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Testing the Implications of the Permanent Income
Hypothesis in Sweden

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Abstract

The purpose of this thesis is to test the implications of the permanent income – life cycle hypothesis. According to Hall (1978), if the permanent income-life cycle hypothesis is valid, consumption should follow a random walk and no variable other than once-lagged consumption should help explaining current consumption. Two different tests are conducted. Firstly, consumption is regressed upon its one-period lag and various other lagged variables. Secondly, following the method proposed by Campbell and Mankiw (1990), the alternative that consumption follows a random walk is tested by identifying the fraction of disposable income, rather than permanent income, that is consumed. Both tests reject the permanent income – life cycle hypothesis.

In addition, the last part of this thesis shows that consumption is cointegrated with wealth and income which implies a long-run relationship between these variables. A short-run model is estimated as well and it is used to forecast consumption for the period 2009-2011.

1	Introduction	4
2	Consumption theory	5
2.1	Evidence of Friedman and Modigliani/Brumberg	7
2.2	Modelling consumption	9
3	Data	13
4	Implications of the permanent income – life cycle hypothesis	20
4.1	A first test of Hall’s random walk hypothesis	20
4.2	Testing Hall’s hypothesis using the “ λ -model”	30
5	Obtaining a model of consumption	36
5.1	The long-run model of consumption	36
5.2	The short-run model of consumption	41
5.3	Forecasting	43
6	Conclusion	45
7	References	46
8	Data appendix	48

1 Introduction

Consumption is a very interesting subject in macroeconomics not only because it normally stands for the largest component of a country's GDP. Private consumption is closely linked to welfare which motivates policy makers and autonomous actors in the market to understand how individuals react to changes in the economy. An extensive research can be found exploring the issue and its fundamentals go back to authors such as Keynes, Friedman and Modigliani. The necessity of understanding the consumption allocation pattern is essential in order to foresee future consumption paths. Consuming means that an individual prefers to spend money now instead of having it placed in financial assets so that it would be available in the future summed to the earned interests. Therefore, the foundation of a theory for consumption lies in the individual's choice of consuming today or in the future, a matter that is explained by the intertemporal choice theory which presents the trade-off between the two options.

The purpose of this thesis is to analyse consumption behaviour in Sweden. In Section 1 a short discussion on the fundamentals of consumption theory is presented. Section 2 introduces the past econometric research, most of it based on Hall (1978) who shows that consumption should follow a random walk if the permanent income – life cycle hypothesis holds. In the third section a brief explanation of the variables used in this work is presented. In section 4 the implications of the permanent income - life cycle hypothesis are studied and the hypothesis that it holds is rejected by two approaches employed here. Namely it is firstly rejected following the method proposed by Hall (1978), through the identification of lagged variables that can explain present consumption. Subsequently, the permanent income hypothesis is also rejected by a model proposed by Campbell and Mankiw (1990) which is nested on Hall's hypothesis and a more general model of consumption that assumes that individuals do not consume their permanent income but rather their current income. The last section contains an estimation of the consumption function, rather than an evaluation of an empirical relationship as in section 4. Thus, a long and a short-run models of consumption, with basis on more recent studies from Johnsson and Kaplan (1999) and López at al (1996), are estimated. The permanent income and the life cycle hypothesis receive support from the model estimated. An interesting point, worth to mention, is the period of study which goes from 1950 to 2008, thus including 30 more observations than the study presented by Johnsson and Kaplan (1999). The last topic of the section presents a forecast of private consumption for 2009-2011.

2 Consumption theory

Consumption function as an analytical device is attributed to Keynes (1936) who contributed with the psychological determinants behind consumer's behaviour:

“The fundamental psychological law, upon which we are entitled to depend with great confidence both a priori and from our knowledge of human nature and from the detailed facts of experience, is that men are disposed, as a rule and on the average, to increase their consumption, as their income increases, but not by as much as the increase in their income” (The General Theory, 1936, p.96).

The fact that an increase in income does not lead to a proportionally equal increase in consumption implies that the marginal propensity to consume falls with income. This holds for the average propensity to consume as well. Denoting consumption during period t by C_t and disposable income by Y_t^d the Keynesian consumption function can be written as

$$C_t = a + bY_t^d \quad (1)$$

Where b is the marginal propensity to consume, $C' = dC_t/dY_t^d$, and is less than one. The average propensity to consume, $C_t/Y_t^d = b + a/Y_t^d$, decreases with income.

A work conducted by Kuznets (1946) showed though that the in the long-run, aggregate average propensity to consume in the US was constant. On the other hand, the results obtained for short sample aggregate consumption time series estimates and cross-section individual household consumption regression estimates confirm Keynes's theory that the average propensity to consume diminishes.

Friedman (1957) approached this empirical problem with his permanent income hypothesis where he argues that households consume at a fixed fraction of their permanent income, which is given by the annuity value of lifetime income and wealth. Thus, consumption according to the permanent income hypothesis is given by:

$$C_t = cY_t^p \quad (2)$$

where C is consumption spending, c is the marginal propensity to consume (MPC) and Y^p is permanent income.

Friedman considers the MPC to be constant and equal to the APC which receives support from Kuznet's empirical findings (Kuznets 1946). This leads to the conclusion that transitory changes in income will not affect consumption since the model is built upon expectations on the future. Furthermore, regression estimates for short-run consumption will be flatter than for long-run. In the short-run, actual rather than permanent income is used in the regression and as the former is more spread out than the latter, the slope of the regression will be flatter. Consumption fluctuates less than income since individuals consume according to their permanent income which can be seen as an average of the income earned during a life time period. Consequently, current income may have higher variations than consumption.

Modigliani and Brumberg (1954) developed a theory where the individual chooses a pattern of consumption that maximizes his/her lifetime utility subject to his/her lifetime budget constraint. This theory is known as the lifecycle theory. It takes into account utility functions maximization and likewise the permanent income hypothesis is also forward looking, allowing lifetime income expectations to be taken into the lifetime budget constraint. This model, in addition, makes the presence of credit markets as well as interest rates possible. Most of the predictions made by the permanent income hypothesis also hold for the life-cycle hypothesis and therefore they will often be treated as one hypothesis. The assumption that marginal and average propensity to consume are constant is the most important result of these theories and can be empirically tested.

The permanent income hypothesis may also be written considering the present value of the expected income for an infinite living agent. The reason for doing that is simply that the permanent income is uncertain. With this more realistic approach the effect of interest rates can be observed (the present value of income from different periods is a contribution of Fisher 1907)

$$PV = \sum_{t=0}^{\infty} \frac{EY_t}{(1+r)^t} \quad (3)$$

Where EY_t is the expected income from household at time t and PV is the present value of income. The present value of income is in turn equal to the present value of the expected income's flow

$$\sum_{t=0}^{\infty} \frac{Y^p}{(1+r)^t} = PV = \sum_{t=0}^{\infty} \frac{EY_t}{(1+r)^t} \quad (4)$$

Permanent income is thus given by¹

$$Y^p = \frac{r}{1+r} PV \quad (5)$$

Resulting on an initial consumption that is a function of the permanent income

$$c_0 = f(Y^p) \quad (6)$$

which shows that an expected increase in permanent income raises the level of consumption today, implying that savings and permanent income have opposite directions: a rise in expected permanent income decreases savings today. This development of savings in a pro cyclical manner contributes to the smoothness of consumption during time. In periods of higher income savings grow which makes possible to keep a constant level of consumption if income were to fall in the next period.

2.1 Evidence of Friedman and Modigliani/Brumberg

Empirical works based on the permanent income and on the lifecycle hypothesis have shown different results regarding the evidence of these theories. As the theories put it, consumption will be divided between present and future. Individuals judge their ability to consume in the long-run and estimators of this consumption are formed. The level of current consumption will be a fraction of long-run consumption estimation and can be based either on permanent income, as Friedman supported, or as according to Modigliani and Brumberg in the form of life wealth.

¹ Note that $\sum_{t=0}^{\infty} \frac{1}{(1+r)^t} = \frac{1+r}{r}$

Hall (1978) shows that consumption must follow a random walk process if the life cycle – permanent income hypothesis is true. Hence, no other variable than lagged consumption is useful in explaining actual consumption. The reason for that is that C_t contains all information about permanent income in this period, i.e, consumers use all information available a time t to compute their permanent income and thereby consumption. He finds some empirical support for his theory – that only unsystematic shocks affect consumption - using quarterly data per capita expenditure on non-durables and services. His results showed that present and lagged income (Y_t, Y_{t-1}, \dots) and lagged consumption (C_{t-1}, \dots) were not useful in explaining C_{t+1} . He does find, though, that stock market prices were statistically significant.

Using a similar approach, Mankiw (1982), estimates a model for durable goods. According to his expansion of Hall's method the model should follow an autoregressive-moving average process ARMA(1,1). The empirical work conducted by him did not support, however, his theoretical framework and the hypothesis that consumption of durable goods follows a random-walk model could not be rejected. The latter implies that Hall was too hasty when suggesting that only consumption of non-durables should be unpredictable.

Another important paper about consumption prediction was presented by Flavin (1981). Contrary to Hall, she does not find empirical evidence for the lifecycle – permanent income hypothesis. She comes to that result by investigating the role of current income providing new information about future income and thus signalling changes in permanent income. Using a n ARMA process she quantifies the magnitude of the revision in permanent income due to the new information obtained through observation of current income. Finally, she relates changes in consumption to the contemporaneous revision on permanent income and the change in current income. According to the permanent income hypothesis the response of consumption to current income beyond that attributable to current income indicating changes in permanent income, entitled “excess sensitivity” of consumption to current income, should equal zero. Her empirical results show that this is not the case for the data analysed.

Campbell and Mankiw (1990) test Hall's random walk hypothesis by nesting the permanent-income hypothesis in a more general model in which some fraction of income accrues to individuals who consume their current income instead of consuming their permanent income. Using data for the US for the period 1953:1-1985:4, they come to the result that this fraction

is around 50% which indicates that the permanent income hypothesis does not hold. This in turn implies that the alternative that consumption is unpredictable can be rejected.

The effect of an economic downturn on consumption was studied by Romer (1990). She analyses the consequences of the collapse on stock prices in October 1929 on people's expectation and finds empirical evidence for the uncertainty hypothesis. The former hypothesis can be seen as a result from the theories presented by Friedman and Modigliani/Blumberg. Hence, the crash depressed consumer spending by leading consumers to believe that a depression was coming and thus permanent income was lower. According to her results consumption of durables goods fell as people re-estimated their permanent income after the Great Crash and chose to postpone consumption of such goods, indicating that the shocks in income were accounted as permanent. At the same time the consumption of non-durable goods rose as a consequence of the delay on consumption of durables.

All in all, whatever model of consumption prediction is adopted it has to be based on income expectations. This is mostly due to Lucas (1976) who addressed the researches on consumption at his time with a critique in their manner of computing consumption functions where a stable lag structure was assumed to exist between consumption and income. He highlighted that consumption depends upon expected future income and consequently the link between past and future income expectations is vulnerable to changes, for instance due to new policy, that may alter the way rational agents form expectations on future income given their past incomes. Remarking, consumption depends upon future income which implies that to model consumption it will be necessary to model income so that future income can be used in consumption prediction.

2.2 Modelling consumption

Following a general approach that can be compared to the researches presented in the previous section, consumption can be modelled with regard to future income expectation. As the future is uncertain, agents will have to make guesses based on past experiences. Their forecasts of the random economic variables that may affect their future wage income and wealth might be far from perfect. The same holds for returns on investments and assets in general. Decisions taken today will be based upon the expectations in the future and will be revised at each new future period. In this way, consumption depends on a non-deterministic or stochastic process that makes each decision (at time t , $t+1$, $t+2\dots$) subject to forecast errors.

