Do-It-Yourself Home Improvement:

Changes for Measured GDP and Long-Run Housing Values

By Rachel Soloveichik

The housing bubble and bust become more dramatic when unpaid homeowner labor is included in GDP. Based on the American Housing Survey, I calculate that investment in home improvement increases by 36% for 1997 to 2009 when unpaid homeowner labor is included. This 36% relative increase has been roughly constant from 1997 to 2009. On the other hand, total home improvement investment rose dramatically during the housing bubble and fell slightly after it popped. Therefore, GDP becomes more volatile when unpaid homeowner labor is included.

The run-up in housing prices also becomes more dramatic when unpaid homeowner labor is included in home improvement investment. Between 1929 and 1980, unpaid homeowner labor accounted for 16% of home appreciation. Since 1980, unpaid homeowner labor has become much less common. Accordingly, predicted home value growth falls when I account for past unpaid homeowner labor. Using only hired labor and purchased material investment, I found that home values in 2010 were 9% below what the fundamentals justified. When unpaid homeowner labor is included, 2010 home values were only 7% below the fundamentals. This 2% difference suggests that home values may take longer to recover.

For comparison, I also calculate home-grown food, home-sewn clothing and unmeasured alcohol. I find that all three items were much more important in 1929 than they are in 2010. Average GDP growth falls by 0.06% annually if these three items are included in GDP. In contrast, unpaid homeowner labor is more important now than it was in 1929.

Introduction

Most consumer durables are not counted in capital stock and their flow of services are not counted in GDP. However, the *System of National Accounts 2008* (SNA 2008) recommends that countries treat owner occupied housing as if the homes were owned by outside parties who then rented them out to the homeowners. Under that treatment, the imputed rent for owner occupied housing is counted in GDP as a housing services and major home improvement projects are counted in GDP as a capital investment. In SNA 2008, unpaid home-owner labor, hired labor and purchased materials are all counted when valuing home improvements (Section 6.37). At the current time, BEA only counts hired labor and purchased materials when measuring home improvement in GDP. For new construction, BEA does count unpaid homeowner labor. However, relatively few people construct their own homes in modern America. But do-it-yourself home improvement is still common.

SNA 2008 also recommends that countries include home production of goods in GDP. (Section 6.32) This treatment increases production and consumption by the exact same amount, so it has no effect on capital investment. In this paper, besides do-it-yourself home improvement, I study three important categories of home produced goods: home-grown vegetables or other food, home-sewn clothing and home-brewed alcohol. At the current time, BEA does not include any of these activities in GDP except food produced and consumed on farms. Farm households account for less than 10% of home food production in the modern economy.

The do-it-yourself activities considered in this paper are a small fraction of total household production. In 2004, total household production was valued at $3 trillion (Landefeld, Fraumeni and Vojtech 2009) (Bridgman, Dugan, Lal, Osborne and Villones 2012). In comparison, unpaid home improvement labor and home-produced goods were only $60 billion in 2004. However, the SNA handbook explicitly excludes household services like childcare, cleaning and cooking from GDP (Section 6.28). My paper is focused on calculating GDP within the SNA framework, not calculating a different concept that some researchers might prefer to study.

This paper calculates GDP from 1929 to 2010 when these four unpaid activities are included in the national income and product accounts (NIPA's). All of these unpaid activities are part of the unincorporated private sector, so the change has no impact on the government or corporate sector. However, consumption and private investment will rise significantly with the new treatment. Holding the depreciation rate fixed, private capital stock and the consumption of fixed capital also rise.

Unpaid home improvement labor has the largest impact on GDP of the items considered here since 2000. When unpaid home improvement labor is included, housing prices peaked even farther above the market fundamentals than currently thought. Furthermore, GDP growth increases during the housing bubble and falls more after the bubble burst. In contrast, home production of goods has a much larger impact on GDP before 1950. In particular, nominal GDP growth from 1933 to 1934 falls from 17% to 15% when Prohibition was repealed and home-brewed alcohol shifted to the legal market.

In the discussion below, Section 1 estimates nominal investment from unpaid homeowner labor on home improvement projects for 1901 to 2010. Section 2 creates a price index for that homeowner labor and then uses the price index to calculate real investment by unpaid homeowner labor back to 1901. Section 3 combines nominal investment, prices and BEA's pre-existing depreciation rates to estimate capital stock. Section 4 uses the investment, prices and capital stock number to create a synthetic index for home values. My synthetic index predicts price changes for repeat home sales if prices are not adjusted for the quality of the physical house. I then compare the synthetic index with the actual Case-Shiller housing index. Results are qualitatively similar if I use other housing indexes like Corelogic or the FHA repeat sales index. However, I focus on the Case-Shiller index because it starts earlier than other indexes. Section 5 discusses home production of food, home-sewn clothing and home-brewed alcohol.

1.   Nominal Investment in Home Improvement

This category includes major additions like adding a second story, major remodeling projects like installing a Jacuzzi in the bathroom and long-lived repairs like new furnaces. However, it does not include maintenance activities like cleaning gutters, mowing lawns and minor repairs. I will call this activity 'home improvement' in the remainder of the discussion. BEA has already calculated hired labor and purchased material spending for home improvement for owner-occupied housing back to 1901. Those numbers are available online at http://www.bea.gov/national/FA2004/Details/Index.html. I will call these costs out-of-pocket spending in the remainder of this paper. In this paper, I will not try to calculate home improvement costs from scratch. Instead, I use the American Housing Survey to calculate the value of unpaid homeowner labor relative to out-of-pocket costs for each year from 1901

to 2010. I then use that ratio to calculate what home improvement spending would be if BEA counted unpaid labor when measuring investment.[1]

Unpaid Home Improvement Labor in the American Housing Survey

The American Housing Survey (AHS) has tracked the US housing stock since 1973. Every two years, households are surveyed about mortgage financing, homeowner costs, housing quality and other characteristics. If the house is vacant, the survey collects data from the landlord or owner. Since 1997, the AHS has included a module on home improvement. That module asks home-owners whether they did any major home improvements, the precise project done, how much it cost and who did the work.

In the AHS, home-owners who did work themselves report spending 62% less than home-owners who hired workers for similar projects.[2] I will assume that the 62% lower costs reflect the value of unpaid home-owner labor.[3] In the 2007 AHS, approximately 41% of projects are done by the home-owners. Accordingly, I calculate that unpaid home-owner labor accounted for 25.42% (41%*62%) of all home improvement investment in 2007. The remaining 74.58% (100%-25.42%) of home improvement investment is for hired labor and purchased materials.   In other words, unpaid home-owner labor is 34.5% (25.42%/74.58%) of out-of-pocket spending. I will call this 34.5% the 'unpaid labor adjustment' for the remainder of this paper. My 34.5% 'unpaid labor adjustment' is very similar to an earlier estimate of 33.3% for Canada (Lal 2003).[4]

In 2007, unpaid home-owner labor created $48 billion of value. According to BEA's published statistics, homeowners spent $139 billion for hired labor and purchased materials in 2007. These out-of-pocket costs include 100% of investment on projects with hired workers and 38% of investment on projects with unpaid homeowner labor. I multiply that $139 billion by the 34.5% 'unpaid labor adjustment' to get $48 billion of unpaid labor in 2007.   Results are similar when I look at the 1997, 1999, 2001, 2003, 2005 or 2009 AHS. In all years, home-owners who do work themselves reduce their out-of-pocket spending by more than 50%.

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[1] In order to estimate these numbers, BEA had to make decisions on conceptual issues like the treatment of landscaping, real estate commissions, etc. In this paper, I will take all of those decisions as given.

[2] The precise question is "Did someone in your household do most of the work". The only answers allowed are Yes, No or Missing. We do not know how respondents coded mixed projects with some unpaid labor and contractors.

[3] Material costs may also be different for projects with hired workers vs. those without hired labor.

[4] That paper uses a very different methodology. He starts out with an estimate of $7.5 billion spent by home-owners on alterations and improvements. From alternative datasets, he calculates that home-owners do one third of projects themselves. He also assumes that unpaid labor is worth as much as materials. Therefore, home-owner labor is valued at $2.4 billion (7.5*33%).

It is possible that homeowners do small projects themselves and hire outside workers for bigger projects. In that case, the true cost savings from unpaid homeowner labor is less than 62%. This is a special example of the well-known econometric problem "omitted variable bias". I tested for this by using the precise project done to predict costs.[5] I found that homeowners are in fact less likely to do larger projects themselves – but the effect is very small. On average, do-it-yourself rates drop by only 0.3% for a 10% increase in predicted project costs. This is not a large enough effect to change my results much. I also experimented with further controls for household demographics and geographic location. The regression results are given in Table 1.[6] In general, the controls had very little impact on the 62% cost savings number estimated earlier. Based on that similarity, I do not believe that do-it-yourself projects are very different from projects with outside workers. Therefore, I do not believe that omitted variable bias is a serious concern in my regression. I also found that large projects and small projects had similar cost savings from do-it-yourself, so the AHS data definitely apply to the large home improvement projects that BEA classifies as home improvement investment.

