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Portfolio Implications of Homeownership – Hedging Housing Risk in Urban and Peripheral Sweden

Philip Löfgren

19614@student.hhs.se

Ludvig Mattsson

19581@student.hhs.se

Abstract

This paper investigates the investment implications of the housing consumption choice in a mean-variance framework using quarterly time series ranging from the first quarter 1986 to the last quarter 2005. We analyze the investment portfolio of the Swedish household on a quarterly horizon containing general stocks, real estate stocks, T-bills, government bonds and housing. Furthermore, this paper assesses the potential benefit from hedging the household's housing investment, firstly with general and real estate stocks and secondly with a tradable national real estate price index. In addition, this paper investigates the repercussions of house location throughout the analysis. In contrast to earlier papers investigating hedging of housing risk we use fully comparable time series for the assets in the mean-variance optimization. We find the optimal housing investment to be increasing with desired risk in the span of 3%-151% of net wealth for urban households and practically zero for non-urban households regardless of desired risk level. Observed values of housing investment to net wealth indicate that many Swedish households suffer from an overinvestment in housing, which entails additional risk. Hedging this risk with general and real estate stocks gives limited results. We do however find larger potential gains from hedging with a tradable national housing price index. The gains from hedging are higher the more severe the overinvestment is. The scope for reducing risk through hedging is also higher for the urban households, whether hedging with stocks or with the housing price index.

Keywords: household portfolio, homeownership, hedging, real estate

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"No real estate is permanently valuable but the grave." – Mark Twain, Notebook #42, 1898

1. Introduction

The house constitutes a considerable proportion of most household portfolios. In 2005 people in Sweden spent on average about 24 percent of their disposable income on housing and 48 percent of Swedish households live in owner-occupied housing (Statistics Sweden 2005).[1] There are many factors behind the high percentage of owner-occupied housing in Sweden. Among the institutional factors we can mention differences in tax treatment and credit availability. Furthermore, the restricted rents for rental apartments in Sweden have lead to a constrained rental market with windfall gains for individuals in possession of rental contracts, see Berger & Turner (1991). Having a rental market lead by non profit motives, see Kemeny (2005), creates a short supply of rental housing, see Jackson (1993) and Olsen & Barton (1972), and thus for many households owner-occupied housing is the only available alternative. Turning to the non-institutional factors, we can bring up the house as a heterogeneous good. Owning a house enables the owner to specify it according to taste and needs. Moreover, when owning your own house you have the possibility to make sound decisions about maintenance and renovation, which should prove beneficial in financial terms, see Sweeney (1974). Ownership of a house also insures the owner of the future supply of housing. In addition to these factors, the new right-wing government has significantly reduced tax burden for house owners, which makes it more beneficial to own a house.

When households face the choice of owning their house or not the assessment is twofold. Firstly, consumption entails one part of the choice. Secondly, it is a portfolio choice since a house to a large extent affects the composition of the household portfolio. When owning a house, the development of the real estate market influences the risk and return on the household portfolio. This causes a conflict between consuming the desired amount of housing services and investing the optimal amount for the household portfolio in housing. As Englund et al. (2002) point out; most Swedish households have unbalanced portfolios in the form of overinvestment in housing.

[1] This number does not include tenant-owned flats owned in an economic association, "bostadsrätter" in Swedish.

The overinvestment in housing brings about excessive risk for the household portfolio, see for example de Roon et al. (2002) and Flavin & Yamashita (2002). The extent of this excessive risk is mainly dependent upon two factors. Firstly, the risk is affected by the consumption preferences of the household. The consumption preferences materialize as the amount of net wealth that the household decides to spend on housing, see Englund et al. (2002), Flavin & Yamashita (2002). Secondly, the risk in question is affected by the risk and return on the individual house as an asset. The risk and return on the individual house is in turn dependent on many factors, for a detailed empirical study see Englund et al. (1998). The factor accounting for the lion's share of the difference in the risk and return on the house is its geographical location. Today the Swedish financial market offers no efficient solution to reduce the risk associated with homeownership.

Some attempts to reduce the risk of homeownership have been made in other countries. A derivatives market in contracts on regional house prices was put forth by Case et al. (1993), which would enable homeowners to short-sell contracts and thereby hedge their position in an individual house. In May 2006 the Chicago Mercantile Exchange started such a market with contracts on the 10 largest cities in the United States. So far, interest has been minor and liquidity relatively low. In the United Kingdom some companies have introduced spread betting on real estate prices. Also this market has not prospered, likely since it offers a wide spread and thus an expensive way of hedging your homeownership. One can argue that the reason why these markets have not taken off is the recent years' strong rise in the real estate market and that people tend to neglect the need of hedging in bull markets. Moreover, housing partnerships have been suggested by Caplin (1997) where homeowners collectively own the houses in which they live in. This would enable the homeowners to share the risk of owning a house with other investors and everyone would be better off. However, in order to do this, legislation on the subject needs to be changed which means that it is currently not an option for the Swedish homeowner.

From the above discussion, it is clear that there is no obvious alternative when it comes to hedging housing risk. However, we believe that the most feasible alternative for Sweden would be to start a derivatives market with contracts on a residential real estate price index. This is because there are no legal barriers and it would likely be the most efficient hedging tool. Due to the small population of

Sweden it would not be possible to have contracts on a regional level, keeping in mind the low liquidity on the U.S. market. In order to achieve liquidity in the market we believe one needs derivative contracts tied to a national and residential real estate price index. This would make the derivative contracts less efficient as hedging tools, but on the other hand, liquidity is a necessity in order to hedge at all. The derivative contracts would at least in theory create a market since there are both a buy- and a sell-side. The sell-side is comprised of individual households, banks, lenders and holders of mortgage portfolios who wish to engage in risk management. Furthermore, builders who have an inventory of homes under construction may wish to hedge these until they are sold on the market. On the buy-side there are many institutional investors who wish to take part of real estate as an asset class without incurring the complications of actually executing real estate transactions. Real estate has proven to have low correlation with other asset classes and would therefore serve well as a diversification tool for institutional investors, see for example Goetzmann (1993) and de Roon et al. (2002). Since the Swedish real estate market was estimated to 3 743 billion SEK in 2000 and therefore qualifies as the second largest asset class, below fixed income but above equities, it should prove beneficial for many parties if a properly functioning derivatives market was available. [2]

The purpose of this paper is to investigate portfolio implications in terms of risk and return for Swedish households of owning an individual house and to see if the risk of the household portfolio can be reduced through hedging.[3] In order to do so we will look at mean-variance optimized portfolios and use available instruments as well as a hypothetical derivative on a national real estate price index for hedging purposes. We will look at this topic for households with different consumption preferences in order to determine what implications the proportion of the household's net wealth that is invested in housing will have on the performance of the household portfolio and hedging opportunities. Moreover, we intend to investigate what implications the risk and return on the individual house as an asset will have on the performance of the household portfolio and hedging opportunities. We do this by looking at both an urban and a non-urban household,

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[2] Statistics based on tax values from Statistics Sweden and multiplied by 4/3 to get market value, see www.scb.se.

[3] We define household as all individuals who occupy the same housing unit and make financial decisions as one entity.

represented by a household portfolio that includes an individual house in Stockholm and mid-Norrland respectively. To summarize, this paper investigates:

- The house as an asset in the household portfolio
- The implication on household portfolio risk that comes from the overinvestment in housing due to consumption motives
- The possibility for households to hedge the extra risk incurred from owning a house
- The effects of the geographical location of the house on all three points above

Our paper is organised as follows. In the next section we look at what is known from prior research in the field and what contribution this thesis provides. In section three we explain what data we use, how the housing index is constructed and how mean-variance optimization of the household portfolio is performed. In section four we discuss return patterns from underlying data and their implications on the legitimacy of our results. In section five we look at our results in terms of optimal portfolios in three different scenarios; one with a strict investment perspective, one looking at the cost of housing consumption preferences and one where we investigate the potential risk-reduction of hedging. All three scenarios will be investigated for households with different geographical locations. Concluding remarks are given in section six.

2. Prior Research

Research on the household portfolio implications of homeownership and the quantitative role of housing in the household portfolio is a fairly recent field of research. The late commencement of these types of studies was due to earlier difficulties in deriving housing returns. However, the field took off in 1987 when Case and Shiller published a paper on housing returns based on a weighted repeat sales regression procedure, see Case & Shiller (1987). This method is considered to give relatively accurate time series on the capital appreciation of residential real estate. This enabled researchers to investigate the implications of homeownership to the household portfolio. Based on the Case and Shiller time series, Goetzmann wrote in 1993 the first paper on the effects of including a single family home in the investor portfolio, and then papers on the topic followed by for example

Flavin & Yamashita (2002), de Roon et al. (2002), Englund et al. (2002), Iacoviello & Ortalo-Magné (2003) and Lagarenne & LeBlanc (2004).

Even though the above mentioned papers use different methods of deriving housing returns, they all find low correlations between housing returns and other assets. Englund et al. (2002), Lagarenne & LeBlanc (2004) and Flavin & Yamashita (2002) find for Sweden, France and the U.S respectively, that the real return correlations between the individual house and general stocks, bonds and T-bills to be negative or close to zero. Housing is found to be an efficient diversification tool for the household portfolio, and thus also for institutional and market investors, see for example Goetzmann (1993), Englund (2002) and de Roon et al. (2002). In other words, including an individual house in the household portfolio can reduce the total risk of the portfolio.

There are however much evidence provided that the household often overinvests in the individual house due to consumption motives, see Brueckner (1997) for overinvestment due to consumption distortion and Flavin & Yamashita (2002) for an account of the life cycle pattern of overinvestment in housing. Indications on the optimal level of residential housing investments for the household portfolio range from 0% to 50% for risk-averse investors. Goetzmann (1993), qualifying into the higher range of the spectra, finds 50% of net wealth in residential housing to be optimal. Englund et al. (2002) investigates the holding period and find that for short holding periods the house is uninteresting from a portfolio viewpoint but for longer holding periods housing should constitute between 15%-50% of net wealth. De Roon et al. (2002) conclude that the best diversification effects, for most geographical areas in the U.S., are obtained if 30% of net wealth is invested in residential real estate. When comparing these numbers with actual housing to net wealth numbers, one can observe the overinvestment in housing characteristic for many households. As shown by Edin et al. (1995), investigating mean house value as a percentage of mean net wealth by age category in Sweden, most households have significantly unbalanced portfolios, see figure 1 below. Although these figures only show housing to net wealth during the year 1991 they should be indicative of what proportions hold during our sample period. In other words, most household portfolios seem to take on a large degree of extra risk when overinvesting in an individual house.

Mean House Value as Percentage of Mean Net Wealth by Age Category in Sweden 1991	
Age of Household Head	Mean House Value as Percentage of Mean Net Wealth
25-34	258.0
35-44	161.7
45-54	121.1
55-64	94.6
65-74	78.7
75+	80.6

Table 1

Source: Edin et al. (1995)

An important note when discussing risk is that most research on the field only takes into account the financial risk of the household portfolio. For most assets it does not constitute a problem since the only return is financial. Ownership of an individual house does however entail consumption of housing as well. Thus, by owning a house the owner insures himself of the future supply of housing. Housing is obviously one of the fundamental goods in the consumer basket and thus having an uncertain supply of this good can prove devastating in terms of utility. Most papers looking at risk associated with homeownership, our included, consciously disregard this aspect and the reader shall note that when using the term risk the meaning is purely financial.

Hedging of the risk associated with homeownership has also been investigated within this field of research. Hedging with general stocks and bonds has been studied, but neither has proven to be an efficient hedging tool, see de Roon et al. (2002). Englund et al. (2002) also include real estate stocks as a possible hedging tool, but find very limited hedging properties due to low correlation with the individual house. Furthermore, Englund et al. (2002) examine hedging with futures on real estate prices in Sweden and the futures have shown to be noticeably efficient at reducing the risk associated with homeownership. Similar results are found for London by Iacoviello & Ortalo-Magné (2003).

As mentioned, earlier papers conclude that owning an individual house causes an unbalanced household portfolio and that hedging through derivative contracts potentially can reduce risk.

However, many of these papers create their mean-variance optimized portfolios with assets that differ in terms of what kind of return they generate. To be more precise, the return on stocks is specified with only the price appreciation, whereas the return on the house is specified with both price appreciation and direct return. Clearly, this has large implications on the construction of mean-variance portfolios and therefore yields distorted results.

We will now give a concise review on earlier papers with respect to total return index versus price index as a foundation for the stock return series. Goetzmann (1993) believes that it is a total return underlying the return series.[4] Flavin & Yamashita (2002) use an index which takes the dividend yield into consideration, but their method for estimating house prices can be considered unsatisfactory. Lagarenne & LeBlanc (2004) use a total return index. The papers that our study resembles the most do not use a total return index. The first is Englund et al. (2002), who use the AFGX (Affärsvärldens Generalindex). During the time period, ranging from 1st of January 1981 to 31st of August 1993, the AFGX is a total return index up until 31st of December 1986 but is a price index from the start of 1987, see Frennberg & Hansson (1992). The second is Iacoviello & Ortalo-Magné (2003) who use the FTSE All Share Index which is a price index. To summarize the matter, the two papers concerned with hedging of the household portfolio's risk do not use a total return index for stocks which has negative impact on the accuracy of their results.

As earlier stated, the purpose of this paper is to investigate the implications, in terms of risk and return, of homeownership for Swedish households and to see if the risk of the household portfolio can be reduced through hedging. Our contribution to the research on the field will be threefold. Firstly, we will use fully comparable returns for all assets in our mean-variance optimization, and secondly we will use a more recent time series than the previous research done on Sweden. Finally we will investigate what effects the geographical location of the individual house has on the household portfolio and the scope of hedging in the applied mean–variance setting.

[4] Referring to a statement in e-mail correspondence with Mr. Goetzmann.

3. Data and Method

The data needed to perform the household portfolio optimization are time series data over the sample period of the instruments available to the household. From the time series we get return patterns, variances and a correlation matrix needed to undertake a mean-variance optimization. We consider two types of housing investments, one urban and one non-urban. Furthermore, we add the possibility to invest in a national housing index. For the portfolio optimization we add four standard instruments: general stocks, real estate stocks, T-bills and government bonds. The portfolio optimization analysis is performed at a quarterly investment horizon using time series stretching from the first quarter 1986 to the last quarter 2005.

The time series used for general stocks is an index constructed by Frennberg & Hansson (1992). It was first published in 1992 and has since been continuously updated. The index is based on the Affärsvärldens Generalindex, a price index produced by a leading business periodical, but calculated as a gross index and thus taking into account the dividend paid out. For more information on the construction of the stock index see Frennberg & Hansson (1992).

Real estate stocks are represented by DataStream's Real Estate Index from first quarter 1989 to last quarter 2005. The underlying equities for the DataStream's Real Estate Index are Castellum, Fabege, Hufvudstaden, JM and Kungsleden which are included in the index in different time periods depending on company existence and market capitalization. For the period ranging from the first quarter 1986 to the last quarter 1988 we use an index based on the Hufvudstaden stock. Both indices that represent real estate stocks are total return indices that include dividend yield. The lack of a proper real estate index before 1989 is a result of very few corporations being involved in real estate holding. The alternative would have been a real estate index computed by Affärsvärlden, which goes back to 1980. However, as stated in Graflund (2001), that index is predominately constituted by construction companies. Reasonably the price of the individual house should be more correlated with real estate holding companies than with real estate construction companies and thus we considered the index constructed by Affärsvärlden to be less suitable.

T-bills are represented by the 3-month Swedish Treasury Bill and government bonds by the 5-year Swedish Government Bond. For the T-bills we use data from The Riksbank (the Swedish central bank) on 3 month rates. For the government bonds we use a total return bond index for 5-7 year maturity bonds in Sweden constructed by DataStream.

3.1 Housing Returns

Housing is difficult to price, since it is a heterogeneous good which continuously change due to refurbishment and depreciation. The housing market is also characterized by high transaction costs and thus making pricing even more difficult. There have been several approaches to creating an index for residential real estate. Flavin & Yamashita (2002) use a valuation based technique where the owners assess the house value. The method is due to its rather simple and subjective nature likely to have a limited accuracy. Another technique is the transaction based hedonic regressions method. Here each transaction of a housing unit is seen as a bundle of different attributes and each one is separately estimated, often through the ordinary least squares method, to have a positive or negative impact on the house price. A third approach is the repeat sales method. Here two arms length sales are registered combined with the dates of the sales of the same housing unit. Then, the price is calculated based on the increase of each housing unit. Another method, perhaps the most thorough, is the method proposed by Englund et al. (1998) which is a repeat sales approach with some elements of the hedonic regressions method. Here the repeat sale method is applied with the addition of estimated parameters on attributes of the house, and thereby controlling for differences of a specific housing unit between the two arm length sales. For further reading on the differences between the methods see Meese & Wallace (1997).

We use yet another method for pricing the house. To get a time period long enough to yield reliable returns, variances and correlations we have chosen an index published by Statistics Sweden (SCB), FASTPI. The optimal solution would have been to construct a housing index using the method used by Englund et al. (1998). That is however extremely time consuming and therefore not in the scope of this paper.

The underlying time series for the housing return is FASTPI for the whole of Sweden and the returns on an individual urban and non-urban house are FASTPI for the Stockholm region and mid-Norrland respectively. The choice of Stockholm and mid-Norrland as underlying regions is to test the two extremes in terms of the geographical location's impact in financial terms. Furthermore, it is also to test the efficiency of the housing index as a hedging instrument since it is based on national housing prices and thus the two regions chosen should fully reveal its limits.

FASTPI is an index that estimates the price development of one- and two-dwelling buildings. The index is calculated with the help of the distribution of real estate in the region and price data on transactions made within the region. Prices for the sold real estate are then categorized by taxation value and region (regions in this context are not the same as for example Stockholm and mid-Norrland, rather they are smaller regions within these regions). An average price for both a base year and a reference year is calculated for every category. The average prices for the different points in time are then weighted by dwelling-population to a chained Laspeyres index. The index has a small flaw caused by a real estate taxation reform in 1996. The reform redefines very small properties and thus they do not enter the underlying data for calculating the index resulting in slightly higher values for 1996 and onwards. The effect on the index is "marginal", according to Statistics Sweden.[5]

The reliability of basing returns on housing investments on this type of index instead of an index based on cross-sectional and panel data of repeat sales is somewhat lower. Englund et al. (1998) argue that an index of repeat sales shows a more predictable and higher average change in quarterly returns and slightly higher variances, for more information on the differences between using different types of real estate indices see Englund et al. (1998).

[5] See "Fakta om statistiken" on www.scb.se

The sale of a house can be seen as the product of the price index and the quality of the house

$$V_{it} = P_t + Q_{it} + \varphi_{it} \tag{1}$$

where V_{it} is the logarithm of the selling price, P_t is the logarithm of the housing price index at time t, Q_{it} is the logarithm of the quality of house i at time *t* and φ_{it}, is the idiosyncratic random error of the transaction of the house. The quality Q_{it} of the house at a specific time t is unobserved but can be seen as a function

$$Q_{it} = \beta X_{it} + \xi_{it} + \eta_{it} \tag{2}$$

where X_{it} is a vector of observable characteristics of house i at time t, ξ_{it} is a unit specific factor and η_{it} is a random error. Combining (1) and (2) yield the following equation

$$V_{it} = P_t + \beta X_{it} + \xi_{it} + \varepsilon_{it} \tag{3}$$

where ε_{it} is a composite error term, that is the net of the idiosyncratic error of an individual house and the transaction

$$\varepsilon_{it} = \eta_{it} + \varphi_{it} \tag{4}$$

Assume $E(\varepsilon_{it}) = 0$ and $E({\varepsilon_{it}}^2) = \sigma_\varepsilon^2$

As a proxy for the composite error variance from investing in an individual house we use the variance from our local indices for urban and non-urban areas and we add σ_υ^2 which is the idiosyncratic error variance from investing in a single house as opposed to an aggregate. We use the error variance from Englund et al. (1998), since their extensive study on housing indices using cross-sectional and panel data on arm length repeat sales is the best available indication on the idiosyncratic risk associated with investing in a house.

The return on owning an individual house thus stems from two components: the change in the housing index, where the service flow generated by the owner of the house (net of depreciation and costs) is included, and the change in the house-specific error term. The service flow is difficult to estimate since the rents are regulated in Sweden. If one would impute the service flow from rented housing the results would be distorted. We approximate the service flow generated by owning a house to 1% quarterly following the "one-in-one-hundred" rule in Englund et al. (2002) and Iacoviello & Ortalo-Magné (2003). The one-in-one-hundred rule is at best arbitrary, but seems to have been accepted by the literature on the subject. However, for the sake of comparison it is worth mentioning that Lagarenne & LeBlanc (2004) use a gross annual rental service value of about 6% of the house value. Furthermore, de Roon et al. (2002) suggest that the annual consumption benefits of the house are at least between 2% and 7% and can be as high as 10%, depending on geographical location and the wealth allocated to housing.[6] Using a quarterly service flow of 1% is thus in line with earlier studies on the topic, and if anything it should be regarded as conservative. Other implications of the use of the one-in-one-hundred rule is that it should yield a slight downward bias on the return volatility since it implies that the service flow is a constant fraction of the house value instead of a fluctuating imputed value from market rents.

