Essays on Housing Economics

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Chapter 1

Introduction

Housing, its costs and benefits, and its quality have kept researchers busy for a very long time. New research questions and gaps are being uncovered almost on a daily basis, not only by researchers in real estate finance and economics, but also by scholars in other fields such as gender and cultural studies, psychology, health and political sciences, architecture or urban planning. This is not surprising as housing plays a key role in everyone's life. A basic necessity, it is part of talks with friends and family, of negotiations between a bank and an aspiring homeowner, of taxation, or of people's financial portfolios. Researchers all over the world are wrapping their minds around real-estate-related questions and have even more so since the outbreak of the U.S. housing crisis in 2007, which has triggered a plethora of journal articles, conference presentations, and PhD dissertations.

In this thesis I provide three attempts to explain how housing affects individuals, households, and the economy. Therefore, my dissertation consists of three core chapters in which I study different topics in housing economics: the housing wealth effect in two subsamples of U.S. states (chapter 4), as well as the implications of housing for physical (chapter 5) and economic growth (chapter 6), both in an international sample. Furthermore, this thesis provides two additional chapters which give an overview of different real estate markets (chapter

3) and the theoretical implications of housing and non-housing capital for economic growth (chapter 2). The following sections of this chapter will introduce each of these contributions in greater detail.

1.1 Housing and the growth literature

In the mid-50s, Robert Solow (1956) presented his seminal model which ever since has been used as a starting point to study the determinants of economic growth (e.g., Mankiw et al., 1992). Contrary to the previous literature, Solow assumes diminishing returns to capital and labor, which allows reaching a steady state with full employment of the input factors.

According to Solow, the accumulation of physical capital is the engine which makes the economy prosper: every period, a fraction of the output is spared and reinvested into the capital stock, which then generates even more output. One point of criticism, however, is that Solow assumes that all capital is homogeneous, i.e., that all capital types earn the same return for the economy. What if one departs from this assumption? Mills (1987), for instance, reports for the U.S. that housing and non-housing capital earn different returns, namely that the return to housing capital is only half that to non-housing, i.e., physical, capital. This implies that if capital is not invested exclusively into production of non-housing goods but also into housing, then the resulting output is lower than Solow's original model suggests.

Therefore, **chapter 2** picks up the idea of heterogeneous capital and shows how housing can distort capital allocation and, thereby, economic growth. It also reviews the original Solow model and its extensions made by Mankiw et al. (1992) and presents an overview of empirical tests of the model.

1.2 Housing markets worldwide

Housing markets differ greatly by country—not only in regulatory and political but also cultural and societal aspects. In Germany, for example, it is necessary to register with the municipality where one lives permanently, and everyone receives an identification card with that address on it. In other countries, such as the USA, by contrast, one is not legally tied to their place of residence.

Another example concerns land prices in Japan, which have historically been so high that the share of land in house prices increased from 40 to 90 percent between 1890 and 1990 (Knoll et al., 2017). This provides an incentive to keep properties in the family for speculation and bequests. Moreover, because Japan has an aging population, real estate is a particularly attractive investment for old-age provision.

Chapter 3, which is joint work with Ted Azarmi, has two aims. First, it presents an overview of a number of cultural, taxation, regulatory, and institutional differences. In particular, real estate markets in Germany, the USA, China, and Japan are discussed. Second, this chapter outlines the resulting incentives and economic consequences.

1.3 Housing and its effects on individuals, households, and the economy

Chapter 4, also joint work with Ted Azarmi, revisits the housing wealth effect. The real estate literature, most notably the study by Case et al. (2005), has found by and large that increases in one's housing wealth translate into increases in consumption. In particular, because such changes are viewed as more permanent than changes in, for example, stock market wealth, consumption responds more strongly to housing than to financial wealth. This result has been conventionally used to encourage homeownership.

However, there are also theoretical and empirical studies that give examples of a negative or non-existent housing wealth effect, for instance, when future house prices are expected to rise and homeowners have a bequest motive. In such cases, Skinner (1989) shows that households increase their savings relative to households without a bequest motive. Another example is the study by Calomiris et al. (2009), who point out that the large and positive housing wealth effect largely disappears once common endogeneity issues are properly taken care of.

Lastly, even though it is well-known that consumption increases with the mortgage level (Benjamin and Chinloy, 2008), past studies on the housing wealth effect have not consistently controlled for mortgage debt at the household level.

We take into account the aforementioned criticisms and suggestions. Additionally, to study the effect of housing wealth on households and the economy in more detail, we divide the sample in two mutually exclusive subsamples based on the median homeownership rate. We do this because past research has found that overinvestment in housing may impair economic growth (Mills, 1987, 1989; Hendershott, 1989), which can be directly tied to the argumentation in chapter 2. Hence, we also examine the effect of housing wealth on GDP at the U.S. states level.

Our study reveals that after controlling for mortgage debt and using more appropriate methods to reduce endogeneity, households in U.S. states with above-median homeownership rates do not adjust their consumption to increases in their housing wealth, whereas households in states with below-median homeownership rates do. On top of that, we find that changes in housing wealth have a significantly negative association with changes in GDP in the above-median-homeownership sample, which we see as a confirmation of the findings from the housing overinvestment literature. Our results suggest that homeownership should not be encouraged unconditionally but only up to socially desirable, intermediate levels.

While the previous chapter focused on households, I use anthropometric data in **chapter 5** to study how housing quality affected individual height in a panel of countries from the late 19th to the mid-20th century. In the economic history literature, adult height is an established proxy for health, as there is no other, uniform and unambiguous health indicator that was collected for a large set of countries before the 1950s.

Adult height is determined by environmental influences that a person is exposed to in childhood and adolescence. This is because one's height potential depends critically on the net nutritional status during one's growth phase. A child whose body uses up nutrients because of physically demanding labor or that suffers diseases will become a shorter adult on average than a child that grows up under more favorable circumstances. Such height differentials cannot fully be made up for in later life. Because of this, healthy living conditions and one's disease environment are a crucial determinant of one's final stature.

Housing is part of a person's disease environment and therefore, its quality in one's earlier years of life have an influence on that person's adult height. But housing until the mid-20th century was very different from what we are used to today: the number of persons per dwelling was relatively high (e.g., according to Clark (2002), it was 5.17 in England and Wales during the decade 1870–1879), favoring the spread of contagious diseases like diarrhea or whooping cough, which in turn impaired children's growth potential. Furthermore, bathrooms, access to (hot) water and sewers were very uncommon, especially in earlier periods. Water was mainly taken from town wells and was often contaminated because of defecation in the open. Many of these problems still exist in today's developing countries (Konteh, 2009), highlighting the importance of research in this area.

Unfortunately, detailed records of housing quality for the period 1870–1965 do not exist. However, a study by Eichholtz et al. (2017) reports that housing prices during the past 500 years rose with quality rather than due to increased demand or monopoly behavior of landlords. Moreover, Margo (1996) finds that homes with sanitary facilities and more floor space were traded at higher rent prices than similar houses without these amenities. Therefore, this study uses real house prices as a proxy for housing quality.

My study shows that house prices were a significant determinant of adult height: after controlling for other factors, a one-point increase in the real house price index came along with a 0.05 cm height differential. Over the whole study period, this amounted to 1.5 cm taller adult heights, which was equivalent to 1.2–2.7 more years of life expectancy (Baten and Komlos, 1998).

Besides being the first study to address the studied relationship, this chapter contributes to the literature twofold. First, because housing quality has been consistently omitted in the anthropometric literature, effects of income and nutrition on height were most likely overestimated. Therefore, by controlling for housing quality separately, I can act on these suggestions, which were made by Komlos (1998, on income) and Margo and Steckel (1983, on nutrition). And second, since in most developing countries and many slums, living standards resemble those from past centuries', now developed nations, the present findings are relevant in today's context too.

Housing has been seen as the superior tenure form in many countries. In the U.S., for instance, mortgage interest payments are tax deductible, which makes owner-occupied housing an affordable option for the majority of Americans. Many studies are thus dedicated to exploring the positive externalities of homeownership. For instance, they find that homeowners tend to be wealthier than renters (e.g., Haurin et al., 1996; Dietz and Haurin, 2003; Mathä et al., 2017) or that they create valuable social capital within their neighborhoods (e.g., DiPasquale and Glaeser, 1999). Hence, the promotion of homeownership in many countries seems plausible.

Nevertheless, there is reason to suspect that housing does not only have benefits for an economy. As outlined in chapter 2, not all capital is homogeneous and earns the same social returns. Moreover, in an international comparison, there are large discrepancies in the fraction of owner-occupied versus rented homes.

There are some studies that relate to this phenomenon. First, it is possible that economies with high homeownership rates have overinvested in housing. Hendershott and Hu (1981, 1983) have emphasized that the decline in U.S. productivity in the 1970s and 80s was likely a cause of overinvestment in housing which was caused by preferential treatment of residential investments in the U.S. tax code. Second, Mills (1987, 1989) and Hendershott (1989) have estimated that the social returns to physical capital exceed those to housing investments. Hence, investments in physical capital should yield higher social returns than investments in housing.

A synthesis of these studies suggests that overinvestment in housing can have adverse effects on a country's GDP growth. Therefore, to examine whether housing investments have different consequences for an economy than investments in non-housing, I study the relationship between per-capita GDP growth and the fraction of homes that is inhabited by their owners in a panel of countries in **chapter 6**.

It is not hard to imagine that homeownership is highly endogenous, which is why I use an instrumental variable (IV) approach to study how homeownership affects GDP growth. After additionally controlling for a number of variables to reduce further endogeneity problems, I find evidence for an initially positive impact of homeownership on the economy, as suggested by studies on positive externalities. However, there is a critical homeownership rate after which this relationship becomes inverse: the negative externalities start to outweigh the positive ones at a homeownership rate of roughly 68 percent. Hence, homeownership should not be encouraged beyond this socially optimal rate.

1.4 Conclusion

Housing plays a key role in everybody's daily life and the whole economy. Therefore, research on housing economics is not only important because of the recent housing crisis. The three core chapters 4, 5 and 6 of this thesis shed light on different research questions that relate housing to three key economic variables: wealth, health, and economic growth. Furthermore, these chapters study housing economics from different perspectives by using data at the individual, the household, and at the economy level. Two additional overview chapters (2 and 3) provide further insights into the topic. Together, the chapters in this dissertation contribute to our understanding of the role that housing plays for welfare at different levels of aggregation.

But of course, even though the recent crisis has sparked new interest in housing research, much is left to be done. For instance, the exact channels through which housing investment may adversely affect economic growth have not been studied in detail yet. Furthermore, our finding that housing wealth in above-median-homeownership states comes along with increased consumption but decreased GDP raises new interesting questions that deserve further attention. Why is the link between consumption and GDP in regions with moderate levels different from that in regions with high levels of homeownership? Why do many households build up so much housing wealth in the first place? Is it because of a lack of trust in the public retirement system? Why do many wealthy households continue to rent their homes? More comparative work on cultural and institutional aspects of homeownership could enhance our understanding of such phenomena and result in valuable policy recommendations.

Chapter 2

Homeownership and the Economy: A Primer

2.1 The Solow model

2.1.1 How economies grow

In 1956, Solow presented a very influential model of economic growth and thereby revolutionized the growth literature, which had previously been characterized by constant returns to the inputs into production. Solow's neoclassical growth theory departs from this assumption and allows for the more realistic and plausible notion of diminishing returns to the production factors. His theory permits explaining phenomena such as China's growth, which has consistently outpaced the growth of more mature, industrialized economies, or the fast recovery of the German economy after WWII. Let us focus on the latter of these two examples.

After big parts of Germany were destroyed by bombing raids in WWII, the country had to quickly re-erect harbors and its infrastructure, houses, and factories and, unexpectedly, recovered from the previous destruction within a surprisingly short period of time. At the same time, however, winners of the war, such as the U.S., as well as nations that were not hit as hard continued to grow at their usual, historical rates of around 2–3 percent. How could such a weak economy eclipse the growth of all the winners, and how can the difference in these growth rates be explained? The key ingredient of the Solow model which sheds light on this growth miracle is a production function $Y = F(K, L)$ which is increasing in capital and labor, but with diminishing returns to these input factors, i.e., $\partial F/\partial i > 0$ and $\partial^2 F/\partial i^2 < 0$, $i = K, L$. He furthermore assumes a closed economy.

Let us take a look at how economies grow according to Solow. In order to prosper, an economy with a given labor force and capital stock will try to produce output Y according to a production function:

$$Y = F(K, L). \tag{2.1}$$

This output can be consumed or saved at a constant rate s. Solow also assumes that this output is produced at a decreasing return to capital and labor and that the production function has constant returns to scale[1]. The typical, neoclassical production functions has to satisfy the so-called Inada conditions: (1) $\lim_{r \to 0} F(r, 1) = \infty$ and (2) $\lim_{r \to \infty} F(r, 1) = 0$, where r is the capital stock per capita. Since in Solow's model, rent of capital and wages are flexible, the marginal productivity equation $\partial F/\partial K$ and $\partial F/\partial L$ will adjust to the exogenous amounts of labor and capital and deliver the marginal products which will be paid to the two production factors. By this, it is guaranteed that capital and labor are perpetually fully employed.

With all this information at hand, the economy can finally start up the engine and produce output Y. The population will consume a fraction $(1 - s)Y$ and save the remaining sY, which will be added to the economy's capital stock,

[1] This latter is the distinguishing assumption between exogenous growth models, such as Solow's, and endogenous growth models, which were developed later and incorporated endogenous technological progress. A prominent researcher in this area was, for instance, Romer.

i.e., $K_{t+1} = K_t + sY$. This notation says that capital accumulation is a development over time. This process will repeat itself a finite number of times t because of decreasing returns to capital and labor: at the end of each period, the new values of capital and labor enter the marginal productivity equation and subsequently the production function, and the fraction of the output Y which will be saved is determined. Therefore, all the other variables are time-dependent too as they evolve together with the capital stock, i.e., $K = K(t)$, $L = L(t)$ and $Y = Y(t)$.[2] In continuous time, the equation of motion of the capital stock can therefore be denoted by

$$\frac{dK}{dt} = \dot{K} = sY \tag{2.2}$$

However, at the same time that capital is added to the capital stock, other capital is worn out and has to be replaced. Because of the diminishing-returns-to-inputs property, there will be a point where additions to and deductions from capital are just equal. That is, at some point in time, the economy will eventually reach an equilibrium, i.e., a point where net investments are zero and the economy arrives at a resting state which can only be shaken by exogenous shocks. Formally, this resting state can be derived by substituting equation 2.1 into 2.2:

$$\dot{K} = sF(K, L) \tag{2.3}$$

Because of one equation in two unknowns, another equation is needed to close the system:

$$L(t) = L_0 e^{nt} \tag{2.4}$$

This equation assumes that labor development over time grows as an exogenously given growth rate n.[3] This equation can also be viewed as a labor

[2] To avoid notational clutter, the variables' dependence on t will subsequently be omitted.

[3] In the Solow model, the population size is equivalent to the workforce. Therefore, "per

supply curve where labor is completely inelastic. Combining equations 2.3 and 2.4 and thereby assuming that labor is fully employed perpetually yields the following equation:

$$\dot{K} = sF(K, L_0 e^{nt}) \tag{2.5}$$

This equation contains only one unknown, which is $K(t)$ and represents the capital stock development over time under full labor employment.

Now that the basis is laid, let us move to per-capita values to analyze how an economy grows. Let $r = K/L$ be the capital stock per worker or, in Solow's words, the capital–labor ratio. This expression can be rearranged and complemented by equation 2.4 to yield $K = rL = rL_0 e^{nt}$. As r depends on K and L, which themselves vary over time, $r = r(t)$ is also time-dependent. Differentiating with respect to time thus leads to $\dot{K} = \dot{r}L_0 e^{nt} + nrL_0 e^{nt}$. We can equate this with the expression in equation 2.5 and rearrange terms:

$$\begin{aligned} \dot{r}L_0 e^{nt} + nrL_0 e^{nt} &= sF(K, L_0 e^{nt}) \\ (\dot{r} + nr)L_0 e^{nt} &= sF(K, L_0 e^{nt}). \end{aligned}$$

While r is the capital–labor ratio, $\dot{r} = dr/dt$ captures the additions to or subtractions from the capital–labor ratio over time. To now transform the right-hand side (RHS) into per-capita values, Solow exploits the constant returns property of the production function $F(zK, zL) = zF(K, L)$, which permits taking the labor term $L_0 e^{nt}$ out of the production function[4], and simplifies:

$$\begin{aligned} (\dot{r} + nr)L_0 e^{nt} &= L_0 e^{nt} sF(K/L_0 e^{nt}, 1) \\ \dot{r} &= sF(K/L_0 e^{nt}, 1) - nr \qquad (2.6) \\ \dot{r} &= sF(r, 1) - nr \end{aligned}$$

capita" and "per worker" will from now on be used interchangeably.

[4]Constant returns to scale imply that the size of the economy, measured by its workforce, does not affect the capital–labor and output–labor ratios. Therefore, every variable can be expressed in per-capita values.

This fundamental equation explains how and when a steady state is reached. The first term on the RHS, $F(r,1)$, describes the output that is generated by employing r units of capital and one unit of labor, or, equivalently, it is the output per capita as a function of capital per capita. Multiplied by the saving rate s, the term represents savings per capita. The second term, by contrasts, is the break-even investment that has to be added such that the capital stock does not decrease. As was initially discussed, an equilibrium is reached when additions to and deductions from the capital stock are equal, i.e., when $sF(r,1) = nr$ or, equivalently, $\dot{r} = 0$. This relationship is depicted in figure 2.2. The steady-state level of the capital–labor ratio can be derived by setting equation 2.6 equal to zero:

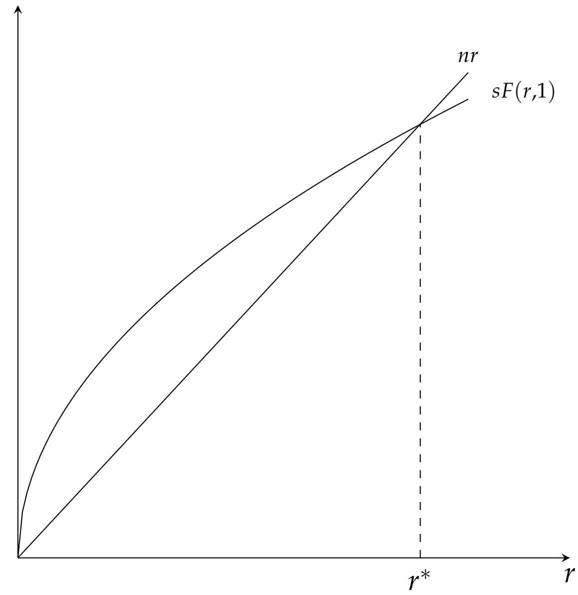
$$r^* = \frac{s}{n} F(r,1). \tag{2.7}$$

The corresponding level of output per person is then

$$y^* = F(r^*,1). \tag{2.8}$$

Figure 2.1 provides four important insights. First, shows what happens when an economy's capital–labor ratio approaches the equilibrium r^* from the left or right, i.e., when $r \neq r^*$. When $r > r^*$, then $nr > sF$. Because of $\dot{r} = sF(r,1) - nr$, we know that in such a case, r would decrease towards r^*. This is because when we approach the equilibrium from the right, then labor L increases at a higher rate than do capital K and output Y, and therefore, the capital–labor ratio $r = K/L$ will decrease and bounce back to its steady-state value r^*. When we think of the nr ray as the depreciation of capital, then the additions that are made to the capital stock are not large enough to compensate for the depreciation of the capital stock. Therefore, the capital stock will gradually decrease until r^* is reached. Analogously, if $r < r^*$, capital and output will increase at a faster pace than labor, and the capital–labor ratio would bounce

Figure 2.1: A steady state of per-capita income.



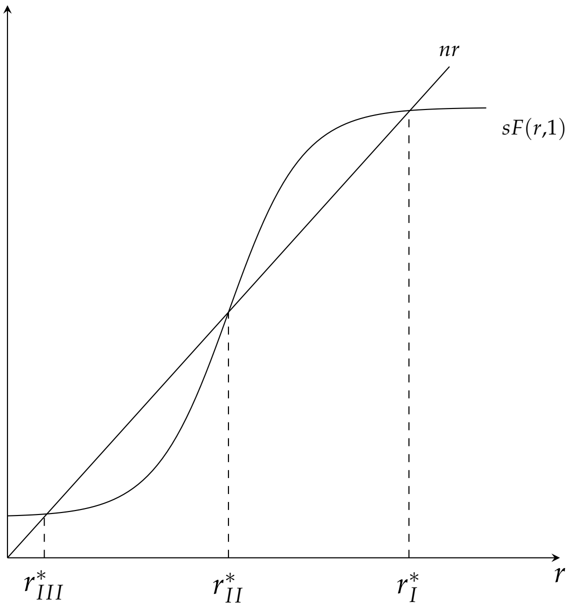
Note: Based on Solow (1956).

back to the equilibrium r^* too. Hence, r^* is a stable equilibrium. In a nutshell, economies that have reached their steady state will remain in this state whereas economies that have not reached it yet, will evolve towards their steady state.

Second, figure 2.1 shows what happens when two economies employ different amounts of capital but have otherwise identical characteristics. Let us compare two economies I and II. The economy of the first type is characterized by large investments in capital, whereas the second economy has a lower capital stock; all other things equal. Let us for now ignore the reasons that may lead to this set-up. Because the first economy has more capital at hand for production, the capital–labor ratio $r_I > r_{II}$. The assumption of identical production functions implies that therefore, the type I economy will produce a higher output per capita than the type II economy: $y_I > y_{II}$. It also implies that an economy of the first type is closer to reaching its steady state than an economy of the second type.

Depending on the shape of the production function, it can also happen that the economy with less capital per capita reaches a stable but inferior equilibrium: with a higher capital–labor ratio than the second economy, the first one will reach r_I^*, which leads to a higher per-capita output than does r_{III}^*, which may be reached by the otherwise identical country with much lower capital investments of $r < r_{II}^*$. This case is depicted in figure 2.2.

Figure 2.2: Two steady states of per-capita income.



Note: Based on Solow (1956).

Third, when $\dot{r} = 0$, the capital–labor ratio is a constant and output per person is a constant too. In other words, in the absence of technological progress, there is no output and capital growth at the per-capita level, as the population and total output grow at the same rate. Therefore, this "plain" version of the Solow model fails to explain the empirically observable growth in per-capita output across countries over the last decades or centuries, as only exogenous shocks, such as a higher saving rate or a more efficient production technology, can raise output per capita to a new, higher steady-state level. To overcome this theoretical shortcoming, technological change was shortly later added to the model and has then become known as the textbook Solow model. In that version, per-capita income in the long-run equilibrium grows at the rate of technological change. This will be shown in the next subsection.

And fourth, it provides an answer to the question raised in the beginning: How could Germany's economy grow so fast after WWII while the winners could not? Because Germany had lost all its capital, the first units of capital put into production generated a very high output. This is due to the concave shape of the production and, consequently, also the savings curve, which have a steep slope at lower capital levels. In other words: the marginal productivity of capital is higher at lower capital levels than at higher ones. Countries whose capital stock was not destroyed did not enjoy such high returns to capital because at higher capital levels, the returns to capital diminish.

This last reason provides an important implication. In essence, holding population growth and saving rates constant, the model predicts that poor countries (i.e., countries with lower capital–labor ratios and therefore lower per-capita output) should grow faster than richer countries and that all these countries should reach similar steady states. This theory is known as conditional convergence. It implies that countries with similar characteristics will converge over time. On the contrary, countries with different saving and population growth rates, such as Germany and Somalia, will not converge according to this theory. This discrepancy in productivity could be shown empirically by Islam (1995), which will be discussed in a later subsection.

2.1.2 Some interim conclusions

The above version of the Solow model makes some powerful predictions: first, countries with higher saving rates should grow faster. Second, countries with higher population growth should grow more slowly. When one looks at these two hypotheses and confronts them with empirical data, they can generally be confirmed. However, another prediction of this version of the model, which so far neglects any technological progress, is that every country reaches a steady state in which output per capita does not grow anymore. On its path to this steady state, the country should exhibit per-capita growth rates that diminish until they become zero. This is due to the concave shape of the production and saving functions. Think of the example with Germany and the U.S. again: according to the model, the U.S. should have zero growth by now given that since WWII, it must have accumulated enough capital to have reached its steady state in the meantime. Hence, according to the model, the U.S. should have ceased to grow in per-capita terms by now. Even though the U.S. has lower growth rates per capita than poorer countries (consider China), its growth rate is still far from zero. Also, we have witnessed improving standards of living and increasing per-capita income over time. In a nutshell, while this basic model has implications that are generally correct, it fails to explain continuous per-capita growth because it does not model technological progress. On top of that, if the Solow (1956) model is considered to be complete, then a lot of countries should exhibit similar steady-state levels of output. This prediction cannot be confirmed empirically as per-capita incomes globally vary a lot. Therefore, Mankiw et al. published a paper in 1992 in which they argue that the Solow model is an incomplete description of the growth process and conclude that it is missing a puzzle piece which could explain more of the observable cross-country variation.

