# The Postwar Conquest of the Home Ownership Dream

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| **Authors** | Matthew S. Chambers, Carlos Garriga, and Don Schlagenhauf |
| **Working Paper Number** | 2016-007B |
| **Revision Date** | April 2016 |
| **Citable Link** | https://doi.org/10.20955/wp.2016.007 |
| **Suggested Citation** | Chambers, M.S., Garriga, C., Schlagenhauf, D., 2016; The Postwar Conquest of the Home Ownership Dream, Federal Reserve Bank of St. Louis Working Paper 2016-007. URL https://doi.org/10.20955/wp.2016.007 |

# The Postwar Conquest of the Home Ownership Dream*

Matthew Chambers
Towson University

Carlos Garriga
Federal Reserve Bank of St. Louis

Don E. Schlagenhauf
Federal Reserve Bank of St. Louis

April 4th, 2016

**Abstract**

The post-World War II witnessed the largest housing boom in recent history. The objective of this paper is to develop a quantitative equilibrium model of tenure choice to analyze the key determinants in the co-movement between home ownership and house prices over the period 1940 to 1960. The parameterized model is consistent with key aggregate and distributional features observed in the 1940 U.S. economy and is capable of accounting for the observed postwar housing boom. The paper shows, both theoretically and quantitatively, that the key to explaining the co-movement is an asymmetric productivity change that favors the goods sector relative to the construction sector. Other factors such as demographics, income risk, and government policy are important determinants of the home ownership rate but have relatively small effects on housing prices.

**Keywords:** Housing finance, first-time buyers, life-cycle
**J.E.L.:**E2, E6

*We acknowledge the useful comments of Benjamin Bridgeman, Morris Davis, Daniel Fetter, Price Fishback, David Genesove, Matin Gervais, Jeremy Greenwood, Shawn Kantor, B. Ravikumar, Richard Rogerson, Juan Sánchez, Olmo Silva, Denis Snowden, Guillaume Vandenbroucke, Dave Wheelock, and Eugene White. Some of the ideas in the text have been presented at the 6th Meeting of the Urban Economics Association, 2011 Society for Economic Dynamics Meetings, 2011 Society for the Advancement of Economic Theory Meetings, 1st European Meeting of the Urban Economics Association, 2011 NBER-URC's Housing and Mortgage Markets in Historical Perspective Conference, Fifth Annual NBER Conference on Macroeconomics Across Time and Space. The editorial comments from Judith Ahlers have been useful. Don Schlagenhauf acknowledges the travel support from De Voe Moore Center. The views expressed herein do not necessarily reflect those of the Federal Reserve Bank of St. Louis or those of the Federal Reserve System. Corresponding author: Carlos Garriga, Federal Reserve Bank of St. Louis, PO Box 442, St. Louis, MO 63166. Carlos.Garriga@stls.frb.org. Tel.: 314-444-7412.

# 1 Introduction

In modern societies home ownership has often been identified as a symbol of prosperity and social status that separates the middle class from the poor.[1] Traditionally, the United States has been identified as a country where the majority of households have access to owner-occupied housing, which happens to be one of the cornerstones of the "American Dream." However, historically high home ownership rates have not always been the norm. Prior to the postwar period, the United States was identified as a nation of renters and access to home ownership was limited to a small fraction of the population. Between the 1940s and 1960s, the fraction of households that owned their home increased from 43 to 64 percent. In the post-World War II period, the U.S. economy had to transition back to a normal production economy from a direct war economy. Millions of individuals, including returning war veterans, desired to reintegrate into normal civilian life. During the late 1940s and early 1950s, government policy was favorable toward home ownership as well as the investment in higher education. As a result, a record number of American households started a family and bought their first home. The increase in the number of participants in the owner-occupied housing market coincided with a significant appreciation of the value of homes. In the aftermath of the postwar housing boom, it seems reasonable to state that for a large number of households the American Dream of home ownership was achieved. Since the 1960s, the home ownership rate has been fluctuating around the levels achieved during the postwar boom.[2]

The key driver of the postwar home ownership boom has been an issue of contention in the literature as a number of factors have been offered as the explanation. Some scholars attribute the increase to economic forces such as income growth and education. Other authors focus more on the role of government policies (i.e., regulation of housing finance, and tax policy) and non-economic factors such as demographics. For example, Kain (1983) and Katona (1964) both argue that the increase in home ownership was due to an increase in real income. Chevan (1989) argues that changes in income and the demographic age composition of the population explain more than half of the growth in home ownership between 1940 and 1960. Others argue that the government played a large role shaping the future of the housing market and the mortgage industry through various programs and tax exemptions. Yearn (1976) argues that federal policies that made mortgage funds available with lower down payment requirements, for longer durations, and at lower interest rates were the critical factor. In contrast to Yearn, Rosen and Rosen (1980) argue that federal tax policy was a key factor. They estimate that about one-fourth of the increase in home ownership between 1949 and 1974 was a result of benefits toward housing embedded in the personal income tax code. Hendershott and Shilling (1982) support this claim by finding that the decline in the cost of owning a home relative to the cost of renting during the period 1955 to 1979 was due to income tax provisions, as well as the easy monetary

[1] The home ownership rate is defined as the ratio of owner-occupied units to total residential units in a specified area.

[2] The 2000s housing boom increased the home ownership rate to a peak of 69.0% before it fell back to the pre-boom levels. Chambers, Garriga, and Schlagenhauf (2009) studied this period and found that mortgage innovation in the form of mortgages that were highly leveraged and had variable-rate interest payments were a key factor in accounting for the increase in the homeownership rate. From a historical perspective, the recent expansion in ownership is small compared with the 1940-1960 period.

policy of the Federal Reserve System. Shiller (2007) argues that the postwar boom was substantially the result of new government policies to encourage home ownership after the surge of mortgage defaults prior to the Great Depression in the 1930s. Fetters (2010) has estimated that the VeteranAdministration (VA) policy of making zero downpayment mortgage loans available to veterans returning from World War II and the Korean War accounts for 10 percent of the increase in home ownership. All of these studies have attempted to measure the importance of a proposed explanation using a regression-based framework that attempts to hold other potential factors constant. The problem with such an approach is the interaction between many of the proposed explanations: a change in the housing participation decision can have an impact on housing markets and thus housing prices, which has further ramifications.

This paper uses a complementary approach based on a structural model that allows the key determinants of the postwar housing boom to be quantitatively analyzed. A stylized version of the quantitative model is developed to show how the various factors discussed in the literature affect the home ownership threshold and housing prices. The stylized model shows that the key to explaining the positive co-movement in home ownership and house prices is a productivity change that favors the goods sector relative to the housing (real estate) sector. In the absence of this asymmetric productivity change, the model can explain the achievement of the home ownership dream, but cannot simultaneously rationalize the increase in house prices. Empirical evidence is presented that supports the presence of a productivity bias toward the goods sector relative to the housing construction that started during the Second World War and lasted through the Korean War.

The quantitative model evaluates the theoretical findings using a multi-sector model version of the model used by Chambers, Garriga, and Schlagenhauf (2009) that allows for various sources of individual heterogeneity to be reflected in the housing tenure decision. In the model, individuals purchase consumption goods and housing services and invest in capital and/or housing. Housing is a lumpy investment that requires a down payment, long-term mortgage financing, while receiving preferential tax treatment. Mortgage loans are available from a financial sector that receives deposits from households and also loans capital to private firms. The goods sector produces consumption and nonresidential investment, while the construction sector produces residential investment. Households provide rental services to individuals who may not want to access owner-occupied housing. The model endogenously determines the price of tenant and owner-occupied housing as well as the factor prices. The government implements a housing policy and collects revenue with a progressive income tax system. In the model, economic agents make optimal decisions in an environment that reflects the relevant economic and institutional conditions observed over the period. This approach allows the different factors to dynamically interact and provides a laboratory to study the effect of changes in economic conditions, government regulation, and relative prices.

The strategy to identify the relative importance of the different factors discussed in the literature is a three-step process. The first step is to parameterize the baseline economy to be consistent with key aggregate and distributional features of the U.S. economy between 1930 and 1940. The second step requires holding the fundamental parameters (preferences and technology) constant, while adjusting all the relevant factors that changed, thus allowing the impact of the change in these factors to jointly determine the model's determination of the total change in 1960.[3] By performing counterfactual experiments, the third and last step provides bounds on the relative contribution of each factor.

The parameterized model is consistent with key aggregate and distributional features observed in the 1940 U.S. economy and is able to rationalize the positive co-movement of home ownership and house prices observed between the 1940s and 1960s. Consistent with the theoretical model that is presented, the critical explanatory factor is the sectoral biased productivity change. According to the model, the sectoral productivity change must increase around 25 percent more in the goods sector than in the construction sector. This magnitude appears to be consistent with the relative sectoral change observed using historical data. It is important to note that any productivity gain in the model generates an increase in the fraction of owner-occupied housing. However, a particular combination of sectoral productivity changes accounts for the observed co-movement. This point is illustrated by performing some counterfactuals cases where the sectoral bias is eliminated. The model suggests that if productivity in both sectors had increased by the sector with the highest growth, home ownership should have increased to 74.7 percent instead of 64.5 percent. However, prices would have increased by only 12 percent instead of the observed 40 percent increase. If the productivity of both sectors is increased by the productivity increase observed in the construction sector, both house prices and home ownership would increase slightly. Use of a two-sector general equilibrium model imposes discipline not only on the magnitude of the income increase, but also on the compositional effect across the different sectors in the economy. While the various factors discussed in the literature continue to play a role, their importance is diminished once relative productivity changes have been considered. More specifically, the role of demographic factors has an impact on the home ownership rate that ranges between 5 and 8 percent, but represents only 3 percent of the increase in housing prices. The impact of government subsidies, housing policy, and regulation of mortgage finance accounts for between 5 and 7 percent of the increase in home ownership and between 1 and 1.5 percent of the increase in housing prices. The key message for explaining the increase in homeownership and house prices is sectoral productivity increases that favor the goods sector relative to the housing (or construction) sector.

The analysis in this paper is limited to a comparison of steady-state equilibriums, rather than a transitional analysis. The period between 1940 and 1960 is characterized by a number of major events that would greatly complicate a transitional analysis. In the early 1940's the United States formally entered World War II. This meant the central government directed resources toward industries that produced war-type goods. The focus was to provide private housing accommodations for recruits and additional workers in key industries. During the war and early postwar years the government established price controls in several sectors in the economy. The aftermath of the Second World War was a period of transformation back to a market-based economy. This meant jobs and housing accommodations were required for returning troops. As a result, a number of new government programs were developed. Many of these programs had direct implications for housing and employment markets. In the early 1950s, the Korean War introduced

[3] This paper follows the tradition of Cole and Ohanian (2000,2004), Hayashi and Prescott (2002), Ohanian (2009), and Perri and Quadrini (2002) that uses quantitative techniques to study historical episodes.

additional frictions, although of a much smaller magnitude. Given the magnitude of the unexpected events and the large scale of the quantitative model, the strategy of the paper is to try to understand the change in levels and abstract from transitional dynamics.

This paper is organized into five sections. Section 2 discusses the evidence of the housing boom in the period 1930-60. Section 3 presents a simple equilibrium model of tenure choice to illustrate the key drivers in the co-movement between house prices and ownership. Section 4 presents the quantitative model, whereas Section 5 discusses the parametrization of the model in 1940 and 1960. The quantitative analysis of the various explanations that have appeared in the literature is conducted in Section 6, and the final section concludes.

# 2 Postwar Housing Boom Evidence: 1930-1960

The economic environment changed substantially between 1929 and 1960. In the late 1930s and early 1940s, the economy was recovering from the Great Depression. Beyond the recovery, the economic environment changed due to a number of institutional changes that occurred as policy responses to the Great Depression. This section documents the change in the home ownership rate and house prices in the United States. In addition, historical background for a number of factors that have appeared in the literature as explanations for the postwar housing boom is provided.

## 2.1 Trends in Home Ownership and House Prices

The decennial Census contains information on the fraction of individuals who own the home they occupy. The evolution of the home ownership rate and real house price index for the period 1920-2000 are summarized in Figure 1. Prior to 1960, the data for the home ownership rate are available only in the decennial Census, which limits the understanding of short-run fluctuations. However, from a long-run perspective, the general consensus is that the home ownership rate prior to 1940 remained relatively stable at about 45 percent. In the postwar boom, the percentage of owner-occupied households increased from 45 to 65 percent. While the increase was quite significant across all age cohorts, the largest increase occurred for relatively young households. This is partially due to the low initial home ownership rate for individuals between 25 and 35 years of age as can be summarized in Table 1. Their access to owner-occupied housing was about half the national average. The literature argues that low income and limited access to credit were limiting factors for this age group.

