Home Productivity

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Abstract

This paper examines the productivity of home production. I calculate annual home production output and productivity for the United States from 1929 to 2010. Both labor and multifactor productivity grew steadily after World War Two, but slowed after the late 1970s. Capital intensity increased in the late 1970s due to increased consumer durables holdings. Including home production significantly reduces the shift from goods to services production relative to published GDP.

JEL classification: D13, D24, E1, O3.

Keywords: Home production; Labor productivity; Multifactor productivity.

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1 Introduction

A large theoretical literature has found that the addition of a home production sector improves the predictions of macroeconomic models[1]. It continues to be an area of active research. For example, a recent literature has examined the effect of productivity growth on changes in the industrial structure of the economy. Kongsamut, Rebelo & Xie (2001) and Buera & Kaboski (2012*b*) feature neutral technical change and non-homothetic preferences while Ngai & Pissarides (2007) feature differences in technical change across sectors. Other theories, such as Acemoglu & Guerrieri (2008), rely on differing factor shares in production. Determining what forces are at work requires data on factor shares and technical change in home production.

However, little is known about the household sector's basic inner workings since practical considerations caused economic statisticians to exclude it from the National Income and Product Accounts (NIPAs)[2]. Models must be parameterized without the discipline of data. Rather, the models are used to back out what is going on in this sector (Ingram, Kocherlakota & Savin 1997). In a recent example, Rogerson (2008) argues that the household sector is essential to understanding different labor market outcomes in the United States compared to Europe. Since "measures of home sector productivity do not exist," he must use an imprecisely estimated elasticity parameter to back out this productivity.

This paper documents a number of facts about the household sector to guide macroe-

[1]Important contributions include Benhabib, Rogerson & Wright (1991) and Greenwood & Hercowitz (1991) on business cycles, Parente, Rogerson & Wright (2000) on the welfare costs of growth distortions and Rupert, Rogerson & Wright (2000) on labor supply elasticities. Greenwood, Rogerson & Wright (1995) surveys its inclusion in macroeconomic models. Recent work includes Aruoba, Davis & Wright (2012), Aguiar, Hurst & Karabarbounis (forthcoming) and Karabarbounis (2012).

[2]It was a concern during the original work on national income measurement (Kuznets 1934). See Abraham & Mackie (2005) for an overview of the measurement issues and Gronau (1986) and Gronau (1997) for surveys of more recent work.

conomic modeling, with an emphasis on productivity measurement. Improvements in the measurement of time use, such as the regular collection of time use data through the American Time Use Study (ATUS), have led to better estimates of the inputs in this sector. Building on work done by researchers at the Bureau of Economic Analysis (BEA) (Landefeld & McCulla 2000, Landefeld, Fraumeni & Vojtech 2009, Bridgman, Dugan, Lal, Osborne & Villones 2012), I estimate annual home production for the United States from 1929 to 2010 using national income accounting principles. I then examine labor and multifactor productivity (MFP) in this sector.

I find that home production has generally declined in importance compared to measured GDP. However during the dislocations of the Great Depression and World War Two, its importance fluctuated significantly. The ratio of home production to measured GDP increased to 70 percent in the depths of the depression (1932) and dropped to 36 percent during the height of the war (1943). The estimates help fill in the historical record on the size of home production by providing the better part of a century of consistent data. Other such estimates include Eisner (1989), Folbre & Wagman (1993) and Soloveichik (2013).

Home productivity grew at a rate similar to that of the market economy in the postwar period until the 1970s. Home labor productivity grew an average of 2.4 percent a year during the period 1948-1977, slightly outpacing the 2.1 percent rate in market. There is a severe slowdown in home productivity in the late 1970s. Labor productivity was nearly flat, growing an average of only 0.01 percent from 1978 to 2010. In contrast, market labor productivity grew 1.6 percent annually.

There have been significant shifts in how the home sector produces output. Labor has been progressively replaced by capital since 1978. Labor share drops from 0.63 to 0.53. Most of this increase is due to consumer durables becoming much more important. This large change in capital share suggests that the household sector's production function must allow for

substitutability between capital and labor, such as the CES form proposed by Greenwood & Hercowitz (1991).

MFP grows 1.4 percent annually from 1929 to 2010. This growth has not been uniform. It follows a pattern similar to labor productivity, with strong post-war growth up to 1978. Since then MFP has declined slightly, falling 0.5 percent annually off its 1978 peak.

The productivity slowdown in the late 1970s coincide with a number of changes in educational and occupational choices and wages. The 1970s mark the beginning of a convergence of male and female labor market and education experiences. Goldin (2006) identifies this period as a revolution in female labor participation, where women began to see paid work as a long term career rather than a temporary job.

1978 also coincides with a shift to market produced services. An increasing share of services that had been produced at home were purchased in the market. A consequence of this "marketization" is that a portion the observed structural shift from goods to services production is a reallocation of home to market produced services. Structural change is much less pronounced is home production is included. From 1929 to 2010, services share of output only grows 22 percent with home production as opposed to 47 percent when it is excluded.

2 Home Production Estimates

This section describes how the estimates of home production are constructed and reports the levels of household output.

2.1 Home Production Industry

Since the analysis focusses on productivity of the home production sector, we need to define what is included in this "industry." The basis for the estimates are a series of papers from BEA that calculate GDP if U.S. household production were included using national accounting

conventions (Landefeld & McCulla 2000, Landefeld et al. 2009, Bridgman et al. 2012). I select the industry boundaries to be consistent with this previous work.

The gross value added of an industry is the net income to the factors of production plus the depreciation of the industry's capital. I define the labor input to be non-market labor engaged in household tasks such as cooking, cleaning, shopping and child care. The capital input is consumer durables, residential capital and governmental capital provided to the household and used in home production[3]. While I think this definition is reasonable, below I show that the results are robust to changing the industry boundary.

The general principle for defining an industry is to include establishments that produce similar products using similar technology. The definition fits this principle and accords with usual view of what constitutes home production. An establishment is a residence where family members produce household services for other family members.