The return on the Housing Index, $r_t^{housing\ index}$, is defined as

$$r_t^{housing\ index} = P_t - P_{t-1} + 0{,}01 \qquad (5)$$

Where P_t is the logarithm of the housing index and $0{,}01$ is a proxy for the service flow, or dividends, generated by the index.

The return on an individual house, $r_t^{house\ urban}$ or $r_t^{house\ non-urban}$, is defined as

$$r_t^{house\ urban} = r_t^{housing\ index} + \varepsilon_t - \varepsilon_{t-1} \qquad (6)$$

where $\varepsilon_t - \varepsilon_{t-1}$ is the error term for an individual house.

To clarify the differences of the housing assets, the returns to the urban house, the non-urban house and the housing index are based on data from Stockholm, mid-Norrland and the whole of Sweden

[6] The fact that we impose the one-in-one-hundred rule for both the urban and the non-urban can be questioned. To our knowledge there is no evidence of differences in the ratio of service-flow to house value with respect to geographical location. We thus assume that the ratio is not especially dependent on geographical location but rather on all house characteristics, geographical location being one of them.

respectively. Furthermore, the return variances for the urban house and the non-urban house include the idiosyncratic risk from owning an individual house whereas the return variance for the housing index only includes market risk.

All variables are transformed into logarithmic returns and deflated using Consumer Price Index. The time series for the Consumer Price Index is obtained from DataStream.

3.2 Portfolio Optimization

Time series for all the variables are now in place and can be put into the mean-variance optimization of the portfolios. The optimization model follows the Markowitz framework and models the rate of return on assets as random variables. The optimization is done by choosing the weights of each asset in the portfolio optimally as to minimize the portfolio volatility at any given rate of return on the portfolio.

Let r_i be the real rate of return on asset i, for

$$i = general\ stocks,\ real\ estate\ stocks,\ housing\ index,\ urban\ house,$$

$$non - urban\ house,\ T - bills,\ government\ bonds$$

Define the covariance matrix as $V = cov(z)$, where z is a random variable

$$z = \begin{pmatrix} r_{general\ stocks} \\ r_{real\ estate\ stocks} \\ \vdots \\ r_{government\ bonds} \end{pmatrix},$$

$\mu_i = E(r_i)$ and

$$m = (\mu_{general\ stocks}, \mu_{real\ estate\ stocks}, \dots, \mu_{government\ bonds})^T.$$

If

$$\omega = (\omega_{general\ stocks}, \omega_{real\ estate\ stocks}, \dots, \omega_{government\ bonds})^T$$

is the weights associated with each asset in the portfolio then the real rate of return on the portfolio $r_p = \sum_{i=1}^{n} r_i \omega_i$ is also a random variable with mean $m^T\omega$ and variance $\omega^T V \omega$. To preserve the budget constraint of the portfolio, the sum of the wealth allocation is set to 1, $\sum_{i=1}^{n} \omega = 1$. The optimization problem is as follows

Minimize $\quad \sigma_p^2 = \omega^T V \omega$

Subject to $\quad m^T\omega$, and $\sum_{i=1}^{n} \omega = 1$

We will optimize a set of different portfolios to be able to draw relevant conclusions. The portfolios will have a different number of available assets and a set of restrictions for each of these assets. All portfolios that include the individual house as an asset will be optimized in two dimensions, urban and non-urban. The mean-variance optimization does not take tax considerations into account.

To evaluate the assets from a pure investment perspective we will optimize three unrestricted benchmark portfolios. The first portfolio consists of the four financial assets available to the household; in the second portfolio the individual house is added; and in the third portfolio the tradable housing index is also available. The assets in these portfolios are subject to the constraints in table 2 below.

Constraints for Unrestricted Portfolios						
Portfolio	general stocks	housing index	house	real estate stocks	T-bills	government bonds
4 Unrestricted Assets						
Maximum allocation	500%	0%	0%	500%	500%	500%
Minimum allocation	-500%	0%	0%	-500%	-500%	-500%
4 unrestricted assets + House						
Maximum allocation	500%	0%	400%	500%	500%	500%
Minimum allocation	-500%	0%	0%	-500%	-500%	-500%
5 unrestricted assets + House						
Maximum allocation	500%	500%	400%	500%	500%	500%
Minimum allocation	-500%	-500%	0%	-500%	-500%	-500%

Table 2

Labelling these portfolios as unrestricted is of course arbitrary since they in fact are restricted. The constraints, of plus minus 500% for all assets except the house and 0%-400% for the house, are questionable. However, we focus on the lower end of the volatility and return spectra and therefore the constraints above do not affect the main implications of our results.

To assess the effect of different households' consumption preferences in terms of risk and return, we optimize four restricted portfolios with exogenously amounts of wealth allocated to housing. We also optimize a restricted benchmark portfolio where wealth allocation to the individual house is endogenously set. The portfolios are subject to the constraints shown in table 3 below.

Constraints for Restricted Portfolios						
Portfolio	general stocks	housing index	house	real estate stocks	T-bills	government bonds
Household Restricted						
Maximum allocation	500%	0%	x	500%	500%	500%
Minimum allocation	0%	0%	x	0%	-500%	-500%
Where House is exogenously given for each type of household except for the benchmark portfolio:						
Benchmark			0%-400%			
Renter			0%			
Wealthy Household			100%			
Average Household			200%			
Poor Household			400%			

Table 3

The non-negativity restrictions set forth on general and real estate stocks are due to the fact that the common household has limited possibility to short financial assets. The exogenously given level of wealth allocated to the individual house is chosen for the sake of comparison with Englund et al. (2002).

To determine the potential risk reduction through hedging, we optimize three portfolios with three sets of restrictions for each of the households with different consumption preferences. The restricted portfolio is as described above; in the semi-restricted the non-negativity constraints on general and real estate stocks are lifted; and in the unrestricted portfolios the tradable housing index is available. This amounts to 15 portfolios with the restrictions shown in table 4 below.

Constraints for Hedging Portfolios						
Portfolio	general stocks	housing index	house	real estate stocks	T-bills	government bonds
Household Restricted						
Maximum allocation	500%	0%	x	500%	500%	500%
Minimum allocation	0%	0%	x	0%	-500%	-500%
Household Semi-Restricted						
Maximum allocation	500%	0%	x	500%	500%	500%
Minimum allocation	-500%	0%	x	-500%	-500%	-500%
Household unrestricted						
Maximum allocation	500%	500%	x	500%	500%	500%
Minimum allocation	-500%	-500%	x	-500%	-500%	-500%
Where House is exogenously given for each type of household except for the benchmark portfolio:						
Benchmark			0%-400%			
Renter			0%			
Wealthy Household			100%			
Average Household			200%			
Poor Household			400%			

Table 4

4. Asset Return Patterns

The legitimacy of any result is dependent on the estimations underlying the results and hence also dependent on the data whereupon these estimations are drawn. To be able to evaluate the asset return patterns in our study we start by looking at the time period underlying the estimations, see figures 1 and 2. Our time period starts off in the first quarter 1986 with the Swedish economy in the middle of an economic boom. In the beginning of the nineties the economy went through a severe recession following the financial crisis. Throughout the later nineties the economy grew considerably only to fall into another recession subsequent to the IT-crash. Lastly, from 2003 to the end of our time period the economy has been characterized by stable growth. To summarize our time period, it starts off in the middle of a boom and ends in the middle of a boom, with two recessions and one boom in between. Our time period thus contains two full business cycles in the sense that the time period begins two years into a boom and ends two years into a boom.

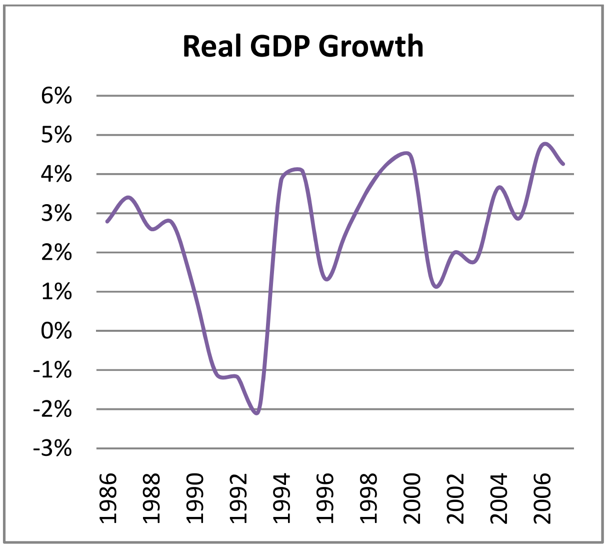

Figure 1

Source: DataStream

Figure 2

Source: DataStream

Our method of mean-variance optimization is entirely based on mean returns, variances and covariances and is therefore especially sensitive to estimation errors. Estimations of asset returns are sensitive to the choice of time period. However, estimations of return variances and covariances are relatively accurate under most time periods. The difficulty in choosing time period is largely obtaining a time period which yields a correctly estimated return, whereas as long as there is a sufficiently large number of observations the return variances will be reasonably well estimated. For longer time periods, estimating the return is not an issue. For shorter time periods however, there will be a bias in the estimated return if the time period is a period of over- or underperformance of the asset due to period-specific shocks and business cycle fluctuations.

In order to investigate the accuracy of our estimations we will look at rolling averages to see what implications different time periods have on the estimation figures, see figure 3. The table shows the quarterly real return mean for a 10 year time period ending with the indicated quarter. The estimated returns are quite unstable over time. Looking at the estimated quarterly real return for the real estate stocks for a ten year period ending with the fourth quarter 1999, we see that the estimation indicates a quarterly real return rate of -0.4%, whereas for the period ending the first quarter 2003 the estimated quarterly real return is 4.2%. Hence the impact of the choice of period is quite substantial.

The estimated quarterly real returns for the ten year periods show one general trend. From the ten year period ending with the last quarter 1999 there is a trend of increasing real quarterly returns for later periods. This trend is valid for all real estate assets and the trend is accentuated once the crash period of 1991-1993 falls out of the period.

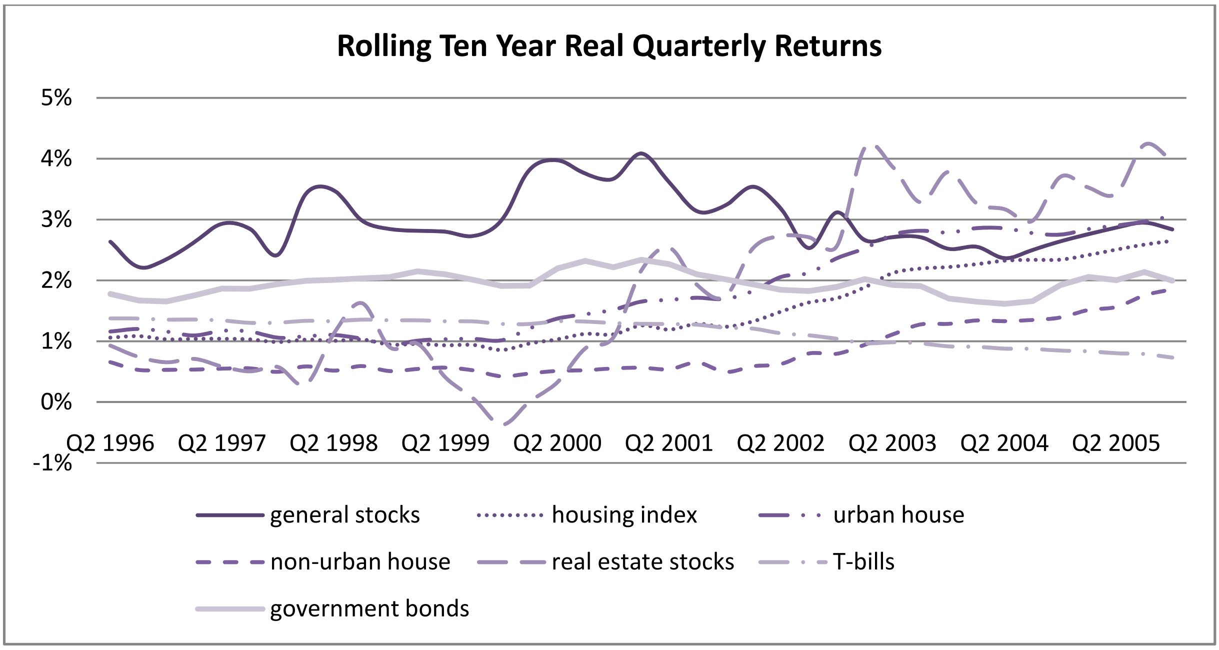

Figure 3

A similar graph over rolling ten year return volatilities shows that estimations of volatilities is less sensitive to the choice of period, see figure 4. We observe a sharp decline in volatilities for the period first quarter 2003 and later periods. This is clearly the effect of the financial and real estate crisis in 1991-1993. Again the assets mostly affected are the real estate stocks and to some extent the housing index which show a substantially lower return volatility. The government bonds also show lower estimated return volatilities for later time periods, most likely due to the abolishment of the accommodation policy and the introduction of inflation targeting and the independency of the central bank.

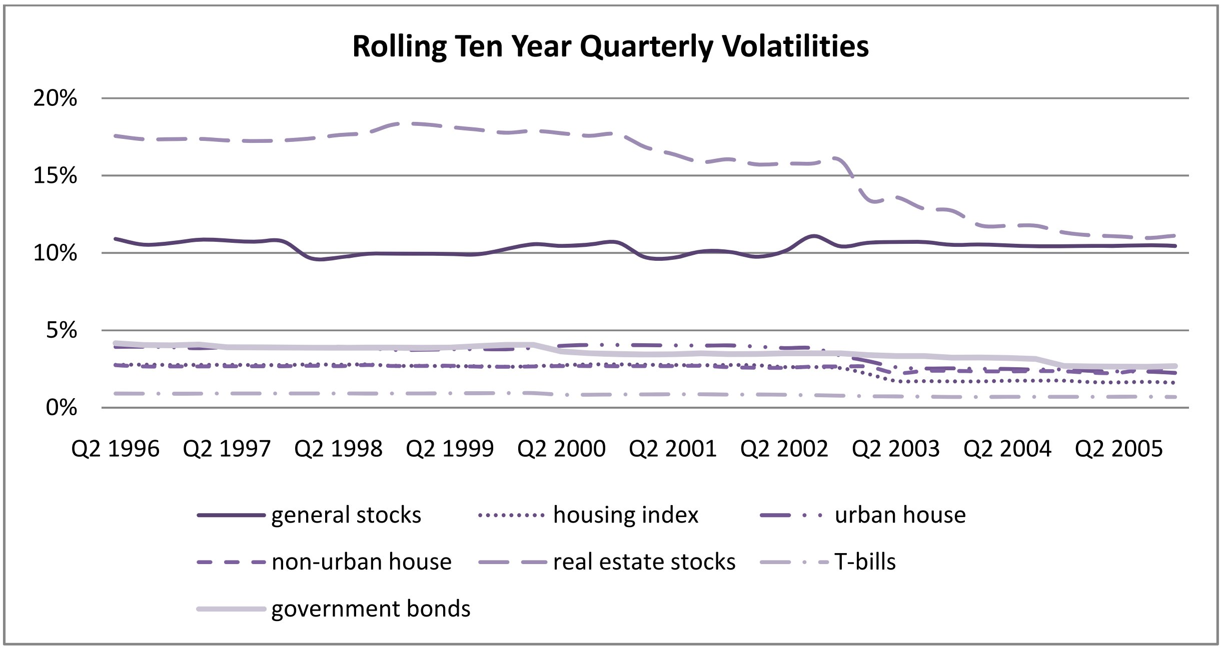

Figure 4

To conclude the discussion of the underlying time period we find it to be satisfactory. It consists of two full business cycles, starting two years into the boom of the eighties and ending two years into the boom of the new millennium. The time period stretches over a severe shock which has some implications on estimations. Demand and supply shocks are however an integral part of the economy and deliberately choosing a period without any shocks should yield distorted estimations. Hence our choice of time period should yield estimated returns, volatilities and covariances of acceptable accuracy.

Above we have discussed the sensitiveness of our estimation figures in terms of real quarterly returns and variances to the choice of time period. To see the full implications of different estimation figures one would optimally also investigate how covariances are affected, and in turn use the estimation figures in the mean-variance framework to see what results would be generated. Even though this would be desirable, it is very time-consuming and is therefore out of scope for this master thesis.

When looking at asset return patterns it would be suitable to have a long time horizon since most households consider their house investment to be long-term. Our time time-period of 20 years is unfortunately too short to attain reliable long-term expected returns, variances and covariances. Other papers on the topic, such as Englund et al. (2002), have circumvented this problem by estimating a vector autoregression (VAR) model. VAR models are rather complex and therefore out of scope for this paper. The fact that we analyze the investment decision at a quarterly investment horizon then poses a problem. Apart from houses, most assets are not affected by the holding period since they are well described by a random walk and thus the single and multi-period investment decision is very much the same, since the single period variances and covariances are just multiplied with the number of periods. Consequently, in our analysis the only asset significantly affected by the short investment horizon is the house.

Housing as an asset suffers from a twofold problem in this context. Firstly, housing is a highly heterogeneous good and the housing market has high transaction costs and heterogeneous conditions of transaction. This implies that the return on investing in an individual house has an idiosyncratic component. Secondly, housing index returns generally show a significant positive autocorrelation, see Englund and Ioannides (1996) for evidence on positive autocorrelation in housing prices. Goetzmann (1993) found, when investigating the impact of the holding problem in this context, that the two phenomena have offsetting effects. That is, the increase in volatility of the index return due to the positive autocorrelation is offset by a decrease in the idiosyncratic component of the return on an individual house. Goetzmann (1993) thus implies that these are two offsetting effects and that the total effect should be limited. Looking at other papers that have estimated a VAR model to analyze investments over longer horizons, they find the return variance on the individual house to be relatively stable for different time horizons compared to the other assets' return variances, see Englund et al. (2002). The implication for this thesis is that while our results are only valid for the quarterly time horizon the results are indicative for longer horizons as well.

We will give a brief run through of the performance of the house as an asset, since its position in a portfolio is a core matter of this paper. The crisis in 1991-1993 clearly had a negative impact on the housing market. However the recession following the millennium shift did not severely affect housing prices. The price development of the urban- and the non-urban area show the same pattern during the time period, see figure 5. However, the urban area constantly outperforms the non-urban area throughout the period. Noteworthy is also that the only period with declining house prices is the recession in the early nineties.

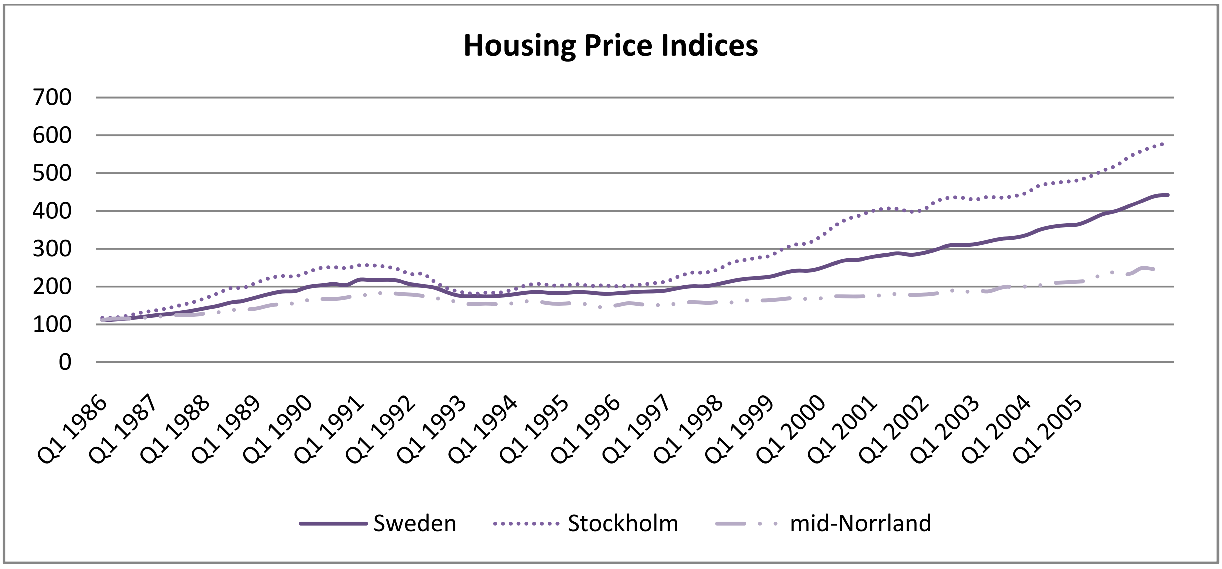

Figure 5

Now we turn to the estimated asset return patterns used in the mean-variance optimization, see table 4 and 5. Firstly we turn to the interest bearing instruments; the T-bills generate the lowest return of the two, but are also the least volatile. The government bonds are surprisingly correlated with general stocks and real estate stocks, but show very low correlation with the housing index and the urban and non-urban houses. The T-bills show low correlation with general and real estate stocks and negative correlation with the urban house and the housing index.

