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Does Recent Volatility in the Housing Market Challenge Traditional Models of Saving?

A Study on the Importance of Housing Wealth for Explaining Household Saving in the United States during the Crisis

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Abstract

The purpose of this thesis is to study the importance of housing wealth for explaining household saving in the United States during the recent crisis. We present two fundamentally different models of saving – the Keynesian model of saving and the LCH model of saving, to investigate whether household saving over the recent crisis follows the path of Keynes or Modigliani. The empirical analysis examines consumption behavior with respect to the evolution of housing wealth to determine potential housing wealth effects associated with the dramatic fall in house prices. We perform empirical measurements of isolated time periods of housing wealth expansion as well as housing wealth declines to identify potential asymmetric wealth effects. The empirical estimates find no evidence of housing wealth effects for the time series and time periods of this study (1975-2010, 1975-2006, 1997-2006 and 2007-2010).

The thesis concludes that household saving during the recent crisis cannot be explained by housing wealth effects, and suggests that the saving behavior to a greater extent seems to follow the traditional path of Keynes rather than the LCH model of saving by Modigliani. The findings reveal no support for any presence of asymmetries in the impact of housing wealth on consumption and saving in the United States.

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1. Introduction

The housing boom and bust in the United States over the past decades are among the truly important economic episodes of the last century (Case, 2008). The housing market has played a key role in the recent economic downturn, and the dramatic fall in house prices is widely believed to be the spark that ignited the financial crisis (Almås et al., 2010).

A highly interesting issue is the association between the housing market and household saving and consumption in the U.S. economy. Personal consumption accounts for as much as 70 percent[1] of real GDP in the country. Hence, the ability of economists to understand consumption and saving to forecast future macroeconomic performance is of severe importance, and policymakers pay close attention to changes in housing wealth and the signals and effects these changes provide (Donihue and Avramenko, 2006).

The literature reveals various transmission channels from wealth to consumption, and the link between housing wealth and consumption is often referred to as a housing wealth effect (see e.g. Ludwig and Sløk (2002)). The well-established theory of housing wealth effects predicts that homeowners change their consumption by some fraction of their housing capital gains or losses (Skinner, 1989), meaning that when house prices increase homeowners tend to spend more and save less, and when house prices decrease homeowners tend to spend less and save more. These transmission mechanisms include realized wealth effects as well as unrealized wealth effects, where both realized and unrealized gains/losses associated with increases/decreases in house prices are expected to change consumption for homeowners (Ludwig and Sløk, 2002).

The aim of this thesis is to identify the relation between housing wealth and consumption, to determine whether housing wealth effects explain household saving during the recent crisis. The traditional life cycle hypothesis (LCH) has become a standard framework for empirical work on the measurement of wealth effects. Economists attempt to model macroeconomic channels of influence arising from changes in wealth by relying on approaches that focus on anticipated changes in income and wealth over the life cycle of consumers (Donihue and Avramenko, 2006).

[1] *Personal consumption expenditure* equals *70.6%* of GDP in Q4 2010, collected from *NIPA table 1.1.10 line 2* in the National Economic Accounts provided by the Bureau of Economic Analysis.

According to the LCH model, unexpected changes in household wealth lead to changes in the household consumption path (Modigliani, 1986). A scenario where changes in housing value has no effect on consumption is more in line with the traditional Keynesian saving theory, which implies that changes in household wealth do not affect consumption behavior as there are no relations between the two variables (Romer, 2001). We examine consumption behavior with respect to the evolution of housing wealth, to understand whether household saving during the recent crisis follows the path of Keynes or Modigliani, two fundamentally different models of saving.

Furthermore, as the literature on wealth effects has at its core the LCH model of consumption, it is reasonable to expect wealth effects to be symmetric[2], meaning that the transmission mechanisms from changes in wealth to changes in consumption are the same independent of whether the changes in wealth are positive or negative. However, previous studies find evidence that questions the expected symmetries in housing wealth effects (see e.g. Engelhardt (1995) and Case et al. (2005)). As a result, there are reasons for policymakers to question the relevance of the LCH model, and its ability to reflect the importance of housing wealth cycles and their impact on the macro economy (Donihue and Avramenko, 2006).

In this thesis we make an attempt to contribute to the literature on asymmetric wealth effects[3] by investigating the link between housing wealth and consumer spending in times of housing wealth expansion (sample period from 1997-2006) as well as in times of housing wealth declines (sample period from 2007-2010), to compare the potential wealth effects for the two periods of boom and bust, respectively. More specifically, we aim to find whether there is a difference in the impact of housing wealth on consumption over the recent crisis compared to the pre-crisis period of large expansion in the housing market, namely if the potential housing wealth effect has been weaker or stronger .

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[2] In the basic LCH model without uncertainty $\Delta C = MPC_A \cdot \Delta A_0$, which infers that changes in consumption are of the same magnitude for wealth declines as for wealth increases (Modigliani, 1986).

[3] Asymmetric wealth effects refer to the presence of a different link between housing wealth and consumer spending in times of recessions than in times of expansions (Donihue and Avramenko, 2006).

The main findings of this thesis are that we find little evidence of wealth effects for the time series[4] and time periods[5] we have been looking at. First, these results show that the observed volatility associated with the global economic crisis challenges the well-established economic theory of wealth effects. With the framework, data series and methodology of this thesis we find no support for the LCH model, where unexpected changes in household wealth lead to changes in the household consumption path. We conclude that household saving over the recent crisis cannot be explained by housing wealth effects, and that the saving behavior to a greater extent seems to follow the traditional path of Keynes rather than the LCH model of saving by Modigliani. Second, these results of no significant link between housing wealth and consumption, both in times of housing market expansion and recession, make it difficult to contribute to the literature on asymmetric wealth effects. As we do not provide any evidence of a different impact of housing wealth on consumption and saving behavior over the recent crisis with dramatic housing wealth declines compared to the pre-crisis period of large housing wealth expansion, we are unable to identify any asymmetries.

There are numerous studies on the association between wealth and consumption in the United States. Until the beginning of the 2000s the empirical evidence of wealth effects on consumption was mainly concentrated around stock market wealth effects, and the empirical importance of housing wealth for consumption was not widely explored. However, there has been a growing interest for estimating housing wealth effects, and the literature within the field has increased.

There is widespread disagreement about the role of housing wealth in explaining consumption. Case, Quigley and Shiller (2005) are among the first to investigate housing wealth effects. They find evidence of statistical significant housing wealth effects, and at best weak evidence of stock market wealth effects, whereas other empirical research that has re-used their data set yield the opposite results (Calomiris et al., 2009). Calomiris et al. (2009) find that housing wealth effects in the United States are likely to be smaller than stock market wealth effects, and argue that the empirical results by Case et al. (2005) may be overestimated. Despite conflicting results, the

[4] Time series of quarterly observations of aggregate national level data (measured as log annual changes and log quarterly changes).

[5] Sample periods are 1975-2010, 1975-2006, 1997-2006 and 2007-2010.

main findings on U.S. housing wealth effects across different studies are that such a relationship of housing wealth on consumption exists, although the magnitude of the strength tend to vary a lot (see e.g. Boone et al. (2001), Catte et al. (2004), Benjamin et al. (2004), Carroll et al. (2006), Case et al. (2005), Case et al. (2011) and Muellbauer (2007) and Kerdrain (2011)).

The work most closely related to this thesis is "Comparing wealth effects: The stock market vs. the housing market" by Case et al. (2005), which examines the link between increases in housing wealth, financial wealth and consumer spending, and compares stock market wealth effects with housing market wealth effects. Their empirical analysis relies upon a panel of U.S. states observed quarterly for the period from 1982 throughout the second quarter of 1999. Hence, when the study was first presented in January 2000 it relied upon the most recent data available, but it fails to incorporate the past decade of unusual volatility in the housing market. The upward trend in the housing market which characterizes the time period used in the study indicates that the sample data might represent an unusual period of housing wealth evolution. Unlike Case et al. we use aggregate national time series, and include data until the fourth quarter of 2010 to incorporate the past decade with housing boom and bust in the U.S. real estate market.

During the writing process of this thesis, Case et al. published a working paper with the purpose to update their previous empirical analysis using data throughout 2009. In "Wealth effects revisited 1978-2009" presented in March 2011, they re-examine the link between changes in housing wealth and consumption. The result reinforces the conclusion of existing housing wealth effects reported in Case et al. (2005), but the magnitudes of the effects are much larger when the most recent data with substantially more variation in housing prices are included (Case et al., 2011). Based on these findings, we run statistical tests from 1975 to 2006 as well as for the whole sample period from 1975 to 2010, to see if our national level time series supports the results generated by the state panel data.

An important aspect in explaining the large variations in findings might be that most of the literature on housing wealth effects is from times of great expansion in the housing market, and the results might to some extent be affected by limited amounts of data from periods of housing wealth declines (Muellbauer, 2007). Over the past decades, U.S. households have experienced substantial volatility in housing wealth unlike any other decade in our total sample period from 1975 to 2010. We find it useful to investigate whether more complex time series which include the increased volatility of the last decade changes the previous documented relationship between housing wealth and consumption, and hence challenges the traditional economic theories of wealth effects.

This thesis is organized as follows. Section 2 presents the theoretical framework of the traditional Keynesian model of saving and the LCH model of saving by Modigliani, and makes the theoretical foundation for the thesis. In Section 3 we describe the data and the construction of a housing wealth variable[6]. Section 4 provides an overview of the U.S. housing market and looks at the evolution of house prices as well as the size and distribution of housing wealth in the country. Section 5 constitutes the main bulk of the thesis, where we attempt to examine the impact of housing wealth on consumption and saving through empirical analysis. First, we present the relationship between changes in housing wealth and changes in consumption and saving behavior through basic correlation analysis. Second, we introduce empirical tests to measure the potential housing wealth effect and present the regression results. Third, we discuss the implications of the results generated by the empirical analysis, and provide an overview of limitations to the study and interesting directions for future research. Conclusions are given in Section 6.

[6] Estimates of housing market wealth are constructed by using a set of variables similar to Case et al. (2005).

2. Theoretical Framework

House price depreciation can have a number of possible effects on household saving behavior. This section makes the theoretical foundation for the thesis, and seeks to find the saving response to wealth changes through two different theoretical approaches, namely the traditional Keynesian model of saving and the LCH model of saving by Modigliani.

2.1 Traditional Keynesian model of saving

The traditional Keynesian model is a linear model of disposable income based on the Keynesian consumption function, which posits that consumption is determined by current disposable income. Keynes argued that the amount of aggregate consumption mainly depends on the amount of aggregate income, and that this relationship is a fairly stable function. He claimed further, that it is also obvious that a higher absolute level of income leads, as a rule, to a greater proportion of income being saved (Romer, 2001).

The Keynesian consumption function is given by

$$C_t = a + b \cdot YD_t$$

where $a > 0$ and $0 < b < 1$. C_t is consumption in period *t*, YD_t is disposable income in period *t*, and b is the marginal propensity to consume (*MPC*). The Keynesian consumption function is illustrated in Figure 2-1.

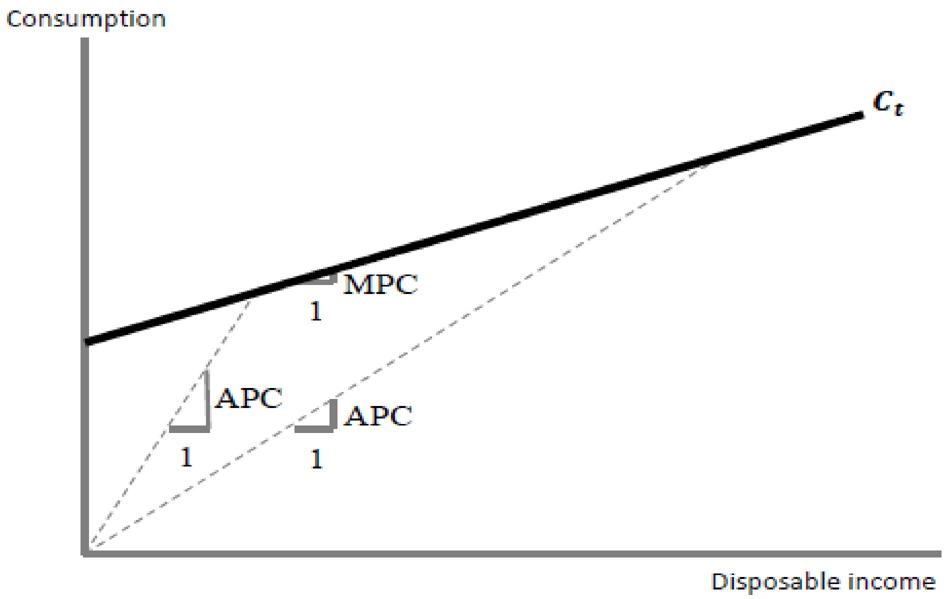

Figure 2-1: Illustration of the Keynesian consumption function

Saving in period *t* is defined as the difference between disposable income and consumption ($S_t = YD_t - C_t$). The saving rate derived from the traditional Keynesian approach is

$$s = \frac{S}{YD} = \frac{YD - C}{YD} = \frac{YD - a - bYD}{YD} = (1 - b) - \frac{a}{YD}$$

2.1.1 Implications of the Keynesian model

The traditional Keynesian model says that consumption depends only on current disposable income. Thus higher disposable income increases consumption, whereas reductions in income levels lead to lower consumption in a given period. The size of the change in consumption due to income changes is given by the *MPC*. The *MPC* is estimated to be *0.7-0.8*, meaning that an increase in disposable income by *1* increases consumption by *0.7-0.8*. However, empirical studies are not able to demonstrate a consistent, stable relationship between consumption and current income. Across households at a point in time the relationship is of the type that Keynes postulates, but within a country over time the model lacks empirical support (Romer, 2001).

The model implies that saving is a growing function of disposable income, both in absolute and in relative terms. First, if income increases, the level of savings increases. Second, when income rises, consumers save a larger *fraction* of their income, as the average propensity to consume (*APC*) falls when disposable income increases, $APC = \frac{C}{YD}$. However, Kuznets (1946) shows that the *APC* does not fall as income rises. The saving rate seems to be close to constant over time, also as disposable income increases, known as the Kuznets' consumption puzzle (Kuznets, 1946). Kuznets shows that $\frac{C}{YD}$ is very stable in long time series data, meaning that aggregate consumption is essentially proportional to aggregate income over time (Mankiw, 2003).

2.2 Traditional life cycle model of saving

The literature on wealth effects has at its core the life cycle model (LCH model) of saving, and this section introduces Modigliani's life cycle hypothesis (LCH). The LCH was developed in the 1950s to describe consumption and saving behavior over individuals' lifetime, and is an appropriate theory to study how changes in wealth affect personal savings. At the general level, the basic idea of the LCH consists of a simple insight about saving, namely that saving is future consumption. Individuals save to consume in the future, and as long as the individuals do not value saving in it-self, the decision about the division of income between consumption and saving is driven by preferences between present and future consumption, as well as information regarding future consumption prospects.

The basis for the LCH model of saving is provided by two essays written by Franco Modigliani and Richard Brumberg, "Utility Analysis and the Consumption Function: An Interpretation of Cross Section Data" (Modigliani and Brumberg, 1954), and "Utility Analysis and the Aggregate Consumption Function: An Attempt at Integration" (Modigliani and Brumberg, 1979). Their purpose was *"to show that all the well-established empirical regularities could be accounted for in terms of rational, utility maximizing, consumers, allocating optimally their resources to consumption over their life"* (Modigliani, 1986, p.152).

2.2.1 Utility maximization and the role of lifetime resources

The hypothesis suggests that an individual's consumption in a given period depends only on his lifetime resources (the present value of labor income and expected bequests), and is independent of current income. Another important implication of the hypothesis is that the consumer chooses to consume at a reasonably stable rate close to the anticipated average life consumption, as individuals prefer a smooth consumption profile over the lifetime. This provides an understanding of individual saving behavior, namely that foreseen wealth- and income changes do not lead to changes in consumption, while unexpected changes lead to changes in the individual's consumption path where the positive or negative change is spread out through the expected remaining lifetime. This means that consumption responds little to temporary changes in wealth and income, and proportionally to permanent changes. Analysis implies that although the time pattern of income is not important to consumption, it is critical to saving, as the individual's saving in period t is the difference between income and consumption ($S_t = Y_t - C_t$). Thus saving is high when income is high relative to its average, while saving is negative in times when current income is less than consumption. The individual uses saving and borrowing to smooth consumption over the life cycle, and this constitutes the main idea of the LCH.

2.2.2 The basic LCH model

The basic model by Modigliani and Brumberg (1954) is based on some simplifying assumptions concerning the lifecycle path of household opportunities and tastes. Individuals have finite horizons and leave behind no assets as bequests for future generations. Each generation is therefore born with zero wealth. For simplicity it is also assumed that individuals earn constant income until retirement and receive no income thereafter, and the interest rate is zero.

Figure 2-2 illustrates one possible allocation of consumption and assets over the lifetime. Individuals save to accumulate wealth until retirement R, and then draw down the stock of wealth until the expected end of life at time T by keeping consumption constant without any labor income during retirement. This ensures a smooth path of consumption that maximizes the individual's utility.

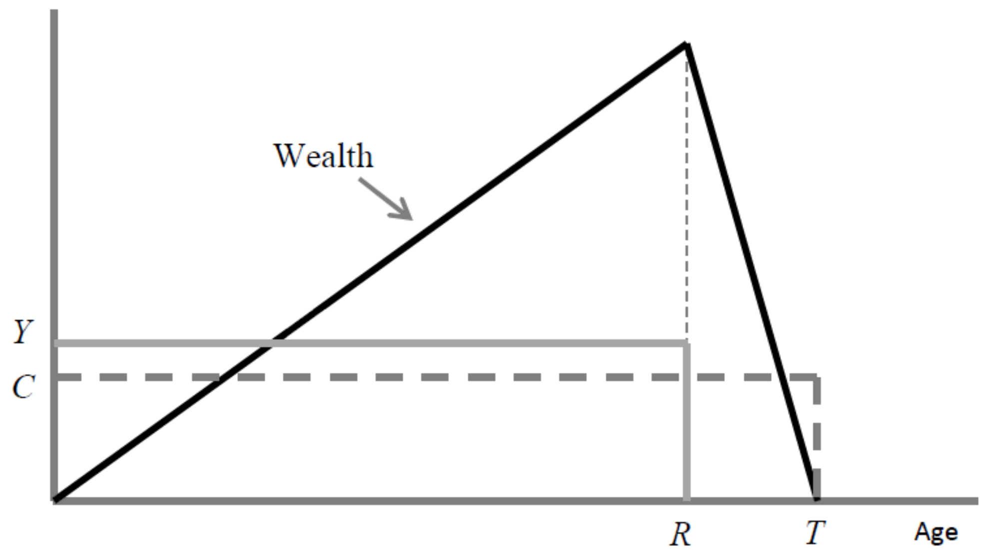

Figure 2-2: Illustration of Modigliani's life cycle hypothesis (LCH)

The LCH model predicts the following path of consumption and assets: before entering into the labor market individuals should borrow, and then accumulate savings while in the labor force, in order to allow for a certain consumption level during retirement. The resulting hump shaped path of wealth is clearly shown in the figure above.