I only include non-market labor to focus on what the NIPAs currently exclude. It also accords with the way most macro models delineate home and market production. Home production hours are not paid a wage in the labor market. The labor of compensated home workers is treated as purchased business services, an intermediate purchase that is excluded from value added in the home industry.

I do include the gross value added of housing even though it is already included in GDP. Structures that house an industry's production are included in its capital stock. Excluding residential capital would lead to the unattractive situation where a stove used in cooking a meal was included, but the kitchen was not.

Including residential capital means that some components are already included in mea-

[3]Governmental capital is half of the "Highways and streets" category of government capital. Half is chosen based on a 2000 survey road use that found that half of car passenger milage was accounted for by non-commuting household travel. Using the 2000 share for the whole period is arbitrary, but has very little quantitative impact since government capital services are tiny.

sured GDP. Therefore, home production is not purely an addition to measured GDP. In what follows, home production will generate two concepts of output. "Home production" is the industry defined above. It includes all household output, not just the new imputations.

"Extended GDP" is GDP if home production were included. Extended GDP is unaffected by whether housing output is included in the definition of the home production industry.

2.2 Methodology

The basic strategy is to estimate value added by imputing income to the factors of production: labor L and capital K. Labor input is uncompensated hours in household production drawn from time use surveys[4]. The imputed wage w is hourly compensation of workers employed in the household sector, under the assumption that market and non-market workers have the same marginal product of labor in the home.

There are three types of capital used by the household: consumer durables, residential capital and governmental capital provided to the household and used in production. The capital services are the asset rate of return r^j for each type of capital plus depreciation δ^j, for $j \in \{Durables, Residential, Government\}$. The rate of returns used are households' financial asset returns for durables and government debt returns for government capital. I use NIPA gross value of housing as the capital income for residential capital. Formally, household output Y is given by:

$$Y = wL + \sum_j [(r^j + \delta^j)K^j] \tag{2.1}$$

The BEA estimates cover the period 1946 to 2010. This paper extends them back to 1929 using as similar methodology as possible. (Details on the data are reported in a data

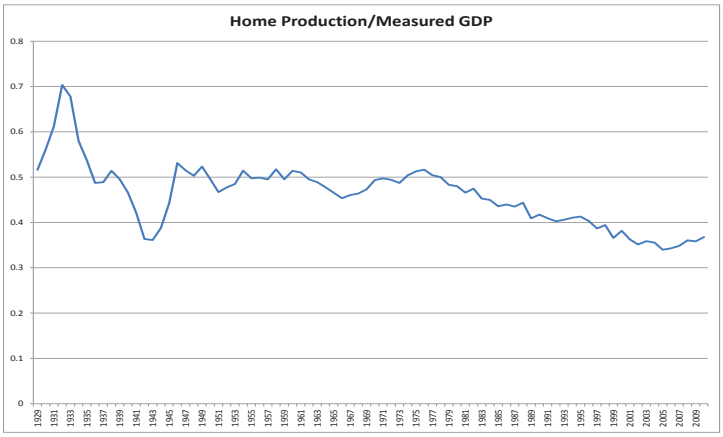
[4]Time use surveys were not conducted annually until 2003, so most years are interpolations. The general methodology is to disaggregate hours data in survey years by demographic group then project non-survey years using data on population size of those groups.

appendix.) There are two main differences in the calculation for the 1929 to 1945 period. First, I use the home production hours estimates from Ramey (2009) and Ramey & Francis (2009) as the measure of labor hours[5]. Second, the capital return series used to impute capital services of consumer durables in the BEA estimates does not exist for the earlier period. Instead I use the Moody's Seasoned Baa Corporate Bond Yield. Both series overlap with the BEA data. They give very similar estimates. I discuss the robustness of the estimates below.

2.3 Home Production 1929-2010

Home production has declined in importance in the economy. As Figure 1 shows, home production fell from 52 percent of measured GDP to 37 percent. This decline in importance has been noted in the BEA work for recent years. It is also consistent with other work that has noted the decline in home production hours (Aguiar & Hurst 2007).

Figure 1: U.S. Home Production/GDP, 1929-2010



[5]I generate total hours by multiplying their estimate of average weekly hours by the population and 52 (the number of weeks in a year).

While the overall trend has been negative, there are significant swings during the Great Depression and World War Two. It peaks in 1932 at 70 percent of measured GDP and drops to 36 percent in 1943. Home production did not fall as much as the rest of the economy during the Depression making it almost as big as measured GDP. Market hours fell significantly while household production hours increase slightly (Ramey 2009). The opposite happens during the war, where home production drops to its lowest percentage of GDP in the series. This shift largely reflects the recovery in the market sector.

Recall that household production includes items that already included measured GDP. Therefore, this ratio is not a measure of how much GDP would increase if household production was included. Rather, it measures the size of this production compared to measured GDP. The amount GDP would increase due to new imputations follows the size of home production relative to measured GDP closely. Extended GDP falls from being 42 larger than measured GDP in 1929 to 28 percent larger in 2010.

3 Labor Productivity

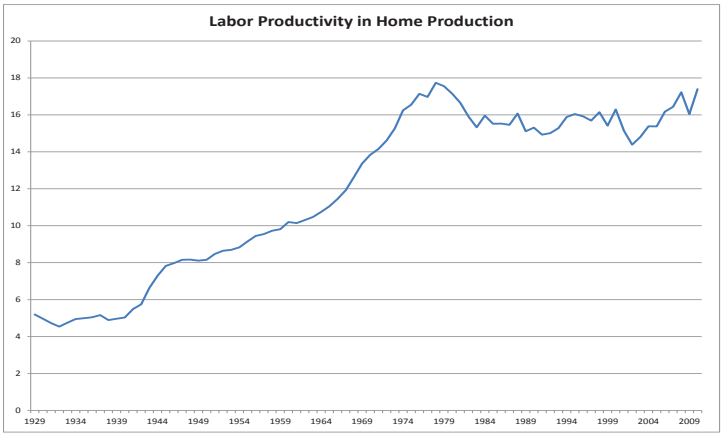
To measure productivity, we need to deflate the nominal household output to put it in real terms. As a baseline, I use the price index for private household output. This sector is comprised of the services of owner-occupied housing and the compensation paid to domestic workers. (See McCulla & Mead (2007) for fuller documentation.) This measure is the closest to the concept of household production in the published NIPAs. I discuss the robustness of this choice below.