Means and Standard Deviations of Real Quarterly Asset Returns	general stocks	housing index	urban house	non-urban house	real estate stocks	T-bills	government bonds
Expected Return	0.0268	0.0190	0.0216	0.0123	0.0249	0.0102	0.0175
Standard Deviation	0.1077	0.0241	0.1055	0.1211	0.1494	0.0086	0.0344

Table 4

Correlation Coefficients Among Real Quarterly Asset Returns	general stocks	housing index	urban house	non-urban house	real estate stocks	T-bills	government bonds
general stocks	1.0000						
housing index	0.1394	1.0000					
urban house	0.2174	0.8536	1.0000				
non-urban house	0.0552	0.6802	0.5117	1.0000			
real estate stocks	0.1916	0.3288	0.2943	0.2115	1.0000		
T-bills	0.0854	-0.2897	-0.2762	-0.0472	-0.0280	1.0000	
government bonds	0.2531	-0.0285	-0.0280	-0.0145	0.2483	0.3855	1.0000

Table 5

Stocks in general generate the highest return, with the general stocks yielding a slightly higher expected return than the real estate stocks at a lower volatility. The general stocks thus dominate the real estate stocks in a mean-variance optimization. Reasonably, the high volatility of the real estate stocks is due to the real estate price crash of 1991-1993. Englund et al. (2002), which have a time period from 1981-1993 where the crash period constitutes a larger share of the time period, have almost double the return variance for their real estate stocks. The correlation between general and real estate stocks is somewhat low compared to figures in other papers, see Englund et al. (2002) and Iacoviello & Ortalo-Magné (2003). A likely reason is that the real estate index we use consists entirely of real estate stocks and no construction stocks. The real estate stocks is in fact more correlated to the housing index than to the general stocks, which appear plausible since real estate holding companies' performance logically is very dependent on the price development of real estate.

Housing generates a return that is in between the return of the interest bearing instruments and the general and real estate stocks. However, the individual house in the non-urban area is outperformed by the government bonds. Urban houses generate the highest return and non-urban houses generate the lowest return of the housing instruments. When looking at the housing index the scope of diversification is apparent, since the housing index almost generates equal return as the urban house but at a significantly lower volatility. Correlations among the housing instruments are high, with the urban house more correlated to the housing index than the non-urban house. The urban house is positively correlated with general stocks. The non-urban house on the contrary shows little correlation with general stocks. Speculating, the most likely answer is that the household income in urban areas is more constituent of capital returns. The housing index and the urban house also demonstrate negative correlations with the T-bill, whereas the non-urban house is virtually uncorrelated with the T-bill. An interpretation is that urban households use a higher degree of leverage when financing their houses.

Overall our estimated values seem reasonable and are in line with other papers. Compared to Englund et al. (2002), which is the closest benchmark, our estimated returns are higher for housing assets but lower for general and real estate stocks and interest bearing assets. Our estimated return volatilities are lower for all assets and our correlations are in line with Englund et al. (2002) to the extent that they have similar signs and we find the same assets to be uncorrelated. The exception being that we find significant negative correlation between T-bills and housing assets, whereas Englund et al. (2002) finds no correlation. However Englund et al. (2002) investigates longer investment horizons. For investment horizons longer than one quarter Englund et al. (2002) finds negative correlation between these assets in the same range as we do.

5. Results

The return patterns discussed above are used to construct mean-variance efficient portfolios. The mean-variance optimization is performed in three different scenarios. We start off by looking at unrestricted benchmark portfolios not affected by housing consumption preferences. Secondly, we look at restricted portfolios distorted by consumption preferences. Finally, we look at the portfolios suffering from the consumption distortion with access to hedging tools in order to determine the potential risk reduction for households with different consumption preferences. In other words, in the first scenario we investigate the financial assets from a pure investment standpoint. In the second scenario we examine the costs in terms of risk associated with owning an individual house and in the third scenario we examine if this risk can be reduced through hedging. Throughout, we have done the analysis in two dimensions, urban and non-urban. We have concentrated most of the analysis to the lower return levels and the lower associated return volatilities, partly since this is the acceptable levels of return volatility for the household portfolio return and partly due to the tendency for estimation errors to be greater at the higher volatilities of the mean-variance frontier, see Jorion (1991).

5.1 Unrestricted Portfolios

The unrestricted portfolios are constructed solely for evaluating the assets from an investment standpoint. The investment in housing is purely determined by mean-variance optimization. The unrestricted portfolios will serve as benchmarks and show the inherent portfolio compositions based on the return patterns of our data. We will look at five different unrestricted portfolios.

The first unrestricted portfolio investigated consists of only four financial assets, general stocks, real estate stocks, T-bills and government bonds. Constraints are set at plus and minus 500% for all financial assets. We can observe that in the minimum variance portfolio, no capital is allocated to the assets general stocks, real estate stocks and government bonds, and the full household wealth is invested in T-bills. As the household desires a higher expected return, at the expense of higher risk, the long position in T-bills is decreased and initially substituted by a long position in government bonds. At 2% expected return the household starts to borrow by shorting T-bills and continues to invest in government bonds. At higher volatilities when the portfolio has an expected return of 6%, the position in government bonds is decreased and larger positions are taken mostly in general stocks and to a lesser extent in real estate stocks.

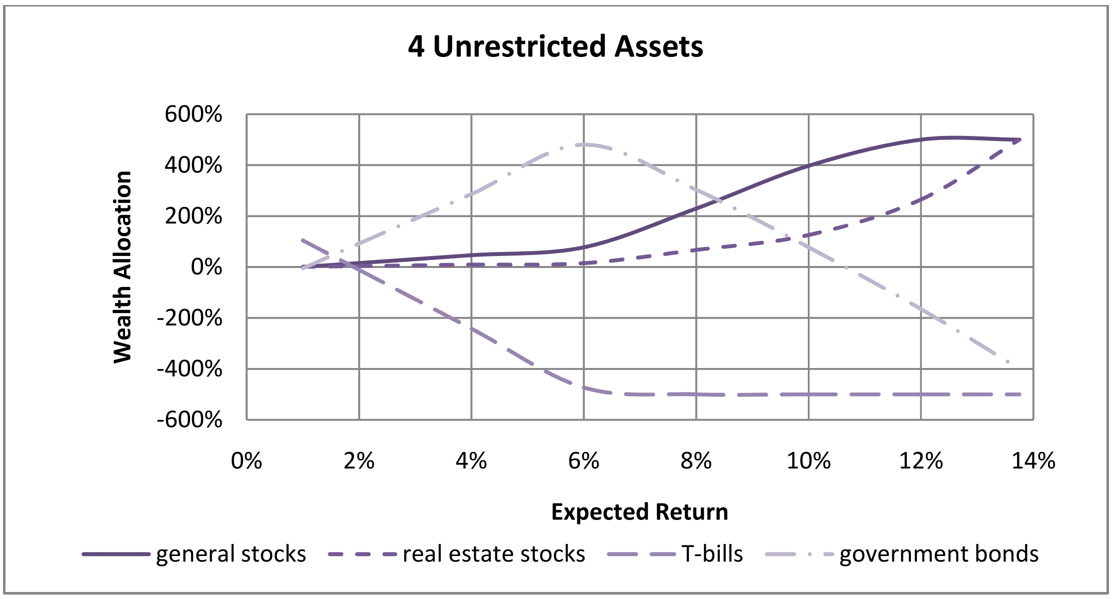

Figure 6

For the urban and non-urban areas we study two different unrestricted portfolios respectively. The first consists of the above four financial assets and an individual house and in the second one we also add the housing index. In these portfolios the individual house is seen purely as a financial asset and the household can thus invest in the house in any desired proportion. Constraints are set at plus and minus 500% for all assets except the individual house, which cannot be sold short and maximum position is set to 400%.

The unrestricted portfolio with four financial assets and an individual house in an urban area shows the same general composition pattern as the above portfolio with purely financial assets. As expected return and volatility rise the investment in the individual house is gradually increased whereas real estate and general stocks receive less capital allocation. The maximum share of investment in the individual house is at 97% volatility when the investment in housing is approximately 150% of net wealth.

The non-urban unrestricted portfolio with four financial assets and an individual house is almost exactly the same as the unrestricted portfolio with four financial assets. This is due to the fact that the individual house in the non-urban region is very unattractive as an investment asset. At mid range expected returns and volatilities there is a small investment in the individual house, however the wealth allocation to the individual house peaks at 7%. From a pure investment standpoint the urban house is an attractive asset for the household whereas the non-urban house is not. The urban house is not a dominating asset but it is sufficiently attractive to gain capital allocation even at low levels of expected returns and volatilities. Thus, it is even attractive for risk averse households to gain exposure in real estate.

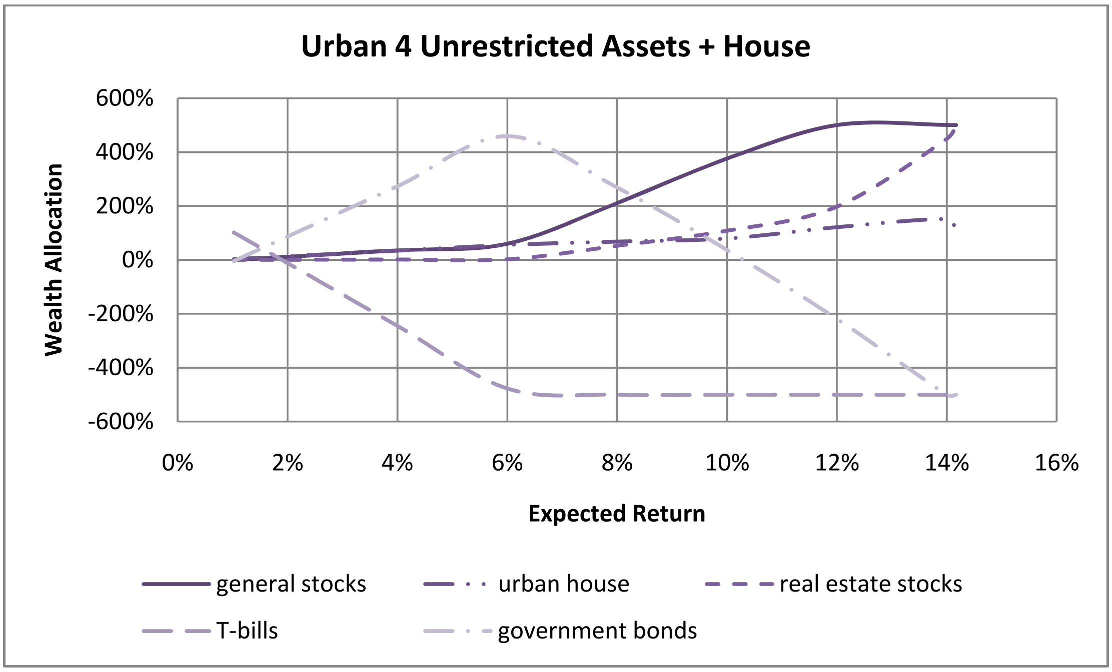

Figure 7

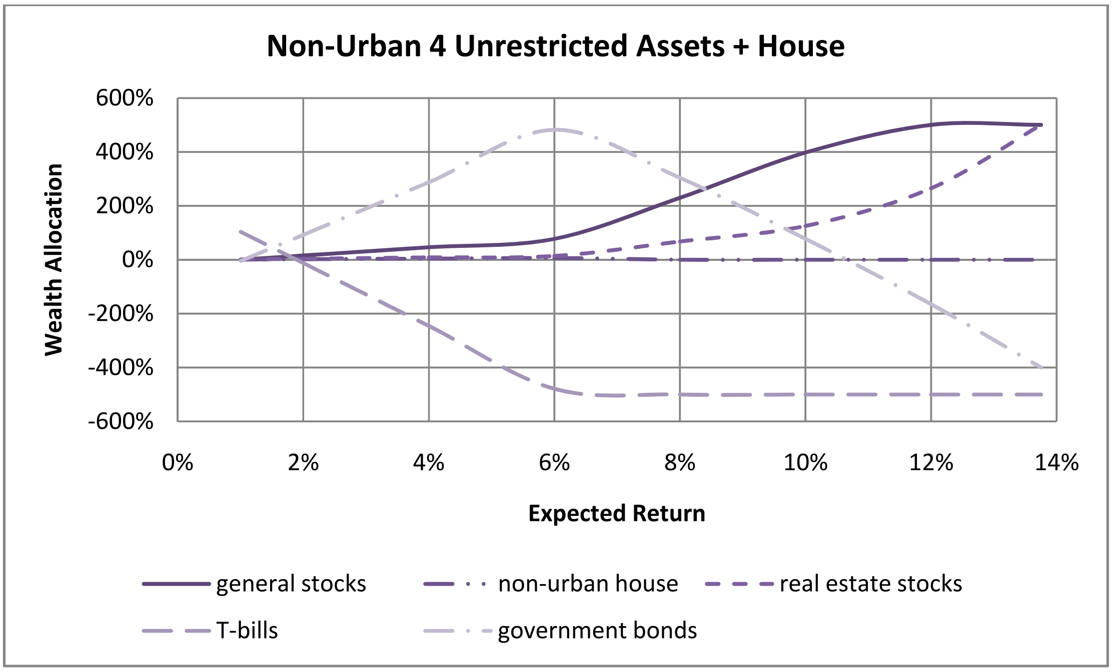

Figure 8

When introducing the housing index as a tradable asset the capital allocation changes. The housing index reduces the incentives to invest in the individual house also for the urban region. The portfolio for both the urban and non-urban area thus behaves in the same manner except for very high volatilities, when the urban household takes large long positions in the individual house. The minimum variance portfolio, for both urban and non-urban households, now consists of mainly T-bills, like in the purely financial asset portfolio, but also an 18.2% share of the housing index. The minimum variance unrestricted portfolio is thus marginally improved when introducing the housing index. The expected return is increased with 0.13 percentage points and the portfolio volatility is decreased with 0.1 percentage points. As expected return and volatility increases, the investment in the housing index is steadily increased. Instead the long investment in government bonds is lowered and earlier reversed than in the scenario without the housing index.

In the urban portfolio the individual house becomes less attractive as an investment asset when the housing index is an available instrument. At high expected returns and volatilities investment rises quickly in the individual house and logically we see a sharp decline in the investment in the housing index. The housing index is only shorted at very high volatilities when the investment in the individual house is high. The long position in government bonds is smaller and reversed earlier when the housing index is available.

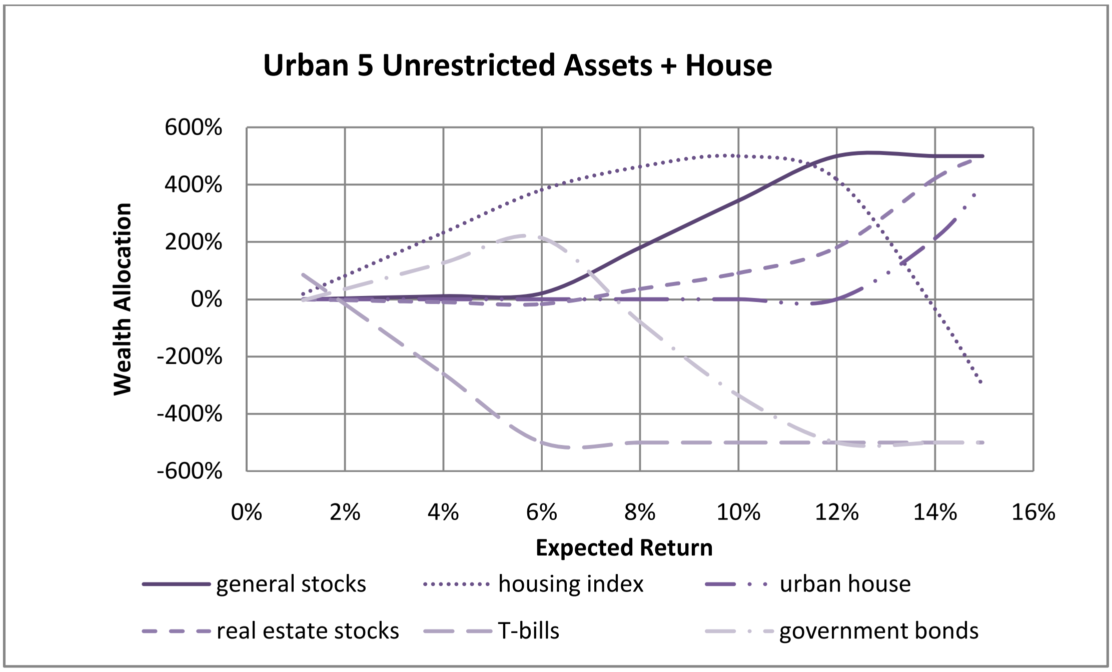

Figure 9

For the non-urban portfolio the individual house becomes completely uninteresting and never receives any capital allocation. The housing index is however used and the same pattern emerges as for the urban region with the exception that short positions in the housing index are not present even at very high expected returns and volatilities.

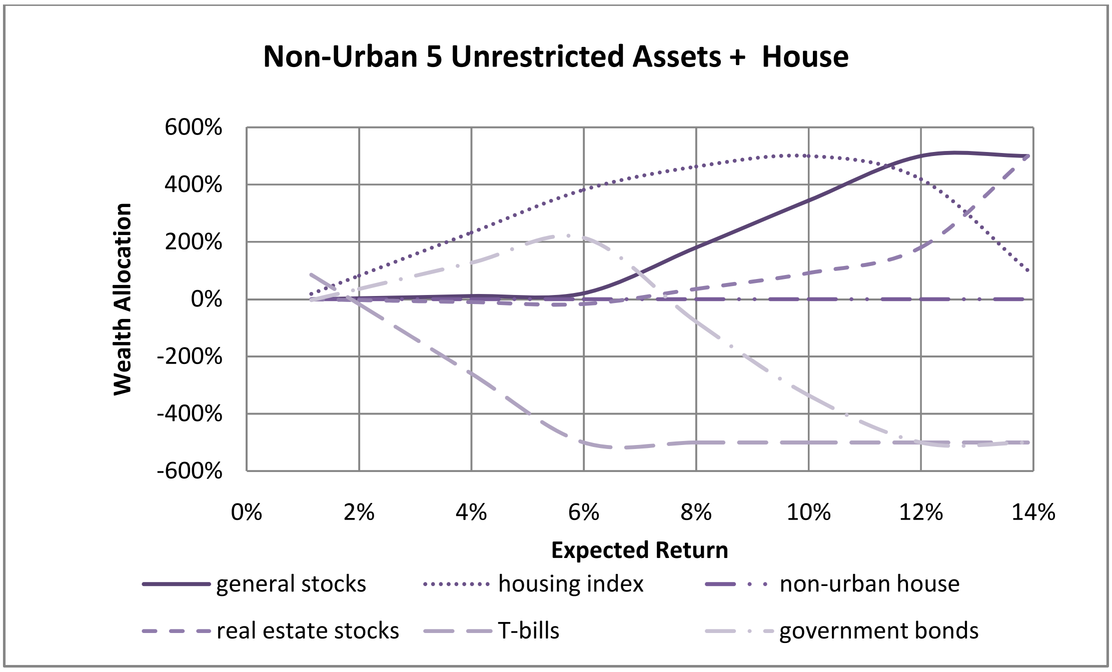

Figure 10

To conclude, we find that the individual house is dependent on location when it is evaluated as an investment asset. For the urban region we confirm that a low fraction of wealth is allocated to housing in line with earlier papers' findings of optimal levels of housing investments. However, we find the non-urban house to be a poor investment. The housing index generally receives extensive capital allocation. It does not only replace the individual house but also general stocks and government bonds at lower volatilities. The housing index thus occurs to be the most attractive asset from a pure investment viewpoint and thus implying that the market should show interest on the buy-side in a tradable housing price index.

5.2 Consumption-Distorted Portfolios

Reasonably a typical household rather considers their house as accommodation than a financial investment. In other words, a household do not make their housing consumption choice entirely from an investment perspective. Therefore we will investigate mean-variance optimized portfolios with the consumption choice of housing exogenously determined. To be more precise, the portfolios will be mean-variance optimized under the condition that a certain amount of wealth will be invested in housing. We do this in order to determine how much the unrestricted mean-variance optimized portfolio deteriorates from imposing housing consumption restrictions. This is a way of determining the "costs" in terms of risk and return on owning your home. For the sake of comparison with Englund et al. (2002), we look at four different household consumption classes ranging from "renter" to "poor". We assume the "renter" invests zero percent of net wealth in housing. The "wealthy" household invests 100 percent of net wealth in housing, the "average" household 200 percent and the "poor" household 400 percent. Please note that the actual terms renter, average, poor and wealthy do not indicate income classes, rather they indicate how much of household wealth is allocated to housing. The restricted portfolios are thus constrained to consumption class when it comes to housing investment. Furthermore, short selling of general stocks and real estate stocks is not allowed and trading in the housing index is not possible.