The series for house prices depicted in Figure 1 corresponds to Robert Shiller's historical house price index. Many historians have used construction cost indices to proxy for a housing price index as measures of repeated sales were not available for the time period. Grebler, Blank, and Winnick (1956) examine the implications of using a construction cost index as a proxy for housing prices. They argue that "*for short-term analysis, then, some margins of error are involved in using the cost index as an approximation of a price index. With regard to long-term movements, however, the construction cost index conforms closely to the price index, corrected for depreciation. ... For long-term analysis* *the margin of error involved in using the cost index as an approximation a price index cannot be great.*" (p. 358)

A selection of the most prominent construction cost indices in the Survey of Current Business is presented in Figure 2. The general pattern across indices seems very clear, despite having different short-term fluctuations probably due to regional variations. These indices suggest that housing costs between 1940 and 1960 increased in the range of 40 percent. The house price index estimated by Shiller for this period is consistent with the various construction cost indices.

The increase in the participation of owner-occupied housing coincided with a significant increase in the average size of houses. Between 1900 and 1940, the average house size in the United States increased from 800 to only 900 square feet. The postwar housing boom started a trend in an increase in the average house size. By 1960, the average house size had increased to over 1,200 square feet and this trend showed no signs of ending. The trend in larger houses relative to population per households can be clearly seen in Table 2. According to the table, the average population per family household did not significantly change during the postwar years; as a result, the space available per person increased by roughly 50 percent in 20 years and nearly doubled in 30 years.[4] This could certainly be an important driver in the demand of housing space. During this period birth rates increased from 20.4 in 1945 to 26.6 in 1947 and stayed at high levels until the early 1960s.[5] Part of the baby boom can be observed by the fraction of population younger than 18 years of age in the household.[6] The potential contribution of demographics in the increase in the home ownership rate is discussed in the next section.

## 2.2 Determinants of Home Ownership

The aftermath of the Great Depression and the postwar period led to very significant changes in the U.S. economy. All these changes could be important contributors to the postwar housing boom. The following subsections describe these changes and their connection with the home ownership rate.

### 2.2.1 Demographics

Demographers, such as Chevan (1989), suggest social norms toward housing changed over this period. This could partially be a result of the baby boom that started in 1945 as well as the return of the large number of war veterans. Many veterans delayed marriage and the formation of families until their military obligation ended and they received their benefits, which made owner-occupied housing more accessible.[7] Demographic changes that could impact home ownership could come in the form of changes in the relative size

[4]The metric equivalence implies an average house size increase from 74 $m^2$ to 84 $m^2$. During the postwar boom house size increased to 112-125 $m^2$.

[5]The birth rate (technically, births/population rate) is the total number of live births per 1,000 persons of the population in a year.

[6]While demographics are a relevant driver of housing demand (see, for example, Mankiw and Weil, 1989, and Garriga, Tang, and Wang, 2015), fertility rates were even larger in the early part of the 1900s and houses were relatively small compared with 1960.

[7]See Fetters (2010).

of age cohorts, a transitory population boom, or an increase in average life expectancy. As shown in Table 3, the percent of the population accounted for by the 20-35 age cohorts in 1940 is 40 percent. In 1960, the relative size of the 20-35 age cohort is 31 percent. Where did the 9 percent difference go? The difference is distributed among the cohorts that comprise ages 36 to 82. As suggested by Table 1, the highest home ownership rates in 1940 occur in cohorts older than age 36. An increase in the size of these cohorts in the total population would result in an increase in home ownership due soley to a composition effect. The data supports a reduced significance of the 20-25 and 26-35 cohorts in 1960. Between 1940 and 1960 the percent of the population between ages 36 and 65 increased from 57.5 percent to 62.6 percent.

Could the change in the observed home ownership rate be entirely due to a composition effect? This question can be partially answered using a simple back-of-the-envelope calculation based on the definition of the home ownership rate. Define the home ownership rate for a given year $t$ as $\Pi_t = \sum_{i \in I} \mu_t^i \pi_t^i$, where $\mu_t^i$ is a population weight for households of age (or type) $i$ in period $t$, and $\pi_t^i$ denotes the fraction of individuals of age (or type) $i$ in period $t$ that own their homes. The results in Table 4 provide an estimate of the composition effect due to demographics. The simple decomposition shows that the decomposition effect, where $\pi_t^i$ is held constant at 1940 values, can only rationalize an increase in the home ownership rate from 42.7 to 45.5 percent, or approximately 14 percent of the total change. A change in individual behavior, where only the $\pi_t^i$ are allowed to change, accounts for over 84 percent of the change.[8] This change is also consistent with the increase in life expectancy. Housing is a long-term and risky investment. An increase in survival rates, which measures the probability of being alive at the beginning of the next period, mitigates the riskiness of a home purchase, and increases the likelihood of making such an investment. Life expectancy increased significantly between 1940 and 1960. This channel for demographics to impact home ownership has not been stressed in the empirical literature.

### 2.2.2 Growth and Wage Income

In the postwar period, the United States witnessed very stable and prosperous economic growth. In 1940 real Gross Domestic Product (GDP) was 101.4 billion (in 1940 prices) and by 1960 real GDP increased by a factor of 2.4 to 243.3 billion (1940 prices). Since the total population increased significantly during this period, a comparison in per capita values would indicate an increase in GDP per capita by a factor of 1.8. This increase in real GDP translates into a 4 percent annual growth rate between 1940 and 1960.

For millions of U.S. households the relevant driver to purchase a house was income growth. Over this period, (real) wage income per capita increased by a factor of 2.6.[9] The real issue is why did real income increase and how did the increase vary by age? Over the 1940-60 period, government programs provided incentives to increase levels of education. Wage levels are correlated with educational levels. If more individuals have

[8] The total effect also includes a small positive covariance term that amounts to 2.4 percent.

[9] Wage income is defined as total compensation of employees plus .65 of proprietors' income. Wage income is expressed in 1940 prices. Converting this into a per capita value requires dividing by total employment.

higher educational levels, the resulting higher income levels may account for the increase in home ownership over this period. Using Census data it is possible to construct (real) wage income efficiency indices for each educational level by age cohort. Figure 3 presents these indices for 1940 and 1960 for individuals with a fewer than 8 years of education, 8 years of education, fewer than 12 years of education, and 12 or more years of education. Relative to 1940, the 1960 efficiency indices are higher within earnings occurring at an early age. In the 1940s the various peaks of income seem to occur between 40 and 50 years of age for most education levels, whereas in 1960 the peak moves to around 40 years of age or earlier. Vandenbroucke, Kong, and Ravikumar (2015) provide supporting evidence that the accumulation of human capital for younger households is a very important mechanism for rationalizing the flattening of the income profile by age. In the context of buying a house, when an individual has access to peak earnings at an earlier age, in addition to a greater ability to borrow (using longer-term mortgages with lower down payments), the result could be an increase in home ownership at a younger age. The argument that an increase in household income is the key driving factor could be plausible.

Another way that income could increase the demand for housing would be through a reduction of income risk. After the Great Depression and Second World War, households could have felt that better times lay ahead by expecting less income instability. Even though panel data to measure the evolution of income risk at the individual level do not exist for this period, Census data can be used to construct measures of income dispersion by educational level. Figure 4 compares the standard deviation of income by age for the four educational groups. As can be seen, the variation of income by age (measured by the standard deviation) increases by age in both periods. The income dispersion for young individuals is relatively small compared with individuals around their peak income in 1940. The increasing variation in income is consistent with some of the facts documented in Badel and Huggett (2014). The relevant fact is the significant reduction in income dispersion between 1940 and 1960 across all groups. Using age specific standard deviation as a measure of income risk, the reduction of this risk could provide incentives to own a home at an early age in 1960 compared with 1940. This would be another way for income changes to be a key driving factor.

### 2.2.3 Regulation of Housing Finance and Government Policy

Over this period, the government played a large role in shaping the future of U.S. housing finance and housing policy. In 1900, mortgage lenders consisted of mutual savings banks, life insurance companies, savings and loan associations, and commercial banks. Mutual savings banks were the dominate lenders, while commercial banks played a small role. This is a direct result of the National Banking Act, which made real estate loans inconsistent with sound banking practice, and mortgage loans were restricted to state-chartered banks. In 1913, the Federal Reserve Act liberalized the restrictions that had limited commercial banks participation in the mortgage market. As a result, the importance of commercial banks in this market steadily increased to the point where they became dominant lender after the Second World War.

Perhaps a more important change was in the structure of the mortgage contract. Before the Great Depression many mortgages were short-term (5-7 years) balloon-type contracts (non-amortizing) with large down payment requirements (50-60 percent). As a result of New Deal policies, government agencies began to offer standard fixed-rate mortgage (FRM) contracts with longer maturities (20-30 years) and a higher loan-to-value ratio (80 percent and above).[10] A government agency was established to create a secondary market to provide additional liquidity and expand credit in housing markets by purchasing primarily Federal Housing Administration (FHA)-insured loans.

What prompted all of these institutional changes? The foreclosure problem that coincided with the 1929 collapse and the Great Depression changed the federal government involvement in the housing market. In 1932, Congress responded initially with Home Loan Bank Act which brought thrift institutions under the Federal regulation umbrella. This legislation was followed by the Home Owners Loan Act Bank in 1933 and the National Housing Act in 1934. The objective of these acts was to stabilize the financial system and prevent future collapses of housing finance. A part of the National Housing Act established the Federal Housing Administration (FHA). The FHA introduced a new mortgage product with longer maturity (20 years), self-amortizing so a homeowner could build equity, more affordable by requiring only a 20 percent downpayment) and with government guarantees with the overall goal of increasing residential investment.[11] According to Carliner (1989) the introduction of this new loan contract had an influence on the behavior of lending institutions, albeit slow. The slow adoption can be explained by the fact that state laws limiting loan-to-value ratios had to be modified. According to Yearn (1976) and Shiller (2007), federal policies towards housing were a critical driver of the home ownership boom.

A second government policy was the benefit package for returning World War II veterans.[12] The Servicemen's Readjustment Act of 1944, commonly known as the "GI Bill of Rights," encouraged home ownership and investment in higher education through low or zero interest rate loans to veterans. In the case of housing, veterans had access to loans with no down payment to help them overcome the need to accumulate savings for the down payment. Were these programs quantitatively significant? Fetters (2010) estimates that the effect of the VA's zero downpayment policy accounts for approximately 10 percent increase in home ownership. Chambers, Garriga, and Schlagenhauf (2014) report that the combined share of FHA and VA loans increased from a 1.3 percent of market share in 1936 to 44 percent in 1952.

The expansion of government and private lending could have important effects on the

[10] Grebler, Blank, and Winnick (1956) examine mortgage loan data from life insurance companies, commercial banks, and savings and loans for the period 1920 to 1940 and find that the share of loans with partial amortization was very limited. Commercial banks had the highest share near 50 percent, whereas insurance companies and savings and loans had significantly lower shares around 20 and 7 percent respectively. However, over the period 1940-1946, Saulnier (1950) reports that 95 percent of mortgage loans issued by savings and loan associations were fully amortizing. In the case of commercial banks, Behrens (1952) claims 73 percent of loans were fully amortized, whereas in the case of savings and loans Edward (1950) finds about 99.7 percent were fully amortized.

[11] Marriner Eccles (1951), a central figure in the development of the FHA, stated that the main intent of the program was "pump-priming" and not reform of the mortgage market.

[12] A "veteran" means an individual served at least 90 days on active duty and was discharged or released under conditions other than dishonorable. Service time was much higher for an individual who was in the military but not on active duty. For World War II active duty was between September 1940 and July 1947. The Korean War covered the period June, 1950 to January 1955.

interest rates. The availability of mortgage rates during these years was very limited. Grebler, Blank, and Winnick (1956, Table O-1, p. 496) provide data for mortgage rates and bond yields for Manhattan (NY) for the years 1900 and 1953. Figure 5 shows that both mortgage and the bond rates were relatively low prior to 1900. Between 1900 and 1920 mortgage interest rates had an increasing trend, and the bond yields declined. Mortgage rates remained high during the 1920s housing boom. During the Great Depression, mortgage rates decline. Some economic historians have used this information to argue that an easy money policy played a large role in the increase in home ownership. Perhaps more important are the government policies that led to the creation of a national credit market and the elimination of regional markets.

Another channel through which the government could have influenced homeownership is via the personal income tax code. Prior to the Great Depression, the role of government programs was limited; as such, a sizable fraction of the population did not pay income taxes. The financing of the Second World War and the Korean War increased direct government spending including the purchase of structures. Financing of this increase in government expenditure came partially through the issuance of government bonds. In addition, an increasing amount of revenue can be attributed to income tax collections. Rosen and Rosen (1980) argue that in the environment with higher marginal tax rates that existed after the World War II and the Korean War, tax provisions toward housing (i.e., the interest rate deduction on the mortgage and the deduction of property taxes) introduced, at the margin, an incentive to purchase homes. They estimate that about one-fourth of the increase in home ownership between 1949 and 1974 can be attributed to benefits toward housing embedded in the personal income tax code. Hendershott and Shilling (1982) support this claim by finding that the decline in the cost of owning a home relative to the cost of renting during the period 1955 to 1979 was due to income tax provisions, as well as the easy monetary policy of the Federal Reserve System in the 1940.

