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# HOME PRODUCTION AND CHINA'S HIDDEN CONSUMPTION

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This paper presents a structural approach to estimating the value of home production in China. The structural model incorporates stylized facts about the time allocation of Chinese households, such as the active participation of retired individuals in home production. Estimates based on the China Health and Nutrition Survey show that the aggregate value of home production as a fraction of adjusted GDP has fallen at a rate of 2.7 percent per year over the past decade in China. However, a significant part of China's private consumption was still satisfied through unpaid home production in 2009, amounting to roughly 18 percent of adjusted GDP.

**JEL Codes:** E01, D13, J22

**Keywords:** Chinese economy, consumption, home production, time use

## 1. Introduction

Standard measures of gross domestic product (GDP) do not account for home-produced goods and services that are not created for the purpose of generating market income.[1] This downward bias in the measurement of aggregate production and consumption is particularly large in poorer countries, where the scope of formal markets for goods and labor is limited (see, e.g., Budlender, 2010). When developing economies begin to catch up with more advanced economies, they undergo changes in a variety of household behaviors, including decisions about consumption, labor supply, and time allocation (Goldin, 1994; Mammen and Paxson, 2000).[2] Much of the work that used to take place within the household is

[1]The components of GDP are personal consumption expenditures, business investment, government spending, and net exports. Calculations of GDP that are based on the System of National Accounts (SNA) include only the production of goods and services that are performed for the purpose of generating income; therefore, home produced goods and services (not for sale) are excluded from SNA.

[2]For example, Goldin (1994) studies the relationship of labor-force participation of married women and economic development and finds that the participation rate initially declines following the movement of production from the household, family farm, and small business to the wider market, but the income effect weakens at some point.

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gradually outsourced into the market and spurs market consumption.[3] How this transition affects the aggregate value of home production remains, however, an open question. Most of the evidence on this issue comes from historical U.S. data: for example, Bridgman *et al*. (2012) show that in the United States (U.S.), the ratio of home production to nominal GDP has fallen from 39 percent in 1965 to 26 percent in 2010.

In this paper, I provide the first analysis of trends in the value of home production from an emerging market, namely China. I use a rich dataset (the *China Health and Nutrition Survey*, CHNS) that tracks the labor income, time use, consumption of home durables, and demographics from over 4,000 households across nine Chinese provinces. Critically, this dataset allows me to document household decisions over time between 2004 and 2009, a period of record growth in China. I focus on China for several reasons. First, some recent estimates suggest that home production is large (see, e.g., Dong and An, 2015). Second, the scope of goods and labor markets (and thus the opportunity cost of engaging in home production) has dramatically increased in China. Third, there has been a rapid diffusion of modern household appliances and other durable goods used in home production, often aided by public programs (such as the Home Appliances Going to the Countryside (HAGC) program launched in 2007; see Tewari and Wang, 2016). I document some of these trends in the first half of the paper, using the U.S. as a benchmark. I show that Chinese people spend more time in home production compared to Americans and less at leisure, although a converging trend is exhibited over the years. One striking feature of home production in China is that retired individuals, especially elder women, play a very active role, possibly due to their low opportunity cost, or cultural reasons and social norms.

The main methodological contribution of this paper is to compute the value of home production and its dynamics using a structural estimation approach. In this approach, I first estimate the home production function by fitting household data to a model of time allocation and then use the estimated parameters to compute the nominal value of total home production. The model I adopt builds upon the standard home production framework (surveyed in its various applications in Aguiar *et al*., 2012). A special feature of my model is that it allows some members of the household not to participate in the labor market, while exploiting intra-household relations to estimate their contribution to home production. The literature has often used simpler methods to estimate the size of the home production sector, based on evaluating the factors employed in home production at their market prices. However, these methods implicitly assume that home production is linear in the household inputs, thus ignoring decreasing productivity and complementarities. The resulting bias in the estimation of home production is potentially important in the context of economic development. Chinese households are experiencing large changes in home production hours and their usage of appliances. However, the final effect on the value of home production depends on how these inputs are combined in the home production function.

To estimate the home production function, I fit the model to Chinese household survey data using non-linear least squares. The empirical results illustrate a number of interesting points. The effective home production hours of different

[3]Similar evidence on U.S. history also exists; see, for example, Ramey (2009).

household members are not perfect substitutes in production, thus confirming that complementarities and joint rents are important. Additionally, individual characteristics affect productivity: older individuals and women have higher marginal productivity in home production. Estimates of the preference side for the model show that people do care about how their time is allocated between the home and the market sector, with a relative preference for formal work over home production for females and less-educated individuals. Finally, I estimate that the share of home production to adjusted GDP was around 26 percent in 2004 but had steadily declined to 18 percent in 2009.[4]

My results have essential implications for studies on time use and national accounts, especially in the context of developing countries. The study of time allocation dates back to the seminal work of Becker (1965) and was further revisited by Gronau (1977). The canonical model of Becker (1965), in which households choose the optimal time allocation to maximize expected utility while being constrained by labor income and the total amount of time, illustrates the important role of non-market work. The measurement of home production relies on time-use data from large-scale time-use surveys or from national representative household surveys. A good amount of work has been done in developed economies, with earlier work by Hawrylyshyn (1976) and Gronau (1986), more recently followed by Ramey (2009), Landefeld *et al.* (2009), Suh and Folbre (2016), Bridgman *et al.* (2012), and Aguiar *et al.* (2012). With more data on time use becoming available in developing countries over the past two decades, a growing interest in time-use patterns and unpaid care work in the context of developing countries (e.g. Sub-Saharan African countries, Argentina, India, South Korea, and Tanzania) has emerged (see, e.g., Budlender and Brathaug, 2004; Blackden and Wodon, 2006; Budlender, 2010; Chang *et al.*, 2011; Dong and An, 2015).

Dong and An (2015) study is one of the first studies to estimate the value of home production in China using representative time-diary data. Dong and An (2015) use the 2008 China Time Use Survey to examine the gender patterns of time spent on market work and home production, and to evaluate the monetary value of home production in China. Using an input-based approach, Dong and An (2015) estimate the unpaid home production to be around 25–32 percent of China's GDP in 2008.[5] This study differs from Dong and An (2015) in a couple of ways. This paper extracts time-use information from three waves of household survey data over 6 years, with rich demographic and socioeconomic information. Therefore, it is possible to make an analysis of time use across households and over time, while Dong and An (2015) provide a snapshot of China's non-market consumption in

[4]The share of home production to unadjusted GDP was around 35 percent in 2004 and 22 percent in 2009.

[5]Note that the estimates of Dong and An (2015) include housework for households' own consumption, care for household members, and voluntary community services. On the other hand, the estimates of Bridgman *et al.* (2012) distinguish among three types of home production, which include not only non-market services but also the return to consumer durables and the return to government capital attributable to home production (although the largest impact of the household production adjustments comes from the inclusion of non-market services). This paper focuses on home production resulting from non-market services and some consumer durables, but does not estimate the value of services resulting from owner-occupied housing.

2008.[6] Methodologically, this paper adopts a structural estimation method by building a partial equilibrium model with home production technology and household preferences over time allocation to measure the potential value of home-produced goods and services and their changes over time.[7]

The rest of the paper is organized as follows. In Section 2, I briefly describe the dataset and present the relevant summary statistics. In Section 3, I present the stylized facts through a comparative study on time allocation patterns between China and the U.S. over the past decade and obtain preliminary regression results. Section 4 offers a theoretical model of home production. In Section 5, I use the estimates from the structural model to quantify the potential value of home production. Section 6 offers some concluding remarks.