Figure 2 shows labor productivity in home production, as measured by real value added per hour. Productivity is flat during the Great Depression and grows quickly during U.S. involvement in World War Two. During the war, inputs fall slightly while the value of hours increases rapidly. The production of home capital was restricted as production was geared to war materiel. The movement of women into the defense industries and out of the home, the

"Rosie the Riveter" effect, does reduce home production hours but is small. Women's average hours in home production does not fall much[6]. The value of those hours increased, as the real wages of home workers grow rapidly during the war.

Productivity increases steadily after World War Two until the late 1970s, growing an average of 2.4 percent a year from 1948-1977. This rate is similar to that of the market economy, which grew 2.1 percent per over the same period[7]. It is flat both during the depression and war and after 1978. Home productivity only grew an average of only 0.01 percent from 1978 to 2010 while market labor productivity grew 1.6 percent per year.

Figure 2: Labor Productivity in Home Production 1929-2010



The home sector is less productive than the rest of the economy, a gap that has been increasing. Figure 3 shows the ratio of home productivity to real GDP per market hour worked.

[6]As documented in Goldin & Olivetti (2013), World War Two had an impact on women's labor participation after the war.

[7]Labor productivity is measured as GDP per hour using BEA's measure of total market hours: NIPA Table 6.9, line 1.

To obtain more data coverage, I use market labor hours calculated as average work week from Ramey (2009) times the population times 52, the number of weeks. These data end in 2005, but give much longer historical coverage. (The BEA data begin in 1948). This measure is broadly consistent with the BEA measure, but has a higher level.

Figure 3: Ratio of Home to Measured GDP Labor Productivity 1929-2005

An hour of work in the home sector has produced progressively less output relative to the market over time. An hour of home production produced nearly two thirds the dollars of value added compared to the economy measured by GDP in 1929. In 2005, an hour of work produced a third of the value added of an hour in the market: \$15.37 versus \$44.19. This finding supports the assumption in Nosal, Rogerson & Wright (1992) that workers would prefer to work in the market.

The data suggest that the economic cost of distortions, such as discrimination (Goldin 1990) or taxes (Rogerson 2008), that increase home production share, has increased over time. This increase may help explain the decline in discriminatory barriers to married women entering

the labor force.

This fact also suggests that home production provides less of a cushion for recessions. Workers that leave the market sector for the home sector have increasing output losses. This finding is consistent with Aguiar et al. (forthcoming) and Bridgman et al. (2012), who find adding a home sector does little to reduce volatility of output. In fact, home productivity is pro-cyclical which accentuates the lack of insurance home production provides. The correlation between market and home labor productivity is 0.47 over the full sample. However, the gap between in the level of productivity is probably more important, as emphasized by McGrattan, Rogerson & Wright (1993).

The slower growth in the household sector is consistent with some estimates of home productivity backed out of models. Rogerson (2008) estimates that productivity growth in the household sector from 1956 to 2003 was slower than market sectors. Over this period, home productivity grew 1.0 percent a year compared to 1.8 for the market sector (using BEA hours).

4 Multifactor Productivity

This section examines multifactor productivity (MFP) in the household sector. This calculation requires taking a stand on how capital and labor are combined. I begin by examining what production functions are consistent with data. I show the evidence is consistent with a production function that allows for substitutability between capital and labor, such as the CES function. I then calculate MFP using a labor augmenting CES function.

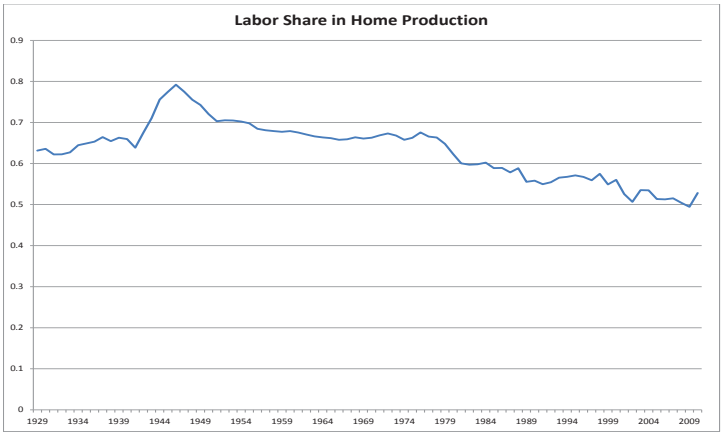
4.1 Production Function

Since there is little data on home production, we have little direct evidence on what the appropriate home production function is. As a result, there is no consensus in the literature on what form to use. The most common production function in macroeconomics is Cobb-Douglas.

It was used by Benhabib et al. (1991) among others.

As shown in Figure 4, home production shows a significant change in labor share which indicates that the Cobb-Douglas production function is a poor fit for the data. In the early period, households invest very little in home capital. As discussed above, World War Two severely restricted home investment. In the later period, the opposite is true. Households replace labor input with capital input. As a result, the labor share of the sector declines.

Figure 4: Labor Share in Home Production 1929-2010



Home production becomes more capital intensive over time. Capital share increases from 0.37 in 1929 to 0.47 in 2010. Consumer durables have become more important, increasing from 5.5 to 21.6 percent of real home capital held by the household from 1929 to 2010. This decline echoes a similar fall in market labor share (Karabarbounis & Neiman 2013).

Given the change in factor shares, a more promising form is a CES production function that allows for more flexible substitution between inputs. (It collapses to Cobb-Douglas when the capital-labor elasticity is equal to one). A difficulty with this form is that the productivity

process is also more flexible. Each input can have a separate productivity process, whereas in Cobb-Douglas productivity is always Hicks-neutral. Identifying the degree of bias in technical change has been a long standing controversy, since the capital-labor elasticity and technical biases are not separately identified. Some structural assumption is required to proceed. (See Leon-Ledesma, McAdam & Willman (2010) for a survey of this literature.)