Looking at the restricted portfolio for the urban area one can observe that the poorer the household, the higher the volatility for the minimum variance portfolio. Noteworthy is that the poorer the household the higher the expected return for the minimum variance portfolio. Yet again, to determine the risk inherent in homeownership, the absolute levels of volatility for the minimum variance portfolios for each urban household are quite revealing. The renter has a minimum variance portfolio of 0.85% volatility whereas the same figure for the poor household is 43.0%. The wealthy and average households show figures in between, with 10.5% and 21.3% respectively.

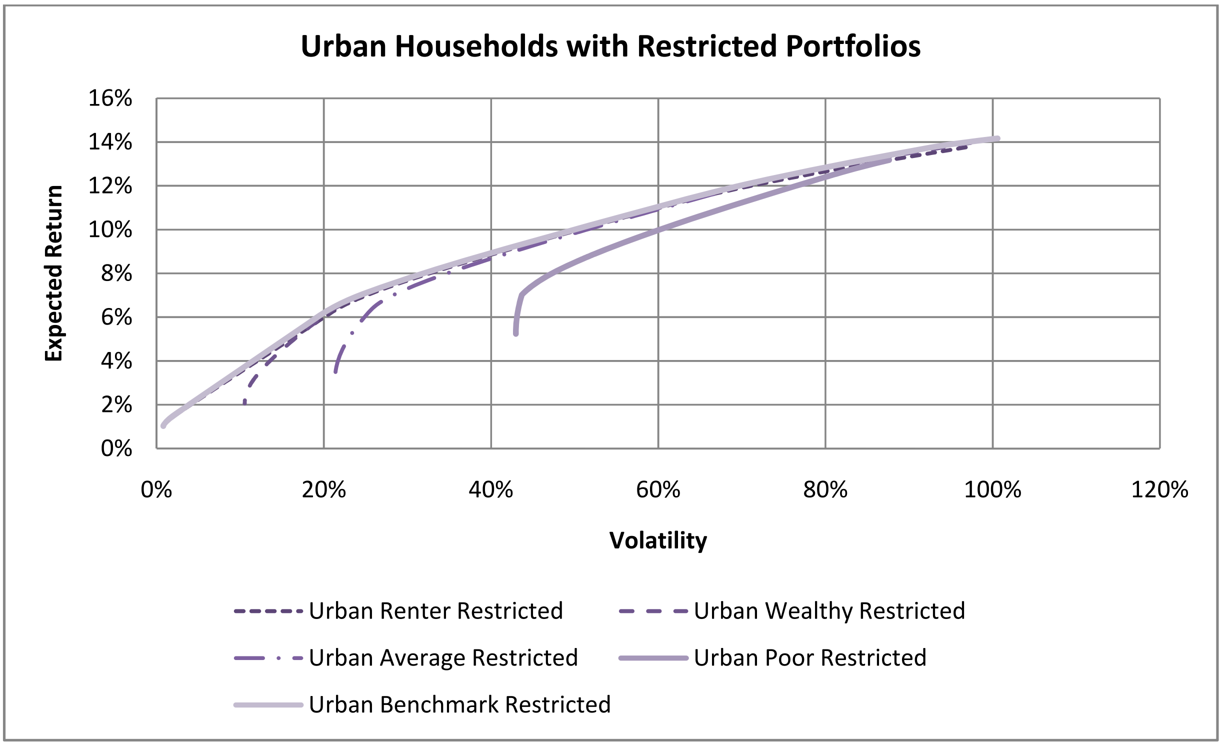

Figure 11

To measure the consumption distortion we compare the expected return on the minimum variance portfolio with the expected return on the benchmark portfolio, where investment in the individual house is endogenous, at the volatility of the minimum variance portfolio. The impact in terms of decreased expected return caused by the consumption distortion at the minimum volatility attainable for the different households are: renter is unchanged, wealthy decreases by 2.1 percentage points from 3.7% to 1.6%, average decreases 3.4 percentage points from 6.5% to 3.1%, and poor decreases 3.8 percentage points from 9.2% to 5.4%. Not surprisingly, we find that the largest distortion afflicts the poor household. This follows logically since the poorer the household the larger the "forced" investment in the individual house that causes the distortion.

One should however bear in mind that the differences in terms of expected return and volatility between the benchmark portfolios and the minimum variance portfolios are the largest for the minimum variance portfolios. At higher levels of expected return and volatility the consumption distortion diminishes. Thus, for the urban households the consumption distortion connected with being a poor household is not a problem if the household desires a high risk level. One should however bear in mind that the span of volatilities available to the poor household ranges from 43.0% to 87.6%, which implicates that already at the minimum variance portfolio level the poor household face a risky subsistence.

Looking at the non-urban region, the location of the household does not affect the renter since the renter portfolio's efficiency frontier is the same in the urban and non-urban region. Similar to the urban region, the poorer households are more affected by the consumption distortion than richer households in the non-urban region. The minimum variance portfolios for the different households show higher volatilities than for the urban portfolios. Wealthy, average and poor households have portfolio volatilities of 12.1%, 24.3% and 48.6% respectively. The loss in terms of expected return caused by the consumption distortion at the minimum volatility attainable for the different households are also higher: wealthy decreases 2.75 percentage points from 4.0% to 1.25%, average decreases 5.4% percentage points from 6.9% to 1.5%, and poor decreases 7.8 percentage points from 9.8% to 2.0%.

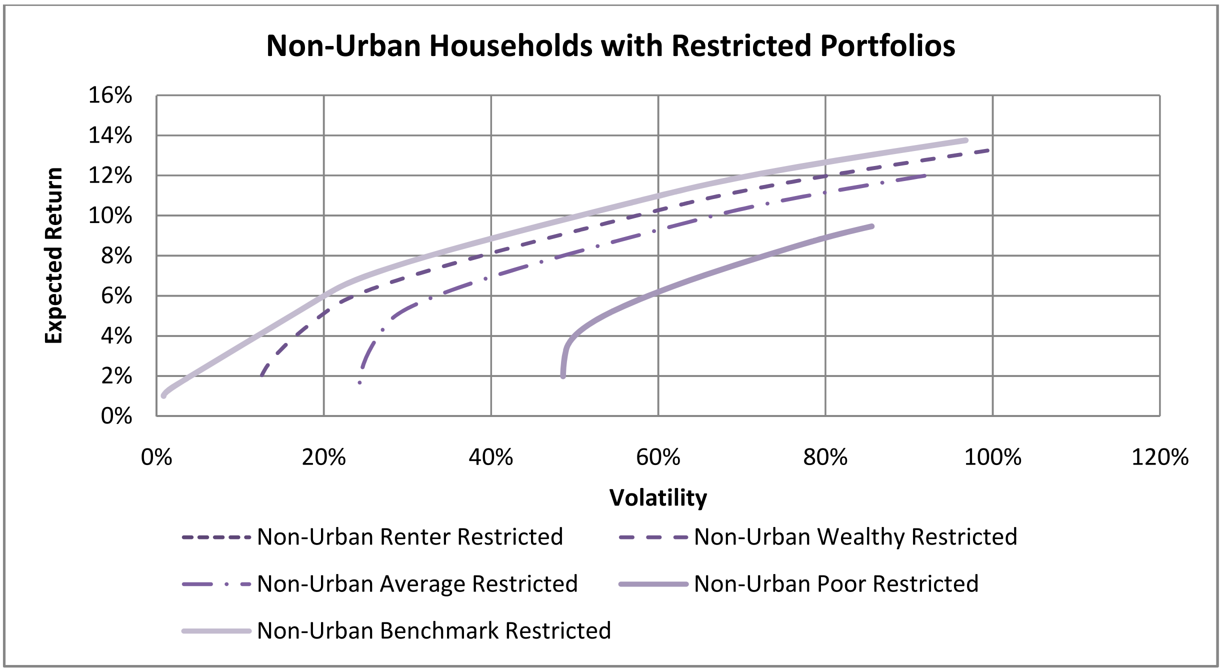

Figure 12

The overall tendency is that overinvestment in housing is associated with quite a substantial amount of extra risk. Furthermore, the non-urban household is worse off, both in terms of the absolute levels of the expected return and volatility, and in terms of the negative effect of the consumption distortion. Furthermore, as shown in the diagram, the consumption distortion in non-urban areas is present over the whole spectra of volatilities and expected returns. The consumption distortion is only slightly reduced and not entirely abolished at higher volatilities, hence the consumption distortion affects all households whether they are risk averse or not. The implication is that overinvestment in housing is a potentially more pressing issue in the non-urban areas. Indebted homeowners in non-urban areas do not only face higher risk due to their overinvestment, compared to their urban counterparts, they also receive a lower expected return.

5.3 Hedging Housing Risk

We now turn to the potential risk reduction that can be achieved through hedging. Firstly, we will look at semi-restricted portfolios where shorting of general and real estate stocks is allowed. When comparing the restricted portfolios with the semi-restricted, one can observe that they do not differ much in terms of expected return and volatility. Looking at wealth allocations, one can however observe that there is a difference. At the low-risk end of the efficiency frontier all households in both regions short both general and real estate stocks to some extent. Since the most visible effect is for the poor household we will show these graphs in the text, and we advise the reader to see the appendix for the graphs of the other households.

The urban household short general and real estate stocks, to hedge the risk inherited in housing, in approximately equal amount. For the minimum variance portfolio the wealthy urban household invest -20.0% of net wealth in general stocks and -20.5% of net wealth in real estate stocks, whereas the poor urban household invest -80.2% of net wealth in general stocks and -84.3% in real estate stocks. The reduction in risk, in comparison with the restricted portfolio, appears as a decrease of 0.7 percentage points from 10.5% to 9.8% for the wealthy urban household and a decrease of 3 percentage points from 43.0% to 40.0% for the poor urban household. For urban areas the shorting of general and real estate stocks provide some hedge against the risk inherent with homeownership, however the cost of this limited hedging ability is high.

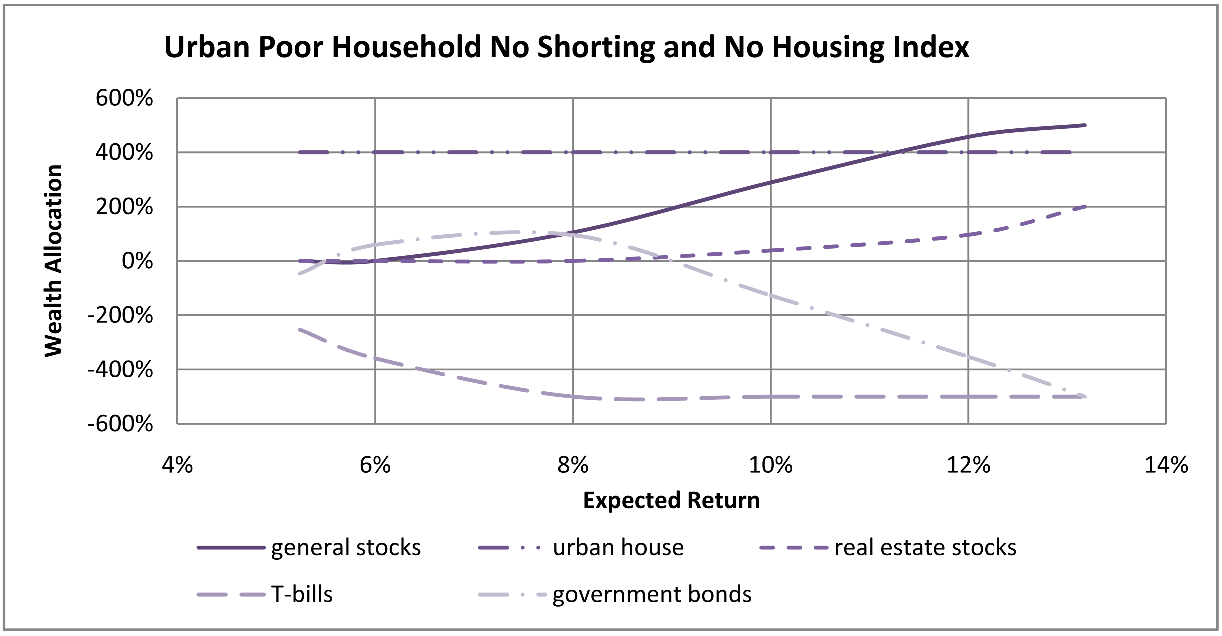

Figure 13

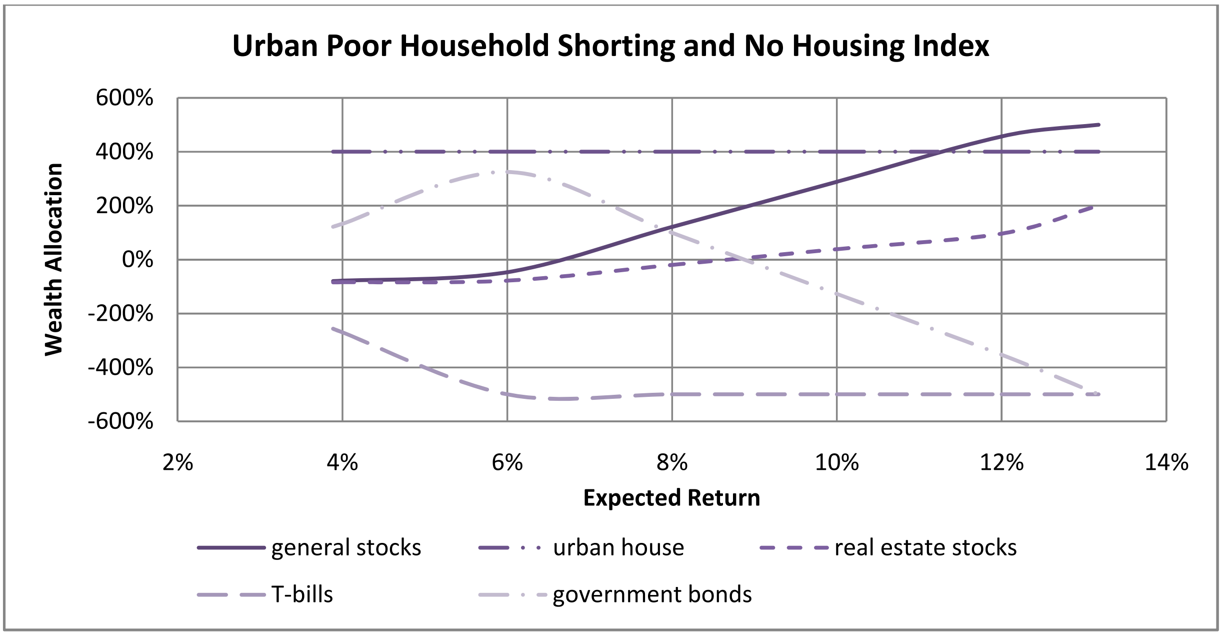

Figure 14

When giving the urban households the ability to trade in the housing index, along with shorting general and real estate stocks, the effect is greater. The housing index is shorted heavily at low volatilities, the wealthy urban household's minimum variance portfolio has a position in the housing index of -303.2% and the figure for the poor household is -500%. Noteworthy is that the poor household has a negative position in the housing index over the whole efficiency frontier, whereas for higher volatilities the wealthy household has a positive position. The possibility to hedge using general and real estate stocks is implemented to a lesser extent when the housing index is introduced. The effect of the housing index as a hedge is quite ample but again costly. The wealthy household can lower their portfolio volatility another 4.0 percentage points down to 5.82% but the cost in terms of expected return is a decrease from 2.06% to -0.73%. The effect on the poor urban household is larger in nominal numbers with a decrease in portfolio volatility of 9.85 percentage points to 30.14%, but again at a cost of a lowered expected return from 5.14% to -0.17%.

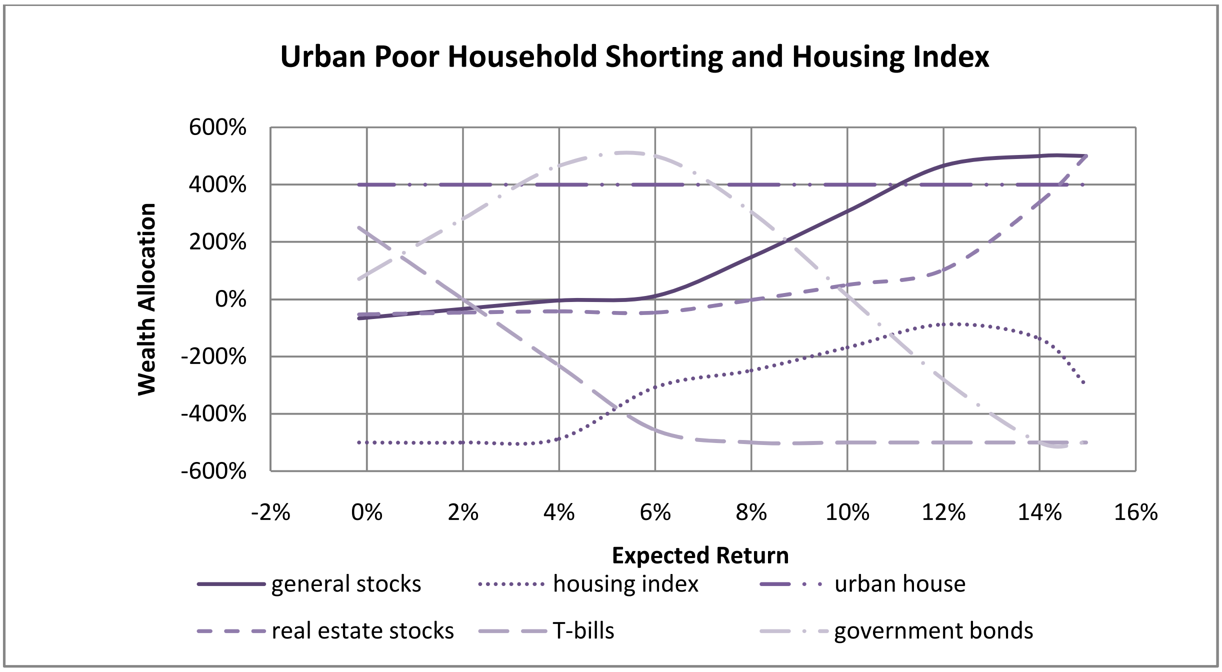

Figure 15

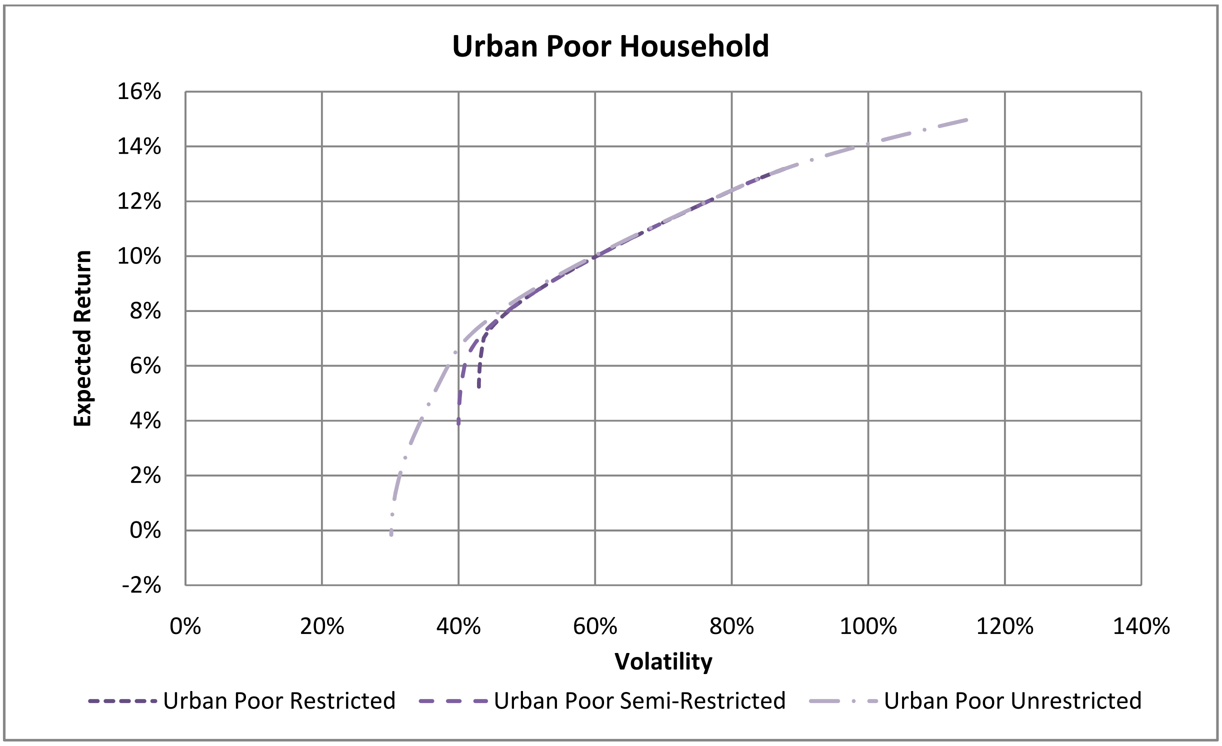

Figure 16

The non-urban household short general stocks to a lesser extent than the urban household, since the correlation between the non-urban house and general stocks is much lower than the correlation between the urban house and general stocks. For the minimum variance portfolios the wealthy non-urban household invests -18.3% in real estate stocks and only -3.6% in general stocks and the poor non-urban household invests -75.3% in real estate stocks and -14.8% in general stocks. Accordingly, the effect of the hedge is also smaller in terms of portfolio volatility; for wealthy non-urban households only -0.3 percentage points from 12.1% to 11.8% and for poor non-urban households -1.3 percentage points from 48.6% to 47.3%. For the non-urban household hedging with general and real estate stocks comes at a high cost in terms of a decrease in expected return and show marginal effects on volatility.