Modigliani (1986) discusses potential effects of changes to the simplifying assumptions that the LCH is based on. His analysis shows that most of the assumptions presented in the basic model of 1954 can be replaced by more realistic assumptions without changing the basic nature of the results (e.g. by allowing for a non-zero interest rate, the life cycle of earnings, family size variations, length of working and retired life as well as liquidity constraints) (Modigliani, 1986).

2.2.3 The LCH model under certainty

The LCH under certainty describes a simplified scenario in which all sizes are known, so that the consumer can make decisions based on perfect information. This section presents the theoretical framework of the basic LCH model of saving under certainty (see e.g. Romer (2001) and Syrtveit (2002)). The following notation is used:

C_t	**Consumption in period *t***
Y_t	**Income in period *t***
A_t	**Wealth at the beginning of period *t***
U_t	**Utility function**
T	**Lifetime**
ρ	**Rate of time preference**
r	**Interest rate**

Table 2-1: Explanation of notations to be used in the theoretical framework

Consider an individual who lives for $T+1$ periods, whose total lifetime utility is

$$U = \sum_{t=0}^{T} U(C_t)\,\beta^t$$

$U(C_t)$ is the utility of consumption in period t, while β is the subjective discount factor measuring the degree of impatience of the individual, where $0 < \beta < 1$. Beta is defined as $\beta = \frac{1}{1+\rho}$, where ρ is the rate of time preference that says how individuals value consumption today versus consumption in the future. A positive value of ρ means that utils are valued less the later they are received. A low beta value thus represents an impatient individual that appreciate consumption today, whereas a high value of beta means a patient individual who prefers to delay consumption into the future. The lifetime utility is assumed to be additively separable between time periods, which implies that marginal utility are not a function of consumption and leisure choices across time. The utility function is increasing and strictly concave, $u' > 0,\ u'' < 0$.

The individual has initial wealth of A_0 and total incomes of $Y_0, Y_1, \ldots, Y_T$ in the $T+1$ periods of life. Total income Y_t consists of labor income and capital income. The individual takes the labor income as exogenously given, and it can vary from time to time. The capital income is related to savings volume and the initial wealth at the beginning of the period. The individual can save or borrow at a constant interest rate *r*. The only constraints are that any outstanding debt must be repaid at the end of life, and all savings and wealth consumed by that time.

Given a constant and exogenously given interest rate and *T+1* time periods the individual's budget constraint is

$$\sum_{t=0}^{T} \frac{1}{(1+r)^t} C_t = A_0 + \sum_{t=0}^{T} \frac{1}{(1+r)^t} Y_t$$

This intertemporal budget constraint states that the present value of lifetime income and initial wealth equals the present value of lifetime spending. The budget constraint thus limits the individual's consumption to the present value of total earnings in addition to initial wealth.

The individual wishes to maximize utility over the lifetime, given the budget constraints it faces. The Lagrangian for the maximization problem gives optimal consumption level

$$L = \sum_{t=0}^{T} U(C_t)\,\beta^t + \lambda \left[A_0 + \sum_{t=0}^{T} \frac{1}{(1+r)^t} Y_t - \sum_{t=0}^{T} \frac{1}{(1+r)^t} C_t \right]$$

The first order condition for C_t is

$$\frac{\partial L}{\partial C_t} = U'(C_t)\beta^t - \lambda \frac{1}{(1+r)^t} = O \rightarrow \ \lambda = \beta^t (1+r)^t U'(C_t)$$

$$\frac{\partial L}{\partial C_{t+1}} = U'(C_{t+1})\beta^{t+1} - \lambda \frac{1}{(1+r)^{t+1}} = O \rightarrow \ \lambda = \beta^{t+1} (1+r)^{t+1} U'(C_{t+1})$$

The relationship between marginal utility at two different points in time can thus be derived as

$$U'(C_t) = \beta(1+r)U'(C_{t+1})$$

This relationship holds in every period, and states that by maximizing utility the individual prefers that marginal utility of consumption today equals marginal utility of consuming *(1+r)* units tomorrow, times the discount factor β. We assume $\beta = \frac{1}{1+\rho}$, and if we further assume that the rate of time preference ρ equals the interest rate r, $(\rho = r)$, the individual maximizes utility by adapting a constant consumption level where $C_0 = C_1 = \ldots = C_T = C^*$. In this special case the consumer discounts future utility at the same rate as the market interest rate, so that there is no incentive to tilt the consumption path over time, and hence consumption level is constant over the lifetime.

Optimal consumption level C^* in this special case is solved for by inserting into the budget constraint. The formula for geometric time series is used to get from the first to the second line[7] (see Appendix A for complete calculations of the optimal consumption level).

$$\sum_{t=0}^{T} \frac{1}{(1+r)^t} C_t = A_0 + \sum_{t=0}^{T} \frac{1}{(1+r)^t} Y_t$$

$$C^* \frac{1 - \left(\frac{1}{1+r}\right)^{T+1}}{1 - \left(\frac{1}{1+r}\right)} = A_0 + \sum_{t=0}^{T} \frac{1}{(1+r)^t} Y_t$$

$$C^* = \frac{r(1+r)^T}{(1+r)^{T+1} - 1} \cdot \left[A_0 + \sum_{t=0}^{T} \frac{1}{(1+r)^t} Y_t\right]$$

[7] Formula for geometric time series is given by $\sum_{t=0}^{T} k^t = 1 + k + k^2 + \cdots + k^T = \frac{1-k^{T+1}}{1-k}, k \neq 1$

It is now possible to analyze how consumption depends on initial wealth when the individual maximizes utility under the given assumptions. The first term in the equation above, $\frac{r(1+r)^T}{(1+r)^{T+1}-1}$, is an expression of the marginal propensity to consume (*MPC*), and shows how much of an increase in wealth the individual would like to spend in one time period. The term in the parentheses is the individual's total lifetime resources. In addition to initial wealth and total lifetime income, the optimal level of consumption is affected by the interest rate and time horizon. A higher interest rate level increases consumption due to higher return on capital. A longer time horizon works in the opposite direction, giving the individual more periods to share consumption over and hence less consumption in each period. The effect of the time horizon implies that various generations respond differently to changes in wealth.

Under less strict assumptions the optimal consumption path is no longer constant. The only case in which constant consumption level represents the individual's optimal choice is when $\beta = \frac{1}{1+\rho}$ and $(\rho = r)$ hold, in other words when $\beta = \frac{1}{1+r}$. If $\beta > \frac{1}{1+r}$ consumption has a positive trend, and if $\beta < \frac{1}{1+r}$ consumption is reduced over the lifetime as *t* increases.

2.2.4 Implications of the LCH model under certainty

The marginal propensity to consume (*MPC*) with respect to wealth shows how much of a change in wealth the individual would like to increase/decrease its consumption with. The relationship can be presented as

$$\Delta C = MPC_A \cdot \Delta A_0$$

where Δ represents the marginal change, and the index *A* indicates *MPC* with respect to wealth. With the assumptions made in this presentation, where $\beta = \frac{1}{1+\rho}$ and $(\rho = r)$, MPC_A is given by

$$MPC_A = \frac{r(1+r)^T}{(1+r)^{T+1} - 1}$$

With these special assumptions the marginal propensity to consume with respect to wealth is only affected by the interest rate r and the time horizon T. The rate of time preference or the degree of impatience of the individual does not affect the degree of changes in consumption in response to changes in wealth in this case.

Table 2-2 shows how MPC_A varies with interest rate and household planning horizon.

	Household planning horizon		
Interest rate	**20 years**	**40 years**	**60 years**
0.01	0.053	0.030	0.022
0.03	0.063	0.041	0.035
0.05	0.074	0.055	0.050
0.07	0.086	0.070	0.067

Table 2-2: Marginal propensity to consume with respect to wealth

The table presents changes in current consumption per dollar of increase in wealth for a life cycle planner consumer with no bequest motive, and with the basic assumptions made in this presentation. Higher interest rate gives higher MPC_A. As the interest rate rises, individuals get higher returns on their wealth, and are able to spend more of this increased wealth each period. Longer planning horizon gives lower MPC_A. A longer planning horizon means more periods to distribute a given wealth increase over, and thus individuals prefer to spend less of the increased wealth today.

Implications of the model under certainty and with the given assumptions are that for a one dollar increase in wealth, consumption increases with around 2 to 9 cents today. For a single household the change in consumption may be almost negligible, but at macro levels such changes can have significant impact. We emphasize that this section provides an understanding of what is known in the general case, and gives predictions for optimal consumption level under simplifying assumptions.

3. The Data

3.1 Housing wealth

Estimates of housing market wealth are constructed by

$$V_t = R_t N_t I_t V_0.$$

Table 3-1 shows the notation used in the construction of the housing wealth variable (see Case et al. (2005) for a similar set of variables).

$\boldsymbol{V_t}$	Aggregate value of owner occupied housing in quarter t
$\boldsymbol{R_t}$	Homeownership rate in quarter t
$\boldsymbol{N_t}$	Number of households in quarter t
$\boldsymbol{I_t}$	House price index in quarter t (index 1980 : 1 = 100)
$\boldsymbol{V_0}$	Mean home price in the base year 1980 ($ 76.400)

Table 3-1: Explanation of variables used in housing wealth estimates

The data are obtained on aggregate national levels based on quarterly observations from 1975 to 2010. The homeownership rate R_t and the number of households N_t are collected from the Current Population Survey (CPS) by the U.S. Census Bureau. The CPS is a monthly survey of about *50,000* scientifically selected households. The data for N_t are only available at annual basis, and therefore the same observation of N_t for one year is used to construct housing wealth estimates for all four quarters within that given year. The mean home price in the base year V_0 is $ *76,400* (1980), and represents the average sales price of new homes sold in the United States. This sales price includes land and is reported by the U.S. Census Bureau.

The indices of quarterly housing prices I_t are obtained from the Federal Housing Finance Agency (FHFA), and are a broad measure of the movement of single-family house prices (index

1980 = 100). The FHFA House Price Index is a weighted repeat sales index, meaning that it measures average price changes in repeat sales or refinancing of the same properties. The use of repeat transactions on the same physical property units helps to control for differences in the quality of the houses, and the index can be described as a constant quality house price index. The index has broad geographic coverage, and because of the breadth of its sample, it provides more information than is available in many other house price indices (Calhoun, 1996).

The available data set from FHFA is reported before seasonal adjustment. Economic data which are affected by seasonal variations are often adjusted to make it easier to identify underlying changes in the economy. For the purpose of this thesis the house price index time series are seasonally adjusted to eliminate regular seasonal patterns, while leaving the underlying trend unaffected (the method applied for seasonal adjustment is presented in Appendix B). Seasonal adjustment increases the unadjusted values in weak months and decreases the unadjusted values in strong months. Hence, this practice may sometimes lead adjusted and unadjusted series to give conflicting results. According to Blitzer et al. (2010), the turmoil in the housing market in the last few years has generated unusual movements that are easily mistaken for shifts in the normal seasonal patterns, resulting in larger seasonal adjustments and sometimes misleading results. This recent research indicates that current market conditions in the housing market make seasonally adjusted data less reliable (Blitzer et al., 2010). Given that the data used in this thesis represent the whole period from 1975 to 2010 we consider it reasonable to adjust for seasonal variations, even though unadjusted time series may be more reliable over the past few years.

Estimates on aggregate housing wealth are expressed per capita in real terms (2005 dollars). A measure of the population is created by dividing real total disposable personal income by real per capita disposable personal income, similar to Ludvigson and Steindel (1999). Data for disposable personal income are reported by the Bureau of Economic Analysis. The GDP deflator is used to express nominal values in real terms. The price index for GDP, which measures the prices of goods and services produced in the United States, is provided by the Bureau of Economic Analysis. As imports are not included in GDP, the GDP deflator is for instance not directly affected by an increase in the import price of a foreign built car. The literature yields little consistency on how time series should be deflated, and while some use the GDP deflator to transform time series from nominal to real terms, others deflate the data with the consumer price index (CPI) (see e.g. Hess and Shin (1998) and Asdrubali et al. (1996)). These two methods of deflation are very different both conceptually and empirically, and estimation results are often sensitive to the choice of deflator (Sørensen and Yosha, 2007). According to Lind et al. (2008), the theory behind the GDP deflator approach is that the deflator which is a Paasche index allows new expenditure patterns to show up as people respond to changing prices. Unlike Laspayres indices, as the CPI which are based on a fixed basket of goods and services, Paasche indices allow consumption and investment patterns to change (Lind et al., 2008). Neither of the two indices is perfectly capable of capturing households' actions resulting from a price change, however, based on its presented characteristics the GDP deflator is considered appropriate for the purpose of this thesis (see e.g. the study of housing wealth by Case et al. (2005)).

The constructed measure of housing wealth V_t takes no account of the size or quality of new construction, or of improvements in existing homes. The wealth measure may thus be described as wealth of homeowners assuming they own a standard unchanging home. This definition of housing wealth keeps focus on the effects of changes in the market price of housing on consumption, and avoids touching into the problems related to housing as both an investment and consumption good. Total value of homes as a measure of housing wealth may be misleading, as there likely exists a relation between housing wealth and consumption just because housing consumption is a component of aggregate consumption. Higher consumption will supposedly give a feedback into housing wealth through changes in house size and quality, meaning that part of the housing wealth increase would be attributable to home improvements.

3.2 Consumption

Consumption data are collected from *NIPA table 2.3.5* in the National Economic Accounts provided by the Bureau of Economic Analysis, *Personal consumption expenditures (PCE) line 1*. PCE represents the primary measure of consumer spending on goods and services in the U.S. economy. It shows how much of the income earned by households is being spent on current consumption as opposed to how much is being saved for future consumption. The PCE is a main driver for future economic growth, as it accounts for more than two-thirds of domestic final spending (personal consumption expenditure equals 70.6% of GDP in Q4 2010). Data on aggregate consumption are expressed per capita in real terms using the GDP deflator, and the quarterly time series are seasonally adjusted.

The PCE measure of consumption includes an imputation for the services of the owner occupied housing stock consumed each year. By subtracting this measure of housing consumption services from aggregate consumption one can compute an adjusted consumption series[8]. Case et al. (2005) find the correlation between the adjusted and unadjusted consumption series to be 0.99959 in real terms and 0.99999 in nominal terms. Subtracting the measure of housing consumption services would therefore only be expected to give a marginal effect, and for this reason we choose not to adjust the consumption series.

3.3 Saving

The definition of U.S. household saving refers to the personal saving item in the National Income and Product Accounts (NIPA) published by the Bureau of Economic Analysis. Saving data are collected from *NIPA table 5.1, Personal saving line 9*. NIPA saving is measured as the portion of disposable income that is set aside rather than spent on consumption and related purposes (personal saving equals disposable personal income less personal outlays). Based on its definition this saving measure excludes some items and activities that affect new worth, but that are not directly associated with current production (Bureau of Economic Analysis, 2010).

There are three different empirical measures of personal saving that are widely reported and common for use in economic analysis. In addition to the NIPA saving described above, there is the Flow of Funds Accounts (FFA) measure of saving, reported by the Federal Reserve Board[9]. The FFA saving rate is based on the net acquisition of assets and it differs from the NIPA saving in several minor respects. According to Lusardi et al. (2001), the main difference between the

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[8] *Housing and utilities* is reported under household consumption expenditures in *NIPA table 2.3.5 line 15* in the National Economic Accounts provided by the Bureau of Economic Analysis.

[9] FFA personal saving rate data are collected from the *Comparison of Personal Saving in the NIPAs with Personal Saving in the FFAs* provided by the Bureau of Economic Analysis, based on data for the components of personal saving taken from table F.10 of the Federal Reserve Board's Flow of Funds Accounts of the Unites States.

two saving measures is that the FFA saving treats expenditures on consumer durable goods as saving, while NIPA treats it as personal consumption. Neither of the two saving measures described so far includes capital gains. The change in net worth is the third commonly used measure of saving, which reflects both personal saving and capital gains on existing assets. The net worth saving measure is the change in net worth expressed as a percentage of an expanded income measure that adds the capital gains to disposable income, and is based on changes in the market value of wealth (Lusardi et al., 2001). This third measure of saving is constructed based on changes in asset balances using the national Balance Sheets published by the Federal Reserve Board[10]. Figure 3-1 reports movements in the three different measures of saving rates over time.

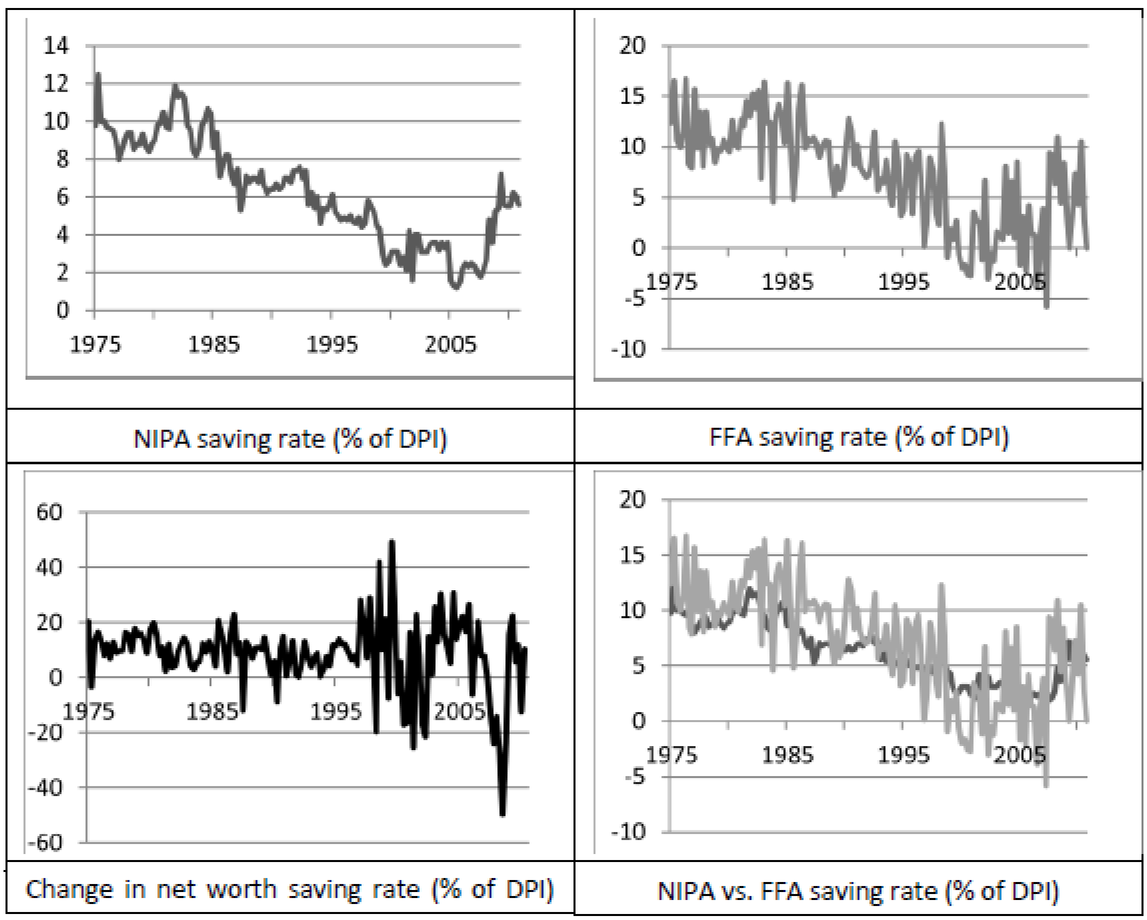

Figure 3-1: Different measures of saving rates from 1975 to 2010

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[10] Data on the net worth of households are collected from the *Comparison of Personal Saving in the NIPAs with Personal Saving in the FFAs* provided by the Bureau of Economic Analysis, based on data on the net worth of households and nonprofit organizations taken from table B.100 of the Federal Reserve Board's Flow of Funds Accounts of the Unites States.

