changes in rent-price ratios, which are shown in the bottom two panels. For fertility lags that correspond to birth cohorts currently in the mid- or late twenties, we document strong increases in house prices and decreases in rent-price ratios. For these lags, a one percent increase in lagged birth rates increase prices by up to five percent, with the effect exactly opposite for rent-price ratios. For fertility lags corresponding to birth cohorts currently in their early 60s we find exactly opposite effects of similar magnitude. These

sions, where we shifted the start year by one year for each regression. This gives similar results.

effects hold both with and without controls, although the effects become slightly larger when including control variables. For house prices, a one standard deviation shock to five-year birth rates increases house prices (8%) and decrease rent-price ratios (-8%) by about half a standard deviation 25 years later.

The key message of Figure 6 is that there appear small effects of lagged fertility rates on rental prices that are at best weakly significant, while the results on house prices and rent-price ratios are much larger. Thus, lagged birth rates primarily appear to impact house prices and not rental prices.

The results in Figure 6 come with several caveats. First, they test for the significance of each fertility lag individually rather than jointly, so that we cannot establish to what extent past fertility lags matter in aggregate. Second, one could be concerned that the effect is not driven by fertility lags, but by any other lagged economic factor that correlates both with lagged fertility and current economic outcomes. We address these concerns using several additional analyses listed in Table 3 and 4.

[Place Table 3 about here]

Table 3 shows the results for rental price growth in Paris and Amsterdam. We report the coefficients on the fertility lags that on average appear to have the largest impact on rental prices: birth rates 20-24 years ago and birth rates 55-59 rates ago.

Columns 1 and 4 do not include control variables and display no statistically significant effects for individual coefficients. Jointly, these two birth rate lags can explain about 3% of the variation in rental price growth in Paris and 1.6% in Amsterdam, and none of the coefficients is individually significant. This suggests that lagged birth rates can explain very few of the changes in five-year rental prices.

Columns 2 and 5 report the coefficients on these birth lags when we also include all other fertility lags (per 5-years), ranging from the 15 to 19 year birth rate lag to the 70 to 74 year birth rate lag. While some of the coefficients become significant, the effects remain small. We also do not find consistent evidence of significant effects for the other birth rate lags: the full set of coefficients, both excluding and including controls, is reported in Internet Appendix Table D.1. Finally, columns 3 and 6 report results for the main coefficients when we also include lagged control variables, where the lag of the control variables matches those of the birth rate variables: five-year changes in the controls 20-24 years ago and 55-59 years ago. Under this set of control variables, we only find a weakly significant negative effect of birth rates 55-59 years ago on Amsterdam rent price growth.

[Place Table 4 about here]

Table 4 presents the results for changes in house prices (columns 1–4) and rent-price ratios (columns 5–8). The first and fifth columns show the result of the most basic specification that only includes the two most relevant lags based on the results in Figure 6. These are birth rates 25-29 years ago and birth rates 60-64 years ago. Jointly, these two lags explain about 13% of the variation in 5-year house price growth and 18% of the variation in five-year changes in rent-price growth. The magnitude and significance of the coefficients is also comparable to the single-lag regression in Figure 6.

In Figure 6 we do not find the coefficients to change much when adding contemporaneous economic and demographic controls. In columns 2 and 6, we report results with these controls adding interest rates. If demographic demand shocks affect asset demand generally, we would expect coefficients closer to zero when controlling for changes in interest rates. However, this does not appear to be the case for both changes in house prices and rent-price ratios.

In columns 3 and 7, we extend the model with control variables by also adding all other fertility lags to the model. The full set of coefficients for all other lags, both excluding and including control variables, is reported in Internet Appendix Table D.2. Again, this does not lead to sizeable changes in the magnitude and significance of the coefficients, and confirms that most of the demographic effect is captured by the selected lags.

Finally, in columns 4 and 8 we report results where we include lagged control variables for the two key lags. Again, the coefficients do not move much, suggesting that the current impact of shocks to past fertility is not driven by the correlation of past fertility with past economic or demographic changes that might still impact housing market outcomes today.

One potential concern with using lagged fertility is that it might underestimate the impact of demographic changes on prices when demand growth is dominated by migration. In Internet Appendix Table D.4, we separately estimate the impact of lagged fertility in periods with significant in-migration. We find some evidence that the effect is smaller in this period but the impact is not always significant and controlling for it only increases the magnitude of the main effect by a small amount.

4.1.1 Impact on other assets

The question is whether these effects are specific to the housing market or whether they operate through general equilibrium effects on all discount rates in the market and thus affect all asset prices. For example, this could be the case if people demand a lot of financial assets when they are young and sell them when they are old or after death. Life-cycle theory predicts this effect might be even stronger for risky assets.

In Table 5 we replicate the analysis in Table 4 using five year changes in bond yields (columns 1–2), rental yields (columns 3–4) and dividend yields (columns 5–6) as dependent variables, where we drop the control variable on changes in interest rates. Columns 1, 3 and 5 report the results without the control variables and columns 2, 4 and 6 with the control variables.

[Place Table 5 about here]

Before interpreting the results, we should note that Dutch/Holland bond yields are not consistently a measure of safe rates, in particular in the late-18th and early 19th centuries when major political changes put the servicing of the debt under threat. In most other periods, Dutch (or Holland) debt was perceived to be very safe with low rates of return compared to other assets, although somewhat less liquid in the early part of the sample (Gelderblom and Jonker, 2011). Until the late 18th century, Holland financed its debt at lower rates than any other major sovereign.

For dividend yields, we only have measures for the Dutch East India Company from 1629 to 1782. One other limitation is that these yields are based on national debt and national companies, while the data for the housing market are more local. This might be a concern if birth rate shocks in Amsterdam have limited correlation with those at a more aggregate level. We do not have good long-term data on birth rate shocks for other cities but we do not believe this is a major limitation given that the bond and stock market were dominated by trading in Amsterdam. A third of Holland inhabitants lived in Amsterdam and an even larger fraction of aggregate wealth was owned by its inhabitants.

Starting with the effect of birth rates 25-29 years ago, Table 5 shows this effect is specific to housing: we find no significant effects both for bond yields (Columns 1–2) and dividend yields (columns 5–6), irrespective of the inclusion of control variables. Given the limitations in the bond and dividend data, we do want to note the direction of the effect on dividend yields matches that for rental yields whereas the effect on bonds is of opposite sign. In a regression with a (moving) single fertility lag and contemporaneous controls, which is plotted in Internet Appendix Figure D.4, we find weakly significant effects for bond yields (+) and dividend yields (-) around age 25-30. Although the effect on rent-price ratios remains both economically and statistically much larger, a small part of the effect might thus operate through changes in risk premia, which might decline if there is a large cohort of young adults in their late twenties. One contributing factor to this pattern is that individuals might sell their savings in bonds to purchase a house.

Moving to the effect of birth rates 60-64 years ago, we find positive coefficients for all three assets but the effect is only statistically significant for housing yields and dividend yields. Again, these effects also turn weakly significant for bond yields in a regression with a (moving) single fertility lag and contemporaneous controls (Internet Appendix Figure D.4). The coefficients are nonetheless still twice as large for changes in rent-price ratios. The most plausible explanation for the stronger alignment between the three assets is the activity of heirs.

Much of the housing sales activity for this birth rate lag is driven by sales of heirs, see Figure 2, and we have argued that this excess supply might cause prices to drop. Similarly, heirs could also decide to liquidate other financial assets they inherited, pushing up yields if demand fell short to support current prices.

In conclusion, the limited impact on rent prices as well as on the yields of other assets suggest that the large impact on house prices is mostly driven by factors specific to housing investments. In the final part of the results section, we aim to provide further evidence and explanation for this claim.

4.1.2 Evidence from portfolios

To highlight the specific role of real estate investment patterns during lifetime, we extend the analysis in Table 2, and link the number of years since marriage to the composition of portfolios, using data from estate tax records discussed in Korevaar (2022). In total, we have 855 such matched portfolios.[9] Conditional on owning any wealth, real estate was the largest item in the typical household portfolio, with a mean portfolio share of around 60 percent. Nearly all other remaining wealth was invested in bonds. Because equity holdings were concentrated among the very wealthy, we have insufficient information to make any inference on those.

We regress the fraction of total wealth in real estate on the number of years since marriage, both linearly and including a quadratic term. Based on the fraction of matched individuals that die before marrying (wrong matches), the data suggest over 60% of observations are matched correctly, implying our estimated coefficients will be slightly biased towards zero. Table 6 reports the results.

[9] The estate tax records provide detailed data on portfolio composition and wealth at death for a third of the population that died with any wealth. Details on this data and the data collection procedure can be found in Korevaar (2022). The original database of portfolio records is much larger, but only a small fraction could be matched accurately to their marriage records given few individuals had unique names.

[Place Table 6 about here]

Column 1 shows that the fraction of wealth invested in real estate decreased over the lifetime, by about 0.25 percent of total wealth per year. In column 2, we show this effect is also non-linear, with the fraction of wealth invested in real estate increasing in the first two decades after marriage, but declining afterward. In absolute terms, we find real estate wealth to increase by age (1.7% per year, column 4), with a peak around 35 years after marriage (at age 60-65) if we include a non-linear term (column 5). These numbers are comparable with the results in Figure 2, and suggest that divestment from real estate before death only happens at very old ages. To address concerns about selection effects in survival, we show our results do not change when we control for year-of-death fixed effects, total wealth, and gender (columns 3 and 6). In Internet Appendix Table D.3 we verify the results for bond investment are indeed exactly opposite to those for real estate.

The main conclusion of this analysis is that the surge in investments in housing in the years after marriage and the corresponding slump in bond investments are driven by the preference of individuals to become home-owners. To a limited extent, this might partially reflect a general preference of young individuals for risky assets. At old ages, individuals gradually divest from housing and move more towards bonds, in line with life-cycle theory. Given that divestment during lifetime is limited, the large decline in prices for birth rate lags over 60 years ago appears to predominantly result from asset sales after inheritance. Such sales might increase again in importance today if the baby boom cohort starts to gradually pass away.

4.1.3 Impact on turnover

While the portfolios reflect the stock of real estate investments at death for people that died at different ages, we can also study the flow of investment by looking at the impact of lagged birth rates on the sale volume.

If the large price effect of young cohorts is driven by the fact that few landlords or incumbent home-owners are willing to put their properties on the market when a large cohort enters it's home-buying years, as asserted in Case 2 of Section 3.1, one would expect a limited effect of lagged birth rates on turnover.

Figure 7 replicates the specifications in Figure 6, using 5-year turnover (in percentage points of the housing stock) as dependent variable. The data only cover the period until 1810, excluding some periods where sale data did not survive entirely and turnover measures thus could not be constructed.

[Place Figure 7 about here]

Relative to the results for prices, the significance of these findings is more sensitive to the inclusion of control variables. Without controls, the only significant relationship is that lagged fertility predicts increases in turnover over 60 years later while reducing beforehand. This relationship becomes more significant when including control variables (contemporaneous and lagged). With controls, we also find an increase in turnover 22 to 26 years year later but a reduction in turnover 27 to 31 years later.

Although these results are more sensitive to the exact specification compared to the effects we document on prices, they are in line with our earlier discussion on the age-dependence of housing investment and home-ownership. One interpretation is that when the first generation of a new cohort enters the housing market in the early- to mid-twenties (i.e. those that settle or marry early), they quickly purchase the available homes of (heirs of) owners that were selling their properties, without large increase in prices. Price start to rise substantially as more prospective buyers of this birth cohort enter the market while the number of owners willing to sell does not increase, implying volume goes down again (the decline in activity at 27-31 years). When a large cohort exits the market and heirs put the property up for sale, property sales increase only significantly after sellers cut prices, resulting in substantially increased volume for several years.

Note that in general volume typically leads prices, both in the modern Dutch market as well as in the United States (e.g. De Wit et al., 2013; DeFusco et al., 2022). In our context, this likely explains why we observe a peak (trough) in sales activity at age 22-26 and 59-64 years, around two years before the increase (decline) in prices peaks.

5 External validity

The results in the previous section point to demographic demand having an economically and statistically limited impact on rental prices, but a much larger effect on house prices and rent-price ratios. The aim of this section is to answer the question whether this still is the case in modern markets. One concern is that demographic and institutional settings could lead to a different impact of lagged birth rates on the housing market today, although institutional settings were not constant over the analyzed period as well. In this section we will discuss survivalship rates and segmentation between the rental and owner-occupied market today and in history, followed by an empirical analysis of the impact of birth rates (the share of young people) on prices, rents, and price-rent ratios for some OECD countries in the period 1970–2020.