As a baseline, I use labor augmenting technical change:

$$Y_t = [\theta K_t^{\lambda} + (1-\theta)(A_t L_t)^{\lambda}]^{\frac{1}{\lambda}} \tag{4.1}$$

where Y_t is home production, K_t is household capital and L_t is hours of home production.

I selected this functional form since it has been used previously in the literature. For example, it was used by Greenwood & Hercowitz (1991) and Gomme, Kydland & Rupert (2001). The MFP calculation is not significantly changed by alternative assumptions on how productivity enters.

4.2 MFP Results

Once we have selected a functional form, we have two additional tasks before we can calculate MFP. We need a measure of real capital inputs and we need parameter values for the production function.

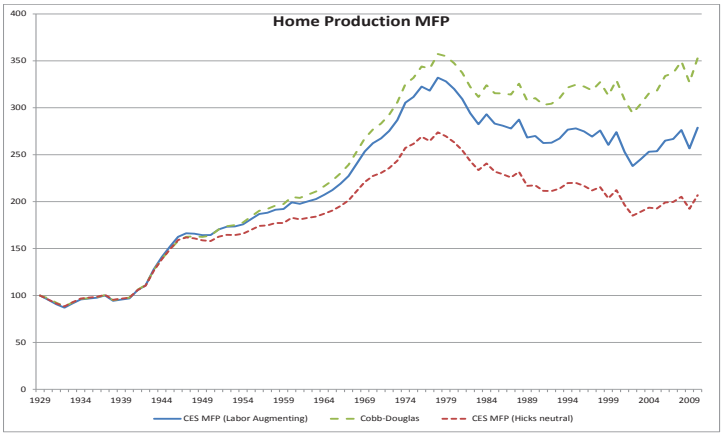
As the measure of capital, I aggregate the three capital inputs (consumer durables, residential and governmental capital) into a capital index. Since BEA's real capital stocks are calculated using chain weighted price indices, we cannot simply add the deflated capital series. Following BEA's methodology, I generated a psuedo-Fisher index of capital input[8].

Finally, for baseline parameter values I use the estimates from McGrattan, Rogerson & Wright (1997). They find $\lambda = 0.19$ and $\theta = 0.22$.

[8]This methodology can be found at http://www.bea.gov/national/FA2004/Details/xls/DetailCDG.xls.

Line "CES MFP (Labor augmenting)" in Figure 5 shows the baseline estimate of MFP. Over the sample period, MFP grows an average of 1.4 percent a year. There are significant differences over time. There is little growth during the Depression. MFP grows steadily during the postwar period prior to 1978 then flattens out. From 1948 to 1977, MFP grew 2.2 percent, compared to -0.5 percent annually from afterward. The slowdown in MFP coincides with the slowdown in labor productivity.

Figure 5: Multifactor Productivity in Home Production 1929-2010



To see how sensitive the results are to the assumption on technical bias, I calculate MFP using a Hicks neutral CES production function using the same values for θ and λ:

$$Y_t = A_t[\theta K_t^{\lambda} + (1-\theta)(L_t)^{\lambda}]^{\frac{1}{\lambda}} \tag{4.2}$$

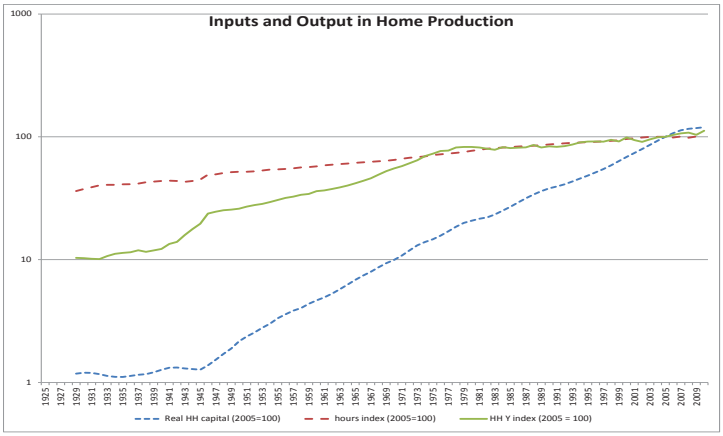
Line "CES MFP (Hicks neutral)" in Figure 5 shows this estimate. The pattern of growth is very similar, though the magnitude of MFP growth is smaller. The average growth rate over the sample is 1.0 percent, compared to 1.4 percent in the baseline case. This slower growth is seen in every subperiod. The postwar growth period (1948 to 1977) is a bit slower (1.7 percent

compared to 2.2 percent in the baseline) and the slowdown a bit worse (-0.9 percent annually versus -0.5 percent a year).

Changing the capital-labor elasticity has a similar effect. I set $\lambda = 1$ to collapse the CES into a Cobb-Douglas function. Again, as seen in line "Cobb-Douglas" in Figure 5, the pattern is unchanged though the magnitudes are larger.

As shown in Figure 6, the productivity slowdown coincides with a slowdown in home output. Capital input is exploding while output grows slowly. Since inputs are growing while output slows, TFP will slow for most functional forms and parameters. It is only the magnitudes that will be sensitive to such changes.

Figure 6: Inputs and Output in Home Production 1929-2010



Like labor productivity, multifactor productivity is pro-cyclical. The baseline TFP measure and real GDP has a correlation of 0.41 over the period 1929 to 2010. This observation matches with Greenwood & Hercowitz (1991) and Fisher (2007), who use models where home and market productivity shocks are correlated to generate the empirical co-movement of home

and market investment. The data confirm this positive correlation.

5 Implications for Theory

In this section, I discuss how the facts in paper fit in with existing theory, focussing on two areas where home production may have significant impact: female labor force participation and structural change.

5.1 Female Labor Force Participation

Women significantly increased their labor force participation after World War Two. Half of women worked in the market in 1980, nearly double the rate in 1950 (27.1 percent)[9]. The strong productivity growth in three decades World War Two is consistent with the "Engines of Liberation" hypothesis, annunciated by Greenwood, Seshadri & Yorukoglu (2005), Greenwood & Guner (2009) and Bar & Leukhina (2011), which argues that the diffusion of household appliances that the eased women's transition from the home to paid work.