The graphs in Figure 3-1 show saving rate movements from 1975-2010 for the three different definitions separately, as well as a comparison of the NIPA and FFA saving within the same chart (where the dark graph illustrates NIPA saving and the lighter graph illustrates FFA saving). The NIPA and FFA savings clearly show the same basic trends, while the change in net worth saving stands out reflecting the significant changes of including capital gains in the saving definition. According to asset price volatility the change in net worth saving rate shows large year to year variations. At the theoretical level the real difference between the measures of saving lies in whether the definition includes or excludes capital gains. Lusardi et al. (2001) find that accounting issues linked to the effect of capital gains on retirement accounts and tax revenues shift savings from the household sector to the government or corporate sectors. Such an effect has significant impact on NIPA saving rate levels (Lusardi et al., 2001), and may explain some of the dramatic decline in the NIPA saving in the decades prior to the recent crisis.

In deciding how to measure saving, it is relevant to look at the objective of the current study. For analysis of wealth effects we consider it more appropriate to exclude capital gains. Allowing for the return on wealth to reflect capital gains revaluations will be more informative in questions about how well households are accumulating assets for retirement or other contingencies, as well as households' ability to consume in the long run (Lusardi et al., 2001). In addition, relying on the NIPA saving seems appropriate with regards to the saving definitions in the theoretical framework presented in Section 2, where the individual's saving in period t is defined as the difference between income and consumption ($S_t = Y_t - C_t$). To sum up, there are different definitions of saving, and based on the previous discussion we consider the NIPA saving by the Bureau of Economic Analysis the most suitable measure for analyzing wealth effects and household saving in this thesis.

3.4 Disposable personal income

Data for disposable personal income are collected from the Bureau of Economic Analysis, *line 27* in *NIPA table 2.1*. Disposable personal income equals personal income less personal current taxes. It thus represents the income that households have available for spending and saving after income taxes have been accounted for.

In the NIPA the definition of income reflects the goal of measuring current production. That is, the NIPA aggregate measures of current income are viewed as arising from current production, and thus they are theoretically equal to their production counterparts (i.e. GDI equals GDP). The NIPA estimate of personal income excludes capital gains as discussed above. In other words it includes ordinary dividends paid to stockholders, but it excludes the capital gains that accrue to those stockholders as a result of rising stock prices (Bureau of Economic Analysis, 2010).

4. Overview of the U.S. Housing Market

In studying the importance of housing wealth for explaining household saving in the United States it is useful to begin with an overall perspective on the housing market. This section analyzes the evolution of house prices, and identifies the size and distribution of housing wealth.

4.1 House prices

The steady performance of the U.S. economy has contributed to a stable housing market for a long time. Until the recent market crash, national measures of house prices show substantial periods of high growth and price increases in the real estate market. The past decade is however characterized by unusual volatility, and we have seen the most dramatic decline in house prices since the Great Depression (Case et al., 2011). The national FHFA index[11] in Figure 4-1 presents the movement of house prices in the United States between 1975 and 2010.

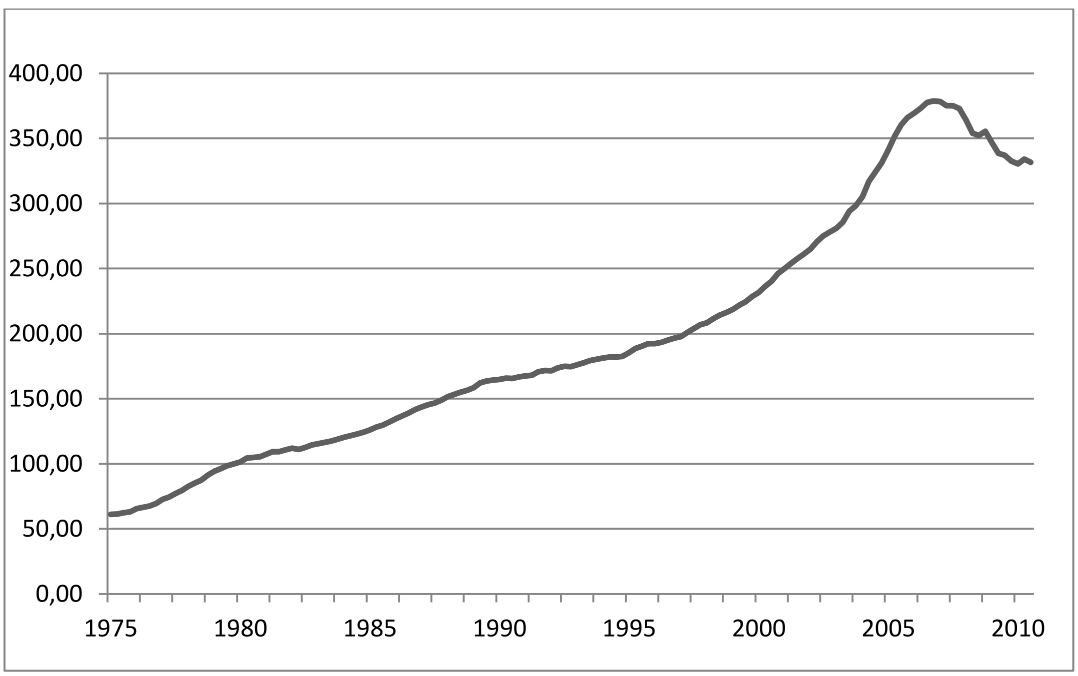

Figure 4-1: Movements in house prices 1975-2010
(FHFA housing price index seasonally adjusted (1980=100))

[11] National FHFA housing price index based on all transactions and seasonally adjusted (1980=100), provided by the Federal Housing Finance Agency.

Analysis of the data in Figure 4.1 reveals that the FHFA index never declines at all between 1975 and 2007 (calculated as annual changes at quarterly intervals), and that national house prices rise nearly six fold[12] between Q1 1975 and Q1 2007.

However, in September 2005 prices begin to fall in Boston. The decline spreads over the country, and by the summer of 2007, prices are declining in all major metropolitan areas of the United States (Case et al., 2011). Based on further analysis of the movements in house prices presented in Figure 4.1, we find that the FHFA-index declines every quarter compared to the same quarter previous year since Q4 2007. The largest annual changes occur late 2008 and the first quarter of 2010 when the index decreases by 6.07% and 6.38% respectively. Quarterly changes start to decline in Q2 2007 and have been declining since, except for two quarters out of fifteen - Q1 2009 and Q3 2010. The largest decline in the index from one quarter to the next is in Q3 2008 when the index decreases with 2.83%.

Income is generally seen as one of the key determinants of demand in the housing market. Hence it is interesting to look at the historical relationship between house prices and household income. This relationship is calculated based on data obtained from the U.S. Census Bureau and the Bureau of Economic Analysis, and presented in Figure 4-2 below. The dark graph reports the ratio of the average sales price of new homes sold in the United States[13] to per capita disposable personal income[14] between 1975 and 2010, and the light graph defines the average value of the ratio[15].

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[12] FHFA index increases *534%* (rises *5.34* times from index value *60* in Q1 1975 to index value *379* in Q1 2007, (*379-60)/60=5.34*).

[13] Average sales prices of new homes sold in the United States provided by the United States Census Bureau.

[14] *Disposable personal income* data are reported in *NIPA table 2.1 line 27* in the National Economic Accounts provided by the Bureau of Economic Analysis.

[15] Average value of the house prices to disposable income ratio is measured as the average of the annual ratios from 1975 to 2010 (where the value of the highest annual ratio equals *9.5* (2005) and the value of the lowest annual ratio equals *7.4* (2010)).

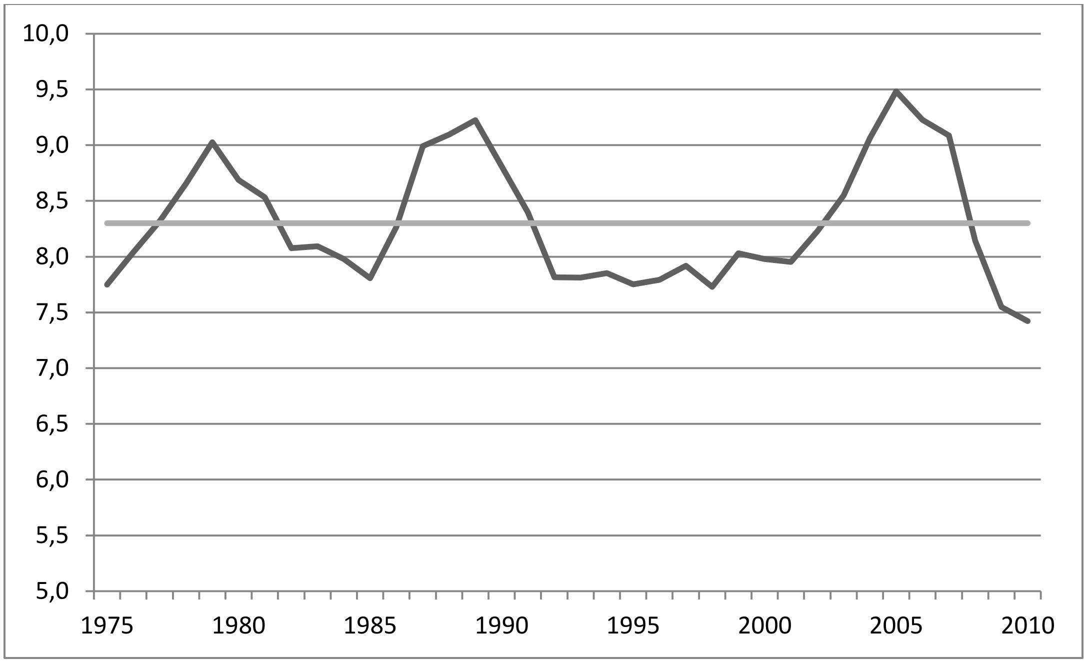

Figure 4-2: House prices to disposable income 1975-2010 (The dark graph shows the ratio of average sales prices of new homes sold to per capita disposable income and the light graph shows the average value of the ratio (8.3) over the given period)

The house prices to disposable income ratio vary around its average of 8.3 for the period. After a quite stable period during the 1990s, the ratio of home prices to income rises from around eight to 9.5 in 2005, the highest level between 1975 and 2010. The graph shows that there are substantial movements in the ratio over the cycle.

According to Case and Quigley (2010), it is natural to expect house prices to stop falling when house prices to income ratios return to normal levels. However, the data collected in this thesis clearly show that the ratio continues to fall way beyond the average level of 8.3. In Q4 2010 the ratio is 7.4, which represents the lowest level during the given period from 1975 to 2010. The recent boom and bust stands out compared to previous periods of volatility and unusual movements, but according to the graph in Figure 4-2, periods of high volatility in the ratio of house prices to income are present also in the decades before the 1990s. The recent housing bust is not the first one, but it is the first one in many decades where U.S. house prices are declining virtually everywhere (Case, 2008).

4.2 Housing wealth

4.2.1 The value and size of national housing wealth

The movements of housing prices discussed above naturally influence the evolution of housing market wealth. Figure 4-3 reports the size of housing market wealth V_t from 1975 to 2010, estimated based on the constructed measure presented in Section 3.1. Variations over time in housing market wealth are significant, and the recent drop is striking.

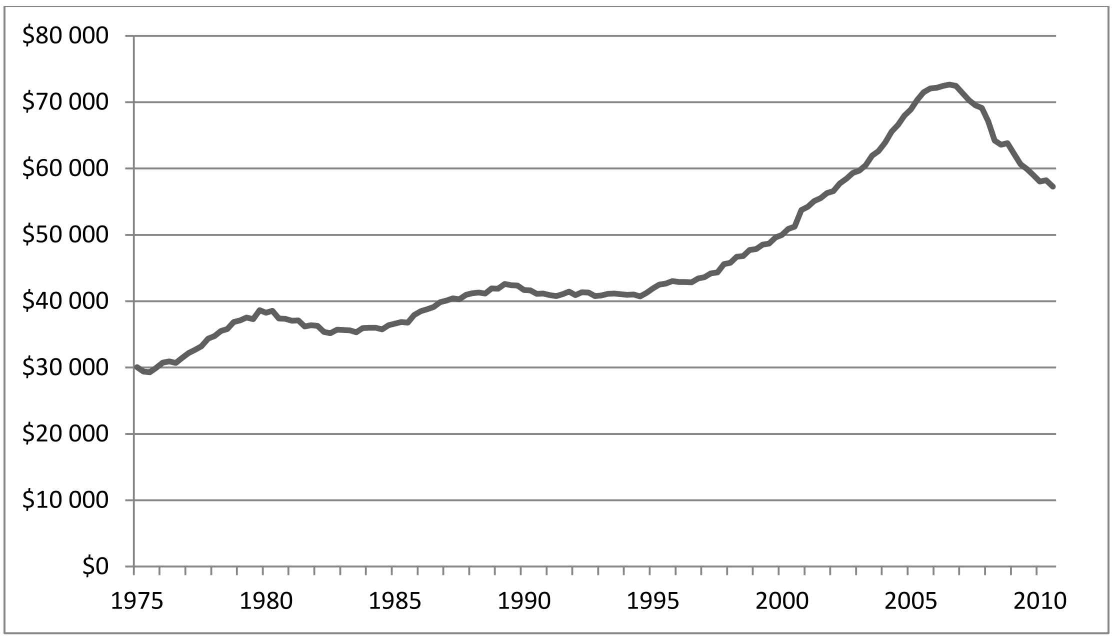

Figure 4-3: Evolution of real per capita owner-occupied housing wealth in 2005 dollars

Based on the current definition of housing market wealth[16], the shape of the graph does to a large extent reflect the movements in the FHFA index presented in Section 4.1. We have seen that the FHFA index never declines at all between 1975 and 2007, but the housing wealth estimates in Figure 4-3, which are reported in real values, reveal evidence of a few periods of declining housing wealth. However, it is worth noting that before inflation adjustment, housing wealth never declines at all in the given period from 1975 to 2007 (measured by quarterly data of annual changes).

[16] The housing wealth variable is estimated based on the formula $V_t = R_t N_t I_t V_0$ (as explained in detail in Section 3).

The unique aspects of housing wealth behavior in the twenty first century are evident when looking at Figure 4-3. From 1975 to 1995 the longest period of continuous growth is 11 quarters in a row from 1977 to 1979, whereas from 1995 the housing wealth evolution reveals 48 quarters of continuous growth, which results in a huge increase in per capita housing wealth lasting until 2007. The severe decline that follows moves far beyond the unwinding of a traditional housing boom, and the result is the dramatic decrease in housing wealth seen lately. This severe volatility is well documented in Table 4-1, which reports the value[17] and changes of housing wealth at five years intervals from 1975-2010.

Year	Housing wealth per capita (2005 dollars)	5 year change
1975	29698	
1980	38650	30 %
1985	36354	-6 %
1990	42370	17 %
1995	41263	-3 %
2000	49578	20 %
2005	67963	37 %
2010	58986	-13 %

Table 4-1: Value of housing wealth 1975-2010
(Measured at five year intervals based on the observation from the first quarter in the respective year)

The table shows that there are substantial gains in housing wealth per capita from 1975 to 2010. However, during the recent recession the size of the U.S. housing wealth is remarkably reduced, and the falling house prices are seen as a force that has compounded the severity of the downturn. This may to a large extent be explained by the central role of housing wealth in the U.S. economy. Data from the "2007 Survey of Consumer Finances" by the Federal Reserve Board show that as much as *68.6%* of families held assets in primary residence and *13.7%* held

[17] Value of housing wealth is measured per capita in 2005 dollars, and is based on the observation from the first quarter in the respective year.

assets in other residential property[18], while only *17.9%* of families held assets in stocks[19] (covering only those stocks and bonds that are directly held by families outside mutual funds, retirement accounts and other managed assets) (Board of Governors of the Federal Reserve System, 2009). The term family used in this survey includes one-person units and is comparable to the U.S. Census Bureau's household concept (U.S. Census Bureau, 2011).

It is evident that most American households are exposed to the housing market, which might indicate that wealth effects operating through the housing sector are especially important. Changes in the value of other assets may generate similar effects, but the central role of residential real estate in national wealth suggests that changes in housing wealth should be considered to have a larger and more important impact on household consumption than for instance stock market wealth. When looking at the type of assets held by American families, we see that only a small share is directly exposed to the stock market. However, the wide diffusion of housing wealth emphasizes the importance of the potential existence of a housing wealth effect over the recent crisis.

An overview of house ownership rates[20] over time is presented in Figure 4-4.

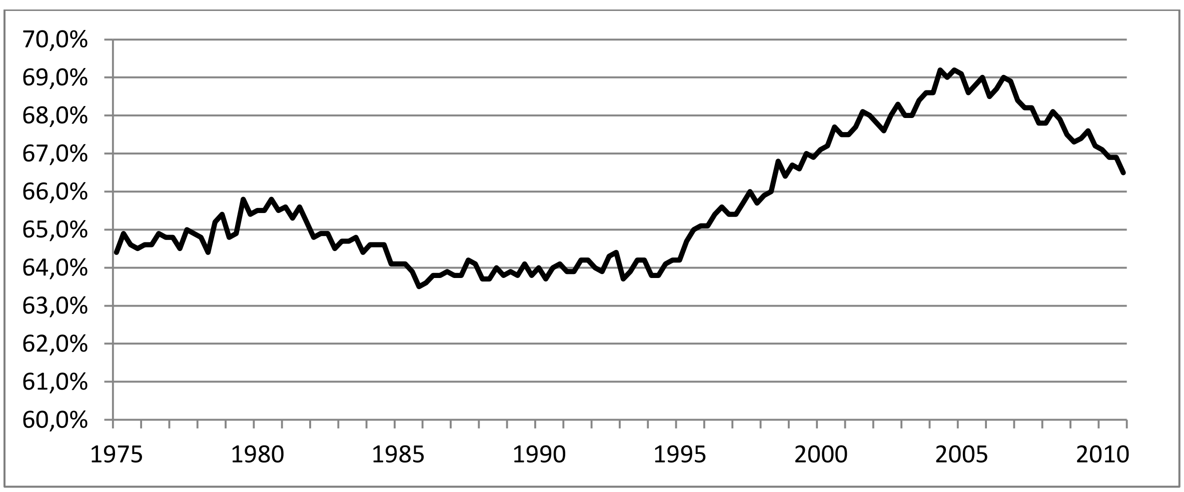

Figure 4-4: House ownership rates 1975-2010

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[18] Data obtained from Table 8-1: Nonfinancial assets held by families by type of asset: 2007 in Appendix C.

[19] Data obtained from Table 8-2: Financial assets held by families by type of asset: 2004 and 2007 in Appendix C.

[20] The house ownership rates are collected from the Current Population Survey by the United States Census Bureau.