The only assumption about individual choices that can be made is that decisions are based on rational expectations. This implies that individual choices account for all the available information about current economic variables. Although its simplicity, the assumption on rational expectation implies that forecasts are unbiased and the error terms to be uncorrelated with the information upon which the forecast was conditioned (Deaton 1992).

The representative individual maximizes the expected value, denoted by E_t , of lifetime utility

$$U_t = E_t \left\{ \sum_{s=0}^{T-t} \beta^{-s} u(C_{t+s}) \right\} \quad (7)$$

Where β is the discount factor that has a value between zero and one and $u(C_t)$ measures the individual's utility originated by some level of consumption C_t a time t .

Following the model proposed by Hall (1978), the utility is maximized subject to

$$\sum_{s=0}^{T-t} (1+r)^{-s} (C_{t+s} - w_{t+s}) = A_t$$

Where w_t denotes earnings and A_t denotes assets apart from human capital. Earnings are stochastic and are the only source of uncertainty. The stock of assets at time t is given by

$$A_t = (1+r)A_{t-1} + w_t - C_t \quad (8)$$

i.e, the interests on the assets obtained at time t plus the difference between labour income and consumption, savings.

By taking the first order condition with respect to an unconditional change in A_{t+1} the individual consumption maximization is found

$$u'(C_t) = \beta(1+r)E_t u'(C_{t+1}), \quad (9)$$

which is a stochastic Euler equation.

Assuming likewise Hall (1978), that the utility function (7) is quadratic with the form

$u(C_t) = C - \frac{a_0}{2} C^2$ we see that the marginal utility of consumption, $u'(C) = 1 - a_0 C$, is linear

in C . By making another simplifying assumption that the discounted factor β is equal to $\frac{1}{1+r}$ and substituting it into (9) it can be observed that consumption follows a random walk

$$E_t[C_{t+1}] = C_t \quad (10)$$

An individual who aims to consume all his assets and income during life time so that his last spends will be made just before his death, will consume according to

$$\sum_{s=0}^{T-t} \frac{C_{t+s}}{(1+r)^s} = A_t + \sum_{s=0}^{T-t} \frac{W_{t+s}}{(1+r)^s} \quad (11)$$

The Euler equation (9) and the martingale process (10) imply that $E_t[C_{t+j}] = C_t$ for all j . Then, taking expectations of (11) and letting T grow to infinity gives

$$C_t = \frac{r}{1+r} A_t + \frac{r}{1+r} \sum_{s=0}^{\infty} \frac{E_t W_{t+s}}{(1+r)^s} \quad (12)$$

Equation (12) can be explained on the basis of the permanent income hypothesis or through an approach that resembles more the life-cycle theory. From the permanent income hypothesis equation (12) is the annuity value of human and financial wealth. The life cycle hypothesis interprets it in a very similar way, as it argues that individuals seek to have a constant consumption during life.

Whether these conclusions drawn by the permanent and life cycle hypothesis are properly made is a matter to be discussed. Romer (1990) shows, for instance, the effect of a change in prediction of future income upon actual consumption. She supports the point taken up by Bernanke (1983) on the uncertainty hypothesis and the formation of expectations based on the prediction of future income. Bernanke (1983) showed that a temporary increase in uncertainty can cause an immediate drop in investment spending, and Romer (1990) suggests that the same can be applied to effects on consumer spending. The works of these authors may indicate that to affirm that consumption can simply be modelled according to past information without accounting for uncertainty may be a naïve method that disregards the fundamentals of intertemporal allocation theory.

Indeed, most of the consumption literature in the past 20 years have rejected the permanent income hypothesis (López et al. 1996). As was shown above, if the permanent income hypothesis holds, there will be no other variables than consumption at time $t-1$ that is useful in explaining consumption at time t . However a relatively large number of articles based on the Euler equation (9) have rejected this result. Hall himself finds some explanation power of the stock market index upon future consumption.

Thus, López et al. (1996) uses an income generation process to get a closed form of consumption, reducing the role of uncertainty into the estimation of future consumption. Hence considering

$$w_t - \bar{w} = a_1(w_{t-1} - \bar{w}) + u_t \quad (13)$$

Where $0 \leq a_1 \leq 1$, \bar{w} is the unconditional expected value of w and u is a random error. Equation (13) says then that deviations from the expected income today are equal to a factor a_1 times the deviation from expected income in the previous period plus an random term.

Substituting (13) into (8) the following consumption function is obtained

$$C_t = (1+r)A_{t-1} + \left[\frac{r}{1+r-a_1} \right] w_t + \left[\frac{1-a_1}{1+r-a_1} \right] \bar{w} \quad (14)$$

Equation (14) above is the equilibrium cointegrating relation for consumption, showing how it depends on the life-cycle wealth: financial and physical wealth, A , and income, w . This relationship says that individuals are able to observe their actual consumption relative to the long-run consumption. Thus, in the short-run consumption will increase if individuals realize that their consumption level is below the one given by the long-run equation. In the same manner, consumption will decrease if individuals experience that their current consumption is above the consumption given by the equilibrium relationship. Hence, if consumption is cointegrated with wealth, A , and income, w , there must be an error correction model (ECM) linking these variables (Engle and Granger 1987).

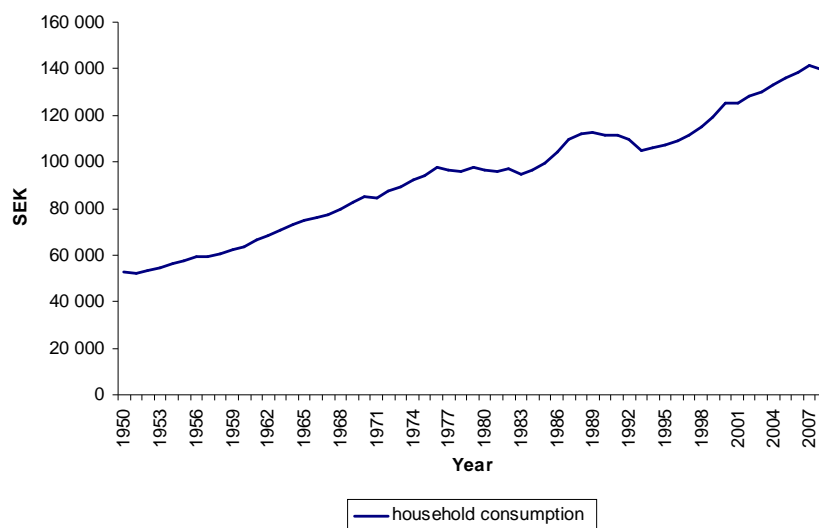
Johnsson and Kaplan (1999) looked at long and short-run models of consumption using yearly Swedish data from 1970-1998. They found indeed a long-run relationship where income and financial and wealth and house stock well explain consumption. In the short-run changes in consumption are explained by changes in income, changes in financial wealth and the relative house prices.

3 Data

A brief explanation of the variables used in the following sections will be given here together with their plotted diagrams. The choice of variables was based mainly in the work of Johnsson and Kaplan (1999) as well as in López et al. (1996). Annual data for the period 1950-2008 and quarterly data for the 1993:1-2008:4 were found at Statistics Sweden (SCB), at the NIER (National Institute of Economic Research) and at the Swedish Riskbanken. Real values are given in 2000 year SEK. The variables for the first sample period, 1950-2008, will be commented in more detail while the raw data for the second sample period, 1993:1-2008:4, are simply presented at the end of this section.

Household consumption per capita

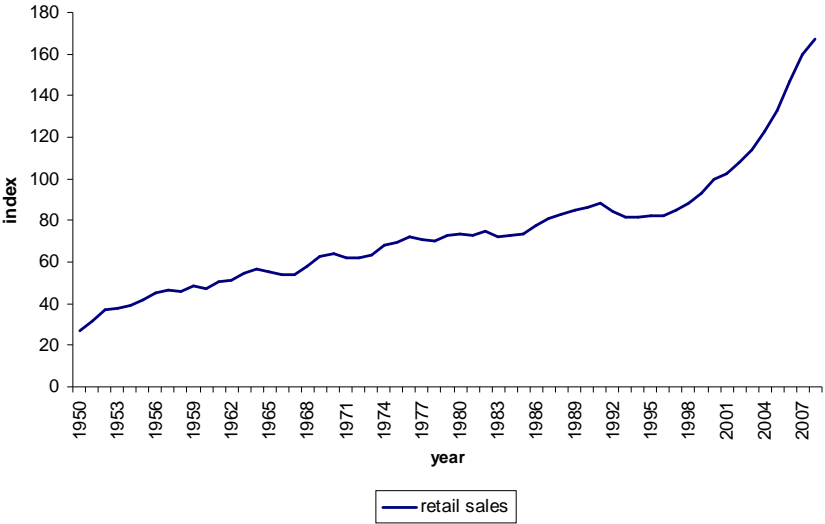
Consumption was divided into two categories: aggregated consumption and non durables consumption. The permanent income hypothesis is usually tested excluding expenditure in durables. It depends on the assumption that consumers, according to the permanent income-life cycle hypothesis, have a utility function that is separable between durable and nondurable goods. Some more careful researches have in fact removed the investment in durable goods and added the imputed service flow of the stock of durables to consumption. Data for aggregated consumption was available at SCB and was divided by the population.



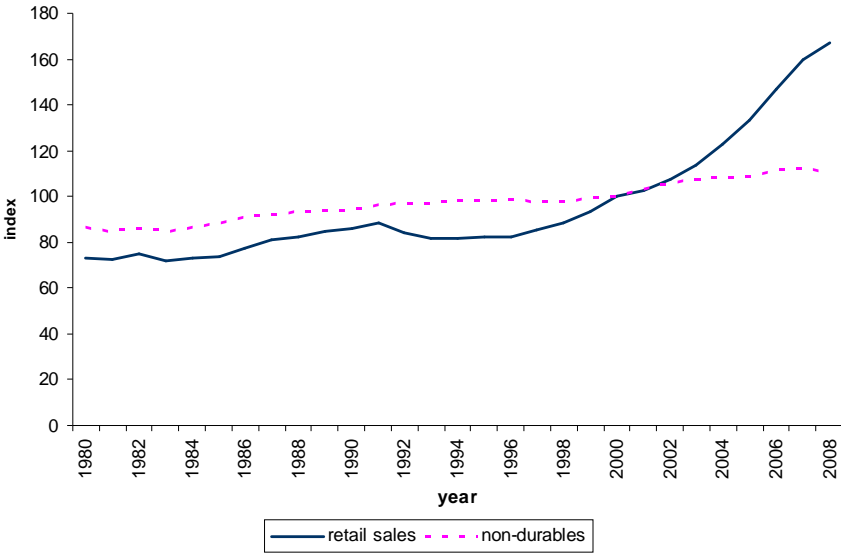
Source: SCB

For non-durables I used data for Retail sales that are available at SCB starting at 1956. Unfortunately, the data series for non-durables consumption that is available at SCB starts in 1980. The choice of retail sales as a proxy can be grounded on Romer (1990), who chooses

the same variable when data for non-durable goods was not available. Indeed this variable seems to behave slightly in the same fashion than non-durable goods from 1980 until the second half of the 1990s when it starts to grow much faster. The series for non-durables consumption grows more constantly, with smaller fluctuations as the diagram shows, The series are indexed to 2000=100



Source: SCB



Source: SCB

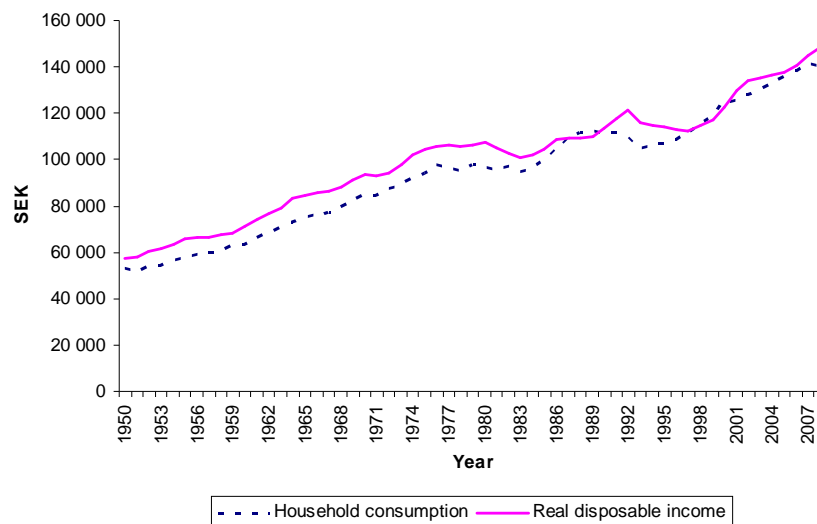
The data for 1950-1956 were estimated assuming that it follows the same percent changes than the series for grocery stores provided by Rodney Edvinsson (2005). This series has a very similar behaviour to the series from SCB and its changes are plotted below together with changes in retail sales starting from 1957 until 1975. The reference year for the index is 2000.