## 2. Data Description

The analysis of this paper uses three waves of survey data—2004, 2006, and 2009—from the China Health and Nutrition Survey (CHNS).[8] The survey adopts a multistage, random-cluster process to draw samples from nine provinces in China with around a 50 percent rural population. In particular, the survey includes a time-use section (e.g. time spent on childcare, domestic chores, entertainment, the primary job, etc.), which documents time spent both in and out of the formal market as well as information on occupation, work intensity, wages, and other key socioeconomic variables. A complete household roster is included, which allows me to link individual household members within the same household and obtain intra-household information with which to conduct the structural analysis.

There are several merits that make the CHNS an ideal source of data for this study. First, it is a longitudinal dataset, which offers both a snapshot of home production in China and, more importantly, the most recent trend in activities related to home production. Second, the CHNS contains rich and unique information at the household and individual level that facilitates my study in several ways. For instance, by using the household roster, I am able to identify and link individual time-use data, labor-market variables, and demographic variables within the same household and exploit intra-household information for estimating my structural

[6]Typically, surveys provide some non-diary recall data on certain aspects of time use. A number of studies have shown that time dairies provide more accurate estimates for non-market time relative to surveys based on recall data (as noted by Dong and An, 2015); however, an issue with time diaries is that a large amount of zero values in time use arise from a mismatch between the reference period and the period of interest, which is much longer (Aguiar *et al.*, 2012). Nevertheless, given data availability, utilizing CHNS survey data over several waves offers valuable information and time variation in this study. More details are discussed in Section 2.

[7]As a robustness check, I also apply two other methods often employed in the literature to measure home production in a national accounting framework—the opportunity cost method and the market cost method. I present these results in Appendix B (in the online Supporting Information). Key methodologies and findings are surveyed in Hawrylyshyn (1976).

[8]I focus on a period of stable economic growth from 2004 to 2009 in China and document the stylized facts of Chinese households' time-use patterns by comparing them with contemporaneous time-use patterns in the U.S. The choice of time interval is based on the availability and quality of data on time use—the main focus of the paper.

TABLE 1
Descriptive Statistics—CHNS

| | Observations | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| **A. Demographic Variables** | | | | | |
| Age | 14,827 | 47.04 | 14.33 | 13.2 | 93.13 |
| Female | 14,827 | 0.53 | 0.49 | 0 | 1 |
| Married | 14,827 | 0.87 | 0.33 | 0 | 1 |
| Education | 14,822 | 20.13 | 8.44 | 0 | 36 |
| Retired | 14,827 | 0.19 | 0.38 | 0 | 1 |
| Household size | 14,827 | 1.94 | 0.88 | 1 | 6 |
| Number of elders | 14,827 | 0.46 | 0.71 | 0 | 3 |
| Urban | 14,827 | 0.45 | 0.49 | 0 | 1 |
| **B. Time Allocation** | | | | | |
| Work hours | 11,719 | 39.71 | 19.96 | 1 | 119 |
| Home hours | 14,827 | 15.73 | 17.80 | 0 | 119 |
| Leisure hours | 14,827 | 19.49 | 15.91 | 0 | 120 |
| **C. Income** | | | | | |
| Annual income | 4,348 | 15.58 | 20.97 | 0.48 | 480 |
| Retirement wage | 2,720 | 13.73 | 11.13 | 0.24 | 119.98 |
| Household income | 14,827 | 21.30 | 38.54 | 4.11 | 628.58 |
| **D. Ownership of Durables** | | | | | |
| Refrigerator | 14,810 | 0.58 | 0.49 | 0 | 1 |
| Washing machine | 14,809 | 0.70 | 0.45 | 0 | 1 |
| Microwave | 14,803 | 0.25 | 0.43 | 0 | 1 |
| Electric rice cooker | 14,810 | 0.77 | 0.42 | 0 | 1 |
| Electric pressure cooker | 14,808 | 0.47 | 0.49 | 0 | 1 |

*Sources*: The CHNS survey and the author's own calculation. Educational attainment is measured as an education index in the survey and the average value of 20.13 roughly represents 1 year of lower middle school. Retired status is identified by self-reporting as retired in the survey data. The number of elders includes the number of individuals above a certain age in the household (the cutoff ages are 55 for women and 60 for men, reflecting the official retirement ages for women and men). Time allocation hours are capped at 120 hours per week on all three activities to provide a common and practical upper limit of time use (for consistency, the same top-coding also applies to the ATUS data). Income is denoted in thousands of Chinese yuan and is trimmed to exclude the top and bottom 1 percent.

model.[9] In addition, the CHNS contains information on ownership of household durables, which can be used as a proxy for home production technology in the structural estimation.

To construct the sample, I include household members who are above 18 years of age, for whom I have complete demographic and time-use information, and who have been reporting in the survey at least for two waves. The sample data include 14,287 individuals and 4,145 households. Table 1 gives detailed summary statistics of the sample. The observations are across nine provinces that vary substantially in geography, economic development, and public resources.

To better illustrate the pattern of time use and home production in China, I also provide information on time-use data from the U.S. In order to make this

[9]Information on labor-market status and earnings is also important for estimating the value of home production using alternative methods, such as the market cost method. By using occupation information at the individual level, I am able to extract wages for a variety of jobs in the service sectors that supply home production substitutes. These wages represent the "market cost" of home production if it was outsourced to the market at a given time in a given province.

comparison meaningful, I construct comparable sets of variables on time-use from the *American Time Use Survey* (ATUS). By linking the ATUS to data files from the *Current Population Survey* (CPS), I am able to link time-use activities with demographic characteristics and information on earnings. To match the time coverage of the CHNS, in the empirical analysis I use ATUS and CPS waves from the same three years—2004, 2006, and 2009. Table A.1 (in the online Supporting Information) provides summary statistics for the ATUS–CPS sample. It contains about 40,049 observations at the individual level (as well as the household level). Definitions of time-use variables in both the CHNS and the ATUS are provided in Table A.2.[10]

The inclusion of the ATUS data in this study serves two purposes. First, they provide us with a "benchmark" in time-use study, given the scarcity of similar studies focusing on a developing-country context. Second, they offer us a unique developed–developing-country framework in which we can observe the general trend of home production and draw insights about characteristics specific to China.[11]

In the rest of the paper, time use for home production is defined as hours per week spent on childcare, cleaning, cooking, doing grocery, and doing laundry. Time spent in the market is defined as weekly working hours spent in the primary occupation. Finally, leisure includes weekly hours spent on physical activities (such as martial arts, gymnastics, swimming, and track and field) and sedentary activity (such as watching television and videos, reading, surfing on the internet, and so on). Additionally, annual income is calculated as annual salary in the previous year plus the total value of all bonuses for the previous entire year. In a later section, I use the label "Elder female" for women who are at least 55 years old and "Elder male" for men who are at least 60 years old.[12]

## 3. Evidence of Home Production in China

In Section 3.1, I present evidence about time use in China, using the U.S. as a benchmark. In Section 3.2, I conduct a preliminary regression analysis to quantitatively examine how home production hours vary with individual characteristics and over time between 2004 and 2009.

### 3.1. *Stylized Facts of Time Use in China*

Between 2004 and 2009, China's GDP experiences a double-digit growth rate, with a mild slowdown around the 2008–9 global financial crisis. At the same time, the growth rate of household consumption increases from around 6 percent to

[10]While the definitions of market work time and home production time are similar in these two survey datasets, there is some variation in how leisure time is measured. Because of cultural differences, people from China and the U.S. may have completely different lifestyles in terms of enjoying their leisure. For example, martial arts, or Taijiquan, is the main activity for Chinese individuals (especially seniors), while Americans spend a fair amount of time using cardiovascular equipment or biking.