The house ownership rate is defined as the share of households occupied by the owner (U.S. Census Bureau, 2011). High values in the home ownership rate can indicate potential strong wealth effects, as more households are affected by housing wealth volatility. After a pretty stable share of housing investments over a decade, the ownership rate increases significantly from the second half of the 1990s. The growth in home ownership lasts until late 2004 when the ratio reaches its peak at *69.2%*. The high numbers of home ownership emphasize the importance of housing wealth and hence expectations of strong housing wealth effects. However, from 2007 the ratio experiences a dramatic decline indicating that many households have been severely affected by the recent crisis and many houses have become foreclosed. The house ownership rate is *66.5%* in Q4 2010, representing the lowest level since 1998.

House ownership has been promoted both directly and indirectly by government policy through tax policy as well as government sponsored entities as Freddie Mac, Fannie Mae and the Federal Home Loan Banks (Case, 2008). The promotion of house ownership by the government through encouraging mortgage borrowing and lending has given rise to debates regarding government policies after the subprime mortgage crisis, but such discussions are beyond the scope of this thesis.

4.2.2 The distribution of national housing wealth

We have seen that housing wealth represents a large share of total wealth in the United States. In addition, housing wealth constitutes the main share of total wealth for U.S. households, and is widely diffused as more than 65% of the households are exposed to the housing market. It is evident that home ownership is one of the main sources of household wealth, there are however large differences across regions, races and age groups.

House ownership rates tend to vary depending on demographic characteristics of households, such as ethnicity and type of household as well as location and type of settlement. House ownership is most common in rural areas as well as in suburbs, where as much as 75% of suburban households own their own house (Case and Quigley, 2010).

Based on data from the U.S. Census Bureau, regional differences are presented in Figure 4-5, which reports house ownership rates by states in 2010[21].

Figure 4-5: House ownership rates by states in 2010

[21] The house ownership rates by states are collected from Table 15 in the Housing and Household Economic Statistics Division, provided by the United States Census Bureau.

The data presented in Figure 4-5 show that the Midwestern states have the highest house ownership rates, whereas the Western states are among the lowest. District of Colombia and New York have the lowest home ownership rates in the country, with 46% and 55% respectively. Regional differences may to a large extent be explained by variations in house price movements between different states. Case et al. (2005) explains such regional differences mainly to arise from differences in the elasticity of land supply, the performance of regional economies and the changing demographics of states.

House price measurements collected from the FHFA state indices show that the state housing markets have been moving in complicated and asynchronous ways over the recent crisis, as presented in Figure 4-6. Figure 4-6 reports annual house price movements across a selection of different states in which house prices have evolved very differently from 1995 to 2010[22].

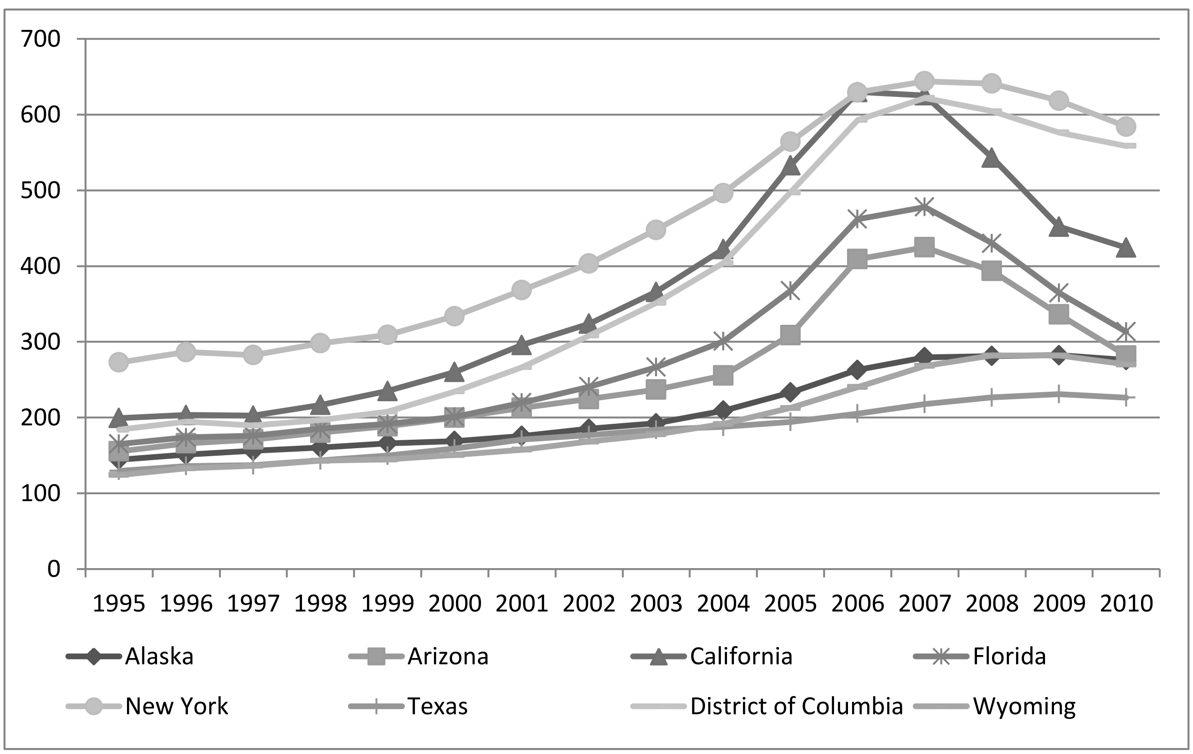

Figure 4-6: House price movements across states 1995-2010
(FHFA state index (1980=100))

[22] FHFA state index (1980=100) based on annual observations from the first quarter in the respective year, provided by the Federal Housing Finance Agency.

The variations in the evolution of house prices across states are striking. The graphs yield evidence that the most substantial growth in house prices prior to the recent crisis occurs in regional booms. The most dramatic patterns are to be found in California, Florida and Arizona, which are out of line with the rest of the country, both in terms of the housing price boom and bust. We find that the FHFA state index for California rises as much as 142% from 2000 to 2006, and in Florida and Arizona indexes are up 130% and 105%, respectively.

Most regions experience severe housing price declines over the recent crisis, but the degree seems to a large extent to depend on the size of the boom in advance. The largest declines occur in regions with the largest price increases and in areas where overbuilding is most extreme. A substantial boom of credit to less qualified buyers in the years before the crisis, may to some extent explain why some states experience such dramatic house price increases, and why some of these same states see the most substantial periods of declines after the crisis is a fact (Case et al., 2011).

Further analyses of the data in Figure 4-6 reveal that house prices in California, Florida and Arizona are down 32%, 34% and 34% respectively. District of Columbia stands out with a tremendous growth in house prices which is followed by a less dramatic period of falling prices (10% decrease from 2007-2010), while other states with the same tremendous growth experience deep declines (e.g. California). The New York house price evolution is quite similar to that of the District of Colombia with high growth, but much weaker declines than many other areas. In contrast to the striking house price movements in many states, some regions do not experience any boom at all. Texas for instance witnesses a steady path with quite stable house prices for many years prior to the crisis, and while other states experience deep declines, house prices in Texas increase by 4% between 2007 and 2010. The patterns in Alaska and Wyoming are much like that in Texas.

Based on data obtained from the U.S. Census Bureau we find that there are differences among racial demographics which impact home ownership rates. European Americans have the highest ratio (*74.4%* in 2010 compared to the national average of *66.9%*), while African Americans have the lowest ratio (*45.4%* in 2010 compared to the national average of *66.9%*)[23]. These differences may depend on the fact that house owners tend to have higher incomes, and there is still an uneven distribution of income across races in the Unites States. Furthermore, the data reveal that for white families house ownership is worth more on average than what is the case for black families. Despite these large differences in the distribution of housing wealth among different ethnicities, we find that the gap decreases in the last decade before the crisis. However, it is now slightly widening again.

When analyzing housing wealth it is also interesting to look at the distribution of wealth among different generations. The amount of wealth is expected to grow over the life cycle, which is confirmed by Figure 4-7. Figure 4-7 reports house ownership rates for different generations in 2010, based on data collected from the U.S. Census Bureau[24]. We find that there is clear evidence of housing wealth accumulation as people get older.

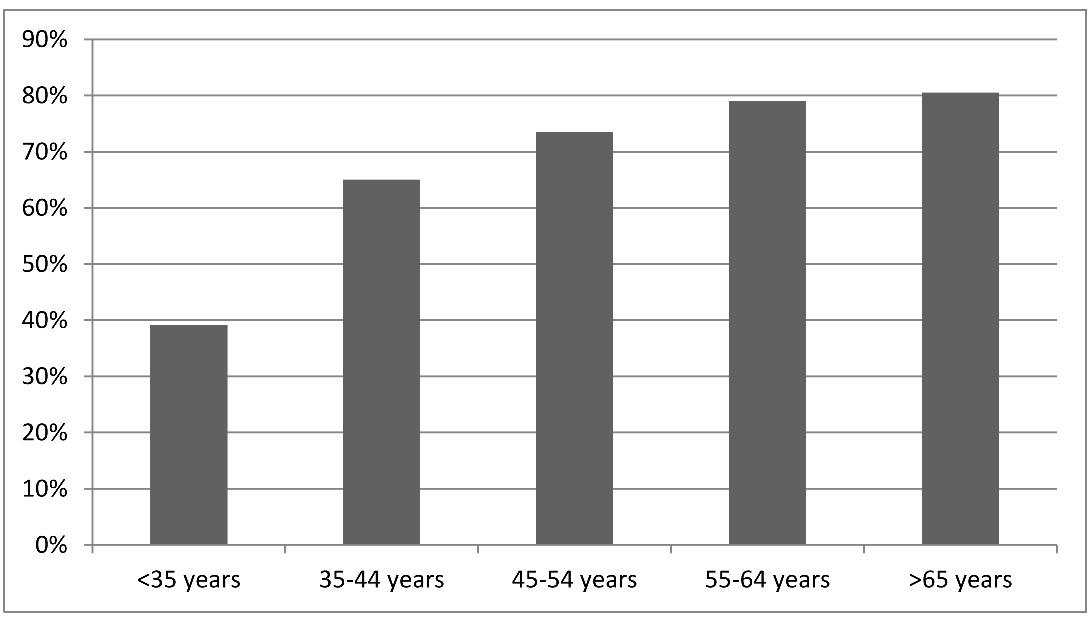

Figure 4-7: House ownership rates by generations in 2010

[23] The house ownership rates by race and ethnicity of householder are collected from Table 22 in the Housing and Household Economic Statistics Division, provided by the United States Census Bureau.

[24] The house ownership rates by generations are collected from Table 17 in the Housing and Household Economic Statistics Division, provided by the United States Census Bureau.

Based on the analysis of housing wealth size and distribution provided in this section, we have seen that despite large regional differences and uneven concentrations of wealth among U.S. households, housing wealth is widely diffused among the population. As a result, it is natural to expect that even a small decline in the value of housing wealth can generate wealth losses that are both large in relation to national income and widely distributed among the population. The significant housing wealth losses seen during the recent crisis are severe, and might affect household consumption and saving over and above what has been associated with previous booms and busts.

5. The Impact of Housing Wealth on Consumption and Saving

This empirical study attempts to examine how changes in housing wealth affect household consumption in the United States, to determine potential housing wealth effects. The objective is to investigate whether household saving is affected by the slump of the U.S. housing market during the recent crisis, where a large number of homeowners suffer from real capital losses. Furthermore, we discuss the implications of the empirical findings for the well-established economic theories presented in Section 2, and provide an overview of limitations to the study and interesting directions for future research.

5.1 Housing wealth and consumption

Evolution of consumption as a share of disposable personal income is calculated based on per capita measures in 2005 dollars, and illustrated in Figure 5-1. It is evident that the consumption to income ratio shows large historical variations. The significant drop over the recent crisis hits bottom in Q2 2009 when PCE as a percent of DPI equals 89.4%, the lowest level on seventeen years since Q2 1992.

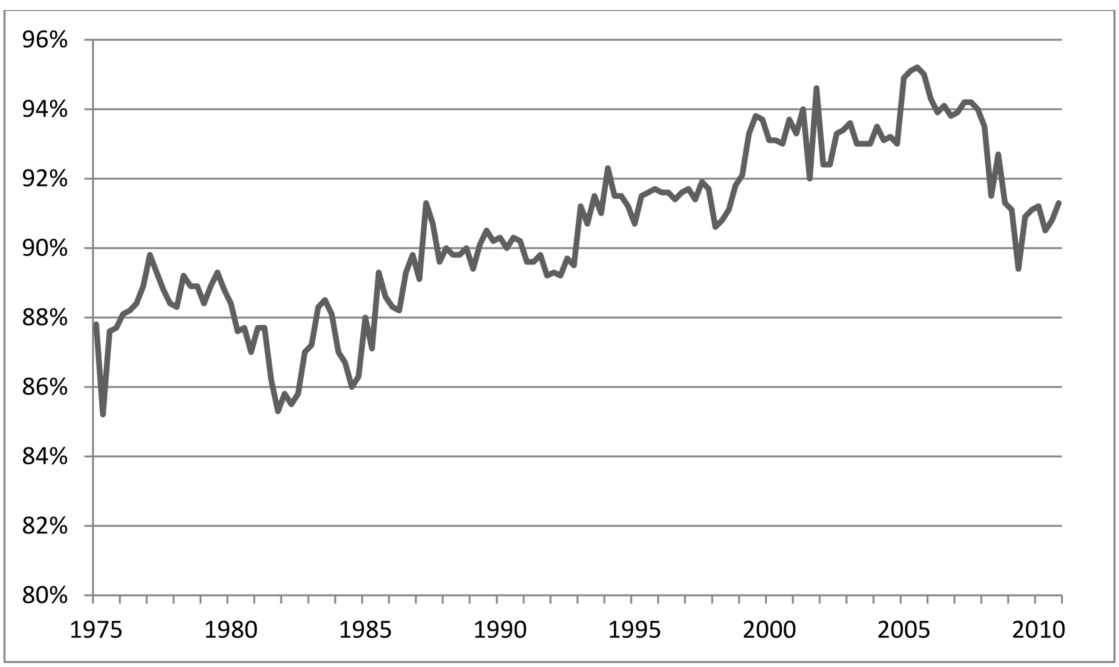

Figure 5-1: Evolution of consumption as share of disposable personal income 1975-2010
(Calculated based on per capita measures in 2005 dollars)

Figure 5-2 provides an overview of the relationship between changes in housing wealth and changes in consumption behavior.

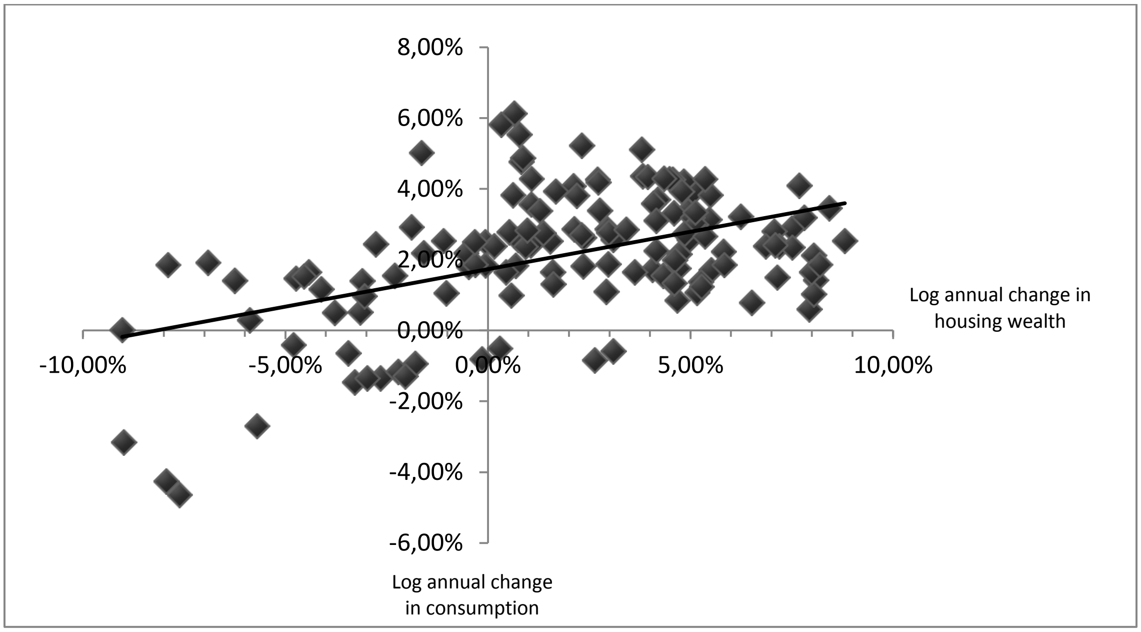

Figure 5-2: Overview of relationship between changes in housing wealth and consumption 1975-2010
(Plots log annual changes in housing wealth vs. log annual changes in consumption across years. All variables are measured per capita in 2005 dollars and based on quarterly observations)

The scatter diagram shows log changes in consumption against log changes in housing wealth, and the straight line represents the relationship between the two variables according to the least square method. Based on observations from 1975 to 2010 the figure suggests that annual changes in consumption are positively correlated with changes in housing wealth. Based on the scatter diagram the relationship seems to be somewhere between weak and medium in strength. The coefficient of correlation is estimated to describe the linear relationship numerically. Calculations give coefficient of correlation between changes in housing wealth and changes in consumption of *0.472* at per capita levels, telling us that the positive relationship is moderately strong. The positive relationship suggests evidence of transmission mechanisms from housing wealth to consumption.

5.2 Housing wealth and saving

The purpose of the empirical analysis is to investigate the relationship between housing wealth and consumption. More specifically we want to determine whether the recent large drop in housing wealth gives significant decline in consumption. Another approach to investigate this relationship is to look at saving rates, and find whether a housing wealth decrease makes household increase their saving. An indication of an existing wealth effect is a negative relationship between the saving rate and the housing wealth to disposable income rate. Figure 5-3 presents the personal saving rate as well as the housing wealth to DPI rate. The left-hand scale with the associated dark graph is NIPA saving as a percent of DPI, and the right-hand scale with the associated light graph measures housing wealth to DPI. Both ratios are calculated based on per capita numbers in 2005 dollars.