5.1 Survivalship rates and segmentation today and in history

Survivalship rates nowadays are much higher than in the analyzed period, see Figure 4. The consequence is that, ceteris paribus, shocks in birth rates in modern times will lead to a higher impact on rents and prices compared to the historical estimates. One should roughly multiply the marginal effects by a factor two: before the demographic transition, only half of children would reach the ages at which they typically enter the rental or owner-occupied housing market. On the other hand, there was a high degree of volatility in mortality rates due to wars, diseases, and famines, resulting in future housing demand being more poorly predicted by current birth rates. Better predictability would potentially reduce the impact of lagged birth rates as housing supply would be able to adapt.

We have argued that investors from other age cohorts, whether they are home-owner or landlord, appear unwilling to absorb any excess demand and supply of homes, causing a differentiated effect on rents and prices. It might be possible that these frictions are caused by the specific institutional arrangement of the housing market in the historical period and do not apply today.

In modern markets, there are typically sizeable advantages to home-ownership such as mortgage interest deduction or different levels of property wealth taxation for owner-occupiers relative to landlords. Similarly, government-provided guarantees on mortgages are more commonly available for owner-occupiers than for landlords. Such regulations might strengthen the segmentation between rental and owner-occupied markets. In Amsterdam, property taxes were independent of the tenure status of a property, such that owner-occupiers paid the same taxes as landlords. Although the use of mortgages fluctuated substantially over time, mortgages were generally less common than in modern markets and there was no formal distinction between mortgages for owner-occupiers and landlords.

A second source of friction might be the nature of rental markets. If rent-setting is sticky, rent price development might lag development in house prices. For example, in modern Amsterdam rent contracts are typically permanent and for most properties rent levels and increases are capped by legislation. However, these regulations did not exist in the period we study. In fact, the rent index for Paris is based entirely on newly signed contracts and the index for Amsterdam only uses contracts where the price deviated from the price paid in the previous year. Rent stickiness is thus not able to explain our historical findings.

There might have been frictions between the market for investment and owner-occupied real estate, implying that changes in the price-to-rent index do not reflect actual levels. However, the markets for investment and owner-occupied real estate were strongly overlapping. Beyond the privately brokered market, a sizeable fraction of properties was sold in public auctions. Most of the properties sold in auctions were acquired for investment purposes (Eichholtz et al., 2021), but anyone was able to bid. In terms of liquidity, about 3% of the housing stock traded hands each year, similar to modern levels.

Finally, transaction costs were on the lower end relative to most modern countries. In Amsterdam, there was 2.5% transaction tax in most time periods and other costs (broker, notary etc.) amounted to around 1.5% of asset value (Van Bochove et al., 2017). They were split between buyer and seller.

In short, if fiscal and financial frictions contribute to the segmentation of rental and owner-occupied markets, then historical Amsterdam constitutes a lower bound for the marginal effects of lagged birth rates on rents and prices.

5.2 Estimates for OECD countries

Our historical estimates point to large and robust impacts of demographic changes on house prices and price-to-rent ratios. If these effects and the underlying mechanism are also quantitatively important in modern markets, we would expect that modern data points in the same direction.

Although data limitations and gradual demographic shifts imply that we cannot perfectly extrapolate our empirical approach to modern data, we use a more limited and modified approach to test whether there is any evidence for similar relationships in a panel of modern OECD countries. We compiled rent and price indices and price-rent ratios and demographic variables for 18 OECD countries[10] for which we have sufficiently long time series. We have an unbalanced panel with 23 to 50 annual observations per country over the sample period 1970–2020.

We make a couple of modifications relative to our main analysis. First, we use annual changes rather than five-year changes to leave more observations in the sample. Relative to the historical indices, noise in the indices is also less of an issue in modern data.

Second, we use lagged (5, 20, and 35 years) changes in the share of young (age < 15) people, which are a close proxy for birth rates and for which all countries report data. We use changes rather than levels: structural population aging implies population shares

[10] AUS, BEL, CAN, CHE, DEU, DNK, ESP, FIN, FRA, GBR, IRL, ITA, JPN, NLD, NOR, NZL, SWE, USA.

of young adults are trending down structurally and using levels causes near-perfect auto-correlation in the independent variables. We also cannot study lags corresponding to older birth cohorts (>35 years) given that this leaves too little data for estimation.

We thus focus primarily on identifying the effect of the arrival of a large cohort to the housing market. To do so, we use the 20-year lag of the change in the under-15 share. The 20-year lag corresponds to people between 20 and 35, on average 28 years old, so representing starters on the housing market and coinciding with the 25-29 year birth rate lag used in the main historical analysis. The range of 15 years is wider than in the main analysis, but the age at which buyers first buy a home will vary more from country to country.

We estimate a panel autoregressive model to estimate the impact of changes in the lagged share of young people (x) on changes in the house price index, the rent price index, and the price-rent ratio (y, in logs),

$$\Delta y_{i,t} = \rho \Delta y_{i,t-1} + \sum_{lag \in \{5,20,35\}} \Delta x'_{i,t-lag} \beta_{lag} + \Delta z'_{i,t} \delta + \lambda_t + \varepsilon_{i,t}, \tag{2}$$

where i denotes the country and t time in years. The panel model includes a lagged dependent variable ($\Delta y_{i,t-1}$), control variables ($z_{i,t}$) and time fixed effects (λ_t). We include a lagged dependent variable, because there is significant persistence in price changes at the annual level. The model is specified and estimated in first differences to avoid potential non-stationarity issues. Since the equation includes a lagged dependent variable we use the standard Arellano and Bond (1991) approach and instrument the differenced lagged dependent variables with its second and third lag in levels.

Internet Appendix Table D.5 provides summary statistics for the dependent and demographic variables (population growth, share of young people, share of elderly), and Internet Appendix Table D.6 for the control variables (log consumer price index, log gross domestic product, long term interest rate).

[Place Table 7 about here]

Table 7 presents the estimation results: columns 1–3 for the house price index, columns 4–6 for the rent price index, and columns 7–8 for the price-rent ratio. In columns 1, 4, and 7, the model includes a 35-year lag of the share of young people, which reduces the sample size since the demographic variables only go back to 1950. In columns 3 and 6 the dependent variable is in real terms, denoted by the superscript r.

The 20-year lag of the share of young people has a statistically significant coefficient in the house price index specifications, columns 1–3. The short-term effect of a one-point increase in the share of young people 20 years ago is a 2.0% increase in house prices (column 1). The long-term effect on house prices is more than two times as large, $0.020/(1 - 0.571) \approx 4.7\%$.

For the rent price index the coefficients on lagged shares of young people are all statistically insignificant, see columns 4–6. Note that the rent price index is based on actual rents, not only rent renewals. Moreover, part of the rents may be subject to rent restrictions. These reasons are likely to make the effect on rents smaller.

Finally, the 20-year lag of the share of young people has a statistically significant (at the 10% and 5% level for columns 7 and 8, respectively) coefficient in the price-rent ratio specifications, where the coefficients are similar to the ones for the house price index specifications. The short-term effect of a one-point increase in the share of young people 20 years ago is a 2.1% increase in the price-rent ratio (column 7) similar to the effect for house prices. The long-term effect is $0.021/(1 - 0.375) \approx 3.4\%$, somewhat smaller than the one for the house price index.

We cannot compare the point estimates in Table 7 one-to-one with our main analysis, given differences in the independent variable as well as structural changes in the demographic regime. However, both in the modern and historical data there is a clear pattern that increases in the share of young children predict prices and rent-price ratios but not rents. This suggests our findings also generalize to modern contexts.[11]

[11]Note that we have also experimented with different specifications, changing the lag length slightly or excluding the formal control for the lagged dependent variable. In all specifications, we find strong effects on house prices and rent-price ratios and smaller effects on rent prices, with some variation in the economic magnitude of the effects.

6 Conclusion

The main conclusion of the paper is that changes in the demographic structure have significant and predictive effects on housing costs, but that these effects vary across rent and house prices.

Based on centuries of historical data, we find that current increases in birth rates lead to negligible increases in rental prices 20–30 years later, but have large and predictive impacts on house prices and rent-price ratios. We document opposite effects for birth rates on housing costs 60–65 years later, when house prices reduce, and rent-price ratios increase. Our findings indicate that changes in the demographic structure are a key determinant in the evolution of house prices and rent-price ratios. In modern demographic regimes, such effects are likely to be even greater, due to higher survival rates. We provide supportive evidence for some OECD countries using data over the period 1970–2020: An increase in the 20 years lagged share of people younger than 15 years old, has a positive on prices and price-rent ratios, but no effect on rents.

We argue that the different responses of demographic demand shocks to prices and rents are attributable to frictions in the housing market. During the historical period studied, housing supply was relatively elastic, apart from periods where large migration-driven demand shocks called for significant planned urban expansions. This might explain the limited effect of changes in lagged birth rates on rent levels.

The substantial effects on house prices and rent-price ratios may be due to the fact that only a small proportion of homes change hands each year, a much smaller proportion than rental renewals. Shocks in the number of potential buyers or homes for sale, as young people enter the housing market or older people leave it, significantly change the ratio of demand and supply. If these young people have a strong preference for home-ownership, they could drive prices up significantly, particularly if investors and other incumbent home-owners do not offer additional homes for sale. The opposite may happen if a large cohort of older people put their homes up for sale, and in the absence of additional buyers, prices will fall.

Our findings imply that in countries with rapidly aging populations, reduced investment demand for housing will likely result in lower house price growth, when baby boomers retire and gradually pass away. In cities that are still growing, the influx of migrants or the arrival of new-born life will either immediately or in the future lead to rising housing costs. However, effects on rent prices will be mild as long as supply is able to adjust accordingly.

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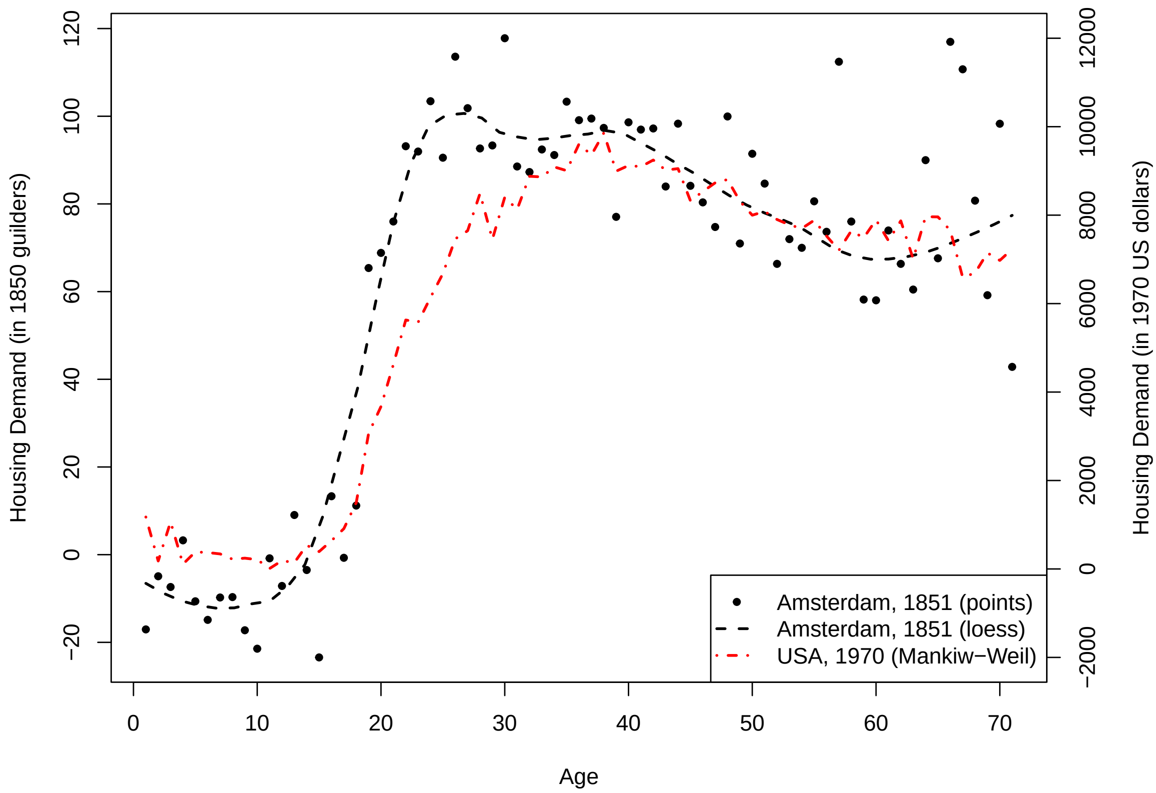
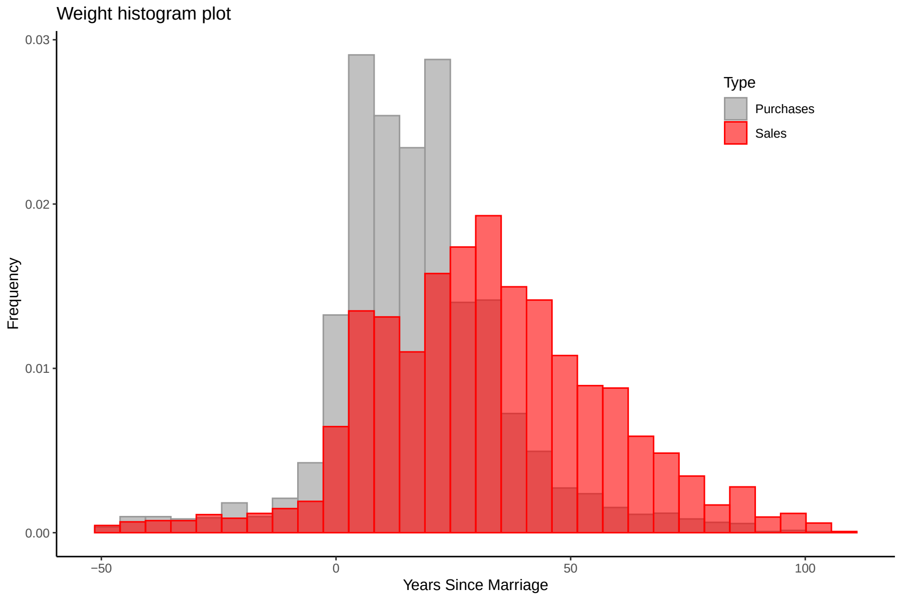
7 Figures