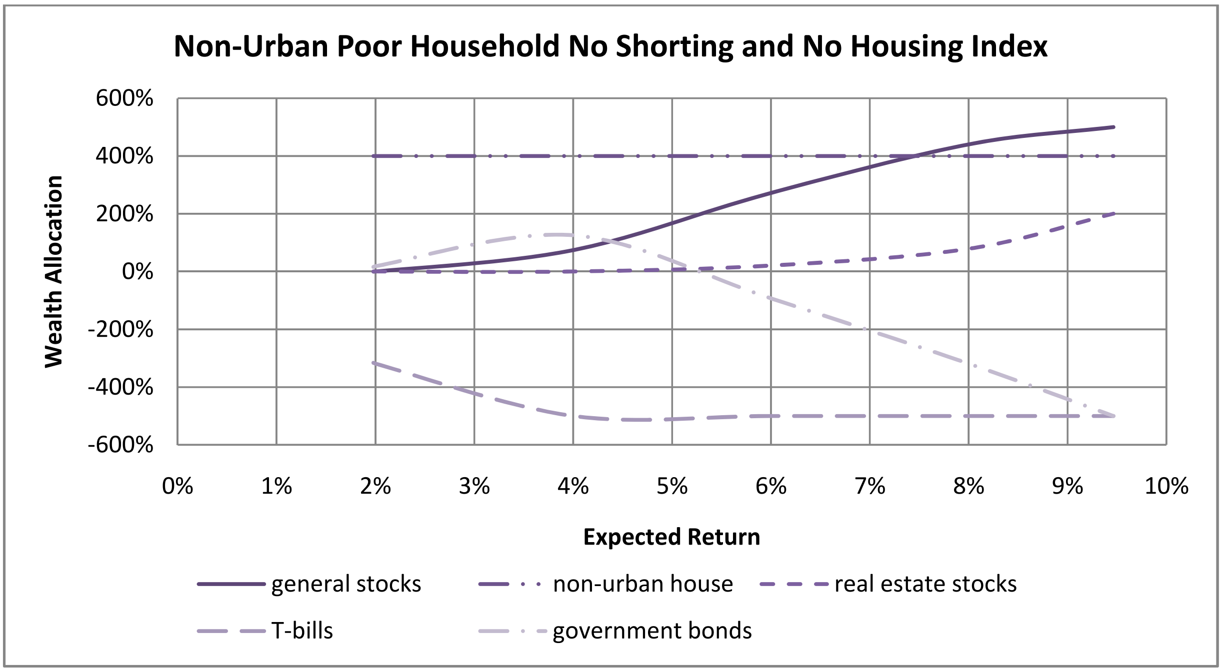

Figure 17

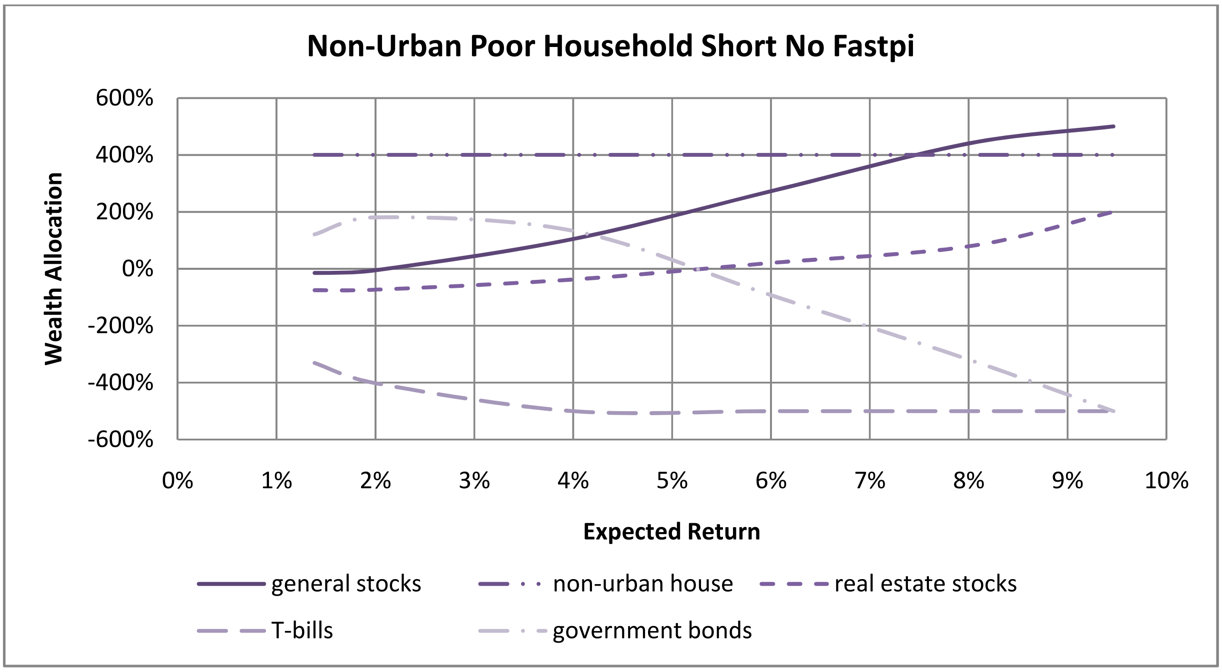

Figure 18

Hedging with general and real estate stocks thus helps the non-urban household to an even lesser extent than the urban household. We now look at the availability of the housing index used as a hedge for the non-urban household. The wealthy non-urban household can lower their portfolio volatility from 11.8% to 9.7% at the cost of a decreased expected return of 1.1% to -1.0%. The poor non-urban household lowers their volatility from 47.3% to 40.8% at the cost of an expected return decrease from 1.4% to -2.7%.

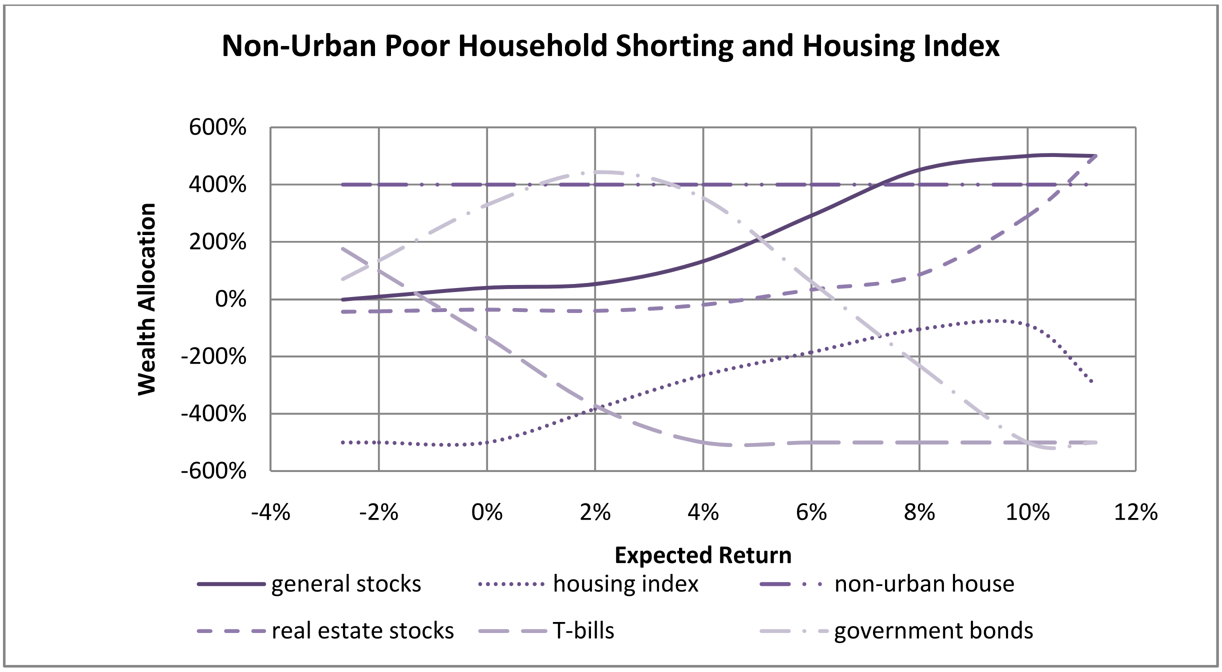

Figure 19

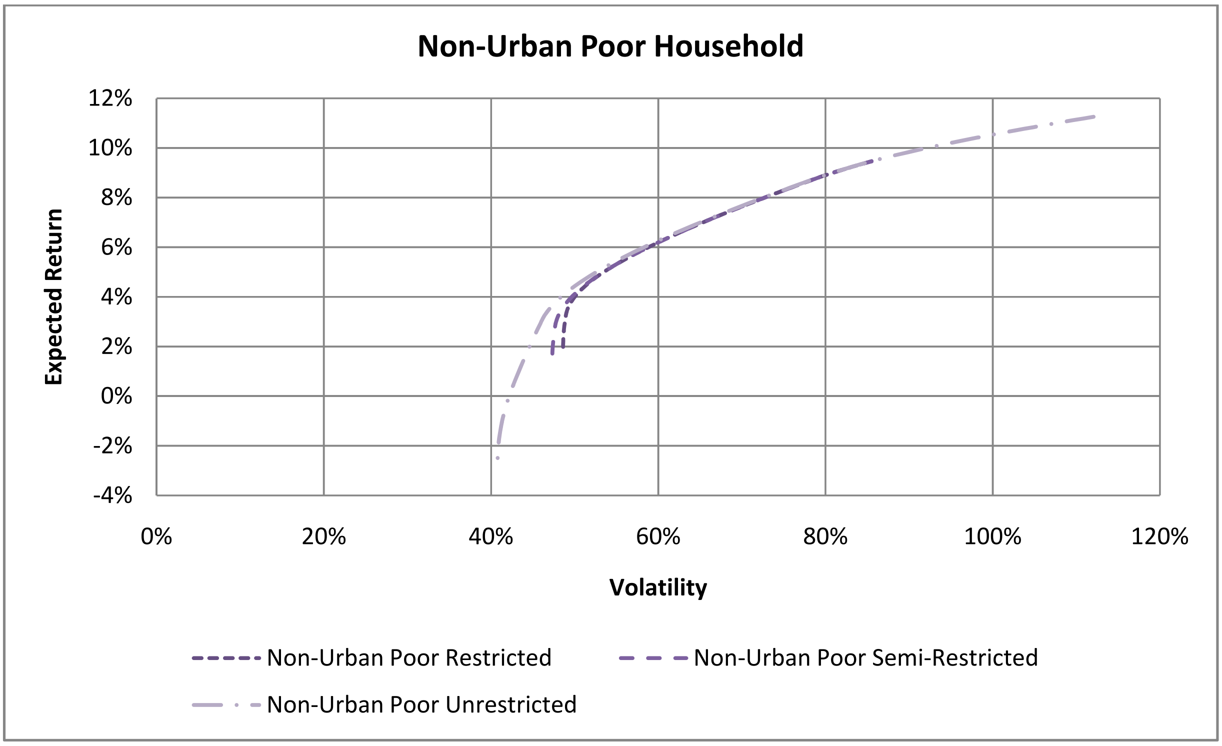

Figure 20

To get the overall effect of introducing the hedging tools one considers the efficiency frontiers for both the urban and the non-urban households. The effect that can be seen is that the availability of hedging tools, that is both the shorting of general and real estate stocks and the tradable housing index, are not shifting the efficiency frontier inwards to any greater extent. Rather, what both the shorting ability and the housing index give the household is an extended efficiency frontier, that is a larger span of wealth allocations yielding a certain expected return and volatility level. This extension of the efficiency frontier is greater the poorer the household. The span of attainable efficient expected return and portfolio volatility levels is increased more for households plagued by consumption distortion. The only efficiency frontier that is shifted is the renter household's, which systematically heightens the renter household's expected return at low and mid range volatilities. The interpretation is that the renter household now gets access to another investment alternative with similar characteristics as housing.

To summarize, we find hedging with general and real estate stocks to be an inadequate tool for households to decrease their risk exposure inherent by homeownership. The ability to short real estate stocks is used when available, but has a limited impact on household portfolio risk. The urban household is slightly better off since it can also hedge with general stocks. The housing index provides a far better hedge for the households, especially the households with large overinvestment in housing. The housing index is shorted heavily for households with large overinvestment in housing, but for low volatilities also for households with smaller over-investment in housing. This indicates that there is a potential sell side for an index of this sort on the market. The scope for lowered volatility is apparent, however the cost for this decrease is high in terms of expected return.

6. Conclusion

This paper analyzes the investment implications of the housing consumption choice in a mean-variance framework using quarterly time series ranging from the first quarter 1986 to the last quarter 2005. Furthermore, this paper assesses the potential benefit from hedging the household's housing investment, firstly with general and real estate stocks and secondly with derivative contracts on a national real estate price index. In addition, this paper investigates the repercussions of house location throughout the analysis. Whereas earlier papers investigating the potential gains of a tradable housing index have used incomparable time series for the assets in the mean-variance optimization, this paper is based on time series incorporating both dividend yield and price appreciation. Our results in this respect shall thus be more accurate.

We find the optimal allocation of wealth to housing for the urban household to be steadily increasing with the desired risk level of the household whereas the non-urban house receives practically no wealth allocation regardless of the household's desired risk level. The urban house thus appears to be an attractive investment alternative whereas the non-urban house seems to be an inferior asset from an investment viewpoint. These results imply that all non-urban households living in owner-occupied houses overinvest in housing. For the urban household the optimal wealth allocation to housing ranges from 3%-151% and does not confirm the observation by Englund et al. (2002), that the optimal investment in housing for short holding periods is practically zero.

The risk that comes with the housing investment is accompanied by high expected return in urban areas. In non-urban areas the overinvestment in housing imposes higher risk for the household without compensating it with a high expected return. To hedge the risk inherent in the individual house with stocks provides a very limited hedge. Urban households can hedge their housing investment slightly better using both general and real estate stocks, whereas non-urban households can only hedge with real estate stocks. We find larger potential gains from a tradable housing price index. Households with consumption preferences causing a severe overinvestment in housing have the most to gain from hedging with a tradable housing price index. However, generally for all households the magnitude of the gains is smaller than in earlier papers. A contributing factor to the lower gains from a tradable housing price index is that we have used a national index to hedge a regional housing investment. Due to lower correlation with the national housing price index, the non-urban household is worse off since the scope for hedging away their housing investment risk is smaller than for urban households. Consequently, the house investment in non-urban areas is not only inferior to the urban house investment but also suffers from limited hedging possibilities.

The results of this paper indicate that many Swedish households would benefit from hedging through a tradable national housing price index. The relatively low correlation with other asset classes also makes real estate attractive for investors. A tradable housing price index would enable investors to gain exposure to real estate without executing actual real estate transactions. This suggests that there is both a buy- and a sell-side present on the Swedish market for a tradable housing price index. Keeping in mind the low liquidity on existing markets offering a tradable housing price index, our suggestion is that future research on this field should be aimed at quantifying the supply and demand for this kind of instrument on the Swedish market.

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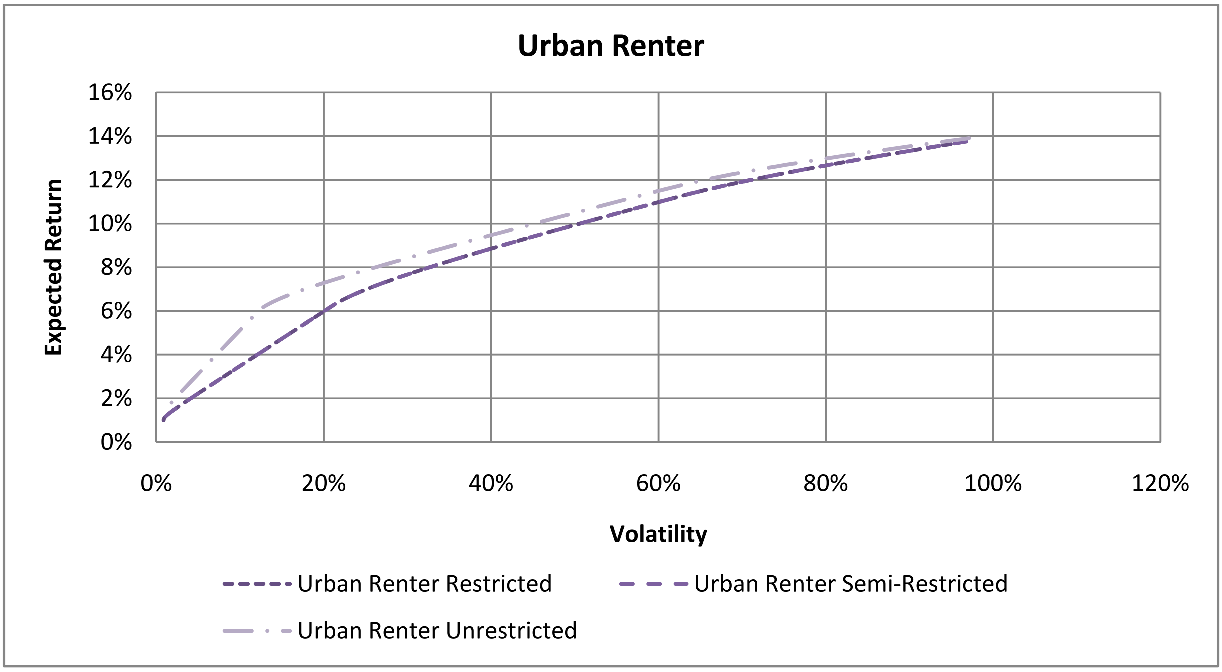
Appendices

Appendix I – Urban Area, Household by Consumption Preference



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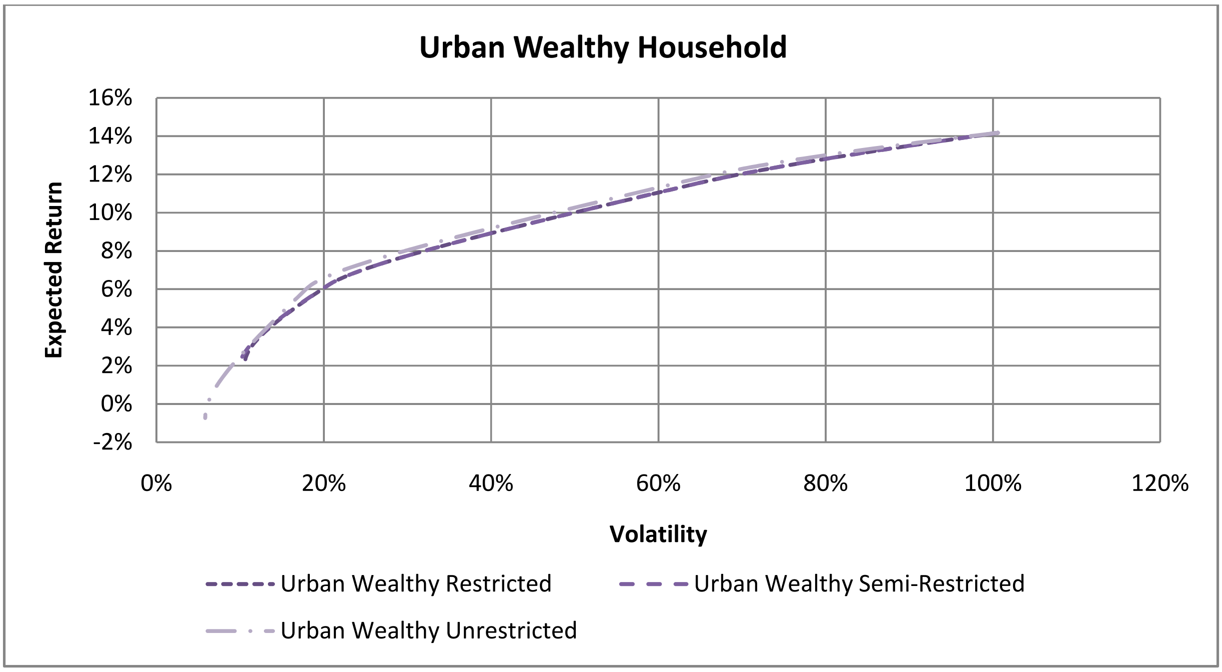