Source: SCB and Rodney Edvinsson (2005)

Real disposable income

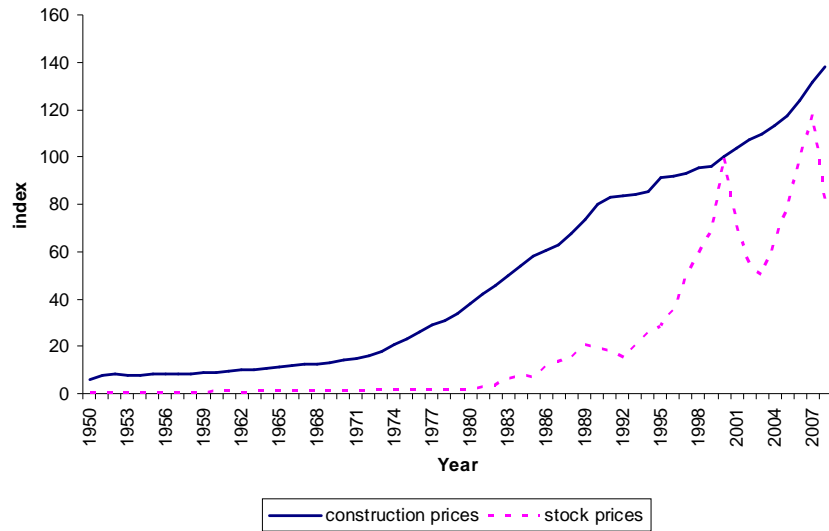
Real disposable income was available at SCB and it was divided by the population. Real household consumption per capita was plotted together with real disposable income per capita in the diagram below.



Source: SCB

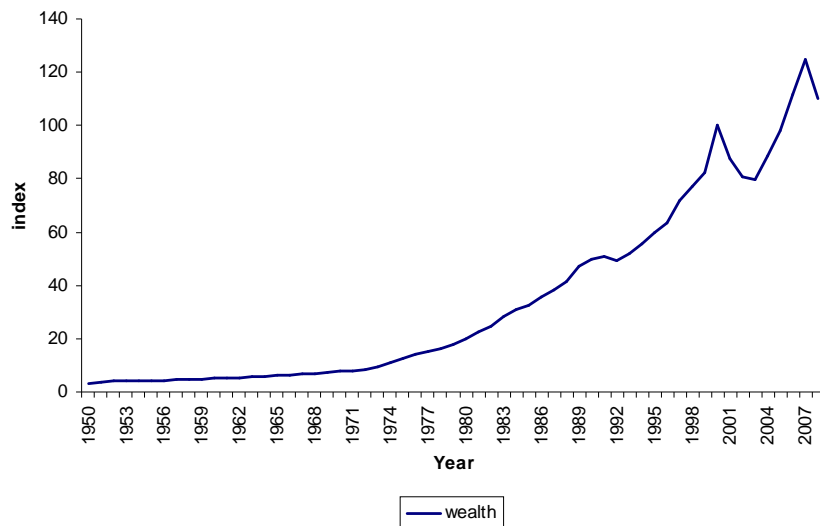
Wealth

For this variable I consider both financial and physical wealth. As financial wealth I use the stock price index available at Riksbanken and for physical wealth I consider the index price for construction of houses that is available at SCB. Both variables were plotted below.



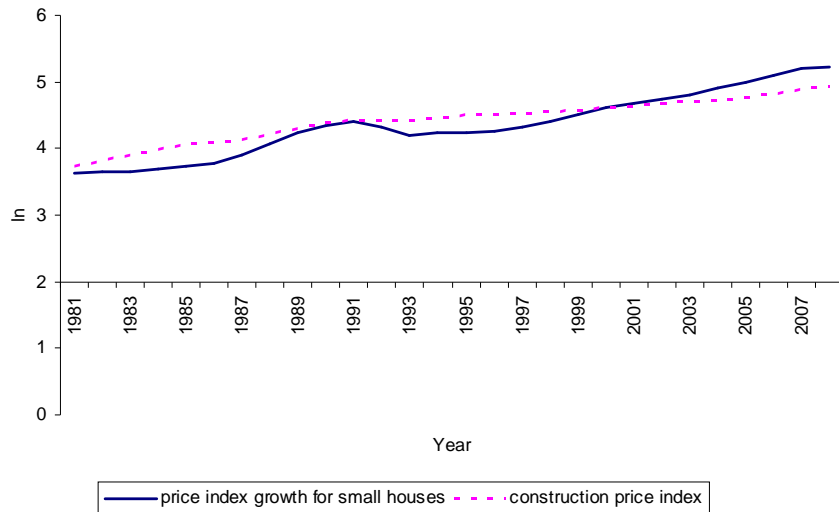
Source: SCB

By making a very general simplification, namely, that financial and physical wealth are weighted equally when forming an individual's wealth, one index accounting for both variables was constructed. This variable will be used in the section that covers the long-run model of consumption and will be called "wealth".



Calculated wealth

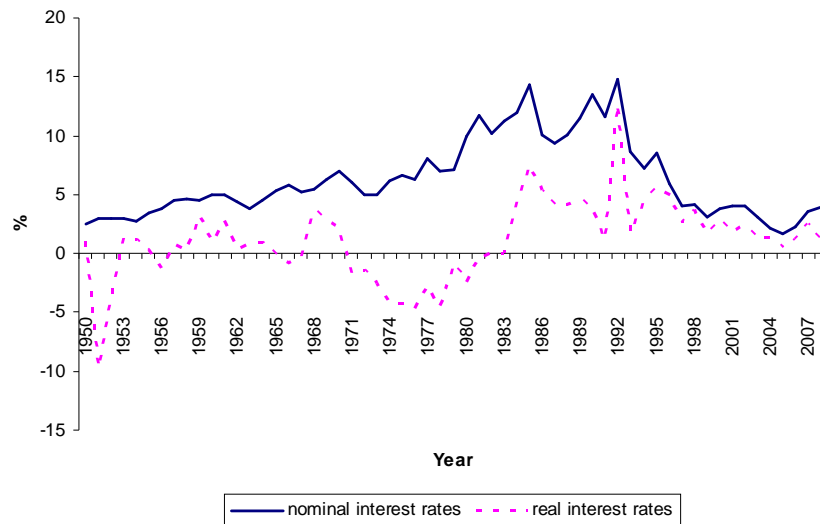
The diagram below shows the plot of the natural logarithms of the construction prices and of the index for the price of small houses that is available at SCB with start in 1981. Both series trend upwards but the construction prices are less volatile than house prices.



Source: SCB

Interest rates

Both nominal and real interest rates will be used in this work. Data for short-run nominal interest rates is available at the Riksbank. Real interest rate was calculated as the difference between nominal interest rate and yearly inflation.

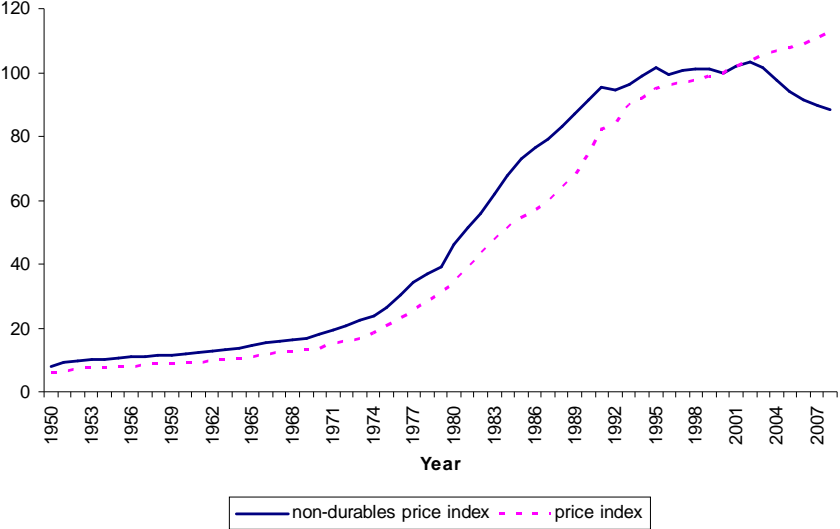


Source: The Riksbank

Prices

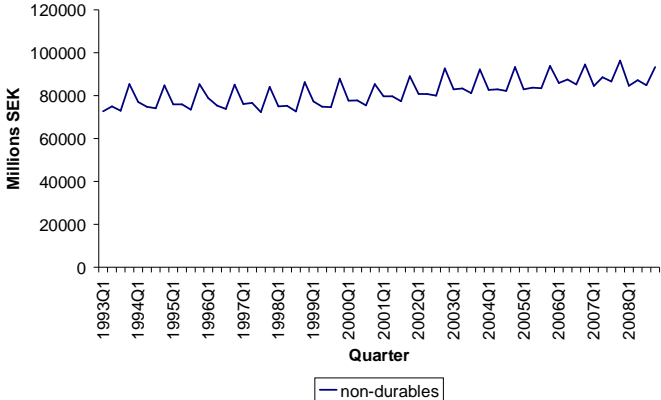
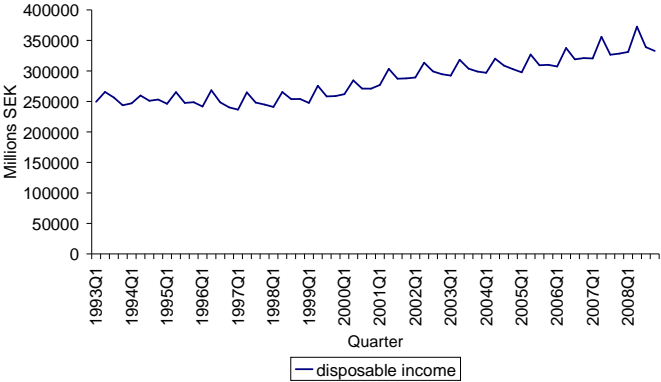
Two price indexes will be used: one for non-durable goods and one for the aggregated basket of goods. The former was constructed from the series for retail sales. The latter is available at