Figure 1: Housing consumption demand by age.

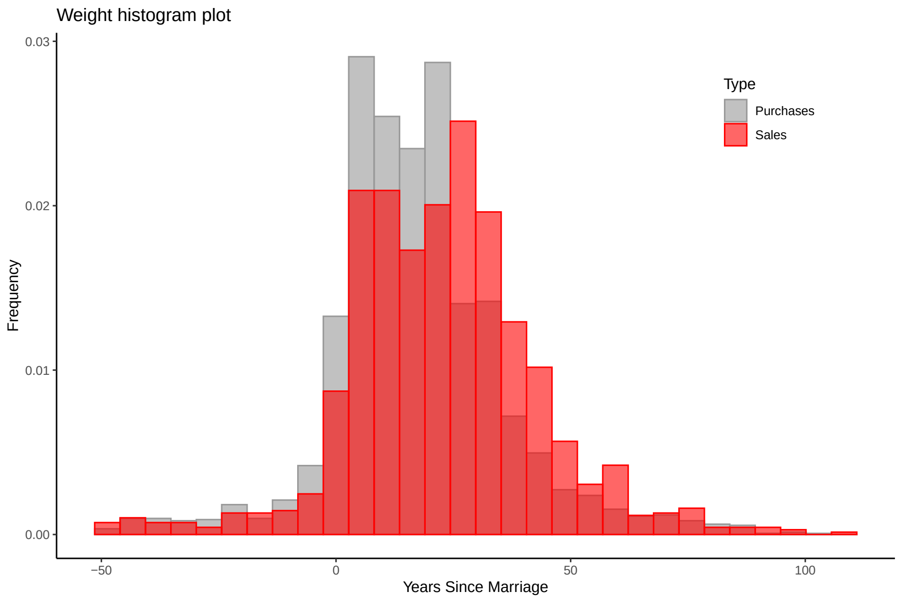


Notes: These figures include point estimates from a regression of rental values in 1832 on age dummies of residents in 1851, for each Amsterdam rental property, following the approach of Mankiw and Weil (1989). We only include properties that remained unchanged between 1832 and 1851 and where fewer than four adults live, to avoid contaminating the measures with multi-family dwellings. Because individual point estimates are imprecise (the sample is comparatively small), we also plot a fitted loess line through the points to depict the trend (quadratic, span = 0.3). For reference, we also plot the estimates reported in Mankiw and Weil based on the 1970 Census (axis on RHS).

Figure 2: Housing transactions by age, Amsterdam, 1700-1760.



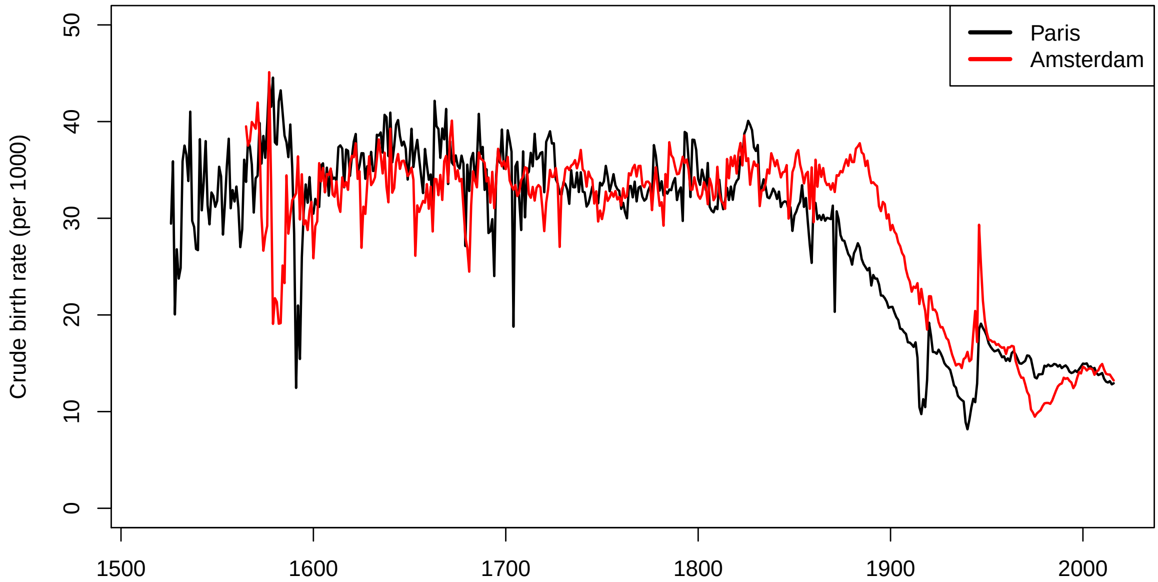
(a) Including Sales by Heirs



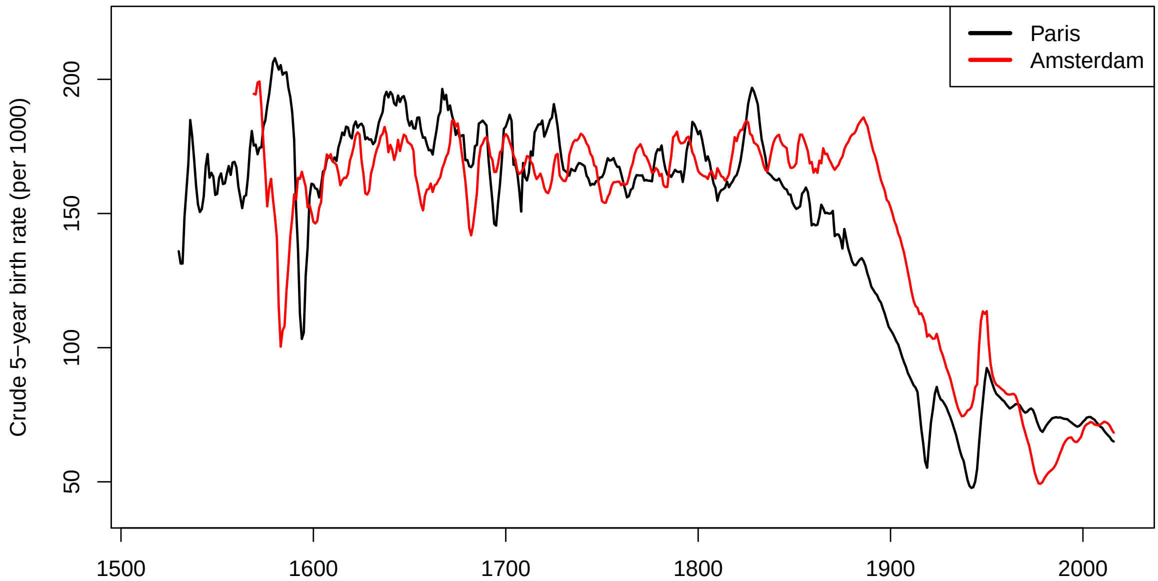
(b) Excluding Sales by Heirs

Notes: These figure plots the distribution of buyer and seller ages by the number of years that has passed since marriage. The plot in the top panel is based on 5167 observations, including 2649 buyers and 2518 sellers. The bottom panel exclude sales by heirs resulting in 2,644 buyers and 1271 sellers. Bins are based per five years, and the frequency (top) or density (bottom) reflects the number or fraction of total persons in that age bin. The tail observations might reflect a small number of mismatches. The plot is truncated at 50 years before marriage, excluding 31 observations.

Figure 3: Birth rates.