Even including $48 billion of unpaid homeowner labor, BEA's accounts might still underestimate the investment value of home remodeling. Whether or not home-owners hire a handyman or contractor, they generally invest considerable time and energy in a remodel. First, they must plan the project, then hire a contractor or handyman and finally monitor the contractor or handyman to make sure the job is done right. In addition, major remodeling projects generally interfere with normal household activity for weeks or even months. Tenants who endure remodeling projects during their leases are normally compensated with reduced rents during the project. Homeowners also need to spend time and energy supervising a custom-built house. However, I was not able to find any dataset that gave a dollar value for the time and energy invested in home remodeling and custom-build houses. In order to be conservative, I will not include those costs in my capital investment series. I welcome suggestions to measure those costs reliably.

From 1997 to 2009, the unemployment rate has no consistent effect on the do-it-yourself share. The 2009 AHS reports a do-it-yourself share of 38.3%, smaller than the 41.4% for 2007. There is also no uptick in do-it-yourself for the 2001 recession.[7] I believe that the stable 'do-it-yourself' share can be explained by three related factors: a) Even if the home-owner does all the work himself, a major home

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[5] Predicted costs are based on projects done with hired labor, so do-it-yourself rates have no direct impact.
[6] I use the 62.27% cost savings from the log regression, column 3 for my estimates.
[7] The AHS asks about home improvement in the past two years, so a recession will not show up immediately. However, a regression of do-it-yourself on lagged unemployment is also insignificant.

improvement still requires some out-of-pocket money to purchase materials. Unemployed people may not be able to afford those costs even if they have the time available; b) Some unemployed home-owners are in foreclosure or planning to short-sale their houses. These homeowners have little incentive to improve their houses; c) Many handymen and contractors have lowered their prices in response to the recession. Accordingly, employed home-owners may contract out work that they would have done themselves during the housing bubble. The net effect of unemployment on do-it-yourself rates is small.

Figure 1 shows the value of home improvement relative to GDP from 1997 to 2010 as measured in the National Income and Product Accounts .[8] Home improvement increased relative to GDP in the mid 2000's and then declined in 2008. This increase is part of the housing bubble, and it has been extensively studied in other contexts. For my paper, the most important result is that unpaid home improvement labor tracks home investment from hired labor and purchased materials closely. Accordingly, the main effect of including unpaid homeowner labor is to magnify the housing bubble. From 1997 to 2006, annual GDP growth increases by 0.01% per year when unpaid homeowner labor is included. From 2006 to 2010, annual GDP growth falls by 0.03% per year when unpaid homeowner labor is included.

Robustness Tests for the American Housing Survey Data

Many economists reading this paper may find the 41% do-it-yourself share of projects reported inconsistent with their real life experience. However, the AHS suggests that economists are a very unrepresentative sample. Highly educated homeowners have a do-it-yourself share of only 20%, half the average rate. According to the AHS data, highly educated homeowners enjoy similar cost savings (67% vs. 62%) when they do projects themselves. However, highly educated individuals generally earn higher wages than the rest of the population. Accordingly, they are better able to afford handymen or contractors to do home remodeling for them.

At first glance, the 62% cost saving from unpaid homeowner labor seem incredibly high. However, this figure is right in line with BEA's pre-existing breakdown of gross output for the home repair industry (part of "other services, except government"). According the BEA's numbers, employee

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[8] I interpolate between the survey years to get an annual series. For 2010, I extrapolate the 2009 numbers forward.

compensation accounts is 40% of gross output and gross operating surplus is 18.5% of gross output. The capital share for home repair is relatively low, so most of gross operating surplus is a return on the owners' labor. Taken together, they add up to a labor share of 60% of gross output. The remaining costs are materials and other inputs. So, it is very plausible that home-owners could save approximately 60% if they do the work themselves rather than hiring a handyman or contractor.

The American Time Use Survey (ATUS) provides further evidence for the reasonableness of the numbers in this paper. According to the ATUS, the average American adult (15+) spent 7.5 minutes per day on interior and exterior repair, maintenance and decoration in 2007. This works out to approximately 10 billion total hours of work in 2007. Assuming that half of the 10 billion hours is spent on unpaid home improvement, homeowners spent 5 billion hours and saved $48 billion from their unpaid labor. This works out to savings of $9.60 per hour. In comparison, handymen generally charge $30-$60 per hour [9] and contractors charge even more. In other words, homeowners only need to be 15%-30% as productive as hired workers to justify the estimates given in this paper.

On the other hand, self-reported housing values in the AHS provide some contrary evidence against my 60% savings. The AHS asks people how much they paid for the house and how much they think it is worth now. I found that every dollar in hired labor or purchased materials raises self-reported values by $1.28.[10] This number is consistent with the hypothesis that homeowners remodel their homes in order to increase the resale value. However, one dollar of unpaid labor reduces self-reported values by $0.29. At first glance, the drop in value from do-it-yourself remodeling suggests that do-it-yourself projects destroy homes rather than improve them.

I believe that the difference in self-reported housing values can be explained by state-level price trends. Across the US, housing demand rose during the 2000's. In some states, new home construction was restricted by zoning laws and other barriers. Those states experienced a huge run-up in housing prices. In contrast, other states allowed much more home construction. Those states had smaller price increases (Glaeser, Gyourko and Saiz 2008). Because of pre-existing demographic differences, areas with more elastic housing supply had lower do-it-yourself rates. The AHS does not provide detailed geographic location, so I cannot control for area specific home values when measuring the value of unpaid labor. Accordingly, the regression suffers from a serious omitted variable bias. In order to

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[9] http://home.costhelper.com/handyman.html Some of this covers travel costs and sales costs, so handymen and contractors' take-home wages are lower.

[10] This regression controls for year of purchase, current year and purchase price. This spending number includes purchased materials for all projects and hired labor for non do-it-yourself projects.

explore those biases, I used age, education, household composition and urban status to predict do-it-yourself activity. I found that areas with high predicted do-it-yourself shares had low housing appreciation and areas with low predicted do-it-yourself shares had high housing appreciation.

It is also possible that the housing bubble directly affected unpaid homeowner labor. During the housing bubble, many home-owners borrowed against their home equity to make investments they could not otherwise afford. For example, a recent paper showed that parents send their children to more expensive colleges if their home increased in value (Lovenheim and Reynolds 2012). It is possible that professional home remodeling also responds to housing wealth.   Therefore, the housing bubble might have caused low do-it-yourself shares. In the next section, I will use demographics to impute do-it-yourself shares back to 1901. In order to avoid confusing the housing bubble effects with general demographics, I will restrict my sample to the 1997-2001 AHS.[11]

Unpaid Homeowner Labor from 1901-1997

In the AHS, homeowners who used their own labor saved approximately 62% of their potential costs. The percentage saved is roughly constant from 1997 to 2010. From 1929 to 1996, I will assume that homeowners always save approximately 60% if they do the project themselves. This assumption is equivalent to assuming a fixed labor share in the home remodeling industry. I have not been able to find any data to check that assumption directly. However, BEA's statistics do track labor shares for the overall economy. According to NIPA Table 1.12, labor compensation accounts for 70%-80% of national income for all years between 1929 and 2011. This suggests that labor shares in the home remodeling industry have not changed dramatically over time.

I use homeowner demographics from the Census to impute do-it-yourself shares back to 1901. The basic intuition is simple. Highly paid workers like doctors or lawyers typically earn more per hour than handymen or contractors charge. Therefore, it makes sense to hire a handyman or contractor for do-it-yourself projects. In contrast, lower earning workers can often save more money from do-it-yourself projects than they would earn at work. In my regression analysis, I consider six separate variables: a) age of the homeowner and their partner; b) family composition; c) education of the

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[11] However, the aggregate imputations are very similar when I use the complete dataset.

homeowner and spouse; d) sex of the household head; e) whether the household head is married or single[12] and f) Whether the household is in a central city, suburbs or rural areas.

Figure 2 shows the imputed 'unpaid labor adjustment' as we add more explanatory variables. If all projects were do-it-yourself, then the 'unpaid labor adjustment' would be 163% (62%/38%). Early in the sample, more than two thirds of households did projects themselves, so the unpaid labor adjustment is more than 100%. In other words, the value of unpaid home-owner labor was once greater than the value of purchased materials and hired workers together.

The most important result from Figure 2 is that the relative value of unpaid labor has been falling over time. This is drop is primarily driven by education and location. In the AHS, homeowners with high school or less education did 52% of projects themselves vs. 40% for homeowners with college or higher. Therefore, the long-run increase in education significantly reduces the imputed do-it-yourself share over time. The second major driver for do-it-yourself projects is location. In the AHS, households living in a central city do 39% of projects themselves vs. 43% for suburban households or 54% for rural households.[13] Accordingly, the long-run shift from farms to cities significantly reduces the imputed do-it-yourself share over time.