The Tax Foundation has constructed marginal tax rates by income level for the period 1935 to 1960. Figure 6 compares the marginal taxes for 1940 and 1960 where the base units have been normalized by the average (real) income in the economy. The dashed line for 1960 indicates how the marginal tax rates increased over all income groups compared to the dotted line for the 1940s marginal tax rates. Since rapid growth in income occurred between 1940 and 1960, we attempt to eliminate this effect by constructing an adjusted income tax rate for individuals in 1940 but based on 1960s progressivity. This adjusted tax rate shows similar marginal tax rates for individuals around average income, but clearly much higher rates for individuals earning above average income.

Since these two decades are periods with rapid income growth it is useful to eliminate this effect and construct an adjusted income tax based on 1960s progressivity for individuals in 1940. The observed change in marginal tax rate provides a rationale for Rosen and Rosen's argument, that shifting investment toward housing is a simple way to mitigate tax obligations.

# 3 Home Ownership and House Prices: The Co-Movement

The evidence presented in the previous section suggests that various factors could be driving the postwar housing boom. This section presents a simple theory and supporting evidence of the key mechanisms that determine the co-movement of house prices and ownership. The model encompasses the aforementioned factors (i.e., income growth, demographics, and government policy) and can be solved in closed-form solution to identify the relative importance of each factor.

## 3.1 A Simple Theory of Home Ownership and House Prices

Consider an economy with a sector that produces consumption goods and another sector that produces housing goods. Each sector has access to linear technologies, $C = z_c N_c$ and $H = z_h N_h$ where the terms $z_c$ and $z_h$ represent the productivity of each sector, and $N_j$ is the labor input of sector $j = c, h$. Households are ex ante heterogeneous in their labor ability $\varepsilon \in [\underline{\varepsilon}, \overline{\varepsilon}]$, where the ability distribution is uniform $\varepsilon \tilde{} U(\underline{\varepsilon}, \overline{\varepsilon}) \equiv f(\varepsilon)$. Preferences are represented by a utility function $u(c, h) = c(\gamma + h)$, where consumption goods are perfectly divisible, $c \in R_+$, and housing is an indivisible/discrete good with only one size of home available, $h \in \{0, \overline{h}\}$.[13] The parameter $\gamma > 0$ is the reservation value for rental housing and can have different interpretations (i.e., preferences for owner-occupied housing, family composition). Note that as $\gamma \to 0$, owner-occupied housing becomes more desirable. Individuals earn income by supplying effective units of labor.

For a consumer of income ability $\varepsilon$, the tenure decision problem solves

$$
\begin{aligned}
v(\varepsilon) &= \max_h \{u^r(c^r, 0), u^o(c^o, \overline{h}), \\
s.t. \qquad c^o &= w\varepsilon - (p\overline{h} + \phi), \\
c^r &= w\varepsilon,
\end{aligned}
$$

where $w$ represents labor compensation per effective unit of labor, $p$ is the price of a house of size $\overline{h}$, and the price of nonhousing goods is the numeraire. The term $\phi$ is a transaction cost associated with buying a house, which is measured in terms of consumption goods. This cost can be interpreted as the transaction cost net of any government subsidies toward housing. For an interior solution to this problem, the optimal decision rule must determine a cutoff level of earning, $\varepsilon^*(\gamma, \overline{h}, \phi, p, w)$, that is required for an individual to become a home owner:

$$
\varepsilon^*(\gamma, \overline{h}, \phi, p, w) \geq \frac{p}{w}(\gamma + \overline{h}) + \frac{\phi}{w\overline{h}}.
$$

In the model, the determinants of ownership are the cost of housing relative to income, $p/w$; the minimum size available, $\overline{h}$; transaction costs, $\phi$; and the reservation value of rental

[13] This formalization is consistent with the housing investment decision in the quantitative model. One distinction in the simplified formulation is that renters consume zero housing, whereas homeowners consume a positive amount. This can easily be relaxed allowing purchases of different size homes at the cost of introducing unnecessary notation.

housing, $\gamma$.[14] In a simple way, these variables represent the main drivers that have been the focus in the literature.

To calculate the equilibrium threshold of ownership, house price and wages need to be determined. Each sector operates in a competitive market and firms must hire workers to produce goods. Total employment is determined by aggregating abilities across workers in the population, $N = \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} \varepsilon f(\varepsilon) d\varepsilon = (\overline{\varepsilon} + \underline{\varepsilon})/2$. The linearity of the production possibility frontier of each sector implies that the labor compensation is given by $w = z_c$ and house prices by $p = z_c/z_h$. The equilibrium quantities are determined from household demand and the sectoral allocation of labor inputs. The formal definition of market equilibrium is defined as follows:

Market equilibrium: *Given $\phi$, a competitive equilibrium consists of decision rules $\{\widehat{c}(\varepsilon), \widehat{h}(\varepsilon)\}$, sectoral employment allocations $\{N_c, N_h\}$, and prices $\{p, w\}$ such that (i) solves the consumer problem, (ii) allows firms in each sector maximize profits, and (iii) satisfies market clearing:*

- *Labor market:* $N_c + N_h = N = \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} \varepsilon f(\varepsilon) d\varepsilon = (\overline{\varepsilon} + \underline{\varepsilon})/2.$
- *Goods market:* $\int_{\underline{\varepsilon}}^{\overline{\varepsilon}} \widehat{c}(\varepsilon) f(\varepsilon) d\varepsilon + \phi \int_{\varepsilon^*}^{\overline{\varepsilon}} f(\varepsilon) d\varepsilon = z_c N_c.$
- *Housing market:* $\int_{\varepsilon^*}^{\overline{\varepsilon}} \widehat{h}(\varepsilon) f(\varepsilon) d\varepsilon = z_h N_h.$

In equilibrium, the fraction of individuals who own a house - home ownership rate - is given by

$$HOR = \int_{\varepsilon^*}^{\overline{\varepsilon}} U(\underline{\varepsilon}, \overline{\varepsilon}) d\varepsilon = \frac{1}{\overline{\varepsilon} - \underline{\varepsilon}} \left[ \overline{\varepsilon} - \left( \frac{(\gamma + \overline{h})}{z_h} + \frac{\phi}{z_c \overline{h}} \right) \right].$$

This expression shows the key determinants of the home ownership and house prices. For instance, a reduction in the reservation value $\gamma$ (i.e., an increase in the family size or taste for more housing amenities) or in the transaction cost parameter $\phi$ (i.e., innovations in housing finance and homogenization of housing markets) reduces the home ownership cutoff level but has no impact on house prices.[15] Increases in the productivity in either sector generates increases in the homeownership rate (via a direct or indirect income effect) and potentially affect house prices. The key to understand the co-movement between both variables, requires an examination of changes in sectoral productivity.

In this economy, the growth rate of (wage) income is entirely determined by the change in the level productivity in the goods sector,

$$\Delta w = w'/w = z_c'/z_c = \Delta z_c.$$

However, a change in housing prices depends on the relative growth of productivity across sectors, or

$$\Delta p = \frac{z_c'}{z_c} \frac{z_h}{z_h'} = \frac{\Delta z_c}{\Delta z_h}.$$

[14] When the transaction cost is proportional to the value of the house. The budget constraint of the buyer is slightly different $c^o = w\varepsilon - (p + \phi)\overline{h}$ and the homeownership threshold is $\varepsilon^* \geq \frac{(p+\phi)}{w}(\gamma + \overline{h})$.

[15] When the transaction cost is proportional to the value of the house. The budget constraint of the buyer is slightly different $c^o = w\varepsilon - (p + \phi)\overline{h}$ and the homeownership threshold is $\varepsilon^*(\gamma, \overline{h}, \phi, p, w) \geq \frac{(p+\phi)}{w}(\gamma + \overline{h})$.

The above expressions have important implications for understanding the dynamics of home ownership and house prices. Consider two different cases:

- **Symmetric productivity changes**, $\Delta z_c = \Delta z_h$ : When the productivity growth in both sector changes at the same rate, $\Delta z_c = \Delta z_h$, the equilibrium homeownership rate increases, $\Delta HOR > 0$, but house prices do not change, $\Delta p = 0$.[16] Clearly, this combination is inconsistent with the observed behavior of both variables.

- **Asymmetric productivity changes**, $\Delta z_c \neq \Delta z_h \geq 0$ : The relevant case is where the change in productivity in the goods sector exceeds the change in housing sector, $\Delta z_c > \Delta z_h$. This combination suggests a sectoral biased technological change that results in an increase in wages that is larger than the increase in house prices, $\Delta w > \Delta p$, which results in a positive co-movement between home ownership and house prices.

The implication of this analysis is that it is possible to explain a change in the home ownership rate in a one-sector model, but it would be very challenging to rationalize the simultaneous change in house prices. A two-sector model can characterize the observed change in house prices and home ownership, but it requires productivity growth in the goods sector to exceed productivity growth in the housing construction sector.[17] The next section explores the empirical evidence on productivity growth across sectors.

## 3.2 Sectoral Asymmetric Productivity Change: 1930-1965

Based on the theoretical results presented in the previous section, an obvious question is what happened to the productivity in the goods sector relative to the productivity in the construction housing sector this period? In order to construct measures of productivity by sector it is important to include capital as a productive input. Ignoring capital can bias the estimated measures of productivity. The production function for each sector is assumed to be of Cobb-Douglas form but allows for different technological coefficients. The technology for the construction sector is represented by $Y_h = z_h K_h^{\alpha_h} L_h^{1-\alpha_h}$, where $\alpha_h$ represents the capital share and $K_h$ is the capital used by this sector. The technology for the goods sector is $Y_g = z_g K_g^{\alpha_g} L_g^{1-\alpha_g}$. For model consistency, the empirical analysis defines the good's sector as the whole economy minus the construction sector. The evolution of the sectoral inputs and outputs is presented in Figure 7.[18] The left panel summarizes the evolution of output, employment, and capital in the goods sector and the right panel represents the construction sector. All the series have been normalized to 1 in 1936. It is clear from these data that the U.S. economy was recovering from the Great Depression

[16] This observation is consistent with the empirical analyses of Katona (1964), Kain (1983), and Chevan (1989) that identify increases in real income as a driver of homeownership between 1940 and 1960 but ignore movements in housing prices.

[17] In this model, the production of homes only used labor inputs, but a more general framework should allow additional inputs such as equipment and materials. A generalization with constant returns to scale technology with more inputs is appears the quantitative section.

[18] The data used in this analysis is sectoral Census data. The time series for sectoral capital stock between 1930 and 1947 are constructed using the perpetual inventory method using investment series and sectoral depreciation rate. The details and definitions of each variable are available in the appendix.

in the late 1930s. The participation in Second World War provided a sizable economic boom mainly fueled by the conversion of the private industrial base to the production of armaments and other war material as discussed by Milward (1979).[19]

The effect of military spending did not benefit the construction sector as much as other sectors in the economy. The initial boom in 1940 lasted only two years. Most of the increase in construction was driven by military relocation to the West from the South and the Midwest as discussed by Kennedy (1999). The large migration flow forced cities to produce temporary housing to accommodate the population growth. Around 1947, output and employment return to their apparent trends. The trend levels in the housing sector appear to be somewhat flatter than the trend in the output sector. The construction sector boomed with the return of war veterans.

The estimated productivities for each sector as well as relative productivity across sectors ($z_g/z_h$) are depicted in Figure 8. In the aftermath of the Great Depression, productivity in the construction sector was growing at a rate similar to the productivity rate in the rest of the economy. The preparedness and the conversion stages of the Second World War are characterized by an increase in the productivity for the overall economy relative to construction. In period 1942-1945, a spike in the productivity in the construction sector is apparent.[20] Dealing with the war period is tricky. However, even if this episode is ignored, the asymmetric change in productivity between the late 1930s and the 1960s is significant. The evidence in Figure 8 seems supportive of the idea that the war years generated an important shift in the level of productivity of the economy relative to the construction sector. What is driving the relative shift in productivity? Historians speculate that the change is partially due to scientific and technological innovations developed during the war years (i.e., the Manhattan Project, aerospace, shipbuilding) that had positive effects on the rest of the productive economy.[21] Certainly, the construction sector had some innovations in the production of single-family units (i.e., Levittown on the East Coast), but from an aggregate perspective these innovations did not appear to be as important as the innovation of the other sectors in the economy.

What are the implications for house prices? In the context of the previous model, the

[19]Further evidence of the government involvement in the economy was the creation of the War Productions Board, which was responsible for awarding defense contracts, allocating scarce resources for military uses (i.e., raw materials such as rubber, copper, and oil), and persuading businesses to convert to military production. As Tassava (2008), suggests the government involvement between the preparedness stage in 1939 through the peak of war production in 1944 was very large: "*American leaders recognized that the stakes were too high to permit the war economy to grow in an unfettered, laissez-faire manner. American manufacturers, for instance, could not be trusted to stop producing consumer goods and to start producing materiel for the war effort. To organize the growing economy and to ensure that it produced the goods needed for war, the federal government spawned an array of mobilization agencies which not only often purchased goods (or arranged their purchase by the Army and Navy), but which in practice closely directed those goods' manufacture and heavily influenced the operation of private companies and whole industries.*"

[20]For example, Kennedy (1999) argues that despite the reconversion period from military production back to civilian production, the U.S. economy did not suffer a postwar recession as many feared. This could partially be due to the high level of defense spending that could have contributed to the developement of a network of private companies, nongovernmental organizations, universities, and federal agencies that collectively shaped American national defense policy and activity during the Cold War.