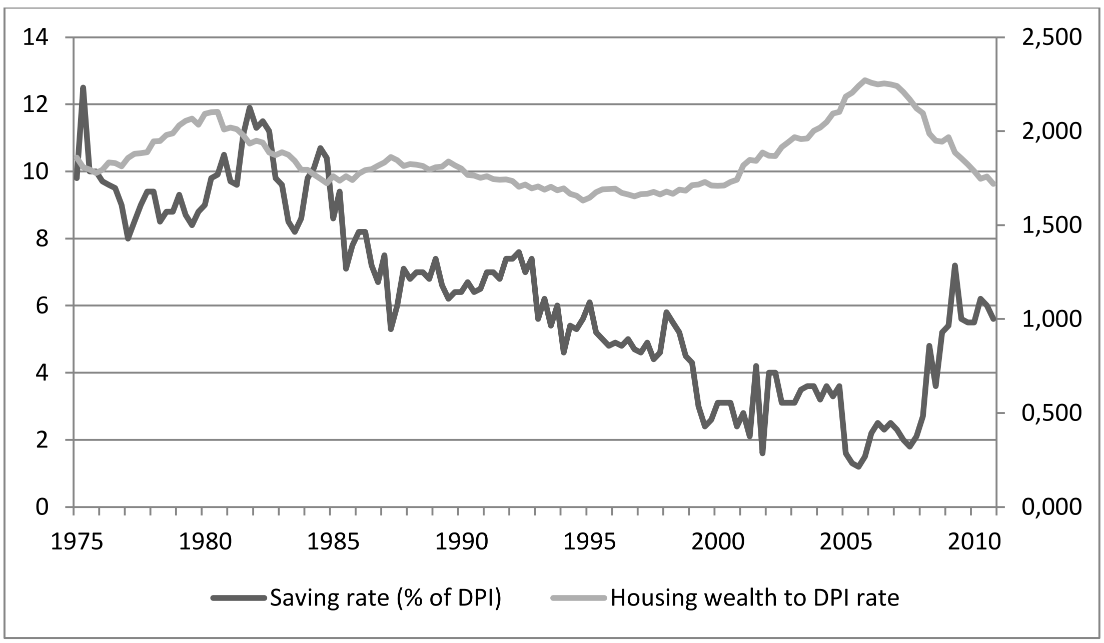

Figure 5-3: Evolution of saving and housing wealth to disposable personal income 1975-2010
(The left-hand scale with the associated dark graph shows the NIPA saving as a percent of disposable personal income, and the right-hand scale with the associated light graph measures housing wealth to disposable personal income. Both ratios are calculated based on per capita measures in 2005 dollars)

The saving rate rises from the beginning of the period to 1981 when it reaches its highest level at *11.9%*, before it declines steadily to very low levels. The saving rate hits its lowest level at *1.2%*

in 2005, and in 2008 it increases remarkably to *5.2%,* the highest level since the 1990s. In Q2 2009 the saving rate reaches *7.2%* and it now seems to have stabilized around *5.5-6.0%.* It is clear from the figure that the housing wealth to disposable income rate is dominated by very low frequency movements, which can make it hard to tell what the relation really is between housing wealth and other slow moving variables. Housing wealth relative to disposable income is virtually steady for a long time in the current period, but the recent boom and bust is clearly evident. After a steady increase from the end of the 1990s the housing wealth to DPI rate reaches its highest level at *2.7* in 2005, the same year as the saving rate is at its lowest. From 2005 the ratio declines significantly and housing wealth is now *1.7* times disposable income at per capita levels, the lowest rate since 2000.

The two time series in Figure 5-3 above indicate the existence of a housing wealth effect in the United States. The recent crisis is expressed by the largest increase in saving as well as the most significant drop in the housing wealth to disposable income rate between 1975 and 2010. The correlation plot in Figure 5-4 also yields evidence suggesting a negative relationship between housing wealth and saving.

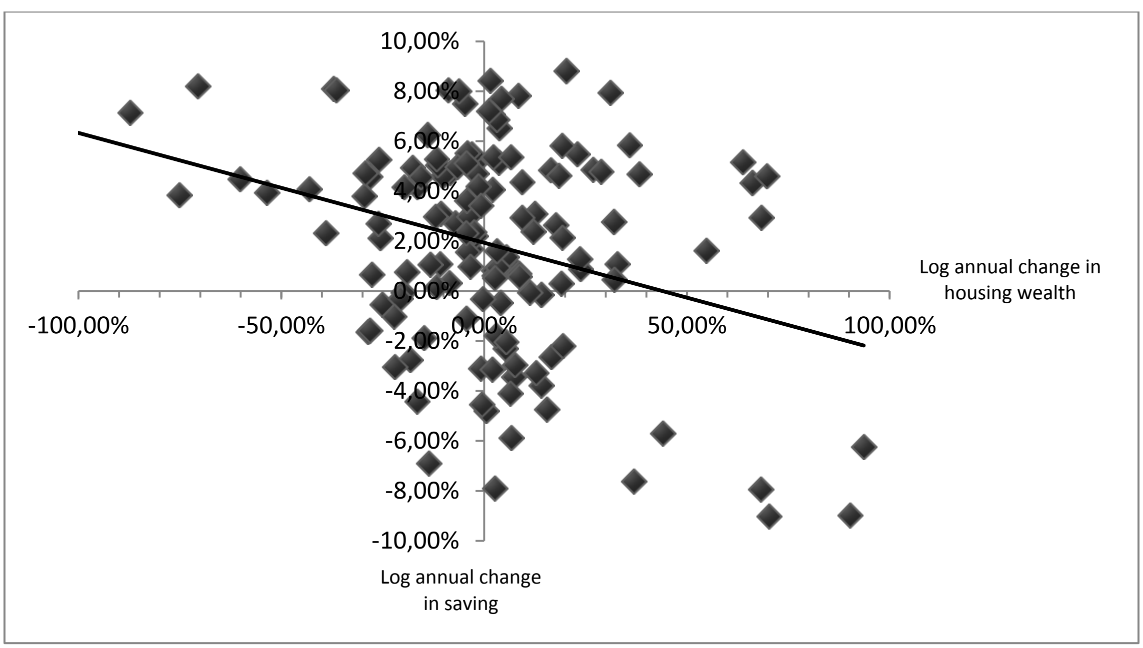

Figure 5-4: Overview of relationship between changes in housing wealth and saving 1975-2010
(Plots log annual changes in housing wealth vs. log annual changes in NIPA saving across years. All variables are measured per capita in 2005 dollars and based on quarterly observations)

The previous figures of Section 5.1 and Section 5.2 provide evidence of a significant positive relationship between housing wealth and consumption, as well as a significant negative relationship between housing wealth and saving. Statistical correlation is used to evaluate the strength and direction of the relation between the variables. This is valuable information that indicates that the variables are associated with each other, and based on these results it might look like a housing wealth effect is present. However, correlation does not imply causation, and to provide sufficient evidence that housing wealth affects consumption, we continue the analysis and introduce statistical regressions to find whether housing wealth effects can be determined through more sophisticated empirical estimates.

5.3 Empirical estimates

The following empirical analysis tries to quantify the potential housing wealth effects indicated by the above correlation analysis. As a point of departure our proposed regression model is a basic ordinary least squares (OLS) relationship between consumption, income and housing wealth given by

$$\Delta c_t = \beta_0 + \beta_1 \Delta y_t + \beta_2 \Delta v_t + \varepsilon$$

where c is personal consumption expenditure, y is disposable personal income, v is housing wealth and ε is the error variable. All variables are stated in 2005 dollars and measured per capita in logarithms. The Δ in front of the variables indicates that we study changes from one time period to another.

We transform the data series from original level terms into a series of period-to-period differences to facilitate compliance with the condition of stationary data in time series analysis and avoid spurious regressions. Spurious regressions refer to a common problem in regressions based on non-stationary data, which increases the chances of *Type I* errors. *Type I* error occurs when we reject a true null hypothesis (Keller, 2005). An example is when the empirical estimates show that there is a significant relationship between variable *A* and variable *B*, whereas in fact both variables are affected by a third variable *C*, which makes it look like the two variables are related even if there is no direct connection. If the variables are not stationary we cannot validly undertake hypothesis tests about the regression parameter (Brooks, 2008).

A stochastic variable is stationary if $E[x_t]$ is independent of time t and $Var[x_t]$ is constant and independent of time t (Brockwell and Davis, 2002). Figure 5-5 presents two time series of log consumption; c_t (log) associated with the dark graph and Δc_t (log difference) associated with the light graph, where $\Delta c_t = c_t - c_{t-1}$.

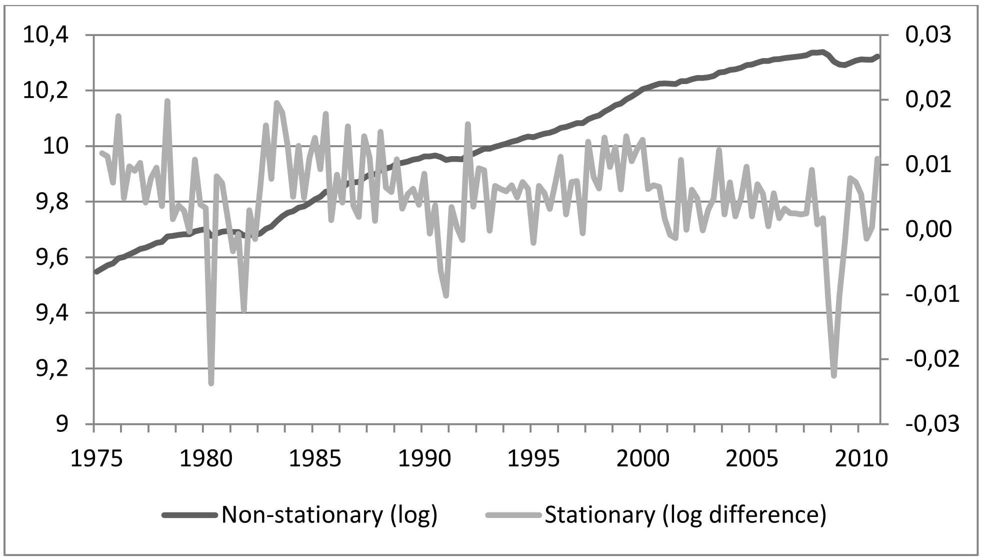

Figure 5-5: Illustration of graphical difference between non-stationary and stationary process
(The left-hand scale with the associated dark graph shows the time series of log consumption from 1975-2010, and the right-hand scale associated with the light graph shows the time series of log difference of consumption)

The time series c_t clearly exhibits trends and represents a non-stationary process, whereas the series of differences, Δc_t, looks like a stationary process where all the observations seem to vary around a common expected value and the variance seems constant throughout the period.

An Augmented Dickey-Fuller (ADF) test can be used to test for non-stationarity. Testing for non-stationarity is equivalent to testing for the presence of a common unit root, and a widely used tool to test for common unit root is the ADF-test formulated by Dickey and Fuller in 1979 (Dickey and Fuller, 1979). The null hypothesis of the ADF-test is the presence of unit rots in the time series, meaning that if we reject the null hypothesis we reject the presence of a common unit root and conclude that the variables are stationary. We perform an ADF-test to support the graphical observations in Figure 5-5. The statistical results of the test are presented in Table 5-1 for the two time series of log consumption; c_t (log) and Δc_t (log difference), where $\Delta c_t = c_t - c_{t-1}$ (for additional test specifications see Table 8-3 and Table 8-4 in Appendix D).

	t-ADF
1975-2010	
$\boldsymbol{c_t}$	-0.469
$\boldsymbol{\Delta c_t}$	-8.747*

Table 5-1: Illustration of statistical difference between non-stationary and stationary process by ADF-test
(The ADF-test tests for a common unit root, where the null hypothesis is the presence of unit roots in the time series. For the time series of $\Delta \boldsymbol{c_t}$ we reject the presence of common unit root and conclude that the data are stationary at 5% level of significance. Note that * indicates evidence of stationarity in this case)

Table 5-1 shows clear evidence that we can only reject the null hypothesis of non-stationary variables for Δc_t, as the ADF critical value is *-2.88* at the 5% level of significance. The statistical evidence confirms our graphical findings from Figure 5-5, and only determines Δc_t to fulfill the conditions of a stationary time series. The reason behind the transformation of our data series, from original level terms into a series of period-to-period differences, is based on these findings that log data are often non-stationary whereas data of log differences are often stationary.

In the empirical analysis we estimate the relations for log annual changes ($\Delta c_t^{annual} = c_t - c_{t-4}$) in addition to log quarterly changes ($\Delta c_t^{quarterly} = c_t - c_{t-1}$) to capture potential differences in empirical results based on each data specifications. We perform an ADF-test on our time series data to test for statistical stationarity and avoid running spurious regressions. Looking at the test results in Table 5-2 we find that all variables meet the condition of stationarity, except the log annual changes of housing wealth with an ADF test statistic of *-1.374*. The ADF critical value is -*2.88* at the 5% level of significance for log annual changes (T=136) as well as the log quarterly changes (T=139) time series (for additional test specifications see Table 8-4 and Table 8-5 in Appendix D).

	t-ADF
1975-2010 (log annual change)	
Δc_t^{annual}	-3.123*
Δy_t^{annual}	-4.560*
Δv_t^{annual}	-1.374
1975-2010 (log quarterly change)	
$\Delta c_t^{quarterly}$	-8.747*
$\Delta y_t^{quarterly}$	-13.69*
$\Delta v_t^{quarterly}$	-8.137*

Table 5-2: Augmented Dickey Fuller (ADF) test 1975 2010
(The ADF-test tests for a common unit root, where the null hypothesis is the presence of unit roots in the time series. The presence of common unit root equals non-stationarity. Note that * indicates evidence of stationarity at 5% level of significance)

The presence of non-stationary variables in the time series of log annual changes of housing wealth increases probability of misinterpreting the empirical results based on these data. These results have implications for our further analysis. We recall that if the variables are not stationary, we cannot validly undertake hypothesis tests about the regression parameters. However, we choose to continue to run empirical estimates based on the time series of annual changes, but will be careful not to draw conclusions only based on these estimates as non-stationarity increases the chances of spurious regressions.

The use of logarithmic data implies that the empirical estimates measure how much log consumption changes as a result of a one unit change in log disposable income and log housing wealth. As a result, the estimate for housing wealth β_2 cannot directly function as a measure of the marginal propensity to consume with respect to wealth ($\mathrm{MPC_A}$). We recall that the MPC_A, which we introduced in the theoretical framework in Section 2, is based on data in absolute terms. As Δc_t approximately equals $(\Delta C_t)/C_t$, the log-transformed regression model captures the response of $(\Delta C_t)/C_t$ from $(\Delta V_t)/V_t$.

The following empirical study is based on quarterly data from Q1 1975 to Q4 2010, (covering *144* observations). To investigate whether potential effects are constant over time we also perform an isolated study of the period from 1997 to 2006 (*40* observations), and the period from 2007 to 2010 (*16* observations). These two studies allow us to capture the potential impacts of housing wealth on consumption in the boom and bust of the housing market related to the recent crisis. Together these two periods represent ten years of substantial housing wealth growth experienced pre-crisis, as well as the dramatic decline in housing wealth seen lately, providing the opportunity to discover potential asymmetric wealth effects. The operationalized version of the OLS regression equation presented in the beginning of Section 5.3 is given by

$$PCE = \beta_0 + \beta_1 DPI + \beta_2 V(t) + \varepsilon$$

where *PCE* is personal consumption expenditure, *DPI* is disposable personal income, *V(t)* is housing wealth and ε is the error variable.

5.3.1 Empirical results 1975-2010

Table 5-3 presents the basic OLS relationships between consumption, income and housing wealth. The statistical results for the log annual changes time series given in the table indicate that the estimated effect of income and housings wealth on consumption is significant and large in the time period from 1975 to 2010. The estimated magnitudes of the evident effects are given by the size of the coefficients reported in Table 5-3. The coefficients for income and housing wealth are *0.715* and *0.129* respectively, indicating that the impact of income on consumption is larger than that for housing wealth. The marginal propensity to consume with respect to housing wealth when looking at annual effects is *0.129*, meaning that a one percent increase in housing wealth on average increases consumption by *0.129* percent in this period, ceteris paribus.

The test results of the OLS model based on log quarterly changes support these findings, revealing that both income and housing wealth have significant impact on consumption over this time period. According to Table 5-3, the magnitude of the estimated effects becomes smaller when the empirical estimates are based on log quarterly changes. This is true for the effects of both income and housing wealth with coefficients of *0.249* and *0.076* respectively. The marginal propensity to consume with respect to housing wealth when looking at quarterly effects is *0.076*.

	Coefficient	t-value (t-prob)
1975-2010 (log annual change)		
Constant	0.005*	2.57 (0.011)
DPI	0.715*	9.85 (0.000)
V(t)	0.129*	4.74 (0.000)
1975-2010 (log quarterly change)		
Constant	0.004*	6.18 (0.000)
DPI	0.249*	4.14 (0.000)
V(t)	0.076*	2.03 (0.044)

Table 5-3: Ordinary Least Square model (OLS) 1975-2010
(* indicates significant effect at 5% level of significance)

As the data constitute a time series there may be a problem of autocorrelation, a condition in which there exists a relationship between consecutive values of the residuals (Keller, 2005). The Durbin-Watson (DW) test determines whether there is evidence of first-order autocorrelation. According to a DW statistic of *0.679*, there is enough evidence to infer that positive first-order autocorrelation exists in the estimated model with log annual changes. The OLS model for the log quarterly changes time series may also be subject to the presence of autocorrelation, as the estimated DW statistic of *1.76* shows that the test is inconclusive. The critical values are $d_L = 1.71$ and $d_U = 1.76$ for *T=150* and *k=2* (for additional test specifications for the OLS model from 1975 to 2010 see Table 8-6 and Table 8-7 in Appendix D).

A common tool to solve the problems of autocorrelation present in the basic OLS model is to introduce Autoregressive (AR) models. When our two models are extended to allow for first order serial correlation the outcomes of the log annual change model remain the same – changes in income and housing wealth still have significant impact on consumption, whereas the results of the log quarterly change model differ from the basic OLS model – only changes in income are still significantly related to consumption. The AR(1) model on log quarterly changes also indicates that the observation of consumption in the previous quarter has a significant effect on consumption in the next quarter (the test specifications on the AR(1) estimation sample for log annual changes and log quarterly changes are given in Table 8-8 and Table 8-9 in Appendix D).

However, to correct the effects of autocorrelation the econometrics literature suggests the use of Newey-West estimators, which are consistent even when there is evidence of autocorrelation (Newey and West, 1987)**.** To overcome the problems of autocorrelation present in our OLS estimated results, we introduce the Newey-West Heteroscedasticity and Autocorrelation Consistent (HAC) estimator. According to Newey and West (1987) the HAC estimator is considered more robust when correcting for the effects of autocorrelation, and in addition the estimated standard errors are heteroscedasticity consistent. Heteroscedasticity consistent refers to the condition when the variance of the error variable is constant (Keller, 2005).

The HAC estimators for our two time series of log annual changes and log quarterly changes from 1975 to 2010 are presented in Table 5-4. We observe that the t-values change, while the coefficients are similar to those in the basic OLS estimates. The econometric specifications show that for the log annual change data the reliable test statistics of the HAC estimator support the previous findings that both income and housing wealth have significant impact on consumption. However, after correcting for autocorrelation and heteroscedasticity in the model of log quarterly changes, we observe that the relationship between housing wealth and consumption is no longer statistically significant. For infinite number of observations the coefficients are significant at *1.96* at 5% level of significance (for additional test specifications for the HAC estimators from 1975 to 2010 see Table 8-6 and Table 8-7 in Appendix D).

	Coefficient	t-HACSE
1975-2010 (log annual change)		
Constant	0.005	1.396
DPI	0.715*	7.839
V(t)	0.129*	3.072
1975-2010 (log quarterly change)		
Constant	0.004*	3.752
DPI	0.249*	2.844
V(t)	0.076	1.934

Table 5-4: Heteroscedasticity and Autocorrelation Consistent (HAC) estimator 1975-2010
(* indicates significant effect at 5% level of significance)

We have seen that the given time period from 1975 to 2010 includes an unusual period of housing wealth growth. The sudden decline in housing wealth seen at the end of the period is in sharp contrast to the former trend. We therefore find it interesting to run our model from 1975 to

2006 to see if the empirical estimates yield different results when we exclude the latest observations of dramatic declines seen over the recent crisis.