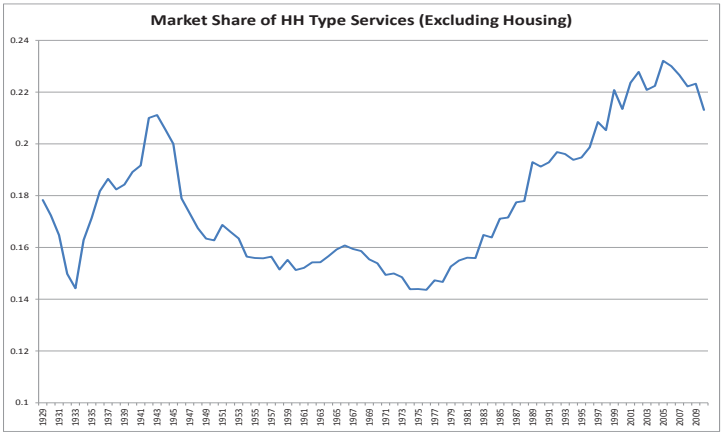
The 1978 productivity slowdown may mark the point at which household capital no longer embodied significant new technologies. The innovations that changed the nature of household work, for example electric washers and vacuum cleaners, were in nearly every home by the 1980s. Falling capital prices led to an increase in capital along the intensive margin but did not lead to a reorganization of household production in the way that the innovations of the early 20th century did. Since home production is not information intensive, improvements in computer technology that revolutionized some market sectors had less impact on the home.

It may be that changes in home production were a cause rather than a consequence of productivity change. The year 1978 marks a significant change in the household sector. It is

[9]Historical Statistics of the United States, Millennial Edition, series ba345. See Costa (2000) for a survey of the evidence.

the year that labor share begins a concerted decline.

Figure 7: Market Share of Home Type Services 1929-2010

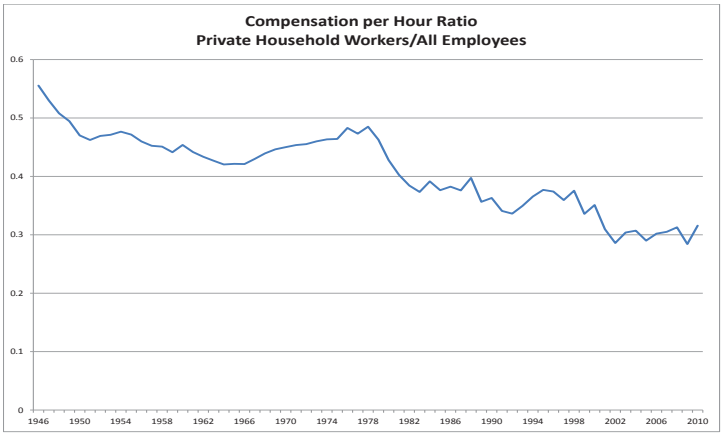


The slowdown coincides with an increasing shift to market services purchases. Figure 7 shows the market share of the type of services that are produced in the home. The numerator is market services purchased by households that are similar to those provided by the household [10]. The denominator is the sum of these purchases and non-housing household production. I exclude housing since it is a mix of market and non-market services. The late 1970s may mark a shift to "marketization," purchasing more services outside the household rather than making them at home (Freeman & Schettkat 2005)[11].

[10]Purchased services are current dollar personal consumption expenditure (PCE) on Transportation, Food Service and Accommodation, Household Maintenance and Personal Services. NIPA Table 2.4.5 lines 68, 81, 105 and 107.

[11]This ratio mixes a value added measure (household production) with a final expenditure measure (Herrendorf, Rogerson & Valentinyi forthcoming). I generate gross home product by adding non-durable PCE and utilities to the value added home production, under the assumption that non-durable PCE is an intermediate input to home production. Movements in the ratio are similar with this measure.

Figure 8: Household Worker and All Employee Wage Ratio: 1946-2010



This marketization of services may have led to a change in the composition of household workers. As shown in Figure 8, it coincides with an increasing gap between women's market wages and the wages of household employees. Buera & Kaboski (2012*a*) argue that increasing returns to skill drew skilled workers in the home sector into market work, a process that has empirical support in Mulligan & Rubenstein (2008). The increasing returns to skill may reflect structural change that favored skilled service industries over physical goods industries (Rendall 2010, Olivetti & Petrongolo 2011, Rendall 2013, Ngai & Petrongolo 2013).

The estimates do not account for the returns to human capital. The slowdown coincides with the time that Goldin (2006) identifies as a revolution in women's attachment to the paid labor force. Though female labor force participation grew steadily in the postwar era, she identifies the 1970s as the period that women's education and expectations shifted from paid work as a temporary or intermittent state (work as a job) to specializing in market work (work as a career). Women's wages and occupational choices begin to converge to men's at that time.

The binary choice of some versus no market hours masks a slower increase in average hours worked by women, especially married white women (Jones, Manuelli & McGrattan 2003). The 1950s marked wide adoption of part time work arrangements, which allowed married women to work some hours in the market without fundamentally changing their focus on home production and a weaker attachment to the paid labor force (Goldin 2006).

Prior to the 1970s, married women with and without a college education had very similar labor participation patterns. Therefore, the skill mix (as measured by education levels) was similar inside and outside the home. In the 1970s, college educated married women were more likely to work in the market. When they worked, they mostly worked full time (Costa 2000). The flow of college educated women from household work into market work would leave less educated workers behind. If the paid portion of household work (from which the imputed wages are calculated) also reflected this change in human capital composition, the imputed wages will reflect a decline in relative productivity.

Strong productivity growth may have initially been a force encouraging married women to remain focused on the household sector. Households may have responded to increasing productivity by increasing home production. Initially, the introduction of household appliances did not reduce married women's hours and may have even increased household work (Mokyr 2000), an effect Cowan (1983) called "more work for mother." Since vacuum cleaners made it easy to keep the rugs clean, married women may have cleaned the rugs more often. When household technology fell behind the market, there was less payoff to home hours compared to the market.