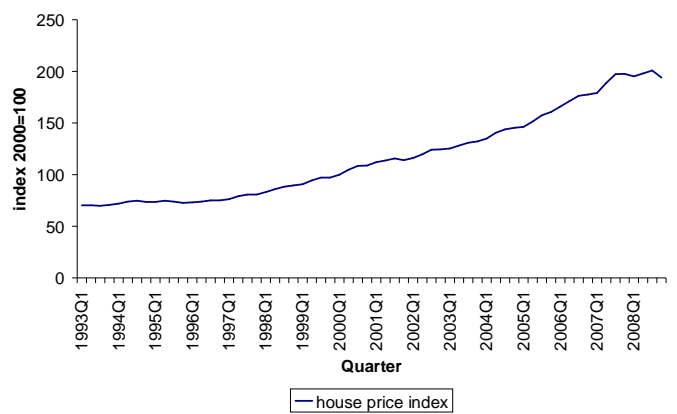
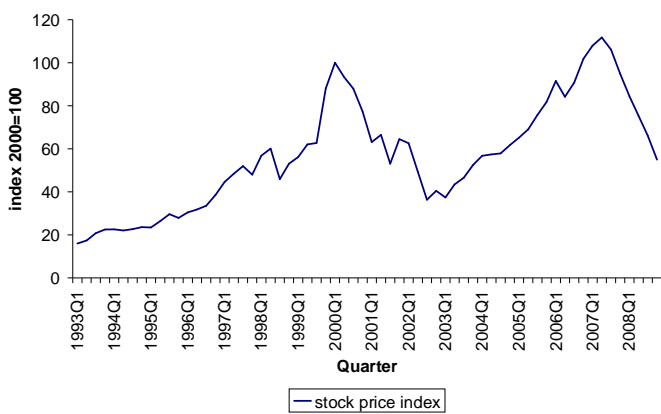
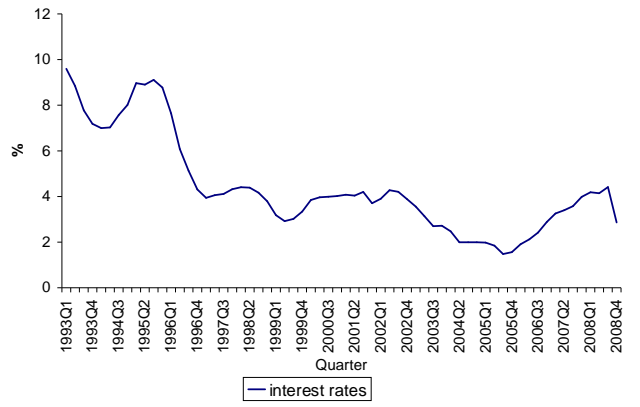
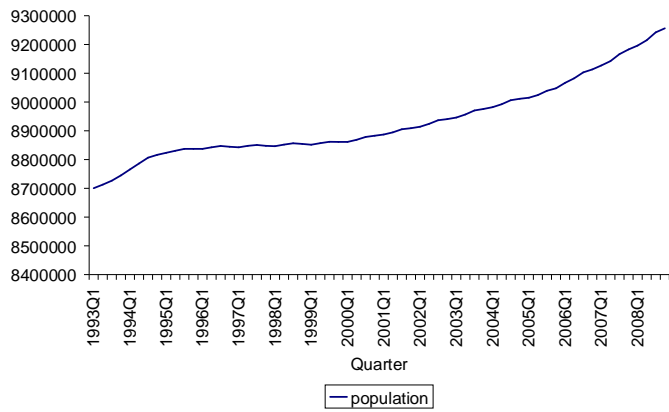
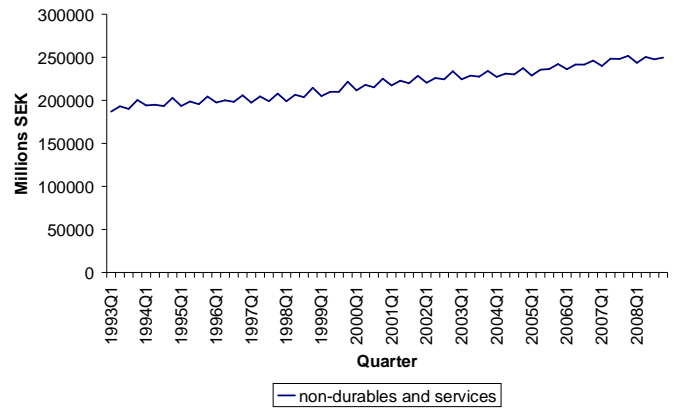
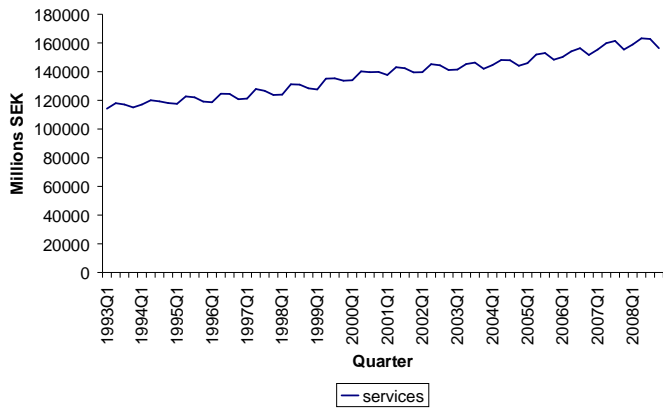
SCB. Both series were indexed to 2000=100. The variables described above will be deflated with one of these series, depending on the regression being estimated.



Source: SCB

Quarterly data for the period 1993:1-2008:4 is shown below. The only necessary modification in order to implement this data was the construction of the variable “non-durables and services” which were available separately. Disposable income, non-durables consumption and expenditure on services are given in 2000 SEK. Stock and house prices were indexed to 2000=100. This sample period will be used in section 4.1 and 4.2. Quarterly data for population, short-run interest rates and stock prices were found in Datastream.



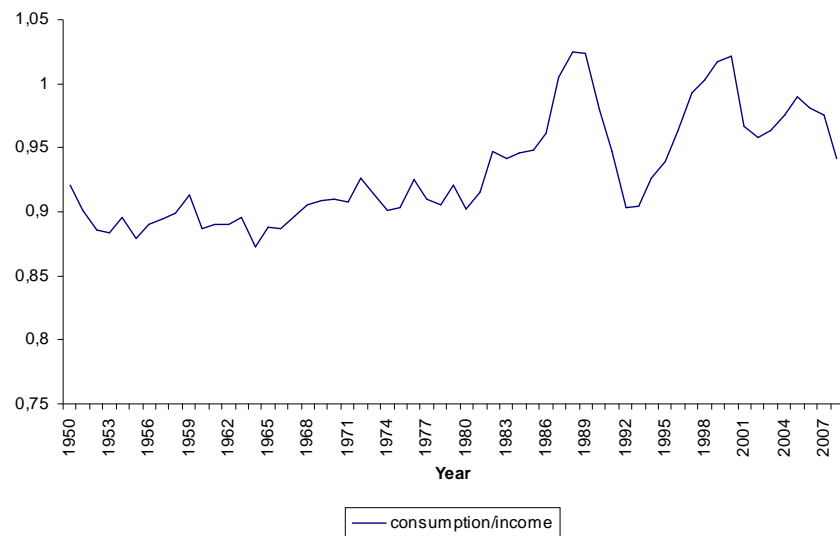


Source: See Data Appendix

4 Implications of the permanent income – life cycle hypothesis

The main discussion in this section will focus on the application of Swedish data for the model described by Hall (1978).

Figure below shows Swedish household consumption in relation to household disposable income from 1950 to 2008.



Source: SCB

This relationship indicates that the average propensity to consume has been somewhat constant until 1985, when the credit market was deregulated and the consumption to income ratio became more volatile. Most of the observations are between 0.9% and 1% supporting the permanent income and the life cycle hypothesis.

4.1 A first test of Hall's random walk hypothesis

According to equation (10) the expectation of C_2 in period 1 equals C_1 . As a result, in each period, expected next-period consumption is equal to current consumption which implies that changes in consumption are unpredictable (Romer 2006). By the definition of expectations the following equation can illustrate that:

$$C_t = E_{t-1}[C_t] + \varepsilon_t \quad (15)$$

To test Hall's random walk one can model future consumption having in the right hand side other variables than one period lagged consumption per capita. Therefore the finding of another variable that turns out to be useful in explaining consumption rejects the permanent income life cycle hypothesis as put by Hall in equation (10). By putting (10) and (15) together we have

$$C_t = C_{t-1} + \varepsilon_t \quad (16)$$

Hence, following the approach used by Hall, a good starting point to test his hypothesis may be to regress consumption of nondurables per capita at time t upon its lag and a constant:

$$C_t = \delta + \gamma C_{t-1} + \varepsilon_t \quad (17)$$

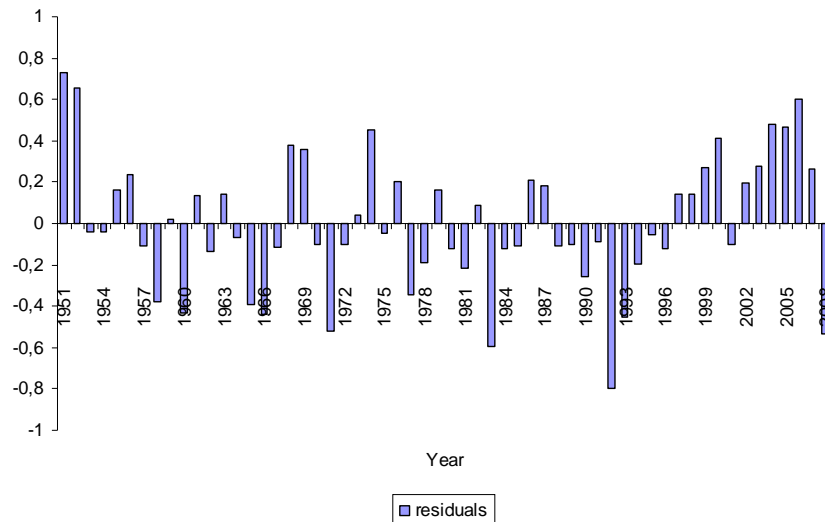
Hall's hypothesis is that changes in consumption follow a random walk with drift which implies that γ would be equal to one so that $C_t - C_{t-1}$ is equal to a constant δ and a random term.

Annual data for nondurables (retail sales) for the period 1950-2008 in 2000 SEK is taken from SCB and was divided by the population. Regression results of (17) are shown below.

Table 4.1 Regression results of non-durables current consumption, C_t on a constant and the lagged value of consumption, C_{t-1} . 1950-2008, annual data

Dependent variable: C_t			
Variable	Estimate	Standard error	t-ratio
δ	-0.319	0.159	-2.00
C_{t-1}	1.064	0.017	60.85
R ² =0.9851 DW=0.8999			

The high value of the fit of the regression shown above does not necessarily say that the life cycle-permanent income hypothesis holds, since it is well known that consumption is highly serially correlated. If the theory holds there are no other variables than C_{t-1} that can help predicting the residuals provided by equation (17). Lagged consumption contains all information individuals need in order to plan future consumption. The residuals show the effect of new information available at time t that individuals use to revise their life time income. A couple of observations can be done out of an analyses of the residuals from the random walk equation.



By observing the residuals it can be noticed that the behaviour of consumption really does not follow a defined pattern during the period considered. The crises of the 70's and 90's can be observed in the residuals. The deepest fall in consumption in a single year is observed in 1992.