The second interesting result from Figure 2 is that unpaid homeowner labor projects spiked in the 1950 Census. The spike was mainly driven by homeowner demographics. After WW2, government mortgage programs and the good economy enabled many young couples to buy homes in the suburbs.[14] In the AHS data, young homeowners are more likely to do projects themselves than older homeowners; married couples are more likely than single heads and suburban homeowners are more likely than city dwellers. Accordingly, I impute a very high do-it-yourself rate for new homeowners in 1950. The book "Do-It-Yourself: Home Improvement in the 20th Century" (Goldstein 1998) also notes an increase in do-it-yourself during the Baby Boom. So, the demographic model in Figure 2 is plausible. Furthermore, the do-it-yourself rates imputed in 1950 are not out of sample extrapolations. The AHS has many young

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[12] In the AHS, cohabiting couples have similar do-it-yourself behavior as married couples. Therefore, I count unmarried partners as if they were legally married. Before 1990, the Census did not identify unmarried partners separately from other non-relatives. Therefore, I may slightly underestimate the number of couples before 1990
[13] The AHS splits into five categories: 1) in central city of MSA, 2) outside central city of MSA, in urban area; 3) outside central city of MSA, in rural area; 4) outside MSA, in urban area and 5) outside MSA in rural area. I combine 2) and 3) into "suburb" and 4) and 5) into rural.
[14] The 1950 Census does not ask about home ownership. I use demographics and geographic location to impute home ownership. This might misestimate the true demographics for homeowners.

homeowners with high school educations living in the suburbs. My imputation assumes that those homeowners had similar behavior in 1950 than they do now.

It is possible that do-it-yourself behavior has changed since the early 1900's. But the direction of the change is unclear. The following trends could cause an increase in do-it-yourself over time:

1) According to economic theory, higher income taxes push homeowners towards more do-it-yourself projects.[15] Over the past century, average tax rates have risen significantly.
2) In the AHS, households who own trucks are much more likely to do projects themselves. Over the past few decades, SUV's have become much more common.
3) Stores like Home Depot and the Internet now provide training and specialized equipment for do-it-yourself projects that were not easily available to amateurs before.

On the other hand, the following trends could cause a decrease in do-it-yourself over time:

1) In general, people with office jobs have less construction skills than blue collar workers. Even after controlling for education, office jobs have become more common.
2) Homeowners who are credit constrained might be more likely to do projects themselves to save money. Over the past few decades, credit cards and home equity loans have made it much easier for homeowners to finance their improvements.
3) Homeowners are more likely to do a project themselves if handyman and contractor wages are high. Over the past few decades, wages for blue collar men have been stagnant. Therefore, do-it-yourself projects save a smaller percentage of income now than they did in 1950.

Unfortunately, I have no data on do-it-yourself projects before the 1997 AHS. Therefore, I cannot disentangle any of these stories with any reliability. For now, I will use the demographic imputations developed earlier to calculate do-it-yourself over time.

Figure 3 shows home improvement relative to GDP from 1929 to 2010. The biggest impact of do-it-yourself labor was immediately after World War 2. During the Great Depression and World War 2, private housing investment was very low. But the good economy and new government mortgage programs allowed returning soldiers to buy homes in the late 1940's. These new home-owners promptly started expanding their houses to accommodate the Baby Boom. Between 1945 and 1950, annual GDP growth increases by 0.16% if unpaid homeowner labor is counted as investment.

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[15] Official tax rates may not be relevant if hire home remodelers do not pay income tax.

2.   Price Indexes for Unpaid Homeowner Labor Improvement

In this paper, home-owner time is a substitute for handyman or contractor labor. Therefore, handy man prices per job would be the best price index for unpaid homeowner labor.   In turn, that price index can be decomposed into wage rates per hour and the hours required for each job over time. I have not been able to find any time series that tracks home improvement project prices over time. As a proxy, I will use a producer price index (PPI) for residential repair and maintenance (PCUBMRS— BMRS).[16] This PPI is available from 1987 to 2011. Before 1987, I use wages for construction workers as a proxy for home improvement project prices.   From 1987 to 2011, residential repair costs grew at 3.04%, 0.15% slower than construction worker wages. I will assume that the slower growth for PPI's is caused by labor productivity growth of 0.15% per year from 1987 to 2011. I also assume that labor productivity grew by 0.15% per year from 1900 to 1986. When calculating historical prices, I adjust the construction worker wages downward to account for their lower productivity in the past.

I also experimented with an alternative price index based on average weekly earnings[17] for self-employed construction workers from the Census and American Community Survey (ACS). The Census is available for 1950-2000. The ACS is available for 2001-2010. Self-employed construction workers have much more volatile earnings than employed workers do. So, prices drop much more during recessions and rise more during booms.   Before 1950 and between Censuses, I use construction worker wages and the unemployment rate[18] to impute earnings for self-employed construction workers. [19]

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[16] That PPI includes some materials, so it is not a perfect proxy for handyman or contractor labor alone. As an experiment, I tried subtracting the BLS PPI for inputs to construction (PCUBCON—BCON). I found that the adjusted price index was very similar.

[17] In the National Income and Product Accounts, BEA adjusts self-employment earnings upward to account for under-reported income. As long as under-reported income is a fixed share of earnings, this does not affect my index. However, it is possible that the share has changed over time.

[18] My construction worker wages are taken from various BLS series 1947- 2011. Before 1947, I use NBER data. My unemployment rate is taken from the BLS back to 1941. Before then, I use academic research.

[19] Across the U.S., self-employed construction workers earn different wages. In general, wages are higher in New York City and other urban areas. Furthermore, those states have lower do-it-yourself rates than average. Therefore, mean earnings in the Census might diverge from prices for do-it-yourself work

I experimented with weighting the state-level wage data with state-level sales for home improvement stores. I found that this re-weighting changed my price index by less than 1%. For simplicity, I will use the unweighted numbers in my paper.

Figure 4 compares my two price indexes for unpaid homeowner labor with BEA's pre-existing price index for out-of-pocket home improvement.[20] For reference, I also include a consumer price index. In the long-run the price index based on construction worker wages grows slightly faster because it is not adjusted for productivity. However, labor productivity growth is small enough that the adjustment has little effect on my qualitative results. The main difference is short-run prices. Over the past five years, self-employed construction worker earnings have dropped 10%. At the same time, the BLS PPI for residential repair and maintenance rose 20%. These differences are related to the high unemployment rate in the past few years. I impute even larger difference during the Great Depression, when unemployment reached 25%. In the remainder of the paper, I will use the BLS PPI as a price index for unpaid homeowner labor. Please contact me for alternative estimates of real unpaid homeowner labor investment, capital stock and synthetic Case-Shiller indexes when I use self-employed construction worker earnings for my price index.

Figure 4 also shows that unpaid homeowner labor prices do not grow at the same rate as consumer prices. Between 1929 and 1970, the price index for unpaid homeowner labor grew at 5.4% per year. Over the same time period, consumer prices grew only 2.0% per year. In other words, real earnings for construction workers grew rapidly from 1929 to 1970. Between 1970 and 2011, real construction worker wages have been stagnant. The problem of low earnings growth for blue collar men has been found and discussed in many other papers.

Figure 5 shows real home improvement relative to real GDP from 1929 to 2010. Just like Figure 3, the most striking difference is just after World War 2. In 1950, unpaid homeowner labor added 1% to nominal GDP and 2% to real GDP (at 2005 prices). I believe that this result is plausible. Many older houses have elaborate moldings and other hand-crafted elements. In contrast, newer home renovations use standardized designs because labor is much more expensive relative to parts. If those hand-crafted elements were valued at today's prices, then they would indeed be significantly more valuable than the wood.

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[20] I use the price index for "Owner-occupied, 1-4 units, additions and alterations". Other sub-price indexes for out-of-pocket spending are very close, but not identical.

3.   Capital Stock of Housing and Consumption of Fixed Capital

Holding the depreciation rate fixed, increased investment raises the capital stock of owner-occupied housing from $14.9 trillion to $15.9 trillion in 2007.[21] Consumption of fixed capital (CFC) also increases, from $214 billion to $240 billion in 2007. It is interesting to note that CFC rises much more than capital stock does. The higher CFC increase is caused by the higher depreciation rate for additions than new housing. In other words, a house 100 years old may still have its original foundation and plumbing. But it is unlikely that kitchen cabinets or bathroom tiles added in 1950 are still useable. In this paper, we add unpaid home improvement labor to housing investment – but new home construction stays fixed.[22] Therefore, the average depreciation rate for housing rises slightly.

Figure 6 shows the nominal stock of owner-occupied housing relative to GDP from 1929 to 2010. The most important result is that adding unpaid homeowner labor does not change the overall time series much. In both time series, the GDP share for owner-occupied housing is relatively steady from 1950 to 2000 and then increases dramatically from 2000 to 2005. After 2005, the GDP share for owner-occupied housing falls. In addition, the two series have been moving closer together as unpaid homeowner labor home improvement becomes less common. But the decrease is very gradual because housing investments have a long lifespan.

Figure 7 shows net investment (investment – CFC) in home improvement relative to personal savings overall. The most important result is a significant increase in personal savings during the housing bubble. Between 2003 and 2007, personal savings were only 2.02% of overall GDP. This is 40% less than the average savings share from 1991 to 2011. However, when unpaid home improvement labor is included, the personal savings rate increases by 6% to 2.14%. This may explain why measured savings during the housing bubble were so low: people thought they were investing with unpaid home improvement projects. In retrospect, many their unpaid projects became worthless when the housing bubble burst. But home-owners who hired workers for renovations experienced similar problems.

It is possible that the capital stock increase shown in Figure 6 is too high.   That number keeps BEA's pre-existing depreciation rates for new home construction, additions and major repairs fixed. It is possible that those depreciation rates are calibrated against data that did not control for unpaid home

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[21] Some owner-occupied housing is later used for rentals and some rental housing is later used for owner occupancy. In order to simplify my analysis, I will ignore these transfers.