[21]Kennedy (1999,p. 648) argues that innovations from the War "*ultimately proved capable of some epochal scientific and technical breakthroughs, [but] innovated most characteristically and most tellingly in plant layout, production organization, economies of scale, and process engineering.*"

observed change in sectoral productivities would generate an increase in the relative price of housing of $\Delta p = \Delta z_c/\Delta z_h \geq 1.4$. This change is consistent with the change observed in Figure 2. In the quantitative model discussed in Section 3, house prices are determined by additional costs in the production of housing units.

# 4 The Quantitative Model

The model is a multisector, incomplete markets, overlapping-generations economy with housing tenure decisions and long-term mortgages. The economy consists of households, a final goods-producing sector, a construction sector producing homes, a rental property sector, a mortgage lending sector, and the government.

## 4.1 Households

**Age structure.** The economy is populated by life-cycle households that are ex-ante heterogeneous. Let $j$ denote the age of an individual and let $J$ represent the maximum number of periods an individual can live. At every period, an individual faces mortality risk and uninsurable labor earning uncertainty. The survival probability, conditional on being alive at age $j$, is denoted by $\psi_{j+1} \in [0,1]$, with $\psi_1 = 1$, and $\psi_{J+1} = 0$. Earnings uncertainty implies that the individual is subject to income shocks that cannot be insured via private contracts. As is usual in this class of models, annuity markets for mortality risk are absent. The lack of these insurance markets creates a demand for precautionary savings to minimize fluctuations in consumption of goods and housing.

**Preferences.** Individuals have time-separable preferences over consumption and housing services according to a momentary utility function $u(c,d)$. This function satisfies the usual properties of differentiability and Inada conditions. The period utility function departs from the standard constant relative risk aversion with a homothetic aggregator between consumption and housing services. This type of preference structure is consistent with an increasing housing services/consumption ratio by age, which is observed in the data.[22] In this paper, preferences over consumption goods and housing services are represented by the period utility function

$$u(c,d) = \gamma \frac{c^{1-\sigma_1}}{1-\sigma_1} + (1-\gamma)\frac{d^{1-\sigma_2}}{1-\sigma_2},$$

where the parameters $\gamma, \sigma_1$ and $\sigma_2$ need to be determined. The relationship between $\sigma_1$, and $\sigma_2$ determines the growth rate of housing services to consumption.[23]

**Asset structure and housing.** Individuals have access to a portfolio of two assets to mitigate income and mortality ris:. financial asset are denoted by $a'$ with a net return $r$ and a housing durable good denoted by $h'$ with a market price $p$, where the prime is used to denote the next period value. This assumption simplifies the problem because households do not need to anticipate changes in house prices. A housing investment of

[22] See Jeske (2005).

[23] When $\sigma_1 > \sigma_2$ the marginal utility of consumption exhibits relatively faster diminishing returns. In general, as income increases households choose to spend a larger fraction of income on housing.

size $h'$ can be thought of as the number of square feet in the house. A house of size $h'$ yields $s$ services.[24] If a household does not invest in housing, $h = 0$, the household is a renter and must purchase housing services from a rental market. The rental price of a unit of housing services is $R$.

**Long-term mortgage contracts.** Housing investment is financed through long-term mortgage contracts. These contracts have a general recursive representation. Consider the expenditure associated with purchase of a house of size $h$ (i.e., square feet ) with a unit price $p$ (per square feet). In general, a mortgage loan requires a down payment equal to $\chi$ percent of the value of the house. The amount $\chi ph$ represents the amount of equity in the house at the time of purchase, and $D_0 = (1 - \chi)ph$ represents the initial amount of the loan. In a particular period, $n$, the borrower faces a payment amount $m_n$ (i.e., monthly or yearly payment) that depends on the size of the original loan, $D_0$; the length of the mortgage, $N$; and the mortgage interest rate, $r^m$. This payment can be subdivided into an amortization (or principal) component, $A_n$, which is determined by the amortization schedule, and an interest component, $I_n$, which depends on the payment schedule. That is, $m_n = A_n + I_n$, $\forall n$,where the interest payments are calculated by $I_n = r^m D_n$.[25] An expression that determines how the remaining debt, $D_n$, changes over time can be written as $D_{n+1} = D_n - A_n$, $\forall n$.This formula shows that the level of outstanding debt at the start of period $n$ is reduced by the amount of any principal payment. A principal payment increases the level of equity in the home. If the amount of equity in a home at the start of period $n$ is defined as $H_n$, a payment of principal equal to $A_n$ increases equity in the house available in the next period to $H_{n+1}$. Formally, $H_{n+1} = H_n + A_n$, $\forall n$, where $H_0 = \chi ph$ denotes the home equity in the initial period.

This formalization is flexible enough to capture the two most prominent mortgage contracts available during this period. Prior to the Great Depression the typical mortgage contract was characterized by no amortization and a balloon payment at termination. A *balloon loan* is a very simple contract in which the entire principal borrowed is paid in full in the last period, $N$. The amortization schedule for this contract can be written as

$$A_n = \begin{cases} 0 & \forall n < N \\ (1-\chi)ph & n = N \end{cases} .$$

This means that the mortgage payment in all periods, except the last period, is equal to the interest rate payment, $I_n = r^m D_0$. The mortgage payment for this contract can be specified as

$$m_n = \begin{cases} I_n & \forall n < N \\ (1+r^m)D_0 & n = N \end{cases} ,$$

where $D_0 = (1 - \chi)ph$. The evolution of the outstanding level of debt can be written as

$$D_{n+1} = \begin{cases} D_n, & \forall n < N \\ 0, & n = N \end{cases} .$$

[24] For the sake of simplicity, we assume a linear relationship between house and services generated that satisfies, $s = h'$.

[25] The calculation of the mortgage payment depends on the characteristics of the contract, but for all contracts the present value of the payments must be equal to the total amount borrowed, $D_0 \equiv \chi ph = \sum_n^N m_n/(1+r)^n$.

The *fixed-rate mortgage loan* appeared after the Great Depression and was sponsored by the FHA. This new mortgage contract was characterized by a longer duration, lower down payment requirements (i.e., higher loan-to-value ratios), and was self-amortizing with a mortgage payment consisting of both interest and principal. This loan product is characterized by a constant mortgage payment over the term of the mortgage, $m \equiv m_1 = ... = m_N$. This value, $m$, must be consistent with the condition that the present value of mortgage payments repays the initial loan. That is,

$$D_0 \equiv \chi ph = \textstyle\sum_n^N \dfrac{m}{(1+r)^n}.$$

If this equation is solved for $m$, we can write $m = \lambda D_0$, where $\lambda = r^m[1-(1+r^m)^{-N}]^{-1}$. Because the mortgage payment is constant each period, and $m = A_t + I_t$, the outstanding debt decreases over time $D_0 > ... > D_N$. This means the fixed payment contract front-loads interest rate payments,

$$D_{n+1} = (1+r^m)D_n - m, \qquad \forall n,$$

and, thus, back-loads principal payments, $A_n = m - r^m D_n$. The equity in the house increases each period by the mortgage payment net of the interest payment component, $H_{n+1} = H_n + [m - r^m D_n]$ every period.

In the absence of refinancing or equity withdrawals, these contracts impose a rigid structure on the path of the loan repayment and home equity accrual. The home buyer takes that into consideration when choosing a particular mortgage loan.

**Household Income.** Household income varies over the life-cycle and depends on whether the household is a worker or a retiree, the return from savings and transfer programs, and the income generated from renting the housing investment decision.

Households supply their time endowment inelastically to the labor market and earns a wage, $w$, a productivity component that is age and education level dependent. This component is denoted as $\epsilon_j^e$. In addition, wage income depends on a transitory component. In each period, the household is subject to an iid shock. The income shock depends on both age and education and is denoted as $\upsilon_{j,i}^e$, where $i \in I$ and is drawn from the probability distribution $\Pi_j^e$. For an individual younger than $j^*$, labor earnings are then $w\epsilon_j^e\upsilon_{j,i}^e$. Households of age $j^*$ and older receive a social security transfer that is proportional to average labor income and is defined as $\theta$. Pretax labor earnings are defined as $y_w$, where

$$y_w(e,i,j) = \begin{cases} w\epsilon_j^e\upsilon_{j,i}^e, & \text{if } j < j^* \\ \theta, & \text{if } j \geq j^* \end{cases}.$$

A second source of income is available to households who invest in housing and decide to rent part of their investment. A household that does not consume all housing services generated from the housing investment, $h' > d$, will receive rental income $y_R(h', d)$ less a fixed cost $\varpi > 0$ that is required to enter the rental market, or

$$y_R(h', d) = \begin{cases} R(h'-d) - \varpi, & \text{if } h' > d \\ 0, & \text{if } h' = d \end{cases}.$$

Saving and accidental bequest transfers provide additional sources of income. Households with positive savings receive $(1+r)a$. The accidental bequest transfers are derived from the households that die with positive wealth. The value of all these assets is uniformly distributed to the households that remain alive in an equal lump-sum amount of $tr$. The (pretax) income of a household, $y$, is simply

$$y(h', a, e, d, i, j) = y_w(e, i, j) + y_R(h', d) + (1 + r)a + tr$$

The various income sources generate a tax obligation of $T$, which depends on labor income, $y_w$; net interest earnings from savings, $ra$; and rental income, $y_R$, less deductions that are available in the tax code, $\Omega$. Examples of deductions could be the interest payment deduction on mortgage loans or maintenance expenses associated with tenant-occupied housing. Total tax obligations are denoted as

$$T = T(y_w(e, i, j) + ra + y_R(h', d) - \Omega).$$

**The Household Decision Problem.** The individuals face multiple discrete choices. For example, each period a renter could purchase a home or a homeowner could change the size of the house or even become a renter. Hence, the household's budget constraint depends on the value of the current state variables. To present the decision-making problem of the consumer it is useful to write it in recursive form. The household state variables are summarized by $s = (a, h, b, z, e, j)$, where $a$ represents asset holding, housing investment is represented by $h$, mortgage balances are represented by $b$, the type of mortgage is captured by $z$, the educational level is noted by $e$, and the age of the individual is represented by $j$. The decision problem for the various cases is described below starting with the problem of an individual who starts as a renter, and then, the decision problem of the individual who starts as a homeowner.

**1. Renters:** A household that begins the period renting and has the option of continuing renting ($h' = 0$) or purchasing a house ($h' > 0$). The discrete choice problem is given by

$$v(a, 0, 0, 0, e, j) = \max\{v^r, v^o\}.$$

- **Continue renting:** The value associated with continue renting is determined by the choice of consumption, $c$; housing services, $d$; and asset holdings, $a$, that solve

$$v^r(a, 0, 0, 0, e, j) = \max_{c,d,a'} \left\{ u(c, d) + \beta_{j+1} \sum_{i=1}^{I} \Pi^e_{j,i} v^r(a', 0, 0, 0, e, j + 1) \right\},$$

$$\begin{aligned} s.t. \quad c + a' + Rd &= y_w(e, i, j) + (1 + r)a, \\ a' &\geq 0. \end{aligned}$$

  Note that the restriction in the choice set indicates that asset markets are incomplete since individuals have access only to an uncontingent asset and borrowing via this asset is precluded.

- **Purchase a house:** When an individual who rents purchases a house solves a different problem with a larger number of choices. This decision problem solves

$$v^o(a, 0, 0, 0, e, j) = \max_{\substack{c,d,a' I_r \in \{0,1\} \\ z' \in \mathcal{Z}}} \left\{ u(c, d) + \beta_{j+1} \sum_{i=1}^{I} \Pi^e_{j,i} v^o(a', h', b', z', e, j + 1) \right\},$$

$$
\begin{aligned}
s.t. \quad c + a' + (\phi_b + \chi(z'))ph' &= y(h', a, e, d, i, j), \\
b' = (1 - \chi(z'))ph', a' &\geq 0.
\end{aligned}
$$

The home buyer needs to decide the size of the house, $h'$, and the type of mortgage used to finance the purchase, $z'$. The purchase requires a down payment that varies with the choice of mortgage $\chi(z')$. The choice of mortgages imposes an exogenous law of motion on mortgage debt, $b'$.

The choice of whether to continue renting or purchase a home is determined by the highest value between $v^r(s)$ and $v^o(s)$. When $v^r(s) \geq v^o(s)$, the individual continues to rent. Otherwise, the individual becomes a homeowner.

**2. Owners:** The decision problem for an individual who starts the period owning a house ($h > 0$) has more choices. The homeowner can choose to stay in the house ($h' = h$), purchase a different house ($h' \neq h$), or become a renter ($h' = 0$). In addition, anytime that the homeowner chooses to sell the property.

$$
v(a, h, b, z, e, j) = \max\{v^s, v^m, v^b\}.
$$

The different value functions are calculated by solving three subproblems.