Furthermore, they remark that an empirical test of the traditional Solow model conflicts with generally accepted values for the share of capital in an economy: their obtained regression coefficients imply a capital share that is about twice the size of the commonly accepted share of capital in GDP of around $\alpha = 1/3$. To come up with this result, they use data from 1960–1985 to test if the paths of the saving and population growth rates over time can predict 1985 GDP per-capita levels. In other words, they test the hypotheses outlined above: that higher saving rates and lower population growth rates can predict economic output per capita. They employ a Cobb–Douglas function and, next to population growth n, explicitly model technological change as increasing at the exogenous rate g:

$$
\begin{aligned}
Y(t) &= K(t)^{\alpha}[A(t)L(t)]^{1-\alpha}, 0 < \alpha < 1 \\
L(t) &= L(0)e^{nt} \\
A(t) &= A(0)e^{gt}
\end{aligned}
\tag{2.9}
$$

Note that this new production function now incorporates labor-augmenting technological change $A(t)$ which leaves capital unaffected, since capital's share in income has been roughly constant over time. Instead of deriving per-capita values, Mankiw et al. turn to values per effective unit of labor, i.e., they set $\tilde{y} = Y/AL$ and $\tilde{k} = K/AL$ (i.e., what was the capital–labor ratio r in the 1956 model is now the capital-per-effective-unit-of-labor ratio $\tilde{k}$). Furthermore, capital depreciates linearly at the rate δ. The fundamental equation of motion of the capital stock is then

$$\dot{\tilde{k}}(t) = s\tilde{k}(t)^{\alpha} - (n + g + \delta)\tilde{k}(t). \tag{2.10}$$

Let us now recall the issue of (conditional) convergence, as the above equation can be used as a starting point to determine the speed at which countries should converge to their steady states. As Solow's model dictates that in the steady state, $\dot{\tilde{k}} = 0$, we can solve equation 2.10 for the steady-state value $\tilde{k}^*$:

$$\tilde{k}^* = \left[\frac{s}{n + g + d}\right]^{\frac{1}{1-\alpha}} \tag{2.11}$$

To approximate the rate of convergence in the vicinity of the steady state, we exploit the fact that because of the concave shape of the production function, the growth rate of the per-effective-unit-of-labor capital stock around the steady state,

$$G(\tilde{k}) = \frac{\dot{\tilde{k}}}{\tilde{k}} = s\tilde{k}^{\alpha-1} - (n+g+\delta), \tag{2.12}$$

is approximately zero. Therefore, we can linearize this growth rate around the steady state with a Taylor approximation of first order:

$$G(\tilde{k}) \approx G(\tilde{k}^*) + G'(\tilde{k}^*)(\tilde{k} - \tilde{k}^*)$$
$$\approx (1-\alpha)(n+g+\delta)(\ln\tilde{k}^* - \ln\tilde{k}).$$

Because $y = \tilde{k}^\alpha$ and therefore, $\ln\tilde{y} = \alpha\ln\tilde{k}$, the output growth rate is approximately

$$\frac{\dot{\tilde{y}}}{y} = \frac{d\ln Y}{dt} = (1-\alpha)(n+g+\delta)(\ln y^* - \ln y) \tag{2.13}$$

That is, $\lambda = (1-\alpha)(n+g+\delta)$ is the speed of convergence. Because the parameters in λ are percentage values, the convergence speed is the percentage gap between $\ln y^*$ and $\ln y$ that is closed every period.

[*For a formal derivation of this result, see the appendix A1*]

Let us now return to the test of the Solow model conducted by Mankiw et al. They determine the steady-state level of per-capita output as follows:

$$\ln\frac{Y(t)}{L(t)} = \ln A(0) + gt + \frac{\alpha}{1-\alpha}\ln(s) - \frac{\alpha}{1-\alpha}\ln(n+g+\delta) \tag{2.14}$$

[*For a formal derivation of this result, see the appendix A2*]

In their empirical analysis, they take GDP per capita in 1985 of a cross-section of countries as the dependent variable and explain this level with pre-1985 average values of the independent Solow variables. By doing this, they assume that in 1985, their sampled countries were already in their steady states and exhibited zero per-capita growth. A test of this equation confirms the predictions of the Solow model; however, the authors realize that something is not right: because of the log-form of the equation, the second and third term on the RHS can be interpreted as the elasticities of income with respect to the saving rate s and to $(n + g + \delta)$, respectively. Because the share of capital in an economy's income is about $\alpha = 1/3$, the coefficients on the two elasticities should be $\frac{\alpha}{1-\alpha} = 0.5$ and $-\frac{\alpha}{1-\alpha} = -0.5$, respectively. Their empirical coefficients, however, are much higher and imply a capital share in income of around 60 percent. Therefore, the magnitudes of the impact of s and $(n + g + \delta)$ are overestimated.

2.1.3 Accounting for human capital accumulation

Mankiw et al. see the aforementioned overestimation of the coefficients on s and $(n + g + \delta)$ as evidence of an omitted variable bias in the Solow model and come up with another version of the model in which output is not produced by capital and labor only but also by human capital. The inclusion of human capital in economic growth models had already been advocated before, e.g., by Romer (1986) or Lucas (1988). Like physical capital, human capital has positive but diminishing returns β. In order to make sure that a steady state can be reached, the assumption of constant returns to scale has to be maintained. Output can now be saved in the form of physical and human capital HC at the saving rates s_k and s_{hc}.

Their new production function takes the form

$$\begin{aligned} Y(t) = K(t)^{\alpha} HC(t)^{\beta} [A(t)L(t)]^{1-\alpha-\beta}, \\ 0 < \alpha < 1, \\ 0 < \beta < 1, \\ \alpha + \beta < 1. \end{aligned} \tag{2.15}$$

Furthermore, they make the assumption that human capital depreciates at the same rate δ as physical capital. The capital accumulation equations are thus

$$
\begin{aligned}
\dot{K} &= s_k Y - dK \\
\dot{HC} &= s_{hc} Y - dHC
\end{aligned}
\tag{2.16}
$$

The economy then evolves according to the following physical-capital and human-capital accumulation processes:

$$
\begin{aligned}
\dot{k}(t) &= s_k y(t) - (n + g + \delta)k(t) \\
\dot{hc}(t) &= s_{hc} y(t) - (n + g + \delta)hc(t)
\end{aligned}
\tag{2.17}
$$

These two equations should not be viewed in isolation. We know from the augmented model that the same production function applies to both capital types, i.e., they are rival production inputs. After output has been produced, part of it is consumed and the rest is now divided between savings in human capital s_{hc} and savings in physical capital s_k. Building up human capital makes the workers more skilled in subsequent periods, which allows them to in turn produce more output. The output per capita in the economy with the augmented production function will increase faster than in an economy with only capital and labor. With more output, more can be reinvested in physical capital, which is then transformed into more output by more skilled workers. The steady-state output per effective unit of labor $\tilde{y}^* = Y^*/AL$ can then be expressed as follows:

$$
\tilde{y}^* = \left[\frac{s_k}{n + g + \delta}\right]^{\frac{\alpha}{1-\alpha-\beta}} \left[\frac{s_{hc}}{n + g + \delta}\right]^{\frac{\beta}{1-\alpha-\beta}}
\tag{2.18}
$$

Because $\left(\frac{Y(t)}{L(t)}\right)^* = y(t)^* = A(t)\tilde{y}(t)^*$, $\tilde{y} = Y/AL$ and $\dot{A}(t) = gA(t)$, it follows that $\frac{\dot{y}}{y} = g$. That is, in the version with labor-augmenting technological change, per-capita income in the steady state grows at the rate of technological progress—irrespective of whether human capital is included or not.

Mankiw et al. then derive the regression equation that they use for the test of their augmented model:

$$\ln\frac{Y}{L} = \ln A(0) + gt + \left[\frac{\alpha+\beta}{1-\alpha-\beta}\right]\ln(n+g+\delta) + \left[\frac{\alpha}{1-\alpha-\beta}\right]\ln(s_k) + \left[\frac{\beta}{1-\alpha-\beta}\right]\ln(s_{hc}) \tag{2.19}$$

What can be said about the differences in steady-state output per capita between the two versions of the model? Note that if we set $\beta = 0$ in equation 2.18 we obtain the output per effective unit of labor for the standard Solow case without human capital:

$$y^{*S} = \left[\frac{s_k}{n+g+\delta}\right]^{\frac{\alpha}{1-\alpha}} \tag{2.20}$$

Therefore, $y^* > y^{*S}$. This result implies that human capital is not only included to generate more realistic coefficients and implied capital shares; the augmented model explicitly allows for human capital to magnify the effect of physical capital for the generation of output: because more skilled workers can use physical capital more productively, the production function of the augmented model lies above an otherwise identical curve without human capital. Therefore, in an economy with the augmented production function, more output can be generated and hence, more output can be saved and reinvested. This leads to a more accelerated accumulation of physical capital per capita and to a higher steady-state level of output per capita.

[*For a formal derivation of this result, see the appendix A3*]

2.2 Empirical tests of the (augmented) Solow model

2.2.1 Mankiw, Romer, and Weil (1992): an OLS approach

Equation 2.19 describes GDP per capita levels as a function of the RHS variables. Studying this equation requires the assumption that the countries be in their steady states or randomly distributed around them. Mankiw et al. (1992) test this equation using a large dataset spanning the period 1960–1985, with 1985-per-capita incomes as their dependent and average values over 1960–1985 as their independent variables. That is to say, even though they could analyze the data in a panel setting, they transform the data to a cross-sectional format. The econometric issue arising from this procedure will be discussed in the next subsection. Their test not only delivers the desired implied capital share of one third—which was the reason why they plead for the inclusion of human capital in the first place—the explanatory power of the observed cross-country productivity differences also increases from $R^2 = 0.59$ to $R^2 = 0.78$.

Mankiw et al. acknowledge that the sampled countries may not be in their steady states or may not randomly depart from them. In a next step, they therefore derive a growth equation which permits analysis of growth paths towards a steady state. Deriving a growth equation requires a linearization in the vicinity of the steady state. They then solve a non-homogeneous differential equation of first degree that depends on the convergence rate. Lastly, the solution of the aforementioned differential equation can be expanded and written as a growth equation:

$$\begin{aligned}\ln y(t) - \ln y(0) = (1 - e^{-\lambda t}) \left[\frac{\alpha}{1-\alpha-\beta}\right] \ln(s_k) + (1 - e^{-\lambda t}) \left[\frac{\beta}{1-\alpha-\beta}\right] \ln(s_h) \\ - (1 - e^{-\lambda t}) \left[\frac{\alpha+\beta}{1-\alpha-\beta}\right] \ln(n+g+\delta) - (1 - e^{-\lambda t}) \ln y(0)\end{aligned} \tag{2.21}$$

where $\lambda = (n + g + \delta)(1 - \alpha - \beta)$.

[*For a formal derivation of this result, see the appendix A4*]

Their model predicts that with conventional values for $\alpha = \beta = 1/3$ and $n + g + \delta = 0.06$, a country should have a convergence rate of $\lambda^{MRW} = 0.02$ and move halfway towards its steady state in $t^{MRW} = \frac{\ln(0.5)}{0.02} = 35$ years. The empirical test of the (augmented) growth regression fits this predicted λ pretty well. The respective values for the textbook Solow model, in contrast, would be much more ambitious: $\lambda^S = 0.04$ and $t^S = 17$ years. The growth literature has, however, come to the conclusion that the convergence rate may range anywhere between low single- and low double-digit numbers. With their paper, Mankiw et al. revived the convergence debate which had been superseded by the development of endogenous-growth models in the 1980s, which abandoned the assumption of a steady state and hence, convergence, completely.

Generally, the Solow model augmented by Mankiw et al. makes three contributions to the growth literature: first, human capital is added as a production factor with positive returns, which generates more credible regression coefficients, implying realistic values for capital's share in GDP (one third) and labor's share in GDP (one third for raw labor and one third for human capital). Second, the explanatory power of the Solow model as measured by R^2 is improved dramatically, which means that much more cross-country variation can be explained when human capital is additionally accounted for. And third, by including human capital, the rate of convergence falls from 0.04 to 0.02.

2.2.2 Islam (1995): a panel approach

However, the analysis done by Mankiw et al. (1992) also suffers from "two sources of inconsistency" (Caselli et al., 1996, p. 364), one of which relates to the term $A(0)$. While they acknowledge that "it [the $A(0)$ term] may (...) differ across countries" (pp. 410–411), they ignore this fact in their empirical test: when country-specific shocks such as preferences or technologies are not observable—which is the case—and potentially correlated with the explanatory variables, then OLS cannot be used and one has to account for this unobservable heterogeneity by using a fixed effects panel approach.

The above argument was analyzed in detail by Islam (1995). He shows that the unobserved heterogeneity lies in the term $A(0)$ which "reflects not just technology but resource endowments, climate, institutions, and so on" (Mankiw et al., 1992, pp. 410–411). Nevertheless, they let $\ln A(0) = a + \varepsilon$; but while a is a common intercept, ε is assumed to be independent from s and n. This last assumption is highly debatable, and there are two reasons why this assumption may be wrong: (1) some components of $A(0)$ may be correlated with the observed RHS variables; it is, for instance, very likely that population growth and technology are correlated. If this is true, then the omission of $A(0)$ from the regression causes omitted variable bias. And (2), Islam shows that this $A(0)$ term is time-invariant. His formal derivation of this result is as follows:

$$\begin{aligned}\ln \hat{y}(t_2) - \ln \hat{y}(t_1) = (1 - e^{-\lambda\tau})\frac{\alpha}{1-\alpha}\ln(s) - (1 - e^{-\lambda\tau})\frac{\alpha}{1-\alpha}\ln(n+g+\delta) \\ - (1 - e^{-\lambda\tau})\ln \hat{y}(t_1)\end{aligned} \tag{2.22}$$

The above equation is the one that Mankiw et al. use to test the textbook Solow model. The $\hat{y}$'s are per effective worker. To test the model, however, they use per-capita data. This requires a slight modification of the equation. As the per-effective-worker income is

$$\hat{y}(t) = \frac{Y(t)}{A(t)L(t)} = \frac{Y(t)}{L(t)A(t)e^{gt}} \tag{2.23}$$

and

$$\ln \hat{y}(t) = \ln\left(\frac{Y(t)}{L(t)}\right) - \ln A(0) - gt = \ln y(t) - \ln A(0) - gt, \tag{2.24}$$

it follows that the *per-capita* income is

$$\begin{aligned}\ln y(t_2) = (1-e^{-\lambda\tau})\frac{\alpha}{1-\alpha}\ln(s) - (1-e^{-\lambda\tau})\frac{\alpha}{1-\alpha}\ln(n+g+\delta) \\ + e^{-\lambda\tau}\ln y(t_1) + (1-e^{-\lambda\tau})\ln A(0) + g(t_2 - e^{-\lambda\tau}t_1)\end{aligned} \tag{2.25}$$

The above equation shows that the $A(0)$ term is time-invariant, and it was already outlined earlier that it is highly unlikely that components of $A(0)$ are independent from the RHS variables. These two reasons render the OLS estimator invalid. Therefore, Islam proposes a panel approach and abandons the assumption of identical production functions across countries. He thereby makes another contribution to the growth literature: because he uses the LSDV estimator, which is otherwise identical to the fixed effects estimator, he gets coefficients on the country dummy variables, which represent institutions, resource endowments, or country-specific technology[5].

To test this model, Islam uses a very similar dataset to that used by Mankiw et al. (1992) and employs the fixed effects estimator to both the textbook and the human-capital-augmented Solow model. Because he corrects for omitted variable bias, which is commonly known to alter the coefficient of the exogenous variables with which the omitted factor is correlated, he obtains an implied capital share α which comes much closer to the conventional value of one third. In that respect, he provides evidence in favor of the Solow model. Because of the mathematic relationship between the estimated coefficient on initial capital, γ, on the one hand and the convergence rate on the other, $\lambda = \frac{\ln(\gamma)}{\tau}$, a correct—i.e., a lower—estimate of γ leads to convergence rate that must be higher than that estimated by Mankiw et al.. As a result, he obtains convergence rates between roughly 4 and 10 percent, depending on the sample. Islam explains this finding as

"consistent with the generic finding of faster convergence among

[5]This assumption challenges the view that technology may be a public good. Instead, the use of technology can be restricted through, i.e., patent laws.

groups of similar countries that have been reported earlier by researchers. Instead of adopting the panel data approach, the other way to control for differences in technology and institutions is to classify the countries into similar groups. Baumol (1986) coined the term 'convergence club' to express this phenomenon. (...) What we have done in this paper is, by adoption of a panel data approach, to allow for differences in the aggregate production function not only across groups of countries (however defined), but across individual countries. As a result, we obtain higher rates of convergence over the samples as a whole" (Islam, 1995, p. 1149).

Another interesting result is that the panel regression including human capital produces broadly the same results as the one without human capital, and that the coefficient on human capital does not behave as expected. This finding is, however, not new in the growth literature, and one explanation may be that human capital may enter the production function in a more elaborate way, e.g., as an interaction effect with the rate of technological change.

Lastly, by allowing for different production functions across his sampled countries, Islam's findings suggest that besides the population growth and saving rate, whose importance has been emphasized by Solow, the components of $A(0)$—like climate, institutions, technology, or resource endowments, which are all potentially correlated with the RHS variables—are important determinants of the steady-state level of income. Nevertheless, while he finds a credible value for the implied share of capital, he rejects the Solow model on the basis of his implied convergence rate.

2.2.3 Caselli, Esquivel, and Lefort (1996): a Difference GMM approach

Islam (1995) was able to solve part of the two pitfalls that the empirical setting in the paper by Mankiw et al. encountered by employing a panel approach in order to control for unobserved heterogeneity across countries. However, there remains another source of endogeneity which Islam has not resolved. This econometric issue lies in the set-up of the regression equation

$$\ln(Y_{i,t}) - \ln(Y_{i,t-\tau}) = \beta \ln(Y_{i,t-\tau}) + W_{i,t-\tau}\delta + \eta_i + \xi_t + \varepsilon_{i,t}, \tag{2.26}$$

where η_i are unobservable individual fixed effects. This equation can be rewritten as follows:

$$\ln(y_{i,t}) = \tilde{\beta} \ln(y_{i,t-\tau}) + W_{i,t-\tau}\delta + \eta_i + \xi_t + \varepsilon_{i,t}, \tag{2.27}$$

where $\tilde{\beta} = 1 + \beta$ and $y_{i,t} = \ln(Y_{i,t})$. Per-capita income is clearly a function of the lagged per-capita income, and consequently, this model is dynamic and requires special estimation procedures which can handle endogeneity. While Islam rightly accounted for unobserved heterogeneity, he did not properly account for this last issue. This implies that the convergence rate and other coefficients in his analysis are unreliable. Caselli et al. (1996) recognize this problem and propose to employ a Difference General Method of Moments (GMM) estimator in order to generate more credible results. This is a panel-data estimator which removes both the individual effects and the problem of endogeneity.

They replicate the tests by Mankiw et al. and Knight et al. (1993) whose paper is close to that of Islam (1995) and additionally test these model specifications using the Difference GMM estimator. Furthermore, they perform a test of the human-capital-augmented version of the Solow model. Their—now, apparently, consistent—results suggest that the convergence rate and their implied capital share are not in line with the Solow model's predictions. In particular, they obtain convergence rates of around 10 percent, and their specification tests indicate that there is endogeneity in the RHS variables. They therefore reject the "restrictive framework of the Solow model and look at more general formulations" (p. 376). In that version, they depart from the strictly model-based specification of the Solow model and run a determinants-of-growth regression in which they control for a set of additional variables proposed by Barro. In that step, they also add measures of international trade and thereby adopt an open-economy version of the neoclassical model. They still find evidence against the Solow model's predictions concerning the convergence rate, but they also find support for an open-economy version of the Solow model. Again, their specification test rejects the hypothesis of exogenous explanatory variables, which leads them to the conclusion that the saving rate is determined simultaneously with the level of income per capita.

Because they obtain high convergence rates, they deduce that the sample countries must be in the neighborhood of their steady states most of the time. This, however, conflicts with their observed, rather high growth rates, which in theory should be rather small (and diminishing to zero) when an economy is close to its steady state. They interpret this result as follows. Because the control variables on the RHS of the equation may vary, they represent shocks to the steady states of the sampled economics. "Such shocks to the steady state set the transition process in motion again. Countries with exceptionally high growth rates are countries that experience repeated shifts 'forward' in the steady state during the sample period" (p. 381).

The paper by Caselli et al. is another one that rejects some assumptions and implications of the Solow model. However, it must be noted that they also find evidence for some important determinants of growth, such as international measures of trade. While this paper represents another step in the right direction and removes another technical issue of growth empirics, econometricians have yet produced another, better estimator for growth regressions: System GMM (Arellano and Bover, 1995; Blundell and Bond, 1998) was developed after Caselli et al. wrote their paper. This estimator is even more efficient than the Difference GMM estimator and is nowadays state-of-the-art in growth empirics.

2.2.4 Growth empirics and convergence: some points of criticism

The empirical growth literature has been somewhat inconclusive about the question how the growth patterns of economies can be best described. After endogenous growth models had evolved more or less in parallel during the 1980s, it was the paper by Mankiw et al. (1992) which led to a revival of the exogenous growth literature. The endogenous growth literature aimed at endogenizing technological progress because up to 1992, empirical tests of the Solow model had not been able to explain a lot of the observable differences in productivity around the globe. With the publication of the paper by Mankiw et al. and their implementation of human capital as an additional production factor, researchers conceded that exogenous growth models could explain much more of the cross-country variation than had been expected and reported in earlier studies. In that literature, however, inconsistent results have led to ongoing debates[6]. Therefore, this concluding subsection briefly discusses some criticisms that the findings of the exogenous growth literature, especially those relating to convergence, have drawn in the past three decades.

Counter-intuitively, researchers have reported "poorly-behaved", i.e., negative, or positive but insignificant, coefficients on human capital. One possible explanation for this phenomenon relating to the specification of the production function was outlined earlier in this chapter. Notwithstanding these empirical findings, economists agree that human capital contributes significantly to economic growth (Islam, 1995).

Much of the critique in the growth literature also refers to the rate of

[6] In their introductory section, Caselli et al. (1996) jokingly remark that reaching a consensus among empirical macroeconomists is "a rare occurrence".

convergence—theoretically and empirically. Strictly speaking, computing a convergence rate from a coefficient obtained in a growth regression requires that a country be in the neighborhood of its steady state. This is because the convergence rate is derived from a linearization of the capital accumulation process in the vicinity of that country's long-run equilibrium. If a country is not in that neighborhood, then the convergence rate is not informative, as the mathematical error becomes larger.

This also implies that, theoretically, convergence rates should be higher for countries that are closer to their steady state than for countries that are a little farther away, as with a higher convergence rate, it takes less time to reach the steady state. Caselli et al. (1996) argue that a high convergence rate implies a relatively short distance from that country's steady state. Therefore, growth empiricists have come to the conclusion that convergence rates may be acceptable even if they surpass the predicted value of the Solow model of 2–3 percent. Caselli et al., for instance, find convergence rates up to around 13 percent for the textbook Solow model and of around 10 percent for an alternative model including several additional control variables.

The aforementioned argument requires that (as countries may find themselves in different positions on their path towards their steady state) there be different convergence rates for each individual economy. However, from a regression on an arbitrarily large number of economies, only one single convergence rate can be derived. This implies that for all the sampled economies and across all years, the convergence rate has to be the same. This idea is highly questionable. Under certain conditions, the same argument applies to the rate of technological progress, g, which is commonly assumed to be the same across countries: as long as a very diverse set of countries is studied, the assumption of identical technological change can be challenged. Baumol (1986), therefore, coined the term "club convergence", which suggests that groups of very similar countries should have very similar convergence rates. Another example is the paper by Barro and Sala-i Martin (1992), where not a panel of countries but of U.S. states is studied. In such a setting, it is relatively safe to assume that preferences and technology are roughly identical across economies. And in fact, the authors even find evidence for absolute convergence across the U.S. states.

Nevertheless, all the above arguments referring to convergence do not make the study of growth empirics obsolete—it should, however, be acknowledged that computing a convergence rate from a regression coefficient on initial capital may not always contribute to our understanding of the growth process. Something similar is true for the implied capital share in GDP that can be derived from the coefficient on the saving rate: it is well-understood that the saving rate, as well as the population growth rate, are important policy variables and contribute significantly to economic growth. However, as different studies try to explain economic growth from different perspectives, the theoretical coefficient on saving, as it was developed by Solow (1956), may take very different mathematical forms. Therefore, deriving an implied capital share from that coefficient may not always be straightforward.

Last but not least, even though the above discussed papers by Mankiw et al. (1992), Islam (1995) and Caselli et al. (1996) reject the strictly model-based specification of the Solow model, they still agree that the general predictions of the textbook and the augmented version(s) referring to the explanatory variables (i.e., that the saving rate, population growth, or human capital determine the steady state level of income and the growth path towards the long-run equilibrium) are valid. In particular, Caselli et al. (1996) plead for the use of more general formulations instead of the specific functional form of the original Solow model. This view is broadly shared in the growth literature. Therefore, notwithstanding the criticism that its implications and assumptions have received, the Solow model is still one of the most prominent growth models and probably the most cited starting point for further extensions in the growth literature. This has to do also with the emergence of appropriate econometric techniques which now make it possible to prevent several pitfalls that earlier researchers had faced and to estimate growth models that can explain a relatively large fraction of the observed differences in GDP levels or growth rates.

2.3 How housing can distort capital allocation and growth

Let us now return to the traditional Solow model[7] and assume that an economy with a given initial endowment V can invest in residential investment (housing) and business investment (in Solow's language: capital). Investing more in one of the two assets inevitably results in lower investment in the other. One finding which supports this argument is the one by Hendershott and Hu (1981, 1983) who have criticized the overinvestment in housing in the U.S. of the 1970s which led to a decrease in the capital–labor ratio and therefore to diminishing economic growth. This result can easily be derived with the Solow model because under the same production technology, a worker with less capital at hand cannot produce more than another worker with more capital. One could therefore say that, while businesses are productive assets because of their entrepreneurial value to society, investment in housing may not lead to the same economic growth as does business activity. Mills (1987), for instance, estimated that the social return to housing capital is only half that to non-housing capital. More drastically, housing investment may even lead to no growth at all. Under this assumption, then in this modified version of the Solow model, housing does not enter the production function as an additional production factor (likewise, one could assume that $dF/dH = 0$). Instead, it will be captured indirectly through a relationship with capital K: business investment K and housing investment H are rivals, i.e., a dollar can be put either into housing or into pro-

[7]This is done for the sake of simplicity. The following analysis holds true regardless if one accounts for human capital or not.

duction. Therefore, there is no reason to model housing investments separately. Moreover, this implies that for every dollar that an economy invests in housing instead of the entrepreneurial sector, it forgoes a return for the economy. This assumption fundamentally differs from the way how Mankiw et al. (1992) incorporate their additional production factor, who assume a positive return to human capital. In particular, let

$$\begin{aligned} K &= K(H) \\ \text{where } \frac{dK}{dH} &< 0. \end{aligned} \tag{2.28}$$

The value of K depends on the value of H. This idea fundamentally challenges the assumption made by Solow that all capital is homogeneous and earns the same return for the economy. But because $V = K + H$, any additional investment in housing decreases capital investment and, consequently, also the capital–labor ratio. Using the aforementioned example, $dK/dH = -1$. The resulting production function in the augmented Solow model is therefore $Y = F[K(H), L]$, or, in per-capita terms,

$$y = F[r(H), 1]. \tag{2.29}$$

Note that all the other properties that the classical Solow setup possesses are not affected by this modification. Also, because the inclusion of housing investment does not affect the production function and its diminishing-returns-to-the-inputs property, the predictions of (conditional) convergence theory still hold. In other words, the Inada conditions, which describe a neoclassical production function, are still fulfilled.