[22] Earlier in the century, do-it-yourself home construction did exist. For example, Sears sold ready-to-build housing kits. However, I cannot measure this from the American Housing Survey.

improvement labor. In that case, the pre-existing depreciation rates falsely attribute steady home values to low depreciation rates for housing capital. In reality, homes depreciate faster and home-owners compensate by investment time and energy in improvements for their house. I experimented with adjusting depreciation rates to hold capital stock fixed for a reference year. If 2007 is selected as the reference year, then average depreciation rates[23] must increase from 2.5% per year to 3.1% per year. However, I believe that it is more appropriate to hold depreciation rates fixed and allow aggregate capital stock to vary. For the remainder of the paper, I will use BEA's pre-existing depreciation rates to calculate capital stock numbers.

The capital stock changes shown in Figure 6 may also affect GDP indirectly. In 2007, BEA estimates that owner-occupied homes provided $1,141 billion in housing services for their owners (Table 2.4.5, line 52). In other words, homeowners would need to pay $1,141 billion to rent equivalent homes. If the ratio of housing services to capital stock is held fixed, then the 7% increase in housing stock shown in Figure 6 corresponds to an $82 billion increase in housing services. However, it is more likely that the ratio of housing services to capital stock is variable. In that case, the increased housing stock has no direct effect on housing services.[24]

4.   Predicting Home Values Over Time

This section is somewhat speculative. Home values change over time for many possible reasons. In areas with good economies, home values may rise because local homes provide access to good jobs. Conversely, home values could fall when a local employer closes. In areas with restricted construction, home values are usually far above the cost of new construction (Glaeser, Gyourko and Saiz 2008). Nevertheless, the value of the physical dwelling as opposed to the land is an important driver for home values in most of the country. The results in this section primarily apply to those areas.[25]

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[23] BEA has separate depreciation rates for new construction, additions and major repairs. Single family homes and condos also have separate depreciation rates. I weight each rate by the capital stock to get average depreciation.
[24] BEA might use a fixed ratio to estimate housing services annually, but that ratio was probably calibrated against some alternative dataset once.
[25] I have also experimented with adjusting for land values using BEA's data on local capital stock. For example, a home located next to a brand new school is worth more than a home with an out of date school. My preliminary

The Case-Shiller index is the best known index for home values. Historical data for the Case-Shiller index from 1890 to 2011 is available at http://www.irrationalexuberance.com. The Case-Shiller index uses repeat sales for the same property to control for unobservable location quality. However, the Case-Shiller index is not equivalent to a price index for physical housing stock. Even if the true price for housing capital was held completely fixed, a home might lose value because the physical construction depreciates. Conversely, a home might gain value because of renovations. In other words, the Case-Shiller index does not control for quality of the physical dwelling, only quality of the location.

In this section, I construct two synthetic home value indexes over time. The first index uses BEA's pre-existing price indexes for housing investment, depreciation rates and prices to predict home values over time. The second index includes unpaid homeowner labor when I calculate investment, depreciation and prices over time. The formula for the synthetic indexes is relatively simple:[26]

$$[(\text{Home Value}_{t+1})/(\text{Home Value}_t)] = (\text{Home Inflation}_t)*(\text{Home Improvement Rate}_t)*(1-\text{Depreciation Rate}_t)$$

$$(\text{Home Inflation}_t) = (\text{Price Index for Housing Investment}_{t+1})/(\text{Price Index for Housing Investment}_t)$$

$$(\text{Home Improvement Rate}_t) = (\text{Home Improvement Investment}_t)/(\text{Capital Stock of Existing Houses}_t)$$

For example, the synthetic home value index could show a 5% jump if construction prices jumped by 5% from year t-1 to year t. It could also show a jump if construction prices held steady, but homeowners added improvements worth 5% of the initial housing value.

Figure 8 compares the two synthetic indexes with the actual Case Shiller index from 1929 to 2010.[27] In order to make the graph easier to see, I divide all three indexes by the PCE deflator for owner-occupied housing. So, Figure 8 shows home values relative to PCE prices – not actual home values. The most important result from Figure 8 is that the synthetic index with unpaid homeowner labor matches the long-run Case Shiller index much better. In 1929, the synthetic index with only hired labor and purchased materials is 44% higher than the Case-Shiller index. In contrast, the synthetic index with unpaid homeowner labor is only 15% higher. However, the two indexes match closely from 1965 onwards. The close match is primarily driven by the low 'unpaid labor adjustment' share in recent years.

results suggest that land values **relative** to physical dwelling value hasn't changed much over time. In order to simplify the paper, I will not present my results. Please e-mail me for more information.
[26] In reality, BEA has separate price indexes and depreciation rates for new home construction and home improvements. In my calculations, I weight these price indexes by capital stock to get an aggregate price index.
[27] I use 2000 as a base year because the housing bubble peaked in 2005. That bubble would force the Case Shiller index to be higher than the synthetic indexes for every year of the sample.

Figure 9 decomposes the different growth rates into the three component parts. For all years, new investment increases and depreciation increases slightly. From 1929 to 2010, net annual unpaid labor investment is 0.16% of the housing stock. Over 80 years, that 0.16% annual investment rate works out to 14% higher home values. In addition, inflation rates are higher when unpaid labor investment is included. The higher inflation rate is a direct result of the higher price growth for unpaid homeowner labor seen in Figure 4. On average, inflation rises by 0.14% per year when unpaid homeowner labor is included. Over 80 years, this 0.14% higher inflation rates work out to 12% higher home values.

I can also use the synthetic price index to predict future home values. Between 1929 and 2000, the actual Case-Shiller index rose by 4.11% per year. Using only out-of-pocket investment, my synthetic home value index rose 3.58% per year over the same time period. In order to match the Case-Shiller index better, I add an "unexplained growth factor" of 0.53% per year to synthetic home value index. By construction, the adjusted synthetic home value index matches the Case-Shiller index perfectly in 1929 and 2000. In contrast, the synthetic home value index with unpaid homeowner labor rose 3.91% per year from 1929 to 2000. Therefore, I only need to add an "unexplained growth factor" of 0.20% per year to match the Case-Shiller index. Once again, this adjusted index matches the Case-Shiller index perfectly for 1929 and 2000. Using these two adjusted indexes, I can compare actual Case-Shiller prices to synthetic home prices created from BEA's housing investment data and unpaid labor.

Going forward, the synthetic price index with unpaid homeowner labor predicts lower home values. In 2005, I calculate that Case-Shiller prices were 32% above the synthetic home prices without homeowner labor and 35% above the synthetic price index with homeowner labor. In 2010, the Case-Shiller prices were 9% below the synthetic home prices without unpaid homeowner labor and 4% below the synthetic home prices with unpaid homeowner labor. The difference is caused by a decrease in unpaid homeowner labor home improvement since 1980. As a result, my synthetic index with unpaid homeowner labor included predicts lower home appreciation going forward. The lower predicted appreciation may mean that home values will take longer to recover than analysts had hoped.

5. Home-Production of Goods

Section 6.32 of the SNA 2008 handbook states:

Although services produced for own consumption within households fall outside the boundary of production used in the SNA, it is nevertheless useful to give further guidance with respect to the treatment of certain kinds of household activities which may be particularly important in some developing countries. The SNA includes the production of all goods within the production boundary. The following types of production by households are included whether intended for own final consumption or not:

a. The production of agricultural products and their subsequent storage; the gathering of berries or their uncultivated crops; forestry; wood-cutting and the collection of firewood; hunting and fishing;

b. The production of primary products such as mining salt, cutting peat, etc;

c. The processing of agricultural products; the production of grain by threshing; the production of flour by milling; the curing of skins and the production of leather; the production and preservation of meat and fish products; the preservation of fruit by drying, bottling, etc.; the production of dairy products such as butter or cheese; the production of beer, wine, or spirits; the production of baskets or bats; etc

d. Other kinds of processing such as weaving cloth; dress making and tailoring; the production of footwear; the production of pottery, utensils or durables; making furniture or furnishings; etc.

e. The supply of water is also considered a goods-producing activity in this context. In principle, supplying water is a similar kind of activity to extracting and piping crude oil.

In this paper, I will consider three goods that were commonly produced in US households: regular food items, home-sewn clothing and unmeasured alcohol. All three items are explicitly mentioned in the SNA's list for 6.32.

Data on Home-Produced Food

The main dataset used in this paper is the USDA's published estimates. On their website, they estimate the market value of home produced food back to 1860. This includes home vegetable gardens, chickens kept for fresh eggs, hunted game and other non-market food sources. The USDA's estimates

are based on occasional survey data and their own model. More detail on USDA's methodology is provided in the report "Developing an Integrated Information System for the Food Sector" (Alden 1987). Because the USDA's numbers are modeled, they are extremely smooth. In particular, they do not show any spike in home-produced food during World War 2 – even though victory gardens were pushed heavily.[28] They also do not show increase in the past few years despite media reports of increased home gardening (Horovitz 2009). Accordingly, my adjustments to GDP might not match annual growth rates perfectly. But they should show the correct long-term trend.