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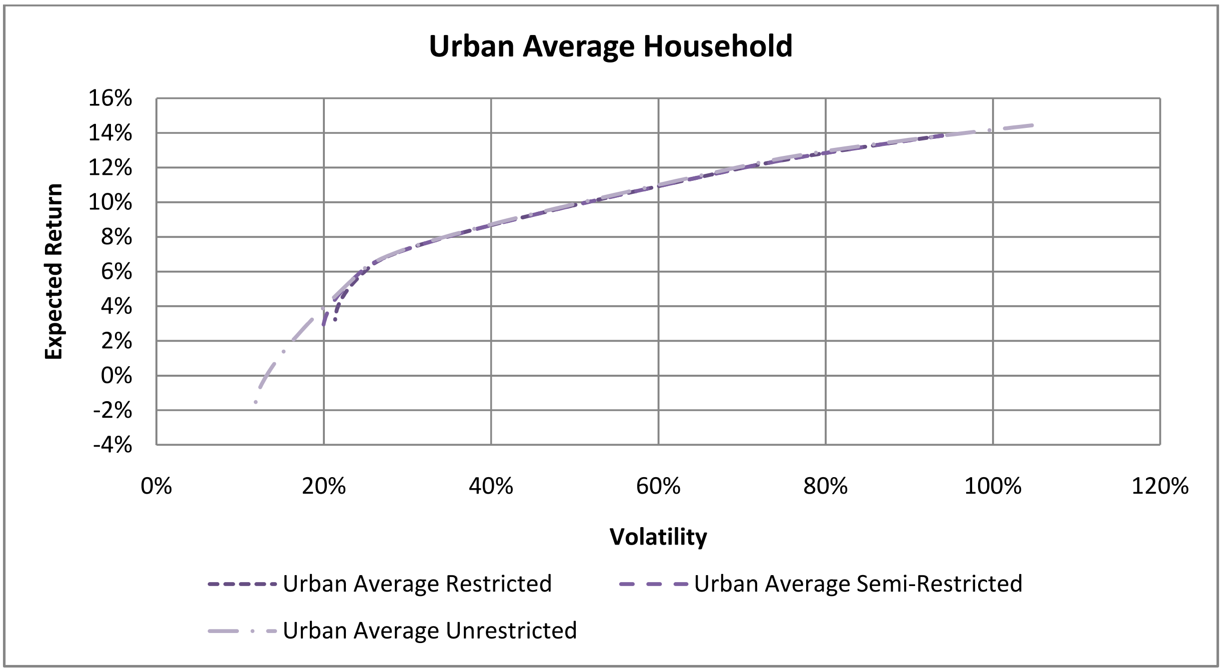

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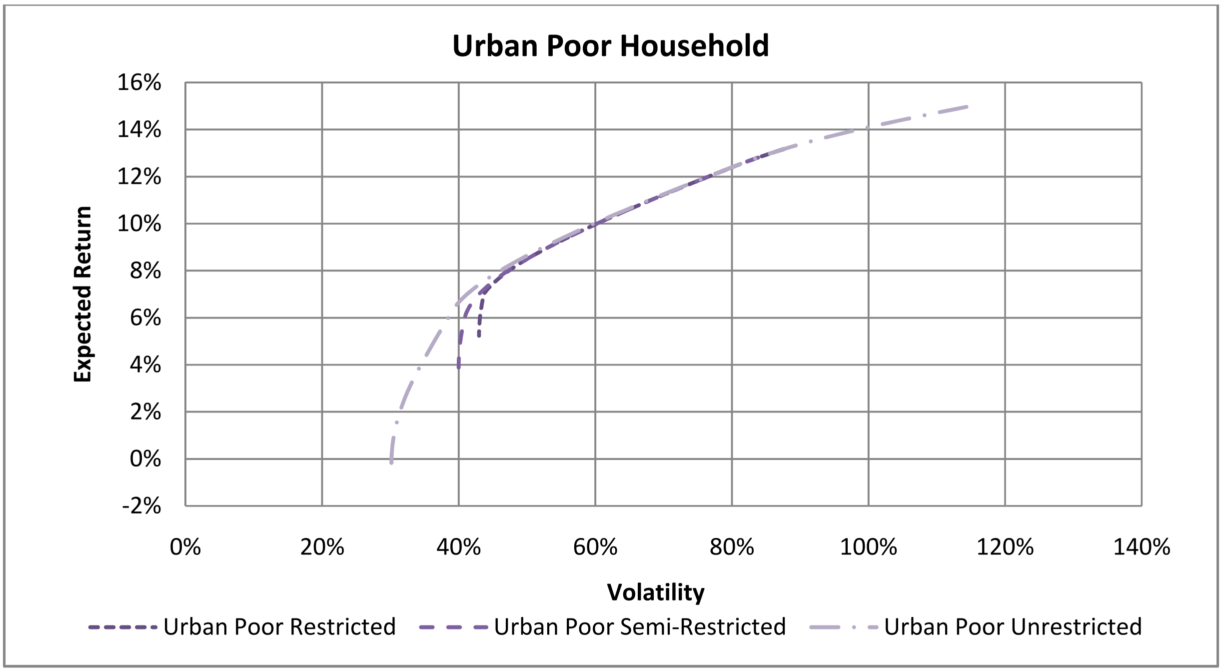

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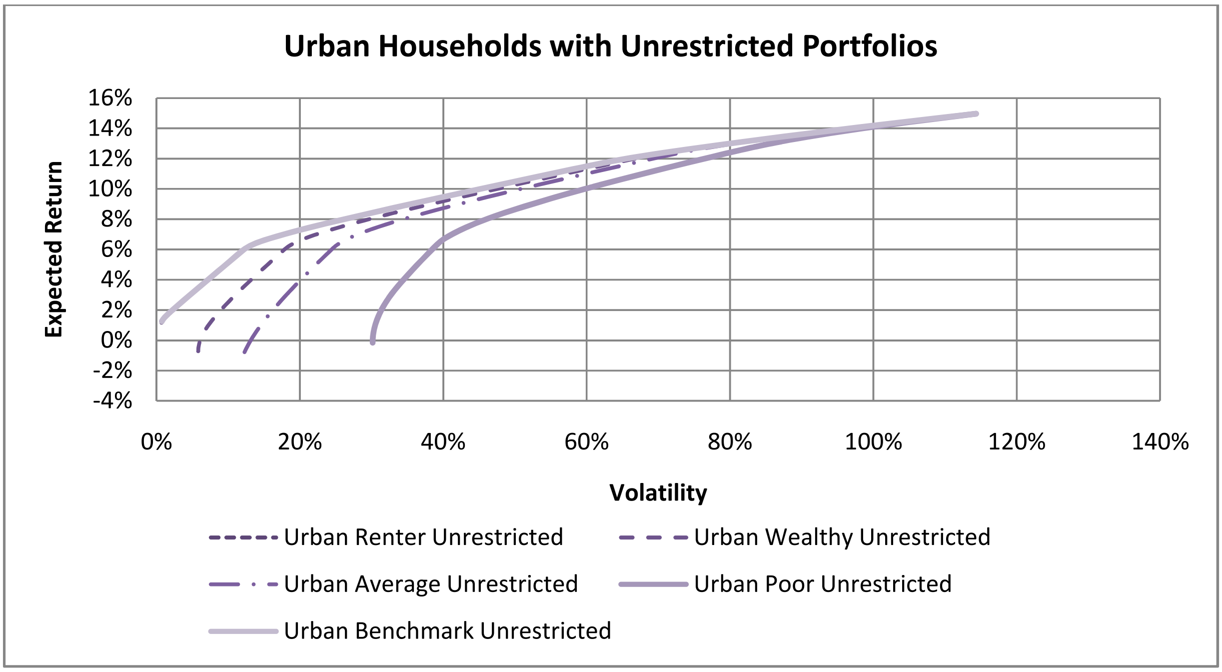
Appendix II – Urban Area, Households by Set of Restrictions



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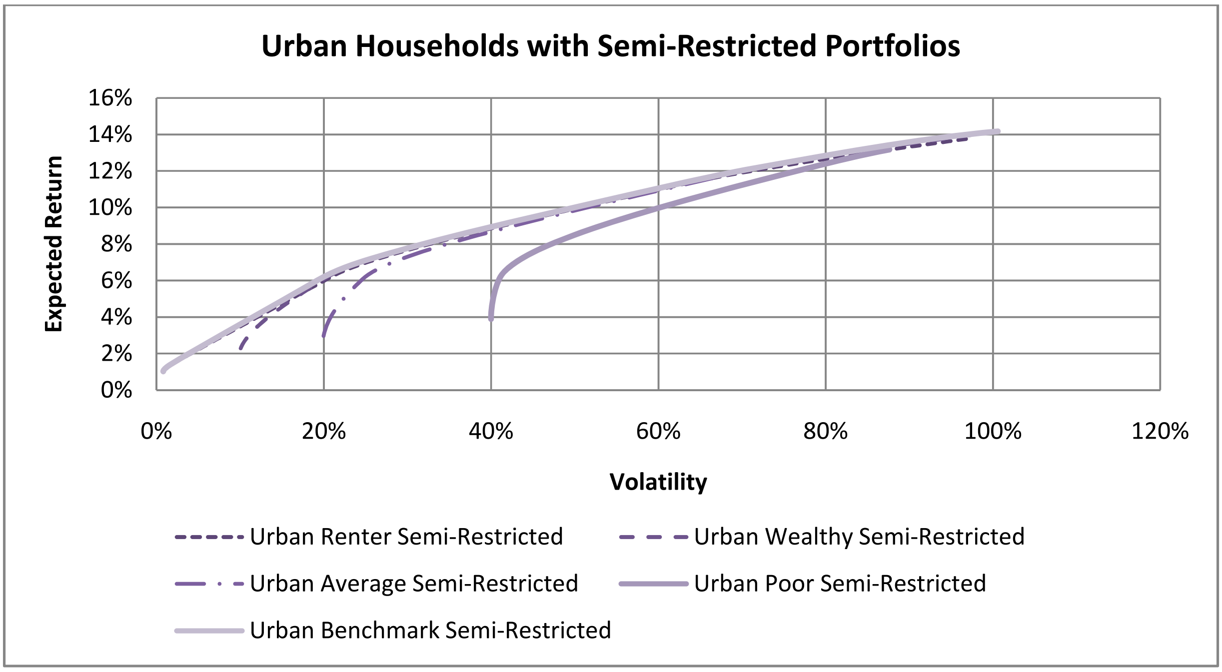

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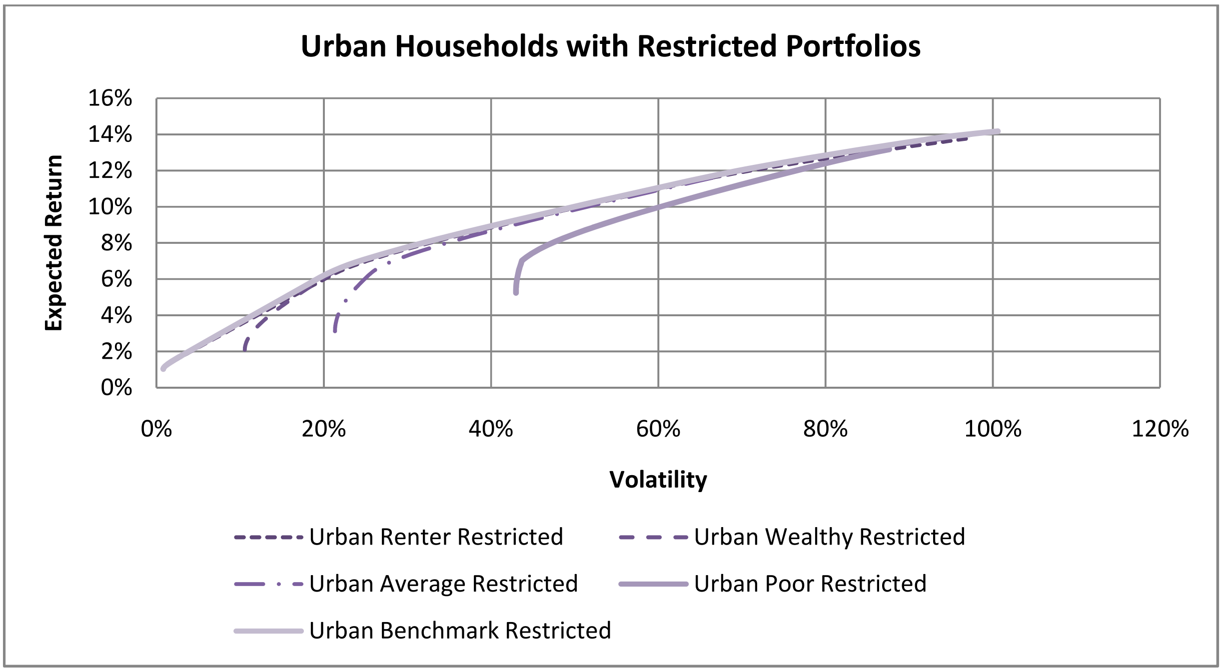

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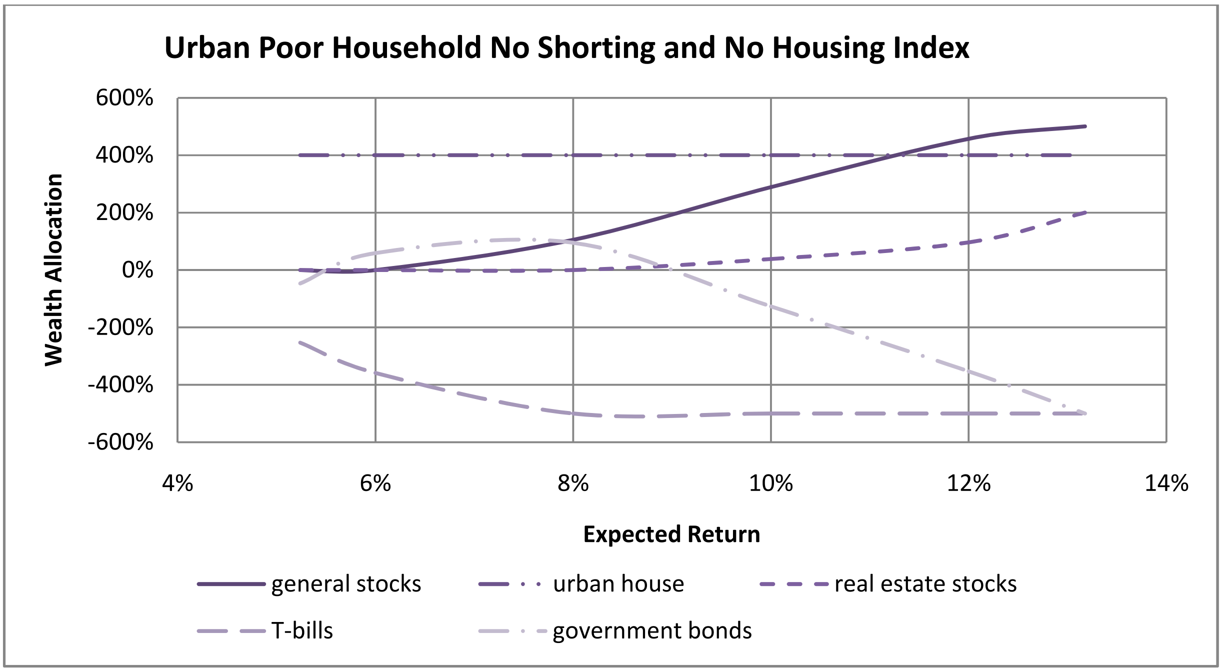
Appendix III – Urban Area, Household Portfolios' Wealth Allocations



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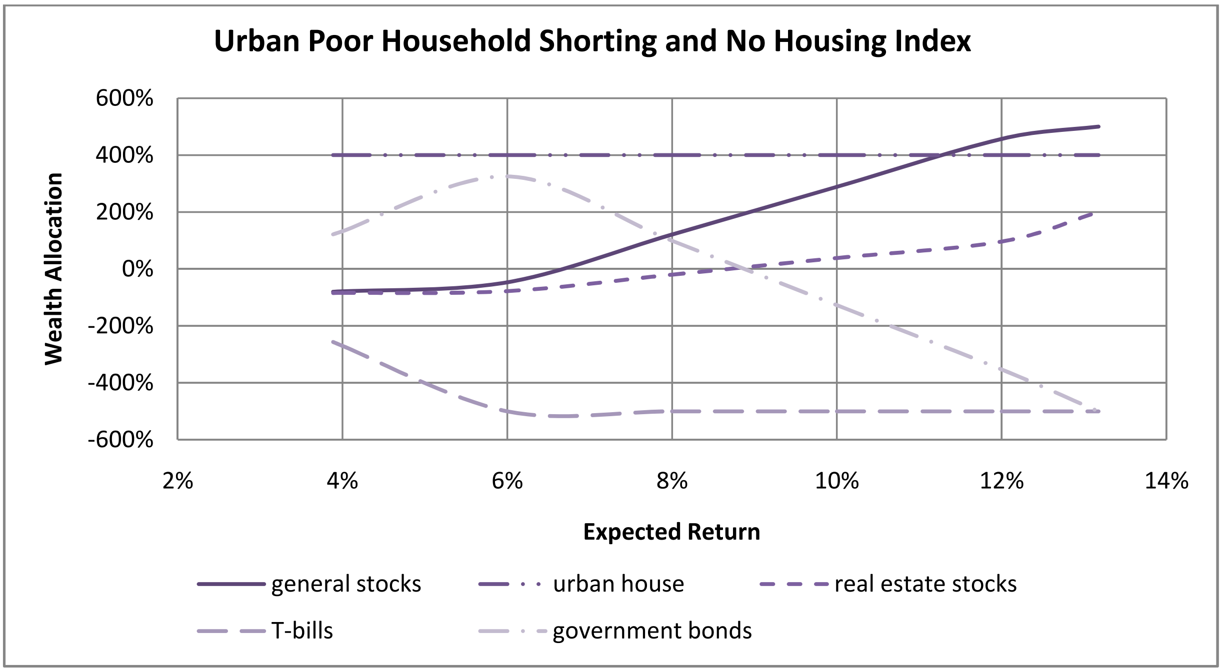

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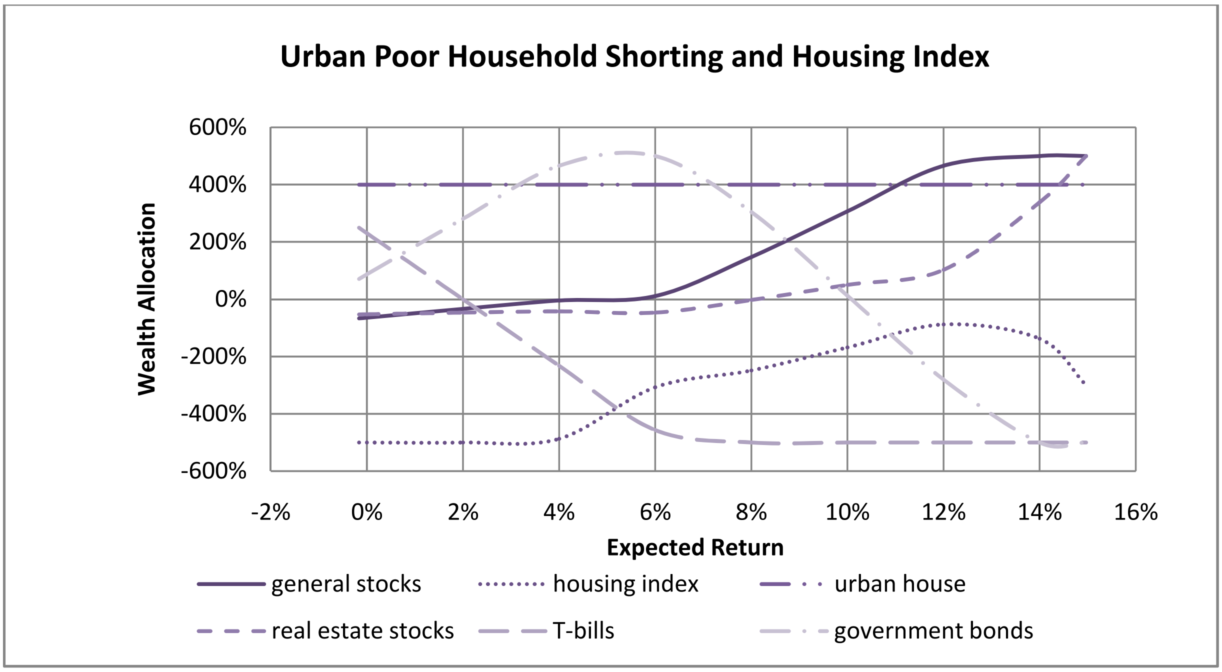