The capital–labor ratio r is a function of capital K, which in turn is a function of housing H: $r = r[K(H)]$. So what happens when housing investment increases?

$$\frac{\partial r}{\partial H} = \frac{dr}{dK} \cdot \frac{dK}{dH} < 0. \tag{2.30}$$

Of course, capital per capita will decrease, because, while $dr/dK > 0$, capital and housing investment are negatively related as posited in equation 2.28. With this result and the standard Solow assumption that higher capital-labor ratios lead to more output per capita, one can find that output per capita $y = Fr[K(H), 1]$ decreases when housing investment increases:

$$\frac{\partial y}{\partial H} = \frac{\partial F}{\partial r} \cdot \frac{dr}{dK} \cdot \frac{dK}{dH} < 0. \tag{2.31}$$

This result refutes the prevailing view that housing boosts the economy. A testable implication of this augmented model is that countries that heavily invest in housing should exhibit lower output per capita than countries that invest less in housing.

The above finding is due to two reasons: (1) business and housing investments are rivals: an economy with higher residential capital has less business capital left for production which would otherwise generate a positive return for the economy, and (2) subsequently, when the output decreases because of the aforementioned reason and we maintain the assumption of a constant saving rate, less can be saved and reinvested in the capital stock. This is because the saving curve will lie below a hypothetical saving curve of an otherwise identical economy with less residential and more business capital. In other words, this augmented version of the Solow model does not assume that there is a separate saving function for housing capital, as Mankiw et al. (1992) do for human capital, because of the aforementioned assumption of zero returns on housing. Analogously, this model does not proceed as Mankiw et al. when they assume that "the same production function applies to human capital, physical capital, and consumption" (p. 416).

To test a version of this model empirically, chapter 6 departs from the above setup in a number of ways. First of all, I will transform the model in such a way that it explains per-capita growth rates, not per-capita GDP levels. That is, my tested model will become a dynamic one, which has the lagged value of the dependent variable on the RHS and has thus to be analyzed with special econometric methods. Also, while my empirical model will predict economic growth based on homeownership, my empirical setup will allow for countries to be off-steady-state: according to Solow's theory, unless an economy is at its steady state, per-capita growth rates must be different from zero. Therefore, when positive per-capita growth rates can be observed, this may imply that my sampled countries have experienced technological change and can therefore achieve a higher steady state in the future. In other respects, I will rely on Solow's hypotheses that countries with higher saving rates and such with lower population growth rates grow faster, and will also incorporate human capital according to Mankiw et al. (1992). In essence, as these variables predict the path towards a steady state, they also predict growth rates.

Second, I will relax the assumption of capital inputs insofar as homeownership rates, not residential capital, are used to examine the impact of housing investment on economic per capita growth. The reason is that my aim will be to examine the relationship between growth and homeownership on the one hand and growth and "non-homeownership" on the other. This distinction cannot be made using residential investment or other real-estate-related variables. I will use homeownership rates even though they cannot easily be accommodated mathematically in the traditional Solow setup for the following reason: "rates" cannot produce output, whereas capital can. Although the Solow model is more intuitive when one uses capital inputs, in empirical applications it is standard to augment the Solow model by additional control variables, which may not be monetary, to safeguard against omitted variable bias. This is what chapter 6 will do: next to the traditional Solow variables and additional, empirically tested variables, homeownership will enter the empirical model to examine how it affects growth.

The third point of departure will be that the result derived in equation 2.31 only refutes the prevailing view that ever more housing leads to ever more growth, while on the contrary, it can be observed in practice that homeownership has positive external effects for an economy. This can, of course, not be ignored. To picture this ambiguous relationship, I will allow for a hump-shaped curve between homeownership rates and economic growth which assumes that there is a positive relationship between the two up to a certain "optimal" point. This is the critical homeownership rate which generates the highest economic growth: it is above zero because of positive externalities, but well below 100 percent because of negative externalities that kick in when economies invest excessively in homeownership, as could be witnessed during the housing crisis. To empirically model this, homeownership rates will enter the regression as a linear and a squared term to capture the inverse relationship with growth starting at higher homeownership rates. Hence, I will analyze the constant growth-trade-off induced by homeownership by letting homeownership generate positive "net" returns for the economy up to the critical homeownership rate and negative "net" returns thereafter.

As opposed to the textbook Solow model, which assumes that the saving rate is exogenous, my econometric estimation procedure will assume an endogenous saving rate. Besides a very intuitive argument in favor of this procedure, it is also justified on the grounds that Caselli et al. (1996) advocate an open economy version of the Solow model which assumes that the saving rate is endogenous. Likewise, my empirical model will control for trade openness and terms of trade, which turns my model economy into an open economy.

Lastly, it should be mentioned that my augmented model will not aim at testing the validity of the Solow model by deriving a rate of convergence or other implied values from the estimated coefficients. This is because historically, growth empiricists have come to very different conclusions concerning these values. Furthermore, the math behind the convergence rate requires that the studied economies be very close to their steady state, which is highly unlikely owing to the fact that I will study the years around the recent financial crisis. I will instead focus on a number of tested and accepted control variables to safeguard against omitted variable bias. Moreover, as was mentioned earlier, the inclusion of "new" production factors into the Solow model necessarily alters the mathematical expression of the growth coefficients, and hence, implied values cannot be simply derived using "textbook coefficients" derived in other papers. The goal of the following paper is instead to contribute to the housing literature and to provide policy advice regarding the promotion of homeownership in a country.

2.4 Appendix

A1: Speed of convergence

For better readability, tildes on the per-effective-unit-of-labor values are suppressed.

Assuming a Cobb–Douglas production function

$$Y = K^{\alpha}(AL)^{1-\alpha}$$
$$\frac{Y}{AL} = y = k^{\alpha}$$
$$\text{with } y = \frac{Y}{AL} \text{ and } k = \frac{K}{AL},$$

the fundamental equation of motion of the capital stock per effective unit of labor is

$$\dot{k} = sk^{\alpha} - (n + g + \delta)k \tag{2.32}$$

In the steady state, $\dot{k} = 0$ and therefore, $sk^{\alpha *} = (n + g + \delta)k^{*}$ so that

$$k^* = \left[\frac{s}{n+g+\delta}\right]^{\frac{1}{1-\alpha}}. \tag{2.33}$$

Also because in the steady state, $\dot{k} = 0$, it follows that $\frac{\dot{k}}{k} = 0$:

$$\frac{\dot{k}}{k} = sk^{\alpha-1} - (n+g+\delta) = G(k) = 0 \tag{2.34}$$

We can now linearize $G(k)$ in the direct vicinity of the steady state using a Taylor approximation of first order and $G(k^*) = 0$:

$$\begin{aligned} G(k) &\approx G(k^*) + G'(k^*)(k-k^*) \\ &\approx (\alpha-1)sk^{*\alpha-1-1}(k-k^*) \\ &\approx (\alpha-1)sk^{*\alpha-1}\left(\frac{k-k^*}{k^*}\right) \end{aligned} \tag{2.35}$$

Substituting equation 2.33 into 2.35 and simplifying leads to

$$\begin{aligned} G(k) &\approx (\alpha-1)s\left[\frac{s}{n+g+\delta}\right]^{\frac{\alpha-1}{1-\alpha}}\left(\frac{k-k^*}{k^*}\right) \\ &\approx (\alpha-1)s^{\frac{1-\alpha}{1-\alpha}}s^{\frac{\alpha-1}{1-\alpha}}\left[\frac{1}{n+g+\delta}\right]^{\frac{\alpha-1}{1-\alpha}}\left(\frac{k-k^*}{k^*}\right) \\ &\approx (\alpha-1)(n+g+\delta)^{\frac{\alpha-\alpha}{1-\alpha}}\left(\frac{k-k^*}{k^*}\right) \\ &\approx (\alpha-1)(n+g+\delta)\left(\frac{k-k^*}{k^*}\right) \end{aligned}$$

We can further approximate $\ln k$ around k^*:

$$\begin{aligned} \ln k \approx \ln k^* + \frac{1}{k^*}(k-k^*) &\rightarrow \frac{k-k^*}{k^*} = \ln k - \ln k^* \\ G(k) &\approx (\alpha-1)(n+g+\delta)(\ln k - \ln k^*) \\ &\approx (1-\alpha)(n+g+\delta)(\ln k^* - \ln k) \end{aligned}$$

Because $y = k^\alpha \rightarrow \ln y = \alpha \ln k$ and $\frac{d\ln x}{dt} = \frac{\dot{x}}{x}$ it follows that

$$\begin{aligned} g_y = \frac{\dot{y}}{y} = \frac{d \ln y}{dt} = \frac{d\alpha \ln k}{dt} = \alpha \frac{d \ln k}{dt} \\ = \alpha \frac{\dot{k}}{k} = \alpha G(k) \\ = \alpha[(1-\alpha)(n+g+\delta)(\ln k^* - \ln k)] \\ = (1-\alpha)(n+g+\delta)(\alpha \ln k^* - \alpha \ln k) \\ = (1-\alpha)(n+g+\delta)(\ln y^* - \ln y) \\ = \lambda(\ln y^* - \ln y) \end{aligned} \tag{2.36}$$

A2: Output per capita in the standard Solow model

Physical capital accumulation is governed by:

$$\dot{K} = sY - \delta K = \frac{dK(t)}{dt}$$

Let us compute log returns in order to make the model mathematically more tractable:

$$\begin{aligned} \frac{d \ln K(t)}{dt} = \frac{d \ln K(t)}{dt} \cdot \frac{dK(t)}{dt} \\ \frac{1}{K} \cdot \dot{K} = \frac{\dot{K}}{K} \end{aligned}$$

Moreover, $\ln k = \ln\left(\frac{K}{AL}\right) = \ln K - \ln L - \ln A$ and therefore, analogously,

$$\begin{aligned} \frac{d \ln k(t)}{dt} = \frac{d \ln K(t)}{dt} - \frac{d \ln L(t)}{dt} - \frac{d \ln A(t)}{dt} \\ \frac{\dot{k}}{k} = \frac{\dot{K}}{K} - \frac{\dot{L}}{L} - \frac{\dot{A}}{A} \end{aligned} \tag{2.37}$$

From $\dot{K} = sY - \delta K$ we get

$$\frac{\dot{K}}{K} = s\frac{Y}{K} - \delta \tag{2.38}$$

Inserting equation 2.38 in 2.37 yields

$$\frac{\dot{k}}{k} = s\frac{Y}{K} - \delta - \frac{\dot{L}}{L} - \frac{\dot{A}}{A}$$
$$= s\frac{Y}{K} - \delta - n - g,$$

or, equivalently

$$\begin{aligned}\dot{k} &= sy - (n+g+\delta)k \\ &= sk(t)^{\alpha} - (n+g+\delta)k(t).\end{aligned} \tag{2.39}$$

In the steady state, k converges to a value where $sk^{*\alpha} = (n+g+\delta)k^*$, so that

$$k^{*\alpha-1} = \frac{n+g+\delta}{s}$$
$$k^{*\alpha} = \sqrt[\alpha-1]{\frac{n+g+\delta}{s}} = \left[\frac{n+g+\delta}{s}\right]^{\frac{1}{\alpha-1}} = \left[\frac{s}{n+g+\delta}\right]^{\frac{1}{1-\alpha}}$$

Note that $\frac{dk^*}{ds} > 0$ and $\frac{dk^*}{di} < 0, \quad i = n,\ g,\ \delta.$

Because $k = \frac{K}{AL}$, $y = \frac{Y}{AL} = k^{\alpha}$ and $A(t) = A(0)e^{gt}$, it follows that

$$y = \left[\frac{s}{n+g+\delta}\right]^{\frac{\alpha}{1-\alpha}}$$
$$Y = A(t)L \cdot \left[\frac{s}{n+g+\delta}\right]^{\frac{\alpha}{1-\alpha}}$$
$$\frac{Y}{L} = A(t) \cdot \left[\frac{s}{n+g+\delta}\right]^{\frac{\alpha}{1-\alpha}} = A(0)e^{gt} \cdot \left[\frac{s}{n+g+\delta}\right]^{\frac{\alpha}{1-\alpha}}$$
$$\ln\left(\frac{Y}{L}\right) = \ln A(0) + gt + \left(\frac{\alpha}{1-\alpha}\right)\ln(s) - \left(\frac{\alpha}{1-\alpha}\right)\ln(n+g+\delta)$$

A3: Output per capita in the human-capital-augmented Solow model

We know that physical capital accumulation is governed by

$$\dot{K} = s_k Y - \delta K \rightarrow \frac{\dot{K}}{K} = s_k \frac{Y}{K} - \delta$$

or

$$\dot{k} = s_k y - (n + g + \delta)k \tag{2.40}$$

Equivalently, human capital accumulation is governed by

$$\dot{HC} = s_{hc}Y - \delta HC \rightarrow \frac{\dot{HC}}{HC} = s_{hc}\frac{Y}{K} - \delta$$

or

$$\dot{hc} = s_{hc}y - (n + g + \delta)hc \tag{2.41}$$

Because of

$$\begin{aligned} Y &= K^{\alpha}HC^{\beta}(AL)^{1-\alpha-\beta} \\ y &= \frac{Y}{AL} = \left(\frac{K}{AL}\right)^{\alpha}\left(\frac{HC}{AL}\right)^{\beta} = k^{\alpha}hc^{\beta}, \end{aligned} \tag{2.42}$$

inserting equation 2.42 into equation 2.41 yields for $\dot{hc} = 0$

$$\begin{aligned} s_{hc}k^{\alpha}hc^{\beta} &= (n + g + \delta)hc \\ hc^{\beta} &= \left[\frac{(n + g + \delta)hc}{s_{hc}}\right]k^{-\alpha} \\ hc^{\beta-1} &= \left[\frac{n + g + \delta}{s_{hc}}\right]k^{-\alpha} \\ hc^{*} &= \left[\frac{n + g + \delta}{s_{hc}}\right]^{\frac{1}{\beta-1}}k^{-\frac{\alpha}{\beta-1}} \\ &= \left[\frac{s_{hc}}{n + g + \delta}\right]^{\frac{1}{1-\beta}}k^{\frac{\alpha}{1-\beta}} \end{aligned} \tag{2.43}$$

Inserting equation 2.41 into equation 2.40 yields for $\dot{k} = 0$

$$
\begin{aligned}
s_k k^{\alpha} hc^{\beta} &= (n+g+\delta)k \\
s_k k^{\alpha} \left[\frac{s_{hc}}{n+g+\delta}\right]^{\frac{\beta}{1-\beta}} k^{\frac{\alpha\beta}{1-\beta}} &= (n+g+\delta)k \\
k^{\alpha-1} \left[\frac{s_{hc}}{n+g+\delta}\right]^{\frac{\beta}{1-\beta}} k^{\frac{\alpha\beta}{1-\beta}} &= \frac{n+g+\delta}{s_k} \\
k^{\frac{(\alpha-1)(1-\beta)}{1-\beta}+\frac{\alpha\beta}{1-\beta}} &= \left[\frac{s_k}{n+g+\delta}\right]^{-1} \cdot \left[\frac{s_{hc}}{n+g+\delta}\right]^{-\frac{\beta}{1-\beta}} \\
k^{\frac{\alpha+\beta-1}{1-\beta}} &= \left[\frac{s_k}{n+g+\delta}\right]^{-1} \cdot \left[\frac{s_{hc}}{n+g+\delta}\right]^{-\frac{\beta}{1-\beta}} \\
k^* &= \left[\frac{s_k}{n+g+\delta}\right]^{-\frac{1-\beta}{1-\alpha-\beta}} \left[\frac{s_{hc}}{n+g+\delta}\right]^{(-\frac{\beta}{1-\beta})(\frac{1-\beta}{\alpha+\beta-1})} \\
&= \left[\frac{s_k}{n+g+\delta}\right]^{\frac{1-\beta}{1-\alpha-\beta}} \left[\frac{s_{hc}}{n+g+\delta}\right]^{\frac{\beta}{1-\alpha-\beta}}
\end{aligned}
\tag{2.44}
$$

Inserting equation 2.44 into equation 2.43 yields

$$
\begin{aligned}
h^* &= \left[\frac{s_{hc}}{n+g+\delta}\right]^{\frac{1}{1-\beta}} \left[\left(\frac{s_k}{n+g+\delta}\right)^{\frac{1-\beta}{1-\alpha-\beta}} \left(\frac{s_{hc}}{n+g+\delta}\right)^{\frac{\beta}{1-\alpha-\beta}}\right]^{\frac{\alpha}{1-\beta}} \\
&= \left[\frac{s_{hc}}{n+g+\delta}\right]^{\frac{1-\alpha}{1-\alpha-\beta}} \left[\frac{s_k}{n+g+\delta}\right]^{\frac{\alpha}{1-\alpha-\beta}}
\end{aligned}
\tag{2.45}
$$

Inserting equations 2.44 and 2.45 in equation 2.42 leads to

$$
\begin{aligned}
y^* &= k^{*\alpha} hc^{*\beta} \\
&= \left[\frac{s_k}{n+g+\delta}\right]^{\frac{\alpha}{1-\alpha-\beta}} \left[\frac{s_{hc}}{n+g+\delta}\right]^{\frac{\beta}{1-\alpha-\beta}}
\end{aligned}
\tag{2.46}
$$

Because $k = \frac{K}{AL}, y = \frac{Y}{AL}, h = \frac{HC}{AL}$ and $A(t) = A(0)e^{gt}$ it follows that

$$
\begin{aligned}
Y = y^* \cdot AL \rightarrow \frac{Y}{L} =& y^* \cdot A \\
\frac{Y}{L} =& \left[\frac{s_k}{n+g+\delta}\right]^{\frac{\alpha}{1-\alpha-\beta}} \left[\frac{s_{hc}}{n+g+\delta}\right]^{\frac{\beta}{1-\alpha-\beta}} A(0)e^{gt} \\
\ln\left(\frac{Y}{L}\right) =& \ln A(0) + gt + \frac{\alpha}{1-\alpha-\beta}\left(\ln(s_k) - \ln(n+g+\delta)\right) \\
&+ \frac{\beta}{1-\alpha-\beta}\left(\ln(s_{hc}) - ln(n+g+\delta)\right) \\
=& \ln A(0) + gt + \frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) \\
&+ \frac{\alpha}{1-\alpha-\beta}\ln(s_k) + \frac{\beta}{1-\alpha-\beta}\ln(s_{hc})
\end{aligned}
$$

A4: A growth equation for off-steady-state dynamics

We know from equation 2.36 that

$$g_y = \lambda \ln y^* - \lambda \ln y$$

Substituting for $b = \lambda \ln y^*$ and $x = \ln y$ leads to

$$\dot{x}(t) = b - \lambda x(t)$$

The general solution of such a non-homogeneous differential equation is $y = y_c + y_p$ where y_c is the solution of a homogeneous differential equation and y_p is a particular integral, i.e., $x = Ae^{-\lambda t} + \frac{b}{a}$. The definite solution of such a differential equation is

$$x = x(0)e^{-\lambda t} + \frac{b}{\lambda}(1 - e^{-\lambda t}).$$

Reinserting $b = \lambda \ln y^*$ and $x(t) = \ln y(t)$ yields

$$
\begin{aligned}
\ln y(t) &= \ln y(0)e^{-\lambda t} + \ln y^*(1 - e^{-\lambda t}) \\
\ln y(t) - \ln y(0) &= \ln y(0)e^{-\lambda t} + \ln y^*(1 - e^{-\lambda t}) - \ln y(0)
\end{aligned}
$$

Now insert $y^* = \left[\frac{s_k}{n+g+\delta}\right]^{\frac{\alpha}{1-\alpha-\beta}} \left[\frac{s_{hc}}{n+g+\delta}\right]^{\frac{\beta}{1-\alpha-\beta}}$ and simplify:

$$\begin{aligned}\ln y(t) - \ln y(0) =& (1-e^{-\lambda t})\frac{\alpha}{1-\alpha-\beta}\ln(s_k) + (1-e^{-\lambda t})\frac{\beta}{1-\alpha-\beta}\ln(s_{hc}) \\ & - (1-e^{-\lambda t})\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+g+\delta) - (1-e^{-\lambda t})\ln y(0)\end{aligned}$$

Chapter 3

Housing Markets in Germany, the USA, Japan, and China

3.1 Introduction

Real estate is a special asset in the sense that it has political, cultural and economic ramifications that go beyond a simple rate of return calculation for an investment. For instance, real estate developers have historically triggered significant change in our culture and way of life. A prominent example is William Jaird Levitt who took advantage of the U.S. veterans' need for affordable housing after WWII. A combination of high car ownership rates, housing subsidies, and efficient construction methods allowed him to make the "suburban" real estate innovation where similar cookie-cut style houses using assembly-line type techniques led to substantial savings. These real estate developments and the suburban living style were exported to other countries such as the case of the "Neubau" neighborhoods in Germany.

Nevertheless, housing markets around the world vary greatly as regards their differing political, economic, and social backgrounds. To give an overview of some of these differences, this paper presents stylized facts on real estate markets in Germany, the USA, Japan, and China. It discusses cultural and societal aspects, taxation and regulation as well as the resulting incentives.

3.2 Germany

Germany ranks among the countries with the lowest homeownership rates in the industrialized world (roughly 45 percent). One reason may be the tax treatment of homeownership: contrary to other industrialized countries, the German tax system does not favor owning over renting. For instance, the largest government subsidy to homeownership (*Eigenheimzulage*) was discontinued in 2005. Moreover, mortgage payments are only tax-deductible if the home is rented out, but not if the house is owner-occupied. Still, mortgage interest rates in Germany have been among the lowest in Europe (European Mortgage Federation, 2016). Therefore, financing costs may not necessarily be a deterring factor. According to Voigtländer (2009), other reasons for Germanys low homeownership rate may be its sophisticated and renter-friendly rental market, no or little rent control and accompanying market distortions, and historically stable house prices. Because Germans tend to be renters rather than owners, it has been argued that the housing crisis had little effect on the German economy (Kofner, 2014).

But despite long periods of low and stable house and rent prices, some German cities have seen soaring prices in the past few years. Particularly in some distressed housing markets, owning has become more and more unaffordable, which is why new approaches to facilitating the purchase of homes are being discussed by the government. Furthermore, rent control (*Mietpreisbremse*) was introduced in 2015 which links rent prices in certain cities to the local rent index. However, this regulation has not been proven to be successful in practice (Deschermeier et al., 2017).

In Germany the landlord has to provide a confirmation of provision of residence (*Wohnungsgeberbestätigung*) to a tenant. This form is used together with an application for residency with a city hall. The landlord may be fined up to €50,000 for filing a fictitious confirmation of provision of residence and the requirement must be met in order to avoid a fine of up to €1,000. Without this document, a municipality administrative unit will not issue a registration certificate which is needed for enrolling children at the local schools, getting an ID card or a drivers' license.

Upon purchase of a property, a transfer tax fee has to be paid. These tax rates are determined by the German federal states and can be up to 6.5 percent of the property value. However, rates as low as 3.5 percent can be found in two of the 16 states. Yet, this tax rate is relatively high compared to the U.S., where it is only a fraction of the German rate.

When capital gains, e.g., on the sale of a home, are realized, there is a speculation tax (*Spekulationssteuer*). Practically, capital gains from selling privately held real estate after a holding period of up to ten years is considered speculation and fully taxed. However, there is an exception for houses that were owner-occupied for a period of at least three years before the sale of the house. This provides an incentive for Germans to hold to the same real estate for a longer period of time. The same speculation-tax logic applies to family home inheritances, which may be inherited free from tax as long as the heirs move into that house and live there for at least 10 years. Furthermore, houses can be inherited tax-free as long as the value of the entire inheritance does not exceed €400,000.

3.3 USA

Contrary to Germany, U.S. Americans are not legally required to establish residency that effectively ties them to a dwelling for most economic purposes except for access to public schools. This is because public schooling is primarily financed by local real estate taxes. Therefore, effectively one needs to reside in an area where one wants to send children to public schools. Because tax revenue spent on schooling is substantially higher in "good' neighborhoods, families have an incentive to buy property in these areas and maintain their neighborhoods. As a consequence, house prices increase, which in turn raises the levied taxes which finance public schools. With increasing house prices, however, consumption spending may increase too, as many homeowners use their homes as a collateral against which they borrow (Benjamin and Chinloy, 2008).

Owning a home doesn't prevent Americans from moving. Between 2015 and 2016, more than 10.3 million homeowners moved, representing 29.42 percent of all those who relocated during that time (U.S. Census Bureau, 2016). Therefore, they sell their homes relatively often, and sales gains proceeding from these trades are fully taxed. However, there is a home sale exclusion which makes home sale profits tax-exempt when a specific exclusion amount, which is $500,000 for married couples and $250,000 for singles, is not exceeded. For sellers of investment property, there is an exception when the entire proceeds of the sale are reinvested in a more expensive property. The incentive effect of this real estate tax is that Americans increase the wealth that is tied in housing.

To avoid inheritance tax, a common method of ownership of a family house is joint tenancy. Under this form of ownership, the surviving spouse automatically receives free title to the house without having to pay inheritance taxes or to share the inheritance with the other survivors. This provides an incentive for accumulating housing wealth instead of financial wealth.

Moreover, the U.S. tax code does not tax imputed rents on owner-occupied houses but allows mortgage payments and real estate taxes to be deducted from the federal income tax. Thus, in effect, owning is subsidized at least twice. In their analysis of the U.S. tax code, Hendershott and Hu (1981, 1983) show that the housing tax subsidy decreases the user cost of residential capital below that of non-residential capital, which provides an incentive to (over)invest in housing.

3.4 Japan

In Japan, land is extremely expensive. Noguchi (1994), for instance, reports that a square meter of land in Tokyo in the 1980s cost around £4 million—forty times as much as a square meter in a comparable location in the inner city of London (£100,000 million). Moreover, Knoll et al. (2017) estimate that between 1890 and 1990, the average share of land in Japan's house values increased from 40 to 90 percent, while the shares for Germany and the USA have been much lower (between 13 and 40 percent). Noguchi (1994) points out that in large Japanese cities and suburban sites of Tokyo and Osaka, the land purchase cost could be up to 98.5 percent of the housing cost.