Using the HAC estimator we can only state that income has a significant effect on consumption between 1975 and 2006. When the unusual volatility over the recent crisis is excluded from the data series, housing wealth has no longer a significant effect on consumption for the estimates based on log annual changes. According to Table 5-5 the coefficient of income is *0.643*, which is slightly lower than the magnitude of the effect of income on consumption from 1975 to 2010, measured as *0.715*. The principle results for the log quarterly change series in the previous findings are unchanged, but the estimated magnitude of the effect of income on consumption is slightly lower than when the more recent observations from 2007 are included in the analysis, *0.216* versus *0.249* (for additional test specifications for the HAC estimators from 1975 to 2006 see Table 8-10 and Table 8-11 in Appendix D).

	Coefficient	**t-HACSE**
1975-2006 (log annual change)		
Constant	0.008*	1.981
DPI	0.643*	7.575
V(t)	0.084	1.492
1975-2006 (log quarterly change)		
Constant	0.005*	3.973
DPI	0.216*	2.279
V(t)	0.037	0.747

Table 5-5: Heteroscedasticity and Autocorrelation Consistent (HAC) estimator 1975-2006
(* indicates significant effect at 5% level of significance)

We notice that the effects of income on consumption are fairly stronger when looking at the estimates for log annual changes compared to the model of log quarterly changes. It is also interesting to observe that that the estimated magnitudes of the impact of income are slightly smaller when excluding the latest observations of consumption declines over the recent crisis. This is true for the model of log annual changes as well as the model of log quarterly changes, where the coefficients of income decrease from *0.715* to *0.643* and *0.249* to *0.216* respectively.

5.3.2 Empirical results 1997-2006

Table 5-6 presents the empirical results of the OLS model when used on data from Q1 1997 to Q4 2006 only. These *40* observations represent ten years of substantial housing wealth growth, but according to the estimated results there is no evidence of a significant relationship between housing wealth and consumption for neither of our two data series. For the model of log annual changes the regression output shows evidence of a significant effect of income on consumption, whereas the model of log quarterly changes indicates no such effect (for additional test specifications for the OLS model from 1997 to 2006 see Table 8-14 and Table 8-15 in Appendix D).

	Coefficient	t-value (t-prob)
1997-2006 (log annual change)		
Constant	0.016*	2.24 (0.031)
DPI	0.478*	3.75 (0.001)
V(t)	-0.025	-0.256 (0.799)
1997-2006 (log quarterly change)		
Constant	0.007*	5.28 (0.000)
DPI	0.095	1.09 (0.285)
V(t)	-0.114	-1.44 (0.158)

Table 5-6: Ordinary Least Square model (OLS) 1997-2006
(* indicates significant effect at 5% level of significance)

The OLS model of log annual changes is also subject to autocorrelation, questioning the validity of the results indicated by Table 5-6. DW statistic of *0.57* yields clear evidence of positive first-order autocorrelation, with critical values of $d_L = 1.39$ and $d_U = 1.60$.

In order to get reliable test statistics for the coefficients and allow for better correction of the problems of autocorrelation, we use HAC estimators instead of AR-models with lagged dependent variables. The estimated results in Table 5-7 below confirm that housing wealth is not significantly related to consumption during the period from 1997 throughout 2006. There is however sufficient evidence to infer that the relationship of income and consumption is linearly related in the model of log annual changes, while the empirical estimates of log quarterly changes yield no such evidence. In the model of log quarterly changes the estimated HAC statistics imply that none of the variables have a significant effect on consumption, indicating that there are probably other factors driving the strong increase in consumption during this period of unusual housing wealth growth. The critical value is *2.02* for *40* observations at 5% level of significance (for additional test specifications for the HAC estimators from 1997 to 2006 see Table 8-14 and Table 8-15 in Appendix D).

	Coefficient	t-HACSE
1997-2006 (log annual change)		
Constant	0.016	1.716
DPI	0.478*	4.737
V(t)	-0.025	-0.215
1997-2006 (log quarterly change)		
Constant	0.007*	4.261
DPI	0.095	0.723
V(t)	-0.114	-1.754

Table 5-7: Heteroscedasticity and Autocorrelation Consistent (HAC) estimator 1997-2006
(* indicates significant effect at 5% level of significance)

Looking at the estimated magnitudes of the significant effect of income on consumption for the log annual change model, we note that the effect is slightly smaller between 1997 and 2006 than the previous estimates for the longer time periods. The coefficient of income is *0.478*, compared to *0.643* for 1975 to 2006 and *0.715* for 1975 to 2010.

5.3.3 Empirical results 2007-2010

The regression output of the OLS model of the most recent period from 2007 to 2010 is presented in Table 5-8. The *16* observations represent four years of dramatic declines in housing wealth, but despite dramatic decreases, the OLS estimates find no evidence of a significant impact of housing wealth on consumption for our two data series. The empirical results in Table 5-8 indicate that income is the only variable with significant effect on consumption determined from our data over the recent crisis. According to the statistical results the effect of income is only statistically significant for the estimated model of log annual changes (for additional test specifications for the OLS model from 2007 to 2010 see Table 8-18 and Table 8-19 in Appendix D).

	Coefficient	t-value (t-prob)
2007-2010 (log annual change)		
Constant	0.003	0.399 (0.697)
DPI	1.130*	5.48 (0.000)
V(t)	0.227	1.94 (0.074)
2007-2010 (log quarterly change)		
Constant	-0.001	-0.182 (0.858)
DPI	0.376	1.99 (0.068)
V(t)	-0.005	-0.029 (0.977)

Table 5-8: Ordinary Least Square model (OLS) 2007-2010
(* indicates significant effect at 5% level of significance)

The OLS models of log annual changes and log quarterly changes are however subject to inconclusive evidence of autocorrelation, with a reported DW statistic of *1.17* and *1.29* respectively, and critical values of $d_L = 0.98$ and $d_U = 1.54$.

Similar to the above analysis we compute and use HAC estimators in order to get reliable test statistics for the coefficients. Table 5-9 presents the HAC statistical values. There is enough evidence to confirm the significant and strong effect of income on consumption in the model with log annual changes observed in Table 5-8 above. The coefficient of income of *1.130* shows that changes in income have large impact on consumption over the recent crisis. This finding is strengthened by the test statistics for the model with log quarterly changes. Its HAC estimator supports the evidence of significant effects of income on consumption. However, the estimated magnitude of the effect in this model is fairly lower with a coefficient of income of *0.376*. The critical value is *2.13* for *16* observations at 5% level of significance (for additional test specifications for the HAC estimators from 2007 to 2010 see Table 8-18 and Table 8-19 in Appendix D).

	Coefficient	t-HACSE
2007-2010 (log annual change)		
Constant	0.003	0.468
DPI	1.130*	3.675
V(t)	0.227	1.824
2007-2010 (log quarterly change)		
Constant	-0.001	-0.173
DPI	0.376*	2.296
V(t)	-0.005	-0.049

Table 5-9: Heteroscedasticity and Autocorrelation Consistent (HAC) estimator 2007-2010
(* indicates significant effect at 5% level of significance)

The empirical estimates for the most recent period from 2007 to 2010 find no evidence of a significant impact of housing wealth on consumption. The effect of income on consumption is however significant and strong for both of our two data series, and the estimated magnitudes are fairly larger than our estimates for the other time periods. For the data series of log annual changes the coefficient is *1.130*, compared to *0.478* from 1997 to 2006, *0.643* from 1975 to 2006 and *0.715* from 1975 to 2010. For the data series of log quarterly changes the coefficient is *0.376*, compared to *0.216* from 1975 to 2006 and *0.249* from 1975-2010 (we recall that there is no significant effect of income on consumption for the quarterly data series between 1997 and 2006). What we can draw from this finding is that the strength of the impact of income on consumption seems to be very strong over the recent crisis. This is evident from the isolated analysis on the period from 2007 to 2010, and supported by the fact that including these observations in the longer time series analysis from 1975 increases the magnitude of this effect. We recall that the coefficient of income increases from *0.643* to *0.715* in the model of log annual changes from 1975 to 2006 when the time series are extended throughout 2010. This also holds for the model of log quarterly changes where the coefficient of income increases from *0.216* to *0.249*.

5.3.4 Summary of empirical results

While the aim of the empirical analysis has been to quantify potential housing wealth effects, the empirical results generated above show little evidence of such effects for the time series and time periods we have been looking at. The summary of the reliable test statistics generated by the

HAC estimator based on annual changes data is presented in Table 5-10. The empirical estimates based on annual changes show evidence of significant relations between income and consumption for all time periods, whereas the housing wealth effect is only significant when looking at the overall time period from 1975 to 2010.

	Coefficient
1975-2010	
DPI	0.715
V(t)	0.129
1975-2006	
DPI	0.643
1997-2006	
DPI	0.478
2007-2010	
DPI	1.130

Table 5-10: Summary of empirical evidence of significant relations with consumption based on annual change data
(Estimated by HACSE at 5% level of significance)

However, we recall the presence of non-stationary variables in the time series of log annual changes of housing wealth, which increases probability of misinterpreting the empirical results based on these data. We will be careful not to draw conclusions only based on the empirical results in Table 5-10. The summary of the reliable test statistics generated by the HAC estimator based on quarterly changes data is presented in Table 5-11. The empirical estimates based on quarterly changes data show evidence of significant relations between income and consumption only for the three time periods from 1975 to 2010, 1975 to 2006 and 2007 to 2010 (no significant effect of income on consumption when studying the subset of years in the time period from 1997 to 2006). The empirical results based on quarterly changes do not support the evidence of housing wealth effects suggested by the annual changes data estimates.

	Coefficient
1975-2010	
DPI	0.249
1975-2006	
DPI	0.216
2007-2010	
DPI	0.249

Table 5-11: Summary of empirical evidence of significant relations with consumption based on quarterly change data
(Estimated by HACSE at 5% level of significance)

In the two cases with conflicting results indicated by the two different data specifications (annual vs. quarterly changes) we prefer to emphasize the results generated by the quarterly changes data, as all the variables in these time series meet the conditions of stationarity. Where the empirical results are independent of the data specifications, we consider the annual change data results to provide additional substance to the proof of the findings. However, for the further discussions relating empirical findings to theory in Section 5.4, we rely on the empirical results generated by the preferred data specifications of quarterly changes.

5.4 Findings and interesting directions for future research

5.4.1 Traditional models of saving

The empirical analysis estimates how households respond to changes in housing wealth with respect to consumption. Two fundamentally different saving models were presented under the theoretical framework in Section 2, the traditional Keynesian model of saving and the LCH model of saving.

The traditional Keynesian saving model states that consumption only depends on current disposable income. As a result, the evolution of household wealth does not impact household consumption and saving behavior in a traditional Keynesian scenario. Large movements in housing prices affect household wealth, as seen lately in the U.S. housing market, but the Keynesian theory implies that changes in household wealth do not affect consumption behavior as there are no relations between household wealth and consumption.

The LCH model suggests that an individual's consumption in a given period depends only on life resources and not at all on current disposable income. According to the LCH, households plan their lifetime consumption based on expectations about development in their total wealth. As a result, the theory implies that unexpected changes in household wealth lead to changes in the household consumption path, supporting the existence of housing wealth effects.

The two theories give widely different implications of how households respond to changes in wealth, and more specifically quite opposite answers to how households respond to changes in housing wealth as seen over the recent crisis.

The analysis of the housing market in Section 4 emphasizes the size, distribution and importance of housing wealth in the U.S. economy. We find that housing wealth is a large share of total wealth for most households, and based on its wide distribution we expect consumption behavior in the United States to be affected by severe movements in housing wealth. The occurrence of such housing wealth effects are in line with the LCH model of saving. The studies performed in Sections 5.1 and 5.2 further support these findings, where correlation analyses provide evidence of a significant positive relationship between housing wealth and consumption, as well as a significant negative relationship between housing wealth and saving. Despite these indications of existing housing wealth effects, the empirical results generated in Section 5.3 find no significant impact of housing wealth on consumption. Neither for the longer time period from 1975 to 2010, nor the recent period with dramatic declines in housing wealth from 2007 to 2010, does this master thesis find evidence of empirical support to the LCH model of saving.

On the contrary, the empirical results of no significant effects of changes in housing wealth on consumption confirm the traditional Keynesian findings, which imply that changes in household wealth do not impact consumption behavior. The empirical study further supports the Keynesian model of saving with strong evidence of significant relations between income and consumption, both for the longer time period from 1975 to 2010 and the recent period with dramatic declines in housing wealth from 2007 to 2010.

Hence, we consider the consumption and saving behavior of U.S. households over the recent crisis to be more in line with the traditional Keynesian saving model. We find no statistical evidence of relations between housing wealth and consumption, and thereby no empirical support for the saving behavior implied by the LCH model of saving. While household levels of consumption decrease along with the dramatic declines in housing wealth, we do not have enough evidence to infer that there is a statistically significant housing wealth effect that drives the current changes, or that household saving over the recent crisis follows the saving behavior implied by the LCH model of saving.

We notice that the lack of evidence of housing wealth effects, as well as the lack of empirical support to the LCH model of saving, is in sharp contrast to the findings by related literature (e.g. Case et al. (2005) and Case et al. (2011)). Both studies by Case et al. show strong evidence that variations in housing market wealth have important effects on consumption, and thus demonstrate more in favor of the LCH model of saving than the results implied by the analysis here. We suggest that the deviations between the results may be caused by differences in the framework, data series and methodology. For instance, Case et al. rely upon a panel of U.S. state data. The use of regional (state level) measures exploits the fact that house prices have evolved very differently in different parts of the country. We recall from the analysis of the housing market in Section 4.2, that state house prices have been moving in complicated and asynchronous ways over the recent crisis. Unlike Case et al. we use aggregate national time series and include data until the fourth quarter of 2010, which together with differences in the empirical specifications may explain why the findings of this paper do not support the results generated by the previous studies on state panel data.

5.4.2 Asymmetric wealth effects

The literature on wealth effects has at its core the LCH model of consumption and saving. The traditional LCH framework implies that wealth effects should be symmetric, meaning that the transmission mechanisms from changes in wealth to changes in consumption are the same independent of whether the changes in wealth are positive or negative. We recall that $\Delta C = MPC_A \cdot \Delta A_0$ in the basic LCH model without uncertainty, which infers that changes in consumption are of the same magnitude for wealth declines as for wealth increases.

Previous studies find evidence that questions the expected symmetries in housing wealth effects (e.g. Engelhardt (1995) and Case et al. (2005)). However, there seems to be large variations in the empirical results across different studies. While some yield statistical support to the symmetric wealth effects implied by the LCH framework (Case et al., 2011), other studies imply that households that experience housing wealth losses have a statistically significant change in consumption and saving, whereas households that experience housing wealth increases do not change their consumption and saving behavior (Engelhardt, 1995), and yet others suggest that increases in housing wealth have positive effects on consumption, but that declines in housing wealth have no significant effects (Case et al., 2005).

Asymmetric wealth effects refer to the presence of a different link between housing wealth and consumer spending in times of recessions than in times of expansions. An important aspect in explaining the large variations in findings of the existing literature on asymmetric wealth effects might be that most of the literature on housing wealth effects is from times of great expansion in the housing market. Over the recent crisis we have witnessed severe declines in housing wealth, and it is interesting to see whether more complex time series that include the increased volatility of the last decade can provide additional value to the discussion of asymmetric wealth effects.

Based on the empirical analysis in Section 5.3, we find at best weak evidence of housing wealth effects. We recall that the only empirical estimates that imply the existence of a housing wealth effect are generated by time series based on log annual changes, which do not facilitate compliance with the condition of stationary data in time series analysis. Based on the preferred specifications of the data with quarterly changes, the empirical measures find no evidence of significant effects of housing wealth on consumption. While household levels of consumption increase over the *40* observations from ten years of substantial housing wealth growth between 1997 and 2006, we do not have enough evidence to suggest that there is a statistically significant housing wealth effect which drives the changes. The *16* observations from 2007 to 2010 represent four years of substantial declines in housing wealth, but despite this dramatic fall, the regression results yield no evidence of significant impacts of housing wealth on consumption. While household levels of consumption decrease along with the dramatic declines in housing wealth over the recent crisis, we do not have enough evidence to suggest that there is a statistically significant housing wealth effect that drives the current changes.

Based on the lack of evidence of a significant housing wealth effect, both in times of housing market expansion and recession, the empirical estimates of this master thesis find no support for a different impact of housing wealth on consumption behavior over the recent crisis compared to the pre-crisis period. Hence, we are unable to identify any asymmetries.

5.4.3 Limitations and interesting directions for future research

5.4.3.1 Causality

In statistical analysis it is important to raise the question of causation, to avoid false inferences of causality where a cause is incorrectly identified. In terms of the empirical estimates in Section 5.3, we raise the question of whether the quantified relationship between income and consumption is based on an effect running from income to consumption as imposed by the above analysis, or whether the observed relation is due to the presence of a spurious relationship. We recall from Section 5.3 that a spurious relationship refers to the situation where both variables are affected by a common third variable. The lack of control for key factors constitutes a major limitation in many of the empirical studies within the literature of housing wealth effects (Muellbauer, 2007). Hence, extending the empirical analysis to control for additional relevant variables may be an interesting experiment for further research to help reduce the chances of false inferences of causality.

In terms of the empirical estimates in Section 5.3, it is also essential to raise the question of whether the empirical results of no significant link between housing wealth and consumption are due to the lack of a direct wealth effect, or whether the lack of relationship between the two variables is a result of common cause. By common cause we mean that the lack of an identified wealth effect is actually the response of consumption and housing wealth to a change in a third variable, as expectations of the future economic outlook like changes in income or productivity (Brady and Stimel, 2011). Several studies strongly reflect causality from general economic conditions to both consumption and house prices (e.g. Muellbauer, 2007; Carrol et al., 2006; Disney et al., 2002). Overall macroeconomic prospects may for instance influence the evolution of house prices as well as the movements in consumption. Further, psychological effects and overall future purchasing power of current and future homeowners are closely tied to expectations on the broader economy, and it has been widely observed that such effects affect house prices (Carroll et al., 2006).

The constructed measure of housing wealth used in this study will to some extent help prevent causality problems, as it does not incorporate housing wealth changes due to changes in the size or quality of homes (see Section 3.1 for specifications regarding the construction of the housing wealth variable V_t). Such quality changes are likely to be correlated with consumption changes, as housing services are a component of consumption (Case et al, 2011). Nevertheless, for further research it may be useful to take additional variables into account in the model, to make the results more precise based on increased control for key factors.

5.4.3.2 Limitations in the data set

The use of various methods and datasets, as well as different results due to inappropriate use of variables and adverse trade-offs, can explain the considerable variations of wealth effects estimates in the existing literature (Kerdrain, 2011). The different results implied by the different time series specifications in our estimated models (annual versus quarterly change data) illustrate this sensitivity, and might to some extent question the degree of robustness in this study.