[11]In the structural estimation part, I use only CHNS data because the main goal of this study is to quantify China's home production. Numerous previous studies have already attempted to provide estimates of home production in the U.S. In addition, the ATUS is based on individual-level time-use diaries. Thus these data cannot be used to estimate my model because there is no intra-household information.

[12]The way in which I define older females and males is consistent with the majority retirement age in China: 55 for women and 60 for men.

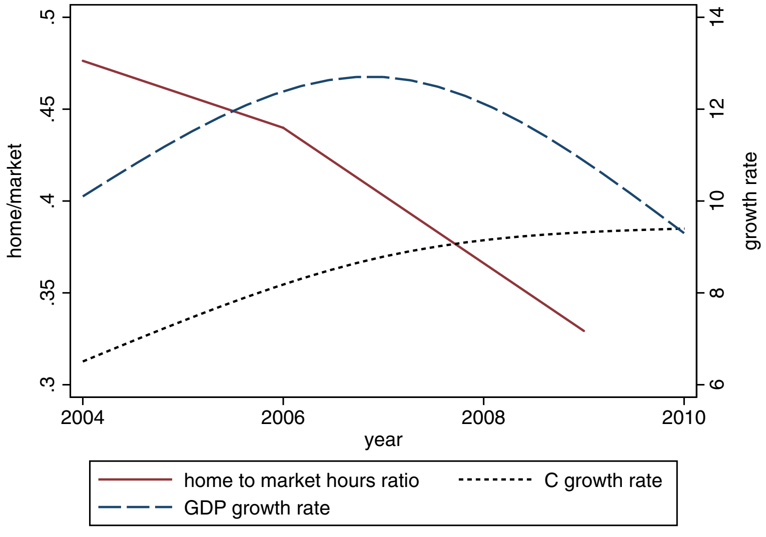


Figure 1. The Home to Market Hours Ratio and the Growth Rates of Consumption and GDP

*Sources:* Consumption and GDP data are World Bank World Development Indicators; home production time and market work time are constructed using the CHNS.

*Note:* C is defined as the household final consumption expenditure. [Colour figure can be viewed at wileyonlinelibrary.com]

almost 10 percent, while the ratio of home production time to market work time falls considerably, from nearly 50 percent to less than 35 percent.[13] Figure 1 describes the overall trend of all three indicators. It provides us with suggestive evidence that as an economy develops, households reallocate more and more hours from home production to market work. To understand how economic growth affects the evolution of aggregate consumption, it is necessary to explore the connection between time allocation and home production.

Figure 2 illustrates the patterns of time allocation in China and the U.S., in 2004, 2006, and 2009. On average, Chinese people spend more time in home production compared to Americans (but less at leisure). However, this difference becomes less striking over the years. The average weekly hours spent in home production in China drop significantly, from 18 hours in 2004 to 13 hours in 2009 at the individual level, approaching the level of U.S. individual average home production hours.[14] A closer look further reveals that China experiences a broad reduction in time allocation across all home production categories.[15] This pattern can be explained by a decrease in the relative prices of market substitutes for home

[13]The detailed definition of home production time is discussed in Section 2.

[14]Over the same time period, weekly working hours in China increased only slightly, from 38 to 40 hours, indicating that only a small proportion of the time reduction from home production goes into market work in China. There is a steady increase in the amount of hours spent in leisure over the same time range.

[15]Chinese households spend more time than their American counterparts on all categories of household production except house cleaning. One potential reason is that the average American household size is 3, while the average Chinese household size is around 2. The time spent on childcare in the two countries is almost equal. On the other hand, Chinese households spend much more time on laundry, grocery, and cooking activities. Cultural and economic differences may offer an explanation.

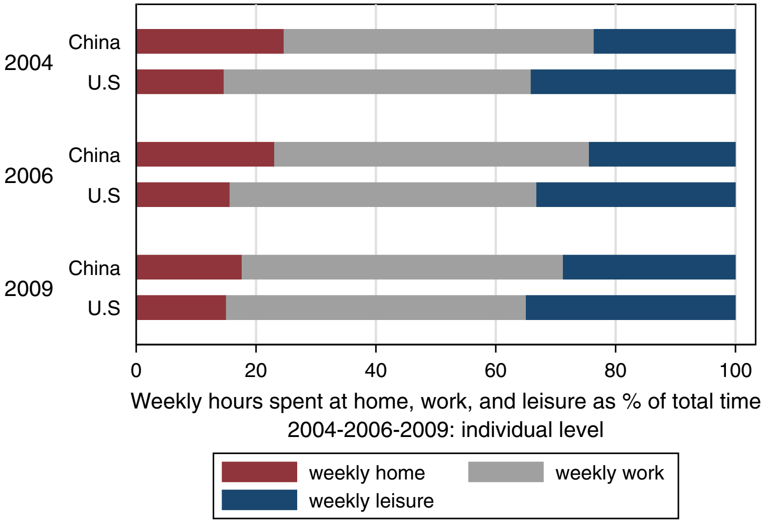


Figure 2. The Converging Pattern in Time Allocation Between China and the U.S.

*Sources:* The time-use data for China are taken from the CHNS; those for the U.S. are taken from the ATUS. Variables on time use are based on the author's calculation as weekly hours time spent on home production, market work, and leisure.

*Notes:* More details about the variable construction are given in Section 2. Observations of time use are reported at the individual level. [Colour figure can be viewed at wileyonlinelibrary.com]

production and improvements in home production technology resulting from the adoption of time-saving durables (see, e.g., de Cavalcanti *et al.*, 2008; Tewari and Wang, 2016). This trend is also consistent with the recent service-sector development in China (growth in the dining service sector, the home-cleaning service sector, etc.), which offers more choices for households to outsource home production.

Having examined the aggregate trend in home production hours in China, next I look at how home production hours vary with demographics such as gender and age, with a special focus on the role of retired people in the home production sector. Table 2 presents the average amount of time individuals spend in home production by gender and age (Panel A), as well as the distribution of home production hours within households (Panel B). In both China and the U.S., women spend more time in home production. The home production time of older Chinese women is remarkably high, especially when they live together with their adult children.

Because of our definition of elderly women, many of them may be retired and therefore are likely to earn a lower income stream (through their retirement wage). This category of individuals is thus likely to face lower opportunity costs when engaging in home production. To verify my hypothesis, I further look at how home production varies with retirement status. Figure 3 shows that, on average, a retired individual spends more time in home production. The gap in home production between retired and non-retired appears to be larger in China than in the U.S.[16]

[16]A very striking fact is that despite a general decreasing trend of average home production hours in China, the home production hours for older females do not change much from 2004 to 2009. As a result, there is an increasing gender gap in home production among older individuals, with important implications in terms of equality and welfare.

TABLE 2
Statistics on Home Production Time

| | CHNS | | ATUS | |
|---|---|---|---|---|
| | Observations | Mean (weekly hours) | Observations | Mean (weekly hours) |
| **A. Different Age Groups** | | | | |
| All age cohorts | 14,827 | 15.72 | 40,049 | 11.24 |
| Young female | 4,961 | 21.88 | 15,110 | 17.23 |
| Young male | 4,827 | 7.29 | 13,537 | 6.06 |
| Older female | 2,975 | 23.03 | 7,658 | 11.85 |
| Older male | 2,064 | 10.08 | 3,744 | 4.75 |
| **B. Household Level** | | | | |
| Individual | 7,648 | 14.11 | | |
| Spouse | 6,876 | 18.16 | | |
| Elderly mother | 853 | 25.05 | | |
| Elderly father | 598 | 11.52 | | |
| Household | 7,648 | 32.21 | | |

*Notes*: Home production time is computed as hours per week spent on relevant housework. In panel B, home production time at household level is not available from the ATUS, as the ATUS surveys one individual per household.