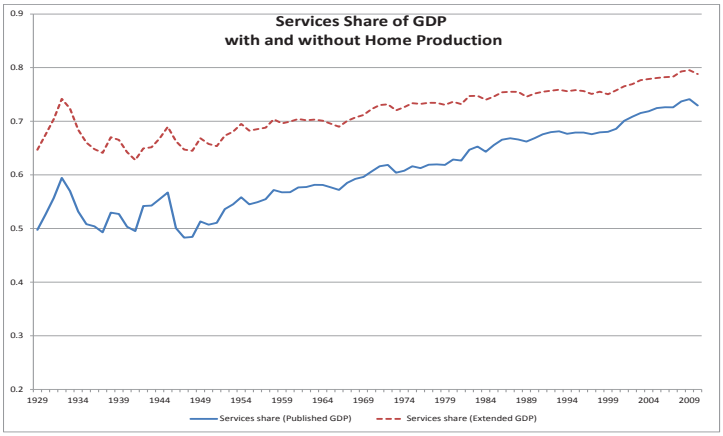
A related issue is the welfare cost of discrimination that restricts women to home work or involuntary unemployment from market work, which forces people of both genders into the home. Jones et al. (2003) argue that discrimination kept married women in home production. Such discrimination, such as "marriage bars" where married women were forbidden

from market work, is well documented in Goldin (1990). Hsieh, Hurst, Jones & Klenow (2012) argue the efficiency losses of such discrimination are large. The data suggest that the cost of discrimination and unemployment has increased, as the market has become progressively more productive than the household.

5.2 Structural Change

A large recent literature has attempted to explain the shift from goods to services production. (See Herrendorf, Rogerson & Valentinyi (2012) for a survey.) The exclusion of home production from output leaves out a significant source of services production. Further, there have been shifts within services production. The marketization of services means that some production that is excluded from GDP is moving into the market where it is included in GDP.

Figure 9: Services Share, 1929-2010

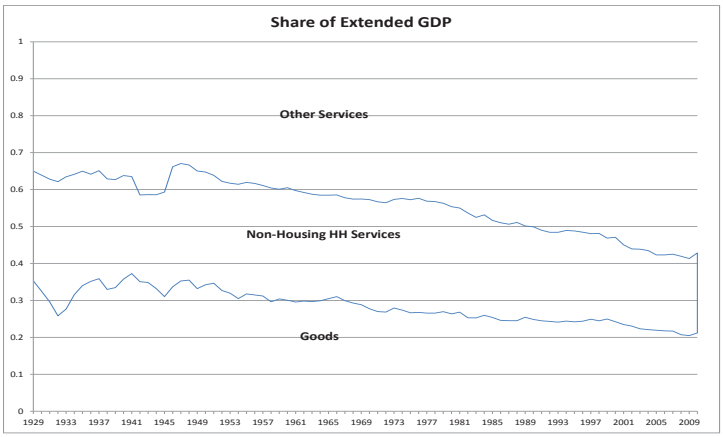


The degree of structural change is muted when home production is included. Figure 9 shows services share of GDP when home production is excluded (published GDP) and if home

production were included (extended GDP). While there is a shift from goods to services using extended GDP, it is much smaller than when it is excluded. Services production is a majority of output throughout the period, growing from 65 percent to nearly 80 percent. In published GDP, goods production falls from half of output to 26 percent.

To get a sense of how important marketization is for structural change, I examine the shift between market and non-market services. Figure 10 shows the goods and services shares of extended GDP. Services are split between non-housing home produced (non-market) services and all other services including housing (market services). As above, I exclude housing since non-market housing services are already included in GDP.

Figure 10: Structural Change in Extended GDP, 1929-2010



A significant portion of the rise of services is a shift from home to market produced services. Other services grows from 35 percent to 57 percent of output, a 22 percentage point increase. A third of this increase (8 percentage points) was due to the decline of household production's share. These findings lend support to theories that emphasize the role of home

production in structural change, such as Buera & Kaboski (2009), Buera & Kaboski (2012*b*) and Buera, Kaboski & Zhao (2013).

6 Robustness

This section examines the robustness of the results to alternative data sources and assumptions.

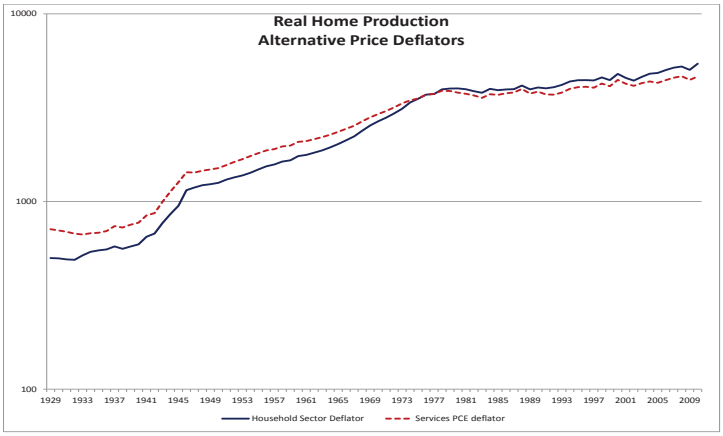
6.1 Price Deflators

The deflator is composed of private household production that is currently included in GDP. The private household deflator excludes some services and has a different weighting than the household sector. The vast majority of this deflator is made up of residential housing services. The results are robust to alternative price deflators. Figure 11 shows real home production using the original private household deflator and the services personal consumption expenditures (PCE) deflator. The services PCE deflator expands the set of services covered relative to the private household deflator.

The choice of deflator does not significantly change the overall picture, though it has some impact on year to year movements. Productivity growth is slower overall using the services PCE deflator. Labor productivity grows an average of 1.0 percent a year compared to the 1.5 percent baseline rate. Much of the difference is early in the sample. The growth rate is 1.9 percent from 1948 to 1977, only somewhat below the 2.4 percent in the baseline. The productivity slowdown is more severe, with -0.3 percent average growth from 1978 to 2010 rather than 0.8 percent growth in the baseline.