The USDA values home-produced food at typical retail prices. This may underestimate the value of home vegetable gardens if consumers prefer the taste of home-produced vegetables to store bought items. The value of home produced food would be much higher if the USDA valued it at the price for locally grown organic products. On the other hand, home vegetable gardens are lower in quality on other attributes. For example, home gardens often provide massive amounts of each item for a short period of time. This is much less convenient than grocery stores. The net difference in quality between home produced food and store bought food is ambiguous. For simplicity, I will take the USDA estimates of home food production as given.

According to the USDA, consumers produced $19.1 billion of food in 2007.[29] Approximately $0.4 billion of that food is produced and consumed by farm families. That production is already counted in GDP. However, BEA does not currently count food production by non-farm families in GDP. Therefore, total food production would rise by $18.7 billion if BEA followed SNA's guidelines for food production. I estimate that households spend 25% of the final value of food on intermediate expenses such as seeds, tools and lawn space. Therefore, home vegetable gardens provided $14.1 billion in value-added for 2007.

Measuring Home-Sewn Clothing from 1929 to 2010

I calculate that home-sewn clothing added $6.1 billion to GDP in 2007. The main dataset is BEA's pre-existing estimates of personal consumption expenditure. In the NIPA table 2.4.5U, BEA estimates that households purchased $4.04 billion of clothing material (line 108) and $1.16 billion of

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[28] World War 2 was also associated with much lower unemployment and higher labor force participation. Taken alone, those factors might have reduced home gardening significantly. It is possible that the push for victory gardens was necessary to keep food production stable.

[29] Taken from http://www.ers.usda.gov/briefing/cpifoodandexpenditures/Data/Expenditures_tables/table5.htm

sewing supplies (line 133) in 2007. I assume that 90% of the clothing materials purchased by households and 50% of the sewing items purchased are used to create new outfits and so should be considered home production of goods.   Based on the industry literature, I estimate that final clothing is worth 2.45 times the material costs.[30] Therefore, I estimate that households used $4.06 billion of raw material to produce $10.08 billion of clothing.

BEA's detailed expenditure tables only go back to 1959. Before then, I use home-food production as a proxy for home-sewn clothing. I assume that the two ratios (home-grown food)/(total food) and (home-sewn clothing)/(total clothing) move similarly. For example, rural households are more likely to produce both products themselves. In 1959, home-grown food accounted for 9% of total food and home-sewn clothes accounted for 3.7% of total clothing. In 1929, home-grown food was 31% of total food. Therefore, I calculate that home-sewn clothing was 12.8% of total clothing. I welcome suggestions to improve my estimate.

Unmeasured Alcohol from 1929 to 1935

Unlike the other home-produced goods, I only track unmeasured alcohol during Prohibition (January 1920- December 1933) and immediately afterwards. Furthermore, I only track the **increase** in unmeasured alcohol that occurred because of Prohibition. Even after Prohibition was repealed, some hobbyists continued to brew their own alcohol. The home-brewing was more common when alcohol taxes were high. However, I have not been able to locate any data measuring that home production after 1935. In contrast, there are many academic papers that study how individuals substituted from market purchased alcohol to home-brewed alcohol during Prohibition. After Prohibition was repealed, those same individuals switched back to market purchased alcohol. Accordingly, GDP growth from 1933 to 1934 decreases from 17% to 15% (nominal) when unmeasured alcohol is included.

I use the term unmeasured alcohol because it makes no judgment about the legality. Under Prohibition, the commercial sale of alcohol was illegal except for religious or medical use. However, households were permitted to ferment up to 200 gallons per year for their own use (Okrent 2010). In

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[30] My main source is http://www.onlineclothingstudy.com/2011/10/cost-breakdown-of-mens-woven-cotton.html. They report that wholesale costs are 2.45 larger than materials costs. Retailers also mark up the product by about 150%. However, I assume that the same retail mark-up applies to home sewing material, but not sewing material used by commercial manufacturers. Therefore, the imputed value of final clothing is 2.45 times what the households paid for the cloth and yarn.

addition to legal production, households and small businesses often sold alcohol in the black market. In a separate section, SNA 2008 (6.44) clearly recommends that countries include black market activity in GDP. Accordingly, unmeasured alcohol should be counted whether or not it was legal

According to the industry literature, alcohol consumption decreased very little during Prohibition (Miron and Zweibel 1991).[31] Diverted industrial alcohol probably supplied 6%-10% of the alcohol consumed.[32] I could not find reliable data on imported alcohol, but it seems reasonable that they accounted for a similar fraction. I will assume that home produced alcohol provided 85% of the total alcohol consumed. I also assume that every dollar of unmeasured alcohol required 35 cents worth of raw materials.[33]

In 1929, I calculate that unmeasured alcohol added $2.00 billion to GDP. My main dataset for this number is BEA's pre-existing estimate of food-at-home consumption and alcohol consumption. These numbers are given in NIPA Table 2.4.5, lines 27 and 28. According to BEA's current estimates, alcohol consumption was 0 from 1929 to 1932, very small in 1933 and then grew rapidly in 1934 and 1935. From 1936 to 1941, the ratio of purchased alcohol to food-at-home hovered around 0.21. For this paper, I will assume that the true ratio of alcohol consumed to food-at-home was actually 0.21 from 1929 to 1935.[34] Based on that ratio, I calculate that Americans consumed $3.1 billion of unmeasured alcohol in 1929. I also estimate that Americans spent $0.8 billion on food to be fermented into alcohol and $0.3 billion storing the raw material while it fermented. Therefore, the value-added from unmeasured alcohol was $3.1-$0.8-$0.3 = $2.0 billion in 1929.

Home Production Relative to GDP

Figure 10 shows all four types of home production relative to nominal GDP from 1929 to 2010. Overall, home production was much more important before 1950. Home brewed alcohol averaged 1.9% of GDP from 1929 to 1933 and then shrank quickly when Prohibition was repealed. Home-grown food

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[31] This estimate is based on cirrhosis deaths and other health proxies for alcohol consumption. Their numbers may be flawed if black-market alcohol creates more health problems than the same amount of legally produced alcohol.
[32] In 1936, total alcohol consumption was approximately 1.5 gallons of pure ethanol per adult, or 150 million total http://www.niaaa.nih.gov/Resources/GraphicsGallery/Pages/consfigs1text.aspx. Diverted industrial alcohol probably supplied 9 to 15 million gallons a year. http://xroads.virginia.edu/~hyper/allen/ch10.html.
[33] Fruit or other sugars are the main input, but closet space was also important.
[34] Even if BEA chooses not to track illegal alcohol sales or home-brewing, it should still have a small positive number for the legal sales during prohibition. However, the religious use might be tracked in the non-profit sector and the medical use might be tracked in the drug category.

averaged 2.1% of GDP from 1929 to 1941 and home-sewn clothing average 1.4% of GDP over the same time period. In contrast to home-production of goods, unpaid home improvement labor was small until 1945. After World War 2, home ownership skyrocketed and the new home-owners quickly remodeled their houses. By 2010, unpaid home improvement labor accounted for 65% of home production studied in this paper.

Technology changes are the main reason that do-it-yourself activity has shifted over time. In 1929, it was difficult for households to get fresh vegetables unless they grew them in their backyard. Since then, food storage and shipping has improved dramatically. As a result, fresh vegetables are cheap enough that most gardeners are doing it for pleasure. In addition, households have moved from rural areas to urban areas with less space for gardening. Similarly, home-brewed beverages and home-sewn clothes are primarily hobbies now. In contrast, the technology for home remodeling has changed very little. Homeowners can still save significant amounts of money by doing simple projects themselves.

Another reason for the shift in do-it-yourself activity is changes in the overall economy. In 1929, purchased food at home accounted for 14% of GDP and purchased clothing accounted for 7% of GDP. By 2010, the food share fell to 5% and the clothing share fell to 2%. Even if (home-grown food)/(total food) and (home-sewn clothing)/(total clothing) had been absolutely fixed, home-production both items would gradually become less important over time. In contrast, out-of-pocket home improvement was 0.38% of GDP in 1929 and 0.83% of GDP in 2010. Therefore, do-it-yourself home improvement should become more important over time.

Conclusion

The *System of National Accounts 2008* (SNA 2008) recommends that countries classify unpaid home improvement labor as an investment activity in GDP (6.37). In a separate section, SNA 2008 also recommends that countries include home production of goods in GDP (6.32). However, BEA does not currently follow those recommendations at this time. In the paper, I calculate nominal investment, prices and capital stock from 1929 to 2010 if BEA included unpaid home-owner time in home-owner investment. I also calculate the value of home-produced goods from 1929 to 2010. These time series could be used to re-calculated the NIPAs if BEA someday chooses to include these activities in GDP.

Since 2000, unpaid home improvement labor has the largest impact on GDP. When unpaid homeowner labor is included, housing prices peaked even farther above the market fundamentals than currently thought. Furthermore, GDP growth increases during the housing bubble and falls more after the bubble burst. In contrast, home production of goods has a much larger impact on GDP before 1950. In particular, GDP growth from 1933 to 1934 falls by 2% (17% to 15%) when unmeasured alcohol is included in GDP.