One possible reason is that the combination of a low statutory retirement age in China and increased longevity has resulted in a low opportunity cost of time for individuals in their fifties and sixties.[17] A complementary explanation of the different level of participation of old people in home production is that there is a stronger pattern of intergenerational transfers in China. Traditional family-based informal mechanisms of support for elderly parents give rise to an upward transfer within households in China, from younger couples to old parents (Cai *et al.*, 2006). While elders rely on adult children for support, they also in turn provide their children with services in terms of childcare, cooking, and cleaning (Lee and Xiao, 1998). This suggests that there might be interactions in the allocation of time among family members. An individual's home production time can be affected by the presence of his or her older parents in the household.[18] Previous work on home production has typically ignored this issue and estimated only individual models of time allocation.[19] The home production model that I will discuss in Section 4 allows interactions between young adults and retired relatives.

[17]The Chinese statutory retirement age for blue-collar women is 55 and that for blue-collar men is 60. Although in these samples the average age of the retired individuals is similar between China and the U.S., 34 percent of the Chinese individuals retire by 60 years of age, whereas only 18 percent Americans retire before they turn 60.

[18]For example, it is possible that living with parents in China significantly reduces the burden of home production on the young adult individual, increasing his or her labor supply. This hypothesis is supported by the recent study of Maurer-Fazio *et al.* (2011), who find that co-residence with older adults increases prime-aged women's labor-force participation rates in urban China.

[19]This might be much less of a problem for studies on American households, as the co-residence rate of elderly parents with their non-elderly children is much lower. Co-residence of an elderly parent with an adult child in the U.S. is often associated with disability, and around 10–15 percent of elderly parents live with their adult children (according to the 2000 and 2015 U.S. Census), while in China this rate is around 40–50 percent (see World Bank, n.d.). Complementarity of time use among family members who reside in the same household may still be important.

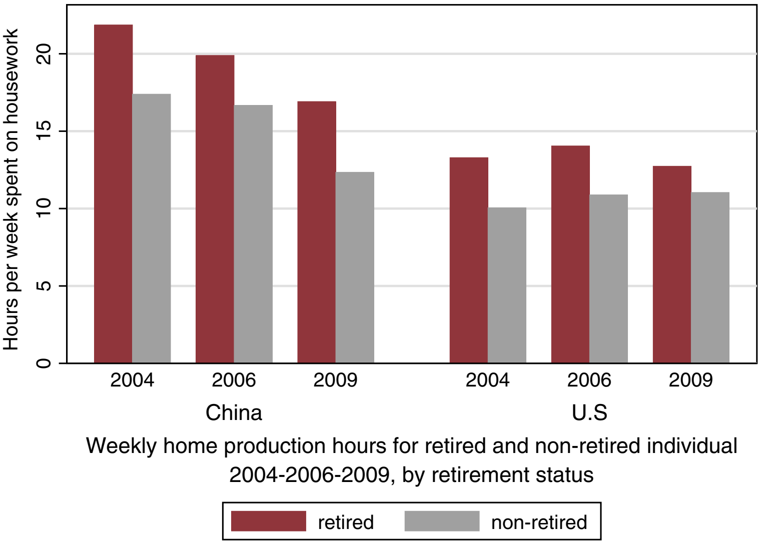


Figure 3. The Key Role of Retired Individuals in China

*Note:* Retirement status is self-reported in the CHNS and the ATUS survey. [Colour figure can be viewed at wileyonlinelibrary.com]

### 3.2. *Regression Analysis*

To briefly summarize and quantify the effect of individual characteristics and time trends on home production hours in China, in this section I conduct a simple regression analysis. The regression uses CHNS survey data as well as ATUS survey information for comparison. The estimation results provide support for the graphical evidence presented in Section 3.1.

The dependent variable is weekly hours spent on home production as defined in Section 2. "Retired" is a dummy for the individual's retirement status. "Earnings" are given by annual income in Chinese yuan for columns (1) and (2), and annual income in U.S. dollars for column (3). In both cases, I rescale annual income, dividing by 10,000. For Chinese individuals, "Urban" is a dummy equal to 1 if the individual belongs to an urban type of household registration and equal to 0 if the individual belongs to a rural type of household registration.[20] The variable $t$ represents years since 2004. The regression results show similar patterns for both datasets, but independent variables seem to have effects of very different magnitudes.[21]

Table 3 shows that the effect of age on home production time for both countries follows an inverse-U-shaped pattern. An additional plot of the age profile (Figure 4) reveals that home production peaks at around 40 years old, on average, and the shape of the age profile is different: as an individual becomes older, the drop in home hours in China is much slower than the drop in the U.S.

Turning to the rest of the regression results, we see that a retired individual tends to work at home around 6 hours per week more than a non-retired individual

[20]For U.S. individuals, "Urban" represents living in a metropolitan area.

[21]The random effect model estimates for the CHNS are very similar to the pooled-OLS (ordinary least squares) results. Therefore, I will use pooled-OLS estimates in the following discussion.

TABLE 3
Household Production Home Hours Regression Results

| | CHNS | | ATUS |
|---|---|---|---|
| | (1) Pooled OLS | (2) Random Effects | (3) Pooled OLS |
| Age | 0.295*** | 0.309*** | 0.645*** |
| | (0.095) | (0.093) | (0.022) |
| Age$^2$ | −0.004*** | −0.004*** | −0.008*** |
| | (0.0009) | (0.0009) | (0.0002) |
| Retired | 6.350*** | 6.193*** | 5.153*** |
| | (0.647) | (0.648) | (0.256) |
| Female | 11.270*** | 11.542*** | 9.675*** |
| | (0.615) | (0.608) | (0.220) |
| Urban | −0.973** | −0.989** | 0.191 |
| | (0.438) | (0.428) | (0.181) |
| $t$ | −0.229** | −0.236 | 0.0444 |
| | (0.153) | (0.154) | (0.062) |
| Male × $t$ | −0.730*** | −0.673*** | 0.113 |
| | (0.167) | (0.163) | (0.072) |
| Earnings | −0.369*** | −0.350*** | −0.115*** |
| | (0.084) | (0.081) | (0.028) |
| Constant | 6.354*** | 5.800*** | −5.694*** |
| | (2.181) | (2.133) | (0.496) |
| $N$ | 14,827 | 14,827 | 40,049 |

*Notes*: The dependent variable is weekly home production hours. The coefficients reported in columns (1) and (2) are pooled-OLS and random-effects estimators, respectively, using CHNS data. All standard errors are clustered at the county level for the CHNS. The coefficients reported in column (3) are OLS estimators with robust standard errors using the ATUS data. Earnings are scaled by 10,000. *$p$<0.05, **$p$<0.01, ***$p$<0.001.

in China, while the differential impact of retirement is around 5 hours in the ATUS data. On average, individuals from urban households in China work one hour less at home than individuals from rural households. There is an overall decreasing trend of home production over time in the CHNS: on average, Chinese people work at home half an hour less with each additional year from 2004 to 2009.[22] I also allow for a differential trend for females and males. "Male × $t$" is an interaction term for addressing both gender and time effects. The estimation results demonstrate a significant effect of gender on the hours of home production. From 2004 to 2009, home production hours per week for male individuals decrease by around one hour every year, while the weekly home production hours of female individuals only decrease by 13 minutes every year.[23] Finally, earnings are nega-

[22]This can be shown from a regression with a year-fixed effect and without year–gender interaction. As mentioned above, this general trend is likely to reflect some changes in the macroeconomy, such as a decline in the market prices of household services.