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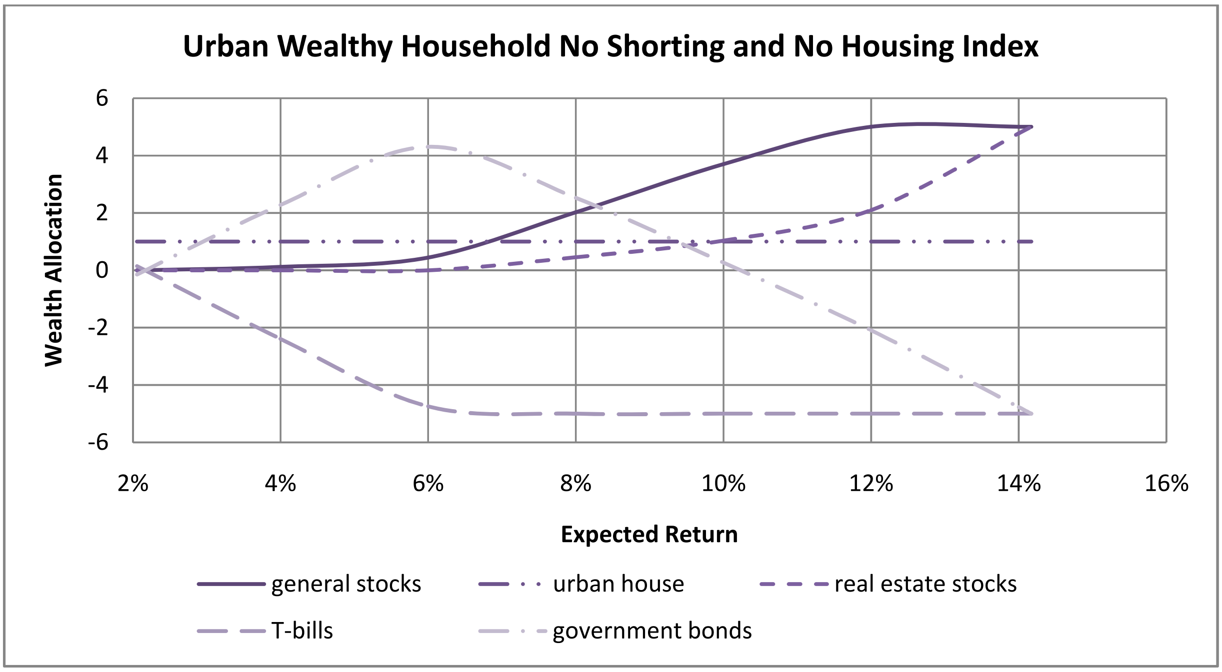

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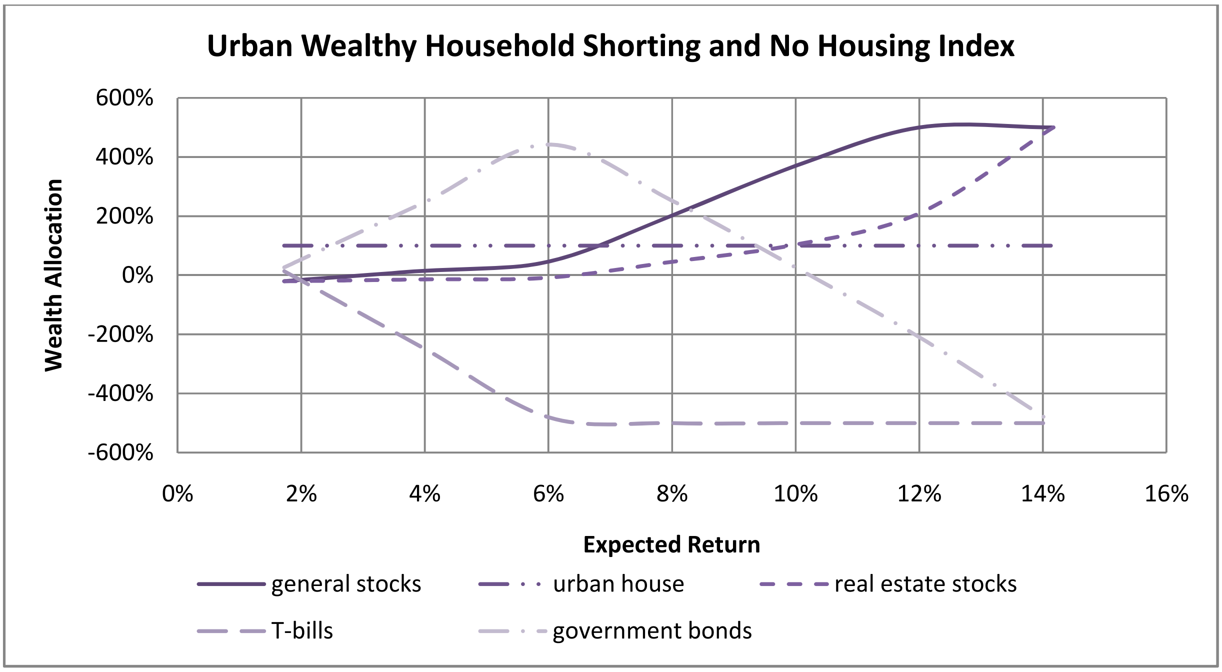

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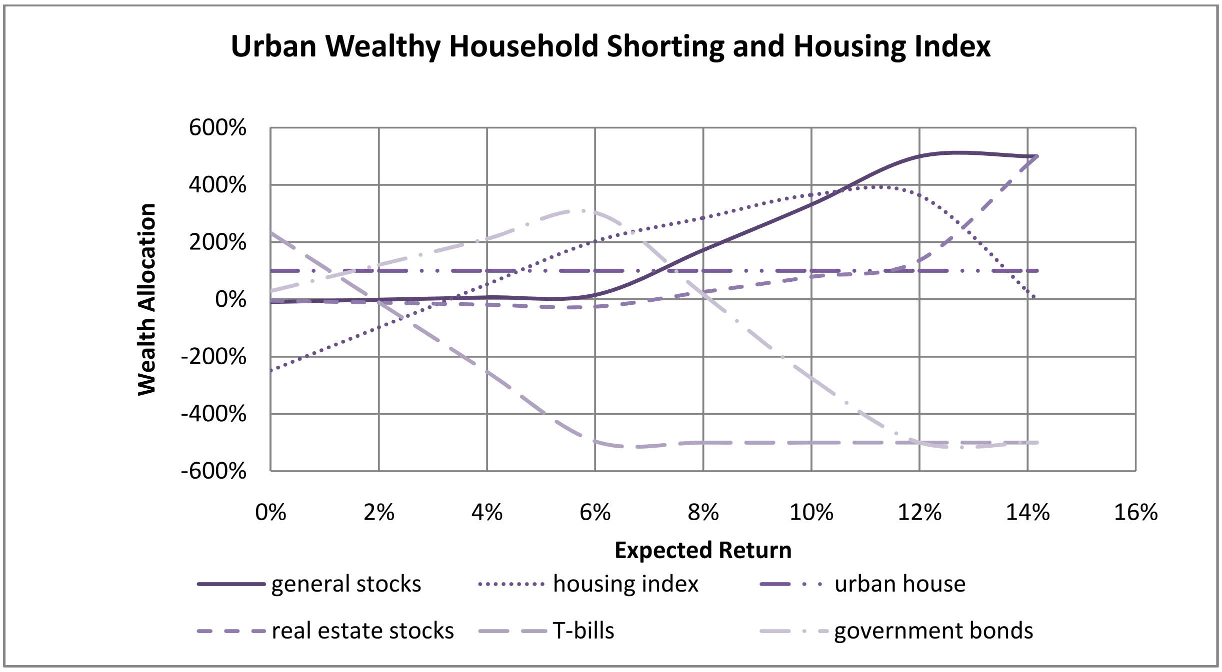

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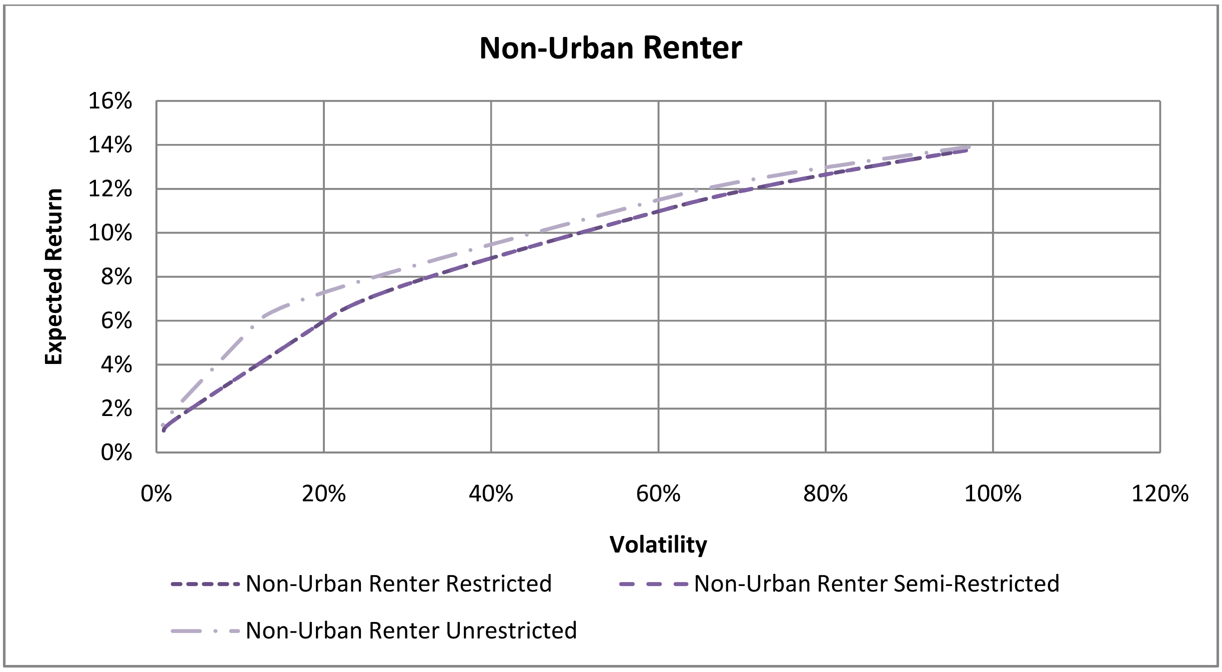
Appendix IV – Non-Urban Area, Households by Consumption Preference



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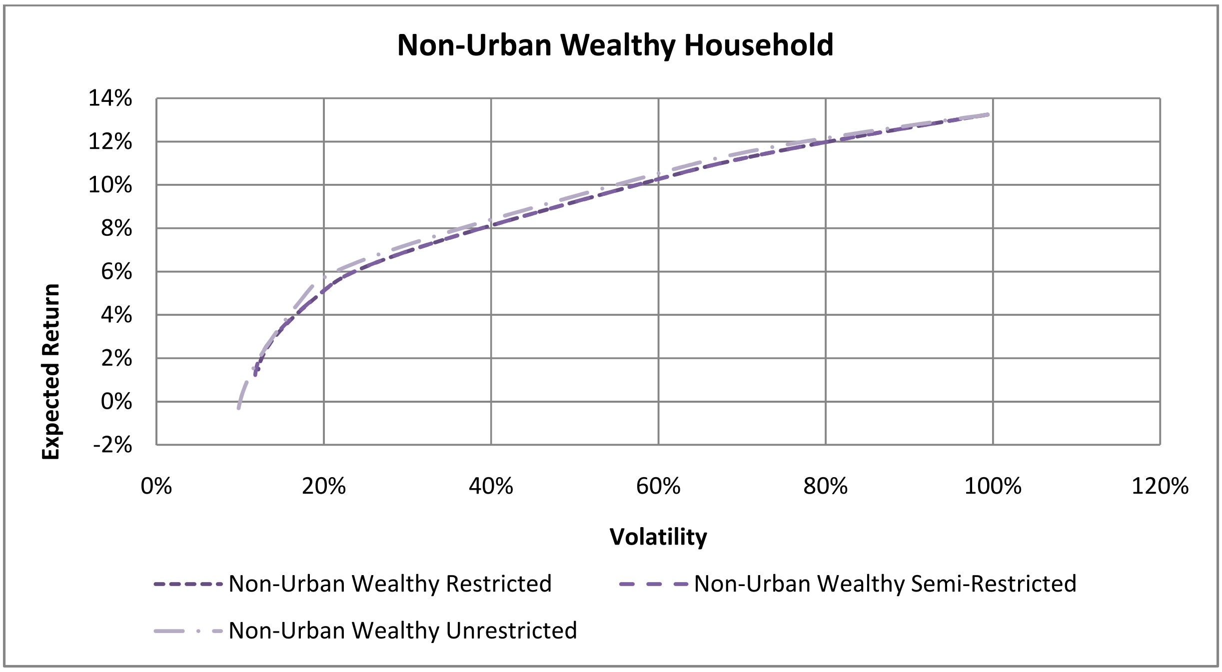

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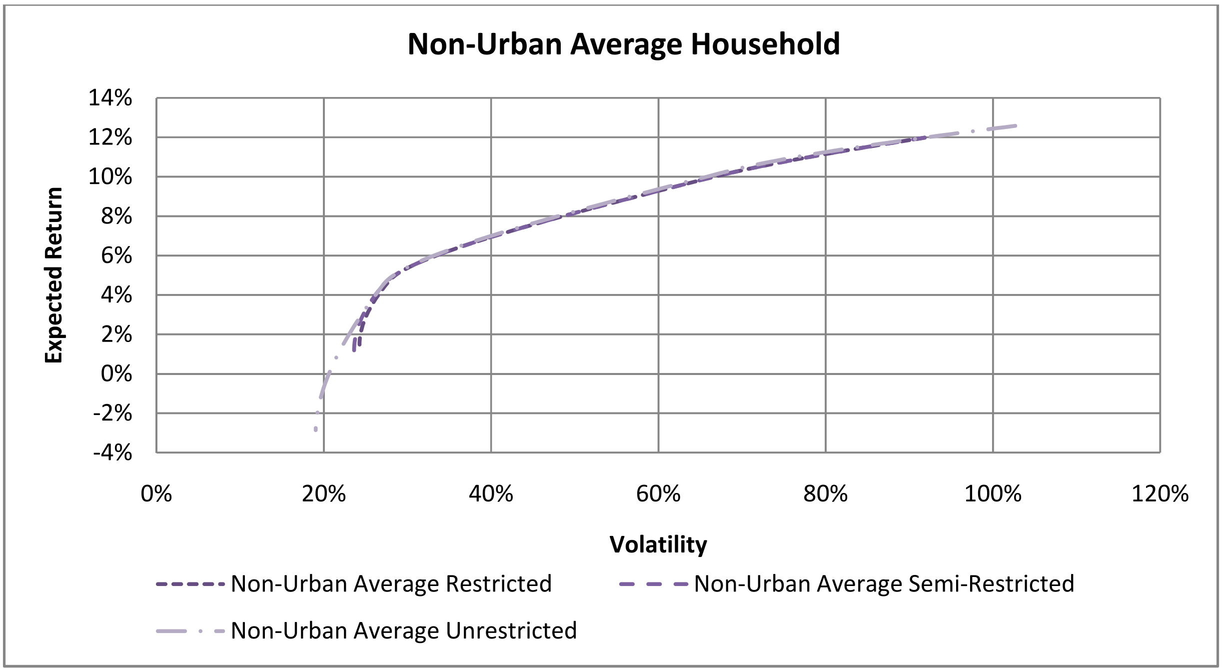

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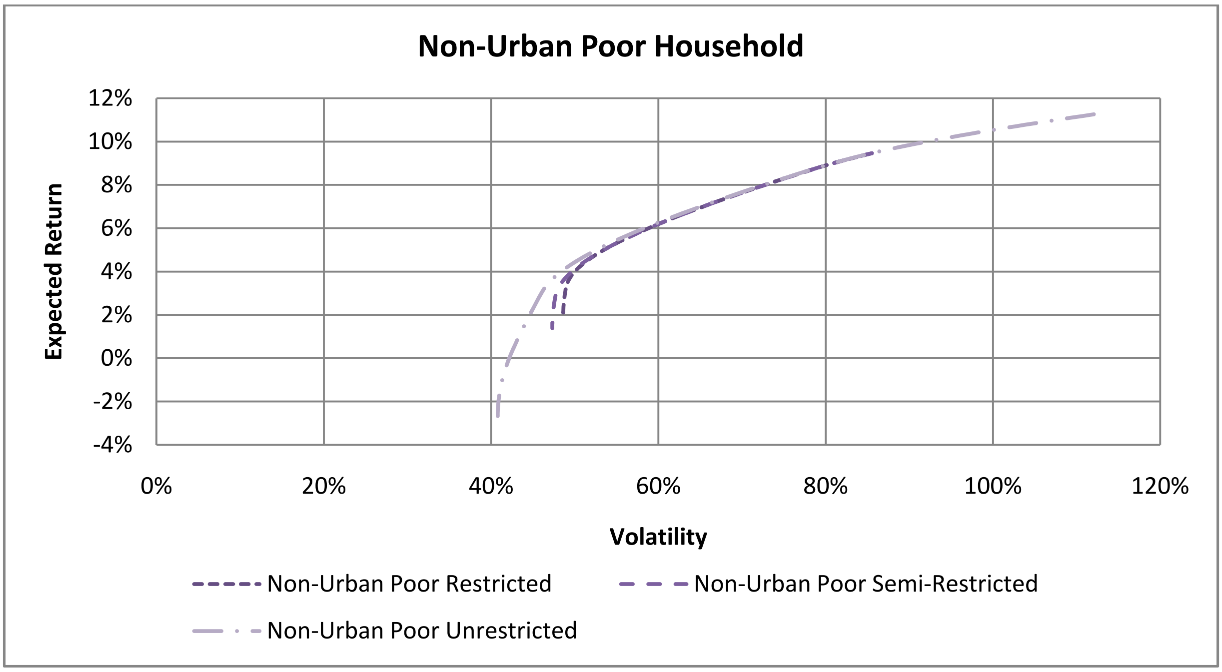

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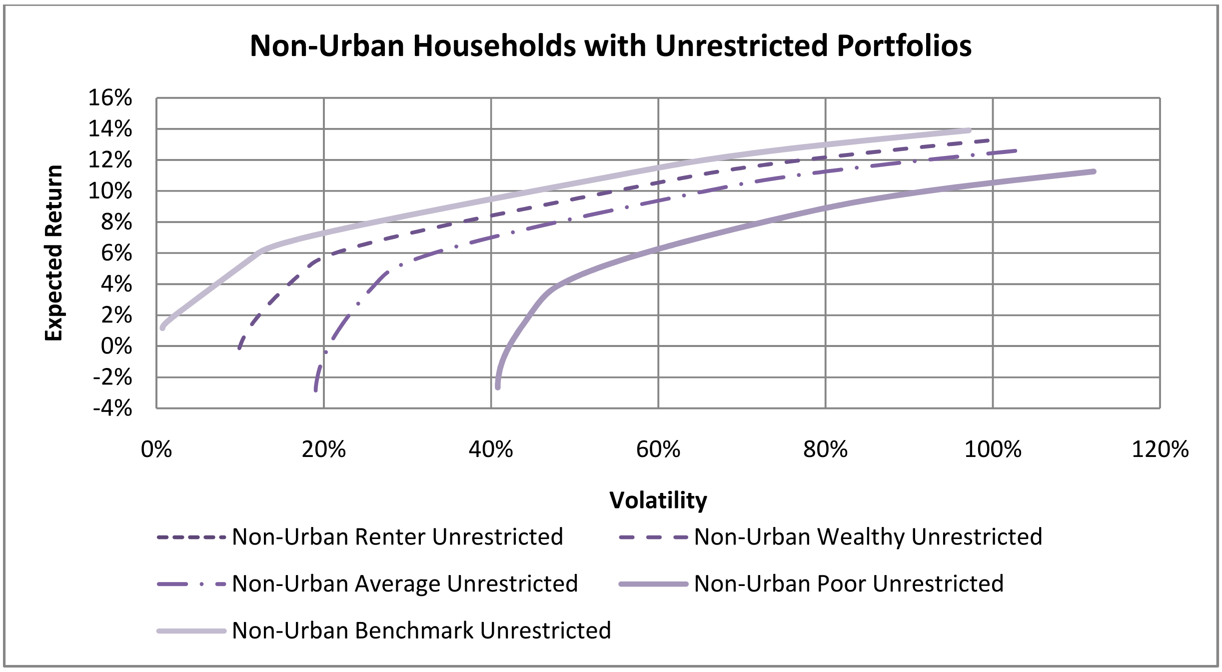
Appendix V– Non-Urban Area, Households by Set of Restrictions