Despite the immense cost, the majority of Japanese are homeowners (Mori, 1998). One explanation may be speculation. Land in Japan is so valuable that "all landowners, even in the remote country (...) may hope one day that their land will be demanded for development, especially when the economy is booming" (Mori, 1998, p. 1545). Hirayama (2010) attributes this to the aging population in Japan, which is being faced with the need to cut back on social spending and is encouraged to acquire property to maintain economic security.

Hirayama (2010) also reports that one third of Japanese expect to inherit real estate. This is very attractive in light of the aforementioned demographic change. To facilitate the accumulation of wealth, inheritance taxes are substantially decreased when residential property is bequeathed. Furthermore, property taxes are relatively low and are even decreased by one fourth for small residential sites. A lower tax burden and high land prices create an incentive to acquire rather small plots of land.

3.5 China

China has a distinct and complex household registration system (*hukou*), which classifies every Chinese as either "rural/agricultural" or "urban/non-agricultural" and ascribes a permanent residence based on the parent's hukou classification. This system was introduced in order to regulate and restrict labor mobility towards big cities when China started to become urbanized. Rural workers wanting to move to cities had to send an application to the government. When denied legal migration, many Chinese workers moved to cities illegally and were then excluded from most welfare benefits (access to urban housing and schooling, insurance, etc.) to which only legal migrants were entitled. Nowadays—even though the hukou system still exists—Chinese workers are said to be free to move to any place in China (Song, 2014).

Usually, a person with rural hukou is automatically allocated a piece of land in the area of residence (Song, 2014). However, ownership of that land is not permitted. Instead, land is leased from the government and the maximum land-use rights transfer is for 70 years in the case of residential real estate (Li and Huang, 2006). A year prior to the expiration of the 70-year land lease period a homeowner may apply for lease renewal or return the land and the house to the government without receiving compensation for the value of the residential property. The application is costly and may be rejected at the governments discretion. This event is unlikely and is an extreme outcome which is a source of worry for Chinese homeowners. On top of that, the 2007 property law did not explicitly describe the procedure for such an application. Therefore, just recently, the Chinese government announced the draft of a provision which would allow land leasers to unconditionally renew their lease contract after 70 years (Hsu, 2017).

Because homeowners don't own the the land on which the home is built, it is difficult to accumulate wealth. Therefore, especially closer to larger cities, individuals with land-use rights have an incentive to build multi-story houses on their lots and rent out the dwellings to (illegal) migrants who work in the close-by cities and are denied access to urban housing (Li and Huang, 2006).

3.6 Conclusion

This paper contrasted housing markets in Germany, the USA, Japan, and China—countries whose markets vary greatly as regards their political, societal, and cultural backgrounds. While individuals in the U.S. are free to move anywhere they desire, Chinese farmers are only granted 70-year land-use rights with the prospect of losing their home after the lease ends. Germany, as Japan, is an aging society whose public pension system will face challenges in the future; yet only the minority of Germans own a home. The regulatory, political and institutional differences shaping these markets are of course not exhaustive; yet, it was the aim of this paper to show how diverse housing markets around the world can be.

Chapter 4

Excess Homeownership: Consumption, Wealth Effects and Distortions

4.1 Introduction

Should governments encourage homeownership? Case et al. (2005) use a novel metric to show that housing wealth has a positive effect on consumption. This metric has several advantages over similar variables that have been used by other researchers (see Calomiris et al., 2009). In particular, it more accurately reflects housing wealth as it is based on actual house prices and the number of owner-occupied houses in an economy. It does therefore not rely on housing wealth as a residual measure of total wealth net of stock wealth and, consequently, reduces the risk that the results are driven by measurement problems.

However, previous studies have typically ignored mortgage debt. This may generate misleading results, as it has been shown that households typically finance consumption with debt (Benjamin and Chinloy, 2008), i.e., when the value of their homes increases, they borrow in order to consume. This could lead to a lower net housing wealth when debt increases more strongly than house prices, and omitting this variable would misstate the housing wealth effect. Bostic et al. (2009), for instance, compute net-of-debt housing wealth, whereas many other studies typically consider gross-of-debt housing wealth. When net household wealth is used to explain consumption behavior, Bostic et al. find that the housing wealth effect becomes less conclusive than when gross housing wealth is used as a regressor.

Yet, the study by Case et al., as many other studies on the housing wealth effect, are subject to severe endogeneity bias, which are discussed in detail by Calomiris et al. (2009): first, Case et al. regress levels of consumption on levels of income, which are both non-stationary. By this, they violate an important requirement for the validity of OLS. And second, they use current changes in income and housing wealth to explain current changes in consumption. But because current changes in income do not capture permanent income shocks, it is highly likely that the error term correlates with housing wealth: households that expect permanent income growth may well bid up house prices and thereby raise their housing wealth. In fact, after correcting for endogeneity bias, Calomiris et al. (2009) report that the large wealth effect found by Case et al. vanishes.

We also examine the implications of housing wealth for the economy. One may hypothesize that homeowners are more likely to purchase furniture and spend on remodeling related goods as well as local amenities, particularly when they have more equity in their house. That additional consumption then may drive production, leading to an increase in GDP. The policy implication is that the government should encourage homeownership on the grounds that it may contribute to growth. In fact, the debt-tax shield of home mortgages may be viewed as a subsidy that encourages homeownership in the USA. However, as studies by Mills (1987, 1989) and Hendershott (1989) have shown, too much investment in housing may have detrimental effects for the economy. Therefore, housing may also lead to a decrease in GDP when there is housing overinvestment.

Consequently, we run our regressions on two subsamples which we distinguish by the median U.S. homeownership rate. We do this because there is evidence that (1) homeowner communities have an impact on investment in, and consumption of, local amenities and that (2) overinvestment in housing may have adverse effects on economic growth. We therefore condition our analyses on two mutually exclusive subsamples to study how the relationship between housing on the one hand and consumption and GDP on the other differ. Our results indicate that housing wealth has no impact on consumption and GDP in low-homeownership states. However, more housing wealth increases consumption in high-homeownership states but depresses GDP. We attribute the findings for the high-homeownership group to the fact that on the one hand, homeowners invest in local amenities to develop social capital, but that on the other hand, overinvestment in housing leads to underinvestment in other business activity with higher social returns to capital.

This paper contributes to the housing wealth literature in three ways. First, we correct for endogeneity bias by instrumenting changes in the explanatory variables by their lags, which has not been done across the board in past studies. Second, when we study consumption behavior, we additionally control for mortgage debt at the household level as an increase in housing wealth is likely accompanied by a rise in household debt. And third, we base our analysis of consumption and GDP on two subsamples defined by high vs. low average homeownership.

The remainder of this paper is structured as follows. The next section reviews the theoretical and empirical literature on the housing wealth effect and the impact of housing on production. That section is followed by the empirical analysis which focuses on consumption as well as GDP per capita across the U.S. states. Section 4.5 briefly summarizes the findings and concludes.

4.2 Related literature

4.2.1 The housing wealth effect

There is an extensive literature on the effect of different types of wealth on consumption. Case et al. (2005), for instance, find that changes in housing wealth have a much larger effect on consumption than do changes in financial wealth; both in cross-country and U.S. states panels. In fact, there is a consensus in the literature that the marginal propensity to consume (MPC) from housing wealth is larger than the MPC from financial wealth. The theoretical foundation for this finding is the permanent income hypothesis (e.g., Lettau and Ludvigson, 2004), which claims that consumption is only affected by permanent, not transitory, wealth shocks.

Yet, empirically and theoretically, the positive housing wealth effect has not been confirmed across the board. Skinner (1989), for instance, argues that homeowners with a bequest motive consume less. This effect is especially pronounced when house prices increase a lot and the homeowners' heirs have to spend more to buy a house. Hence, in this case, a negative housing wealth effect seems plausible.

Engelhardt (1996) finds an asymmetric effect of housing wealth on consumption: increasing housing wealth has no effect whereas a drop in housing wealth is associated with a fall in consumption.

Sinai and Souleles (2005) argue that rising house prices simultaneously increase future housing costs, and consequently, the housing wealth effect should at best be small. Also, they note that in studies using aggregate data, the housing effect is usually smaller than when micro data are used, because someone's gains are someone else's losses when houses are traded. The latter argument has also been presented by Buiter (2010).

Lastly, it is important to account for household debt. Benjamin and Chinloy (2008) report that consumption is increasing in the mortgage balance, thereby providing evidence for the hypothesis that households use housing wealth to smooth their consumption. This is because when house prices rise, the household increases its mortgage balance in order to consume more. This may leave the household's net wealth unaffected.

4.2.2 Housing overinvestment

How could housing investment affect the economy? Across countries worldwide, productivity levels differ. This difference in wealth may, for instance, be due to historical or political developments. Discrepancies in GDP may also arise because of differences in production technologies and efficiency. That is, there may be countries that predominantly invest in productive assets whereas other economies rather focus on assets that are comparatively less productive. Hendershott and Hu, among others, studied this phenomenon extensively in the 1980s for the U.S. market. They find that unanticipated inflation reduces the real user cost of housing. This depresses stock prices and thereby increases the real user cost of corporate capital, which leads to a misallocation of capital (Hendershott and Hu, 1981).

Hendershott and Hu (1983) point out that the economic growth and capital–labor ratio in the U.S. of the 1970s diminished compared to previous decades. They build a two-sector economy with a housing and a non-housing good and find a misallocation of capital towards residential uses because the real user cost of housing was lower than the real user cost of corporate capital. This underinvestment in the business sector was caused by the U.S. tax code (1966–1978) and depressed the capital-labor ratio, which harmed the economy. In a similar vein, Rosen (1979) estimates that the U.S. productivity would have gained $107 per household if the housing tax subsidy was eliminated.

Mills (1987) also finds that the U.S. has overinvested in housing relative to industrial capital, but that there is no difference between owner-occupied and rented housing. He determines the social returns to the two types of capital and finds that the return to housing capital is about half that to non-housing capital. This result is broadly confirmed by Mills (1989) and Hendershott (1989) and implies that investment in residential uses yields a lower output than does non-residential investment.

4.3 Research design

4.3.1 Data

We use data at the state level to study how per-capita consumption and GDP responded to housing wealth, constructed following Case et al. (2005), across U.S. states between 2004 and 2015. It would make sense to subtract mortgage debt from housing wealth to study the effect of an increase in actual net wealth on consumption; but because the housing wealth variable is an index rather than a dollar figure, we separately control for the level of household mortgage debt.

The mortgage debt data was sourced from the Federal Reserve Bank New York, while the remaining variables were retrieved from the FRED database. All values are in constant 2010 dollars and per-capita terms.

The use of state-level data guarantees that the data collection process as well as the definition of the variables across states are consistent, and we can thereby safeguard against measurement problems that may arise in cross-country samples. Moreover, as Calomiris et al. (2009) have noted, panel data—as opposed to time-series data—increases the number of observations and the power of the empirical tests.

Table 4.1 reports summary statistics of the full U.S. states sample and the two subsamples, which have been divided according to the median U.S. homeownership rate of 69.60 percent. A two-sample t test was conducted to test whether the two subsample averages differ significantly from each other. The test has been run on all subsample averages and was highly significant in all cases. This means that households in states where there is high homeownership have a lower per-capita GDP and income. On top of that, they have lower consumption levels even though their gross housing wealth is significantly higher.

4.3.2 Method

Typically, consumption and income are non-stationary, which is why we use changes in these variables instead of their levels. On top of that, we also address the problem of endogeneity: when current changes in consumption are regressed on contemporaneous changes in income, expected changes in future, permanent, income may end up in the error term. This induces endogeneity because the error term may be correlated with housing wealth as, when expected incomes rise, households may bid up house prices, which is then reflected in rising housing wealth (Calomiris et al., 2009). To overcome this bias, we instrument the changes in the independent variables with their lags. In order not to lose too many years of data, we include up to the third lag of the independent variables.

We distinguish between states with excess homeownership rates (above or equal to the median of 69.60 percent) and states with low to intermediate homeownership levels (below the median). With this procedure, we would like to understand how consumption behavior across households in neighborhoods with high homeownership differs from those with lower homeownership. Also, since overinvestment in housing may harm the economy, we examine if GDP at the state level varies with homeownership.

Table 4.1: Summary statistics.

	Full sample					Low-homeownership subsample				High-homeownership subsample			
Variable	Obs.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Homeownership rate	612	68.51	6.05	40.40	81.30	64.21	5.71	40.40	69.50	72.71	2.21	69.60	81.30
Consumption	612	33787.65	4923.70	24732.16	50827.97	34981.41	5210.63	25737.71	50827.97	32624.69	4328.88	24732.16	43534.50
Log consumption	612	10.42	0.14	10.12	10.84	10.45	0.14	10.16	10.84	10.38	0.13	10.12	10.68
GDP	612	51403.37	19531.69	32106.54	177844.90	56313.57	25203.44	33898.05	177844.90	46619.9	9436.33	32106.54	87125.09
Log GDP	612	10.8	0.26	10.38	12.09	10.88	0.29	10.43	12.09	10.73	0.19	10.38	11.38
Housing wealth	612	0.28	0.05	0.16	0.49	0.25	0.04	0.16	0.49	0.30	0.04	0.20	0.49
Log housing wealth	612	-1.30	0.17	-1.82	-0.71	-1.38	0.16	-1.82	-0.72	-1.22	0.13	-1.59	-0.71
Income	612	40822.68	7070.37	28932.12	68163.76	42904.23	7327.22	30947.82	68163.76	38794.84	6179.77	28932.12	62126
Log income	612	10.60	0.16	10.27	11.13	10.65	0.16	10.34	11.13	10.55	0.15	10.27	11.04
Mortgage debt	612	31244.88	11563.55	10719.07	73698.60	34325.91	12538.54	15042.71	73698.60	28243.37	9640.62	10719.07	58628.72
Log mortgage debt	612	10.28	0.37	9.28	11.21	10.38	0.37	9.62	11.21	10.19	0.34	9.28	10.98
Building permits	612	1621.38	2503.63	11.00	20176.00	1952.54	2878.15	11.00	17836.00	1298.76	2028.16	38.00	20176.00
Log building permits	612	-8.48	0.69	-10.87	-6.51	-8.51	0.69	-10.87	-6.51	-8.45	0.69	-10.33	-6.76
Unemployment rate	612	6.82	2.17	2.50	14.40	7.22	2.20	2.50	13.90	6.44	2.08	2.70	14.40
Log unempl. rate	612	1.87	0.32	0.92	2.67	1.93	0.31	0.92	2.63	1.81	0.31	0.99	2.67
Population (in 1,000)	612	6028.55	6754.07	509.11	39000.00	7503.32	8581.55	567.14	3900.00	4591.84	3777.37	509.11	18700.00
Log population	612	15.11	1.03	13.14	17.48	15.24	1.14	13.25	17.48	14.98	0.90	13.14	16.74

Note: All dollar values are expressed in real per-capita terms. The two subsamples are divided according to the median homeownership rate, which is 69.60 percent.

Our housing wealth variable is constructed according to Case et al. (2005) as follows:

$$V_{it} = R_{it} N_{it} I_{it}, \tag{4.1}$$

where V_{it} is the aggregate (owner-occupied) housing wealth, R_{it} is the homeownership rate, N_{it} is the number of households and I_{it} is a real house price index (in state i and year t for all the aforementioned variables).

4.4 Results

4.4.1 Regressions of consumption

Regression (1) in table 4.2 shows consumption as a function of housing wealth computed according to Case et al. (2005) as well as mortgage debt and income from 2005 to 2014. In this regression, we deliberately do not try to reduce endogeneity. As a result, we can confirm the housing wealth effect on consumption that has been found in many previous studies, as our estimated elasticity is significant and large. However, the coefficient on income is unrealistically low, as according to Campbell and Mankiw (1990), it should be in the range 0.3–0.7. Moreover, mortgage debt has a negative sign. This stands in contrast with, e.g., Benjamin and Chinloy (2008), who find that consumption increases in mortgage debt when credit constrained households borrow to consume. These results hold true also when we analyze subsamples in columns (2) and (3) of the same table.

The coefficients in table 4.2 are a consequence of endogeneity bias induced by using endogenous explanatory variables, as discussed by Calomiris et al. (2009). Therefore, in a next step, endogeneity will be reduced by instrumenting the endogenous independent variables with up to their third lags.

Table 4.2: Fixed effects regression of changes in consumption.

	(1) Full sample	(2) Low	(3) High
Housing wealth	0.1352***	0.1382***	0.1269***
	(0.000)	(0.000)	(0.000)
Mortgage debt	-0.1777***	-0.1922***	-0.1497***
	(0.000)	(0.000)	(0.000)
Income	0.0599**	0.0647**	0.0451
	(0.020)	(0.044)	(0.307)
Constant	0.0080	0.0088	0.0065

Note: p-values in parentheses. ***, **, and * refer to significance levels of 1%, 5%, and 10%, respectively. All constants are significant at the 1% level. The dependent variable is differences in log consumption. The independent variables are log differences lagged by one period, which does not correct for endogeneity issues. All values are in per-capita terms.

We decided to omit state-fixed effects for two reasons. First and foremost, the number of regressors becomes too large compared to the number of observations. Because we use 2SLS, which has no built-in fixed effects option, every state enters the regression with its own dummy variable, which uses up degrees of freedom. Second, the state dummies turned out to be mostly insignificant. This could be the case because once we subdivide our sample into subgroups based on their homeownership rate relative to the median, it is likely that a lot of state-specific heterogeneity is lost when placing them in two buckets with likely similar within-groups characteristics.

Column (1) in table 4.3 shows that, once endogeneity is corrected for and the whole dataset is used, the housing wealth effect vanishes when mortgages and income are kept constant: the effect is almost zero and insignificant. The mortgage variable, by contrast, has a positive sign and is significant. Households seem to increase their mortgage debt in order to consume, which confirms the results found by Benjamin and Chinloy (2008). The coefficient on income is significant and positive and in the typical 0.3–0.7 range as postulated by Campbell and Mankiw (1990).

Table 4.3: IV regression of changes in consumption.

	(1) Full sample	(2) Low	(3) High
Housing wealth	-0.0080	0.0031	0.1757**
	(0.759)	(0.902)	(0.034)
Mortgage debt	0.0725**	0.1263***	-0.2916**
	(0.016)	(0.000)	(0.050)
Income	0.5075***	0.3095***	0.0040
	(0.000)	(0.002)	(0.986)
Constant	0.0133	0.0171	0.0219
Year fixed effects	Yes	Yes	Yes

Note: p-values in parentheses. ***, **, and * refer to significance levels of 1%, 5%, and 10%, respectively. All constants are significant at the 1% level. The dependent variable is differences in log consumption. The independent variables are instrumented by log differences up to their third lag. All values are in per-capita terms.

When we concentrate on households in low-homeownership states, the above result is largely confirmed. These results are documented in column (2) of table 4.3. The income coefficient has a plausible size and the mortgage coefficient is positive and significant. But again, there is no housing wealth effect. One explanation for the result that increases in housing wealth exert no effect on consumption is that consumption may be mainly financed by household income. This is justified on the grounds that in the low-homeownership sample, incomes are significantly higher on average than in the upper half of the distribution. Again, the coefficient on income lies in the 0.3–0.7 range found by Campbell and Mankiw (1990).

According to some studies, a non-existing housing wealth effect is not implausible. With a representative-agents model, Buiter (2010) argues that when house prices increase, there is only a redistributive effect of wealth from those long housing (i.e., those who expect to decrease their housing services, e.g., the elderly) towards those short housing (i.e., those who expect to increase their housing services, e.g., younger households), as the marginal propensities to consume across those two groups are the same: when homes are traded between two households, someone's losses are simply someone else's gains. The theoretical model by Sinai and Souleles (2005) confirms this idea. Alternatively, the authors point out that an increase in house prices simultaneously increases housing liabilities and therefore, the housing wealth effect should at best be small. Furthermore, households with a bequest motive may decide to consume less from their housing wealth (Skinner, 1989).

Lastly, we focus on households in high-homeownership states. Interestingly, in that subsample, the housing wealth effect becomes positive and significant whereas the effect of income on consumption completely disappears. This large housing wealth effect could be explained in light of social benefits of homeownership: in this subsample, the homeownership rate is above-average and neighborhoods are therefore predominantly characterized by homeowners rather than renters. That is, social benefits of homeownership may play a dominant role in this subsample. Various studies (e.g., DiPasquale and Glaeser, 1999; Engelhardt et al., 2010) confirm that homeowners invest more in local amenities and home improvements in order to maintain their neighborhoods. Therefore, the housing wealth effect in these areas might be larger and significant. However, this explanation should be treated with caution, as housing wealth is a function of house prices, which in turn is a function of investments in local amenities and improvements, rendering house prices possibly endogenous.

Moreover, when income and housing wealth are controlled for, an increase in mortgage debt decreases consumption. The short-run effect of a rise in house prices may be that consumption is expanded; however, households cannot consume their housing equity indefinitely. At some point in time, this additional debt has to be paid off. Therefore, the above result points to the possibility that homeowners who have borrowed heavily against their housing equity in the past are eventually inclined to pay off their debt.

4.4.2 Regressions of GDP

Table 4.4: IV regression of changes in GDP.

	(1) Full sample	(2) Low	(3) High
Housing wealth	-0.1254	0.1085	-0.2673*
	(0.361)	(0.446)	(0.053)
Real income	1.4644**	0.9790**	1.0800*
	(0.016)	(0.033)	(0.061)
Building permits	-0.0296***	-0.0208**	-0.0318***
	(0.003)	(0.050)	(0.006)
Unemployment rate	-0.0053*	-0.0037	-0.0069
	(0.090)	(0.306)	(0.113)
Population growth	-0.5042	-0.9530**	-0.5724
	(0.234)	(0.043)	(0.276)
Constant	-0.0362*	-0.0254*	-0.0142
	(0.051)	(0.088)	(0.483)
Year fixed effects	Yes	Yes	Yes

Note: p-values in parentheses. ***, **, and * refer to significance levels of 1%, 5%, and 10%, respectively. The dependent variable is differences in log consumption. Housing wealth and mortgages are instrumented by log differences up to their third lag. All values except the population growth and unemployment rates are in per-capita terms.

Consumption is included in the calculation of GDP. If housing capital affects consumption, then one may conclude that it affects GDP. Therefore, in table 4.4 we analyze GDP growth at the U.S. states level as a function of housing wealth. Moreover, we follow Miller et al. (2011) and include income, the number of building permits, unemployment, and population growth as control variables. Again, all variables are log differences and instrumented as in the previous section.

The results for the full sample are presented in column (1). We find that the coefficients on income, unemployment and population growth have the expected signs; however, the latter is insignificant. The number of building permits depresses GDP growth significantly. However, there is no offsetting positive effect of housing wealth on GDP growth in the full sample; the coefficient is negative and insignificant. To further investigate this result, we again divide our sample in states with homeownership rates lower than or higher than the median homeownership and report the results in columns (2) and (3) of table 4.4.

We find that there is no significant reduction in GDP associated with housing wealth in states that do not overinvest in homeownership (column (2)). However, there is a relatively large and significant reduction in GDP growth in states with excess homeownership (column (3)). In both cases, the number of building permits is held constant. Our intuition for this result is that excess homeownership causes individuals to underinvest in other economic activity. The reason may be overinvestment in housing construction and housing-related consumption, as was shown in column (3) of table 4.3. In addition, the fact that building permits have a more detrimental effect on GDP growth in high- than in low-homeownership states can be seen as further evidence for our hypothesis, since an additional housing unit in states where there is already high homeownership may harm economic growth. We interpret this result as a broad confirmation of Mills (1987), who reports that a dollar investment in residential capital yields only half the return of a dollar investment in non-residential capital. Therefore, too much homeownership may have adverse effects on the economy. This overinvestment in housing may be induced by an economic distortion caused by the mortgage debt tax shield (Hendershott and Hu, 1981, 1983).

4.5 Conclusion

Most studies of the housing wealth effect have found a positive impact of housing wealth and consumption. However, there is reason to believe that these results may be subject to endogeneity issues (Calomiris et al., 2009). We therefore re-examined the housing wealth effect in the U.S. states but ran IV regressions in order to safeguard against endogeneity bias.

Furthermore, we argued that housing wealth as it is computed by, e.g., Case et al. (2005) may not be real wealth because homeownership usually involves high levels of debt. That is, when mortgage debt increases, house prices are not a good measure of housing wealth. For example, if the mortgage debt more than doubles while house prices only double, then Case et al.'s measure would inaccurately indicate an increase in housing wealth. We therefore studied how capital tied up in housing affects consumption while explicitly controlling for mortgage debt.

Lastly, we studied the implications of housing wealth conditional on high vs. low homeownership rates for both consumption and economic growth. That is, we analyzed two mutually exclusive subsets of states separately which we based on the upper and lower half of the homeownership distribution.

Our results indicate that in the whole sample and the low-homeownership subsample, there is no housing wealth effect on consumption. However, in states with high levels of homeownership, consumption increases with housing wealth. We attribute this to the existence of social benefits to homeownership, which give households an incentive to spend on local amenities. Moreover, we find that in these same high-homeownership states, there is a significant and negative effect of housing wealth on GDP, which is not present in states with lower rates. We see this as a confirmation of the research conducted by Mills (1987, 1989) and Hendershott (1989), who showed that the social return to housing capital is considerably lower than that to non-housing capital. Households in states with many neighboring homeowners spend more on local amenities and thereby underinvest in other business activity. This is also a consequence of the U.S. tax code, which subsidizes homeownership and may create economic distortions (Hendershott and Hu, 1981, 1983). We therefore conclude that the answer to the question whether governments should encourage homeownership is "it depends": even though homeownership may fuel consumption, this does not necessarily translate into an increase in GDP—especially not when there is already overinvestment in housing.

Chapter 5

Home is where the Health is: Housing and Adult Height from the Late 19th to the Mid-20th Centuries

5.1 Introduction

Health, which is a crucial component of welfare, is heavily influenced by a person's exposure to disease environment and sanitation in the early years of life, and was especially so during the 19th and early 20th centuries when knowledge about hygiene and disease was not widespread. However, little attention has been paid to the possible relationship between housing—as being an important part of someone's environment—and that person's health between 1870 and 1965. This paper argues that sanitation and better living standards, and thus the ability to mitigate health hazards, are reflected in the quality of housing which a person enjoys over their lifetime. The quality of housing can be proxied by the value of a home, which was recently confirmed by Eichholtz et al. (2017)

who constructed rental price indices for seven major European cities over the past 500 years. They concluded that most of the house price increases were due to improved housing quality—which includes, for instance, heating, access to water and sewers—rather than to rising market values or local monopoly behavior of landlords. At the same time, average human height has increased as well in some of the decades and countries under study, giving rise to this paper's research question.