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Table 1: Regression Results from American Housing Survey

% Cost Savings From Unpaid Labor, Log Regression	67.80%	63.49%	62.27%	60.98%	61.33%
	(0.56%)	(0.49%)	(0.76%)	(0.78%)	(0.78%)
% Cost Savings From Unpaid Labor, Linear Regression of [(Cost)/(Mean Cost)	58.99%	61.18%	75.89%	69.37%	70.50%
	(0.96%)	(0.96%)	(1.97%)	(2.03%)	(2.04%)
Controls for Precise Job Type?	N	Y	Y	Y	Y
Controls for Year & Household Location?	N	N	Y	Y	Y
Controls for Home-Owner Demographics?	N	N	N	Y	Y
Controls for Other Family Member Demographics?	N	N	N	N	Y

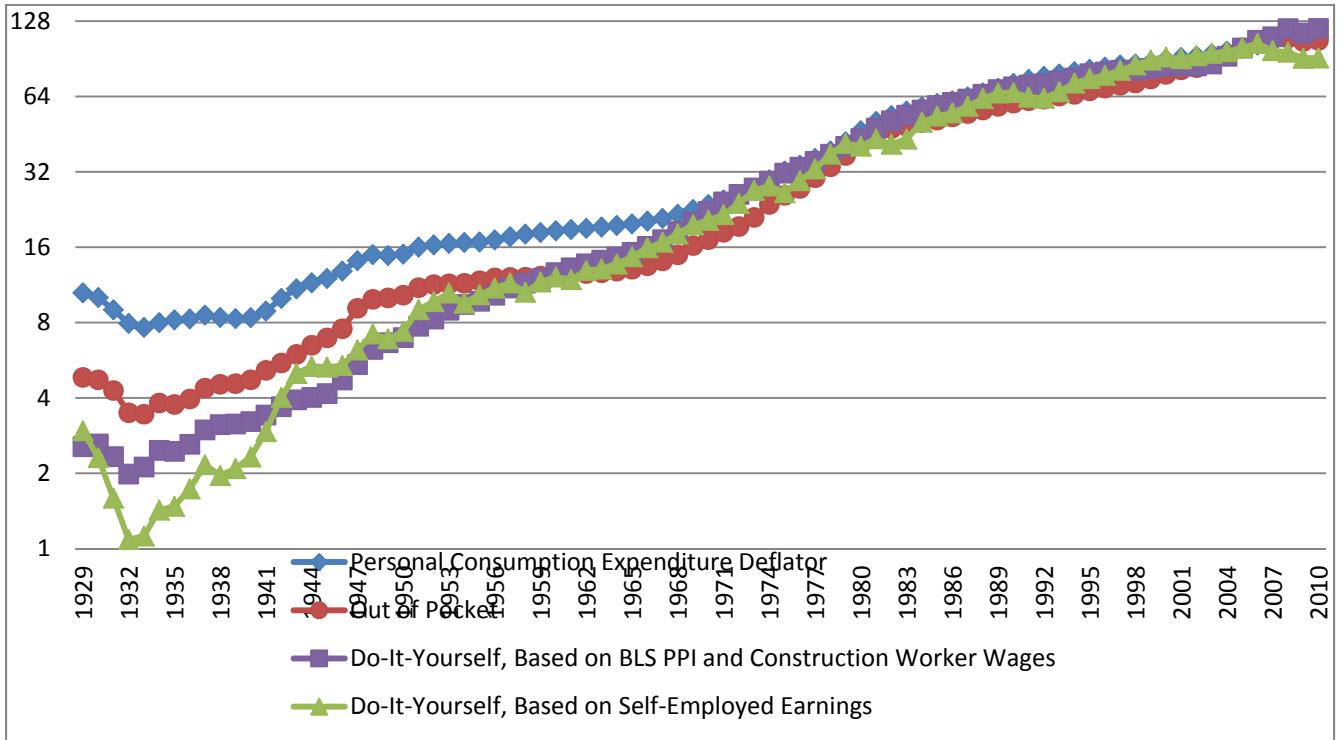## Figure 1: Nominal Home Improvement vs. Nominal GDP, 1997-2010
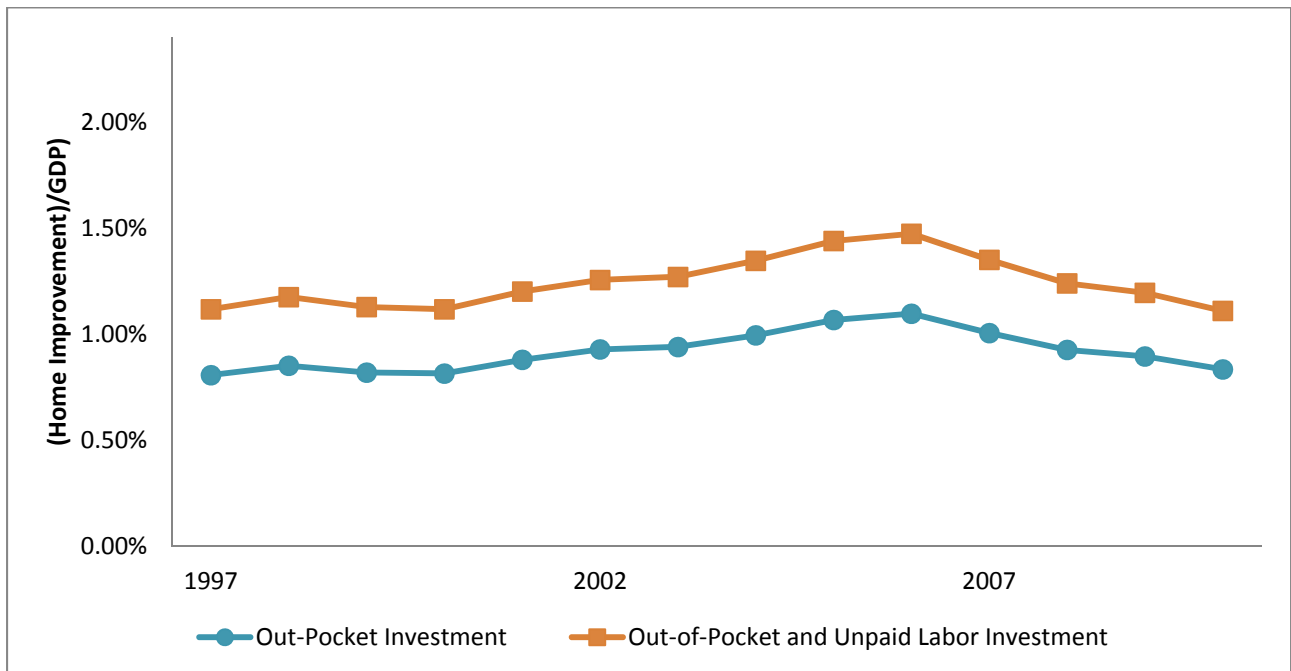
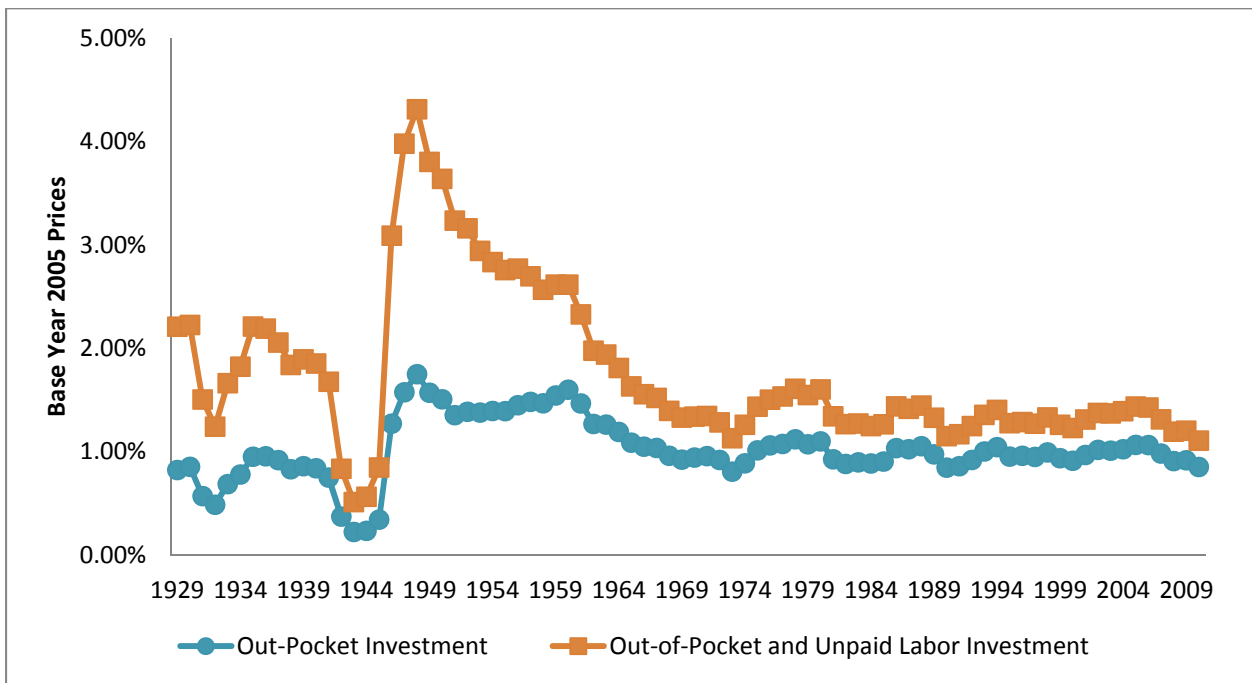## Figure 2: Unpaid Labor Relative to Out-Of-Pocket Spending, 1900-2000
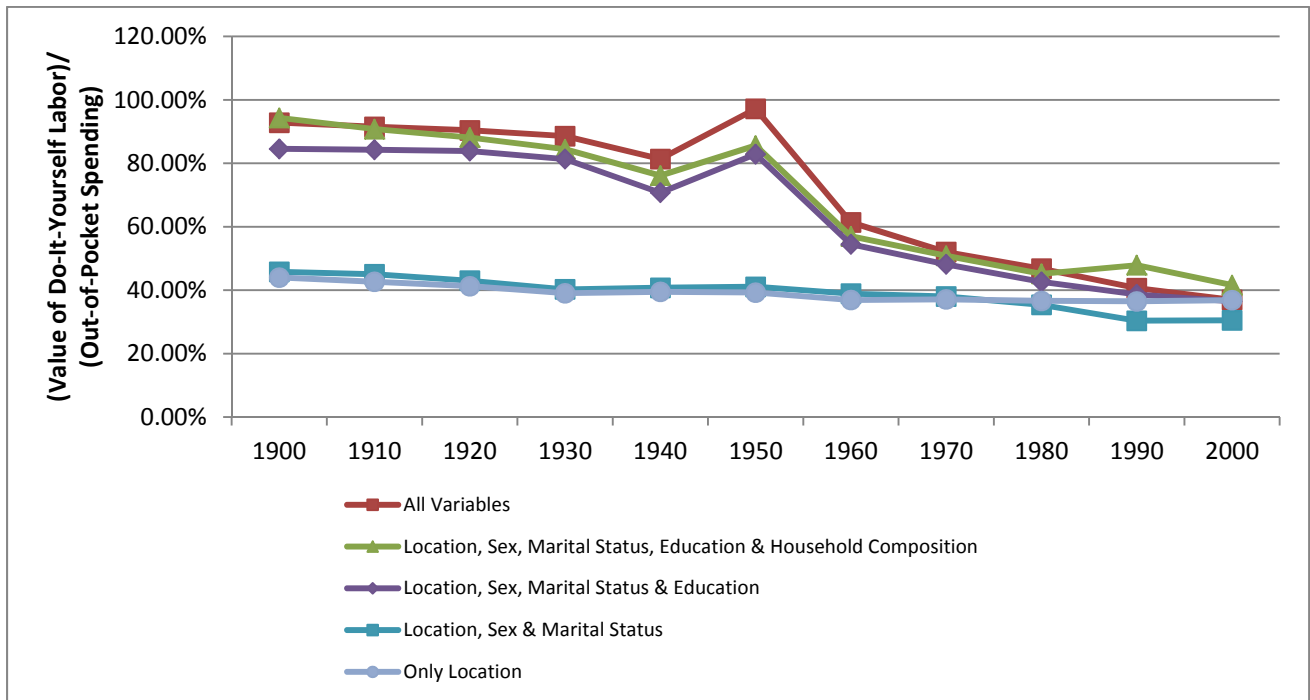
Figure 3: Nominal Home Improvement vs. Nominal GDP, 1929-2010
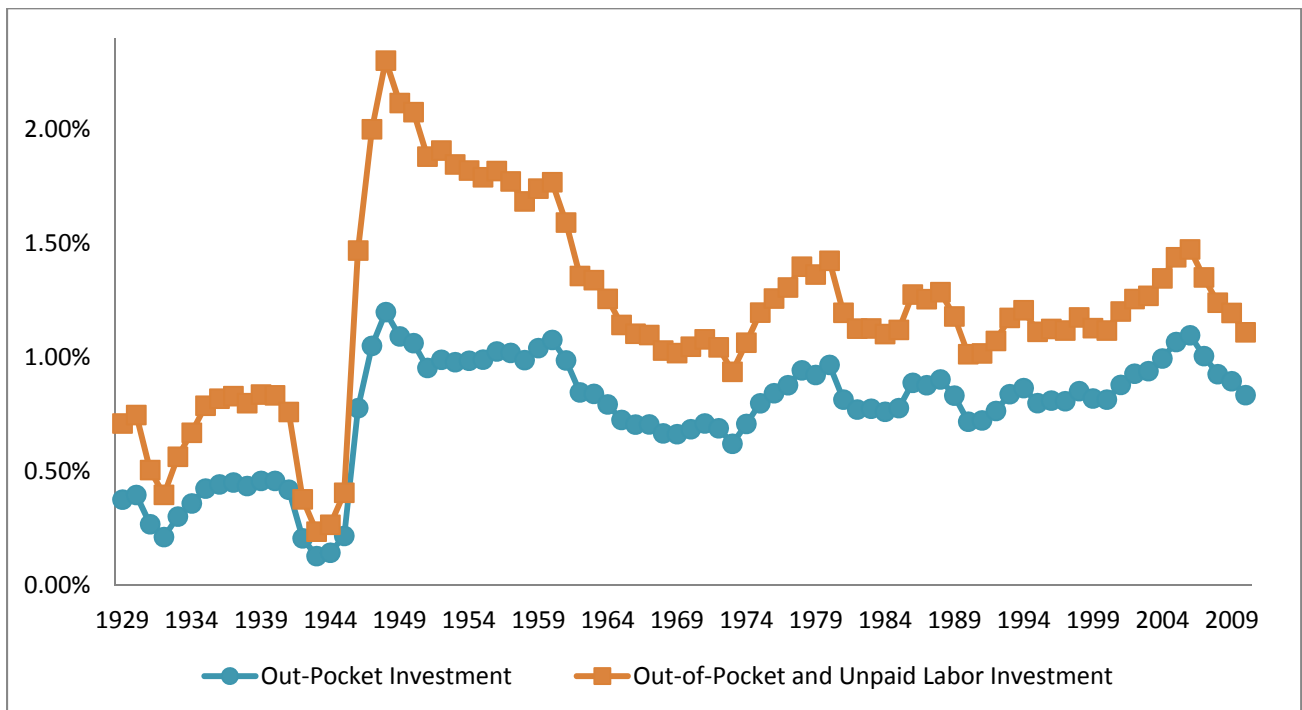
## Figure 4: Prices for Home Improvement, 1929-2010