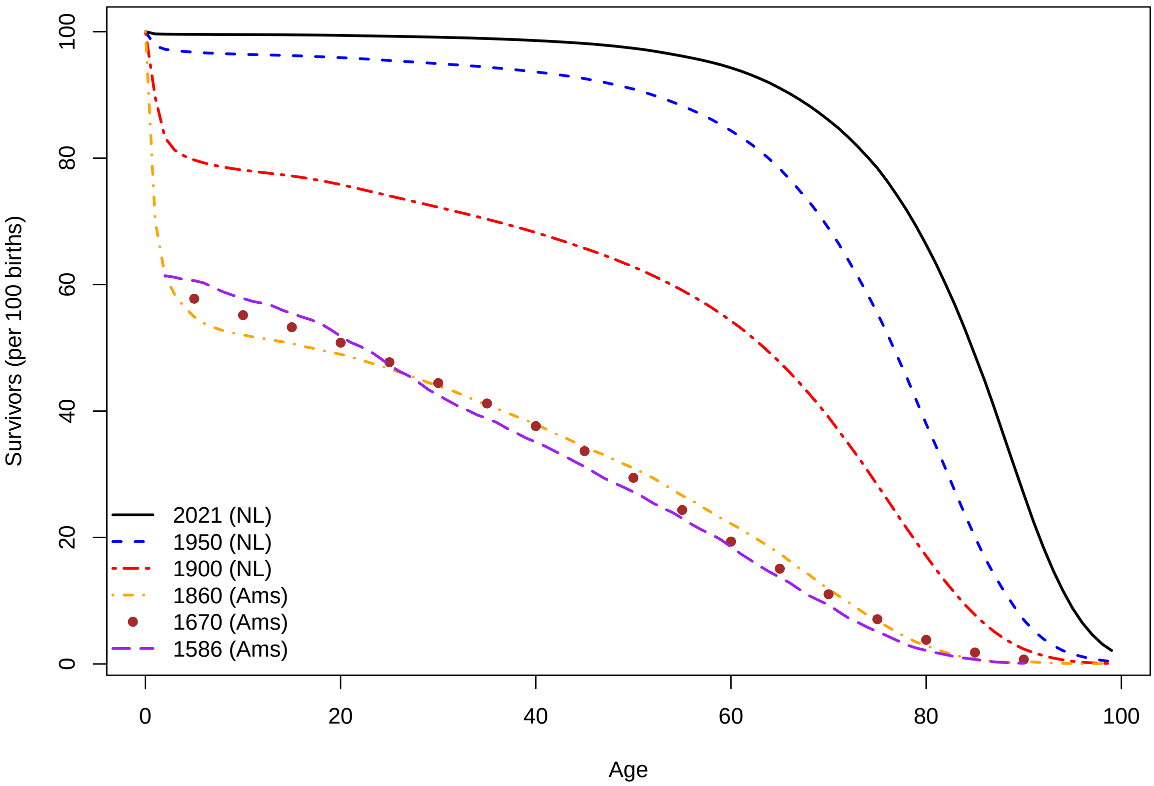
(a) Annual birth rates



(b) 5-Year birth rates

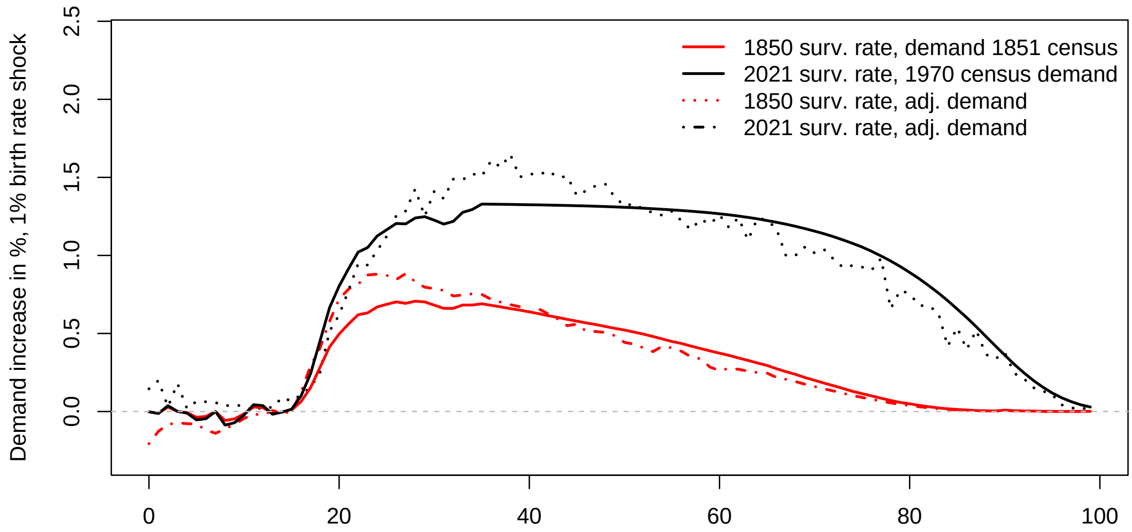
Notes: These figures report the estimated birth rates per 1000 inhabitants for both Paris and Amsterdam. Birth rates are high and volatile until the late 19th century, when they gradually start declining. Birth rates increase again after World War I (in Paris) and after World War II (both cities).

Figure 4: Survivalship rates.

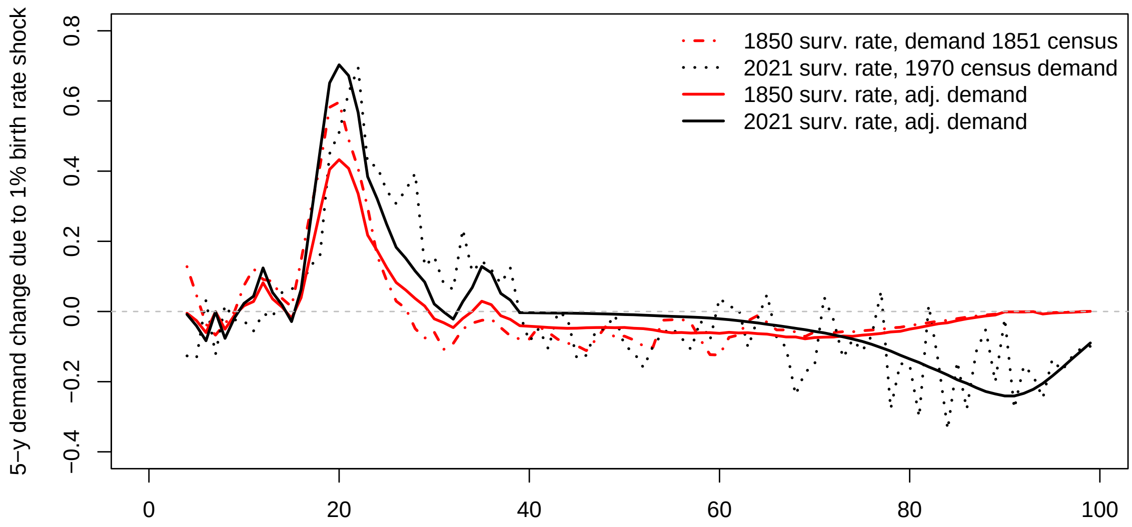


Notes: These figures report the estimated survival rates rates per 100 newborns for Amsterdam (pre-1900) and The Netherlands (post-1900).

Figure 5: Housing demand change in response to a one percent shock.



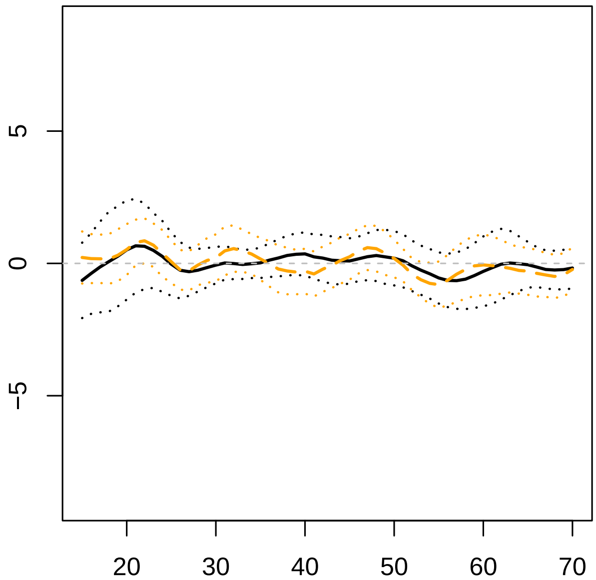
(a) Total change in demand



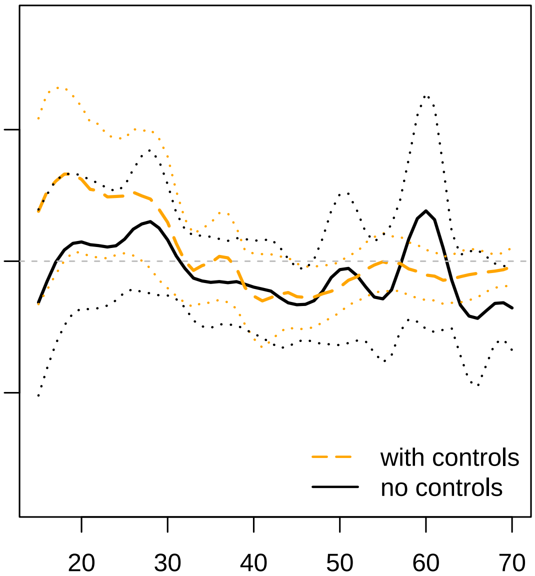
(b) 5-Year change in demand

Notes: These figures report the estimated effect of a one percent birth rate shock on total housing demand over time. Panel 5a reports the total demand effect and panel 5b the five-year change in total demand. Demand at each age is estimated as the survival rate multiplied by the estimated housing consumption. Estimates use both the 1850 survival rates, the 2021 survival rates and the consumption schedule based on the 1851 Amsterdam housing census (3-year moving-averages for each age) and the estimates reported in Mankiw and Weil (1989) for the 1970 US census. For both survival schedules, we also plot a case that uses average demand growth under the two consumption schedules until age 35 and assumes housing demand stays flat afterwards ("adjusted demand"). The latter might be more in line with modern age patterns in housing consumption.

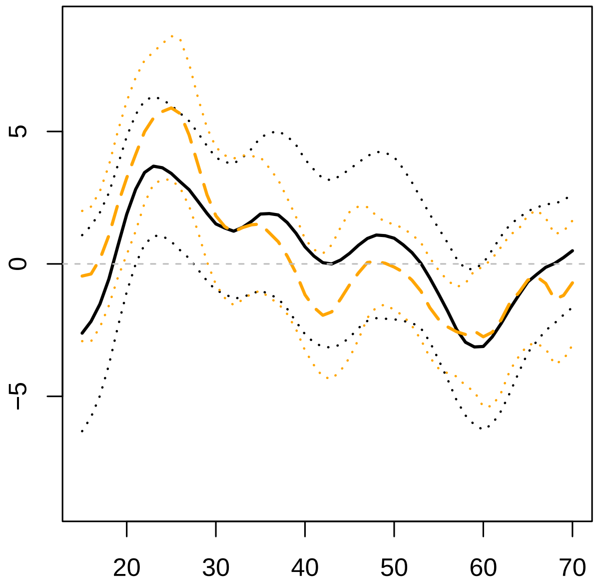
Figure 6: Lagged birth rates and the housing market.



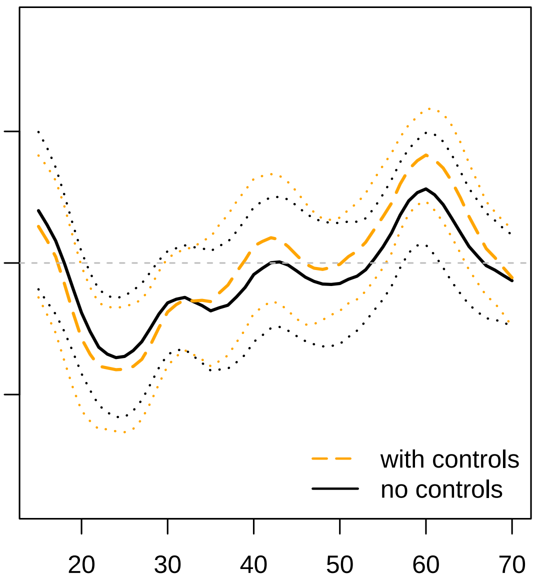
(a) Rent prices, Amsterdam



(b) Rent prices, Paris



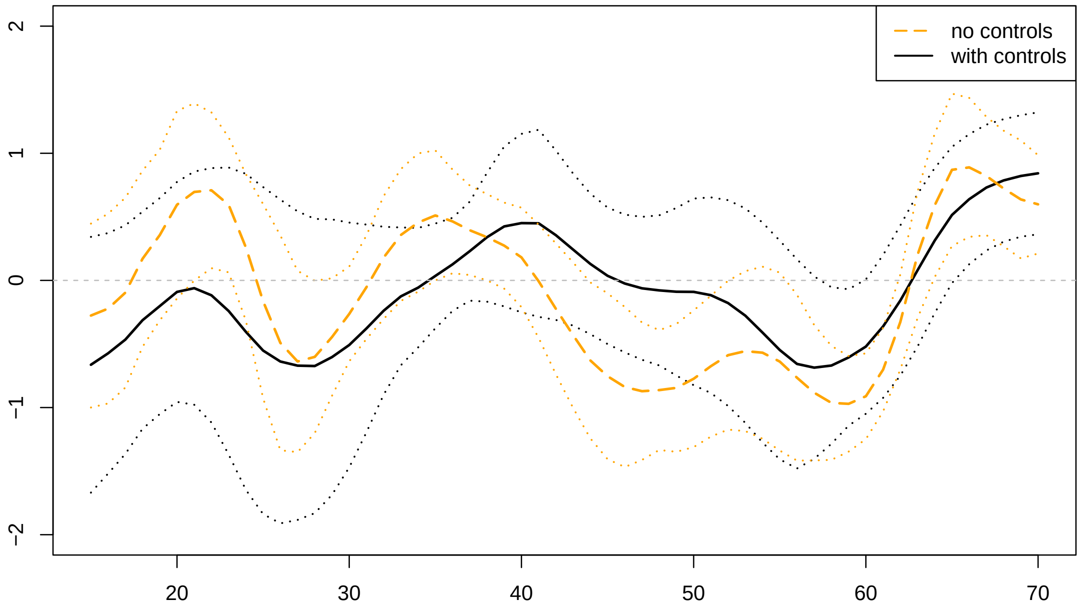
(c) House prices, Amsterdam



(d) Rent-price ratios, Amsterdam

Notes: These figures report the elasticity (in %) of lagged five-year birth rates on 5-year changes in nominal rents in the period up to 1831 for Paris (panel b) and on changes in rents (panel a), house prices (panel c) and rent-price ratios (panel d) in Amsterdam up to 1884. Each point corresponds to a different regression, with the birth rate lag and starting year changing over regressions. The birth rate lag is reported on the x-axis. For example, a birth rate lag of 20 corresponds to the birth cohort currently aged 20-24. Birth rate data for Paris start in 1526 and for Amsterdam in 1565. Regressions either include no controls (full line) or contemporaneous + lagged economic and demographic controls (see Table 3 and 4). Dashed lines reflect 95% confidence intervals, based on Newey-West standard errors using a lag-length of five years.