The Jarque Bera test has a p-value of 0.93 confirms the result of the diagram above and thus cannot reject the null that the residuals are normally distributed at the 5% significance level. The number of observations that exceed $2*SE$ corresponds to what would be expected with symmetric distributed data. These observations are found in 1951, 1952, 1992 and 2006. Although the normality of the residuals has been attested, the Durbin-Watson has a value of 0.89 which says that the residuals are positively serially correlated². The latter implies that inferences based on the OLS estimator will be misleading because the standard errors will be based on the wrong formula³. Actually, even if the DW had not given signal of autocorrelation on the residuals, the standard t-ratio of the estimation of (17) does not have a t distribution. Dickey and Fuller (1979) showed that although an OLS estimation of a variable upon a constant and its one period lag gives consistent estimators, under the null that $\gamma=1$ the standard t-ratio does not have a t distribution due to the nonstationarity of the series

Hence, to test the null that $\gamma=1$ one can use the critical values given for Dickey-Fuller tests,

² The Breush-Pagan also rejects the alternative of no-autocorrelation

³ see for example Verbeek, page 109

$$DF = \frac{\hat{\gamma} - 1}{se(\hat{\gamma})}$$

Where $\hat{\gamma}$ is the OLS estimator of the regression and $se(\hat{\gamma})$ is the standard error.

The value of this test for (17) is 3,70 far above the DF 5% critical value, implying that the null hypothesis of a unit root ($\gamma = 1$) against stationarity ($|\gamma|$ less than one) cannot be rejected and consumption can be said to follow a random walk with drift.

Following the approach used by Hall (1978), Mankiw (1981) and other authors, the hypothesis of the random walk model of consumption can be tested by confrontation. This can simply be done by regressing consumption upon lagged variables that according to economic intuition should affect consumption. The finding of variables other than one period lagged consumption that can help explaining current consumption may refute the random walk hypothesis. Thus, the next step in the analyses is to test whether consumption can be explained by its own past further than one period ago. The result of the estimation of consumption at time t upon a constant and consumption at times $t-1$, $t-2$ is shown below:

Table 4.2 Regression results of non-durables current consumption, C_t on a constant and the lagged values of consumption, C_{t-1} and C_{t-2} . 1950-2008, annual data

Variable	Estimate	Standard error	t-ratio
δ	-0.161	0.148	-1.08
C_{t-1}	1.574	0.017	14.23
C_{t-2}	-0.543	0.119	-4.55

R²=0.9897 DW=2.045 F = 2603,5

These results indicate that consumption can be rather explained by an AR(2) model. The hypothesis of a unit root can be tested for this model as well. The DF statistic is equal to 1,71, providing no evidence for the rejection of a random walk.

Recording section 2 and equation (12) consumption was given as a function of expected income. Even if future income can be predicted in order to model future consumption, a regression of consumption per capita upon current and lagged income per capita may give interesting results, serving as test to the random walk model for consumption. The hypothesis that consumption responds to predictable income movements was proposed by Flavin (1981)

and is referred as the excess sensitivity of consumption. Annual data for disposable income for 1950-2008 in 2000 SEK was available at SCB and has been divided by the population. As the series for non-durables goods is an index, disposable income has also been indexed in order to make the interpretation of the coefficients easier. The following equation was estimated⁴ and the alternative being tested is whether $\gamma = 1$ and $\beta = 0$ which would imply that lagged values of income have no explanatory power.

$$C_t = \delta + \gamma C_{t-1} + \sum_i^j \beta_{i+k} Y_{t-i} + \varepsilon_t \quad (18)$$

This equation can be estimated using OLS and the estimators will be consistent for all parameters given that ε_t are stationary even if C_t and/or Y_t are I(1), i.e, integrated of order one⁵. In fact, the DF test indicates a unit root in the disposable income series and as it was shown above that the presence of a unit root in the consumption of non-durables series cannot be rejected either. As (18) includes lagged values of both the dependent and independent variables no spurious regression problem will arise because there exist parameters values such that the error term ε_t is I(0)⁶. Two equations have been estimated, varying the lag length of disposable income:

Table 4.3 Non-durables current consumption, C_t , regressed on a constant, the one-period lagged consumption and lagged income. 1950-2008, annual data

Variable	equation 1	equation 2
δ	-0.182 (0.221)	0.085 (0.209)
C_{t-1}	1.185*** (0.046)	1.186*** (0.047)
Y_{t-1}	0.010 (0.032)	-0.018*** (0.006)
Y_{t-2}	-0.052 (0.057)	
Y_{t-3}	0.040 (0.057)	
Y_{t-4}	-0.013 (0.029)	
R^2	0.988299	0.986925
DW	1.366	1.132

The significance of the coefficients is marked as *, **, and *** to indicate significance levels of at least 10, 5, and 1% respectively.

Equation 1 supports the random walk pattern, as no of the lags of income is significant. In equation 2, however, the one period lagged income is significant at explaining current

⁴ Disposable income has been denoted by Y and will be considered to be equal to labour income denoted in section 2 by w

⁵ Section 5 presents a more details about the cointegration of nonstationary variables

⁶ See for example Verbeek, page 328

consumption which is strengthened by the stationarity of the residuals, which in turn confirms the cointegration of the consumption and income series⁷. Although its significance, Y_{t-1} is remarkably small and its sign may be puzzling since it indicates that an increase in income reduces consumption. The latter and the fact that the fit of the regression is vaguely improved when income is added suggest that the explanation power of this variable is very low and could be left out of the model.

Regression (18) above investigates the excess sensitivity of income on consumption. The life cycle- permanent income hypothesis considers besides income how wealthy and individual is so that the present value of her/his assets are accounted when she/he plans consumption. In order to catch the effect of wealth upon consumption the stock market index can be used⁸. Again, according to the permanent income-life cycle hypothesis, all information contained in lagged wealth is given by lagged consumption. Table 4.4 below shows the results of the regressions of consumption upon lagged stock prices, denoted by S . Two regressions are estimated, the first containing four lags and the second one lag of the stock prices. The stock price index is taken from Riksbanken and was deflated by the deflator for non-durables.

Table 4.4 Non-durables current consumption, C_t , regressed on a constant, the one-period lagged consumption, C_{t-1} and lagged stock prices. 1950-2008, annual data

Variable	equation 1	equation 2
δ	0.171 (0.257)	0.318 (0.218)
C_{t-1}	0.978*** (0.035)	0.964*** (0.030)
S_{t-1}	0.009** (0.005)	0.010*** (0.002)
S_{t-2}	-0.003 (0.008)	
S_{t-3}	-0.004 (0.008)	
S_{t-4}	0.011 (0.005)	
R^2	0.989466	0.988287
DW	1.477	1.209

The significance of the coefficients is marked as *, **, and *** to indicate significance levels of at least 10, 5, and 1% respectively. Stock prices lagged with more than 1 period have no significant explanation power on current consumption. The reason for that is the high volatility of the stock markets compared to the much smoother behaviour of non-durables consumption. Hall (1978) and Mankiw (1982) find

⁷ Engle Granger test rejects unit root, ADF = -4,21, critical value = -4,10. Akaike criteria was used to determine the lag length

⁸ See for example Hall (1978), Romer (1990) and Mankiw (1991)

significant values using quarterly data. Nevertheless, a regression run with Swedish quarterly data from 1993:1 to 2008:4 does not give more significant lags either and these results can be seen on table 4.7 in page 29. The fit of the regression 2 above is, though, slightly improved and the residuals are stationary⁹ which denotes that the regression is not spurious as it would be expected given the non-stationarity of both series.

Still another variable that can be tested in order to evaluate the role of changes in wealth upon consumption are house prices. The data available at SCB is an index for building prices and was deflated by non-durables. The results of the regressions containing three respectively one lagged house price are shown below:

Table 4.5 Non-durables current consumption, C_t , regressed on a constant, the one-period lagged consumption, C_{t-1} and lagged house prices. 1950-2008, annual data

Variable	equation 1	equation 2
δ	-1.472***	-1.576***
	0.517	0.301
C_{t-1}	0.948***	0.916***
	0.042	0.035
H_{t-1}	0.043***	0.029***
	0.020	0.006
H_{t-2}	-0.039	
	0.031	
H_{t-3}	0.021	
	0.020	
R^2	0.989557	0.989329
DW	1.440812	1.259367

The significance of the coefficients is marked as *, **, and *** to indicate significance levels of at least 10, 5, and 1% respectively.

Also in this case, only the one lagged term is significant. A Wald test says, though, that the alternative that the three lags are equal to zero can strongly be rejected. The improvement of the R^2 and the coefficients of regression 2 support the presence of this variable in explaining consumption.

Finally, consumption can be regressed upon lagged nominal interest rate values. Low interest rates stimulate consumption but at the same time reduce the present value of the assets an individual owns which can lead to less expenditure. Once more, according to the permanent

⁹ Engle Granger test rejects unit root, ADF = -3.75, critical value -3.74. Akaike criteria was used to determine the lag length

income – lifecycle income hypothesis lagged interest rates do not have any effect on current consumption.

Table 4.6 Non-durables current consumption, C_t , regressed on a constant, the one-period lagged consumption, C_{t-1} and lagged interest rates. 1950-2008, annual data

Variable		equation 1	equation 2
	δ	-0.140 (0.150)	0.050 (0.143)
	C_{t-1}	1.082*** (0.014)	1.067*** (0.014)
	i_{t-1}	-0.047** (0.024)	-0.062*** (0.011)
	i_{t-2}	-0.009 (0.030)	
	i_{t-3}	0.0004 (0.024)	
	R^2	0.991485	0.990580
	DW	1.645938	1.486186

The significance of the coefficients is marked as *, **, and *** to indicate significance levels of at least 10, 5, and 1% respectively.

The results above show that the one period lagged interest rates have, as intuition says, a negative impact on consumption of non durable goods.

The results obtained with annual data showed that Hall's hypothesis is always rejected. In all the cases the once lagged variable other than consumption itself is significant in explaining current consumption, even if it is done in a small extension.

Regressions with quarterly data for the period 1993:1-2008:4 confirm the results obtained with annual data, refuting the hypothesis that consumption would follow a random walk. The difference is, though, that data for non-durables and services was used rather than only non-durables. Table 4.7 in page 29 reports the results. The same equations have been regressed. In total 9 regressions are shown, two for each variable with exception for house prices which was used just once. The variables were, as above, lagged four times and then just once. In a couple of cases the four lags are (and the once-lagged consumption as well) significant, namely, for disposable income per capita and house prices. The data for these regressions is reported in section 3. Stock and house price index were, as in Hall (1978) deflated by non-durables and divided by the population. When consumption was regressed upon its own lag and four lags of stock prices respectively nominal interest rates, only one lag of the these variables was significant. Hence, past values of house prices and disposable income result to

be best predictors of current income. It is, therefore, not a coincidence that the lowest coefficients of the once lagged consumption are observed also in the regressions involving income and house prices, without accounting for equations 1 and 2 in table 4.7.