- **Stayer or non-mover:** The decision problem of the home owner that stays in the same house is given by

$$
v^s(a, h, b, z, e, j) = \max_{c,d,a' I_r \in \{0,1\}} \left\{ u(c, d) + \beta_{j+1} \sum_{i=1}^{I} \Pi^e_{j,i} v^s(a', h, b', z, e, j+1) \right\},
$$

$$
\begin{aligned}
s.t. \quad c + a' &= y(h', a, e, d, i, j) + (b' - b) - i(z)b, \\
b' &= g(b, z), a' \geq 0.
\end{aligned}
$$

If the mortgage balance is positive. the law of motion determines the new value of mortgage debt, $b'$. If the mortgage balance is zero, the consumer solves a standard dynamic consumption-savings problem with the option of obtaining rental income from the housing stock.

- **Sell the current property and rent:** Negative income shocks or retirement might induce individuals to sell the current property, $h$, and rent. The individuals who sell and rent solve

$$
v^m(a, h, b, z, e, j) = \max_{c,d,a',} \left\{ u(c, d) + \beta_{j+1} \sum_{i=1}^{I} \Pi^e_{j,i} v^r(a', 0, 0, 0, e, j+1) \right\},
$$

$$
s.t. \quad c + a' + Rd = y_w(e, i, j) + (1 + r)a + (1 - \phi_s)ph - b,
$$

whereas the term on the right side of the budget constraint captures the revenue associated with selling the property net of transaction costs, $(1 - \phi_s)ph - b$.

- **Sell current property and buy:** Similarly, individuals could choose to purchase a different house size, $h' \neq h$. The problem of the individuals who change house size solves

$$v^b(a,h,b,z,\epsilon,j) = \max_{c,d,a',h',z'} \left\{ u(c,d) + \beta_{j+1} \sum_{i=1}^{I} \Pi^e_{j,i} v^o(a',0,0,0,e,j+1) \right\},$$

$$s.t. \quad c + a' + (\phi_b + \chi(z'))ph' = y(h',a,e,d,i,j) + (1-\phi_s)ph - b.$$

The net proceedings from selling the house, $(1-\phi_s)ph - b$, are used to purchase a new one, $ph'$.

## 4.2 Mortgage Lending Sector

The financial intermediary is a zero-profit firm. This firm receives deposits from households, $a'$, and uses these funds to make loans to firms, $K$, and households, $b$. Firms acquire loans of capital to produce goods, and households use long-term mortgages to finance housing investment. Conditional on the legal lending arrangements, lenders provide credit and receive flows of payments to maximize profits. In addition, financial intermediaries receive principal payments from those individuals who sell their homes with an outstanding mortgage position, as well as the outstanding principal of individuals who unexpectedly die.[26]

## 4.3 Goods Sector

A representative firm produces a good in a competitive environment using a constant returns to scale Cobb-Douglas production function, $Y_g = z_g K_g^{\alpha_g} L_g^{1-\alpha_g}$, where $K_g$ and $L_g$ denote the amount of capital and labor used by the sector, and the term $\alpha_g$ represents the capital-income share. The aggregate resource constraint is given by $C + I_K + G + \Upsilon = Y_g$, where $C$, $I_K$, $G$, and $\Upsilon$, respectively, represent aggregate consumption, capital investment, government spending, and transactions costs (i.e., resources used in the transaction of homes and leasing tenant-occupied property).[27]

## 4.4 Construction Sector

The stock of new homes is produced by a competitive real estate construction sector. Producers manufacture housing units using a Cobb-Douglas technology $Y_h = z_h K_h^{\alpha_h} L_h^{1-\alpha_h}$. The optimization problem of the representative firm in the construction sector is given by

$$\max_{K_h, L_h} pY_h - (r + \delta_h)K_h - wL_h.$$

In competitive factor markets all sectors have to yield the same return:

$$w = (1-\alpha_g)\left(K_g/L_g\right)^{\alpha_g} = p(1-\alpha_h)\left(K_h/L_h\right)^{\alpha^h}.$$

[26] The formulation of the market clearing condition derived from zero profit on the lender side is available in an appendix available from the authors upon request.

[27] The definitions for aggregate housing investment and total transaction costs appear in the appendix.

Given that both sectors have access to the same capital market, the optimal capital-employment ratio satisfies

$$\frac{K_g}{L_g} = \left(\frac{\alpha_g z_g}{r + \delta_k}\right)^{\frac{1}{1-\alpha_g}}.$$

For a given $r$, the value of homes adjusts to eliminate factor pricing arbitrage. Replacing the optimal capital-employment condition generates the expression that determines house prices in this economy,

$$p = \widetilde{z}_h (r + \delta_h)^{\alpha_h} (w)^{1-\alpha_h},$$

where $\widetilde{z}_h = z_g / z_h \alpha_h^{\alpha_h} (1 - \alpha_h)^{1-\alpha_h}$. The house price is determined by the marginal cost of the inputs used to produce one unit of housing. In this model, changes in the price of housing are driven entirely by changes in fundamentals. As suggested by the empirical evidence reported in Section 3.2, most of the change in house prices is driven by relative changes in productivity between the goods and the construction sector.

New residential investment is added to the existing housing stock as either new units or as repairs of the existing stock. The aggregate law of motion for housing investment is

$$Y_h = (1 + \rho_n) H' - H + \varkappa(H, \delta_o, \delta_r),$$

where $\rho_n \geq 0$ represents the population growth rate. The depreciation of the housing stock $\varkappa(H, \delta_o, \delta_r)$ depends on utilization (i.e., owner- vs. tenant-occupied housing). The larger the size of the rental market, the larger the investment in housing repairs. If the depreciation rate is the same for owner-occupied and rental housing, $\delta_o = \delta_r$, then residential investment is linear in the stock, or $\varkappa(H, \delta_o, \delta_r) = \delta H$. All the aspects of the supply side of the market can be controlled by changing the technological parameter $z_h$. For example, innovations in the process of producing homes (i.e., Levittown on the East Coast) would be an increase in $z_h$.

## 4.5 Government Activities

In this economy, the government regulates markets by imposing particular lending arrangements on the mortgage loan market. This includes a reduced interest on certain mortgage contracts that could be a result of direct policy, such as a veteran's benefit or an implicit government guarantee on a specific mortgage product. The government can encourage housing ownership through the tax code. In addition to these passive regulatory roles, the government plays a more active role through other programs. First, retirement benefits are provided through a pay-as-you-go social security program. Social security contributions are used to finance a uniform transfer upon retirement that represents a fraction of average income. Second, exogenous government expenditure is financed by using a non-linear income tax scheme. The financing of government expenditure and social security is conducted under different budgets. Finally, the government redistributes the wealth (housing and financial assets) of individuals who die unexpectedly. Both housing and financial assets are sold and any outstanding debt on housing is paid off. The remaining value of these assets is distributed to the surviving households as a lump-sum payment.

## 4.6 Stationary Equilibrium

In the model, a stationary equilibrium includes optimal decisions that are a function of the individual state variables, prices, market clearing conditions, and a distribution over the state space $\Phi(x)$ that are constant over time.[28]

# 5 Parameterization and Analysis

This section quantifies the relative importance of the different factors driving the home ownership rate and housing prices during the period 1940-1960 using a parametrized version of the quantitative model.

## 5.1 Parameterization of the 1940s

The parameterization strategy is primarily based on the method of moments estimation to replicate key properties of the U.S. economy in the aftermath of the Great Depression (1935-1940). This period is chosen to minimize the potential structural effects on the housing market such as the National Housing Act. While this act was passed in 1934, the substantive effects of this legislation did not begin to impact housing markets until the late 1930s. Some of the model parameters are taken directly from data, whereas as others are parametrized using a minimum distance approach.

**Population Structure:** A period in the model corresponds to five years. An individual enters the labor force at age 20 (model period 1) and lives a maximum of 83 years (model period 14). Mandatory retirement occurs at age 65 (model period 11). The survival probabilities $\{\psi_{j+1}\}$ are from the National Center for Health Statistics, United States Life Tables (1935, 1940). The initial size of a cohort, $\mu_{ij}$, is endogenously determined by the share of these individuals at age 25 or younger and the population growth rate.

**Family Size:** The size of the average household family is constructed using Census data for the relevant years. Since the baby boom takes place during this period, the goal is to allow for the effects of changing household family size on the demand for owner-occupied housing. In a more detailed theory, changes in institutional arrangements could affect fertility decisions. In the model, the demographic structure is taken as exogenously determined and does not depend on education types.

**Functional Forms:** The utility functions require values for the parameters $\gamma, \sigma$, and $\rho$. The parameter $\sigma$ is set to 2, and the intertemporal elasticity of substitution is taken from the range of estimates in the literature and set to 1. The parameter $\gamma$, which measure the relative importance of consumption to housing services, and the discount rate $\beta$ are estimated. The first parameter, $\gamma$, is estimated to be consistent with a housing-to-consumption ratio of 0.180. The individual discount rate is determined to match a capital-output ratio of 2.54. The capital stock is defined as private fixed assets plus the stock of consumer durables less the stock of residential structures (to be consistent with the capital stock in the model). Output is GDP plus an estimate of the service flow from consumer durables less the service flow from housing.

[28] A formal definition of the recursive equilibrium is available from the authors.

Each production sector in the model is assumed to have production functions of the Cobb-Douglas form. The approach to specify the capital share parameters for each sector, $\alpha_h$ and $\alpha_g$, closely follows Cooley and Prescott (1995) who emphasize how to allocate Proprietors' income and some of the smaller categories of national income between capital and labor income. The data required to specify these parameters are from The National Income and Product Accounts of *the* United States, 1929-1965 from the U. S. Department of Commerce (1965). The estimated coefficient for the construction sector has an average value for the capital-income share for the period 1938-1962 of $\alpha_h = 0.16$. The goods sector, defined as total industry output less the construction sector output, has a capital-income share of $\alpha_g = 0.33$.[29] Both sectors have a common depreciation rate with an annual value of 6 percent. The calculation of the sector Solow residuals, $z_h$ and $z_g$, is based on the analysis in Section 3.2. The details on how the various series required for the construction of the historical residuals are discussed in the appendix.

**Income Endowments:** A household's income depends on its education level, $i$. Four exogenous education levels are available: (i) fewer than 8 years of education, (ii) 8 years of education, (iii) fewer than 12 years of education, and (iv) 12 or more years of education. For each education level, a household's income has two components; one is deterministic and the other is stochastic. The values of these components are constructed from Public Use Microdata Series (PUMS) for the 1940 and 1960 Censuses. The deterministic, or life-cycle component, $\epsilon_j^e$, is generated using the average salary and wage income by age and education. A polynomial is fit to age-specific averages per education level to smooth this component. Figure 3 presents the wage efficiency patterns for 1940 and 1960 for each educational level.[30] As shown, the wage efficiency indices for each educational level are higher in 1960 compared with 1940.

The determination of the uncertain component hinges on the available data. The reliance on Census data (which restricts data availability to once every 10 years) does not allow the estimation of a serially correlated income process.[31] Our strategy is to assume the stochastic component, $\upsilon_{j,i}^e$, is independent and identically distributed over education and age. This component of income, along with the associated probabilities, is estimated using a kernel density estimation for every age cohort, $\Pi_j^e(\upsilon)$, for the cross section of individuals. Since the unit in the model is the household, the estimation considers only households that work full-time. Therefore, the model captures the observed dispersion of labor income for each education level. One measure of the income risk is the standard deviation over the mean for each age group as presented in Figure 4. This shock combined with the ex ante heterogeneity is the main driver of labor earning heterogeneity in the model. The initial distribution of ex ante types is 0.11 for fewer than 8 years of education, 0.20 for 8 years of education, 0.43 for fewer than 12 years of education, and 0.25 for 12

[29] These values are consistent with the values presented in Koh, Santaeulália-Llopis, and Zheng (2015).

[30] The wage efficiency index for an educational level is created by taking the wage income of an individual and distributing to the appropriate age cohort. After all distributions, averages of wage income for each age cohort are calculated.

[31] Storesletten, Telmer, and Yaron (2004) find that income shocks have a persistent component even when conditioned on all the observables. Their finding is based on a sample of household data over many periods from the Panel Survey on Income Dynamics. Other recent works (e.g., Castaneda, Diaz-Giminez, and Rios-Rull (2003) find that a smaller persistent component is needed once ex ante heterogeneity is considered. Their model is constructed to generate the observed income and wealth differences.

or more years of education.

**Government and the Income Tax Function:** In 1940, the government funds the Social Security program and finances government spending/subsidies via income taxes. Even though the U.S. Social Security program was in its infancy, the quantitative model accounts for this program. Using data from the U. S. Social Security Administration allows setting the payroll tax rate for a worker to be 1 percent of wage income up to a wage income of $3,000.