Figure 7: The effect of lagged fertility on turnover.



Notes: These figures report the effect of lagged five-year fertility on 5-year changes in turnover. Measures of turnover are based on the total number of non-foreclosure sales divided by the total housing stock and cover the period from 1582-1810, although data is missing in some periods where not all sale registers survived. Controls include current demographic rates, wages, consumer prices, interest rates and lags of them. A coefficient of one implies that a one percentage point increase in lagged birth rates predicts a one percentage point increase in turnover. Dashed lines reflect 95% confidence intervals, based on Newey-West standard errors using a lag-length of five years.

8 Tables

Table 1: Descriptive statistics, annual.

Statistic	Symbol	N	Mean	St. Dev.	Min	Max
			Amsterdam, 1550-1884			
Rental Growth (log)	Δr	334	0.007	0.040	−0.191	0.278
House Price Growth (log)	Δh	259	0.003	0.058	−0.231	0.191
Wage Growth (log)	Δw	334	0.006	0.014	−0.063	0.072
Inflation (log)	Δp	334	0.004	0.079	−0.258	0.337
Mortality	M	331	0.036	0.011	0.011	0.123
Nuptiality	N	320	0.010	0.002	0.006	0.020
Birth Rate	B	320	0.034	0.004	0.019	0.045
Migration (Impl.)	Mi	335	0.010	0.018	−0.016	0.110
Migration (Norm.)	MiN	321	−0.049	0.979	−2.540	4.829
Population Growth (Estim., log)	pop	334	0.007	0.022	−0.168	0.105
Δ Bond Yield (log)	Δi	288	−0.001	0.087	−0.405	0.463
Δ Dividend Yield	Δd	153	−0.001	0.042	−0.135	0.138
			Paris, 1500-1831			
Rental Growth (log)	Δr	331	0.010	0.064	−0.475	0.434
Wage Growth (log)	Δw	331	0.009	0.058	−0.223	0.223
Inflation (log)	Δp	331	0.009	0.074	−0.264	0.411
Mortality	M	287	0.036	0.012	0.012	0.153
Nuptiality	N	312	0.007	0.002	0.001	0.017
Birth Rate	B	306	0.034	0.005	0.012	0.045
Population Growth (Estim., log)	Pop	331	0.004	0.027	−0.260	0.174

Notes: This table reports descriptive statistics for series of demographic rates, house prices, rental prices and control variables for both Amsterdam and Paris. Economic variables are log differences, demographic variables are rates (0.01 = 1 percent rate). All series are continuous, and end in 1884 (Amsterdam) and Paris (1831). The starting years differ per variable due to differences in data availability. Note that the difference in mean rent price growth and house price growth is primarily driven by significant increases in rental prices between 1550 and 1625, which are not covered by the house price series.

Table 2: Age of home-buyers and sellers.

Locality	Time	Range	% buy	% sell	ratio
Young-age transactions					
United States	2021	23-31 years	18%	6%	3.00
United States	2021	23-41 years	43%	26%	1.65
Netherlands	2020/21	25-35 years	38%		
Netherlands	2020/21	25-45 years	58%		
Amsterdam	1700s	0-10 years post-m.	26%	13%	2.00
Amsterdam	1700s	0-20 years post-m	54%	27%	2.00
Old-age transactions					
United States	2021	57-66 years	17%	23%	0.74
United States	2021	57-75 years	29%	42%	0.69
Netherlands	2020/21	55-65 years	8%		
Netherlands	2020/21	55+ years	13%		
Amsterdam	1700s	30-40 years post-m.	11%	19%	0.58
Amsterdam	1700s	30-50 years post-m.	16%	33%	0.49

Notes: This table reports the age composition of buyers and sellers in the 2021 US housing market, the 2020/21 Dutch housing market and the Amsterdam housing market in the 1700-1760 period. Sales data for Amsterdam include sales by heirs, where the number of years since marriage is based on the years of marriages for the deceased owner. We only include sales less than 5 years before marriage and up to 80 years after marriage. This data is not available for the USA and The Netherlands (7% of sales by heirs). Data for the USA is from the National Association of Realtors, Dutch data from the Land Registry (Kadaster).

Table 3: Effect of lagged fertility on rent prices.

	Dependent variable: $\Delta_5 r$					
	Amsterdam			Paris		
	(1)	(2)	(3)	(4)	(5)	(6)
Birth Rate$_{t-20/24}$	-0.004	0.202	-0.468	1.600	1.368**	0.390
	(0.698)	(0.575)	(0.705)	(1.435)	(0.572)	(0.607)
Birth Rate$_{t-55/59}$	-0.562	-1.253^{**}	-0.917^{*}	-1.495	0.243	-0.242
	(0.486)	(0.628)	(0.473)	(1.249)	(0.481)	(0.655)
Controls						
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Demographic	No	Yes	Yes	No	Yes	Yes
Economic	No	Yes	Yes	No	Yes	Yes
Other Fertility Lags	No	Yes	No	No	Yes	No
Demographic (lagged)	No	No	Yes	Yes	No	Yes
Economic (lagged)	No	No	Yes	Yes	No	Yes
Observations	260	245	260	246	231	221
R^2	0.016	0.359	0.401	0.030	0.386	0.394
F Statistic	2.037	6.636	7.574	3.766	7.881	8.872

Note: *p<0.1; **p<0.05; ***p<0.01

Table 4: Effect of lagged fertility on house prices and rent-price ratios in Amsterdam.

	Dependent variable:							
	$hpi_t - hpi_{t-5}$				$(r - hpi)_t - (r - hpi)_{t-5}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Birth Rate$_{t-25/29}$	3.666***	4.684***	3.717***	4.906***	-3.952^{***}	-4.730^{***}	-4.498^{***}	-5.436^{***}
	(1.382)	(1.146)	(1.211)	(1.101)	(1.126)	(1.005)	(1.235)	(0.970)
Birth Rate$_{t-60/64}$	-3.126^{*}	-3.936^{***}	-3.769^{***}	-3.467^{***}	2.803**	3.433***	3.725***	2.843***
	(1.639)	(0.859)	(1.280)	(1.235)	(1.091)	(0.668)	(0.940)	(0.979)
Controls								
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Δ Interest rates	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Demographic	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Economic	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Other Fertility Lags	No	No	Yes	No	No	No	Yes	No
Demographic (lagged)	No	No	No	Yes	No	No	No	Yes
Economic (lagged)	No	No	No	Yes	No	No	No	Yes
Observations	255	255	245	255	255	255	245	255
R^2	0.128	0.644	0.676	0.701	0.182	0.576	0.604	0.628
F Statistic	18.569	44.044	23.330	24.703	28.117	33.129	17.102	17.835

Note: *p<0.1; **p<0.05; ***p<0.01

Table 5: Effect of lagged fertility on bond (i), rental ($r - hpi$) and dividend (d) yields (Amsterdam).

	Dependent variable:					
	$i_t - i_{t-5}$		$(r - hpi)_t - (r - hpi)_{t-5}$		$d_t - d_{t-5}$	
	(1)	(2)	(3)	(4)	(5)	(6)
Birth Rate$_{t-25/29}$	1.494	1.881	-3.952^{***}	-4.227^{***}	-0.807	-1.192
	(1.685)	(1.554)	(1.126)	(1.127)	(0.748)	(0.796)
Birth Rate$_{t-60/64}$	1.876	2.018	2.803^{**}	3.973^{***}	1.255^{**}	1.549^{**}
	(1.197)	(1.354)	(1.091)	(0.852)	(0.634)	(0.767)
Controls						
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Demographic	No	Yes	No	Yes	No	Yes
Economics	No	Yes	No	Yes	No	Yes
Observations	255	255	255	255	145	145
R^2	0.033	0.080	0.182	0.470	0.063	0.138
F Statistic	4.296	2.376	28.117	24.125	4.807	2.392

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 6: Real estate wealth by age, Amsterdam, 1688–1780.

	Dependent variable:					
	% Real Estate Wealth			log (Real Estate Wealth +1)		
	(1)	(2)	(3)	(4)	(5)	(6)
Years since Marriage	−0.239***	0.561*	0.710**	0.017**	0.072***	0.070***
	(0.088)	(0.292)	(0.293)	(0.007)	(0.025)	(0.026)
Years since Marriage^2		−0.012***	−0.013***		−0.001**	−0.001**
		(0.004)	(0.004)		(0.0004)	(0.0004)
log Total Wealth			−7.418***			
			(0.910)			
Gender			4.946			0.360
			(3.014)			(0.264)
Constant	66.446***	56.839***	144.230***	5.663***	5.004***	6.462*
	(2.982)	(4.476)	(41.909)	(0.252)	(0.379)	(3.630)
Year FE	No	No	Yes	No	No	Yes
Observations	855	855	855	855	855	855
R^2	0.009	0.018	0.188	0.006	0.012	0.117
Adjusted R^2	0.008	0.016	0.095	0.005	0.010	0.019
Residual Std. Error	42.968	42.787	41.022	3.630	3.621	3.605
F Statistic	7.456	7.873	2.035	5.288	5.362	1.189

Notes: This table reports the results of a regression of the fraction of wealth in real estate (columns 1–3) and log Total Real Estate Wealth (columns 4–6) on the years since marriage, either linearly (columns 1 and 4), including a quadratic term (columns 2 and 5), and adding controls (columns 3 and 6). *p<0.1; **p<0.05; ***p<0.01

Table 7: Estimation results for OECD countries: Prices, rents and price-rent ratios.

Dependent	Δ HPI	Δ HPI	Δ HPI^r	Δ RPI	Δ RPI	Δ RPI^r	Δ P_R	Δ P_R
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L.Dependent	0.571***	0.543***	0.435***	0.495***	0.589***	0.409***	0.375***	0.315***
	(0.043)	(0.041)	(0.046)	(0.109)	(0.083)	(0.083)	(0.104)	(0.064)
Δ L5.< 15 share	0.006	0.012	0.000	-0.005	0.001	-0.004	0.012	0.014
	(0.011)	(0.01)	(0.01)	(0.010)	(0.009)	(0.009)	(0.007)	(0.013)
Δ L20.< 15 share	0.020**	0.022**	0.017**	0.008	0.006	0.000	0.021*	0.022**
	(0.010)	(0.009)	(0.008)	(0.009)	(0.007)	(0.006)	(0.013)	(0.011)
Δ L35.< 15 share	0.006			0.007			0.001	
	(0.007)			(0.007)			(0.009)	
Δ ≥ 65 share	-0.019	-0.010	-0.019	-0.007	-0.001	-0.004	-0.020	-0.016
	(0.012)	(0.012)	(0.012)	(0.011)	(0.010)	(0.009)	(0.016)	(0.015)
Δ Population	-0.025	0.325	0.005	0.472	0.417	0.264	-0.188	0.123
	(0.355)	(0.345)	(0.338)	(0.347)	(0.309)	(0.245)	(0.449)	(0.423)
Δ GDP	0.766***	0.837***	0.914***	0.090	0.066	0.069	0.814***	0.967***
	(0.083)	(0.084)	(0.087)	(0.081)	(0.075)	(0.062)	(0.118)	(0.113)
Δ IRLT	0.000	0.002		0.003	0.005**		0.000	0.001
	(0.003)	(0.002)		(0.003)	(0.002)		(0.004)	(0.003)
Δ IRLT - Inflation			0.004***			-0.002**		
			(0.001)			(0.001)		
Observations	600	723	717	600	721	716	600	713
R^2 Within	0.686	0.679	0.659	0.254	0.416	0.115	0.527	0.523
R^2 Between	0.873	0.905	0.750	0.844	0.940	0.591	0.715	0.778
R^2 Overall	0.704	0.702	0.658	0.283	0.463	0.122	0.534	0.528
Year FE	yes	yes	yes	yes	yes	yes	yes	yes

Notes: Included countries: AUS, BEL, CAN, CHE, DEU, DNK, ESP, FIN, FRA, GBR, IRL, ITA, JPN, NLD, NOR, NZL, SWE, USA (18). It is an unbalanced panel with 23 to 50 observations per country in the period 1970–2020. HPI, RPI, and P_R denote the house price index, the rent price index, and the price-rent ratio, respectively. The superscript r denotes real values. The dependent variables, population and GDP are specified in natural logarithm. $<$ 15 share is the share of the population under 15, children. $\geq$ 65 share is the share of 65 and over, elderly. IRLT is the long-term interest rate, per cent per annum. Summary statistics on dependent and independent variables can be found in the Internet Appendix, Tables D.5 and D.6. The panel model is provided by Eq. (2). Note that including the 35th lag of '$<$ 15 share' reduces the sample size considerably. This variable is not available until 1950.