Table 4.7 Results for the regressions of current consumption of non-durables and services, C_t , upon a constant, one-period lagged consumption and other various lagged variables varying in lag length. 1993:1-2008:4, quarterly data

Variable	1	2	3	4	5	6	7	8	9
δ	428.858 (494.188)	768.373 (807.511)	628.092 (977.583)	3773.884*** (1394.436)	3757.849** (1692.513)	4229.624** (1651.866)	9070.481*** (2364.068)	5752.626*** (2089.198)	11018.34*** (2211.993)
C_{t-1}	0.096 (0.076)	0.172*** (0.076)	0.955*** (0.103)	0.682*** (0.114)	0.826*** (0.077)	0.808*** (0.075)	0.674*** (0.086)	0.790*** (0.076)	0.420*** (0.118)
C_{t-2}	0.142** (0.076)	0.802** (0.075)							
C_{t-3}	0.142 (0.076)								
C_{t-4}	0.80*** (0.076)								
Y_{t-1}			-0.087** (0.035)	0.128** (0.059)					
Y_{t-2}			0.243*** (0.029)						
Y_{t-3}			-0.385*** (0.045)						
Y_{t-4}			0.246*** (0.032)						
S_{t-1}					-0.015* (0.012)	0.008* (0.005)			
S_{t-2}					0.035 (0.018)				
S_{t-3}					-0.016 (0.018)				
S_{t-4}					0.006 (0.012)				
i_{t-1}							203.317 (288.371)	-121.448** (61.909)	
i_{t-2}							-875.804 (553.819)		
i_{t-3}							1238.820 (549.817)		
i_{t-4}							-787.125*** (283.131)		
H_{t-1}									1.504*** (0.269)
H_{t-2}									-1.747*** (0.450)
H_{t-3}									1.259*** (0.439)
H_{t-4}									-0.775*** (0.281)
se	251.977	431.168	709.993	703.975	709.993	718.884	664.891	708.174	520.561
R	0.979	0.9385	0.837	0.838	0.837	0.824	0.857	0.836	0.912
F	645.487	450.473	55.627	155.943	55.627	135.874	64.944	153.744	112.769
DW	1.05	2.07	3.272	3.53	3.272	3.276	3.08	3.28	2.33

The significance of the coefficients is marked as *, **, and *** to indicate significance levels of at least 10, 5, and 1% respectively.

4.2 Testing Hall's hypothesis using the " λ -model"

Campbell and Mankiw (1990) use an instrumental-variables approach to test Hall's hypothesis against the alternative that a fraction of individuals simply spend their current income. According to Hall (1978) a change in consumption from period $t-1$ to period t equals the change in estimated permanent income between $t-1$ and t . The alternative says that a change in consumption between t and $t-1$ equals the change in income between t and $t-1$. Thus, there will be two groups of individuals, one which consumes their current income and the other consumes their permanent income. Both alternatives are shown below:

$$C_t - C_{t-1} = Y_t - Y_{t-1} \quad (19)$$

$$C_t - C_{t-1} = E(Y_t - Y_{t-1}) = e_t \quad (20)$$

Denoting the fraction of income that accrues to individuals who consume their current income by λ and the remainder by $(1-\lambda)$ the following equation can be written:

$$\begin{aligned} C_t - C_{t-1} &= \lambda(Y_t - Y_{t-1}) + (1-\lambda)e_t \\ &\equiv \lambda Z_t + v_t \end{aligned} \quad (21)$$

A λ equal to one gives equation (19), meaning that the whole change in consumption is due to changes in income, so people consume their current income. If in the other extreme situation, λ is equal to zero, equation (21) gives the result proposed by Hall, namely that changes in consumption will follow a random walk as the new information obtained by individuals is random itself. So, e_t is the change in consumer's estimate of permanent income.

Estimations of (21) by OLS will give biased estimates of λ . This happens because Z_t and v_t are certainly correlated. Increases in income probably correspond to the arrival of good news about individuals' total life time income as well, implying that the error term in (21) is positively correlated with the right hand side variables (Romer 2006).

The solution to this problem is to estimate (21) by Instrument Variables (IV). An instrument variable is a variable that can be assumed to be uncorrelated to the model's error term but

correlated to the endogenous regressor¹⁰. The instrument variable can be used in a two-stage least squares. First, the right-hand-side variable, Z_t , is regressed on the instruments and the fitted value, \hat{Z}_t , is saved. Then, the dependent variable, $C_t - C_{t-1}$, is regressed on the fitted value \hat{Z}_t . Thus, as Romer (2006), puts it, we have

$$\begin{aligned} C_t - C_{t-1} &= \lambda \hat{Z}_t + \lambda(Z_t - \hat{Z}_t) + v_t \\ &\equiv \lambda \hat{Z}_t + \tilde{v}_t \end{aligned} \quad (22)$$

where \tilde{v}_t consists of two terms, v_t and $\lambda(Z_t - \hat{Z}_t)$. Since \hat{Z}_t is neither uncorrelated with v_t or $Z_t - \hat{Z}_t$, the regression of $C_t - C_{t-1}$ upon \hat{Z}_t gives a valid estimate of λ .

The question that arises then is about the choice of instrumental variables, which may not be an easy task as they have to be uncorrelated with the residuals and at the same time have, of course, to be correlated with ΔY . Campbell and Mankiw (1990) argue that any lagged stationary variables are potentially valid instruments due to their orthogonality to the residuals if the model is correct. They consider various sets of instruments and some of them will be used here: ΔY_{t-k} , ΔC_{t-k} , and Δi_{t-k} where $k = 2, \dots, 6$. In their article from 1990 they use even savings S_{t-k} , as instrument. This variable is used in levels since Campbell and Mankiw argue that as C_t and Y_t are cointegrated so that $Y_t - C_t$, savings, is stationary.

The employment of raw data in levels demands that the series follow homoskedastic linear processes, with or without unit roots. Therefore, the time series of consumption and income will need to be corrected because their mean change and innovation variance grow with the levels of the series (Campbell and Mankiw 1990). One way of doing that, which was used by Campbell and Deaton (1989) and will be used here is to divide ΔC_t and ΔY_t by the lagged level of income Y_{t-1} .

Previous studies applying the Campbell/Mankiw approach to Swedish data found both significant and insignificant values for λ . The significant values lie around 0.19 and 0.52 and hence reject the permanent income-life cycle hypothesis, namely, that changes in

¹⁰ See for example Verbeek, page 140

consumption should follow a random walk (Hansson 2001). Values of λ that are significant different from zero indicate that a fraction of the population consumes current income rather than the expected change in permanent life income.

I show below the estimation of equation (22) using both annual data from 1950 until 2008 and seasonally adjusted quarterly data from 1980:1 to 2008:4. In order to adjust for seasonality in the quarterly series a ratio to moving average method has been used as in Campbell and Mankiw (1990). Previous studies using Swedish data have both annual and quarterly series covering as long as 1992. For the estimation using annual series I use aggregate consumption per capita, disposable income per capita and nominal interest rates. For the regression with quarterly data, expenditure on consumption of non-durables and services per capita is used as well as disposable income per capita and nominal interest rates. The extra lag in the instruments is aimed to eliminate potential problems. First, due to delay on government publication of statistics, the aggregated variables are not contemporaneous with individuals' information set. Accounting for lagged periods avoids this problem that may be factual only using quarterly data. Second, there may be problems related to white noise error in the levels of consumption and income variables which stems from transitory consumption or measurement errors. According to Campbell and Mankiw (1990) the white noise errors in level become first order moving average when the series is differenced and could be correlated with once-lagged instruments. Furthermore, the reported standard errors are calculated using Newey-West which provides heteroskedasticity consistent and autocorrelation consistent standard errors. The reason for that is the fact that the error terms in equation (21) and (22) have a first-order moving average structure when these equation account for twice-lagged instruments (Campbell and Mankiw 1990).

In table 4.8 and 4.9 the results of estimations for the 1993:1-2008:4 respective 1950-2008 sample period are shown. The first column in the tables gives the instruments used. A constant has always been included as instrument and as a regressor but is not reported. The second column gives the IV estimate of λ and its standard error. The third and fourth columns give the adjusted R^2 for the OLS regressions of $\frac{\Delta C_t}{Y_{t-1}}$ and $\frac{\Delta Y_t}{Y_{t-1}}$ on the instruments. Following

Campbell and Mankiw, the p-value for a Wald test for the hypothesis that all coefficients with exception of the intercept are equal to zero have been reported.

The first row in tables 1 and 2 reports the result for the OLS regression of consumption upon income and the remaining consider different sets of instruments.

Table 4.8 Basic Permanent Income Model (scaled values).1993:1-2008:4, quarterly data

Instruments (Z)	λ	OLS regressions on Z	
		ΔC equation	ΔY equation
None (OLS)	0.387** (0.042)		
$\Delta Y_{t-2}, \dots, \Delta Y_{t-4}$	0.507** (0.160)	0.072 (0.070)	0.056 (0.105)
$\Delta Y_{t-2}, \dots, \Delta Y_{t-6}$	0.610** (0.240)	0.097 (0.069)	0.010 (0.362)
$\Delta C_{t-2}, \dots, \Delta C_{t-4}$	0.666** (0.204)	0.062 (0.090)	-0.011 (0.508)
$\Delta C_{t-2}, \dots, \Delta C_{t-6}$	0.376 (0.248)	0.035 (0.239)	-0.061 (0.870)
$\Delta i_{t-2}, \Delta i_{t-4}$	0.349 (0.245)	-0.029 (0.721)	-0.020 (0.613)
$\Delta i_{t-2}, \dots, \Delta i_{t-6}$	0.533** (0.271)	-0.009 (0.495)	-0.028 (0.633)

The significance of the coefficients is marked as *, **, and *** to indicate significance levels of at least 10, 5, and 1% respectively.

Table 4.9 Basic Permanent Income Model (scaled values).1950-2008, annual data

Instruments (Z)	λ	OLS regressions on Z	
		ΔC equation	ΔY equation
None (OLS)	0.672** (0.123)		
$\Delta Y_{t-2}, \dots, \Delta Y_{t-4}$	0.836** (0.413)	0.026 (0.232)	0.102 (0.040)
$\Delta Y_{t-2}, \dots, \Delta Y_{t-6}$	0.713** (0.318)	0.002 (0.413)	0.161 (0.022)
$\Delta C_{t-2}, \dots, \Delta C_{t-4}$	6.874 (18.95)	-0.002 (0.418)	-0.059 (0.995)
$\Delta C_{t-2}, \dots, \Delta C_{t-6}$	1.314 (0.717)	0.028 (0.281)	-0.073 (0.900)
$\Delta i_{t-2}, \dots, \Delta i_{t-4}$	0.238 (1.719)	-0.040 (0.813)	-0.046 (0.880)
$\Delta i_{t-2}, \dots, \Delta i_{t-6}$	0.946 (1.017)	-0.023 (0.578)	-0.074 (0.913)

The significance of the coefficients is marked as *, **, and *** to indicate significance levels of at least 10, 5, and 1% respectively.

In table 4.8 it can be seen that the regression of scaled consumption¹¹ upon the instrument gives higher adjusted R^2 than the scaled income indicating some forecasting power on the instruments. Particularly, the adjusted R^2 provided by the regressions of consumption upon income are higher than the regressions of consumption on its lagged values: the explanation power of six lags of income upon consumption is close to 10% and can be used as evidence against the permanent-income hypothesis. The value of the Wald test supports this alternative as it can reject at 10% significance level the hypothesis that all lagged variables are equal to zero. In table 4.9 the values of the adjusted R^2 are considerably smaller with exception for the

¹¹ $\frac{\Delta C_t}{Y_{t-1}}$

high predictability power that lagged income has upon current income. In fact, the regressions give an adjusted R square of 10% and 16% for 2-4 and 2-6 lags respectively.