The lack of panel data may represent a limitation to the data set which can impact the quality and robustness of the empirical analysis. In addition to the time series dimension of the data, observations in panel data involve a cross sectional dimension that allows for greater capacity and improvement in the efficiency of econometric estimates (Baltagi, 2008). According to Hsiao (2003), the use of panel data can also contribute to simplify computation and statistical inference. The empirical analysis of this study only includes time series for the United States at national level measures. An expansion of the data set to include panel data can increase the capacity and efficiency in the empirical estimates by increasing the number of data points and reducing the collinearity among variables. We recall that the housing wealth variable is non-stationary in the data set based on log annual changes. Strictly speaking, an implication of non-stationarity is that we cannot validly undertake the results implied by the empirical estimates. However, our data set includes fairly few observations in terms of time series analysis, and the availability of panel data may solve the problem of non-stationarity. The econometric literature infers that if panel data are available, and observations among cross-sectional units are independent, one can invoke the central limit theorem across cross-section units to show that the limiting distributions of many estimators remain asymptotically normal (Hsiao, 2003).

According to Carroll et al. (2006) there are reasons to be skeptical to results based on aggregate data. Each observation in our data set represents aggregate numbers where averaging smooth out the variations within the data set. House price measurements across different states collected in Section 4.2 show that regional house prices evolve very differently over the past decades, and that the state housing markets move in complicated and asynchronous ways over the recent crisis. As the empirical analysis in Section 5.3 is based on time series at the national level, the estimates fail to exploit these variations in the evolution of house prices across states. Another potential issue with the use of aggregate data refers to the inappropriate assumption that relationships at the aggregate level also hold at individual level. Empirical estimates of relations between housing wealth and consumption at aggregate levels do not necessarily describe the relations at household level. On the other hand, the only method to describe the overall average development in the United States is in the course of aggregate levels, as the individual level may not hold for the aggregate level. Many authors have attempted to use microeconomic data in empirical analysis of housing wealth effects, but in order to produce empirical estimates they depend on excessive assumptions, as microeconomic datasets designed for this purpose are not yet available (Carroll et al., 2006).

The length of the time series can affect the empirical results. According to Gelper (2008) there is a general belief that more observations lead to higher explanatory power for regression tests. Lack of observations may represent a limit to the smaller time series in our two estimated models for 1997-2006 and 2007-2010. As these time periods only consist of *40* and *16* observations respectively, it may be questionable whether there are sufficient observations to imply powerful results. We would also like to emphasize that the adopted data series represent quite unusual periods. The upward trend in the housing market during most of the sample period in addition to the extensive volatility seen recently might question the robustness of the empirical results.

The empirical estimates in Section 5.3 exclude the effects of time-lagged variables, except for the AR(1) models. Studies conclude that incorrectly chosen lag lengths can lead to model misspecifications that affect empirical results (Gelper, 2008). As individuals keep track of wealth slowly and information processing constraints impact consumption dynamics, it may be too simplistic to assume that the effects of income and housing wealth on consumption are immediate effects without any time lags. Extending the research to consider alternative assumptions about lag lengths would certainly be useful in terms of future research on the topic.

Finally, it is worth noting that a common mistake of empirical studies within the literature of housing wealth effects is the use of inappropriate functional form of variables, such as income and consumption, which can impact the empirical results (Muellbauer, 2007). Whether housing is treated as a consumption or investment good and how different consumption measures treat for instance housing services expenses or expenditures to purchase new residences, can have substantial impact on the calculations and empirical estimates (Perozek and Reinsdorf, 2002).

6. Concluding Remarks

In this thesis we provide an analysis of the housing market in the United States from 1975 to 2010, with a particular focus on the housing market boom and bust in the country over the past decade. We show that this past decade is characterized by unusual volatility, and that the recent boom and bust stands out compared to previous periods of volatility and unusual movements in the housing market. We find that housing wealth constitutes a large share of total wealth in the United States, and that despite large regional differences and uneven concentrations of wealth among households, housing wealth is widely diffused among the population.

The main topic of this thesis is the importance of housing wealth for explaining household saving. The significant housing wealth losses we determine over the recent crisis are severe, and based on the size and distribution of the housing wealth we expect significant housing wealth effects prevalent during the recent crisis. First, we assess the relationship between housing wealth and consumption and saving through correlation analysis. The results provide support for the existence of housing wealth effects through evidence of a significant positive relationship between housing wealth and consumption, as well as a significant negative relationship between housing wealth and saving. Second, we extend our analysis and provide empirical estimates to measure the potential effects of housing wealth on consumption. We find that there is lack of empirical evidence to infer statistically significant housing wealth effects for the time series and time periods we have been looking at. While household levels of consumption decrease along with the dramatic declines in housing wealth over the recent crisis, we do not have enough evidence to suggest that there is a statistically significant housing wealth effect that drives the current changes. However, the empirical estimates yield evidence of significant effects of income on consumption for the three time periods from 1975 to 2010, 1975 to 2006 and 2007 to 2010 (no significant effect of income on consumption in the time period from 1997 to 2006).

Based on these findings we conclude that with the framework, data series and methodology of this thesis we find no empirical support for the LCH model, where unexpected changes in household wealth lead to changes in the household consumption path. We suggest that household saving over the recent crisis cannot be explained by housing wealth effects, and that saving behavior to a greater extent seems to follow the traditional path of Keynes rather than the LCH model of saving by Modigliani.

Furthermore, we make an attempt to contribute to the literature on asymmetric wealth effects. We estimate the effects of housing wealth on consumption in times of housing wealth expansion (sample period from 1997 to 2006) and in times of housing wealth declines (sample period from 2007 to 2010) to provide evidence of potential asymmetries. Based on the lack of evidence of a significant housing wealth effect, both in times of housing market expansion and recession, the empirical estimates of this master thesis find no support for any presence of asymmetries.

The findings in this master thesis challenge the theoretical framework of the life cycle hypothesis as well as the well-established literature on wealth effects. We do not have enough evidence to suggest that household saving over the recent crisis follows the saving behavior implied by the LCH model of saving. Insights from this master thesis on how household consumption and saving is related to changes in housing wealth can be useful in future forecasts of macroeconomic performance and further analyses of private consumption and saving behavior.

7. Bibliography

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8. Appendix

8.1 Appendix A: Optimal consumption level

To derive the optimal consumption level for LCH under certainty:

$$\sum_{t=0}^{T} \frac{1}{(1+r)^t} C_t = A_0 + \sum_{t=0}^{T} \frac{1}{(1+r)^t} Y_t$$

$$C^* \frac{1-\left(\frac{1}{1+r}\right)^{T+1}}{1-\left(\frac{1}{1+r}\right)} = A_0 + \sum_{t=0}^{T} \frac{1}{(1+r)^t} Y_t$$

$$C^* \frac{1-\left(\frac{1}{1+r}\right)^{T+1}}{\left(\frac{r}{1+r}\right)} = A_0 + \sum_{t=0}^{T} \frac{1}{(1+r)^t} Y_t$$

$$C^* \left[\frac{1}{\left(\frac{r}{1+r}\right)} - \frac{\left(\frac{1}{1+r}\right)^{T+1}}{\left(\frac{r}{1+r}\right)}\right] = A_0 + \sum_{t=0}^{T} \frac{1}{(1+r)^t} Y_t$$

$$C^* \left[\frac{1+r}{r} - \frac{(1+r)(1+r)^{-T-1}}{r}\right] = A_0 + \sum_{t=0}^{T} \frac{1}{(1+r)^t} Y_t$$

$$C^* \left[\frac{1+r}{r} - \frac{1}{r(1+r)^T}\right] = A_0 + \sum_{t=0}^{T} \frac{1}{(1+r)^t} Y_t$$

$$C^* \frac{(1+r)(1+r)^T - 1}{r(1+r)^T} = A_0 + \sum_{t=0}^{T} \frac{1}{(1+r)^t} Y_t$$

$$C^* \frac{(1+r)^{T+1} - 1}{r(1+r)^T} = A_0 + \sum_{t=0}^{T} \frac{1}{(1+r)^t} Y_t$$

$$\boldsymbol{C^* = \frac{r(1+r)^T}{(1+r)^{T+1} - 1} \cdot \left[A_0 + \sum_{t=0}^{T} \frac{1}{(1+r)^t} Y_t\right]}$$

8.2 Appendix B: Seasonal adjustment

It is assumed that the time series y can be divided into four components: a trend component L, a seasonal component S, a cycle component C, and an irregular factor I. An unadjusted time series can be expressed by the following equation

$$y = L * S * C * I$$

The purpose of seasonal adjustment is to eliminate the seasonal component S. The method used for manual seasonal adjustment of time series is performed through five steps.

(1) Isolate the trend and the cycle component ($L*C$)

The moving average is defined by observations from all four quarters of a given year, to eliminate the seasonal variations and irregularities

$$y_t^{L*C} = \frac{1}{4}(y_{t+2} + y_{t+1} + y_t + y_{t-1})$$

(2) Define y_t without trend and cycle (y_t^{S*I})

Based on the given components of an adjusted time series $y = L * S * C * I$, it follows that

$$y^{S*I} = \frac{L * S * C * I}{L * C} = S * I = \frac{y}{y^{L*C}}$$

(3) Eliminate the irregular factor I

To isolate the seasonal component of y_t^{S*I}, it is necessary to eliminate the irregular factor I. We calculate seasonal indexes for each season from the average measure of all observations from each given quarter

$$s_1 = \frac{1}{N}\left[y_{K1,yr1}^{S*I} + y_{K1,yr2}^{S*I} + \cdots + y_{K1,yrN}^{S*I}\right]$$

$$s_2 = \frac{1}{N}\left[y_{K2,yr1}^{S*I} + y_{K2,yr2}^{S*I} + \cdots + y_{K2,yrN}^{S*I}\right]$$

$$s_3 = \frac{1}{N}\left[y_{K3,yr1}^{S*I} + y_{K3,yr2}^{S*I} + \cdots + y_{K3,yrN}^{S*I}\right]$$

$$s_4 = \frac{1}{N}\left[y_{K4,yr1}^{S*I} + y_{K4,yr2}^{S*I} + \cdots + y_{K4,yrN}^{S*I}\right]$$

(4) Correct seasonal indexes

To eliminate the long-run trend entirely the indexes are corrected based on the following method

$$s_q^{corrected} = s_q * \frac{4}{\sum_{q=1}^{4} s_q}$$

Where q represents a given quarter, $q = \{1,2,3,4\}$. Which gives

$$\sum_{q=1}^{4} s_q^{corrected} = 4$$

(5) Adjust each observation with the seasonal index

Finally, all observations are adjusted based on the following method

$$y_t^{seasonally\ adjusted} = \frac{y_t}{s_q^{corrected}}$$

Where all observations from Q1 are divided by $s_1^{corrected}$, all observations from Q2 are divided by $s_2^{corrected}$etc. This final measure represents the seasonally adjusted time series (y_t^{L*C*I}).

8.3 Appendix C: Financial and nonfinancial assets

Financial and nonfinancial assets data from the "2007 Survey of Consumer Finances" by the Federal Reserve Board (Board of Governors of the Federal Reserve System, 2009).

Table 8-1: Nonfinancial assets held by families by type of asset: 2007

Source: Board of Governors of the Federal Reserve System, 2009, <http://www.census.gov/compendia/statab/2011/tables/11s0719.pdf>

Family characteristic	Any financial or non-financial asset	Any non-financial asset	Vehicles	Pri-mary residence	Other resi-dential property	Equity in nonresi-dential property	Bus-iness equity	Other asset
PERCENT OF FAMILIES HOLDING ASSET								
All families, total	**97.7**	**92.0**	**87.0**	**68.6**	**13.7**	**8.1**	**13.6**	**7.2**
Age of family head:								
Under 35 years old	97.1	88.2	85.4	40.7	5.6	3.2	8.0	5.9
35 to 44 years old	96.9	91.3	87.5	66.1	12.0	7.5	18.2	5.5
45 to 54 years old	97.6	95.0	90.3	77.3	15.7	9.5	17.2	8.7
55 to 64 years old	99.1	95.6	92.2	81.0	20.9	11.5	18.1	8.5
65 to 74 years old	98.4	94.5	90.6	85.5	18.9	12.3	11.2	9.1
75 years old and over	98.1	87.3	71.5	77.0	13.4	6.8	4.5	5.8
Race or ethnicity or respondent:								
White non-Hispanic	98.9	94.6	89.6	75.6	15.3	9.0	15.8	8.4
Non-White or Hispanic	94.9	85.8	80.9	51.9	10.0	5.9	8.2	4.3
Tenure:								
Owner occupied	100.0	100.0	93.8	100.0	17.5	10.8	17.5	8.0
Renter occupied or other	92.8	74.5	72.3	(B)	5.6	2.1	5.0	5.3
MEDIAN VALUE [1] ($1,000)								
All families, total	**221.5**	**177.4**	**15.5**	**200.0**	**146.0**	**75.0**	**92.2**	**14.0**
Age of family head:								
Under 35 years old	38.8	30.9	13.3	175.0	85.0	50.0	35.0	8.0
35 to 44 years old	222.3	182.6	17.4	205.0	150.0	50.0	59.0	10.0
45 to 54 years old	306.0	224.9	18.7	230.0	150.0	80.0	76.8	15.0
55 to 64 years old	347.0	233.1	17.4	210.0	157.0	90.0	100.0	20.0
65 to 74 years old	303.3	212.2	14.6	200.0	150.0	75.0	300.0	20.0
75 years old and over	219.3	157.1	9.4	150.0	100.0	110.0	225.0	25.0
Race or ethnicity of respondent:								
White non-Hispanic	271.0	203.8	17.1	200.0	136.5	75.0	100.0	15.0
Non-White or Hispanic	89.2	102.0	12.0	180.0	175.0	62.7	50.0	8.0
Tenure:								
Owner occupied	344.2	253.5	18.4	200.0	150.0	80.0	100.0	20.0
Renter occupied or other	13.6	10.1	8.6	(B)	85.0	38.0	33.0	5.4

Table 8-2: Financial assets held by families by type of asset: 2004 and 2007

Source: Board of Governors of the Federal Reserve System, 2009, <http://www.census.gov/compendia/statab/2011/tables/11s1168.pdf>

Age of family head and family income	Any financial asset [1]	Trans-action accounts [2]	Certifi-cates of deposit	Savings bonds	Stocks [3]	Pooled invest-ment funds [4]	Retire-ment accounts [5]	Life insur-ance [6]	Other man-aged [7]
PERCENT OF FAMILIES OWNING ASSET									
2004, total	93.8	91.3	12.7	17.6	20.7	15.0	49.7	24.2	7.3
2007, total	**93.9**	**92.1**	**16.1**	**14.9**	**17.9**	**11.4**	**52.6**	**23.0**	**5.8**
Under 35 years old	89.2	87.3	6.7	13.7	13.7	5.3	41.6	11.4	(B)
35 to 44 years old	93.1	91.2	9.0	16.8	17.0	11.6	57.5	17.5	2.2
45 to 54 years old	93.3	91.7	14.3	19.0	18.6	12.6	64.7	22.3	5.1
55 to 64 years old	97.8	96.4	20.5	16.2	21.3	14.3	60.9	35.2	7.7
65 to 74 years old	96.1	94.6	24.2	10.3	19.1	14.6	51.7	34.4	13.2
75 years old and over	97.4	95.3	37.0	7.9	20.2	13.2	30.0	27.6	14.0
Percentiles of income: [8]									
Less than 20	79.1	74.9	9.4	3.6	5.5	3.4	10.7	12.8	2.7
20 to 39.9	93.2	90.1	12.7	8.5	7.8	4.6	35.6	16.4	4.7
40 to 59.9	97.2	96.4	15.4	15.2	14.0	7.1	55.2	21.6	5.3
60 to 79.9	99.7	99.3	19.3	20.9	23.2	14.6	73.3	29.4	5.7
80 to 89.9	100.0	100.0	19.9	26.2	30.5	18.9	86.7	30.6	7.6
90 to 100	100.0	100.0	27.7	26.1	47.5	35.5	89.6	38.9	13.6
MEDIAN VALUE [9]									
2004, total	25.3	4.1	16.5	1.1	16.5	44.4	38.7	6.6	49.4
2007, total	**28.8**	**4.0**	**20.0**	**1.0**	**17.0**	**56.0**	**45.0**	**8.0**	**70.0**
Under 35 years old	6.8	2.4	5.0	0.7	3.0	18.0	10.0	2.8	(B)
35 to 44 years old	25.8	3.4	5.0	1.0	15.0	22.5	36.0	8.3	24.0
45 to 54 years old	54.0	5.0	15.0	1.0	18.5	50.0	67.0	10.0	45.0
55 to 64 years old	72.4	5.2	23.0	1.9	24.0	112.0	98.0	10.0	59.0
65 to 74 years old	68.1	7.7	23.2	1.0	38.0	86.0	77.0	10.0	70.0
75 years old and over	41.5	6.1	30.0	20.0	40.0	75.0	35.0	5.0	100.0

3) Covers only those stocks and bonds that are directly held by families outside mutual funds, retirement accounts, and other managed assets

8.4 Appendix D: Regression tables

8.4.1 Augmented Dickey Fuller test

Table 8-3: Regression results ADF-test log quarterly observations 1975-2010

(The estimation sample is: 1977:1-2010:4)

c_t: ADF tests (T=136, Constant; 5%=-2.88 1%=-3.48)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
3	-0.3772	0.99911	141.1	0.2773	0.7819	9.935	
2	-0.3727	0.99912	140.6	2.020	0.0454	9.921	0.7819
1	-0.3731	0.99911	142.2	4.513	0.0000	9.937	0.1311
0	-0.4690	0.99880	152.1			10.06	0.0000

y_t: ADF tests (T=136, Constant; 5%=-2.88 1%=-3.48)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
3	-0.2342	0.99914	216.8	-1.836	0.0686	10.79	
2	-0.2810	0.99896	218.7	1.220	0.2248	10.80	0.0686
1	-0.2501	0.99908	219.1	-2.342	0.0206	10.80	0.0908
0	-0.2884	0.99892	222.8			10.83	0.0175

v_t: ADF tests (T=136, Constant; 5%=-2.88 1%=-3.48)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
3	-1.535	0.99350	576.6	1.831	0.0694	12.75	
2	-1.409	0.99400	581.8	5.287	0.0000	12.76	0.0694
1	-1.182	0.99448	638.0	6.391	0.0000	12.94	0.0000
0	-1.163	0.99381	726.7			13.19	0.0000

*** Indicates evidence of stationarity at 5% level of significance**

Table 8-4: Regression results ADF-test log quarterly change data 1975-2010

(The estimation sample is: 1976:2-2010:4)

$\Delta c_t^{quarterly}$: ADF tests (T=139, Constant; 5%=-2.88 1%=-3.48)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
3	-4.726*	0.45668	0.006280	1.155	0.2501	-10.11	
2	-4.608*	0.50322	0.006287	-1.074	0.2847	-10.11	0.2501
1	-5.569*	0.45467	0.006291	-2.793	0.0060	-10.12	0.2912
0	-8.747*	0.29277	0.006445			-10.07	0.0187

$\Delta y_t^{quarterly}$: ADF tests (T=139, Constant; 5%=-2.88 1%=-3.48)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
3	-5.811*	-0.052286	0.008228	-0.3303	0.7417	-9.565	
2	-6.959*	-0.082599	0.008201	0.7902	0.4308	-9.579	0.7417
1	-7.862*	-0.014080	0.008190	-1.413	0.1599	-9.588	0.6951
0	-13.69*	-0.15253	0.008219			-9.588	0.4419