Internet Appendix

A Estimation of Amsterdam Demographic Rates

Prior to the Amsterdam Statistical Office started to formally report numbers of births, deaths and migration, we had to make use of archival sources or other estimates. These records were not always complete. This implies we cannot simply divide aggregate numbers of births and deaths by population to estimate demographic rates.

First, in some years a substantial set of church or cemetery records is missing, implying our data do not cover all churches or cemeteries active in Amsterdam in registering births and deaths. For example, in the early period, after the Reformation of Amsterdam in 1578, Catholic baptisms might be under-registered for extended periods. Additionally, registration of Jewish births, which we retrieved from Hart (1976), only survived from the late 18th century onwards.[12]

To compute crude Amsterdam birth and death rates in this period, we use an annual weighted-average of the normalized number of births and deaths per church or cemetery. In any year, we only include churches or cemeteries for which records are complete, and normalize these based on the 25-year moving average of the number of births or deaths in that particular church or cemetery. For births, we normalize for the period 1565–1780, while for deaths we do so for the period 1554–1685. To transform this to a crude birth and death rate, we assume that average fertility between 1565 and 1780 was the same as between 1780 and 1810. For mortality, we use the average rate in the period 1685–1810. For other periods, records are sufficiently complete such that we can use annual counts scaled by population numbers.

For the normalized series, there is no need to scale using population estimates. As long as there are no significant non-linear population changes, the normalization is an accurate estimate of actual birth and death rates. Amsterdam population grew significantly in the late 16th and early 17th century, but there is significant uncertainty regarding the level of

[12]For a more detailed discussion of these issues, see Nusteling (1985).

population in this period, as also acknowledged in Nusteling (1985). For this reason, we also normalize marriage rates between 1565 and 1585: scaling by the contemporaneous population estimates leads to extreme values.

To approximate actual annual migration numbers before 1850, we construct estimates on the migration of wealthier citizens by looking at citizenship purchases (*poorterschap*) between 1564 and 1733, which were not necessary to live in Amsterdam, but provided certain privileges.[13] For the period 1733–1830, we use estimates of attestations from the Dutch Reformed Church, the largest congregation in Amsterdam, as published in Hart (1976). Such an attestation was requested when a member of the church moved from or to Amsterdam. The Dutch Reformed Church was the largest congregation in Amsterdam, covering about half of the population. From 1850, actual migration estimates are based on the yearbooks of the Amsterdam Statistical Office. Since the various migration estimates have different scales, we normalize each component of the entire series by $z-$scores.

B Matching sales to marriages

Using data and matching procedures described in Korevaar (2022), we link data on buyers and sellers to their marriage records for all housing transactions in Amsterdam in the period 1700–1760. Due to limitations in the registration of names in the birth records, it was not possible to link housing transactions to birth records and link housing transactions to the actual ages of buyers and sellers.

We only match individuals that have a unique name. This implies that their name, or a very close approximation of it, only occurs once in the marriage registers of Amsterdam (1650–1810). Matches are computed for each individual in the transaction or estate tax records by computing the minimum Jaro-Winkler (JW) distance to the closest person

[13]Source: ACA 5014, Archief van Burgemeesters: stadsrekeningen. Privileges included access to the municipal orphanage, membership of guilds, and the possibility to be considered for a position in the Amsterdam government. It was either acquired at birth, through marriage with a 'poorter', or could be purchased for 50 guilders. Based on population estimates, around 10% of migrants bought 'poorterschap', which probably belonged to the upper class of society (Kuijpers et al., 2002).

in the marriage register (p=0.10). We compute the distance separately for first and last names and calculate the total JW-distance as the sum of the score for the first name plus twice the score of the last name. This JW-distance should be less than 0.1, and the name should (in expectation) be unique. See (Korevaar, 2022) for the exact computation of the uniqueness scores. In total, our matched database contains information on 5,694 individuals transacting property, from which we exclude 527 observations, where widows execute the purchase or sale.

Although the marriage records do not provide information on age, about 45% of individuals would marry before age 25, 31% between age 25 and 29 and about 25% at age 30 or more (De Vries and Van der Woude, 1997). The average age at first marriage was 27. For the subset of 2,649 buyers and 2,518 sellers with unique names, Figure 2 provides the estimated distribution of housing purchases and sales grouped by years since marriage, both including (Figure 2a) and excluding heirs (Figure 2b). Almost 50% of the sales happened after the death of the owner, where the name would be registered as the "heirs of" the original owner.

Figure 2 shows that very few individuals transacted property long before they married or more than sixty years after they married, suggesting the matching procedure resulted in very few mismatches. More importantly, there are clear differences between the ages at which individuals buy real estate, and at which they sell real estate.

C Housing Scarcity & Supply Responses

If lagged birth rates increase total housing demand this effect might partially offset by supply adjustment, implying the impact on rental prices and house prices is mitigated. Our estimates are thus conditional on the 'average' conditions in the housing market in the period we study. During the long period of study, supply elasticities and housing market tightness varied over time. Unfortunately, we do not have enough statistical power to identify the impact of such heterogeneity precisely. We therefore limit our discuss here to basic descriptive evidence.

It is difficult to identify exactly how the supply of rental housing in Amsterdam and Paris responded to increased demand from young adults. For both cities, there are no sources available that allow to construct a complete series of housing construction. In general, most construction was private with limited regulation on building and occupancy compared to modern times.

For Amsterdam, property tax appraisals for newly completed construction allow to make an assessment of housing construction in the period from 1633 to 1739 and from 1763 to 1782. Although there is too few data to investigate this link formally and test for significance, the direction of the correlation is generally in line with the evidence presented before. Birth rates 20 to 30 years ago correlates positively with new construction ($\rho = 0.20$), while we find negative but varying correlations for longer birth rate lags. Figure D.5 provides a full plot of the correlation coefficients. There is no correlation with contemporaneous birth rates ($\rho =$ -0.03). The direction of the correlation suggests housing construction might have only responded to increased demographic demand when it arrived, and not beforehand. This inattention to predictable housing demand is in line with evidence presented by DellaVigna and Pollet (2007), who suggest a similar mechanism in the stock market.

Note that in general, housing supply in Amsterdam was responsive to population growth, with a correlation of 0.47 between five-year population growth and cumulative five-year construction. For Paris, no housing construction estimates are available. In summary, the available evidence suggests there likely was a supply response to changes in demographic demand.

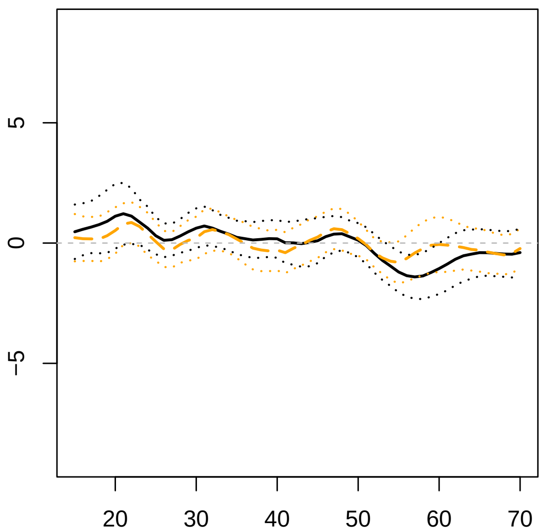
Housing supply responses were likely more gradual in response to very large demand shocks, which required more complicated and lengthy expansions of the city that typically took decades to be realized (Eichholtz et al., 2020). In the period of study, Amsterdam experienced two significant episodes with significant population growth and coordinated urban expansion: the Golden Age from the 1580s until the 1660s and the growth of the city during its industrialization in the second part of the 19th century. In between, city limits were stagnant and the urban population declined periodically.

Because large demand shocks were typically migration-driven they also might influence the impact of lagged birth rates on house prices. In a very tight market with high levels of housing scarcity the arrival of a large cohort of home-buyers might have smaller price effects given that very few of this cohort will have enough savings to enter the housing market after marriage. Secondly, lagged fertility might not be a good predictor of future demand growth when most urban growth is driven by in-migration. Conversely, in a stagnant or declining city with a excess housing supply priced below replacement cost the arrival of a large new generation might have larger price effects.

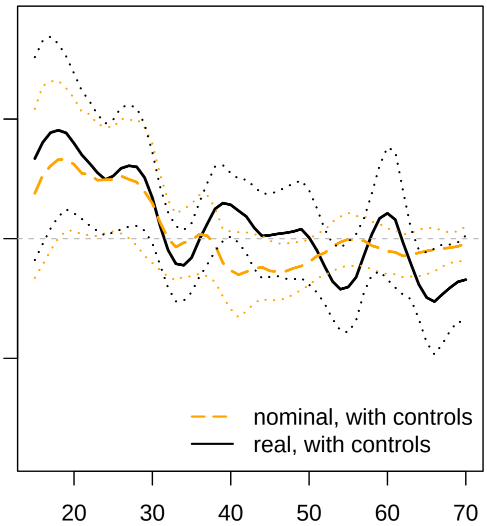
In Table D.4, we provide some weak evidence that price effects of lagged fertility on house prices and rent-price ratios were indeed smaller in periods when the city expanded significantly, although the effect is much smaller for rent-price ratios and varies significantly depending on the included controls. Note that in general, supply adjustment and scarcity itself cannot explain why prices diverge from rents, in particular since supply is expected to adjust more in the long term than in the short term.

D Supplementary Figures and Tables

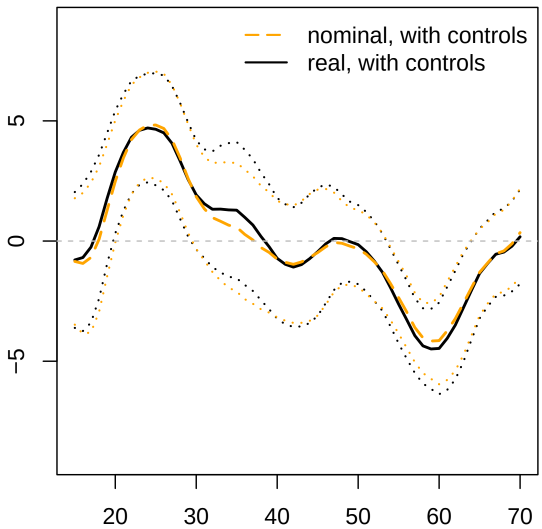
Figure D.1: Lagged birth rates and the housing market, nominal and real terms.



(a) Rent prices, Amsterdam



(b) Rent prices, Paris



(c) House prices, Amsterdam

Notes: These figures report the elasticity (in %) of lagged 5-year birth rates on 5-year changes in rents in the period up to 1831 for Paris (panel b) and on changes in rents (panel a) and house prices (panel c) in Amsterdam up to 1884, distinguishing the effect in nominal and real terms. Regressions include contemporaneous economic and demographic control variables (see Tables 3 and 4). Economic controls are in real terms (real wages in the rent regression, real wages and real interest rates in the house price regression). Each point corresponds to a different regression, with the birth rate lag and starting year changing over regressions. The birth rate lag is reported on the x-axis. For example, a birth rate lag of 20 corresponds to the birth cohort currently aged 20-24. Birth rate data for Paris start in 1526 and for Amsterdam in 1565. Dashed lines reflect 95% confidence intervals, based on Newey-West standard errors using a lag-length of five years.

Figure D.2: The effect of lagged birth rates on rent prices (non-overlapping regressions).