[23]This implies that the gap in home production time between women and men increases over time: women spend 11 home production hours per week more than men in 2004. In 2006, this number reaches roughly 12.3 hours per week, and rises further, to around 14.75 hours per week, in 2009. The estimates of the coefficients on "Urban," $t$, and "Male × $t$" from the ATUS dataset are not significant, implying that there has been no significant change in home production over time since 2004, nor a significant change in the gender gap over time.

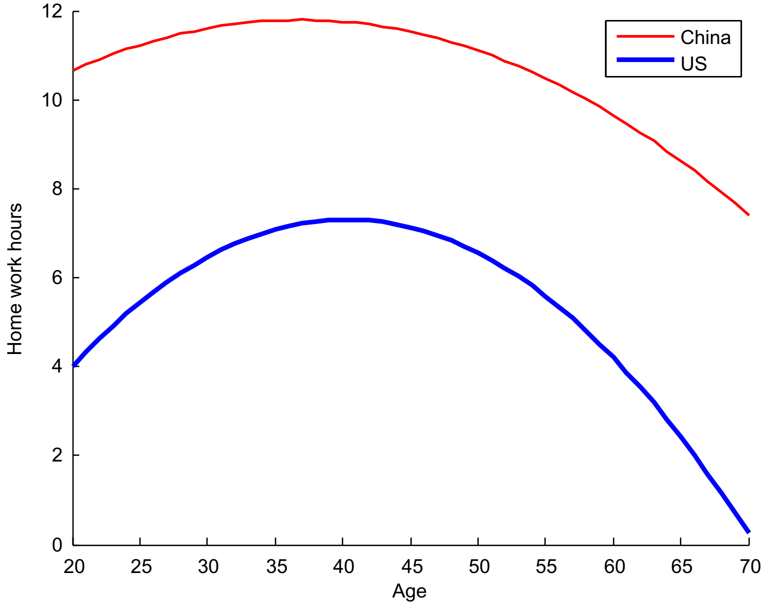


Figure 4. Age Profiles for China and the U.S.
[Colour figure can be viewed at wileyonlinelibrary.com]

tively related to home production in both countries: if weekly income increases by around US$30, weekly home production hours in the CHNS fall by around 23 minutes, while those in the ATUS only fall by one minute.[24]

## 4. The Structural Method

### 4.1. *An Overview of the Methodology*

In the previous section, I have shown that Chinese households spend a considerable amount of time in home production. However, for many individuals home production hours have steadily declined over the past decade. How has this recent trend in time allocation affected the value of home production in China? To answer this question, I use a structural estimation approach that involves first estimating the home production function by fitting household data to a model of time allocation and then using the estimated parameters to compute the nominal value of total home production.

The monetary value of an individual's home production, $V$, is ideally given by $V = pX_H$, where $p$ is the market price of the good and $X_H$ is the home production

[24]The dependent variable is weekly hours, but earnings are measured as yearly earnings (in U.S. dollars or yuan, respectively) divided by 10,000. To interpret the coefficients, I consider an increase in weekly income of US$30. For the U.S. regression, this is equal to an increase in the earnings variable of $30 \times$ number of weeks in a year/10,000 = $30 \times 52/10{,}000 = 0.156$. The predicted effect on weekly hours is $-0.115 \times 0.156 = -0.01794$ hours, which is equal to a change of $-0.01794 \times 60 = -1.08$ minutes, and thus roughly 1 minute (per week). For the China regression, an increase in weekly income of US$30 corresponds to an increase of roughly 210 yuan per week, and similar calculations lead to a change of $-23$ minutes (per week).

output. However, $X_H$ is not observable (or very difficult to measure) and $p$ may be difficult to compute as well. Thus, the literature has usually proceeded by valuing the inputs to home production, namely $H$—the hours of home production. There are essentially two standard methods of evaluating the productive services rendered by family members at home: (a) evaluating time inputs at the market cost (or replacement cost) and (b) evaluating time inputs at their opportunity costs.

While the market cost and opportunity cost methods are standard in the valuation literature, they suffer from a number of limitations. First, both methods may underestimate the true value of home production if there are diminishing returns to home production. This fact has been overlooked in the accounting literature, but was pointed out in Gronau 1977, p. 1122).[25]

Similarly, standard valuation methods fail to capture the value of potential complementarities among the household members' home production hours (joint rents). Here, I present a third methodology—a structural method based on the theory of home production.

In my structural approach, household data are fitted to a model of time allocation that builds upon the standard home production framework (surveyed in its various applications in Aguiar *et al.*, 2012). I formulate a version of this model that incorporates the stylized features of China's home production presented above: (1) active participation of retired individuals in home production; (2) distinctive effects of individual characteristics, such as gender, on time allocation; and (3) a general downward trend in home production hours.

### 4.2. *The Household Model*

I describe a simple home production model that belongs to a broader class of models first pioneered by Becker (1965) and Gronau (1977).[26] As an illustration, I consider a household with three members: the wife ($w$), the husband ($h$), and an older relative who is retired ($o$).[27] The household utility depends on household consumption and the time allocation of the household members:

[25]Gronau makes the following statement: "the product of the average wage rate and the number of hours worked at home therefore understates the value of home production to the extent that diminishing marginal productivity prevails. This imputation does not account for the rent (i.e., the producer's surplus) accruing to a person who is self-employed in his own home."

[26]Gronau (1977) constructs a model for a married woman where the husband's decision is exogenous. It is a model of one individual who allocates time among market work, home production, and leisure. The model assumes that home time produces a good that is a perfect substitute for a composite good that may be purchased on the market. Gronau (1977) tests the model predictions using data from the 1972 panel of the Michigan Study of Income Dynamics. Graham and Green (1984) extend the Gronau (1977) model to a two-wage-earner household and allow home production and leisure to overlap to some degree. Their focus is on the estimation of the household consumption technology, and consists of a Cobb–Douglas function and a "jointness" function. They estimate the home production value for married women using data from the Panel Study of Income Dynamics for 1976 and provide estimates for the value of home production.

[27]The model can be easily extended to include more complicated household structures. In the estimation, I will allow an arbitrary number of working and non-working household members. The main results (namely equations (7) and (8)) can also be obtained from more complicated models, such as intra-household bargaining, where consumption allocation is Pareto efficient.

$$U\left(C,\ H_w,\ N_w,\ H_h,\ N_h,\ H_o\right), \tag{1}$$

where $C$ is the household consumption, $H_i$ is the home production time for household member $i$, and $N_i$ is the market working time for member $i$, and thus $N_o = 0$.[28] The total consumption of household services ($C$) can be obtained from the market ($X_M$) or produced at home ($X_H$):[29]

$$C = X_M + X_H. \tag{2}$$

Home production is described by the following technology, where the production function is twice continuously differentiable with positive first derivatives and is strictly concave:[30]

$$X_H = f(H_h,\ H_w,\ H_o). \tag{3}$$

The household faces a budget constraint:

$$pX_M = W_h N_h + W_w N_w + v, \tag{4}$$

where $v$ is non-labor income (including the retirement income of the older relative) net of expenditure on other goods. $W_h$ and $W_w$ are hourly wages, and $N_h$ and $N_w$ are the hours of work of the husband and wife, respectively.

In addition, each household member faces a time allocation constraint:

$$L_i + H_i + N_i = T, \quad i = h,\ w,\ o, \tag{5}$$

where $T$ equals total time and $N_o = 0$.