On the one hand, we would expect higher housing prices to reduce real income, ceteris paribus, and the quality of nutrition and health spending. On the other hand, better and healthier housing required investments that were paid via the rent or house prices. It is an empirical question which of the two influenced health stronger. This paper hypothesizes that rising house prices, interpreted as house quality improvements, led to taller final adult heights during the period between 1870 and 1965. A more expensive house may be healthier than a less expensive one. This decreases the density of people per room or house, which lowers the risk of the spread of infectious diseases such as diarrhea or tuberculosis. Moreover, expensive houses feature better sanitary facilities than houses of lower value, as demonstrated by Eichholtz et al.. Therefore, this paper hypothesizes that less crowding and better sanitary standards such as clean bathrooms, access to water, and wastewater disposal that have been established over the past two centuries have contributed to the real house price increases in some countries, which are depicted in figure 5.1, whereas in other countries, housing prices did not rise much before the 1960s. Improvements in disease environment due to housing could have led to better health and therefore rising adult heights.

So far, no study has interpreted house prices as an indicator of the quality of housing and potential disease environments to study this relationship. But it has been criticized that studies on human stature had frequently omitted the cost of housing, which likely led to an overestimation of the influence of income

Figure 5.1: Historical real house prices, 1870–1965 (1990=100).

Note: The curve representing average house prices is based on available data and therefore does not include all countries at all times. *Data sources:* Jordà et al. (2017); Knoll et al. (2017)

(Komlos, 1998) or food consumption (Margo and Steckel, 1983) on adult height. The purpose of this paper is therefore to shed light on the relationship between housing quality and human stature while controlling for several well-known determinants of height. To this end, this study uses real house price and height data for a sample of 14 countries over the years 1870 to 1965. We end the period in 1965 because thereafter, a strong an monotonous upward trend sets in, which reduces the possibility to clearly identify height determinants, as their might be unit root problems. Moreover, it has been argued that height gradually loses its health indicator function because even lower income strata could afford a good condition of health.

The next section will expand on the causal relationship between housing and health as well as on historical developments in this area. That section will also motivate the empirical research. Section 5.3 will discuss the data and methodology used to analyze the research question before section 5.4 will eventually provide answers and discussions. Section 5.5 concludes.

5.2 Literature review on housing and health

Because there is no widely accepted, unambiguous indicator of public health that was recorded for all countries for the time before the 1950s, adult height can be drawn upon as a proxy for the biological standard of living since much of it is determined by nutrition and diseases that the person experienced during the first three years of childhood (Margo and Steckel, 1983; Case and Paxson, 2008). Amongst others, height is positively related with labor market outcomes and is thus an indicator of welfare and human development (Strauss and Thomas, 1998; Deaton, 2003; Case and Paxson, 2008; Steckel, 2009).

Hence, height potential is strongly correlated with one's socio-economic status. In fact, Silventoinen (2003) estimates that 20 percent of the variation in height can be attributed to changes in one's environment. Since especially food consumption plays a major role in household expenses, changes in height are foremost a consequence of changes in one's economic conditions (Komlos, 1987). Thus, height has become an established proxy for the biological standard of living in the economic history literature (e.g., Komlos, 1985, 1993; Deaton, 2008; Baten and Blum, 2012; Baten et al., 2013; Baten and Blum, 2014; Akachi and Canning, 2015). Height measures can be found in military or prison records, for instance, and are nowadays readily available (Baten and Blum, 2012).

There is a consensus in the literature that housing is a key determinant of public health. A number of studies (e.g., Dunn, 2002; Evans, 2003; Northridge et al., 2003; Diez Roux, 2003; Thomson et al., 2009; Egan et al., 2013) have found that housing which offers healthier living conditions has positive impacts on both physical and mental health, whereas housing in poorer living conditions has the opposite effect.

In general, two channels through which housing affects health can be identified (Shaw, 2004): first, the "hard" factors, e.g., temperature, humidity, ventilation, toxins, or homelessness; and second, the "soft" factors, e.g., the low social status attached to housing debt, deprived neighborhoods, etc. Poor housing can lead to high blood pressure and serum cholesterol, allergies and asthma, infectious and respiratory diseases, and similar health problems.

The relationship between poor housing conditions and ill health holds true across various geographical, cultural, and temporal contexts; and it is important to recall that illnesses affect adult height mostly early in life; namely during childhood, when diseases use up nutrients and lead to a negative net nutritional status which impairs growth. Diseases after an adult has reached their final height do not affect the dependent variable in my analysis anymore. Hence, height is always organized by birth cohorts.

Two possible sources of diseases, which are related to poor housing quality, will be discussed in the following: poor sanitation and overcrowding. Sanitation is an undisputed determinant of public health; yet there were times when the effects of sanitation on public health were unknown or difficult to handle. Poor hygiene during the industrial revolution, for example, was mainly due to low wages, minimal investment in public health services as well as uncontrolled and ill-planned city and slum growth (Evans, 2004), causing sanitation and living conditions in the European and American cities to deteriorate significantly (Konteh, 2009). As a consequence, overcrowded, damp and unclean houses and cities led to massive outbreaks of cholera, tuberculosis, diarrhea, and whooping cough (Shaw, 2004). Evans (1988) elaborates on the six waves of cholera that spread over Europe, where most of the sampled countries for the present study are located. Three of these waves happened in the sampled time period (1863–74, 1881–96, 1899–1923) and could have been favored by poor quality of housing, e.g., poor hygienic standards or overcrowding.

The British Parliament passed the first Public Health Act in 1848, which suggested that health is determined by sanitation and revolutionized this field. Subsequently, municipal boards of health received the mandate to supervise and regulate public sanitation (Tulchinsky and Varavikova, 2014) and thereby tried to contain the spread of diseases. Similar developments have been witnessed in other parts of the world, e.g., with the formation of the Massachusetts Sanitary Commission in 1850, Max von Pettenkoffer's public lectures on health in the 1870s in Munich, etc. (Tulchinsky and Varavikova, 2014). However, these improvements took place very slowly, especially as rapid city growth increased the problems at the same time. Better disease control improved health not much before the 20th century (Easterlin, 1999).

Hatton and Bray (2010) studied heights of European men in the 19th and 20th centuries and found an average increase of about 1 centimeter per decade. While the southern European countries experienced accelerated growth between 1951 and 1976, northern and middle-European men grew the most in the transwar period, after which growth rates returned to more modest levels. The authors attribute the strong growth between 1911 and 1955 to a fall in the relative price of food as well as to a significant improvement in urban sanitation.

The relationships between sanitation, housing quality, and health have been studied empirically for today's developing countries. Vyas et al. (2016), for instance, analyze the height of Cambodian children from 2005 to 2010 and find that better sanitation accounts for an increase in child height. In Cambodia, more than three-quarters of all households defecated in the open as late as in 2005. This rate was reduced to two thirds by 2010. As soon as sanitation improved, i.e., open defecation was reduced, children started to grow taller than before. Also in the 19th and early 20th centuries, open defecation and shared privies have been identified to be the most common sources of infections as most houses during this period did not have their own sanitary arrangements.

In fact, according to Meeker (1971), deaths caused by infectious diseases in U.S. cities only started to diminish after a sanitary revolution in the 1880s. This change was triggered by a preceding severe yellow fever epidemic in Memphis, Tennessee; sparking an interest in public health. Yet, it was only in the 1930s that (mostly tiny) bathrooms became the standard in American homes (Cowan, 1976).

The link between housing quality and health was also studied longitudinally. Marsh et al. (2000), for instance, conclude that adult ill health is more likely among people who lived in poor housing conditions in their younger days. Likewise, Mendall et al. (1992) report that a lack of hot water supply in earlier life favors the spread of *helicobacter pylori*, a bacteria found in the digestive tract, which can cause gastritis, gastric ulcers, and cancer. Coggon et al. (1993) analyze a sample of more than 8000 English men and women who were born after 1900 and conclude that children living in houses without hot water exhibited higher death rates from diseases as adults. Moreover, besides the lack of household amenities and appropriate sanitation, both aforementioned studies identify domestic overcrowding as one reason for the observed health hazards.

An important determinant of health is crowding in houses. Using infant mortality rates, Cage and Foster (2002) compare overcrowding in Scotland during the first half of the 20th century and conclude that average room density led to much worse outcomes in Glasgow than in Edinburgh where houses were less crowded. Likewise, analyzing data from the Census of England and Wales on over 21 million births given by roughly 6 million women, Haines (1995) reports that infant and child mortality between 1890 and 1911 was considerably higher for households with a low number of rooms. In fact, the detrimental effect on child mortality almost halved when the number of rooms per house increased from 1 to more than 10. Even though the study does not clarify whether the number of people per room diminished when the number of rooms rose, a study by Clark (2002) reports that the average density per house in England and Wales decreased from 5.17 persons in 1870–1879 to 4.99 in 1900–1909. This suggests that height gains could be (partly) due to more generous housing space per capita. In a study similar to that by Haines, Kuh and Wadsworth (1989) examine a panel of English, Welsh and Scottish people born in the same week in March 1946 and find that having lived in overcrowded conditions (more than 1.5 people per room) up to age eleven led to 4 cm shorter adult height compared to adults who had not experienced such conditions in childhood.

Our study hypothesizes that less overcrowding results in higher prices and therefore, disease environments should be less demanding. There are two reasons for this argument. First, infectious diseases are easily transmitted in overcrowded places. Hence, more spacious houses per family, which tend to be costlier, should mitigate the spread of such diseases. And second, sanitary facilities add space to a house. A bathroom requires at least one additional room and the necessary infrastructure such as drain pipes, taps, and boilers, has to be installed. Therefore, houses with better sanitary facilities should be more expensive on average. However, better sanitation alone does not account for an improvement in health as it can hardly mitigate the spread of respiratory diseases such as tuberculosis which are mostly transmitted through the air. Therefore, it is also necessary to additionally take (over)crowding into consideration as one determinant of housing quality. For the empirical part of this paper, however, it has to be noted that the present analysis does not take into account that there were different house and room sizes, as has been done by Cage and Foster (2002). Instead, it is simply assumed that a room density of, say, 1.5 people per room harbors more health hazards than a lower room density. Such a case would be reflected by a lower house price.

The idea that additional rooms, a bathroom or household amenities such as water supply could increase house prices is not far-fetched and has been shown using a hedonic price model estimated by, e.g., Margo (1996)—albeit for rental prices in a slightly different time period (1830–1860). He analyzed rental announcements in the newspaper and found that additional rooms and additional bathrooms increased the cost of renting in New York. Among other variables, he determines the partial effects of the number of rooms per dwelling, the presence of a bathroom, and the quality "modern" on logarithmic rent prices per day. Modern rental units are dwellings that feature improvements such as gas and water supply. Table 5.1 reports these regression coefficients, which show by how much a certain characteristic can increase the daily rent price in percent. More recent work by Eichholtz et al. (2017), who construct rental price indices for seven European cities from 1500 to present, has confirmed that housing prices have increased because of better housing quality (including increased housing space per capita, heating, water supply, and the like) rather than because of rising market prices. Even though these two studies construct rental price series, the logic that additional quality increases housing costs also holds for house prices, as the price of a house can be viewed as the present value of perpetual rent.

Table 5.1: Rental price premiums for certain dwelling characteristics.

	Non-New York City	New York City
Number of rooms (log)	0.775	0.746
	(14.100)	(22.651)
Bath	0.149	0.110
	(1.582)	(2.474)
Modern	0.078	0.129
	(1.437)	(3.371)

Note: t-values in parentheses. *Source*: Margo (1996)

Public health and living conditions actually deteriorated during the years of the industrialization and only improved slowly during the late 19th and early 20th centuries. Particularly in the 19th century, this was mainly due to massive and unplanned urbanization, little investment spent on sanitation as a public good, and the mostly unknown or ignored link between poor hygiene and ill health. At the same time, house prices increased, raising the question whether there could be a causal relationship between the two.

It is also well understood how housing quality, which entails appropriate sanitation, household amenities, and low crowding that a person did or did not enjoy during his or her early years, impairs their health and adult height. The question of interest is therefore if the improvement in housing quality over the observed period had a measurable impact on human stature or if increasing house prices rather reduced a household's disposable income and therefore impaired health.

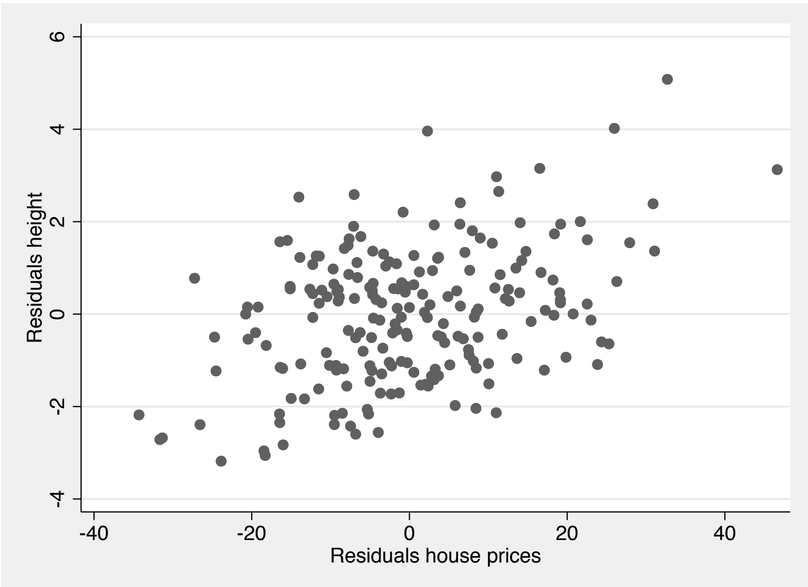
5.3 Data and method

To study the hypothesized relationship, nominal house price data is taken from Jordà et al. (2017) and Knoll et al. (2017). These prices were deflated using the CPI and are actual values that are not interpolated. In contrast, some control variables are interpolated to get 5-yearly data and thus guarantee sufficiently large sample sizes. The analyses are based on 5-yearly data.

Male height data is sourced from Baten and Blum (2012) and mostly based on military data. The authors used several techniques to obtain a dataset of male adult height that is representative of the countries under study. For instance, in cases where height data of teenagers was used, the authors estimated the likely final, adult height of these teenagers. Furthermore, potential biases arising from migrant populations were eliminated by adjusting their heights by appropriate centimeter differentials, yielding data that more accurately reflected adult heights in the country of destination. Moreover, since it has been shown that men tend to overestimate their stature, self-reported heights were corrected using the method proposed by Hatton and Bray (2010). In general, different biases pertaining to, for instance, the incarceration in prison or slave trade were taken care of with great effort.

House prices are used as proxies for increasing housing quality, i.e., less crowding in houses and better sanitation, which is hypothesized to have a positive influence on adult height. Figures 5.2 and 5.3 depict this relationship and suggest a positive correlation. The correlations between height and house prices at the country level are graphed in figure 5.5 in the appendix.

Figure 5.2: House price residuals against height residuals.



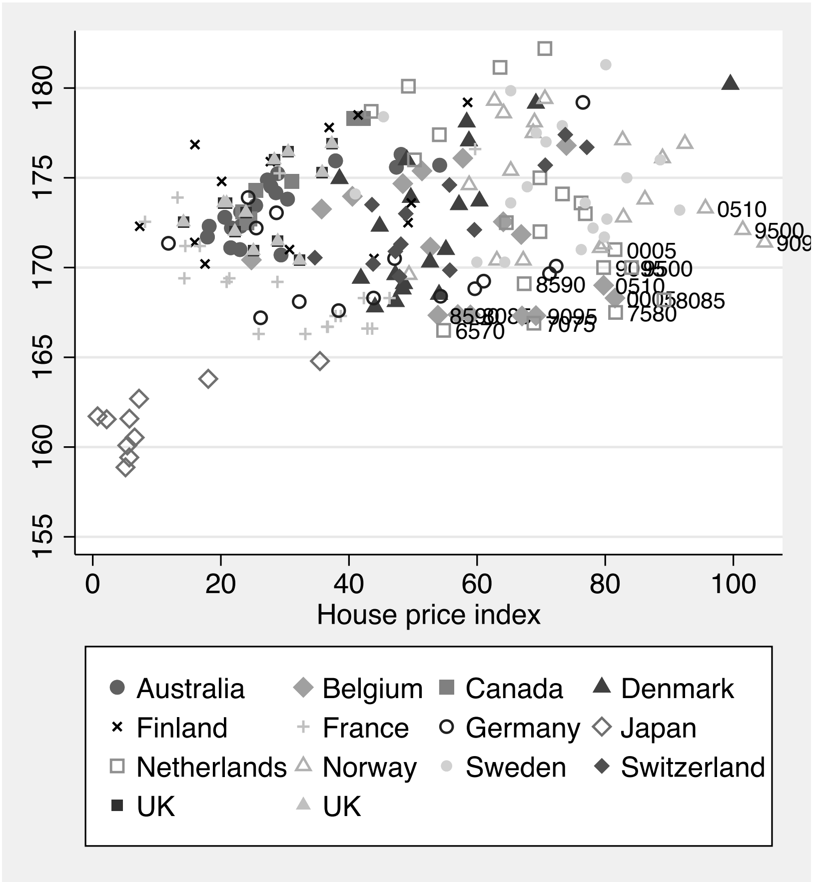
Note: This figure plots the residuals from a regression of house prices on the explanatory variables against the residuals from a regression of height on all explanatory variables but house prices. *Data sources:* Jordà et al. (2017); Knoll et al. (2017) for house prices and Baten and Blum (2012) for adult height.

It may be objected that the housing markets may have been influenced by strong market power of house owners or landlords who could set prices above the fair value of a house, especially in the earlier half of the studied period. However, the historical housing literature does not agree with this hypothesis: Morgan and Daunton (1983), in contrast, report that tenants in England gained even more legal power than landlords towards the late 19th century. Even though legal power is not necessarily the same as market power, it could be argued that landlords could have faced legal action if they had required horrendous rents and house prices. Furthermore, Eichholtz et al. (2017) report that rental markets in Europe were not dominated by monopolistic landlords.

Figure 5.3 reveals some moderate outliers: Belgium, the Netherlands, and Norway. These countries display relatively high house prices between 1865 and 1905 for given height levels (for greater detail, please refer to figure 5.4). The original sources that Knoll et al. use for that period rely on urban house price data from Brussels, Amsterdam, and Oslo, and therefore, explanations for the national house price developments may be found by taking a look at the economic developments in these three capitals. In the case of Amsterdam, house prices may have been driven upwards because of a strong increase in the population of Amsterdam in the second half of the 19th century, while the supply of housing remained more or less constant (Eichholtz, 1997). In Oslo, house price surges may be traced back to the booming construction sector starting in the decade 1890–1900 (Eitrheim and Erlandsen, 2005). Lastly, for the case of Brussels, De Bruyne (1956) mentions that the upward development in house prices in the decades around 1900 coincide with a boom in the Brussels economy. In a nutshell, the inverse relationship between house prices and health at the country-level are likely driven by the exceptional house price developments in the aforementioned capitals. However, section 5.4 will demonstrate that the overall positive relationship between the two variables is not affected by these outliers.

Merging the datasets by Jordà et al., Knoll et al. and Baten and Blum results in a final sample of 14 countries. This sample contains Austria, Belgium, Canada, Switzerland, Germany, Denmark, Finland, France, Japan, the Netherlands, Norway, Sweden, the United Kingdom, and the United States of America. Even though the data are available to present, this study deliberately looks only at the period 1870–1965 since after that, houses have started to become also a financial asset besides providing shelter. Therefore, it cannot be guaran-

Figure 5.3: House prices and height across countries and years.



Note: A more detailed representation of the outliers can be found in figure 5.4. *Data sources:* Jordà et al. (2017); Knoll et al. (2017) for house prices and Baten and Blum (2012) for adult height.

teed that house price increases after 1965 have only reflected improvements in quality and not higher demand.

Another factor contributing to welfare is nutrition. This link is twofold. First, better nutrition is a result of higher income because higher-quality foodstuffs become available. And second, the composition of the nutrition determines health and human stature (Hatton, 2013). In fact, a person's net nutritional status in the first few years of life determines most of their adult non-genetically determined height (Komlos, 1987, 1993; Case and Paxson, 2008; Sunder, 2013; Baten and Blum, 2014). More specifically, the intake of animal proteins such as from cattle, which (among other things) favor the development of antibodies and amino acids to fight infectious diseases (Grigg, 1995; Baten, 1999), and calcium have proven to be important determinants of physical growth (De Beer, 2012). By contrast, a person who supplies physically demanding labor over a long term is shorter than a less physically-hard working person because the first uses up more nutrients.

Even though these nutrients can be supplied by a variety of foodstuffs, cattle per capita is used here to proxy protein and calcium intake for two reasons; on one hand because cattle were kept in all the sampled countries and on the other hand because they can supply both meat (protein) and milk (calcium), as opposed to pigs, for example, which cannot be milked. Data on protein intake are sourced from Baten and Blum (2014).

Furthermore, income is used as a control variable for two reasons. First, individuals tend to self-select into renting or owning depending on their income or social class, which might affect their health[1]. Macintyre et al. (2003) survey owners and renters of social dwellings in west Scotland and find that owners lead healthier lives than renters. Luginaah et al. (2010) find similar results for owners and renters in Ghana. Consequently, this implies that, because individuals with higher incomes tend to be homeowners rather than renters, the first may be taller than the latter. Moreover, Evans (1988) reports that income is negatively correlated with cholera death numbers.

Second, house prices can have a positive and a negative impact on human stature. The positive impact has already been explained in detail. The negative impact can arise because more expensive housing cuts disposable household income and thus impairs access to health services, healthier housing conditions, and quality nutrition. Adjei and Kyei (2013), for instance, conclude that poor-quality housing and sanitation conditions in Ghana are determined by low household income levels. The inclusion of income should eliminate these

[1]For an extensive overview of further possible explanations, see Dietz and Haurin (2003).

problems and permit comparison of households with identical income. At the end of the day, however, the question whether the positive or negative effect will predominate is mainly an empirical issue. Since the data for laborers' real wage are scanty, real GDP per capita growth is used to proxy income.

A number of control variables are used to preclude omitted variable bias. Population density is used as another control variable as it may be healthier to live in cities that are less densely populated because the lower risk of spread of infectious diseases. Long-term interest rates by Jordà et al. (2017) are included too: they should proxy the cost of buying a house and make sure that this cost is not captured by the house price variable.

The inclusion of other variables measuring inequality would have been desirable. However, since democracy values did not vary a lot over the observed time and countries, they could not be considered explicitly because of the fixed effects regression. The same is of course true for the proportions of mountainous areas in a country, which have an effect on the variety of foods and animals that can be grown and consumed. Table 5.2 provides an overview of the included variables.

Fixed effects method is employed because it is reasonable to believe that there are unobservable country characteristics that would lead to endogeneity problems if omitted. Moreover, this methodology filters out the genetically determined growth potential in each society and permits analysis of the remaining 20 percent of body height growth that is non-genetic (Silventoinen, 2003). To control for aggregate trends around the globe, birth half-centuries are used as time dummies, which allows to differentiate between certain birth cohorts. Moreover, standard errors are heteroskedasticity-robust and clustered around countries to safeguard against potential serial correlation.

Table 5.2: Descriptive statistics, 1870–1965.

Variable	Obs.	Mean	SD	Min.	Max.
Height	280	171.53	4.90	156.57	182.2
House prices	221	49.66	23.75	0.75	104.90
Population density	280	88.62	87.63	0.23	362.81
Cattle (p.c.)	250	0.54	0.53	0.01	3.24
Cattle (p.c., ln)	250	-0.96	0.91	-4.41	1.18
Interest rate	274	4.49	1.67	2.21	16.40
GDP growth (p.c.)	280	0.10	0.16	-0.53	1.23

5.4 Results

The following analysis focuses on examining the relationship between housing quality and a person's biological standard of living. The data are actual observations; only the cattle variable has been interpolated because otherwise the sample would have shrunk significantly due to missing values. This should not be problematic, however, since cattle is not of central importance.

The results of the baseline regression are reported in table 5.3. All regressions are carried out with time fixed effects based on birth half centuries and with standard errors that are clustered by country. The first column contains the regression results including only house prices and time fixed effects. The results in the adjacent columns (2) to (5) show that adding more control variables does not change the relationship between house prices and final adult height qualitatively or quantitatively. In the first four columns, the coefficient of house prices is significant at the 1 percent level. A one-point increase in the real house price index thus leads to a gain in final adult height by 0.04 to 0.05 cm. The coefficient of per capita GDP growth is also positive and statistically significant. This coefficient captures the effect of disposable household income net of food expenditures, housing financing costs, and other housing-related expenses, which are already controlled for separately by the other variables. Since the inclusion of income does not alter the effect that housing quality has on height, it can be concluded that even though theoretically, increasing house prices may adversely affect household income, this effect cannot be witnessed here. In two countries with identical income, the person with the higher-quality—and thereby more expensive—house is on average taller and therefore healthier.

Population density turns out to be positively related to height. This seems counterintuitive as one would think that densely populated places are more hazardous to health than ones with lower population density. However, this result could also be interpreted differently: a person living in a loosely populated country might not easily have access to a doctor or a pharmacist, whereas a person living in a densely populated country might have a variety of health services available in their neighborhoods, which would result in a positive relationship with human stature.

Cattle per capita and long-term interest rates do not behave as expected. As for the cattle variable, it has been argued that it is just a rough proxy for the quality of one's nutrition. However, even though quantitatively, cattle was the most important provider of meat and milk, the composition of protein-rich nutrition could have changed over time (Baten and Blum, 2014) and therefore, cattle per capita may not capture protein and calcium consumption adequately. Nevertheless, at the end of the day, cattle and interest rates are not of central interest in this paper but were only included to safeguard against omitted variable bias.