The values of the IV estimates of λ are significant different from zero in all the case but one using the sample period form 1993:1-2008:4. On the other hand, using annual data from 1950-2008 the IV estimates are significant in only two cases, where both have income as instrument variable. The significant results in table 4.8 are between 0.50 and 0.66 and in table 4.9 they are 0.83 and 0.71. According to these results, a high fraction of income goes to individuals who consume their current income rather than their permanent income, refuting strongly the permanent income hypothesis. The different results of estimations of λ reported in tables 4.8 and 4.9 may depend on a series of factors. Firstly, the periodicity of the series itself may influence the results. Shorter time periods may catch more efficiently movements in consumption and income and the relationship between them and other variables, which is shown in columns 3 and 4 by the values of the adjusted R^2 . Secondly, aggregated consumption for the estimation of the 1950-2008 sample period was used, rather than expenditure on non-durables and services. A third point and perhaps the most relevant, is the choice of sample period. The first estimation, in table 1, considers the period after the deregulation of the credit market in Sweden and thus, does not account for the different consequences that reforms and changes may have had on consumption and disposable income. Actually, as the deregulation of the credit market was in effect since 1985, the result one would expect when studying a sample period starting in 1993 was that the permanent income hypothesis would receive more support. This means that the estimates of λ would have come closer to zero as a more efficient credit market allows individuals to plan consumption out of their expected permanent income, which changes randomly. Following this same reasoning, individuals who consume their current income can be considered to be liquidity constrained which also implies that the deregulation of the credit market should permit consumption to depend on permanent income rather than on current income.

The results in tables 4.8 and 4.9 can be compared to the results obtained in previous studies. Campbell and Mankiw (1991) estimate a value of λ equal to 0.36 using Swedish data for non-durables and services for the sample period 1972:2-1988:1. Agell and Berg (1996) estimate a value of λ equal to 0.52 using aggregate consumption for the period 1952-1989. Both estimations are lower (when compared to 1993:1-2008:4 and 1950-2008 respectively) than the ones obtained here indicating that during the more recent years consumption behaviour has changed to some extend and a higher fraction of current income has been consumed.

5 Obtaining a model of consumption

The aim of this section is to obtain, rather than to evaluate, an empirical relationship. Hence, a long-run model of consumption will be estimated in subsection 5.1 starting from the assumption made by the permanent income-life cycle hypothesis where consumption is given as a function of disposable income and wealth and individuals can save or borrow at an exogenous interest rate. The following subsections, 5.2 and 5.3, present the estimation of a short-run model and a forecast for consumption for the years 2009, 2010 and 2011.

5.1 The long-run model of consumption

Estimating a long-run model means that the variables included in it are cointegrated. Two nonstationary variables, Y_t and X_t , are cointegrated if there exist β such that $Z = Y_t - \beta X_t$ is integrated of order zero, $I(0)$. Given the stationarity of Z , Y_t and βX_t must have long-run components that cancel out to produce Z . Thus, if the long-run equilibrium is given by $Y_t = \alpha + \beta X_t$ then $z_t = Z_t - \alpha$ is the equilibrium error which measures the deviations of Y_t from its long-run equilibrium $\alpha + \beta X_t$. There will only be an equilibrium if z is $I(0)$. This long-run equilibrium is characterized by stationarity and fluctuations around zero, which would not happen if z was $I(1)$ ¹². The adjustment towards equilibrium is denominated error correction model (ECM). Since the short-run model is $I(0)$, nonstationary variables that are incorporated in the long-run model will be differenced when accounted for the short-run model. Besides differenced long-run variables, the short-run model may have other variables that have no explanation power in the long-run.

The first step in order to estimate a long-run model for consumption is to verify whether the variables included are cointegrated. In turn, the cointegration between variables will only be possible if they are nonstationary. Therefore, the Augmented Dickey Fuller test will be used to verify the order of integration of the variables.

¹² See for example Verbeek, page 329

Equation (14) gives the long-run behaviour of consumption which according to López et al. (1996) can be rewritten in a static version as $c = \beta_1 + \beta_2 A + \beta_3 w$ where

$$\beta_1 = \frac{(1-a_1)}{(1+r-a_1)} \bar{w}, \beta_2 = (1+r) \text{ and } \beta_3 = \frac{r}{(1-a_1+r)}$$

Taking logarithms and using a Taylor expansion¹³, the static specification for consumption can be rewritten as:

$$\ln c = \beta_0 - \gamma r + \ln(\beta_3 w) + \frac{\beta_2 A}{\beta_3 w} \quad (23)$$

Where $\ln c$ is the logarithm of aggregated consumption, r stands for the real interest rates, w is disposable income and A is wealth. The ratio of assets to income gives what Muellbauer (1994) calls “spendability”. A rise in asset to income ratio clearly increases opportunity for spending via a wealth effect.

The table below shows the results of the unit root tests. The Akaike information criteria was used in order to determine the order of lags included in the ADF test. For most of the series a linear trend was included in the estimation, which is denoted by t under “test”. If the test was based on an intercept it will be denoted by c .

Table 5.1 Augmented Dickey Fuller Test

Variable	test	lags	t-statistic	McKinnon critical values 5%	McKinnon critical values 10%	Integration order
<i>cons</i>	c_t	1	-2.302	-3.4889	-3.1727	I(1)
<i>inc</i>	c_t	2	-1.885	-3.4904	-3.1735	I(1)
<i>R</i>	c	3	-1.907	-2.9146	-2.5947	I(1)
<i>A/INC</i>	c_t	2	-2.301	-3.4904	-3.1735	I(1)

The variables in upper case letters are in levels whereas the variables in lower case letters are logarithmized. As expected all the series are I(1) and consumption, income and the ratio between wealth and income trend. A graphical analysis of real interest rates does not argue for a trending series but an intercept can be added.

Having found nonstationary series a test for cointegration can be conducted so that the vector error correction model can be estimated. The Johansen test for cointegration was used. This

¹³ See for example Zhang, page 464

method tests the restrictions imposed by cointegration on the unrestricted VAR involving the series. The basic VAR model can be formulated as:

$$Y_t = K_1 Y_{t-1} + \dots + K_p Y_{t-p} + BX_t + \varepsilon_t$$

Where Y_t is a vector of I(1) variables, X_t is a d vector of deterministic variables, and ε_t is a vector of innovations. This VAR can be rewritten as:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + BX_t + \varepsilon_t$$

Where

$$\Pi = \sum_{i=1}^p K_i - I \quad \text{and} \quad \Gamma_i = - \sum_{j=i+1}^p K_j$$

If the coefficient matrix Π has reduced rank $r < k$, then there exist $k \times r$ matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta'Y_t$ is stationary. The cointegrating rank (r) is the number of cointegrating relations and each column of β is the cointegrating vector. The elements of α are known as the adjustment parameters in the vector error correction model. Johansen's test estimates the Π matrix in an unrestricted form, then test if the restrictions implied by the reduced rank of Π can be rejected¹⁴.

Given that we have a set of 4 I(1) variables there may exist up to $k-1$ independent relationships that are I(0) while any linear combination of these relationships is also I(0). Both the trace and maximum eigenvalue test indicate the presence of one cointegrating equation, i.e., there is a single combination of the levels of the endogenous series $\beta'Y_{t-1}$ that should be added to the VAR. This term multiplied by α is referred to as an error correction term.

The maximum lag length was set equal to 5 according to the results of the Akaike criteria. When estimating the Johansen test I allow for an intercept and a trend in the error correction equation.

The normalized cointegrating coefficients are shown below.

Table 5.2 Normalized cointegrating coefficients

<i>cons</i>	<i>inc</i>	<i>R</i>	<i>A/DISP</i>	<i>TREND</i>	<i>C</i>
1	-0.85	-0.00086	0.000801	-0.005	-1.51

Which can be written as:

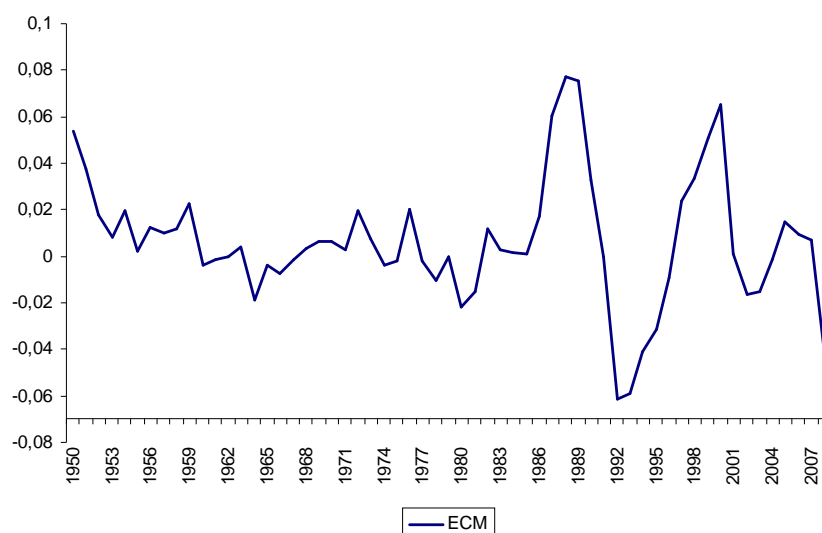
¹⁴ See for example Verbeek, page 343

$$cons_t = 0.85inc_t + 0.00086R_t - 0.0008\frac{A_t}{INC_t} + 0.005TREND + 1,51 \quad (24)$$

According to this relationship an increase in income with 1% increases consumption by 0.85%. The effect of real interest rates is positive: an increase by one point leads consumption in the long-run to increase by 0.086% while a one point increase in wealth reduces consumption by 0.08%. This may say that monetary policy probably has effect in the short-run when for instance an increase in interest rate actually decreases consumption. In the long-run, the income effect may be stronger than the substitution effect. The sign of the ratio between wealth and income is puzzling. In the short-run there is some evidence of increased consumption due to decreases in financial wealth (Romer 1990). In the long-run, though, one would expect a positive relationship between these variables. However, theoretically this is not so clear. At the same time that an increase in the present value of assets allows a higher level of consumption, when the assets' prices rise current consumption may decrease so to compensate the higher prices of assets. For instance, when house prices rise, consumption may decrease given unchanged present value of income so that the sufficient capital to acquire a house can be reached. Another way to understand that is to think that an increase in assets may depend upon an increase in savings. Higher savings will increase asset prices and reduce consumption. Moreover, the simplification made when constructing the variable assets may be unrealistic, i.e, house and financial assets may not be accounted equally when an index for wealth including both variables is composed. Johnsson and Kaplan (1999), who distinguish between financial and house wealth, find the values of the long-run marginal propensity to consume out of disposable income, financial assets and the net housing stock, to be 0.80, 0.16 and 0.04.

The cointegrating relation can be visualised below¹⁵:

¹⁵
 $cons_t - 0.85inc_t - 0.00086R_t + 0.0008\frac{A_t}{INC_t} - 0.005TREND - 1,51$



The residuals show the deviations of consumption from its long-run equilibrium. It can be observed that the deregulation of the credit market in 1985 had a quickly and deep effect upon consumption behaviour. Individuals are constantly trying to adapt the short-run consumption to the long-run equilibrium. During the years before the deregulation, consumption was more homogeneous in time, showing a much smaller volatility. Individuals noticed that they were above or below their long-run consumption level and quickly changed their consumption activity. From the perspective of the permanent income – life cycle hypothesis, consumption tends to be greater than current income when current income is low but is expected to increase. Consequently, when current income is expected to fall, consumption will be lower. Hence, the deregulation of the credit market raised consumption by increasing income expectation, probably because individuals had not taken the effects of the deregulation of the credit market into the estimation of their permanent income.

It could be argued that the long-run equilibrium of consumption was not as clear as before 1985 and individuals needed more time to realize deviations from long-run consumption. The resulting opposite movement that follows the first years after the deregulation in 1985 can be interpreted as an attempt to return to long-run level of consumption. The following years show a tendency of smaller departures from equilibrium which would be an indication that the credit market has gradually been consolidated and, according to the permanent income – life cycle hypothesis, permanent income is being better estimated.