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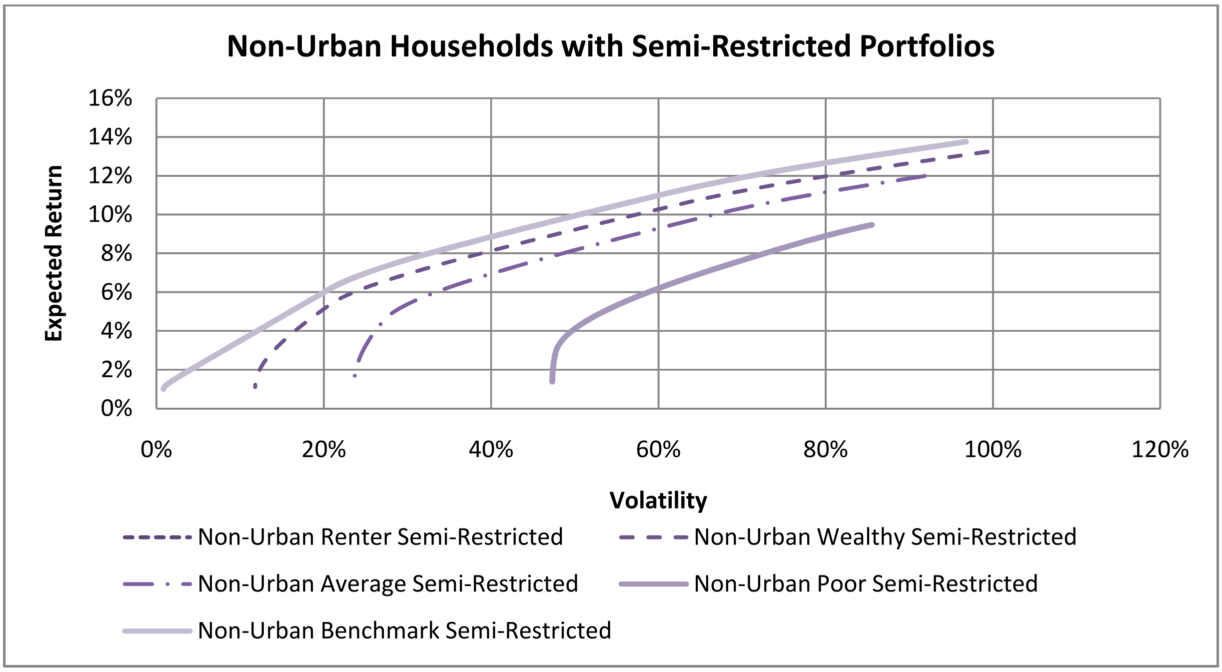

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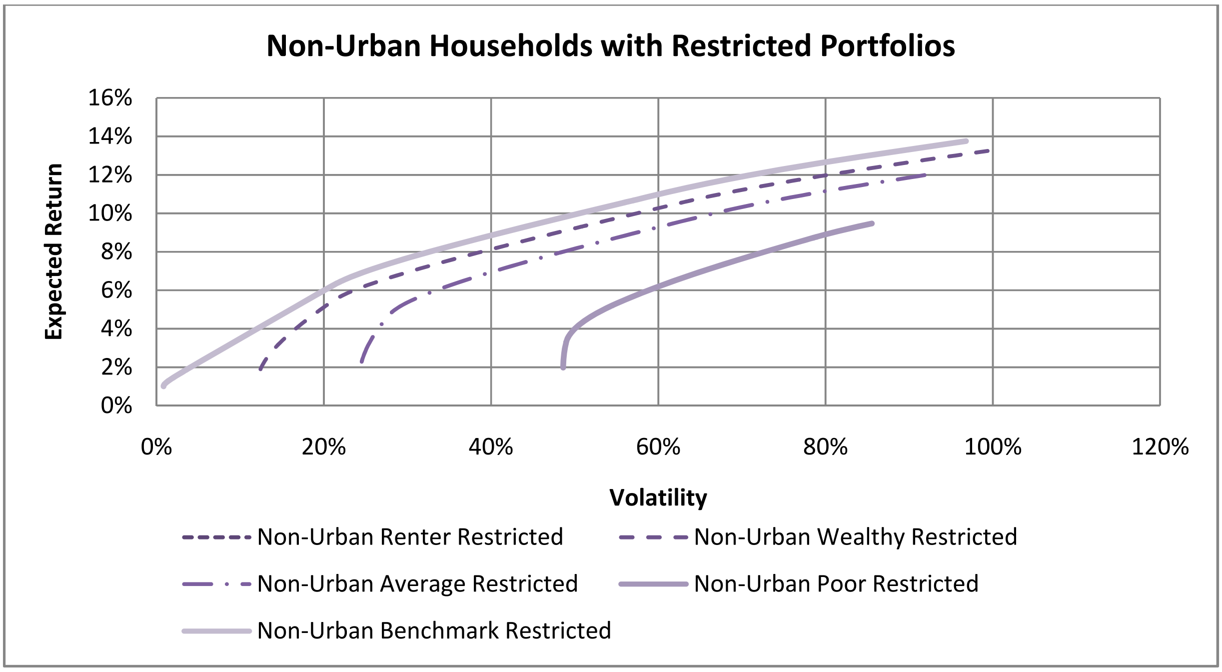

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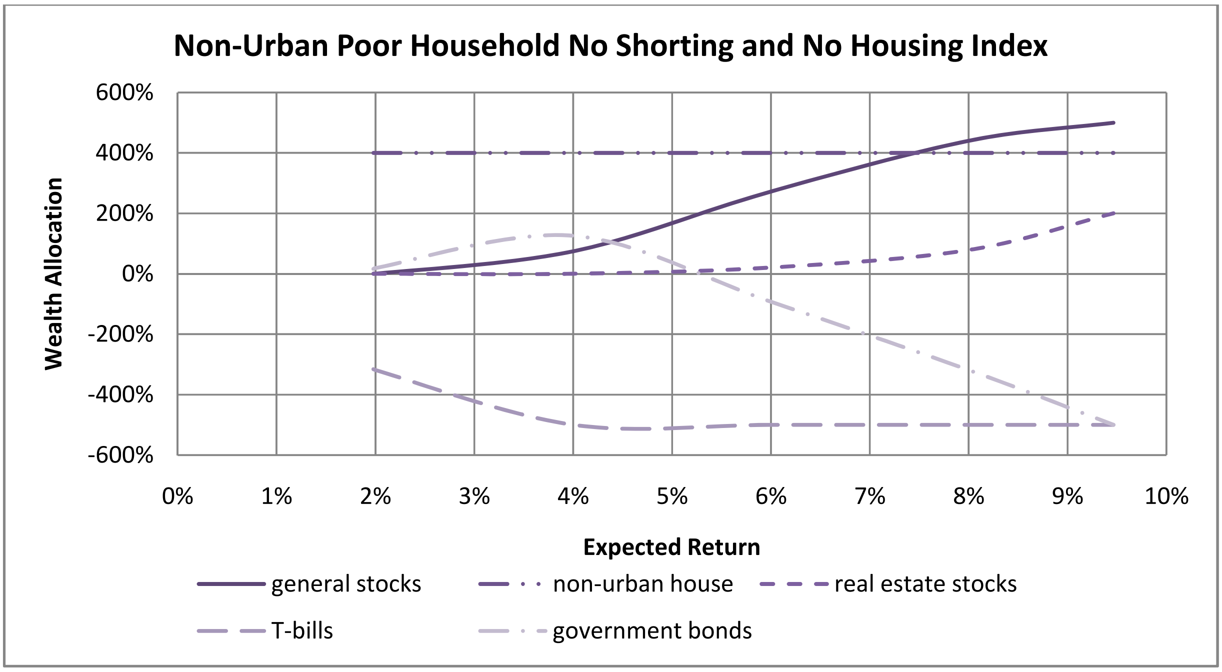
Appendix VI – Non-Urban Area, Household Portfolios' Wealth Allocations



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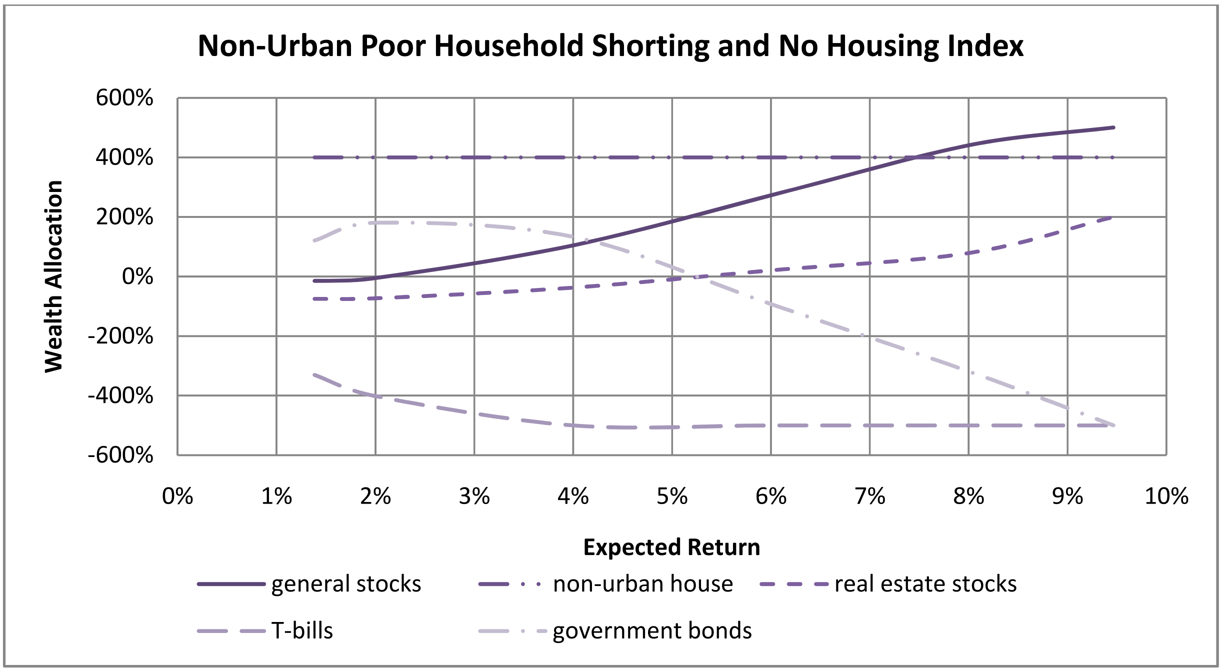

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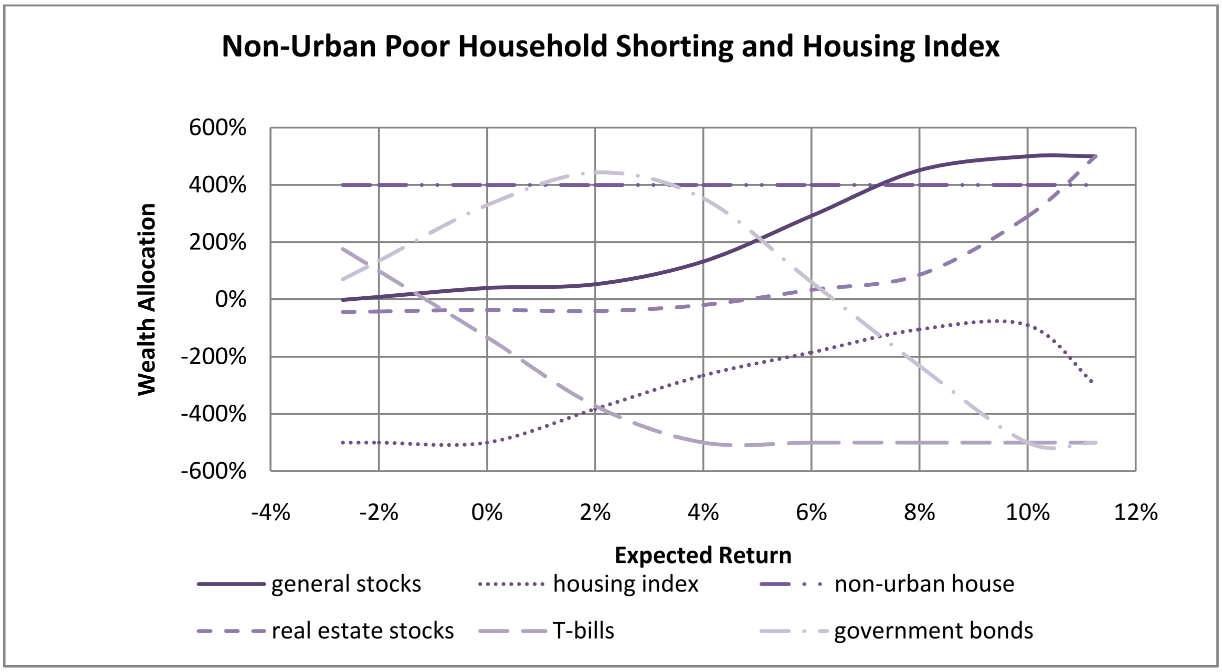

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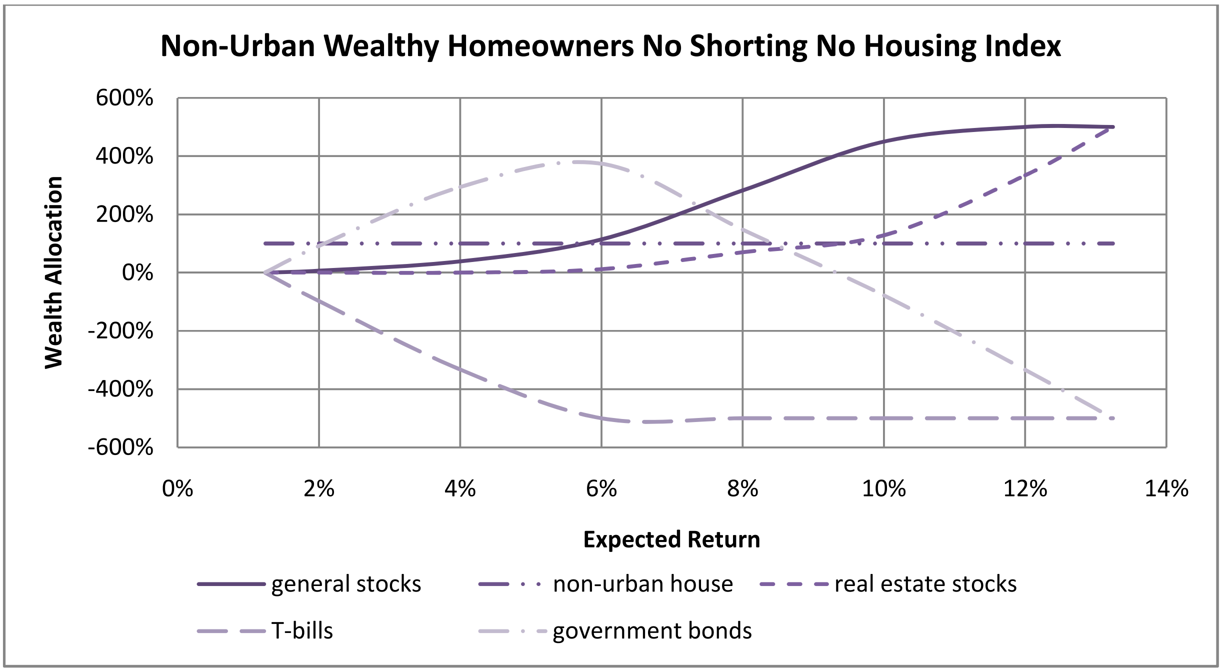

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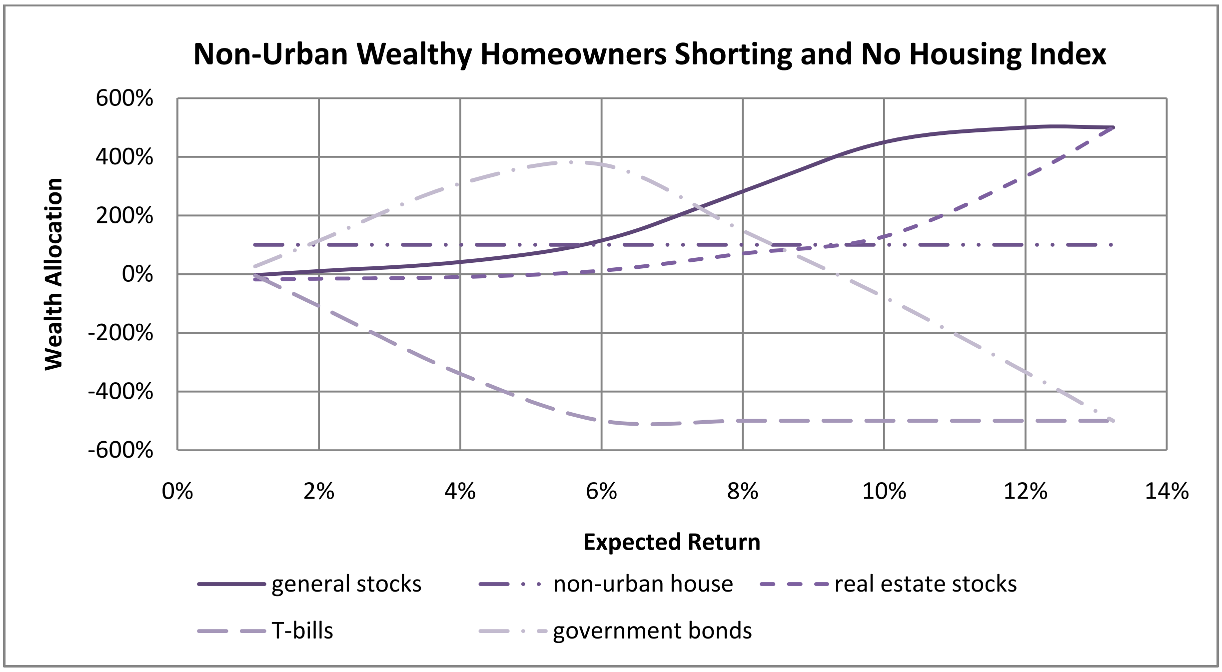

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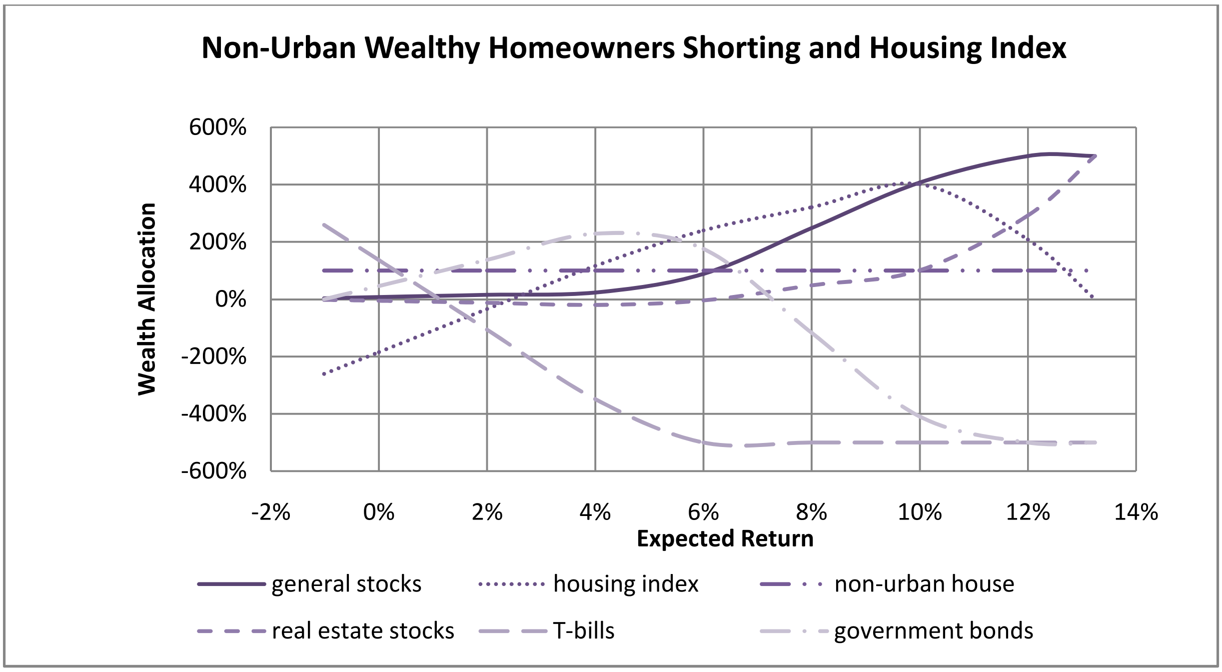

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