Heights in the sampled countries rose by 10 cm over the period 1870–1965, while at the same time, average real house price indices gained roughly 30 points. According to the regression results in the first row in table 5.3, each of these points came along with a height increase of roughly half a millimeter. In total, the presented house price increases, which represent improving housing quality, were thus responsible for a gain in final adult height of roughly $30 * 0.05 = 1.5$ cm across the sampled countries. This seems economically insignificant. However, Baten and Komlos (1998) report that a height differential of 1 cm in 1860–1900 translated to 1.8 years of life expectancy. For 1950, 1 cm was equivalent to 1.2 years. Since this table shows results for the period between 1870 and 1965, it can be concluded that an increase of 1.5 cm came along with an additional life expectancy of between 1.2 and 2.7 years, on average, which is anything but insignificant.

Table 5.3: Housing and health, fixed effects: regression of height.

	(1)	(2)	(3)	(4)	(5)
Conventional coefficients					
House prices	0.05***	0.05***	0.04***	0.04***	0.04***
	(0.006)	(0.000)	(0.001)	(0.001)	(0.001)
Beta coefficients					
House prices	1.19***	1.09***	1.00***	1.05***	1.02***
	(0.006)	(0.000)	(0.001)	(0.001)	(0.001)
Conventional coefficients					
Population density		0.04***	0.05***	0.05***	0.04***
		(0.000)	(0.000)	(0.000)	(0.000)
Cattle p.c.			-3.10	-3.78*	-3.71*
			(0.154)	(0.062)	(0.064)
Interest rate				0.32**	0.30**
				(0.013)	(0.019)
GDP p.c. growth					1.11*
					(0.052)
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Constant	166.81	163.82	161.33	159.41	159.65
Observations	221	221	209	207	207
Adj. R^2	0.66	0.79	0.79	0.81	0.81

Note: p-values in parentheses. Standard errors are clustered by country. ***, **, and * refer to significance levels of 1%, 5%, and 10%, respectively. Time fixed effects are based on birth half centuries. Constants are significant at the 1% level.

While it is difficult to imagine how much a one-point increase in the real house price index is, running the regressions with standardized house prices might be more insightful. Therefore, table 5.3 also reports the beta coefficients of house prices in the second row, which show how strongly final adult height is affected when house prices change by one standard deviation. This can be viewed as a rather extreme case. The findings suggest that such an increase in real house prices leads to a gain in final adult height of between 1 cm and 1.20 cm. According to Baten and Komlos (1998), such an increase was equivalent to 1.2 to 2.1 more years of life expectancy.

As a final robustness check, the regressions were run without Japan, as after looking at figure 5.3, it could be suspected that Japan drives the results. However, by omitting Japan, the effect of house prices on height increases only marginally, i.e., by less than 0.02 mm per one-point increase, or 0.4 mm per standard-deviation increase in the house price index.

5.5 Conclusion

The literature on the biological standard of living in a historical context is vast and significant effort has been devoted to exploring the determinants of adult height. This paper made a contribution to this strand of the literature by quantifying two characteristics of housing quality—sanitation and crowding—which have, so far, only been vaguely subsumed under the term "disease environment". Taking this approach, this paper examined the influence of housing quality on human stature in the period from 1870 to 1965. After witnessing some severe epidemics especially in Europe, this period was marked by increasing awareness concerning the implications of sanitation for health, which was accompanied by improving sanitary standards and living conditions at home. This paper is the first to approximate housing quality with real house prices to study their effect on adult height. This approach stood to reason since house price developments reflected housing quality more than did higher demand (Eichholtz et al., 2017).

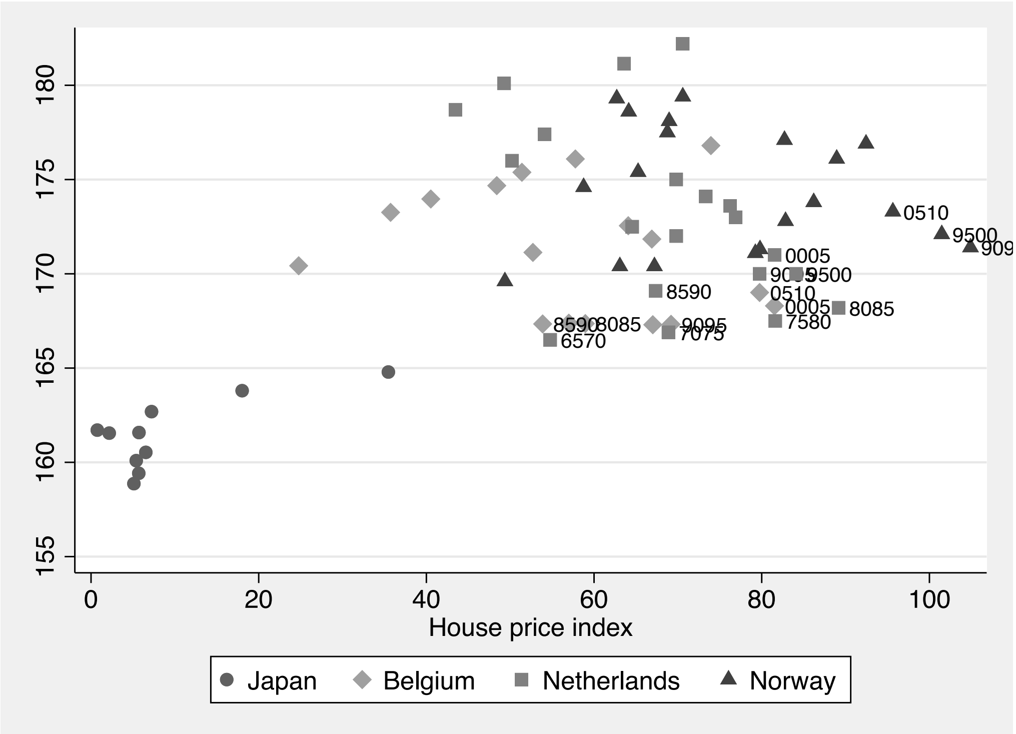
Across all model specifications, the coefficient of housing is statistically significant. This result implies that countries with better housing quality had taller populations. Possible explanations for this relationship are sanitary facilities that were added to the homes and more housing space per capita, which were both reflected by higher real house values. The average contribution of a one-point gain in house prices to adult height was 0.05 mm, or 1.5 cm over the studied period. A one-standard-deviation increase in real house prices came along with a 1.00–1.20 cm taller adult height. This was roughly equivalent to 1.2 to 2.1 more years of life expectancy (Baten and Komlos, 1998). Moreover, as soon as income is controlled for, this effect remains unchanged. This result implies that house prices do not adversely affect health via decreased household income.

This paper also acts on the suggestion by Komlos (1998) who criticizes that in past research, the effect of rising income on height was likely confounded with the effect of increasing housing costs. Hence, the impact of income on height was probably overestimated whenever housing costs were omitted from the analyses. Similarly, Margo and Steckel (1983) point to the possibility that increasing housing costs could have impaired access to high-quality nutrition, resulting in shorter adult height. This present study tackles these two points of criticism by separately controlling for house prices besides protein intake and income in order to disentangle these effects and isolate the contribution of housing quality to height.

Of the total 10 cm increase in average height across all the sampled countries, 1.5 cm could be attributed to increasing housing quality. This seems negligible at first sight but is a relatively large fraction of the total height increase in light of other, groundbreaking achievements during that period: one should not ignore the significant advances in medicine, food storing, or technological change, which without doubt improved living conditions so much that they accounted for the largest portion of these 10 cm. Against this backdrop, a contribution of housing quality to height of 15 percent is clearly impressive.

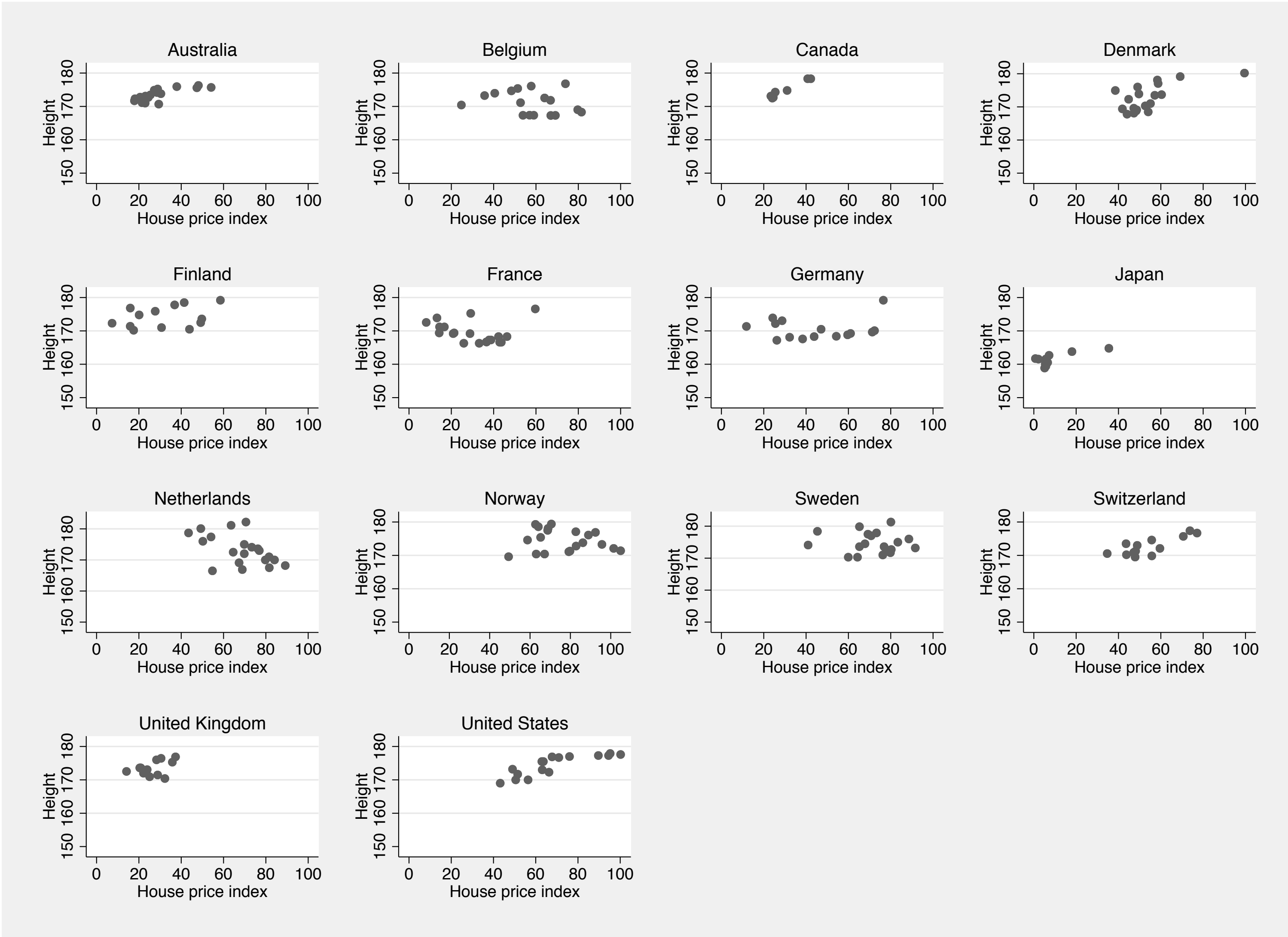
5.6 Appendix

Figure 5.4: House prices and height in Belgium, the Netherlands, and Norway.



Note: Japan is depicted as a reference point. The numbers in the graph refer to the 5-year periods which are represented by each data point (e.g., 8085 is the period 1880–1885).
Data sources: Jordà et al. (2017); Knoll et al. (2017) for house prices and Baten and Blum (2012) for adult height.

Figure 5.5: Correlation between real house prices and height by country, 1870–1965.



Chapter 6

Homeownership: Boon *and* Bane

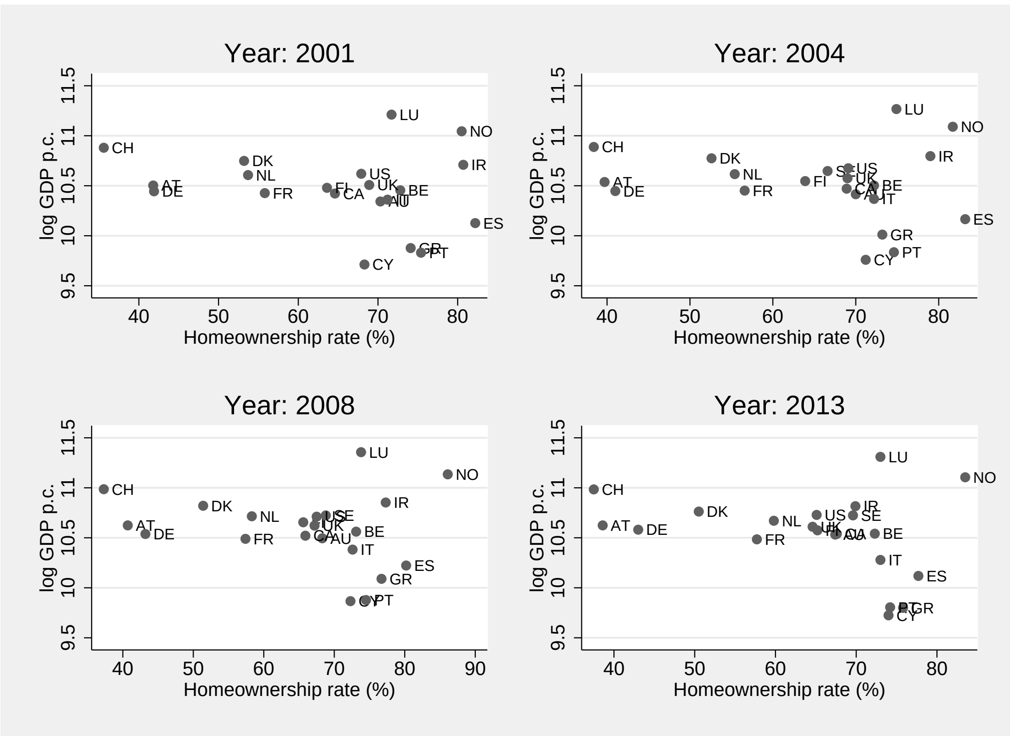
6.1 Introduction

The growth literature has long overlooked one factor that has the potential to inhibit economic growth: homeownership. Even though homeownership varies across countries, it plays an important role in an economy and its households. For example, according to the U.S. Census Bureau (2011), more than 65 percent of U.S. homes were occupied by their owners in 2010, and the largest part of an average household's consumption expenditures is being spent on housing and related services. Moreover, the aggregate value of median owner-occupied housing constituted almost 95 percent of the U.S. GDP in 2010[1]. Despite these figures, the relationship between homeownership and GDP growth has been largely ignored in past studies, while the body of literature on the positive relationship between homeownership and consumption is huge. Even though consumption is probably the most important component of GDP, it does not tell the whole story about GDP growth. In light of the recent financial crisis and the importance that is attached to homeownership, this gap in the literature is surprising.

[1] For this value, the aggregate housing wealth as proposed by Case et al. (2005) was computed and divided by that year's GDP.

There is consensus that housing fuels consumption, as suggested by the permanent income hypothesis (e.g., Lettau and Ludvigson, 2004), and it has been somewhat assumed that an increase in consumption should lead to an increase in GDP. Even though it has been confirmed that homeownership, which is defined as the fraction of homes that are occupied by their owners, increases consumption, there is no reason to believe that this unconditionally translates into an increase in GDP, as other components of GDP may decrease at the same time. Therefore, it is possible that a country that exceeds a critical point of homeownership loses part of its economic performance as investment in housing crowds out investment in more productive, non-residential uses (Mills, 1987). Related to this issue, figure 6.1 depicts that even before the financial crisis, there had been no straightforward positive relationship between homeownership rates and GDP per capita.

Figure 6.1: GDP p.c. is negatively associated with the homeownership rate



Note that the negative relationship at high homeownership rates existed even before the financial crisis.

This paper does not dispute that—at least up to that certain point—homeownership is a positive driver of growth. The consumption of housing and related goods and services creates jobs and income, owning provides a hedge against inflation and increasing rents, and for already wealthy buyers an additional asset in their portfolio helps them diversify, to mention just a few. However, once a critical homeownership rate is exceeded, there are two reasons why GDP growth could suffer.

(1) As we move along the range of homeownership rates, one has to ask who these owners are. Part of them may have incomes that do not suffice to sustain such a standard of living without difficulty. Rather, owning a house comes at high costs such as the obvious ones: taxes, mortgage costs, insurance or maintenance; but also a decrease in alternative investment possibilities in general, or, for low-income owners, a very poorly diversified portfolio because the largest part of their portfolios consist of just one asset (Goetzmann, 1993; Brueckner, 1997; Yamashita, 2003). Yet, it is well-known that diversification is the key to reducing risk. These low-income households are always at a high risk of being unable to service their mortgages and running into bankruptcy. Furthermore, it has been shown that owning can decrease the mobility of labor.

(2) Too much homeownership could be the outcome of a flawed consumption versus investment decision. A conventional wisdom says that consumption is the engine of economic growth. However, it is actually investment that is every economy's driver. Yet, money that is bound in a house is actually not invested—it is consumed: because people spend money on goods and services that do not produce any additional output for the economy. If the down-payment was instead saved in a bank account and used to pay for a monthly rent, the banks could fulfill their role as an intermediary, i.e., bundle the savings of all tenants and make them available as loans to firms that have a promising business model and projects with a positive net present value. This way, the money is used to produce an additional output. Similarly, firms could invest in

order to make their production technologies more efficient. In fact, Mills (1987) estimates that the social return to housing is only half that to non-housing investment. While a "reasonable" homeownership rate is essential to a country's GDP for the aforementioned reasons, an excessively high homeownership rate implies that a lot of money is not invested in productive assets in the economy. In fact, this problem is well-known to policy-makers: various studies (Hendershott and Hu, 1981, 1983) have noted that already in the 1970s and 80s, there was a need to increase U.S. productivity growth, which was declining at that time. Some policies were therefore targeted at increasing business investment by, for instance, shifting capital flows from residential towards non-residential, industrial sectors in order to decrease overinvestment in housing in favor of the capital–labor ratio.

This paper adds to the housing and growth literature in the following ways. First, it is the first research paper that addresses the relationship between homeownership and GDP growth in more detail at the aggregate level. It does not rely on consumption data because an increase in consumption only leads to a rising GDP when the other components of GDP are not affected. Furthermore, this paper also differs from other analyses as it does not use variables such as house prices or residential investment, which do not distinguish between owner-occupied and rented dwellings. Instead, it argues that the fraction of owned houses of all dwellings in a given country has more explanatory power for economic growth.

Second, it investigates not only the linear but also the non-linear relationship between owning and growth. Thereby, the analysis allows to draw conclusions about the positive effect of owning at low to intermediate homeownership rates and a critical point at which the sign of the relationship gets reversed. This result is robust to various specifications of the model, which are estimated using system GMM to reduce potential simultaneity in the model. This way, the risk that homeownership rates affect GDP growth and GDP growth affects homeownership rates can be circumvented to some extent. However, to fully overcome endogeneity problems, instrumental variable (IV) regression is conducted as well.

The paper is organized as follows. Section 6.2 summarizes the main findings of the related literature before 6.3 outlines the theoretical basis for the empirical analysis. Also, the hypotheses which will be tested are derived in this section. The data and the estimation method are presented in section 6.4. Section 6.5 discusses the results and section 6.6 concludes.

6.2 Related literature

6.2.1 Housing and the economy

The question how strongly housing, as opposed to non-housing, contributes to GDP was addressed by several researchers. For example, in a two-sector growth model with a housing and an "everything else" sector, Mills (1987) introduces a parameter θ which represents the degree of capital market distortions and permits derivation of the social returns to housing and non-housing capital. His empirical results using data for 1929–1983 show that the social returns to non-housing were about twice that of the social returns to housing. His research also confirms the hypothesis that the U.S. overinvested in the residential sector during the period under study. Two years later, Mills' findings for housing overinvestment and the difference in returns to the two types of capital were confirmed by Mills (1989) and Hendershott (1989), although to a less dramatic extent. In sum, this research shows that despite resulting in a lower output to the society, capital was predominantly concentrated in housing, which ultimately decreased the U.S. productivity.

This distortion was also investigated by Hendershott and Hu (1981, 1983) who blame the U.S. tax code, which gives preferential treatment to homeownership, for the decline in productivity. Moreover, Rosen (1979) estimates that without the housing tax subsidy, the U.S. productivity could have increased by $107 per household. Mills (1987) furthermore finds an increase of around 10 percent in real income if there were no overinvestment in housing. Thus, the crowding out of non-residential investment leads to a socially non-efficient resource allocation. Green et al. (1994) even speculate that countries where the government encourages non-residential investment could be more successful economically than those which allow for extensive residential investment. Because of these findings, researchers have often referred to housing as "unproductive" and to non-housing as "productive" assets, especially in the development economics literature (Mills, 1987).

Green (1997) builds on Mills' results to examine the influence of the two capital types on the business cycle. Using Granger-causality tests, he shows that residential investment Granger-causes GDP, but not the other way around. Furthermore, non-residential investment does not Granger-cause GDP, while GDP Granger-causes non-residential investment. In sum, Green concludes that housing leads the business cycle while non-housing lags it, and that residential investment could therefore be "a true 'cause' of GDP" (p. 260). However, Green acknowledges that housing could simply be a forward-looking investment made by households that expect higher future incomes. That is, as households expect to prosper, they may decide to expand their housing investment. This raises concerns that homeownership may be highly endogenous and that even lagged homeownership rates may not solve this problem.

Green's finding of Granger causality was confirmed for consumption by Coulson and Kim (2000). From this result, the authors conclude that housing indirectly affects GDP. Moreover, using impulse response functions and variance decomposition, the authors find that GDP responds more strongly to shocks in residential than in non-residential investment, even when the latter is placed first in the causal ordering. They also report that residential investment explains more of the variation in GDP than non-residential investment, which makes it an especially powerful multiplier.

The literature has argued that plant and equipment, such as that used in agriculture and industry, tend to produce more output than the housing sector (Mills, 1987). But at the same time, many studies have found a large housing wealth effect on consumption, which means that homeowners consume more from housing than from financial wealth. This will be discussed in further detail in the next subsection. That implies that, if housing investment increases consumption but decreases GDP, other components of GDP must be adversely affected by housing. A common argument is that productivity can only be improved when technologies become more efficient; however, investment in housing can hardly improve production technologies. When market distortions such as housing subsidies divert the flow of capital away from more productive assets, less capital is left to replace and improve plant and equipment, i.e. productive assets. An improvement in production technologies would lead to more output for the same dollar of input, but any additional dollar invested in housing due to an economic distortion does not earn the higher social return to capital. This implies that the economy suffers productivity losses once housing investment is expanded beyond its socially efficient level. And indeed, studies finding lower social returns to housing than to non-housing, as the aforementioned, have provided evidence for this idea.

This literature review does not dispute that there is a positive social return to housing, but it has been shown that the returns to residential capital are small. Furthermore, once we subdivide residential investment into investment going towards owner-occupied versus rented dwellings, we could gain more interesting insights. The next subsection is devoted to that literature.

6.2.2 Positive and negative externalities of homeownership

There are a number of reasons why a household would want to become an outright-owner or transition from renting to owning. Many of them are related to life's uncertainties. Besides the mere accumulation of wealth, one reason may be lack of trust in the retirement system of the country of residence, which makes people take care of their own retirement planning rather than rely on the schemes provided by the government or employer. Therefore, becoming a homeowner would be a strategy to save up for retirement. Interestingly, homeowners indeed tend to be wealthier than their renting counterparts (e.g., Haurin et al., 1996; Dietz and Haurin, 2003; Mathä et al., 2017) even when such two households start out with the same initial endowment. This is somewhat puzzling since it implies that there occurs a change in a household's (saving) behavior in the moment of becoming a homeowner. This empirical observation has kept researchers busy for a long time and the puzzle has not yet been fully solved.

Another reason which is linked to uncertainty is that housing wealth exhibits a low correlation with financial assets and inflation, which makes it a good companion for financial assets in a (wealthy) household's portfolio. Moreover, homeownership serves as a hedge against rising rents (Goetzmann and Spiegel, 2000) and can be found predominantly in regions with high rent risk (Sinai and Souleles, 2005).

Consumption is another important factor to consider, as it is commonly said to be an economy's engine. A number of studies have analyzed the impact of housing wealth on consumption behavior and have found a considerable housing wealth effect. Using U.S. data, Benjamin et al. (2004a,b); Kishor (2007), to name just a few, document that the marginal propensity to consume (MPC) from housing wealth is higher than the MPC from financial wealth. This is confirmed by Slacalek (2009) for U.S. data and, to a lesser extent, using data on other countries. The link between housing wealth and household consumption was also studied by Case et al. (2005) who find a significant and large housing wealth effect on consumption. Furthermore, Simo-Kengne et al. (2015) show that real housing returns have a positive effect on real per-capita consumption growth. In addition, Bostic et al. (2009) have estimated for U.S. data that a decrease in consumption (relative to 2005 levels), triggered by a 10 percent decrease in housing wealth, translates into a one-percentage-point drop in real GDP growth.

To analyze the consumption behavior of older and younger households as a reaction to house price changes, Calcagno et al. (2009) use panel data of Italian households. They conclude that older households are more affected by house price changes than younger ones. Campbell and Cocco (2007) find similar results for the U.K.

It appears that owning is indeed superior over renting, but there is also evidence that homeownership may harm the economy. For example, the well-known Oswald hypothesis (Oswald, 1996) states that due to mobility costs, homeowners are less mobile in the labor market than renters and are therefore more likely to become unemployed. The empirical evidence on this issue is, however, mixed. Munch et al. (2006), for instance, find a negative correlation between homeownership and the duration of unemployment but also a positive association between homeownership and the chances of finding local jobs. In a later study, Munch et al. (2008) find a negative link between homeownership and mobility but a positive one with wage levels. Moreover, while some studies (e.g., Coulson and Fisher, 2002, 2009) argue that, in aggregate, high homeownership levels are associated with new jobs and better labor market outcomes, Blanchflower and Oswald (2013) find that fewer businesses are started when owner-occupation rates increase. On top of that, Blanchflower and Oswald document that a rise in the U.S. homeownership rate is usually followed by a rise in the unemployment rate and that the labor mobility of owners is much lower than that of renters. Similar results have been found by Green and Hendershott (2001), albeit only for middle-aged households, who are still part of the labor force and have accumulated sufficient housing wealth to suffer from their limited mobility. Furthermore, Ferreira et al. (2010) state that every additional $1,000 in real annual mortgage costs decrease household mobility by roughly 12 percent.