The economic problem facing the household is to choose an allocation of time that maximizes utility subject to the available technology, the household budget constraint, and each member's time constraint:

$$\max U\left(C,\ H_w,\ N_w,\ H_h,\ N_h,\ H_o\right) . s.t.(2),(3),(4),(5)$$

The fact that all household members attribute the same value to an additional unit of household consumption—that is, the term $U_c$ appears in all the first-order conditions—implies an important form of interdependence of choices within the

[28] I make no specific assumption on the household utility function $U(\cdot)$, beyond the intuitive requirements that $U_C \equiv \frac{dU}{dC} > 0, U_H^i \equiv \frac{dU}{dH_i} < 0, U_N^i \equiv \frac{dU}{dN_i} < 0$, and the usual conditions for existence of a maximum hold. When home production time and market work time are perfect substitutes, only the total working time matters, and this model reduces to a more standard utility function with consumption and leisure times as its arguments.

[29] $X_H$ is measured in the same units as market-purchased goods. To keep other aspects of the model as simple as possible, here I focus on market and household products that are perfect substitutes in consumption, which is in line with Gronau (1977). This may seem a restrictive assumption; however, the main results (again equations 7 and 8) also apply for a more general model where *some* market goods are perfect substitutes of home production.

[30] For simplicity, the use of market-purchased intermediate inputs is not considered in this formulation. Instead, household time-saving durables are taken into account as home production technology in Sections 4.3 and 4.4.

household. Maximization of household utility implies that the ratio of the marginal disutility of home production to the marginal product of home production and the ratio of the disutility of market work to the real wage are equalized across the household members:

$$\frac{U_H^i}{f_i} = \frac{U_N^j}{W_j/p}, \quad i \in \{h,w,o\}, j \in \{h,w\}. \tag{6}$$

It is also possible to rewrite these optimality conditions as the following two conditions:

$$W_i = p \cdot f_i \frac{U_N^i}{U_H^i}, \quad i = h,\ w, \tag{7}$$

$$W_j = p \cdot f_i \frac{U_N^j}{U_H^i}, \quad i = o;\ j = h,\ w. \tag{8}$$

Equation 7 is a straightforward extension of the standard condition equating the nominal wage to the nominal marginal product of home production for an individual. Here, the marginal product is adjusted by the ratio of marginal disutilities of work times. All the previous studies have focused on estimating the home production function for individuals who participate in the labor market and thus have a wage (as in most of the models surveyed by Aguiar *et al.*, 2012). Time allocation data on individuals who do not have a wage cannot be used to derive a production function if we rely only on estimating equation 7. I emphasize that it is still possible to estimate the parameters of a home production function for unemployed individuals by using equation 8. This first-order condition equates the marginal product at home of individual $i = o$ to the wage of individual $j = h,\ w$, corrected by the ratio of marginal disutilities of formal working time and home production time of two individuals: $\frac{U_N^j}{U_H^i}$. Equation 8 exploits the fact that the marginal utility of total consumption $U_c$ is the same for all the household members.[31]

I estimate the parameters of the household production function using data from the CHNS sample. I consider only households that have at least one working member, so that equations 7 and 8 can be estimated.[32] Instead of using the simple three-member household introduced above, the estimation allows for a variable household size and thus the household is denoted by $\mathcal{H}$.

[31]The same marginal utility of consumption for all the household members is actually the feature of a unitary household model. However, a similar condition can also be obtained from a non-unitary household model, such as a bargaining model, where consumption allocation is Pareto optimal.

[32]Within each household, I drop individuals who are 18 years old or younger, as their time-allocation decisions may not be correctly described by the model: schooling or studying is probably a major time use for these individuals, but the model and the data do not include such activities.

### 4.3. *The Estimation Strategy*

At this point, it is necessary to adopt specific functional forms. First, I model the household preferences in equation (1) as additively separable between consumption and labor with a constant elasticity of substitution (CES) feature:

$$U\left(C,\{T_i\}_{i\in\mathcal{H}},\right) \tag{9}$$

where $T_i$ serves as an index to represent total working time for household member $i$ (and $\frac{dU}{dT_i}<0 \quad \forall i$). Each member's total working time index is set as a CES composite of formal working time ($N_i$) and working time at home ($H_i$):

$$T_i \equiv \left[d_i N_i^{\eta} + (1-d_i) H_i^{\eta}\right]^{\frac{1}{\eta}}. \tag{10}$$

The parameter $\eta \in (-\infty,1]\setminus\{0\}$ measures the elasticity of substitution between home production time and formal working time. When $\eta = 1$, home production time and formal working time are perfect substitutes and the individual cares only about total working time or, equivalently, leisure time. The parameter $d_i \in (0,1)$ implies a disutility weight on market work time: a larger $d_i$ reflects a relative preference for home production and it is individual specific.[33] Empirically, I assume that an individual's preference for home production versus market work can be measured by the characteristics education, age, and gender:[34]

$$d_i = \{1+\exp\left[-(\delta_1 edu_i + \delta_2 age_i + \delta_3 female_i)\right]\}^{-1}. \tag{11}$$

A positive (negative) value of a $\delta$ coefficient implies a relative preference for home production (formal work) when the associated dummy is 1.

Second, the home production function is described by a CES technology with equal weights on labor inputs:

$$X_H = A\left[\sum_{i\in\mathcal{H}} (E_i H_i)^{\theta}\right]^{\frac{1}{\theta}}. \tag{12}$$

The parameter $\theta \in (-\infty;1]\setminus\{0\}$ measures elasticity of substitution among inputs. When $\theta$=1, inputs are perfect substitutes; when $\theta \to -\infty$, inputs are perfect complements. Additionally, $E_i$ represents the individual-level productivity (or human capital), whereas the $E_i H_i$ are in fact the "effective" home hours of each household member $i$. I assume that the individual productivity index $E_i$ can be measured through a combination with individual $i$'s age, educational attainment, and gender:[35]

$$E_i = \exp(\beta_1 edu_i + \beta_2 age_i + \beta_3 female_i). \tag{13}$$

[33]The standard modeling choice for total working time in the literature assumes perfect substitution, as in most of the models surveyed by Aguiar *et al.* (2012). Here, I use a flexible specification of the degree of substitutability between working at home and working in the market. This is important since in order to consistently estimate the value of home production, it is necessary to separate technology from preferences over time use. In addition, allowing each individual to put different disutility weights on market work and home production provides consistent estimates.

[34]Note that in this specification, $d_i$ is set to be bounded between 0 and 1.When $\delta_1$=$\delta_2$=$\delta_3$=0, $d_i$=0.5.

[35]My choice of the variables that affect $E_i$ and $d_i$ is guided by the assumption of Graham and Green (1984) that human capital is embodied capital and that an individual carries it into all activities, such as work, leisure, and home production.

The parameters $\beta_1$, $\beta_2$, and $\beta_3$ capture the effect of each of the three elements, respectively, on individual home productivity.

Next, the index of household level productivity $A$ is modeled as the usage of time-saving home durables.[36] Five types of durables are considered: washing machines, refrigerators, microwaves, electric rice cookers, and electric pressure cookers. For each of these durables, I use a binary variable denoting whether or not the household owns the appliance ($K_1$, $K_2$, $K_3$, $K_4$, and $K_5$, respectively). Additionally, household-level productivity is also assumed to be affected by whether the household lives in an urban or rural setting:

$$A = \exp(\alpha_1 K_1 + \alpha_2 K_2 + \alpha_3 K_3 + \alpha_4 K_4 + \alpha_5 K_5 + \alpha_6 urban). \tag{14}$$

All these six variables are expected to enter positively into the production function ($\alpha_i$>0), since the usage of time-saving durables and other services available to urban households is supposed to improve household productivity.