The services PCE deflator does not have the same weighting as an ideal home production deflator would have. A potential exercise would be to create a new deflator by re-weighting services deflators. I do not do so for the following reasons. I do not have a expenditure weights. The ATUS gives a breakdown of hours by task, which gives a sense of the inputs, but does

Figure 11: Real Home Production under Alternative Deflators 1929-2010



not give output shares. Some components, such as shopping, do not have an easy market price analog among the published series. For example, shopping is relatively important in home production but market shopping services are small and do not have a published price index. Finally, the components that would be re-weighted do not show much variation so changes to the weights would not have a significant impact. Most of the price movements are overall inflation that do not change relative prices much. To get significantly different outcomes, some prices would have to differ a great deal while services prices move in nearly lock-step.

6.2 Early Data Sources

Some of the data sources used for the post war estimates do not extend back to 1929. Therefore, replacement series were used. The two deviations were the use of hours estimates from Ramey (2009) and the use of Moody's corporate bond returns to value consumer durable output.

The replacement series overlap with the baseline data sources, so we can directly com-

pare them. The use of these series has no quantitative impact on the results.

The Ramey (2009) hours data is nearly identical to the hours used in the post war era, so home production is essentially unchanged using them. The underlying time use sources are the same, so the interpolated hours are very similar.

The estimates of household capital are also not significantly changed using the bond yields. During the period immediately after the war (1946-1957), the estimates are nearly indistinguishable. Even if the yields were different in the 1930s and 1940s, consumer durables make up a small portion of household capital. Therefore, the impact on overall output is limited.

6.3 Industry Definition

The baseline definition includes residential housing services and excludes paid private household workers. The findings are also robust to alternative home production industry boundaries.

Including paid private household workers has little impact since they make up so little of the hours in home production. They make up less then 5 percent of total hours in home production in 1929 and decline to less than one percent by the early 1970s.

Excluding the services of residential capital shifts the level of home production, but has little effect on the path of labor productivity. Labor productivity excluding housing services grows an average of 1.4 percent a year, similar to the 1.5 percent in the baseline. It also retains the late 1970s slowdown.

7 Conclusion

This paper calculates labor and multifactor productivity for home production in the United States from 1929 to 2010. Many of the facts about household sector that this paper generates are consistent with theoretical work. For example, there has been a shift from labor to capital

in the form of consumer durables as suggested by the "Engines of Liberation" literature. It also generates a number of novel facts. Home production shows a productivity slowdown in the 1970s and exhibits pro-cyclical productivity. These observations can help guide model and parameter choice for a large number of areas in macroeconomics.

References

Abraham, Katherine & Christopher Mackie (2005), *Beyond the Market: Designing Nonmarket Accounts for the United States*, National Academies Press, Washington.

Acemoglu, Daron & Veronica Guerrieri (2008), 'Capital deepening and nonbalanced economic growth', *Journal of Political Economy* **116**(3), 467–498.

Aguiar, Mark & Erik Hurst (2007), 'Measuring leisure: The allocation of time over five decades', *Quarterly Journal of Economics* **122**(3), 969–1006.

Aguiar, Mark, Erik Hurst & Loukas Karabarbounis (forthcoming), 'Time use during the Great Recession', *American Economic Review* .

Aruoba, S. Boragan, Morris A. Davis & Randall Wright (2012), Homework in monetary economics: Inflation, home production, and the production of homes, Working paper, University of Wisconsin.

Bar, Michael S. & Oksana Leukhina (2011), 'On the time allocation of married couples since 1960', *Journal of Macroeconomics* **33**(4), 491–510.

Benhabib, Jess, Richard Rogerson & Randall Wright (1991), 'Homework in macroeconomics: Household production and aggregate fluctuations', *Journal of Political Economy* **99**(6), 1166–1187.

Bridgman, Benjamin, Andrew Dugan, Mikhael Lal, Matthew Osborne & Shaunda Villones (2012), 'Accounting for household production in the national accounts, 1965–2010', *Survey of Current Business* **92**(5), 23–36.

Buera, Francisco & Joseph Kaboski (2009), 'Can traditional theories of structural change fit the data?', *Journal of the European Economic Association* **7**(2-3), 469–477.

Buera, Francisco & Joseph Kaboski (2012*a*), 'The rise of the service economy', *American Economic Review* **102**(5), 2540–2569.

Buera, Francisco & Joseph Kaboski (2012*b*), 'Scale and origins of structural change', *Journal of Economic Theory* **147**(2), 684–712.

Buera, Francisco, Joseph Kaboski & Min Qiang Zhao (2013), Quantifying the growth in services: the role of skills, scale, and female labor supply, mimeo, UCLA.

Costa, Dora L. (2000), 'From mill town to board room: The rise of women's paid labor', *Journal of Economic Perspectives* **14**(4), 101–122.

Cowan, Ruth Schwartz (1983), *More Work for Mother*, Basic Books, New York.

Eisner, Robert (1989), *The Total Incomes System of Accounts*, University of Chicago Press, Chicago.

Fisher, Jonas D. M. (2007), 'Why does household investment lead business investment over the business cycle?', *Journal of Political Economy* **115**(1), 141–168.

Folbre, Nancy & Barnet Wagman (1993), 'Counting housework: New estimates of real product in the United States, 1800-1860', *Journal of Economic History* **53**(2), 275–288.

Freeman, Richard B. & Ronald Schettkat (2005), 'Marketization of household production and the EU-US gap in work', *Economic Policy* **20**(41), 7–50.

Goldin, Claudia (1990), *Understanding the Gender Gap: An Economic History of American Women*, Oxford University Press, New York.

Goldin, Claudia (2006), 'The quiet revolution that transformed women's employment, education and family', *American Economic Review, Papers and Proceedings* **96**(2), 1–21.

Goldin, Claudia & Claudia Olivetti (2013), Shocking labor supply: A reassessment of the role of World War II on U.S. women's labor supply, Working Paper 18676, NBER.

Gomme, Paul, Finn E. Kydland & Peter Rupert (2001), 'Home production meets time to build', *Journal of Political Economy* **109**(5), 1115–1131.