$\Delta v_t^{quarterly}$: ADF tests (T=139, Constant; 5%=-2.88 1%=-3.48)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
3	-1.730	0.84954	0.01050	-7.015	0.0000	-9.078	
2	-3.640*	0.65118	0.01223	-0.9015	0.3690	-8.780	0.0000
1	-4.233*	0.62068	0.01222	-5.341	0.0000	-8.788	0.0000
0	-8.137*	0.34584	0.01339			-8.612	0.0000

*** Indicates evidence of stationarity at 5% level of significance**

Table 8-5: Regression results ADF-test log annual change data 1975-2010

(The estimation sample is: 1977:1-2010:4)

Δc_t^{annual}: ADF tests (T=136, Constant; 5%=-2.88 1%=-3.48)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
3	-4.368*	0.79772	0.008789	1.455	0.1480	-9.433	
2	-4.102*	0.81892	0.008826	1.977	0.0501	-9.431	0.1480
1	-3.650*	0.84391	0.008922	2.325	0.0216	-9.417	0.0518
0	-3.123*	0.86849	0.009067			-9.392	0.0108

Δy_t^{annual}: ADF tests (T=136, Constant; 5%=-2.88 1%=-3.48)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
3	-5.850*	0.57545	0.01025	2.226	0.0277	-9.126	
2	-5.334*	0.64204	0.01040	2.384	0.0186	-9.103	0.0277
1	-4.705*	0.70310	0.01058	1.235	0.2190	-9.076	0.0056
0	-4.560*	0.73154	0.01060			-9.079	0.0076

Δv_t^{annual}: ADF tests (T=136, Constant; 5%=-2.88 1%=-3.48)

D-lag	t-adf	beta Y_1	sigma	t-DY_lag	t-prob	AIC	F-prob
3	-2.756	0.93005	0.01128	2.467	0.0149	-8.933	
2	-2.137	0.94674	0.01150	1.346	0.1805	-8.902	0.0149
1	-1.863	0.95478	0.01154	2.873	0.0047	-8.903	0.0209
0	-1.374	0.96623	0.01184			-8.857	0.0013

*** Indicates evidence of stationarity at 5% level of significance**

8.4.2 Regression tables 1975-2010

Table 8-6: Ordinary Least Square and Heteroscedasticity consistent standard errors
(Log annual change data and the estimation sample is: 1976:1-2010:4)

Modelling PCE by OLS

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.00450452*	0.001755	2.57	0.0113	0.0459
DPI(Y)	0.715277*	0.07259	9.85	0.0000	0.4148
V(t) (Y)	0.128831*	0.02720	4.74	0.0000	0.1407

sigma	0.0126022	RSS	0.0217577752
R^2	0.544959	F(2,137) =	82.04 [0.000]**
log-likelihood	415.208	DW	0.679
no. of observations	140	no. of parameters	3
mean(PCE(Y))	0.0214168	var(PCE(Y))	0.000341536

Heteroscedasticity consistent standard errors

	Coefficients	SE	HACSE	HCSE	JHCSE
Constant	0.0045045	0.0017547	0.0032264	0.0020900	0.0021510
DPI(Y)	0.71528	0.072589	0.091252	0.072816	0.075255
V(t) (Y)	0.12883	0.027200	0.041934	0.026842	0.027625

	Coefficients	t-SE	t-HACSE	t-HCSE	t-JHCSE
Constant	0.0045045	2.5671	1.3961	2.1553	2.0941
DPI(Y)	0.71528*	9.8538	7.8385	9.8231	9.5047
V(t) (Y)	0.12883*	4.7365	3.0723	4.7996	4.6635

*** Indicates significant effect at 5% level of significance**

Table 8-7: Ordinary Least Square and Heteroscedasticity consistent standard errors
(Log quarterly change data and the estimation sample is: 1975:2-2010:4)

Modelling PCE by OLS

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.00378530*	0.0006129	6.18	0.0000	0.2141
DPI	0.248547*	0.06001	4.14	0.0001	0.1092
V(t)	0.0760699*	0.03739	2.03	0.0438	0.0287

sigma	0.00624416	RSS	0.00545853169
R^2	0.155563	F(2,140) =	12.9 [0.000]**
log-likelihood	524.491	DW	1.76
no. of observations	143	no. of parameters	3
mean(PCE)	0.00541142	var(PCE)	4.52036e-005

Heteroscedasticity consistent standard errors

	Coefficients	SE	HACSE	HCSE	JHCSE
Constant	0.0037853	0.00061288	0.0010088	0.00082494	0.00084581
DPI	0.24855	0.060010	0.087381	0.078138	0.080567
V(t)	0.076070	0.037395	0.039329	0.036437	0.037809

	Coefficients	t-SE	t-HACSE	t-HCSE	t-JHCSE
Constant	0.0037853*	6.1762	3.7522	4.5886	4.4754
DPI	0.24855*	4.1417	2.8444	3.1809	3.0850
V(t)	0.076070	2.0342	1.9342	2.0877	2.0120

*** Indicates significant effect at 5% level of significance**

Table 8-8: Autoregressive *AR(1)*
(Log annual change data and the estimation sample is: 1976:2-2010:4)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
PCE_1	0.105868	0.08864	1.19	0.2344	0.0104
Constant	0.00162296	0.0008598	1.89	0.0612	0.0255
DPI(Y)	0.127661*	0.03868	3.30	0.0012	0.0742
V(t) (Y)	0.0287385*	0.01351	2.13	0.0352	0.0322

sigma	0.00613375	RSS	0.00511671135
R^2	0.19866	F(3,136) =	11.24 [0.000]**
log-likelihood	516.531	DW	1.88
no. of observations	140	no. of parameters	4
mean(PCE)	0.00531162	var(PCE)	4.56086e-005

*** Indicates significant effect at 5% level of significance**

Table 8-9: Autoregressive *AR(1)*
(Log quarterly change data and the estimation sample is: 1975:3–2010:4)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
PCE_1	0.219834*	0.07853	2.80	0.0059	0.0537
Constant	0.00278788*	0.0006943	4.02	0.0001	0.1046
DPI	0.228391*	0.06340	3.60	0.0004	0.0860
V(t)	0.0622334	0.03692	1.69	0.0941	0.0202

sigma	0.00611144	RSS	0.00515425473
R^2	0.197604	F(3,138) =	11.33 [0.000]**
log-likelihood	524.398	DW	2.21
no. of observations	142	no. of parameters	4
mean(PCE)	0.00536674	var(PCE)	4.52364e-005

*** Indicates significant effect at 5% level of significance**

8.4.3 Regression tables 1975-2006

Table 8-10: Ordinary Least Square and Heteroscedasticity consistent standard errors
(Log annual change data and the estimation sample is: 1976:1-2006:4)

Modelling PCE(Y) by OLS

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.00781479	0.002100	3.72	0.0003	0.1027
DPI(Y)	0.642894	0.07591	8.47	0.0000	0.3722
V(t) (Y)	0.0842000	0.03500	2.41	0.0177	0.0456

sigma	0.0123232	RSS	0.0183751266
R^2	0.417377	F(2,121) =	43.34 [0.000]**
log-likelihood	370.708	DW	0.642
no. of observations	124	no. of parameters	3
mean(PCE(Y))	0.0242153	var(PCE(Y))	0.000254344

Heteroscedasticity consistent standard errors

	Coefficients	SE	HACSE	HCSE	JHCSE
Constant	0.0078148	0.0021002	0.0039450	0.0024488	0.0024916
DPI(Y)	0.64289	0.075913	0.084871	0.069399	0.071150
V(t) (Y)	0.084200	0.035000	0.056425	0.034926	0.035589

	Coefficients	t-SE	t-HACSE	t-HCSE	t-JHCSE
Constant	0.0078148*	3.7209	1.9810	3.1913	3.1365
DPI(Y)	0.64289*	8.4689	7.5750	9.2638	9.0358
V(t) (Y)	0.084200	2.4057	1.4922	2.4108	2.3659

*** Indicates significant effect at 5% level of significance**

Table 8-11: Ordinary Least Square and Heteroscedasticity consistent standard errors
(Log quarterly change data and the estimation sample is: 1975:2-2006:4)

Modelling PCE by OLS

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.00461339	0.0006706	6.88	0.0000	0.2762
DPI	0.215719	0.06260	3.45	0.0008	0.0874
V(t)	0.0369116	0.04259	0.867	0.3878	0.0060

sigma	0.00592467	RSS	0.00435261489
R^2	0.102399	F(2,124) =	7.073 [0.001]**
log-likelihood	472.649	DW	1.9
no. of observations	127	no. of parameters	3
mean(PCE)	0.00606984	var(PCE)	3.81824e-005

Heteroscedasticity consistent standard errors

	Coefficients	SE	HACSE	HCSE	JHCSE
Constant	0.0046134	0.00067061	0.0011612	0.00097165	0.0010083
DPI	0.21572	0.062600	0.094659	0.082519	0.085580
V(t)	0.036912	0.042590	0.049434	0.044636	0.046515

	Coefficients	t-SE	t-HACSE	t-HCSE	t-JHCSE
Constant	0.0046134*	6.8793	3.9729	4.7480	4.5756
DPI	0.21572*	3.4460	2.2789	2.6142	2.5207
V(t)	0.036912	0.86668	0.74668	0.82695	0.79354

*** Indicates significant effect at 5% level of significance**

Table 8-12: Autoregressive *AR(1)*
(Log annual change data and the estimation sample is: 1976:2-2006:4)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
PCE(Y)_1	0.759738	0.05967	12.7	0.0000	0.5767
Constant	0.00200536	0.001449	1.38	0.1688	0.0158
DPI(Y)	0.166817	0.06208	2.69	0.0082	0.0572
V(t) (Y)	-0.00151138	0.02398	-0.0630	0.9499	0.0000

sigma	0.00805603	RSS	0.00772305618
R^2	0.750726	F(3,119) =	119.5 [0.000]**
log-likelihood	420.528	DW	1.86
no. of observations	123	no. of parameters	4
mean(PCE(Y))	0.0240243	var(PCE(Y))	0.000251887

*** Indicates significant effect at 5% level of significance**

Table 8-13: Autoregressive *AR(1)*
(Log quarterly change data and the estimation sample is: 1975:3–2006:4)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
PCE_1	0.111700	0.08651	1.29	0.1991	0.0135
Constant	0.00398641	0.0008182	4.87	0.0000	0.1629
DPI	0.211457	0.06829	3.10	0.0024	0.0729
V(t)	0.0348444	0.04265	0.817	0.4156	0.0054

sigma	0.00592887	**RSS**	0.00428849014
R^2	0.109639	**F(3,122)** =	5.008 [0.003]**
log-likelihood	469.364	**DW**	2.14
no. of observations	126	**no. of parameters**	4
mean(PCE)	0.00602472	**var(PCE)**	3.82268e-005

*** Indicates significant effect at 5% level of significance**

8.4.4 Regression tables 1997-2006

Table 8-14: Ordinary Least Square and Heteroscedasticity consistent standard errors
(Log annual change data and the estimation sample is: 1997:1-2006:4)

Modelling PCE(Y) by OLS

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.0155612*	0.006948	2.24	0.0312	0.1194
DPI(Y)	0.478337*	0.1277	3.75	0.0006	0.2750
V(t) (Y)	-0.0248796	0.09708	-0.256	0.7992	0.0018

sigma	0.0103005	RSS	0.0039257002
R^2	0.326514	F(2,37) =	8.969 [0.001]**
log-likelihood	127.824	DW	0.57
no. of observations	40	no. of parameters	3
mean(PCE(Y))	0.0249097	var(PCE(Y))	0.000145723

Heteroscedasticity consistent standard errors

	Coefficients	SE	HACSE	HCSE	JHCSE
Constant	0.015561	0.0069477	0.0090708	0.0069119	0.0071716
DPI(Y)	0.47834	0.12769	0.10098	0.095003	0.097808
V(t) (Y)	-0.024880	0.097085	0.11556	0.089376	0.093535

	Coefficients	t-SE	t-HACSE	t-HCSE	t-JHCSE
Constant	0.015561	2.2398	1.7155	2.2514	2.1699
DPI(Y)	0.47834*	3.7460	4.7370	5.0350	4.8906
V(t) (Y)	-0.024880	-0.25627	-0.21530	-0.27837	-0.26599

*** Indicates significant effect at 5% level of significance**

Table 8-15: Ordinary Least Square and Heteroscedasticity consistent standard errors
(Log quarterly change data and the estimation sample is: 1997:1-2006:4)

Modelling PCE by OLS

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.00706772*	0.001338	5.28	0.0000	0.4300
DPI	0.0946873	0.08723	1.09	0.2848	0.0309
V(t)	-0.113510	0.07868	-1.44	0.1575	0.0533

sigma	0.00452553	RSS	0.000757775853
R^2	0.0786732	F(2,37) =	1.58 [0.220]
log-likelihood	160.723	DW	1.75
no. of observations	40	no. of parameters	3
mean(PCE)	0.00609023	var(PCE)	2.05621e-005

Heteroscedasticity consistent standard errors

	Coefficients	SE	HACSE	HCSE	JHCSE
Constant	0.0070677	0.0013377	0.0016586	0.0014109	0.0014819
DPI	0.094687	0.087235	0.13098	0.10565	0.11627
V(t)	-0.11351	0.078677	0.064699	0.058850	0.060372

	Coefficients	t-SE	t-HACSE	t-HCSE	t-JHCSE
Constant	0.0070677*	5.2834	4.2613	5.0093	4.7694
DPI	0.094687	1.0854	0.72292	0.89620	0.81435
V(t)	-0.11351	-1.4427	-1.7544	-1.9288	-1.8802

*** Indicates significant effect at 5% level of significance**

Table 8-16: Autoregressive *AR(1)*
(Log annual change data and the estimation sample is: 1997:1-2006:4)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
PCE(Y)_1	0.782624	0.09105	8.60	0.0000	0.6724
Constant	0.00471750	0.004224	1.12	0.2715	0.0335
DPI(Y)	0.137089	0.08406	1.63	0.1116	0.0688
V(t) (Y)	-0.0506558	0.05641	-0.898	0.3752	0.0219

sigma	0.00597694	RSS	0.00128605903
R^2	0.779366	F(3,36) =	42.39 [0.000]**
log-likelihood	150.144	DW	2.22
no. of observations	40	no. of parameters	4
mean(PCE(Y))	0.0249097	var(PCE(Y))	0.000145723

*** Indicates significant effect at 5% level of significance**

Table 8-17: Autoregressive *AR(1)*
(Log quarterly change data and the estimation sample is: 1997:1–2006:4)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
PCE_1	0.194443	0.1623	1.20	0.2387	0.0383
Constant	0.00613993	0.001539	3.99	0.0003	0.3066
DPI	0.0757666	0.08815	0.859	0.3958	0.0201
V(t)	-0.126787	0.07900	-1.60	0.1173	0.0668

sigma	0.00449914	**RSS**	0.000728722675
R^2	0.113997	**F(3,36) =**	1.544 [0.220]
log-likelihood	161.504	**DW**	2.25
no. of observations	40	**no. of parameters**	4
mean(PCE)	0.00609023	**var(PCE)**	2.05621e-005

*** Indicates significant effect at 5% level of significance**

8.4.5 Regression tables 2007-2010

Table 8-18: Ordinary Least Square and Heteroscedasticity consistent standard errors
(Log annual change data and the estimation sample is: 2007:1-2010:4)

Modelling PCE(Y) by OLS

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.00302914	0.007601	0.399	0.6967	0.0121
DPI(Y)	1.12998*	0.2062	5.48	0.0001	0.6980
V(t) (Y)	0.226929	0.1170	1.94	0.0744	0.2245

sigma	0.0119491	RSS	0.00185616166
R^2	0.761397	F(2,13) =	20.74 [0.000]**
log-likelihood	49.7916	DW	1.17
no. of observations	16	no. of parameters	3
mean(PCE(Y))	-0.000271258	var(PCE(Y))	0.000486206

Heteroscedasticity consistent standard errors

	Coefficients	SE	HACSE	HCSE	JHCSE
Constant	0.0030291	0.0076008	0.0064737	0.0061522	0.0086888
DPI(Y)	1.1300	0.20616	0.30745	0.29480	0.44935
V(t) (Y)	0.22693	0.11696	0.12443	0.10658	0.14182

	Coefficients	t-SE	t-HACSE	t-HCSE	t-JHCSE
Constant	0.0030291	0.39853	0.46791	0.49236	0.34863
DPI(Y)	1.1300*	5.4810	3.6753	3.8330	2.5147
V(t) (Y)	0.22693	1.9402	1.8237	2.1292	1.6001

*** Indicates significant effect at 5% level of significance**

Table 8-19: Ordinary Least Square and Heteroscedasticity consistent standard errors
(Log quarterly change data and the estimation sample is: 2007:1-2010:4)

Modelling PCE by OLS

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	-0.000600858	0.003298	-0.182	0.8583	0.0025
DPI	0.376431	0.1894	1.99	0.0684	0.2330
V(t)	-0.00498852	0.1714	-0.0291	0.9772	0.0001

sigma	0.00813758	RSS	0.000860861923
R^2	0.233344	F(2,13) =	1.978 [0.178]
log-likelihood	55.9383	DW	1.29
no. of observations	16	no. of parameters	3
mean(PCE)	0.000185224	var(PCE)	7.018e-005

Heteroscedasticity consistent standard errors

	Coefficients	SE	HACSE	HCSE	JHCSE
Constant	-0.00060086	0.0032982	0.0034749	0.0030332	0.0033349
DPI	0.37643	0.18942	0.16385	0.18510	0.24130
V(t)	-0.0049885	0.17135	0.10190	0.12654	0.17563

	Coefficients	t-SE	t-HACSE	t-HCSE	t-JHCSE
Constant	-0.00060086	-0.18218	-0.17292	-0.19810	-0.18017
DPI	0.37643*	1.9873	2.2975	2.0336	1.5600
V(t)	-0.0049885	-0.029112	-0.048956	-0.039423	-0.028403

*** Indicates significant effect at 5% level of significance**

Table 8-20: Autoregressive *AR(1)*
(Log annual change data and the estimation sample is: 2007:1-2010:4)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
PCE(Y)_1	0.336384	0.2052	1.64	0.1270	0.1830
Constant	0.00379468	0.007166	0.530	0.6061	0.0228
DPI(Y)	0.768264	0.2937	2.62	0.0226	0.3631
V(t) (Y)	0.185114	0.1130	1.64	0.1272	0.1829

sigma	0.0112414	RSS	0.00151642486
R^2	0.805069	F(3,12) =	16.52 [0.000]**
log-likelihood	51.4089	DW	0.879
no. of observations	16	no. of parameters	4
mean(PCE(Y))	-0.000271258	var(PCE(Y))	0.000486206

*** Indicates significant effect at 5% level of significance**

Table 8-21: Autoregressive *AR(1)*

(Log quarterly change data and the estimation sample is: 2007:1-2010:4)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
PCE_1	0.551848	0.2311	2.39	0.0343	0.3221
Constant	0.000964745	0.002901	0.333	0.7452	0.0091
DPI	0.280439	0.1672	1.68	0.1194	0.1899
V(t)	0.0754164	0.1507	0.501	0.6257	0.0205

sigma	0.00697352	**RSS**	0.000583560551
R^2	0.4803	**F(3,12)** =	3.697 [0.043]*
log-likelihood	59.0486	**DW**	1.73
no. of observations	16	**no. of parameters**	4
mean(PCE)	0.000185224	**var(PCE)**	7.018e-005

*** Indicates significant effect at 5% level of significance**