Concerning the household portfolio, Goetzmann and Spiegel (2000) point out that homeownership among low-income households bears significant risks such as negative home equity and bankruptcy. Additionally, at the household level, overinvesting in housing distorts portfolio allocation (e.g., Goetzmann, 1993; Brueckner, 1997; Yamashita, 2003).

Yet, capital allocation may not only be distorted at the household but also at the macro level. A number of relevant studies in that area (e.g., Rosen, 1979; Hendershott and Hu, 1981, 1983; Mills, 1987, 1989; Hendershott, 1989) have already been discussed in the previous subsection.

To sum up, housing can have various influences on GDP. On the one hand, housing can stimulate the economy since it increases consumption. On the other hand, however, it can also harm the economy as some studies have hinted at the possibility that overinvestment in residential capital might result in underinvestment in business investments despite higher returns in that sector, thereby risking diminishing economic growth. At the end of the day, all these negative consequences will eventually show up in the GDP; the question is whether or not the positive externalities of owning are large enough to outweigh the negative ones.

6.2.3 Contribution

Very few studies analyze the implications of the housing market for economic output, and to the best of my knowledge, most of these studies do not distinguish between owner-occupied and rented dwellings. In his study on social returns to housing and non-housing, Mills (1987) additionally analyzes the returns to owning and renting separately and concludes that they do not differ from each other. However, he acknowledges that due to econometric and computational challenges, the estimates may not be reliable. By contrast, this present study argues that it is the sum of benefits and disadvantages of, or behaviors related to, homeownership that might affect a country's output.

In light of the recent financial crisis and the importance that is attached to homeownership in an economic and household-related sense, it is striking that the link between homeownership and growth has not been studied in greater detail yet. As Miller et al. (2011) point out, consumption is an important indicator; however, "it is not a complete statistic for the economy" (p. 528). This paper tries to fill this void.

The underlying hypothesis of this paper is that the increase in consumption may be counterbalanced by decreases in other components of GDP such that the overall net effect of homeownership on GDP will be negative at certain ownership levels. One explanation could be that housing is inferior to non-housing investment because it is not an investment in that it doesn't increase an economy's future productivity. The other may be that, as more and more households transition from renting to owning, more and more low-income households become owners, who would be better off renting. Therefore, this study uses aggregate growth data as dependent and homeownership as explanatory variables. To overcome endogeneity problems, IV regression will be conducted as well.

My research addresses the question whether homeownership is an unconditional, positive driver of economic growth or not, i.e., whether homeownership should always be preferred over renting from an economic perspective. To this end, a determinants-of-growth regression based on an augmented Solow growth model is estimated which captures the positive and negative effects of owner-occupied housing in a panel of 21 countries over the period 2000–2014—

a relatively large sample compared to previous studies. The inclusion of a linear and a squared homeownership term permits computation of the turning point, i.e., the point where the positive effects of homeownership start to be offset and outweighed by the negative ones. In this regard, the results found in studies on consumption do not contradict the findings of this study but rather explain the movement on the upward-branch of the hump-shaped relationship between homeownership and GDP growth.

6.3 Model and hypotheses

The basis is an augmented Solow model that relates growth to various country-specific factors:

$$g = f(i, (n + p + \delta), Y, S, h, h^2, \mathbf{Z}) \quad (6.1)$$

In this model, g is the per capita GDP growth rate of a country. i and $(n + p + \delta)$ come from the original Solow (1956) model, where i is a country's investment or saving rate, and $(n + p + \delta)$ is the sum of the population growth rate n, technological progress p, and capital depreciation δ. Y is a country's initial income, which can also be understood as a proxy for a country's physical capital stock, and S is human capital. The latter two factors have augmented the traditional Solow model in a number of studies (e.g., Mankiw et al., 1992; Barro, 1991, 2001, 2003). Novel in this setting is the inclusion of the homeownership rate as a linear and a quadratic term, h and h^2.

According to this model, each country will arrive at a steady state which depends on its unique characteristics, hence the country-specific control variables in the vector $\mathbf{Z}$. The controls are standard in the empirical growth literature (e.g., Barro, 2001, 2003; Checherita-Westphal and Rother, 2012; Sassi and Gasmi, 2014) and include country characteristics and policy variables: the government consumption ratio, trade openness, inflation, the terms of trade, democracy and democracy squared, and life expectancy.

The core hypothesis from neoclassical growth models is conditional convergence: countries with a lower initial GDP Y should grow faster than those which started at high levels of initial GDP and are thus closer to their steady state. Human capital S should also have a positive influence on GDP growth for obvious reasons. Furthermore, the model predicts that GDP growth g is higher when the saving rate i grows and the adjusted population growth rate $n + p + \delta$ diminishes.

The following control variables are standard in the empirical growth literature; their expected signs will thus be discussed only briefly. Government consumption, even though there are more favorable and less favorable types of spending (Kneller et al., 1999), should have an overall negative impact on GDP growth. The sign of trade openness should be positive since countries that are more actively engaged in the world markets should have a higher GDP growth. The terms of trade are a measure of external competitiveness, and more competitive countries should grow faster than less competitive ones. The inflation rate should have a negative impact on GDP growth, as a higher inflation rate implies macroeconomic instability. Democracy is measured on a range between -10 and +10 where higher positive values stand for more democracy. Whereas the sign of democracy should be positive, the sign of the squared term should be negative, allowing for an adverse net effect of this variable at certain democracy levels. Last but not least, life expectancy should affect GDP growth positively.

My interest lies in the parameters that measure the influence of the rate of owner-occupied housing. This influence is twofold. When it is considered to have a linear relationship with growth, the expected sign of the coefficient h is probably positive because there are many good reasons for homeownership being a driver of economic growth. However, the empirical model also accounts for a potential negative impact of owning, since the homeownership rate will also be considered in its squared version. The squared version allows for a negative net effect of the explanatory variable, h^2, and is often used in empirical applications (e.g., with age, democracy, etc.). The reason for my hypotheses is that up to a certain critical threshold of homeownership, the advantages outweigh the disadvantages. At that point, however, the relationship turns around because of a lack of investment into productive assets of the economy.

6.4 Research design

6.4.1 Data

I collected yearly data for a sample of 21 countries, namely Australia, Austria, Belgium, Canada, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Switzerland, the United Kingdom, and the United States for the period from 2000 to 2014. The availability of data for the homeownership rate h was the limiting factor of the sample. Also, Eastern European countries were intentionally left out because their housing sector was significantly influenced by political changes in the early 1990's and therefore, the mechanisms between housing and growth could work differently.

For the saving rate, a country's total investment as a fraction of its GDP is used. These data are sourced from the World Economic Outlook (WEO) database published by the International Monetary Fund. In the original Solow model, the sum of the population growth rate, n, a rate of technological progress, p, and a depreciation rate for capital, δ enter the model as one variable. In empirical applications, it has become a convention to set $p + \delta$ equal to 0.05 (e.g., Mankiw et al., 1992; Islam, 1995; Bond et al., 2001). This is done because the depreciation rate cannot be observed and technological change is assumed to be the same for all countries and years. While Mankiw et al. take the growth rate of the working-age population (aged 15–64), I follow the procedure of Islam and use the countries' entire population. Annual population growth rates come from the World Development Indicators (WDI) 2016 database provided by the World Bank.

Following Mankiw et al., I further augment the Solow model human capital, which is used instead of raw employment data as a proxy for labor supply. This is done because the mere number of workers does not adequately account for the quality of labor (e.g., Romer, 1994; Lucas, 1988; Mankiw et al., 1992; Islam, 1995; Barro, 1991, 2001, 2003; Caselli et al., 1996). Human capital can be defined in many ways: as school enrollment rates, literacy, or the number of years of schooling, to mention just a few. I decided to take the fraction of the labor force with secondary education. The well-known Barro and Lee (2013) data for educational attainment were not used because they are only available in 5-year intervals. Initial per capita GDP and schooling data are sourced from the WDI database.

Homeownership rates h come from various sources such as the Organization for Economic Cooperation and Development (OECD), the World Bank, or the Economic Commission for Europe of the United Nations (UNECE). The starting point, however, was a data set from Eurostat for the period 2005–2014. In cases where the time series for a given country was too short, the quality of the data was questionable or the data even drastically contradicted the data provided by that country's statistical office, that time series was compared to and complemented by other sources. In particular, this was necessary for a number of European countries, since data on housing are not collected as often as in, say, the United States.

Missing data for gaps of one to three years were interpolated linearly using adjacent homeownership rates because it is more than likely that, in the short run, the homeownership rate increases linearly. Sometimes for two time series from different sources (let's say one for 2000–2008 and another one for 2009–2014) there didn't seem to be a smooth transition between the two series as the values for 2000–2003 deviated from the data for 2004–2014 by several percentage points. Because in these cases it wasn't clear which of the two sources measured the homeownership rate with error, the entire series was replaced with data provided by the statistical offices of the respective country. After this harmonization, the resulting time series covers the period spanning 2000–2014.

The control variables were gathered from the WDI and World Economic Indicators (WEO) 2016 databases. GDP is measured in constant 2005 US dollars and expressed as per-capita value (divided by that country's population) and the terms of trade are defined as export prices relative to import prices. The saving rate, trade openness, government consumption, life expectancy and the sum of population growth, technological progress and the depreciation rate are expressed as logarithms. Data on long-term interest rates come from the OECD and the European Central Bank.

Summary statistics and pairwise correlations are presented in tables 6.1 and 6.2, respectively. More information on data sources, the definition of the variables and further descriptive statistics can be found in the appendix in table 6.6 and figures 6.2–6.6.

Table 6.1: Summary statistics.

Variable	Obs.	Mean	SD	Min.	Max.
GDP growth (p.c., %)	294	0.652	2.430	-9.305	6.517
Saving rate (%)	315	3.094	0.157	2.441	3.462
Population growth (%)	315	1.741	0.105	1.197	2.066
Initial GDP (p.c., ln)	315	10.530	0.371	9.691	11.383
Education (% with second. educ.)	302	44.399	11.173	12.1	65.2
Homeownership rate (%)	302	65.028	12.854	34.6	86.1
Government consumption (%)	314	2.961	0.195	2.301	3.312
Trade openness	314	4.384	0.529	3.098	5.925
Inflation (%)	315	2.053	1.259	-4.480	5.565
Interest rate (%)	311	4.186	1.917	0.647	22.498
Terms of trade	294	1.001	0.125	0.621	1.673
Democracy	315	9.902	0.374	8	10
Life expectancy (ln)	294	4.379	0.018	4.335	4.416

Table 6.2: Correlation matrix.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) GDP growth	1												
(2) Saving rate	0.420	1											
(3) Population growth	0.120	0.447	1										
(4) Initial GDP	0.134	0.091	0.236	1									
(5) Education	0.077	-0.219	-0.141	0.515	1								
(6) Homeownership rate	-0.062	0.060	0.310	-0.227	-0.598	1							
(7) Government cons.	-0.151	-0.192	-0.378	-0.178	-0.117	0.189	1						
(8) Trade openness	0.070	-0.005	0.260	0.430	0.061	-0.086	-0.154	1					
(9) Inflation	0.274	0.279	0.217	-0.178	-0.225	0.266	0.054	-0.033	1				
(10) Interest rate	-0.262	-0.318	-0.200	-0.448	-0.239	0.309	0.110	-0.161	0.162	1			
(11) Terms of trade	-0.219	-0.411	-0.273	0.117	-0.019	-0.124	-0.212	0.185	-0.211	0.390	1		
(12) Democracy	0.034	-0.066	-0.019	0.012	0.062	0.001	-0.220	-0.074	0.018	0.067	0.098	1	
(13) Life expectancy	-0.220	-0.016	0.012	0.163	0.077	-0.071	-0.126	-0.054	-0.216	-0.164	0.052	-0.118	1

6.4.2 Methods

6.4.2.1 System GMM

To investigate the relationship of owner-occupied housing on economic growth, the empirical model is underpinned by conditional convergence theory. This theory claims that different economies reach different steady states depending on their unique characteristics.

The baseline growth model is as follows:

$$\begin{aligned} g_{it} &= \alpha + \beta_1 savingrate_{it} + \beta_2 npdelta_{it} + \gamma_1 gdp_{i,t-1} + \gamma_2 schooling_{it} \\ &\quad + \lambda_1 hosrate_{it} + \lambda_2 hosrate_{it}^2 + \xi inflation_{i,t-1} + \rho' z_{it} + \varepsilon_{it} \end{aligned} \tag{6.2}$$

The coefficients β stand in front of the standard Solow variables, γ marks the variables that appear in most augmented models, λ are the coefficients of the actual variables of interest of this paper—the homeownership rate and its square—and z_{it} is a vector that contains all contemporaneous control variables. Inflation appears separately because its lag and not its contemporaneous value is used in the baseline model.

In a first naive regression set-up, the data was analyzed in a pooled ordinary least squares (OLS) setting. The results should, however, be interpreted with caution since OLS does not account for the heterogeneity of the sampled countries. In addition, given the panel structure of the dataset and the heterogeneity of the economies in the sample, fixed effects regression analysis was conducted. In both cases, however, the techniques only produce unbiased results when strict exogeneity of the regressors can be guaranteed. This is, however, not the case here because the lagged log GDP per capita shows up as a regressor on the right-hand side of the equation:

$$g_{it} = f(y_{i,t-1}; ...) \tag{6.3}$$

When g_{it} is the logarithmic per capita GDP growth rate and $y_{i,t}$ and $y_{i,t-1}$ are the logarithms of per capita GDP, the equation may be written as follows:

$$y_{it} - y_{i,t-1} = f(y_{i,t-1}; ...) \tag{6.4}$$

The lagged dependent variable $y_{i,t-1}$ on the right-hand side turns the model into a dynamic model. Such models can be properly analyzed with methods that can tackle predetermined and endogenous variables. Nonetheless, it is standard in the empirical growth literature to also report the results of OLS and fixed effects even though they may be biased. The standard errors of the fixed effects regression are heteroskedasticity-robust[2].

To reduce a potential omitted variable bias, a range of standard socio-economic variables enter the model as controls. But at the same time that the control variables reduce an omitted variable bias, they introduce additional endogeneity into the model, which means that some of the regressors could be correlated with past and also current realizations of the error term. Moreover, it is more than likely that the regressors are measured with error and that there is reverse causality or simultaneity—meaning that GDP growth could also lead to higher homeownership. Therefore and for the above stated reasons regarding the panel dynamics, I use the system GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998) to estimate the coefficients. This is a standard technique used in the empirical growth literature[3] and is suitable for my analyses for a number of reasons.

First, system GMM is an appropriate method for dynamic models, i.e., for models where the dependent variable is a function of its own lagged values.

Second, system GMM is applicable to panel datasets that are of the type

[2]Using clustered standard errors does not change the results.

[3]The system GMM estimator is an augmented version of the difference GMM estimator, which was developed by Holtz-Eakin et al. (1988) and Arellano and Bond (1991). It uses more instruments than the difference GMM estimator and is thus more efficient (Roodman, 2009). For a comprehensive overview of the advantages of system GMM over difference GMM, see Bond et al. (2001).

"large N, small T" (here: $N = 21$, $T = 15$). Past values of the dependent variable may be correlated with the fixed effects in the error term, which would result in estimates that are likely to be inconsistent. Nickell (1981) labels this phenomenon "dynamic panel bias". It is especially pronounced if there are only few periods. System GMM helps reduce this problem of endogeneity.

Third, it is a good method to handle cases with endogeneity issues (such as reverse causality, simultaneity, and omitted variables), which is usually the case when aggregate measures such as GDP or growth are the dependent variable. To solve the omitted variables problem, one could alternatively carry out an IV regression. However, system GMM can handle over-identified systems—which is the case when there are more instruments than regressors—and does not require that there be good instruments available outside the system. Instead of that, the potentially endogenous variables are simply instrumented by their own lagged realizations. Nevertheless, an IV regression will be conducted in the next section as well.

One-step and two-step system GMM estimation was carried out. The one-step procedure assumes that the residuals are homoskedastic whereas the two-step procedure relaxes this assumption by using the first-step residuals to construct a consistent variance-covariance matrix in a second step, thus yielding more asymptotically efficient results. Furthermore, the Windmeijer (2005) finite-sample correction is made in the two-step regression to safeguard against a potential downward bias of the estimates. Moreover, test of over-identifying restrictions (the Hansen (1982) test), a joint F test of the variables, *homeownership rate* and *(homeownership rate)*^{2}, and the Arellano and Bond (1991) m2 test for autocorrelation are reported.

System GMM requires specifying which of the regressors are exogenous and which are potentially endogenous. The terms of trade variable, adjusted population growth, democracy and its squared term were assumed to be exogenous; the others to be either endogenous or predetermined.

Finally, the turning-point homeownership rate is computed as long as the coefficients of the regression are significant. This is done following Checherita-Westphal and Rother (2012) by optimizing a quadratic equation that yields the maximum of a parabola of the form $g(h) = ah^2 + bh + c$. Using the quadratic formula, the two roots of such a parabola are $h_{1,2} = -\frac{1}{2}\frac{b}{a} \pm \frac{\sqrt{b^2-4ac}}{2a}$. I exploit the fact that a parabola is symmetric around its maximum, which lies right between the two roots, i.e., at $h^{crit} = -\frac{1}{2}\frac{b}{a}$. To compute the maximum, all one needs are the two coefficients in front of the homeownership rate and its square, a and b.

6.4.2.2 Instrumental variables regression

One typical problem and well-known challenge in empirical applications is to find an exogenous identification strategy. Since homeownership rates are endogenous, i.e., they may be affected by GDP growth and unobservable characteristics that cannot be controlled for, it cannot be guaranteed that the measured effects on GDP growth can actually be attributed to a change in the homeownership rates. This problem can be only partly reduced by system GMM. To fully overcome this problem, an instrumental variable (IV) regression is estimated as well; i.e., a regression where the endogenous variable is instrumented by another variable that is exogenous. The IV regression will be estimated by two-stage-least-squares (2SLS).

The selection of an appropriate instrument is challenging, as the instrument has to satisfy two conditions: it must be relevant (i.e., the instrument has to be correlated with the endogenous variable) and exogenous (i.e., it may affect the dependent variable only through the endogenous variable but may not have a direct relationship with the dependent variable). Such an instrument could be divorce rates, which have no direct effect on GDP growth but on homeownership rates, and are likely to be independent from economic hardship. The latter was shown by Cohen (2014) who studies divorce during the U.S. recession in 2008–2011. He concludes that strengthening family bonds or costs of divorce during an economic downturn could prevent couples from divorcing their spouse and that the additional stress level that a crisis exerts on an unhappy married couple has a much lower effect.

Divorce rates as an instrument are far from perfect: divorcing is a lengthy process whose outcome is observed long after the household has been dissolved (Lersch and Vidal, 2014). Additionally, in some cases, couples do not divorce at all even though they have separated (Andreß et al., 2006). Notwithstanding these flaws, divorce rates are good instruments for the following reasons. Even though they may not account for the level of homeownership rates (Germany has similar crude divorce rates like Cyprus; yet, their homeownership rates differ by roughly 30 percentage points), they might well account for changes in these rates. Moreover, compared to marriage rates, divorce rates have a stronger association with homeownership rates because not every couple that owns a home is married but most likely the majority of married couples that get a divorce will leave their joint home and transition from owning to renting (at least one of the two, temporarily). It can thus be argued that divorce rates satisfy the exogeneity condition.

While the exogeneity condition cannot be tested empirically, the relevance condition can be assessed by having a closer look at the first-stage regression, where the endogenous variable is regressed on the instrument and all other exogenous variables. In this regression, the instrument is used to extract and predict only the exogenous fraction of the independent variable while the endogenous part is omitted. As a rule of thumb, the F-statistic of that regression should be higher than 10, which indicates that divorce rates are a good instrument for homeownership rates.

6.5 Results

6.5.1 Full sample regression

The results of the baseline regression of equation 6.2 using different estimation techniques are presented in columns (1)-(4) of table 6.3. These columns document the results of (1) OLS, (2) fixed effects (FE) panel estimation, (3) one-step system GMM with robust standard errors, and (4) two-step system GMM with the Windmeijer (2005) correction. Columns (5) and (6) show the results for slightly different specifications of the baseline model where schooling and the homeownership rates are lagged by one period. Column (7) reports the IV regression results, for which the 2SLS estimator is employed. The F-statistic of the first-stage regression reveals that divorce rates are a relevant instrument for homeownership rates.

The coefficients of the variables of interest, the homeownership rate and its square, confirm the hypothesis that there is a hump-shaped relationship between the degree of homeownership in a country and its GDP growth. In all specifications, the coefficient of the linear term takes on positive values whereas the coefficient of the squared term is negative. This confirms the hypothesis that homeownership is beneficial to economic growth up to a certain critical value. When this rate is exceeded, however, the negative effects outweigh the positive ones, and the net effect becomes negative. Divorce rates, which are used as instrumental variables for the homeownership rates, provide further evidence of a statistically significant relationship. In almost all cases, the coefficients of the homeownership rates are statistically significant at the conventional levels. Only in the FE regression, these coefficients become insignificant. This is likely a consequence of the very little variation that the within-country homeownership rates exhibit from year to year: since fixed effects method is a transformation of OLS where averages at the country-level are subtracted, most of the (already little) variation in homeownership rates is further reduced and the resulting differences have an almost unmeasurable impact on the dependent variable.

One of the most interesting results of this paper is the homeownership rate at which the relationship between owning and growth becomes inverse. Regardless of the model specification, this turning point seems to be at a rate of around 68 percent[4]. Up to this point, the net effect of owning is dominant, but any additional percentage point of homeownership higher than the threshold harms the economy.

Most of the control variables show the expected signs; however, life expectancy as well as democracy and its squared version do oftentimes not behave as expected. This could be due to very little variation that the latter variable shows in the data set. While democracy is distributed on the interval [-10; 10], it takes on only the values from 8 to 10 in the sample. This is also the reason why in the fixed-effects regression the linear term is omitted: on this range of data, the squared variable is an almost perfect linear combination of its linear version, and the variable is dropped.

Regarding the robustness of the results against other specifications of the model, one can see that the results of the estimations (5) and (6) confirm the results previously found in the two-step system GMM baseline regression (4).

[4]Since it makes only sense to compute the turning point for coefficients that are significant at the conventional levels, it is not computed for regression (2).

Table 6.3: Homeownership and economic growth.

	OLS	FE	One-step	Two-step	Two-step	Two-step	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Homeownership rate	0.623***	0.159	2.973**	3.278*	1.660**$^{(L)}$	1.713**$^{(L)}$	0.576***
	(0.000)	(0.728)	(0.012)	(0.061)	(0.025)	(0.018)	(0.000)
(Homeownership rate)^2	-0.005***	-0.001	-0.022**	-0.025*	-0.012**$^{(L)}$	-0.012**$^{(L)}$	-0.004***
	(0.000)	(0.884)	(0.022)	(0.062)	(0.033)	(0.039)	(0.000)
Saving rate	11.009***	11.193***	17.249***	20.992***	16.619***	23.223***	9.838***
	(0.000)	(0.000)	(0.002)	(0.004)	(0.009)	(0.000)	(0.000)
Population growth	-4.560***	-6.034***	-20.446***	-16.956	-18.624*	-16.502	-5.484***
	(0.006)	(0.003)	(0.002)	(0.163)	(0.085)	(0.152)	(0.001)
Initial GDP	-1.860***	-32.699***	-0.962	-1.956	-2.180	-8.546	–
	(0.002)	(0.000)	(0.774)	(0.787)	(0.667)	(0.267)	

Table continued on next page...

Table 6.3: Homeownership and economic growth (continued).

	OLS	FE	One-step	Two-step	Two-step	Two-step	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Education	.093***	0.114*	0.290	0.317	0.286	0.306***$^{(L)}$	0.051***
	(0.000)	(0.097)	(0.188)	(0.362)	(0.280)	(0.009)	(0.000)
Government consumption	-3.053***	-15.627***	-12.411	-12.747	-12.656	-19.050	-3.464***
	(0.001)	(0.000)	(0.268)	(0.407)	(0.247)	(0.206)	(0.000)
Trade openness	0.716**	5.793***	4.976	4.394	4.200**	-0.032	0.315
	(0.041)	(0.002)	(0.187)	(0.292)	(0.033)	(0.993)	(0.354)
Inflation (lagged)	-0.726**	-0.568***	-0.912***	-0.973***	-0.870**	-0.806**	-0.691***
	(0.000)	(0.000)	(0.010)	(0.008)	(0.026)	(0.028)	(0.000)
Interest rate	-0.301***	-0.285***	-0.188	0.214	-0.151	-0.084	-0.162**
	(0.000)	(0.000)	(0.503)	(0.737)	(0.742)	(0.871)	(0.032)
Terms of trade	3.754**	-2.317	6.40	10.717	3.960	9.410	1.177
	(0.038)	(0.325)	(0.276)	(0.371)	(0.672)	(0.150)	(0.447)

Table continued on next page...

Table 6.3: Homeownership and economic growth (continued).

	OLS	FE	One-step	Two-step	Two-step	Two-step	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Democracy	18.844**	0.403*	82.082	-20.000	14.228	omitted	13.290
	(0.046)	(0.091)	(0.193)	(0.605)	(0.652)		(0.153)
Democracy^2	1.015**	omitted	-4.457	1.115	-0.800	-0.092	-0.714*
	(0.050)		(0.192)	(0.598)	(0.651)	(0.458)	(0.161)
Life expectancy	-42.078***	27.784	-24.367	-8.131	-24.977	7.681	-45.224***
	(0.000)	(0.264)	(0.409)	(0.888)	(0.444)	(0.695)	(0.000)
Constant	71.916	207.100**	-374.201	omitted	omitted	omitted	105.609**
	(0.154)	(0.012)	(0.138)				(0.039)
Adj. R^2	0.45	0.71					0.42
F-test	0.000	not reported	0.000	0.000	0.000	0.000	0.000
F(HOS rate, HOS rate^2)	0.000	0.632	0.010	0.164	0.067	0.018	0.001
m2 test			0.083	0.190	0.068	0.071	–

Table continued on next page...

Table 6.3: Homeownership and economic growth (continued).