Greenwood, Jeremy, Ananth Seshadri & Mehmet Yorukoglu (2005), 'Engines of liberation', *Review of Economic Studies* **72**(1), 109–133.

Greenwood, Jeremy & Nezih Guner (2009), Marriage and divorce since World War II: Analyzing the role of technological progress on the formation of households, *in* D.Acemoglu, K.Rogoff & M.Woodford, eds, 'NBER Macroeconomics Annual 2008', University of Chicago Press, Chicago, pp. 231–276.

Greenwood, Jeremy, Richard Rogerson & Randall Wright (1995), Household production in real business cycle theory, *in* T. F.Cooley, ed., 'Frontiers of Business Cycle Research', University of Princeton Press, Princeton, pp. 157–174.

Greenwood, Jeremy & Zvi Hercowitz (1991), 'The allocation of capital and time over the business cycle', *Journal of Political Economy* **99**(6), 1188–1214.

Gronau, Reuben (1986), Home production: A survey, *in* O.Ashenfelter & R.Layard, eds, 'Handbook of Labor Economics Vol. 1', North-Holland, Amsterdam.

Gronau, Reuben (1997), 'The theory of home production: The past ten years', *Journal of Labor Economics* **15**(2), 197–205.

Herrendorf, Berthold, Richard Rogerson & Akos Valentinyi (2012), Growth and structural transformation, *in* 'Handbook of Economic Growth Vol. 2', North Holland, Amsterdam.

Herrendorf, Berthold, Richard Rogerson & Akos Valentinyi (forthcoming), 'Two perspectives on preferences and structural transformation', *American Economic Review* .

Hsieh, Chang-Tai, Erik Hurst, Charles I. Jones & Peter J. Klenow (2012), The allocation of talent and U.S. economic growth, mimeo, University of Chicago-Booth.

Ingram, Beth F., Narayana R. Kocherlakota & N.E. Savin (1997), 'Using theory for measurement: An analysis of the cyclical behavior of home production', *Journal of Monetary Economics* **40**(3), 435–456.

Jones, Larry E., Rudolfo E. Manuelli & Ellen McGrattan (2003), Why are married women working so much?, Staff Report 317, Federal Reserve Bank of Minneapolis.

Karabarbounis, Loukas (2012), Home production, labor wedges, and international real business cycles, Working Paper 18366, NBER.

Karabarbounis, Loukas & Brent Neiman (2013), The global decline of the labor share, Working Paper 19136, NBER.

Kongsamut, Piyabha, Sergio Rebelo & Danyang Xie (2001), 'Beyond balanced growth', *Review of Economic Studies* **68**(4), 869–882.

Kuznets, Simon (1934), *National Income 1929-1932, Senate Document No. 124, 73rd Congress, 2nd Session*, U.S. Government Printing Office, Washington.

Landefeld, J. Steven, Barbara Fraumeni & Cindy M. Vojtech (2009), 'Accounting for household production: A prototype satellite account using the American Time Use Survey', *Review of Income and Wealth* **55**(2), 205–225.

Landefeld, J. Steven & Stephanie H. McCulla (2000), 'Accounting for nonmarket household production within a national accounts framework', *Review of Income and Wealth* **46**(3), 289–307.

Leon-Ledesma, Miguel A., Peter McAdam & Alpo Willman (2010), 'Identifying the elasticity of substitution with biased technical change', *American Economic Review* **100**(4), 1330–1357.

McCulla, Stephanie & Charles Ian Mead (2007), An introduction to the national income and product accounts, Metholodgy Paper 1, Bureau of Economic Analysis.

McGrattan, Ellen, Richard Rogerson & Randall Wright (1993), Household production and taxation in the stochastic growth model, Staff Report 166, Federal Reserve Bank of Minneapolis.

McGrattan, Ellen, Richard Rogerson & Randall Wright (1997), 'An equilibrium model of the business cycle with household production and fiscal policy', *International Economic Review* **38**(2), 267–290.

Mokyr, Joel (2000), 'Why was there more work for mother?: Technological change and the household, 1880-1930.', *Journal of Economic History* **60**(1), 1–40.

Mulligan, Casey & Yona Rubenstein (2008), 'Selection, investment, and women's relative wages over time.', *Quarterly Journal of Economics* **123**(3), 1061–1110.

Ngai, L. Rachel & Barbara Petrongolo (2013), Gender gaps and the rise of the service economy, mimeo, London School of Economics.

Ngai, L. Rachel & Chrisopher A. Pissarides (2007), 'Structural change in a multisector model of growth', *American Economic Review* **97**(1), 429–443.

Nosal, Ed, Richard Rogerson & Randall Wright (1992), 'The role of household production in models of involuntary unemployment and underemployment', *Canadian Journal of Economics* **25**(3), 507–520.

Olivetti, Claudia & Barbara Petrongolo (2011), Gender gaps across countries and skills: Supply, demand and the industry structure, Working Paper 17349, NBER.

Parente, Stephen L., Richard Rogerson & Randall Wright (2000), 'Homework in development economics: Household production and the wealth of nations', *Journal of Political Economy* **108**(4), 680–687.

Ramey, Valerie (2009), 'Time spent in home production in the 20th century United States', *Journal of Economic History* **69**(1), 1–47.

Ramey, Valerie & Neville Francis (2009), 'A century of work and leisure', *American Economic Journal: Macroeconomics* **1**(2), 189–224.

Rendall, Michelle (2010), Brain versus brawn: The realization of women's comparative advantage, Working Paper 494, IEW.

Rendall, Michelle (2013), The service sector and female market work: Europe vs the United States, mimeo, University of Zurich.

Rogerson, Richard (2008), 'Structural transformation and the deterioration of European labor market outcomes', *Journal of Political Economy* **116**(2), 235–259.

Rupert, Peter, Richard Rogerson & Randall Wright (2000), 'Homework in labor economics: Household production and intertemporal substitution', *Journal of Monetary Economics* **46**(3), 557–579.

Soloveichik, Rachel H. (2013), Do-it-yourself home improvement: Changes for measured GDP and long-run housing values, mimeo, BEA.