Legend:
- Personal Consumption Expenditure Deflator
- Out of Pocket
- Do-It-Yourself, Based on BLS PPI and Construction Worker Wages
- Do-It-Yourself, Based on Self-Employed Earnings

Figure 5: Real Home Improvement vs. Real GDP, 1929-2010

Legend:
- Out-Pocket Investment
- Out-of-Pocket and Unpaid Labor Investment

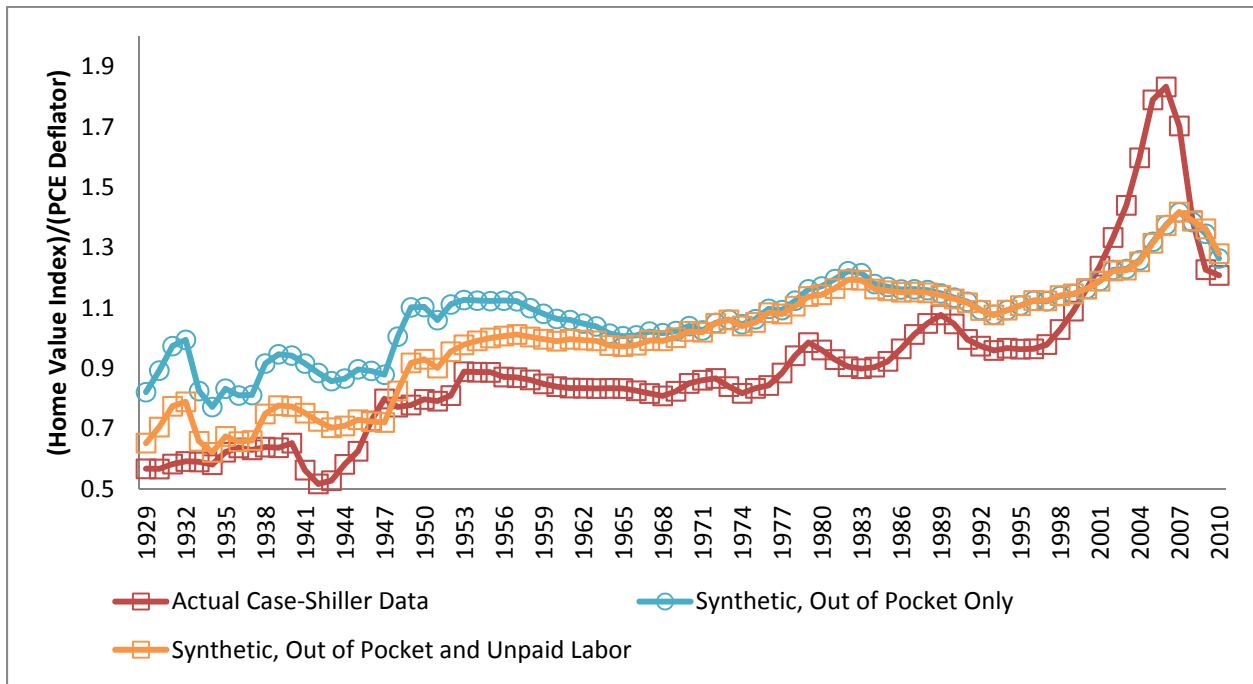## Figure 6: Stock of Housing Relative to Nominal GDP 1929-2010
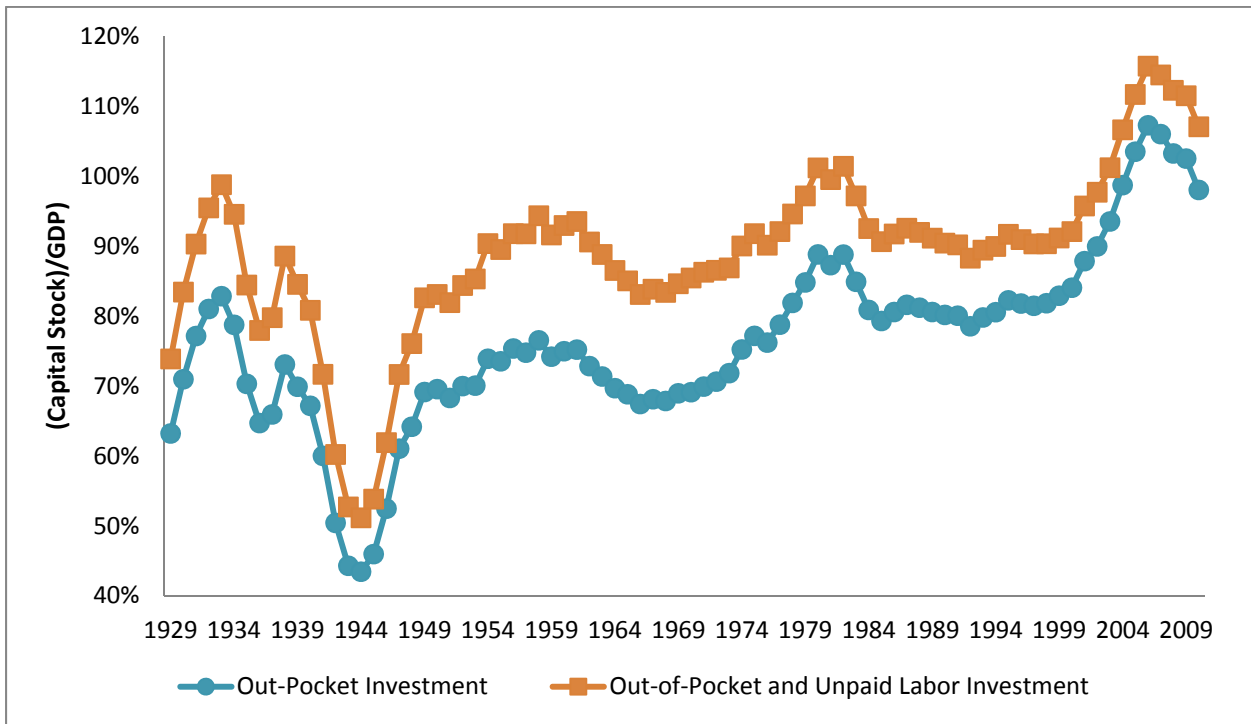
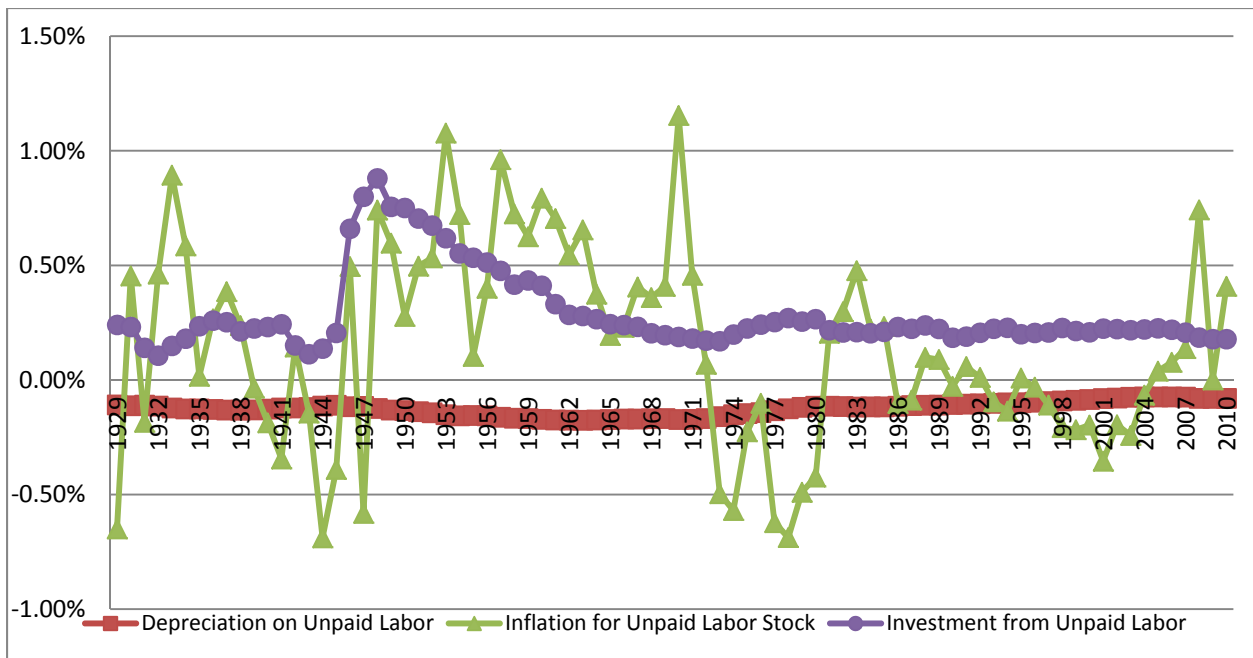## Figure 7: Nominal Net Investment vs. Gross Savings 1929-2010
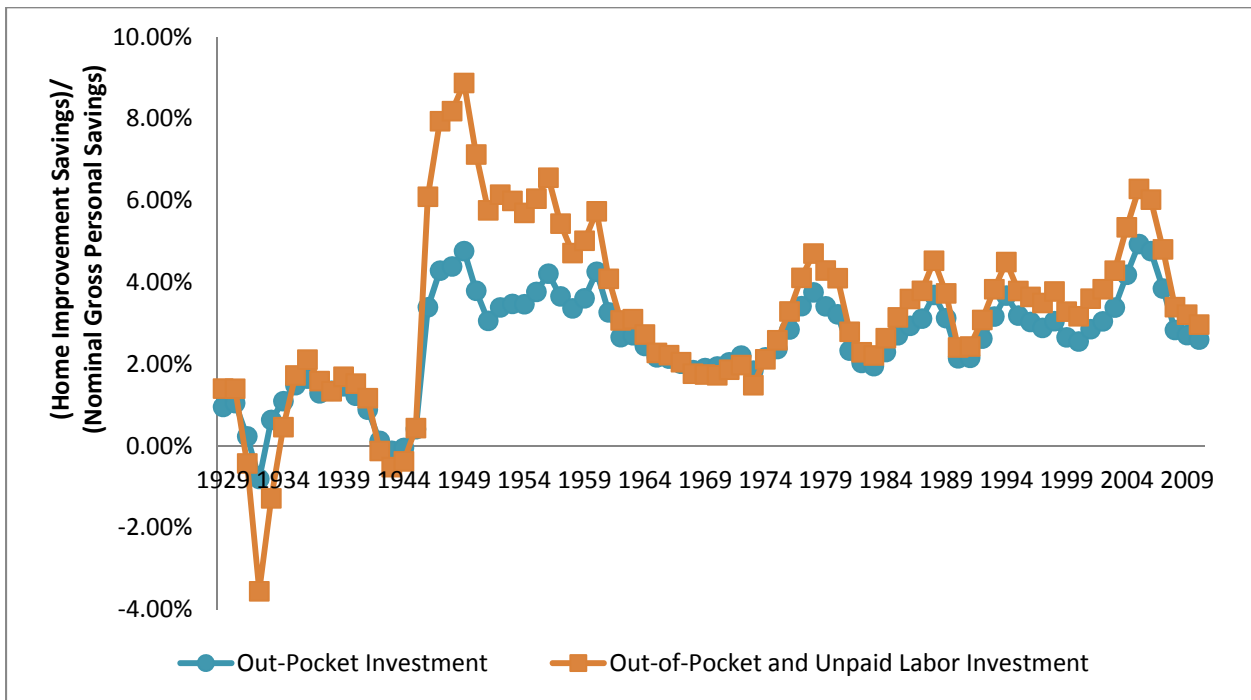
Figure 8: Actual Case-Shiller Index vs. Synthetic Indexes (Reals)

Figure 9: Synthetic Index With Unpaid Labor vs. Out-of-Pocket Only

Decomposing the Growth rate Differences

Figure 10: Home Production of Goods Relative to GDP