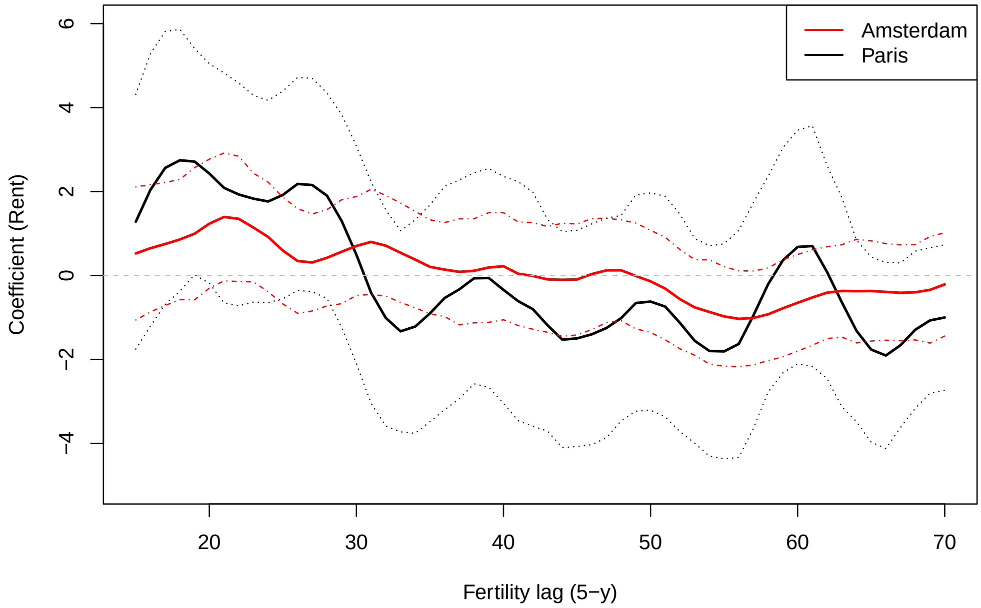
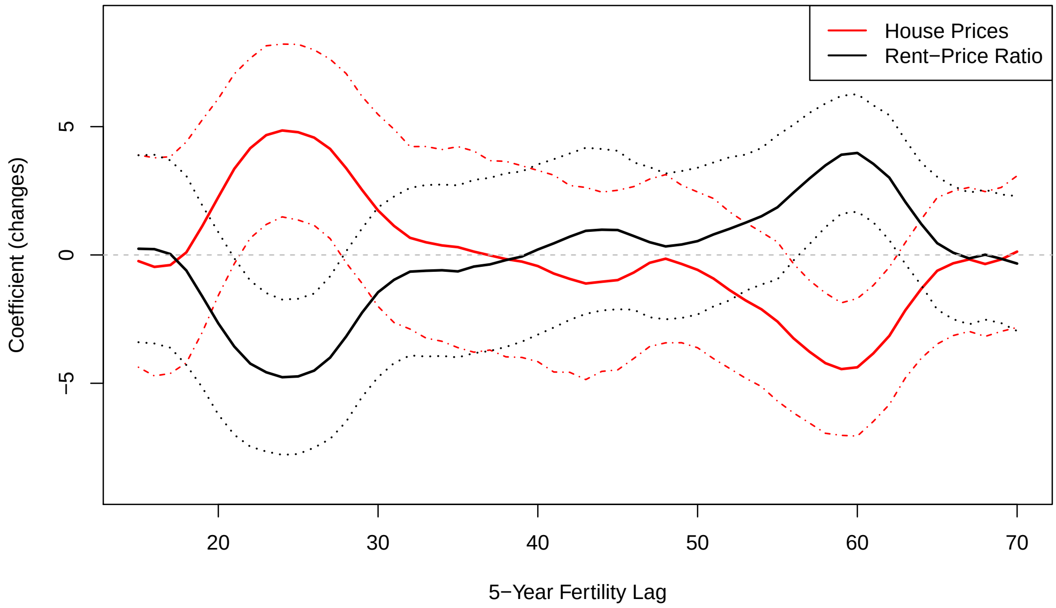
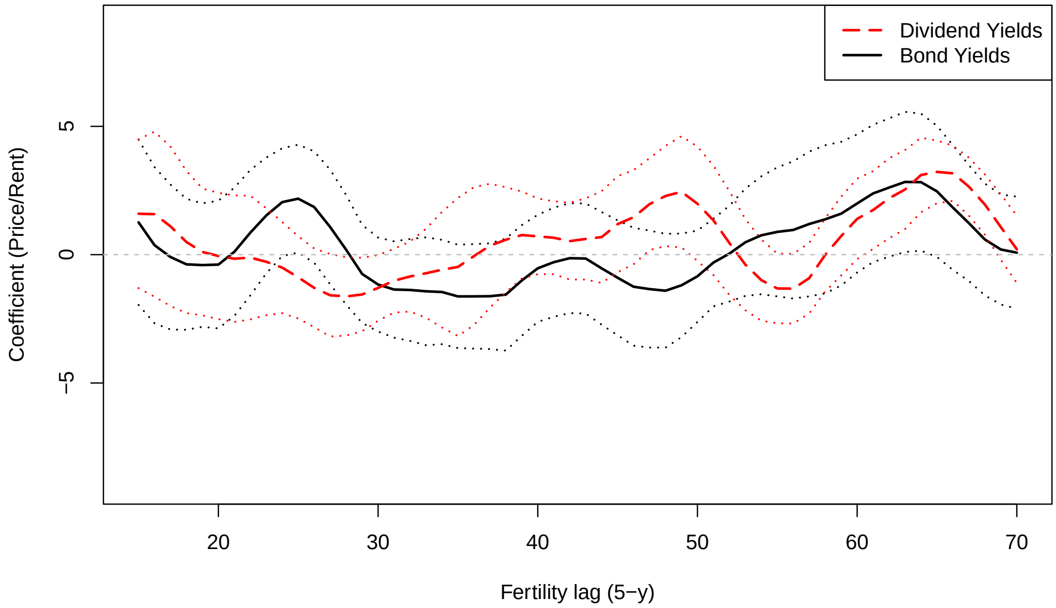


Figure D.3: The effect of lagged birth rates on prices and rent-price ratios (non-overlapping regressions).



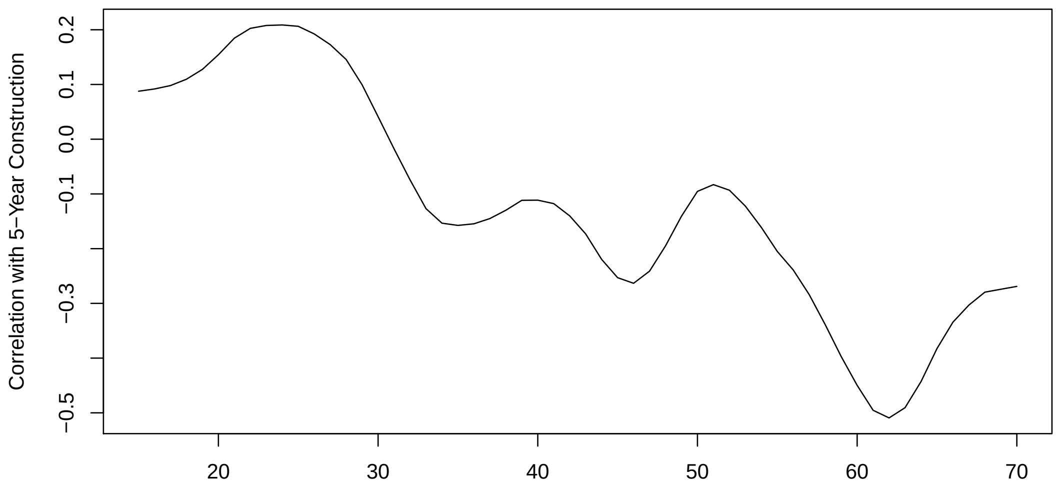
Notes: These figures are constructed similar to Figure 6, except that the estimates are obtained using regressions that do not contain overlapping observations. The coefficients and confidence intervals in the figure are based on the average of five non-overlapping regressions, with the starting year shifted by one year for each regression

Figure D.4: The effect of lagged fertility on bond and dividend yields.



Notes: These figures report the effect of lagged five-year fertility on 5-year changes in bond yields and dividend yields. All regressions control for current demographic rates, wages and consumer prices. These figure are constructed similar to Figure 6d except for the change in dependent variable and the exclusion of the interest rate control.

Figure D.5: Correlations 5-Year Lagged birth rates and Construction.



Notes: This figure plots the point estimate of the correlation between lagged 5-year birth rates and the five-yearly total rental value of newly completed construction as a fraction of total rental value in Amsterdam. Data is available from 1633 to 1739 and from 1763 to 1782

Table D.1: Results for Paris and Amsterdam, 5-year rent changes.

	Paris		Amsterdam	
	(1)	(2)	(3)	(4)
Birth rate: B_{t-15}	-1.368^{**}	-0.731	-0.638	-0.398
	(0.463)	(0.476)	(0.636)	(0.530)
Birth rate: B_{t-20}	1.164	1.467^{**}	1.101^{*}	0.198
	(0.473)	(0.441	(0.591)	(0.578)
Birth rate: B_{t-25}	0.280	0.880^{*}	-1.422	-1.193
	(0.473)	(0.454)	(1.118)	(0.788)
Birth rate: B_{t-30}	0.022	-0.245	0.961	1.024
	(0.471)	(0.450)	(0.972)	(1.119)
Birth rate: B_{t-35}	0.007	-0.637	0.048	-0.781
	(0.469)	(0.446)	(0.806)	(0.738)
Birth rate: B_{t-40}	-0.949	-0.217	0.556	-0.134
	(0.467)	(0.449)	(0.582)	(0.513)
Birth rate: B_{t-45}	-0.544	-0.093	-1.376	-1.418^{**}
	(0.469)	(0.448)	(0.940)	(0.701)
Birth rate: B_{t-50}	-1.144	-1.297^{**}	2.264^{**}	1.407
	(0.466)	(0.430)	(1.015)	(0.967)
Birth rate: B_{t-55}	0.490	0.231	-0.823	-1.251^{**}
	(0.465)	(0.438)	(0.574)	(0.622)
Birth rate: B_{t-60}	-0.808	-1.131^{*}	-0.106	-0.155
	(0.458)	(0.499)	(0.677)	(0.602)
Birth rate: B_{t-65}	-0.042	-0.088	-0.250	-0.823^{*}
	(0.449)	(0.424)	(0.577)	(0.427)
Birth rate: B_{t-70}	-1.509^{*}	-0.669	0.049	-0.207
	(0.404)	(0.394)	(0.343)	(0.484)
Controls				
Constant	Yes	Yes	Yes	Yes
Demographic	No	Yes	No	Yes
Economic	No	Yes	No	Yes
Observations	232	232	246	246
R^2	0.224	0.376	0.102	0.362
Adjusted R^2	0.182	0.327	0.056	0.308

Notes: *p<0.1; **p<0.05; ***p<0.01. These regressions estimated the impact of cumulative lagged birth rates on five-year changes in rent prices, both estimated including and excluding controls. They cover the time period from from 1599–1831 (Paris, Columns 1–2) and from 1638–1884 (Amsterdam, Columns 3–4). All birth rate lags between 15 and 70 are included Between parentheses, Newey-West standard errors using a lag-length of five years, are provided.

Table D.2: Results for Amsterdam: rent-price ratios and house price changes.