Government spending is financed using the actual tax code that existed in 1940. The 1940 tax code differentiated wage income from total net taxable income, which is equal to wage and interest earnings minus interest payments (i.e., mortgage interest payments). Each household received an earned income credit. This credit is equal to 10 percent of wage income as long as net income is less than $3,000. If net income exceeds $3,000, the credit is calculated as 10 percent of the minimum of wage income or total taxable income. The tax credit is capped at $1,400. In addition to the earned income credit, each household received a personal exemption of $800. If these two credits are subtracted from total net taxable income, adjusted taxable income can be determined. For the 1940 tax code, the marginal tax rate is 0.79, which is applicable to income levels exceeding $500,000. In 1940, an income tax surcharge existed, which is equal to an additional 10 percent of taxable income that must be included in the income tax obligation. The documentation for the 1940 tax code is from the Internal Revenue Service and the Tax Foundation.[32] To ensure that the income tax function generates the proper amount of revenue for 1940, an adjustment factor must be added to the tax code, $\tau_0$. This factor is estimated by targeting the personal income tax revenue-to-GDP ratio in 1935 of 0.01.

**Housing:** In the baseline model for 1940, homeowners have choices over two mortgage products: a short-duration balloon loan of 10 years length with a 50 percent down payment and a 20-year FRM with a 20 percent down payment requirement.[33] These values are consistent with the primary mortgage contracts available in the 1935-1940 period as documented by Grebler, Blank, and Winnick, (1956).[34] Changes in housing investment are subject to some transaction costs. The costs of buying and selling are set to $\phi_s = 0$ and $\phi_b = 0.06$, respectively. The minimum house size, $\underline{h}$, is estimated to be consistent with the set of specified targets. The values $\delta_o$ and $\delta_r$ are from Chambers, Garriga, and Schlagenhauf (2009), where the annual depreciation rates for owner- and tenant-occupied housing are $\delta_o = 0.011$ and $\delta_r = 0.014$, respectively.

The estimation of the set structural parameters for 1940 is based on an exactly iden-

[32] This data can be found at http://taxfoundation.org/article/us-federal-individual-income-tax-rates-history-1913-2013-nominal-and-inflation-adjusted-brackets

[33] Formally, $\chi(1) = 0.5$ and $\chi(2) = 0.2$.

[34] In the 1920s and 1930s, mortgage loans tended to originate from life insurance firms and savings and loan associations. Commercial banks played only a small role because of regulations. During the period from 1920 to 1935, the average duration was between 6 and 7 years for mortgages originated by life insurance firms. Mortgages from savings and loan associations tended to be for 11 years. Loan-to-Value (LTV) ratios over this same period for life insurance firms and S & L associations were approximately 50 and 60 percent, respectively. After 1934, commercial banks became a more important alternative for mortgage financing. It is clear that the length of mortgages increased and was starting to approach 20-year mortgages. This was especially true for mortgages offered by life insurance companies. Loan-to-value ratios also changed over this period. While the LTV value ratios in 1920-34 were around 50 percent, these ratios began to increase after 1934. By 1947 LTV ratios started to approached 80 percent.

tified method of moments approach nested with the computation of equilibrium. The parameters we estimate are $\beta, \gamma, \overline{h}, \tau_0, z_h$, and $z_g$. The targets are the ratio of the capital stock to GDP, the ratio of housing consumption to the consumption of nonhousing goods, the homeownership rate, the ratio of personal income tax revenue to GDP, the share of labor in the goods sector, and the share of goods output to total output. The value for the parameter estimates are summarized in Table 5. The estimated parameters are all within the 1 percent error of the observed targets.

## 5.2 Parameterization of the 1960s

Between 1940 and 1960 the U.S. economy went through an important number of institutional changes. To evaluate the contribution of the different factors, the strategy in the quantitative analysis maintains constant the fundamental parameters (preferences and technology) from the baseline model and adjusts the relevant factors documented in Section 2. These include modifications to demographics, labor earnings, housing policy, tax policy, and productivity.

Demographics factors such as cohort size, survival probabilities, and family structure for 1960 are adjusted using United States Life Tables (1960) and Census data. Similarly, the labor income process is adjusted to include the new efficiency profile by educational attainment and a new distribution of income risk.

In terms of policy, the federal government increased its involvement in mortgage markets by proving federal guarantees. This was especially important after 1950. Because of the treatment of veterans after World War I, Congress passed the Servicemen's Readjustment Act of 1944, or the "GI Bill."[35] This program was a benefit to veterans. Initially no down payments were required on the theory that soldiers were not paid enough to accumulate savings and did not have an opportunity to establish a credit rating. Here are the relevant aspects of this program. Under the original VA loan guarantee program, the maximum amount of guarantee was limited to 50% of the loan, not to exceed $2000. Loan durations were limited to 20 years, with a maximum interest rate of 4%. These ceilings were eliminated when market interest rates greatly exceeded this ceiling. The VA also set a maximum value for the house purchase. Because of rising house prices in 1945 the maximum amount of the guarantee to lenders was increased to $4,000 for home loans. The maximum maturity for real estate loans was extended to 25 years for residential homes. In 1950, the maximum amount of guarantee was increased to 60% of the amount of the loan with a cap of $7,500 and the maximum length of a loan was lengthened to 30 years.

Were these programs quantitatively significant? While these government mortgage programs took time to have an impact, by 1940 FHA and VA mortgages accounted for 13.5 percent of mortgages, and by 1945 these mortgages accounted for nearly a quarter of total mortgages. In 1952 the home mortgage share of FHA and VA mortgages was 43.6 percent. In calibration for 1960, the maturity of the FRM is extended from 20 to 30 years, and the interest rate of FRM loans has an implicit government subsidy. The

[35] A "veteran" mean an individual served at least 90 days on active duty and was discharged or released under conditions other than dishonorable. Service time was much higher some an individual who was in the military, but not on active duty. For World War II active duty was between September,1940 to July 1947. The Korean conflict was the period June, 1950 to January 1955.

estimated subsidy implies that FRM mortgages are reduced by 3.6 percent over a 5-year horizon or approximately 0.72 percent annually. A data set reporting the actual differences in interest rates between FHA and VA mortgages and conventional loans does not seem to exist. Behrens (1952, p45) examines a sample of mortgage loan interest rates held by 170 commercial banks in June 1947 and finds the average interest rate on VA loans was 4.0 percent and FHA loans was 4.5 percent. Since the average interest rate on conventional loans was 4.8 percent, the spread between FHA and conventional loans is 0.3 percent annually or approximately 1.5 percent over a 5-year period. Grebler, Blank, and Winnick (1956) report that data from the 1950 Census of Housing indicate that median interest rates on outstanding VA-guaranteed mortgages were 4.0 percent, on FHA-insured mortgages 4.5 percent and conventional loans 5.0 percent. These interest rates suggest the government interest rate subsidy for a five year period should be in the range of 2.0 to 5.0 percent. These studies suggest our estimate of the government mortgage interest rate subsidy is not unreasonable.

In addition to the federal government's role in the mortgage market, the tax code became more progressive due to the need for increased revenue to finance World War II and the Korean War (see Figure 6). Tax provisions toward housing (i.e., deduction of interest payments) have a larger impact in the presence of more progressive taxation as discussed by Chambers, Garriga, and Schlagenhauf (2009), providing at the margin additional incentives toward home ownership. The tax function includes an intercept to ensure that the income tax function generates the proper amount of revenue for 1960. This parameter, $\tau_0$,is estimated to be consistent with the personal income tax-to-GDP ratio for 1960.

As discussed in Section 3.2, perhaps the most important change between 1940 and 1960 occurred in sectoral productivities. The parameterization strategy adjusts the productivity in each sector to match the employment and the output shares observed in 1960. In 1940, the calculated ratio of productivities between the goods and the housing sector was 0.33. According to the model, the estimated ratio for 1960 changes to 0.42, which is a nearly 30 percent increase relative to the baseline in 1960. From the decomposition exercise reported in Figure 8, the range of values of the productivity increase varies between 25 and 40 percent depending on the choice of base year. As such, the parameterized change of productivities is well within the range of plausible values. The next section evaluates the importance of the relative productivity changes for home ownership and house prices. The updated parameter estimates are summarized in Table 6.

## 5.3 The Conquest of the Home Ownership Dream: A Quantitative Evaluation

The quantitative implications of the model parameterized for 1940 and 1960 with respect to the home ownership rate and housing prices are summarized in Table 7. As suggested in the table, the quantitative model can rationalize the positive co-movement between home ownership and house prices. More specifically, the model suggests that the home ownership rate increased from 43.3 in 1940 to 64.5 percent in 1960, or a percent difference of 21.2 points. The corresponding number from the data is a change of 19.9, thus indicating the model slightly overstates the actual increase in the observed increase in the home ownership rate. According to various house price measures, including Shiller's, the appreciation during this period ranged between 40 and 45 percent. The baseline model generates a 40.4 percent increase within the range of plausible values.

The model can be evaluated along several important dimensions. Since the aggregate home ownership rate is an estimation target, it not surprising that the 1940 model economy matches the 1940s value. However, the home ownership rate for the 1960s economy is endogenously determined from the institutional changes and it is not explicitly targeted. Perhaps a better approach to evaluate the model from a home ownership perspective is to examine age-specific home ownership rates. These rates are not targeted in either 1940 or 1960. Table 8 summarizes the compositional differences across age groups between both periods in the data and the model. As can be seen, the differences in the age-specific home ownership rate between 1940 and 1960 generated by the model and the actual Census estimates are relatively close. The model captures not only the aggregate change, but also the fact that most of the contribution is from cohorts between ages 25 and 45.

The model also makes predictions not only about the number of participants accessing owner-occupied housing, but also the size of housing units purchased by the participants. According to the data summarized in Table 2, the average house size increased from 900 square feet in 1940 to 1,200 in 1960, or a 33 percent increase. This increase measured in terms of square feet per person was 36 percent. Relative to the 1940 baseline, the model predicts an average increase in house size of 28 percent in line with evidence.[36]

The shift in housing finance also provides complementary evidence of the fading away of balloon loans with short duration and no amortization. Table 9 summarizes some aggregate statistics about housing finance in the model. From the perspective of 1940, two facts stand out. First, all households choose the balloon contract. According to the estimates by Grebler, Blank, and Winnick (1956, p.243), in 1936 only 1.3 percent of the mortgages held were government-backed FRMs, and this number increases to 13.5 in 1940. In the baseline calibration for 1940, the interest rate for both mortgage contracts (balloon and FRM) were identical. If interest rates on government-sponsored FRM were lower, perhaps due to an implicit subsidy a set of households would choose a fixed-rate contract. It is difficult to find micro data for specific mortgage contracts, but indirect evidence that balloon was the predominant mortgage contract around the 1940s exists. The model is consistent with this observation. The second fact suggests that in 1960 the FRM contract dominates the balloon contract. In the model 89.1 percent of the home owners with mortgage use the fixed rate mortgage contract, while only 10.9 percent use the balloon contract. The dominance of the FRM is partially due to the estimated interest rate subsidy. Repeated buyers with high income prefer a mortgage with a higher downpayment and shorter duration, as such, they use balloon loans.

An important factor behind the results presented in Tables 7 through 9 are the estimates of total factor productivity in the goods and construction-real estate sectors. The model presented in Section 3.2 suggests that an asymmetric productivity change in favor of the goods sector can generate the correct co-movement in ownership and housing prices. The quantitative exercise suggests that the size of the relative change is nearly 30 percent. An obvious question is how important is the asymmetric productivity change to

[36]For home owners, the average increase predicted by the model is 20 percent and for the average tenant-occupied unit 43 percent.

rationalize the change in home ownership and house prices in the postwar period?

In order to address this issue, one can use the model to perform a series of counterfactual experiments to evaluate the importance of the asymmetry in sectoral productivity. In the baseline economy the change is biased toward the goods sector. In the counterfactual simulations, the productivity change is symmetric across sectors as in a one-sector model of housing. In the first experiment, the productivity in both sectors increases at the observed level of the construction sector of 47.5 percent, and in the second at the observed level of the goods sector of 86.5 percent. The implication for home ownership and house prices are reported in Table 10. Compared with the baseline case with an asymmetric productivity change, the first counterfactual generates an increase in the homeownership rate from 43.3 percent to 53.5 percent. In this case the home ownership rate increases only about half relative to that observed in the data and house prices, about a 17 percent. Despite the relatively small increase in house prices, the number of individuals who can access owner-occupied housing is greatly diminished relative to the baseline model. In the second counterfactual, the productivity of both sectors changes at a higher rate as a result of a larger fraction of individuals entering the home ownership status. In this case, the model predicts an increase that is 16 percent larger than the number captured by the baseline. Part of this increase is due to the fact that house prices increase only about 12 percent instead of the 40 percent observed in the data.

These two counterfactuals highlight that there exists a symmetric productivity change, $\Delta z_c^* = \Delta z_h^*$, that matches the observed change in home ownership but would still fail to capture the observed change in house prices. Therefore, acknowledging the sectoral differences is important to understand the postwar housing boom.