Finally, note that the price index $p$ is estimated together with the other elements of the model.[37] Macroeconomic factors are likely to affect the nominal value of home output only through $p$. Thus I assume that $p$ depends in part on year-specific and province-specific factors:

$$p = \exp\left(\pi_0 + \sum_{m=1}^{8} \pi_m province_m + \pi_{t1} year06 + \pi_{t2} year09\right), \tag{15}$$

where the $\{province_m\}$ are eight province dummies and $year$06 and $year$09 are year dummies for 2006 and 2009.[38] The constant $\pi_0$ reflects the average price of household services over the years from 2004 through 2006 to 2009 across all provinces.[39]

Applying the model specification, the optimal conditions given in equations 7 and 8 for each type of individual $i \in \mathcal{H}$ are as follows:

$$W_i = pA\left[\sum_{l\in\mathcal{H}} (E_l H_l)^{\theta}\right]^{\frac{1}{\theta}-1} E_i^{\theta} H_i^{\theta-1} \frac{d_i}{1-d_i}\left(\frac{N_i}{H_i}\right)^{\eta-1}, \quad \text{if } i \text{ works}, \tag{16}$$

$$W_j = pA\left[\sum_{l\in\mathcal{H}} (E_l H_l)^{\theta}\right]^{\frac{1}{\theta}-1} E_i^{\theta} H_i^{\theta-1} \frac{d_j}{1-d_i}\left(\frac{N_j}{H_i}\right)^{\eta-1}, \quad \text{if } i \text{ does not work}. \tag{17}$$

[36]Alternatively, durables could be modeled as arguments of the production function.

[37]The traditional price indexes, such as the GDP deflator or the CPI, are not ideal candidates for use in our model. The reason is that the household decision on how to allocate time and money between home production and market goods depends solely on the household member's wage relative to the price of the household services, not to the price of a larger basket of goods. However, a price index for household services cannot be found in the public statistics.

[38]The omitted province is Liaoning and the omitted year is 2004.

[39]It is clear, however, that if we were to include a constant household productivity term $\alpha_0$ in $A$, then $\pi_0$ would not be identified separately from it. This procedure does not involve any loss of relevant information, since I am not interested in $p$ itself and the purpose of the estimation is to derive the monetary value of home output ($pX_H$), not its real value.

Table 4
Non-Linear Least-Squares Estimation Results for the Home Production Model: Dependent Variable: log ($w$)

| | | |
|---|---|---|
| **Price-Level Parameters** | | |
| Average price | $\pi_0$ | 0.365*** (4.10) |
| Wave 2006 | $\pi_{t1}$ | 0.154*** (6.45) |
| Wave 2009 | $\pi_{t2}$ | 0.536*** (23.52) |
| **Household-Level Productivity Parameters** | | |
| Elasticity of substitution for labor inputs | $\theta$ | 0.940*** (87.15) |
| Washing machine ownership | $\alpha_1$ | 0.057 (1.90) |
| Refrigerator | $\alpha_2$ | 0.048 (1.75) |
| Microwave | $\alpha_3$ | 0.225*** (10.14) |
| Electric rice cooker | $\alpha_4$ | 0.015 (0.48) |
| Electric pressure cooker | $\alpha_5$ | 0.010 (0.48) |
| Urban status | $\alpha_6$ | 0.064** (2.71) |
| **Individual Productivity Parameters** | | |
| Education | $\beta_1$ | −0.013 (−1.24) |
| Age | $\beta_2$ | 0.006* (2.55) |
| Female | $\beta_3$ | 0.559*** (4.30) |
| **Preference Parameters** | | |
| Elasticity of substitution for time use | $\eta$ | 0.861*** (81.83) |
| Education | $\delta_1$ | 0.050*** (4.84) |
| Age | $\delta_2$ | −0.003 (−1.06) |
| Female | $\delta_3$ | −0.861*** (−6.87) |
| $N$ | 4,575 | |

*Notes*: $t$-Statistics in parentheses. *$p$<0.05, **$p$<0.01, ***$p$<0.001. Estimates of eight province dummies are omitted due to space limits.

Note that for non-working individual $i$, a working individual $j$ from the same household $\mathcal{H}$ is assigned by the estimation algorithm; that is, $N_j > 0, i, j \in \mathcal{H}$.[40] Equations (16) and (17), with $p$, $A$, $E_i$, and $d_i$ given above, are the relations that I will estimate. I can further fit these estimation equations into a non-linear specification as follows:

$$\log(W_i) = f(\mathbf{X_i'}, \boldsymbol{\beta}) + \epsilon_i, \quad (18)$$

[40]Note that the estimation includes all types of non-employed household members, including individuals who are self-reported as "currently not working" due to schooling, retirement, seeking work, disability, or other types of unspecified reasons.

where $\mathbf{X}_\mathbf{i}'$ is a row vector of predictors for the $i$th of $n$ observations, specifically,

(19) $\mathbf{X}_\mathbf{i}' = (1 \quad year06 \quad year09 \quad province1-8 \quad K1-5 \quad urban \quad edu \quad age \quad female)$;

$\boldsymbol{\beta}$ is a vector of 25 regression parameters to be estimated, specifically,

$$\boldsymbol{\beta} = (\pi_0 \quad \pi_{t1} \quad \pi_{t2} \quad p1-p8 \quad \theta \quad \alpha1-\alpha6 \quad \beta1-\beta3 \quad \eta \quad \delta1-\delta3); \tag{20}$$

$f$ is a non-linear function given by the log of the right-hand side of equations (16) and (17), representing the response of wages to all the above predictors; and $\varepsilon_i$ is a random error assumed to be normally distributed, iid with expectation 0 and with constant variance. The estimation method that I implement is non-linear least squares; that is, minimizing the sum of the squared residuals:

$$S(\boldsymbol{\beta}) = \sum_{i=1}^{n} \left[ \log(W_i) - f(\mathbf{X}_\mathbf{i}', \boldsymbol{\beta}) \right]^2. \tag{21}$$

Because the relations are non-linear, I obtain the solution by numerical optimization. The estimation of equation 21 requires data on the following variables: the nominal wage $W_i$, the home production time for each individual in the same household $\mathcal{H}$, individual characteristics such as education, age, and gender, as well as household-level ownership of home durables. Most importantly, it requires data that link individuals within the same household.

### 4.4. *The Estimation Results*

Table 4 reports the non-linear least-squares estimation results using the CHNS dataset.[41] The empirical estimates suggest that the nominal marginal product of home production has increased over time.[42] Turning to the estimates for household-level productivity, the estimate of $\theta$ is significantly different from one ($p$-value $= 0.001$), which is consistent with the point discussed in Section 1, that the effective home production hours of different household members are not perfect substitutes, and that evaluating the contribution to home production of each individual separately from the others misses important complementarities and joint rents.

As expected, all the general household productivity (home production technology) parameters have positive signs. In particular, the use of a microwave ($\alpha_3$) significantly improves household-level productivity.[43] Living in an urban area ($\alpha_6$) improves household productivity significantly. As regards to individual-level productivity, education has a negative but insignificant effect ($\beta_1 < 0$). Age has a positive effect on a person's productivity at home, perhaps due to experience ($\beta_2 > 0$). Moreover, women have higher marginal productivity at home ($\beta_3 > 0$). The final set of estimates of the preference side of the model shows that individuals do care how their time is allocated between home production and market work, as they are not perfect substitutes: the estimated elasticity of substitution ($\eta$) is significantly lower

[41]For simplicity, estimates for province dummies are not reported in Table 4, but the effect of provinces on home production will be shown in Section 5.

[42]Both year dummies are positive and significant, with $\pi_{t1} < \pi_{t2}$.