5.2 The short-run model of consumption

The solution given by Johansen procedure above can be interpreted as a partial adjustment model. The last step is the estimation of the vector error correction which restricts the long-run behaviour of the endogenous variables to convert to their cointegrating relationship, allowing short-run dynamics. The final model is hence given by

$$\begin{aligned} \Delta cons_t = & 0.011 + 0.588\Delta cons_{t-1} - 0.225\Delta inc_{t-3} - 0.0025\Delta r_{t-1} \\ & - 0.168(cons - 0.85inc - 0.00086r + 0.0008\frac{A}{INC} - 0.005trend - 1.51)_{t-1} \end{aligned} \quad (25)$$

$R^2=0.332 \quad DW=2.00$

This stationary model gives changes in consumption as a function of one period lagged changes in consumption, three periods lagged changes in income, one period lagged changes in interest rates and the ECM. The parameter alfa in front of the ECM is the speed of the long-run adjustment and says that 16.8% of the adjustment towards equilibrium happens in the first period. Some points may indicate that this short-run model is not well specified. First, the interpretation of the three lagged income may be puzzling. An increase in changes in income three years ago decreases the changes in current consumption, i.e, current consumption growth will decrease by 0.225% when income is incremented by 1% three periods earlier. Furthermore, according to the equation above, lagged values of wealth are not significant at explaining changes in consumption which would be understandable were the series only for physical goods. In this case, though, wealth is also accounting for financial assets which due to its liquidity should have an effect upon consumption at the short-run.

Given these results we can allow for the presence of contemporaneous changes in income and wealth in the short-run model. This will only be possible if these variables are not correlated to the current values of consumption. Tests for exogeneity confirm the latter and the model will be written as¹⁶

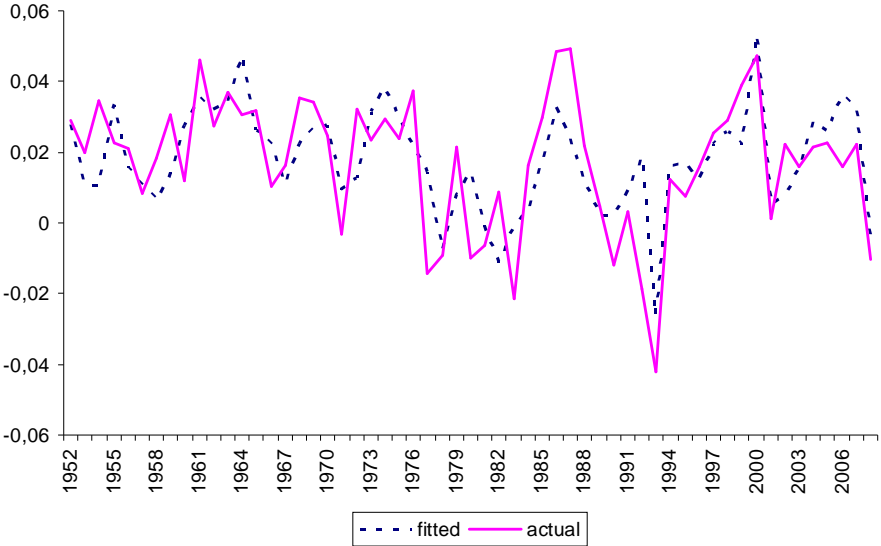
$$\begin{aligned} \Delta cons_t = & 0.375\Delta cons_{t-1} + 0.574\Delta inc_t + 0.00157\Delta\frac{A_t}{inc_t} - 0.00153\Delta r_{t-1} \\ & - 0.256(cons - 0.85inc - 0.00086r + 0.0008\frac{A}{inc} - 0.005trend - 1.51)_{t-1} \end{aligned} \quad (26)$$

$R^2=0.496 \quad DW=1.97$

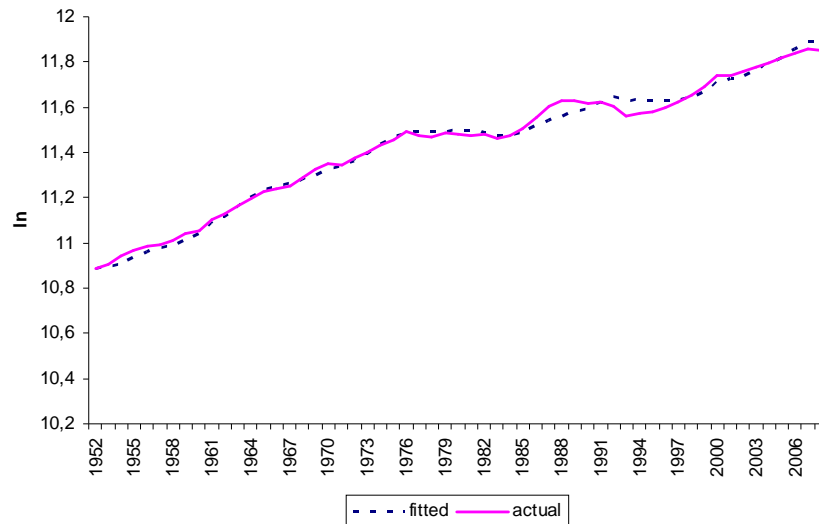
¹⁶ See for example Verbeek, page 368

According to (26) an increase in consumption by 1% during the previous year increases current consumption by 0.375%. The coefficients for the other variables are interpreted in the same way. Hence, a change in the ratio between wealth and disposable income by 1% increases consumption by 0.00157% and a raise in interest rates by 1% decreases consumption by 0.00153%. The ECM coefficient indicates that 25.6% of the adjustment occurs in the previous period.

The statics representation of (26) is shown below together with the actual changes in consumption



The dynamics model can be seen in the diagram below which shows the natural logarithms of consumption. The effect of the oil crisis in the 1970's, the 1990's crisis and the IT crisis in the year 2000 and the current financial crisis can easily be identified.



Tests

The value for the Durbin Watson test for first order serial correlation, 1.97, does not indicate serial correlation. This test is though best performed when an intercept is present in the regression.

The Breush-Godfrey test for higher order serial correlation has the null hypothesis of no serial correlation. This hypothesis cannot be rejected including two, three and four lags in the regression which gives no signs of serial correlation in the model.

The normality of the residuals can be tested with the Jarque-Bera test. The null hypothesis that the residuals are normally distributed cannot be rejected (p-value=0.60).

The White test was used in order to test whether the residuals were homoskedastic. The null hypothesis that the residuals are homoskedastic cannot be rejected at the 5% level (p-value: 0.84).

5.3 Forecasting

Following a similar approach to the one applied by Johnsson and Kaplan an ex ante forecast of changes in consumption was done for the period 1950-2003. A forecast for 2005-2011 can then be done using prognoses for the independent variables in (26) from NIER for the period

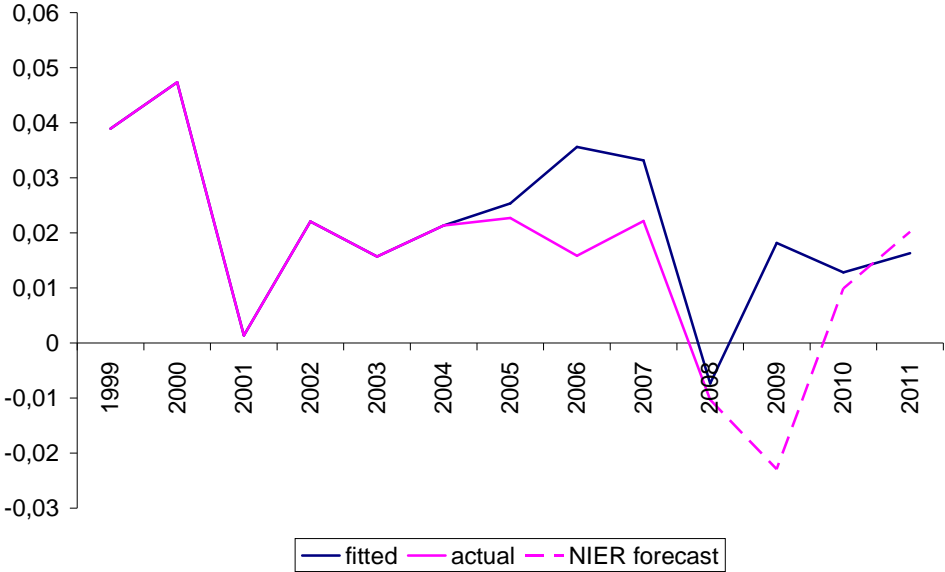
2009-2011. The table below shows the values of the changes in the variables. Interest rates are given in levels.

Table 5.3 Changes in the independent variables

	Income	Wealth*	Interest rates	Prices	Population*
2009	1,1	8,9	0,5	1,3	0,5
2010	1,4	1,7	0,4	0,9	0,5
2011	1,4	3,3	0,4	0,9	0,5

The variables marked with an asterisk are my own.

The dynamics model, the actual values up to 2008 and NIER’s forecast are shown in the diagram below. The model clearly departs from the actual values, showing a tendency to overestimate consumption. It departs as well from the prognosis for consumption made by the NIER for 2009; however, it performs well for the following years, 2010-2011.



6 Conclusion

Hall (1978) showed that the permanent income – life cycle hypothesis would imply that consumption should follow a random walk process, being affected only by surprise elements of other variables. This hypothesis was tested against the alternative that other variables would be able to explain current consumption and was rejected. Two sample periods of Swedish data were used: annual data for 1950-2008 and quarterly data for 1993:1-2008:4. The tests indicated that disposable income and house prices are better predictors of current consumption than stock prices and interest rates.

The rejection of Hall's hypothesis in section 4.1 is confirmed by the results obtained with the " λ -model" in section 4.2. Using quarterly data from 1993:1 to 2008:4 the fraction of consumers who consume their current income is between 50% and 66% depending on the choice of instruments. The estimations for the sample period 1950-2008 reject, though, the permanent income – life cycle hypothesis only when disposable income is used as instrument. Section 5 showed that the permanent income hypothesis results in the cointegration of consumption with income and wealth. The error correction model indicated that disposable income is the main determinant of changes in consumption but even interest rates and wealth have some explanatory power. The residuals from the long-run model give a good illustration of the changes in consumption caused by the deregulation of the credit market in 1985. Additionally, the static short-run model of consumption seems to perform properly as well while the dynamics version does not catch the drop in 2006 but does catch the drop in 2008.

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8 Data appendix

Diagram 1: Disposable income 1993-2008, quarterly, constant prices, reference year 2000. 1993-2008, quarterly. Source: Statistics Sweden

Diagram 2: Non-durables consumption expenditure 1993-2008, quarterly, constant prices, reference year 2000. Source: Statistics Sweden

Diagram 3: Expenditures on Services 1993-2008, quarterly, constant prices, reference year 2000. Source: Statistics Sweden

Diagram 3: Expenditures on Services 1993-2008, quarterly, constant prices, reference year 2000. Source: Statistics Sweden

Diagram 4: Non-durables and services, 1993-2008, quarterly, constant prices, reference year 2000. Source: Statistics Sweden. Obs: this series was constructed by putting the series for non-durables expenditures and expenditures on services together.

Diagram 5: Population 1993-2008, quarterly, constant prices. Source: Datastream

Diagram 6: Short-run interest rates, 1993-2008, quarterly. Source: Datastream

Diagram 7: Stock price index, 1993-2008, quarterly, 2000=100. Source: Datastream.

Diagram 8: House price index 1993-2008 (in Swedish: Fastighetsprisindex för permanenta småhus), quarterly, 2000=100. Source: Statistics Sweden.