# 6 Decomposing the Postwar Housing Boom

After establishing that the quantitative model can capture the observed postwar housing boom, this section conducts a series of counterfactual experiments to re-evaluate the relative contributions of the prominent explanations used in the literature to rationalize the postwar home ownership boom.

The experiments provide two bounds on the relative importance of each factor. One bound is calculated from the 1940s economy, where only one factor is changed, to the 1960s level. The other bound is calculated from the 1960s economy, where the aforementioned factor is maintained, to the 1940s level. Intuitively, the first case abstracts from the importance of productivity changes, whereas the second case incorporates the asymmetric productivity change. Since the model is highly nonlinear, one should not expect the decomposition to be additive.

## 6.1 Demographics

The obvious challenge to measure the contribution of demographic factor is that other relevant drivers were also changing during the period. The use of a structural model mitigates this issue. In order to analyze the role of demographics, the next counterfactuals evaluate the importance of life expectancy, family size and demographic structure.

Decomposing the impact of demographics from the 1960s baseline generates an increase in the home ownership rate of 63.2 percent instead of the predicted 64.5 percent. Decomposing its contribution from the 1940s baseline results in a 46.6 percent increase instead of 43.3 percent. The results are summarized in Table 11. Instead of measuring the difference, it is useful to measure the specific contribution of this factor in absolute terms relative to the benchmark year. The resulting numbers provide bounds on the relative contribution of this factor. In this case, the model suggests that demographic factors account for between 7.8 and 15.3 percent of the increase in the home ownership rate in the postwar boom. These numbers are lower than the empirical findings of Chevan (1989) but still significant. However, the contribution of demographic factors to house prices is substantially lower. The implied bounds suggest that demographic factors had an impact that ranges between 0.8 and 1.7 percent on house prices. As such, the model suggests that demographic changes play essentially no role in explaining the house price appreciation.

## 6.2 Government Policy

**Innovations in housing finance:** Several authors (i.e., Yearn, 1976, Shiller, 2007, Fetters, 2010, and Chambers, Garriga, and Schlagenhauf, 2009) have argued that government policies in the mortgage market played an important role in increasing the home ownership rate. These policies ranged from changes in the regulation of housing finance to changes in mortgage design and assistance programs. Between 1900 and 1940, the type of financial institutions that offered mortgages changed from mutual savings banks, life insurance companies, and savings and loan associations to commercial banks. The growth in the importance of commercial banks is related to the Federal Reserve Act (1913), which liberalized restrictions on commercial banks that limited participation in the mortgage market. An even more important development was the changes that occurred over this period in the structure of mortgage contracts. As discussed in Section 2, in the 1920s mortgage contracts tended to be of short duration with low loan-to-value ratios.[37] By 1940, the length of FRMs started to approach 20 years, and loan-to-value ratios were increasing; around 1947 this ratio started to approach 80 percent.

Chambers, Garriga, and Schlagenhauf (2009) found that mortgage market innovation was the key factor in explaining the increase in the home ownership rate between 1996 and 2005. The introduction of highly leveraged loans with graduated mortgage payments was found to be important as these contracts attracted first-time buyers into the housing market. By 1960, fixed mortgage contracts had become more leveraged as the loan-to-value ratio increased and the duration of the mortgage contract lengthened. It seems that the mortgage contact innovation could be an important determinant of the home ownership boom in the postwar period.

[37] A common belief is that mortgage interest loans were non-amoritizing in the period 1920 to 1940. In other words, the mortgage contract can be characterized as a short-term balloon-type contract with a high down payment. Grebler, Blank, and Winnick (1956) examine data from life insurance companies, commercial banks, and savings and loans and find that partially amortizing loans did exist in the period 1920-1950. Between 1920 and 1940, approximately 50 percent of mortgage loans issued by commercial banks were amortizing contracts. For life insurance companies, approximately 20 percent in the period 1920-1934 were non-amortizing while the percent of non-amortizing loans for saving and loans associations did not exceed 7 percent in this same period.

The contribution of housing finance is also evaluated. The counterfactual simulation allows households to choose between the short-term balloon contract with a 50 percent LTV ratio and a 20-year FRM with a 20 percent LTV ratio. As shown in Table 12, the model suggests that innovations in housing finance accounted for between 5.1 and 13.3 percent of the increase in the home ownership rate. How important were these innovations in explaining the increase in housing prices? Using a similar strategy, innovations in housing finance explain between 0.8 and 2.6 percent of the actual increase in housing prices. In other words, innovations in housing finance played a small role in the house price appreciation.

**Innovation in the Tax structure:** Rosen and Rosen (1980) argued that 25 percent of the increase in home ownership observed between 1949 and 1974 was a result of the benefits to housing included in the tax code that became more valuable due to the more progressive tax structure in 1960. For instance, according to data available from the Tax Foundation, the highest marginal tax rate in 1935 was 63 percent for households earning $2 million or more. In 1960, the top marginal rate was 91 percent for households earning over $200,000. In order to measure the contribution of changes in the tax code between 1940 and 1960, a counterfactual that controls for the effects of the progressivity of income taxes is performed. The results predict two bounds that are significantly smaller than Rosen and Rosen's estimates. The model suggests that the contribution of the tax code accounts for between 2.9 and 3.7 percent of the increase in the home ownership rate. The more interesting result is the role of innovations in the tax structure for the increase in house prices. The model suggests that changes in the tax structure can explain between 1.8 and 13.2 percent of the in increase house prices. The upper bound of this effect is entirely driven by the general equilibrium effects that affect the relative price of capital and labor.

## 6.3 Life-Cycle Labor Earnings Risk

Many authors (Katona, 1964, Kain,1983, and Chevan, 1989) have argued that the key to understanding the postwar home ownership boom was the large increase in real income. In the data real income can be measured in a number of ways. One way is to examine real GDP during this period, which increased by a factor of 2.4. Another approach is to consider the change in per capita real wage income; during this period this measured increased by a factor of 2.6.[38] Either measure suggests real income substantially increased over the 1940-1960 period.

While an increase in real income is important, it is equally important to see how real wage income changed over the life-cycle. This is particularly important as the majority of the increase in home ownership occurred in cohorts of ages between 25 and 45. A problem that plagues economic historical analysis is the lack of panel data. As a result, the analysis has to rely on Census data from 1940 and 1960 to construct (real) wage income as well as the (real) wage efficiency indices by age cohort for various educational levels. These issues are discussed in Section 5.1.

The most important issue is the fact that life-cycle labor earnings are not likely to

[38] Wage income is defined as total compensation of employees plus .65 of proprietors' income. Wage income is expressed in 1940 prices. To convert this into a per capita value, we divide by total employment.

be independent of the large increase sector productivities observed over this period. To avoid mixing explanatory factors, the analysis in this section focuses on one particular income component: idiosyncratic risk. As documented in Section 2.2.2, some measure of income risk changed drastically in the postwar period. In particular, the standard deviations associated with income over the various age groups seem to have a concave pattern in the age cohort in 1940. By 1960, for each education group, the plots of the standard deviation relative to age cohort are relatively flat. This suggests that individual income risk declined between 1940 and 1960, which makes the purchase of a home more attractive. This final decomposition exercise evaluates the relative contribution of wage income risk for home ownership, something not previously examined in the literature.

Starting with the 1960s baseline, the insertion of the 1940s educational-wage risk profiles reduces the home ownership rate from 64.5 to 52.6percent, which is a change of 12.3 as shown in Table 13. This suggests that the higher income risk associated with the 1940s would have limited the increase in the home ownership rate significantly. In other words, the change in educational-income risk account for 56.9 percent of the change in home-ownership explained by the model. Similarly, using the 1940s baseline and introducing the 1960s income risk profiles increases the home ownership rate to 55.5 percent from the baseline 43.3 percent. The lower bound suggests that income risk accounts for 12.2 percent increase in participation in the housing market. The bottom line is that changes income risk are an important driver of the postwar boom in home ownership.

However, the changing income risk profiles are not important factors in the explanation of the large increase in house prices. The bounds implied by the model suggest that this factor can account for only between 0.8 and 1.75 percent of the change in house prices.

# 7 Conclusions

The postwar housing boom led the largest and most sustained increase in home ownership and house prices. Most of the existing literature focuses on a paricular variables, but does not provide a unified theory where home ownership and house prices are jointly determined. The objective of this paper is to evaluate various explanations of the rise in house prices and the home ownership rate using a quantitative general equilibrium model of tenure choice. The parameterized model is consistent with key aggregate and distributional features observed in the 1940 U.S. economy can account for the observed co-movement in prices and ownership. The paper shows, both theoretically and quantitatively, that the key to explaining this co-movement is an asymmetric sectoral productivity change that favors the goods sector relative to the housing (real estate) sector. A Solow residual analysis of these sectors supports that such a change occurred. Demographics, income risk, and government intervention in the housing market are found to be determinants for the homeownership rate, but these factors have a relatively small effect on housing prices. It is important to understand the relative importance of these factors given current proposals to reform America's housing finance market.[39] The lessons learned from

[39] The administration's plan is based on a reduction of the role of the government in housing finance (mainly the government sponsored enterprises), an increase in consumer protection and transparency for investors, improved underwriting standards, and other critical measures. The plan also calls for targeted

this historical episode could provide guidance on reforming housing markets and housing finance.

Simply stated, the quantitative analysis indicates that relative sectoral productivity growth is the critical factor in explaining the co-movement in the homeownership rate and house price movements. While there is a plethora of anecdotal evidence in favor of this shift, this paper does not provide a theory of why that was the case. This is left for future research.

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**Figure 1: House Prices and Home Ownership: U.S.(1920-2000)**

Source: U.S. Census and Alfred©, Federal Reserve Bank of St. Louis

**Figure 2: Construction Cost Indices and House Prices**

Source: Alfred©, Federal Reserve Bank of St. Louis

**Figure 3: Wage Efficiency Indices (1940 and 1960)**

Source: Integrated Public Use Microdata Series (IPUMS).

**Figure 4: Standard Deviation of Income by Age and Education**

**1940**

**1960**

Source: Integrated. Public Use Microdata Series (IPUMS).

**Figure 5: Bond and Mortgage Rates (1900-1953)**

**Figure 6: Marginal Tax Rates in 1940 and 1960**

**Figure 7: Sectoral Performance (1929-1965)**

Source: U.S. Census Bureau and authors' calculations.

**Figure 8: Sectoral Productivity (1929-1965)**

Source: U.S. Census and authors' calculations

**Table 1: Home Ownership by Age (%)**

| Age/Year | 1930 | 1940 | 1960 | Difference |
|---|---|---|---|---|
| 25-35 | 20.0 | 19.1 | 56.2 | 37.1 |
| 36-45 | 48.5 | 42.1 | 68.1 | 26.0 |
| 46-55 | 57.7 | 51.0 | 69.5 | 18.5 |
| 56-65 | 65.1 | 57.5 | 69.3 | 11.8 |
| Total | 48.1 | 42.7 | 62.5 | 19.8 |

Source: U.S. Census Bureau.

**Table 2: Family Households and House Size**

| | Population for Family Household | | | House Size | |
|---|---|---|---|---|---|
| | **All Ages** | **Less than 18** | **18 and older** | **Sq. Ft.** | **Sq. Ft./Person** |
| 1940 | 3.76 | 1.24 | 2.52 | 900 | 240 |
| 1950 | 3.54 | 1.17 | 2.37 | 1,000 | 282 |
| 1960 | 3.67 | 1.41 | 2.26 | 1,200 | 327 |
| 1970 | 3.58 | 1.34 | 2.25 | 1,400 | 391 |

Source: U.S. Census Bureau.

**Table 3: Relative Size Cohort and Survival Rates**

| | Relative Size of Age Cohort* | | | | | | |
|---|---|---|---|---|---|---|---|
| **Year\Age** | **20-25** | **26-35** | **36-45** | **46-55** | **56-65** | **66-75** | **76-82** |
| 1940 | 0.13 | 0.27 | 0.21 | 0.19 | 0.12 | 0.07 | 0.02 |
| 1960 | 0.10 | 0.21 | 0.21 | 0.18 | 0.14 | 0.10 | 0.04 |
| | **Conditional Survival Probabilities** | | | | | | |
| 1940 | 0.986 | 0.969 | 0.949 | 0.898 | 0.798 | 0.609 | 0.483 |
| 1960 | 0.993 | 0.986 | 0.971 | 0.927 | 0.840 | 0.677 | 0.568 |

∗ The relative size is based on age 20 through age 82

Source: U.S. Life Cycle Tables and U.S. Census Bureau.

**Table 4: Estimate of the Composition Effect**

| Expression | Ownership Rate (%) | Total Change (%) |
|---|---|---|
| $\sum_{i\in I} \mu^i_{1940}\pi^i_{1940}$ | 42.7 | |
| $\sum_{i\in I} \mu^i_{1960}\pi^i_{1960}$ | 63.5 | 21.0 |
| $\sum_{i\in I} \mu^i_{1960}\pi^i_{1940}$ | 45.5 | 2.8 |
| $\sum_{i\in I} \mu^i_{1940}\pi^i_{1960}$ | 60.1 | 17.4 |

Source: U.S. Census Bureau.