	OLS	FE	One-step	Two-step	Two-step	Two-step	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Hansen test			0.165	0.091	0.066	0.011	–
Observations	256	256	256	256	255	256	251
Turning point (%)	68.17		67.95	66.34	70.62	69.83	66.49

p-values in parentheses. Standard errors are robust. *, **, and *** refer to significance levels of 10%, 5%, and 1%, respectively. p-values are reported for the F test (Wald test in (7)), joint F, m2 an Hansen tests. $^{(L)}$ denotes that the variable is lagged. Because the democracy values in the sample don't vary a lot (8 to 10), the squared democracy variable may be dropped due to multicollinearity. This is because the realizations of the squared variable—64, 81 and 100—are almost a perfect linear combination of the non-squared realizations 8, 9 and 10.

The null hypothesis of the m2 test for autocorrelation is that the errors are serially correlated. In all regressions except regression (4), the null can be rejected. The null of the Hansen test is that the system is over-identified. In regression (5) and (6) there is some reason to believe that the instruments may not be valid. However, Roodman (2009) points out that this statistic should not be relied upon too much because, as the number of instruments grows, it becomes harder to satisfy all moment conditions at the same time.

6.5.2 Robustness checks

One may now object that the results might be driven by the poor performance of some countries that were hit particularly hard and sustainably by the housing crisis, e.g., Cyprus, Spain, Greece, Italy or Portugal (see figure 6.6 in the appendix). Therefore, a robustness check is conducted by running the regressions without these countries during the housing crisis. A middle way had to be found between leaving out the years 2007–2009 for all countries on the one hand and leaving out only the crisis countries over the whole period on the other hand. In order not to lose too many data points in the already limited sample, the compromise was to leave out only data for the crisis countries during the years of the housing crisis. This way, there are still enough data in the sample to draw sensible conclusions.

The robustness check was run in two steps: first, only Cyprus, Spain, and Greece (2007–2009) were left out. In the second step, Cyprus, Spain, Greece, Italy, and Portugal (2007–2009) were left out. This is because Italy and Portugal were hit not only by the housing crisis but continued to perform badly also during the subsequent European debt crisis. In order to not conflate the two crises, the two regressions were run separately. However, since both lead to the same findings (qualitatively and quantitatively), only the second-step regression results are reported here.

Table 6.4 reports the most important results of the regression. Even though the results are less compelling in terms of the m2 and Hansen tests, the findings concerning the meaningfulness of the homeownership variables and turning point prevail. The turning point is just slightly higher than the previously found average rate of around 68 percent. This is the result of dropping the countries which suffered from their high homeownership rates during the housing crisis on the one hand and, on the other hand, running the regressions on only those countries that enjoyed economic growth even during the housing crisis.

Table 6.4: Homeownership and economic growth for non-crisis countries.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Homeownership rate	0.577***	0.164	2.476**	3.892*	1.379**$^{(L)}$	2.262**$^{(L)}$	0.527***
	(0.000)	(0.730)	(0.028)	(0.071)	(0.035)	(0.017)	(0.000)
(Homeownership rate)^2	-0.004***	-0.001	-0.018*	-0.029*	-0.009*$^{(L)}$	-0.017**$^{(L)}$	-0.004***
	(0.000)	(0.888)	(0.052)	(0.084)	(0.058)	(0.039)	(0.000)
Adj. R^2	0.43	0.70					0.41
F-test	0.000	not reported	0.000	0.000	0.000	0.000	0.000
F(HOS rate, HOS rate^2)	0.000	0.632	0.012	0.180	0.076	0.000	0.000
m2 test			0.040	0.210	0.020	0.059	
Hansen test			0.346	0.089	0.102	0.267	
Observations	241	241	241	241	240	241	236
Turning point (%)	69.42		70.16	67.95	73.04	65.82	67.38

p-values in parentheses. Standard errors are robust. *, **, and *** refer to significance levels of 10%, 5%, and 1%, respectively. p-values are reported for the F test (Wald test in (7)), joint F, m2 an Hansen tests. $^{(L)}$ denotes that the variable is lagged.

6.6 Discussion and conclusion

This paper is the first one that studies the relationship between GDP growth per capita and homeownership at the aggregate level. The hypothesis of this study is that homeownership can initially have a positive and, after reaching a certain point, a negative relationship with economic growth, which is modeled by introducing a linear and a squared term of the homeownership rate. The paper shows that an inverse relationship between GDP growth and owner-occupied housing indeed exists and that the initially positive impact on growth starts to become negative at a homeownership rate of around 68 percent. Up to that point, homeownership has a significantly positive association with GDP growth. The intuition for this finding is that owner-occupied housing has benefits for the economy because of housing-related consumption; however, once the homeownership rate of a given country becomes too high, the negative influences of owner-occupied housing outweigh the positive ones.

One explanation could be, for instance, that money spent on housing is consumed and not invested: in the economic literature, investing implies that we consume less today in order to consume more tomorrow. Tomorrow's higher consumption is possible because investments create additional future output which makes GDP rise. If fewer homes were bought and more money (i.e., the down-payment) was saved in bank accounts instead, banks could fulfill their role as intermediaries and give these funds to companies as a loan, allowing them to make investments with positive net present value that increase the aggregate output of that country to raise future consumption. Mills (1987, 1989), for instance, has estimated that a dollar invested in non-housing uses produces more output than a dollar invested in housing.

Another negative factor that comes along with high homeownership rates is that of personal bankruptcy. Although at first this risk doesn't affect the economy in the aggregate but at the household level, owning leads to decreased investment alternatives because most homes are bought with a mortgage. Also, as we move along the homeownership continuum, more owner-occupied housing usually implies that more and more low-income households start to purchase their homes. These households are most times not sufficiently wealthy to be able to diversify when the bulk of their wealth is invested in one single asset, the house. Thus, the value of their portfolio co-varies strongly with the value of their house, and they are increasingly exposed to fluctuations in the local economy (Goetzmann and Spiegel, 2000).

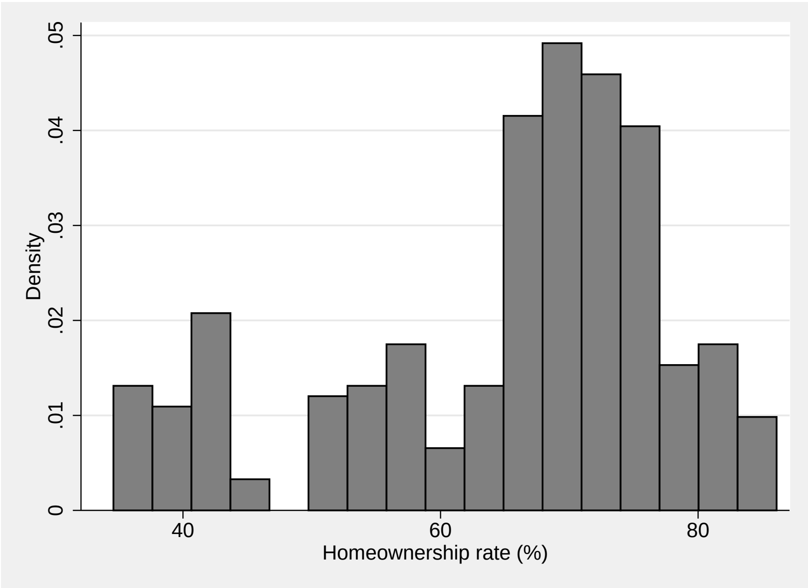
Likewise, a decrease in the labor mobility due to owning could lead to an overall negative effect of high homeownership rates, as analyzed by Ferreira et al. (2010). One consequence of lower mobility of labor is explained by Blanchflower and Oswald (2013). They conclude that doubling the U.S. homeownership rate would be followed by more than a double increase in the unemployment rate.

For policy-makers the findings of this study imply that homeownership should not be encouraged unconditionally. Owning increases consumption but, at the same time, decreases investment in the economy. If at all, homeownership should thus be promoted with caution.

This paper adds to the growth and housing literature because it is the first to address the homeownership–growth nexus at the aggregate level by investigating a hump-shaped relationship between the two. It analyzes GDP growth and not consumption because higher consumption does not necessarily translate into growth, as other components of GDP might be adversely affected when consumption is increased. This research thus fills a gap which has so far been neglected. It remains, however, open through which channels exactly homeownership affects GDP growth negatively. Moreover, of course, it has to be acknowledged that homeownership rates, which result merely from the division of two accounting numbers, may have little interpretative meaning. Therefore, it is up to future research to develop measures that better reflect homeownership, have more meaning, and allow for better causal interpretations.

6.7 Appendix

Figure 6.2: Homeownership rates across countries and years.



Rates per country are depicted in figure 6.4 in the appendix.

Table 6.5: Data sources.

Variable name	Source(s)
GDP at market prices (constant 2005 US$)	WDI
Homeownership rate (%)	Various *
Government final consumption expenditure (% GDP)	WDI
Life expectancy at birth, total (years)	WDI
Inflation, consumer prices (annual %)	WDI
Long-term interest rate (annual %)	OECD, ECB (for Cyprus)
Import value index	WDI
Export value index	WDI
Population Population growth (annual %)	WDI
Total investment (% GDP)	WEO
Trade (% GDP)	WDI
Labor force with secondary education (%)	WDI
Polity2	Center for Systemic Peace
Crude divorce rates (divorces per 1,000)	Australian Bureau of Statistics, Statistics Canada (2001–2008 only), Eurostat, U.S. National Center for Health Statistics

As mentioned earlier, there was no single data set that included all homeownership rates over the period 2005-2014. They were thus obtained from various sources: Eurostat, United Nations Bulletin of Housing Statistics, Australian Bureau of Statistics, HypoStat (European Mortgage Federation), Statistics Austria, Statistics Canada, Statistics Denmark, Statistics Finland, National Institute of Statistics and Economic Studies of France, Federal Statistical Office of Germany, Ministry of the Interior and Kingdom Relations The Hague, Statistics Norway, Federal Bureau of Statistics of Switzerland, Swiss Finance Institute, Office for National Statistics of the UK, U.S. Census Bureau. The data set is available upon request.

Table 6.6: Definition of variables.

Variable name		Exp. sign
Dependent variable:		
GDP growth	Logarithmic 1-year growth rate of real GDP per capita (%)	
Explanatory variables:		
Homeownership rate	Population owning the house in which they live (%)	+
(Homeownership rate)^2	Captures the effect of an inverse relationship	-
Saving rate	Logarithm of total investment (% GDP)	+
Population growth	Logarithmic 1-year growth rate of the population + 0.05 (%)	-
Initial GDP	Logarithm of GDP per capita	-
Schooling	Labor force with secondary education (% of population)	+
Control variables:		
Government consumption	Logarithm of government consumption (% GDP)	-
Trade openness	Logarithm of the sum of imports and exports (% GDP)	+
Inflation	1-year growth rate of the consumer price index (%)—a measure of macroeconomic stability	-
Interest rate	Long-term interest rates—to control for affordability of mortgages (%)	-
Terms of trade	Ratio of export prices to import prices—a measure of external competitiveness	+
Democracy	Polity2 variable—a measure of political stability	+
Democracy^2	Polity2 squared—captures the effect of an inverse relationship	-
Life expectancy	Logarithm of life expectancy at birth (years)—a measure of health capital	+

Figure 6.3: Homeownership and GDP growth

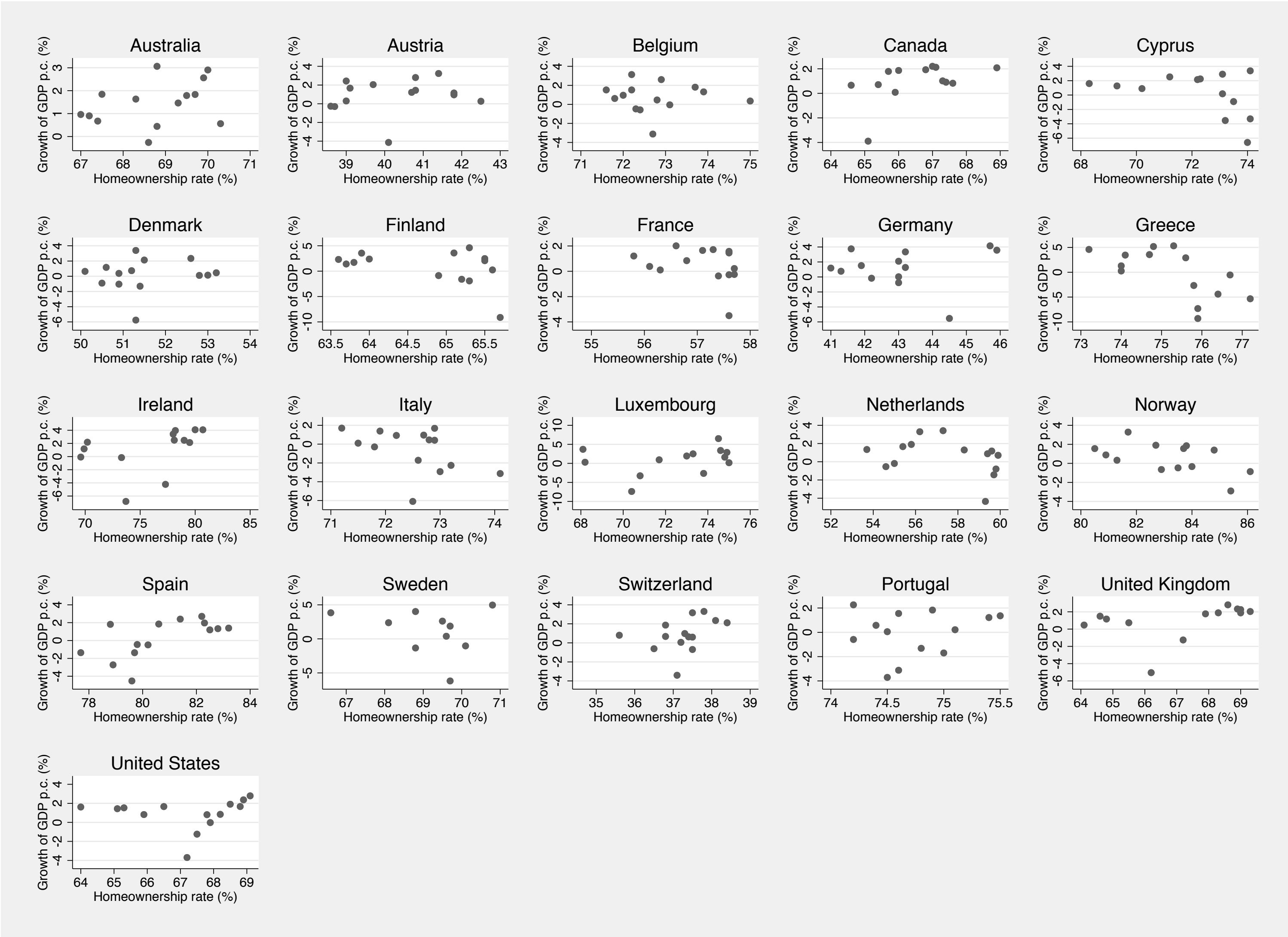


Figure 6.4: Homeownership over time

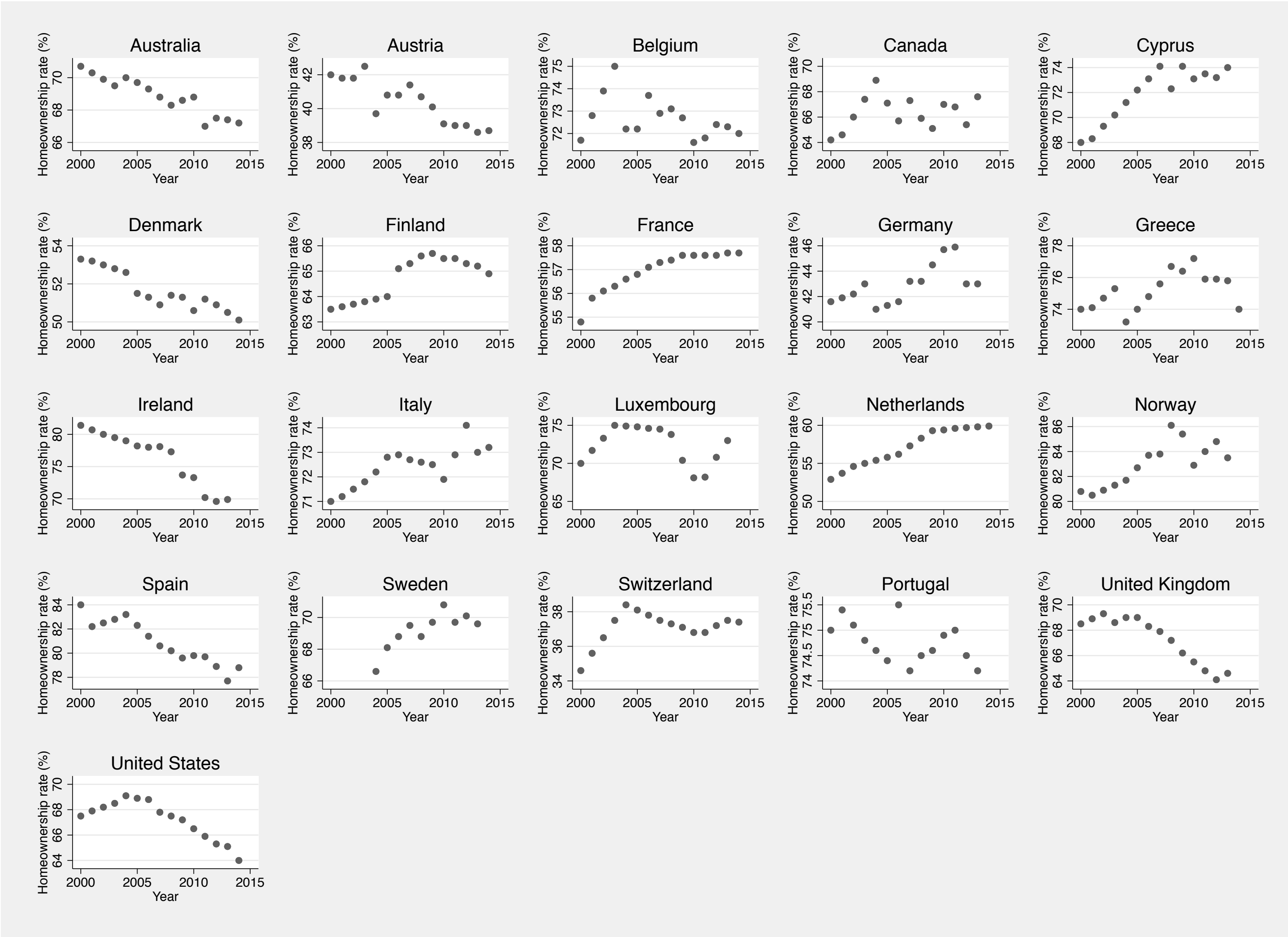


Figure 6.5: GDP growth over time

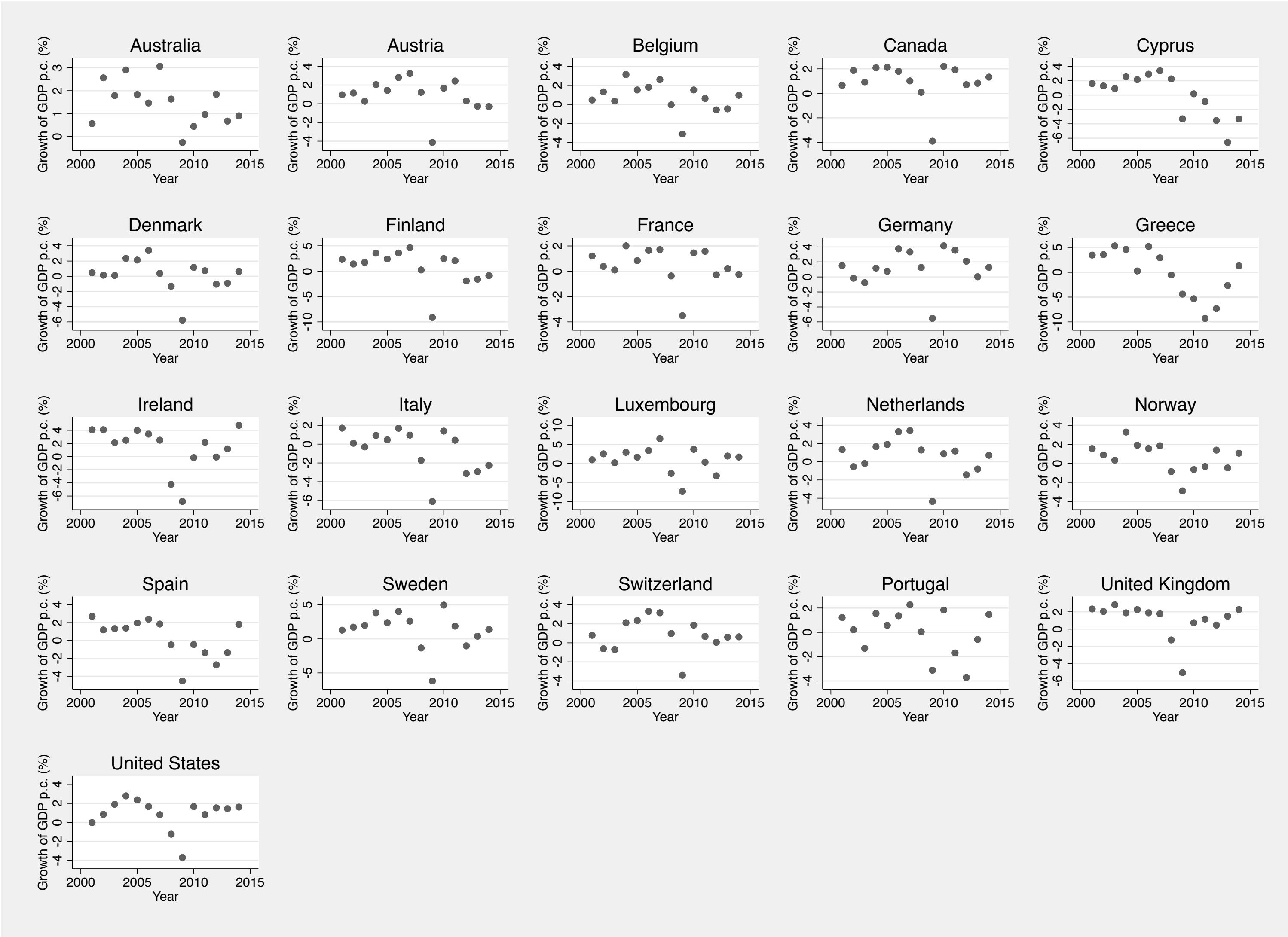
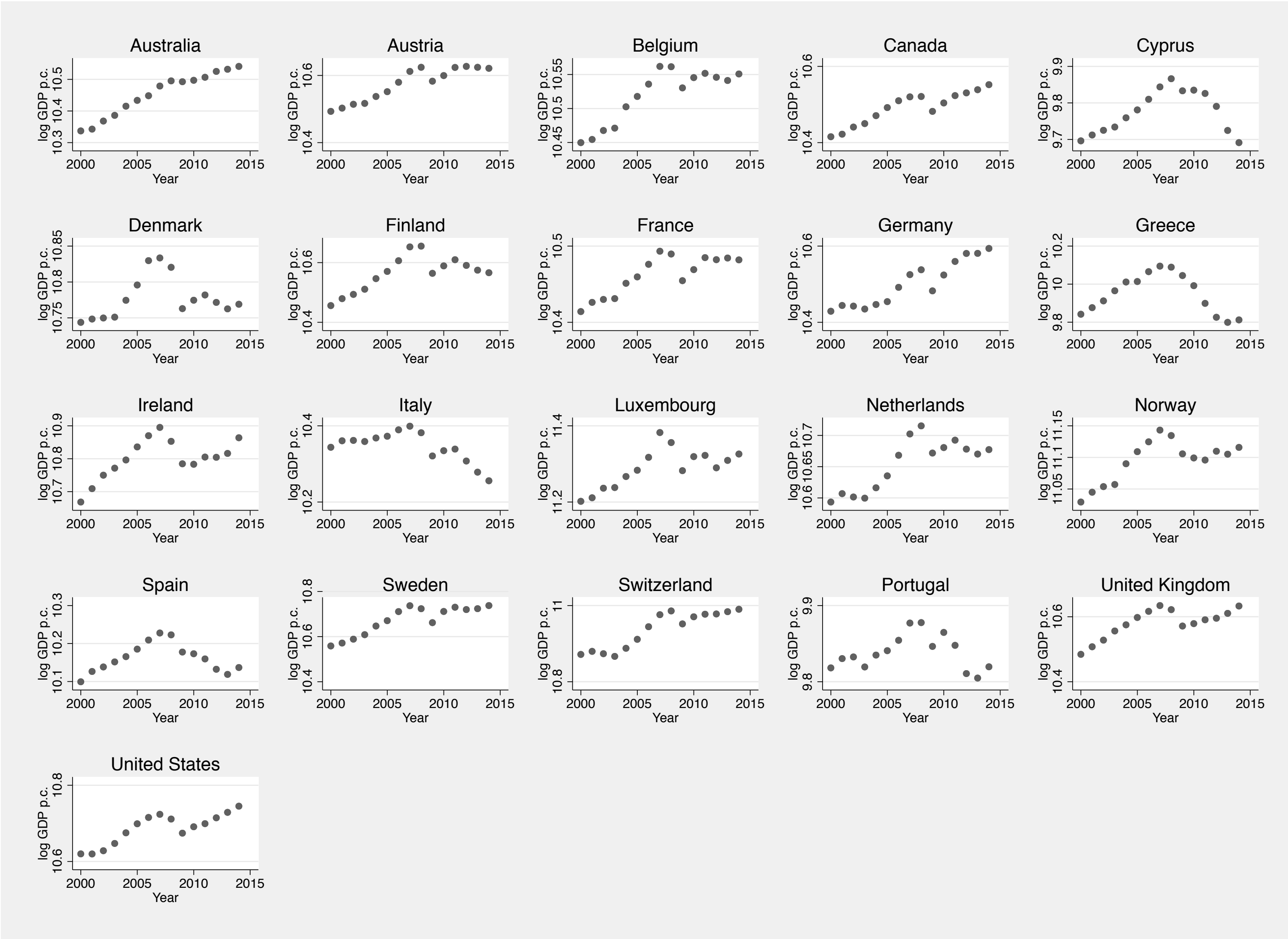


Figure 6.6: GDP over time



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