	Dependent variable:					
	$hpi_t - hpi_{t-5}$			$(r - hpi)_t - (r - hpi)_{t-5}$		
	(1)	(2)	(3)	(4)	(5)	(6)
Birth rate: B_{t-15}	−2.031	−0.456	0.012	1.393	0.058	−0.302
	(2.124)	(1.522)	(1.166)	(1.707)	(1.309)	(1.026)
Birth rate: B_{t-20}	4.184**	3.394**	1.677	−3.083*	−3.196**	−1.873
	(1.856)	(1.674)	(1.427)	(1.587)	(1.458)	(1.240)
Birth rate: B_{t-25}	0.754	1.282	3.112**	−2.175	−2.475**	−3.884***
	(1.660)	(1.314)	(1.226)	(1.403)	(1.235)	(1.178)
Birth rate: B_{t-30}	1.811	1.637	0.457	−0.850	−0.613	0.296
	(1.433)	(1.400)	(1.325)	(1.186)	(1.192)	(1.191)
Birth rate: B_{t-35}	2.937	1.636	0.978	−2.889*	−2.417**	−1.910
	(2.064)	(1.538)	(1.453)	(1.515)	(1.203)	(1.157)
Birth rate: B_{t-40}	1.604	−0.457	−0.594	−1.049	0.323	0.428
	(1.642)	(1.417)	(1.163)	(1.383)	(1.339)	(1.155)
Birth rate: B_{t-45}	−1.791	−2.632	−2.069	0.415	1.213	0.780
	(2.178)	(1.696)	(1.484)	(1.701)	(1.454)	(1.318)
Birth rate: B_{t-50}	5.146***	2.219	1.082	−2.881**	−0.812	0.064
	(1.941)	(1.396)	(1.083)	(1.446)	(0.967)	(0.838)
Birth rate: B_{t-55}	0.436	−1.542	−1.342	−1.258	0.291	0.136
	(1.688)	(1.515)	(1.287)	(1.423)	(1.245)	(1.121)
Birth rate: B_{t-60}	−4.588**	−5.087***	−4.616***	4.481***	4.932***	4.569***
	(2.046)	(1.690)	(1.533)	(1.489)	(1.260)	(1.189)
Birth rate: B_{t-65}	0.682	−0.937	−0.059	−0.932	0.114	−0.562
	(1.396)	(1.080)	(0.923)	(1.049)	(0.859)	(0.766)
Birth rate: B_{t-70}	0.239	−1.317	−1.530*	−0.190	1.109	1.273*
	(1.159)	(1.035)	(0.919)	(0.986)	(0.804)	(0.735)
Controls						
Constant	Yes	Yes	Yes	Yes	Yes	Yes
Demographic	No	Yes	Yes	No	Yes	Yes
Economic	No	Yes	Yes	No	Yes	Yes
Interest Rates	No	No	Yes	No	No	Yes
Observations	246	246	246	246	246	246
R^2	0.287	0.563	0.666	0.321	0.515	0.604
Adjusted R^2	0.250	0.526	0.636	0.286	0.474	0.569
Residual Std. Error	0.153	0.122	0.107	0.123	0.106	0.096
F Statistic	7.802	15.322	22.401	9.196	12.623	17.142

Notes: *p<0.1; **p<0.05; ***p<0.01. These regressions estimated the impact of lagged birth rates on five-year changes in house prices (Columns 1–3) and rental yields (Columns 4–6), estimated for the time period from 1629–1884. All birth rate lags are included, controls vary across specifications. Between parentheses, Newey-West standard errors using a lag-length of five years, are provided.

Table D.3: Bond investment by age, Amsterdam, 1688-1780.

	Dependent variable:					
	% Bonds			log (Bond Wealth + 1)		
	(1)	(2)	(3)	(4)	(5)	(6)
Years since Marriage	0.187**	−0.547**	−0.630**	0.044***	−0.018	−0.022
	(0.080)	(0.269)	(0.275)	(0.009)	(0.030)	(0.031)
Years since Marriage^2		0.011***	0.012***		0.001**	0.001**
		(0.004)	(0.004)		(0.0004)	(0.0004)
log Total Wealth			3.853***			
			(0.857)			
Gender			−6.977**			−0.928***
			(2.837)			(0.317)
Constant	25.950***	34.766***	−15.630	2.887***	3.635***	0.987
	(2.740)	(4.113)	(39.451)	(0.300)	(0.452)	(4.368)
Year FE	No	No	Yes	No	No	Yes
Observations	855	855	855	855	855	855
R^2	0.006	0.016	0.146	0.028	0.034	0.122
Adjusted R^2	0.005	0.013	0.049	0.027	0.031	0.023
Residual Std. Error	39.489	39.323	38.616	4.331	4.321	4.339
F Statistic	5.387	6.817	1.502	24.671	14.839	1.236

Notes: This table reports the results of a regression of the fraction of wealth in government bonds (Columns 1–3) and log total government bond wealth (Columns 4–6) on the years since marriage, either linearly (Columns 1 and 4), including a quadratic term (Columns 2 and 5), and adding controls (Columns 3 and 6). The effects are exactly opposite of those in 6, with both total bond investment and the fraction of wealth in bonds increasing in age, with the increase particularly rapid at older ages. *p<0.1; **p<0.05; ***p<0.01

Table D.4: Housing Scarcity and Price Effects.

	Dependent variable:			
	$hpi_t - hpi_{t-5}$		$(r - hpi)_t - (r - hpi)_{t-5}$	
	(1)	(2)	(3)	(4)
Birth Rate$_{t-25/29}$	3.814**	4.872***	$-$4.104***	$-$4.974***
	(1.556)	(1.285)	(1.285)	(1.176)
Birth Rate$_{t-60/64}$	$-$2.764	$-$4.292*	3.058*	3.796**
	(2.536)	(2.196)	(1.781)	(1.576)
Urban Expansion	0.208	$-$1.849*	0.023	0.791
	(0.810)	(1.049)	(0.613)	(0.878)
Urban Expansion $\times$ Birth Rate$_{t-25/29}$	$-$1.020	$-$4.119**	0.530	3.497*
	(3.013)	(2.029)	(2.374)	(2.108)
Urban Expansion $\times$ Birth Rate$_{t-60/64}$	0.492	$-$0.179	$-$1.089	$-$0.079
	(2.995)	(2.382)	(2.122)	(1.806)
Controls				
Constant	Yes	Yes	Yes	Yes
Demographic	No	Yes	No	Yes
Economic	No	Yes	No	Yes
Observations	256	256	256	256
R^2	0.217	0.604	0.233	0.547
Adjusted R^2	0.201	0.572	0.218	0.511
Residual Std. Error	0.154	0.113	0.125	0.099
F Statistic	13.835	18.939	15.213	15.009

Notes: This table reports the results of a regression of the five year change in house prices (Columns 1–2) and rent-price ratios (Columns 3–4) on lagged birth rates adding an interaction term with periods of urban expansion. In these periods, high levels of in-migration made the housing market in Amsterdam very tight (with increased levels of rents) and the city started significant but projects to expand the size of the city. The Urban Expansion dummy is 1 before 1668 and after 1855. Columns 2 and 4 including contemporaneous controls for demographics and economic conditions. We exclude lagged controls given the large number of coefficients to be estimated relative to the pure sample size. In general, we find limited effects except that the impact of young birth cohorts arriving to the housing market appears smaller in periods of significant growth. This only holds after controlling for demographic and economic controls (in particular migration). *p<0.1; **p<0.05; ***p<0.01

Table D.5: Summary statistics on demographic variables and rent and price indexes for some OECD countries.

	Δ log Pop.		<15 share		≥ 65 share		Δ log HPI_SA			Δ log RPI			Δ log HPI_RPI		
Country	Mean	SD.	Mean	SD.	Mean	SD.	From	Mean	SD.	From	Mean	SD.	From	Mean	SD.
AUS	0.016	0.005	24.17	4.17	10.83	2.43	1970	0.078	0.060	1973	0.050	0.039	1973	0.024	0.058
BEL	0.004	0.002	19.82	2.63	14.78	2.31	1970	0.055	0.049	1977	0.032	0.022	1977	0.013	0.049
CAN	0.014	0.006	23.68	6.18	10.75	3.03	1970	0.066	0.060	1959	0.025	0.020	1970	0.039	0.062
CHE	0.009	0.005	19.55	3.65	13.70	2.76	1970	0.033	0.055	1959	0.033	0.029	1970	0.005	0.059
DEU	0.002	0.005	18.00	3.63	15.47	3.43	1970	0.030	0.034	1960	0.034	0.024	1970	0.001	0.035
DNK	0.004	0.003	20.64	3.43	14.11	2.81	1970	0.059	0.075	1967	0.046	0.031	1970	0.015	0.075
ESP	0.007	0.005	21.56	5.61	12.81	3.88	1971	0.085	0.104	1961	0.057	0.038	1971	0.029	0.091
FIN	0.005	0.003	21.74	5.08	12.66	4.43	1970	0.055	0.082	1959	0.043	0.044	1970	0.012	0.066
FRA	0.007	0.004	21.69	2.83	14.36	2.43	1970	0.058	0.058	1970	0.044	0.037	1970	0.014	0.049
GBR	0.004	0.003	20.60	2.39	14.60	2.18	1969	0.081	0.082	1962	0.062	0.050	1969	0.017	0.083
IRL	0.007	0.008	26.73	4.32	11.34	0.82	1970	0.078	0.101	1959	0.051	0.095	1970	0.029	0.128
ITA	0.003	0.003	19.39	4.93	14.64	4.70	1970	0.069	0.108	1960	0.057	0.052	1970	0.012	0.102
JPN	0.006	0.005	21.07	7.12	13.07	7.49	1960	0.047	0.084	1970	0.024	0.032	1970	0.001	0.055
NLD	0.008	0.004	22.34	5.11	12.33	3.08	1970	0.054	0.082	1960	0.043	0.024	1970	0.011	0.080
NOR	0.007	0.003	21.60	2.88	14.08	2.21	1970	0.068	0.062	1979	0.038	0.026	1979	0.028	0.072
NZL	0.014	0.007	26.10	4.78	10.70	2.08	1970	0.087	0.074	1956	0.056	0.051	1970	0.028	0.061
SWE	0.006	0.003	19.56	2.19	15.74	2.91	1970	0.065	0.058	1980	0.045	0.047	1980	0.011	0.081
USA	0.011	0.003	23.96	4.19	11.54	2.08	1970	0.052	0.044	1960	0.043	0.029	1970	0.007	0.042
Total	0.008	0.006	21.79	4.92	13.20	3.71		0.062	0.075		0.044	0.044		0.016	0.073

Notes: Source: https://stats.oecd.org/, **Demography and Population**. Sample period: 1950–2020. Pop.: Population; <15 share: Share of under 15, children; ≥ 65 share: Share of 65 and over, elderly.
Source: https://stats.oecd.org/, **House prices and related indicators**. The column From indicates the start of the sample period. HPI: Nominal house price index, s.a.; RPI: Rent price index, s.a.; HPI_RPI: Price-to-rent ratio.

Table D.6: Summary Statistics on control variables for some OECD countries.

	Δ log CPI			Δ log GDP			IRLT		
Country	From	Mean	SD.	From	Mean	SD.	From	Mean	SD.
AUS	1950	0.047	0.040	1959	0.033	0.017	1970	7.61	3.86
BEL	1956	0.032	0.025	1970	0.021	0.021	1955	6.15	3.21
CAN	1950	0.034	0.029	1997	0.024	0.025	1955	6.29	3.31
CHE	1956	0.022	0.023	1980	0.017	0.017	1955	3.43	1.84
DEU	1956	0.025	0.016	1970	0.018	0.021	1957	5.55	2.78
DNK	1967	0.041	0.035	1966	0.021	0.021	1987	4.62	3.40
ESP	1956	0.061	0.051	1970	0.023	0.030	1980	7.45	5.17
FIN	1956	0.045	0.040	1970	0.023	0.030	1988	4.86	3.88
FRA	1956	0.040	0.036	1950	0.029	0.025	1960	6.63	3.97
GBR	1956	0.047	0.043	1950	0.024	0.025	1960	7.13	3.88
IRL	1976	0.040	0.048	1970	0.050	0.043	1971	7.88	4.96
ITA	1956	0.051	0.050	1970	0.015	0.028	1992	5.08	3.23
JPN	1956	0.027	0.037	1970	0.022	0.027	1989	1.93	1.90
NLD	1961	0.033	0.024	1969	0.023	0.020	1959	5.51	2.87
NOR	1956	0.042	0.030	1970	0.027	0.018	1985	5.73	3.72
NZL	1950	0.051	0.045	1977	0.024	0.019	1970	7.60	3.94
SWE	1956	0.041	0.034	1950	0.026	0.021	1987	5.08	3.90
USA	1956	0.035	0.026	1970	0.026	0.021	1954	5.66	2.91
Total		0.040	0.037		0.025	0.025		5.91	3.77

Notes: Source https://stats.oecd.org/, The column From indicates the start of the sample period. CPI: Consumer price index; from Consumer and Producer Price Indices; GDP: Gross Domestic Product (output approach), Constant prices, national base year, from National Accounts; IR3TIB: Short-term interest rates, Per cent per annum, from Finance | Monthly Financial Statistics; IRLT: Long-term interest rates, Per cent per annum, from Finance | Monthly Financial Statistics.

Appendix References

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