**Table 5: Parameterization of 1940 Model**

| **Target** | **Data** | **Model** | **Parameter** | **Value** |
|---|---|---|---|---|
| Ratio of capital stock to GDP | 2.54 | 2.68 | $\beta$ | 0.827 |
| Ratio housing to consumption | 0.16 | 0.16 | $\gamma$ | 0.748 |
| Home ownership rate | 0.44 | 0.43 | $\overline{h}$ | 2.900 |
| Income tax revenue to GDP | 0.01 | 0.01 | $\tau_0$ | 0.008 |
| Share of labor in goods sector | 0.95 | 0.96 | $z_h$ | 1.352 |
| Share of output in goods sector | 0.96 | 0.92 | $z_g$ | 4.036 |

Source: NIPA data.

**Table 6: Parameterization of 1960 Model**

| **Target** | **Data** | **Model** | **Parameter** | **Value** |
|---|---|---|---|---|
| Income tax revenue to GDP | 0.05 | 0.05 | $\tau_0$ | -0.160 |
| Employment share goods sector | 0.95 | 0.96 | $z_h$ | 2.514 |
| Output share goods sector | 0.96 | 0.92 | $z_g$ | 5.955 |
| Share of mortgages of FRM type | >0.90 | 0.90 | $subs$ | 0.036 |

Source: NIPA Data.

**Table 7: Ownership and Prices in 1960**

| **Data** | **1940** | **1960** | **Difference** |
|---|---|---|---|
| Ownership rate (%) | 43.6 | 63.5 | **19.9** |
| House price index | 100 | 140.5 | **40.5** |
| **Model** | | | |
| Ownership rate (%) | 43.3 | 64.5 | **21.2** |
| House Prices | 100 | 140.4 | **40.4** |

Source: U.S. Census Bureau and authors' calculations.

**Table 8: Home Ownership Rate by Age**

| | Difference 1940-60 | |
|---|---|---|
| **Age** | **Data (%)** | **Model (%)** |
| 25-35 | 37.1 | 32.1 |
| 36-45 | 26.0 | 23.8 |
| 46-55 | 18.5 | 14.5 |
| 56-65 | 11.8 | 15.7 |
| Total | 19.9 | 21.2 |

Source: U.S. Census Bureau.

**Table 9: Mortgage Choice in the Model (%)**

| Type of Mortgage Loan | 1940 | 1960 |
|---|---|---|
| Share balloon (5-year) | 100.0 | 10.9 |
| Share FRM (20-year) | 0.0 | 89.1 |

Source: Authors' calculations.

**Table 10: Importance of Asymmetric Productivity Change**

| **Productivity Change** | **Ownership Rate (%)** | **ΔHR** | **House Prices** | $\Delta p$ (%) |
|---|---|---|---|---|
| $\Delta z_g > \Delta z_h = 30\%$ | 64.5 | 21.2 | 140.4 | 40.4 |
| $\Delta z_g = \Delta z_h = 47.5\%$ | 53.5 | 10.2 | 106.4 | 6.4 |
| $\Delta z_g = \Delta z_h = 86.5\%$ | 74.7 | 31.4 | 111.6 | 11.6 |

Source: Authors' calculations.

**Table 11: Contribution of Demographic Changes**

| | Ownership Rate | | House Prices | |
|---|---|---|---|---|
| **Benchmark** | **Level (%)** | $\boldsymbol{\Delta}_{60-40}$ | **Level (%)** | $\boldsymbol{\Delta}_{60-40}$ |
| Model 1940 | 43.3 | | 0.283 | |
| Model 1960 | 64.9 | 21.6 | 0.397 | 0.114 |
| **Contributions** | **Level (%)** | $\boldsymbol{\Delta}_{60-40}$ | **Level (%)** | $\boldsymbol{\Delta}_{60-40}$ |
| Model 1960 with 1940 Demographics | 63.2 | -1.7 | 0.395 | -0.002 |
| Model 1940 with 1960 Demographics | 46.6 | 3.3 | 0.284 | 0.001 |

Source: Authors' calculations.

Table 12: Contributions of Government Policy

| | Ownership Rate | | House Prices | |
|---|---|---|---|---|
| **Benchmark** | **Level (%)** | $\Delta_{60-40}$ | **Level (%)** | $\Delta_{60-40}$ |
| Model 1940 | 43.3 | | 0.283 | |
| Model 1960 | 64.9 | 21.6 | 0.397 | 0.114 |
| **Housing Finance** | **Level (%)** | $\Delta_{60-40}$ | **Level (%)** | $\Delta_{60-40}$ |
| Model 1960 with 1940 Mortgages | 63.8 | -1.1 | 0.396 | -0.001 |
| Model 1940 with 1960 Mortgages | 44.9 | 2.9 | 0.286 | 0.003 |
| **Income Tax Structure** | **Level (%)** | $\Delta_{60-40}$ | **Level (%)** | $\Delta_{60-40}$ |
| Model 1960 with 1940 Taxes | 64.3 | -0.6 | 0.412 | 0.015 |
| Model 1940 with 1960 Taxes | 44.9 | 1.6 | 0.281 | -0.002 |

Source: Author's calculations

**Table 13: Contributions of Income Risk**

| | Ownership Rate | | House Prices | |
|---|---|---|---|---|
| **Benchmark** | **Level (%)** | $\mathbf{\Delta}_{60-40}$ | **Level (%)** | $\mathbf{\Delta}_{60-40}$ |
| Model 1940 | 43.3 | | 0.283 | |
| Model 1960 | 64.9 | 21.6 | 0.397 | 0.114 |
| **Labor Income Risk** | **Level (%)** | $\mathbf{\Delta}_{60-40}$ | **Level (%)** | $\mathbf{\Delta}_{60-40}$ |
| Model 1960 with 1940 Risk | 52.6 | 12.3 | 0.399 | 0.002 |
| Model 1940 with 1960 Risk | 55.5 | 9.4 | 0.282 | -0.001 |

Source: Author's calculations.

# 8 Appendix (Not Intended for Publication)

## 8.1 Data for Construction of the Solow Residuals: 1929-1965

In order to empirically evaluate the two-sector model, Solow residuals had to be constructed for the two sectors. In this section of the appendix we explain how these data are constructed for sectoral employment, capital stock, and output. These data are readily available for the period 1948-1960. The problem is data availability for the period 1929-1947, which is a critical period given the focus of this paper.

*Output:* All data pertaining to output is from *The National Income and Product Accounts of the United States, 1929-1965,* (U. S. Department of Commerce, 1966). Sectoral output data are available in Table 1.12 in terms of nationaincome (or valued added) units. Since output is normally reported in final goods prices as in gross national product (GNO), we had to create a measure of construction output in final goods prices. The major hurdle in creating such a measure is the measure of construction output in net national product units. The reason is that sectoral measures for indirect business tax and nontax liability, business transfer payments, statistical discrepancy and subsidies less current surplus of government enterprises are not available. As a result we calculated the ratio of national income to net national product for each year in that sample. This ratio is used with the construction sector national income to generate a measure of construction net national product. The construction sector gross national product adds construction sector capital consumption allowances from Tables 6.9 and 6.18 to the net national product of construction.

*Capital Stock*: The capital stock data are from Musgrave (1992).[40] The aggregate capital stock is defined as constant-cost net stock of fixed reproducible tangible wealth and is presented in Table 2, page 136. The construction sector capital stock is defined by BEA code 2300. The capital stock for the goods sector is defined as the residual after the construction capital stock is subtracted from the sum of all BEA sectoral codes. The BEA data we assembled start in 1940. In order have capital stock data starting in 1930, we reverse engineered the capital evolution equation with the annual sectoral investment data. We constructed estimates of the construction sector investment series based on data provided in Buddy and Gort (1973). In addition, we assumed the various sectoral depreciation rates for the period 1940-1947 are equal to the average sectoral depreciation rate over the period 1947-1950.

*Employment:* Employment is defined as the average number of full and part-time employees. These data are from the The National Income and Product Accounts of the United States, 1929-65. Statistical Tables, (U. S. Department of Commerce, 1966, Table 6.3, pp 98-101). The construction measure is line 10, while the goods sector measure is the total of all industries (line 1) less construction sector employment.

*Annual Earnings*: The wage and salary earnings of labor is defined as the compensation of employees. These data are from the The National Income and Product Accounts of the United States, 1929-65, Statistical Tables, (United States Department of Commerce, 1966, Table 6.1, pp 90-101). The construction measure is line 10, while the goods sector

[40] John C. Musgrave (1992). "Fixed Reproducible Tangible Wealth in the United States, Revised Estimates," *Survey of Current Business,* January 1992.

measure is the total of all industries (line 1) less construction sector employment. Compensation of employees in the construction sector is define as contract construction ( line 11). The goods sector is defined as compensation of employees in all sectors ( line1) less compensation of employees in the construction sector.

*Implicit Price Deflators:* Nominal values were converted to real values using the GNP implicit price deflator reported in The National Income and Product Accounts of the United States, 1929-1965,(U. S. Department of Commerce, 1966, Table 8.3). The base year was adjusted to be consistant with the base year of the constant cost capital stocks.

*Capital Share Parameters*: The calculation of the parameter on capital in the capital and goods sectors production function follows the approach in Cooley and Prescott (1995). The idea of this approach this that proprietors' income (and some other smaller categories of national income) include both labor and capital income. As a result, these measures must address this issue of capital shares are to be properly measured. income. To make these adjustments, we use data available in The National Income and Product Accounts of the United States, 1929-1965, (U. S. Department of Commerce, 1966, various Tables in Section 6). Net national product are not available at a sectoral level. In order to estimate the construction sector net national product, the ratio of national Income (Table 1.9) to net national nroduct (Table 1.9) for the entire economy is calculated. The average value of this ratio between 1929 and 1965, which is 0.904, which is then used along with the value of the construction sector national income to create a value of construction sector net national product. The value of the construction sector GNP is calculated by adding the value of depreciation in the construction sector, defined as the sum of corporate capital consumption allowance (Table 6.18) and noncorporate capital consumption allowance (Table 6.9) to the value of net national product in the construction sector. Unambiguous capital income in the construction sector is defined as Net Interest (Table 6.11) plus construction sector corporate profits (Table 6.13 plus Table 6.10). Rental income for the construction sector is not reported so it is not included as part of unambiguous capital income in this sector. The ambiguous part of capital is then defined as Proprietors Income in construction, which is the sum of income from unnicorporated firms (Table 6.8) and adjusted inventory evaluation adjusted (Table 6.10) plus construction net national product of less construction national income. Given these definitions, the share of capital income in the construction sector is

$$\theta^{Const} = \frac{(\text{Unambiguous Capital Income}^{Const} + \text{ CCA}^{Const})}{(\text{GNP}^{Const} - \text{Ambiguous Capital Income}^{Const})}$$

Data for the goods sector are calculated by subtracting the variable for the construction sector from the aggregate variable for the economy. For example, the goods sector net national product is simply the difference between the economy-wide value of net national product and the construction sector measure of net national product. The share of capital income in the goods sector is defined as

$$\theta^{Goods} = \frac{(\text{Unambiguous Capital Income}^{Goods} + \text{ CCA}^{Goods})}{(\text{GNP}^{Goods} - \text{Ambiguous Capital Income}^{Goods})}$$

Figure A-1 presents the annual values of this parameter by sector. As shown, the capital shares of both sectors fell during the war with the more pronounced decline in the construction sector. This should not be surprising as the government made a conscious decision to allocate resources away from the construction sector and toward sectors needed for the war buildup.

**Figure A-1: Annual Values of Sectoral Capital Share Parameters**

The value of the capital share parameter used in the model calibration is the average of the yearly share parameters from 1929 to 1965. These values are presented in Table A-1.

**Table A-1: Sectoral Capital Share Parameters**
(Average of Annual Values)

| Sector | $\theta$ |
|---|---|
| Goods | 0.334 |
| Construction | 0.162 |

## 8.2 Labor Income Risk

This section discusses the approach used to estimate the income risk for the baseline economy in 1940 and 1960. The main approach uses a kernel density estimate and the other uses the whole distribution observed in the Census data. Figure A2 compares the standard deviation of normalized income by age and education levels. As shown, the kernel density estimation fits remarkably well the underlying income dispersion for both periods. The Figure also allowa a comparison across different age groups. Figure A2 and A3 shows the fit of the kernel density estimation for every age cohort and education level for 1940 and 1960.

**Figure A2: Standard Deviation of Income by Estimation**

**1940** **1960**

Source: US. Census Bureau.

Figure A3 and A4 show the fit of the kernel density estimation for every age cohort and education level for 1940 and 1960.

**Figure A3: Estimation Income Process by Age and Education**

**Age 20** **Age 25**

**Age 30** **Age 35**

**Age 40** **Age 45**

**Age 50** **Age 55**

**Age 60** **Age 65**

Source: US. Census Bureau.

**Figure A4: Estimation Income Process by Age and Education**

**Age 20** **Age 25**

**Age 30** **Age 35**

**Age 40** **Age 45**

Source: US. Census Bureau.