[43]The estimation results for the washing machine ($\alpha_1$) and the refrigerator ($\alpha_2$) are almost significant.

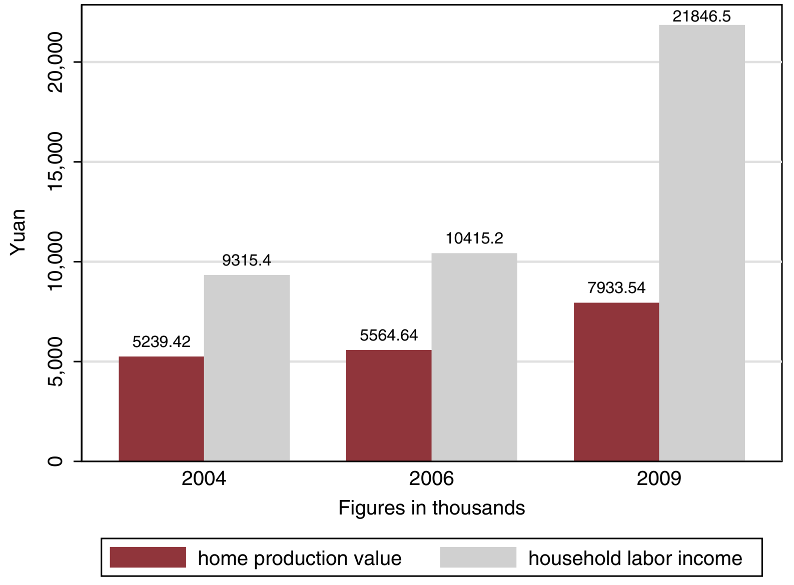


Figure 5. The Value of Home Production and Household Income

*Sources:* The CHNS and the author's calculation.

*Notes:* The estimated home production value is the yearly nominal home production output computed from the structural model. Household labor income is constructed as the reported annual labor income and retirement income from all household members. Both variables are denoted as averages across the household and weighted by the population of the province in the years 2004, 2006, and 2009. [Colour figure can be viewed at wileyonlinelibrary.com]

than one ($p$-value $= 0.001$). Specifically for each individual, a higher education is associated with a relative preference for home production over market work ($\delta_1 > 0$). Women significantly prefer market work over home production ($\delta_3 < 0$), although empirical evidence shows that women work more inside the house than men. Age does not seem to affect an individual's preference in a significant way ($\delta_2$ is insignificant).

## 5. The Value of Non-Market Consumption

The parameter estimates of the home production function can be used to compute the nominal value of home output as follows:

$$V^{\text{structural}} = pX_H = pA\left[\sum_{i \in \mathcal{H}} (E_i H_i)^{\theta}\right]^{\frac{1}{\theta}}. \tag{22}$$

Given information at the individual and household level, I compute the nominal value of home production output or, equivalently, the value of non-market consumption for each of the survey years.[44] In order to gauge the magnitude

[44]The use of the structural method to conduct the computation of the home production value requires information at both the household and the individual level. For example, $pA$ is computed by using the estimates from the household level. Similarly, $E_i$—the individual-level productivity—is computed using the individual-level estimates.

TABLE 5
The Home Production Value

| | 2004 | 2006 | 2009 | Annual change (%) |
|---|---|---|---|---|
| Home production/ adjusted GDP (%) | 26 | 22 | 18 | −2.7 |
| Non-retiree's home production/ adjusted GDP (%) | 17 | 13 | 12 | −2.8 |
| Retiree's home production/ adjusted GDP (%) | 9 | 9 | 6 | −2.2 |
| Retiree's home production/ home production (%) | 17.7 | 18.7 | 13 | −1.5 |

*Notes*: In this table, home production denotes the monetary value of home production imputed from the structural model. The adjusted GDP is the amount of total household labor income if nominal home production was also to count toward the income; that is, revised GDP is obtained from adding up the total amount of household labor income (reported by household members in the survey) and the total home production value imputed from the model. All figures are denoted in percentage terms. Annual change (in percent) is the average yearly growth rate.

of non-market consumption, I compare its aggregate value to the total household labor income in the sample. The total household labor income is obtained by summing all the individual-level income variables, including not only wages but also retirement pensions and profits, among other variables. To be nationally representative, both non-market consumption and household labor income are averaged across households and weighted by the population of the province in each year. Figure 5 presents the valuation results: the nominal value of home output has steadily increased from 2004 to 2009, but over the same period of time household income has more than doubled.

To provide a more direct measure of the size of home production, I use the ratio of the value of non-market consumption to extended household labor income, which incorporates the value of home production as an estimator for the ratio of non-market consumption to measured GDP. This measure is sensible because home production represents additional income that is available for consumption but is not included in labor income, and thus not included in national income. By adjusting the measured GDP, we can obtain the size and the trend of home production as a percentage of adjusted GDP if they were counted in the output.[45] Table 5 presents several relevant ratios. The estimated home production counts for around 26 percent of adjusted GDP (if home production is included) in 2004, but this figure falls to 18 percent by 2009. Between 2004 and 2009, home production in the national output declines at a yearly rate of 2.7 percent. Within the total home production output, the amount produced by non-retired individuals shows a similar decreasing trend. Meanwhile, the retirees' home production value shows a

[45]This accounting method is in line with work on the valuation of home production and the measurement of income inequality; for example, Frazis and Stewart (2011).

slower declining rate, which echoes the previous evidence on the great amount of time allocated by retirees to home production.[46]

Despite the significant change that has occurred over the past decade, non-market consumption still represents a large share of economic activity in 2009, as the estimated ratio of non-market consumption to adjusted GDP is around 18 percent. This estimate is large but not unreasonable, as the same estimate of the value of household services for the U.S. by Bridgman *et al*. (2012) is around 14 percent in 2010. Moreover, the estimate is also in line with that obtained by Dong and An (2015), who find that the value assigned to unpaid care work varies from 25 percent to 32 percent of China's GDP in 2008.

## 6. Conclusion

This paper presents new estimates of China's hidden consumption derived by estimating the size of home production. Utilizing rich survey data over several years, I provide a structural estimation of household time allocation choices in China. The main strategy that I employ allows for intra-household joint rents and complementarities, while also estimating the contribution of retired individuals to home production. I estimate that the aggregate value of home production as a fraction of adjusted GDP has fallen at a rate of 2.7 percent per year over the past decade. However, the nominal value of home production was still sizable in 2009, at roughly around 18 percent of adjusted GDP.

The main implication of this paper is that non-market consumption is quantitatively significant for the Chinese economy, and neglecting it would miss a critical aspect of the economics of Chinese households. One important avenue for further research is accounting for non-market consumption in macroeconomic studies on consumption, saving, and the imbalances of the Chinese economy (see, e.g., Modigliani and Cao, 2004; Qin and Ren, 2008; Guo and N'Diaye, 2010; Xu *et al*., 2017).

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[46]Regardless of the estimation strategy, the estimates of home production value are likely to be downward biased due to the quality of the data on time use. For example, there are no time-use data on volunteer service to the community. Thus these figures should be viewed as lower bounds for the size of home production. Additional accounting exercises using market cost and opportunity cost methods are conducted to provide support for the structural estimation (see Appendix C).

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## Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's web site:

**Appendix A: Additional Tables and Figures**
Table A.1: Descriptive Statistics—ATUS
Table A.2: Definition of Time Use Variables
**Appendix B: Model Derivation**
**Appendix C: Extension—Alternative Evaluation Methods**
*C.1. The Market Cost Method*
*C.2. The Opportunity Cost Method*
Table C.1: Hidden Consumption: Comparison Among Three Valuation Methods