An Econometric Study of Private Consumption Expenditure in Sweden*

Helena Johnsson
Peter Kaplan

Abstract

A consumption function based on the life-cycle hypothesis is estimated using Swedish annual data for the period 1970-1998. Hendry's general to specific approach is applied using an error correction model in order to arrive at the preferred equation. In order to confirm the estimated cointegrating relationship, the Johansen procedure is employed. The preferred equation displays a good fit over the sample period and diagnostic tests indicate that the parameters are robust over time. The long run properties and the dynamic response to shocks in the exogenous variables are evaluated using a system of simultaneous equations containing the preferred equation and a disaggregated form of the savings identity. Results from the simulations are in accordance with intuition and consistent with the life-cycle hypothesis.

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Sammanfattning

Följande ekonometriska studie av de faktorer som bestämmer hushållens konsumtionsutgifter baserar sig på årsdata för perioden 1970-1998. Utgångspunkten för studien är livscykelhypotesen under vilken en representativ individ maximerar sin nytta givet sin budgetrestriktion. Det kan då visas att såväl nutida som framtida inkomst, nutida förmögenhet, förväntad realränta, den subjektiva diskonteringsräntan samt osäkerhet kring framtida inkomst är viktiga förklarande variabler till dagens konsumtion. Utifrån detta resultat formuleras en generell felkorrigeringsmodell som reduceras med hjälp av Hendrys "general to specific" ansats. Johansen proceduren bekräftar det skattade kointegrerande sambandet. På kort sikt förklaras förändringen i privat konsumtion av förändringen i inkomst, förändringen i finansiell förmögenhet samt förändringen i det relativa huspriset. På lång sikt bestäms konsumtionen av inkomst, finansiella tillgångar och nettohusstocken. De långsiktiga marginella konsumtionsbenägenheterna är i tur och ordning 0,80, 0,16 och 0,04. Ca. två femtedelar av anpassningen mot jämvikt sker under det första året. Anpassningen för ekvationen är tillfredsställande, likaså resultaten av de diagnostiska testen och *ex ante* prognosen.

För att kunna göra dynamiska simuleringar använder vi oss av ett simultant ekvationssystem bestående av den skattade ekvationen samt en variant av sparandeidentiteten där 80% av sparandet i varje period läggs till de finansiella tillgångarna och 20% till nettohusstocken. Vi finner att hälften av anpassningen mot långsiktig jämvikt sker på mindre än tio år. Vid simulering av chocker i de exogena variablerna uppför sig modellen på ett sätt som vi intuitivt förväntar oss att konsumtion skulle reagera på sådana chocker. Exempelvis leder en permanent ökning av tillväxttakten i inkomst till en högre sparkvot.

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1 Introduction

1.1 Background

Keynes argued that ”the amount of aggregate consumption mainly depends on the amount of aggregate income” [Keynes (1973, p. 96)]. He further claimed that “it is also obvious that a higher absolute level of income ... will lead, as a rule, to a *greater proportion* of income being saved as real income increases” [Keynes (1973, p. 97)]. In other words, saving is regarded as a luxury good for which ‘expenditure’ is positively correlated with income. However, empirical studies during the 1940’s and early 1950’s did not support Keynes’ conjecture, a puzzle which spurred further research.[1] Two of the most influential theories, Modigliani and Brumberg’s life-cycle hypothesis (1954) and Friedman’s permanent-income hypothesis (1957), were developed at least partly in response to the discrepancy between Keynes’ conjecture and the empirical evidence.

The influential consumption model by Davidson, Hendry, Srba and Yeo (DHSY), published in 1978, was based on Friedman’s hypothesis. The DHSY model was the first econometric consumption model incorporating an error correction mechanism (*ECM*). Three years thereafter, Hendry and von Ungern-Sternberg (1981) presented an extension to the DHSY model built upon the life-cycle hypothesis, i.e. including wealth.

Earlier Swedish consumption studies based on the life-cycle hypothesis and with *ECM* methodology include Kanis and Barot (1993), Markowski (1994), Barot (1995) and Berg and Bergström (1995). As none of these studies incorporate post 1993 data, it is of interest to estimate a consumption function including information from the better part of the 1990’s. Our sample period covers almost three decades (1970-1998), longer than any of the above mentioned Swedish studies.

1.2 Purpose

The purpose of this thesis is to generate a better understanding of the factors determining private consumption in Sweden and to estimate a consumption function to be used for medium term forecasting. Ultimately, the estimated function is to be incorporated into the annual macro model KOSMOS, used by the National Institute of Economic Research (NIER).

1.3 Method

This study is based on the life-cycle hypothesis. The econometric modelling follows Hendry’s general to specific approach in which a general model is reduced through statistical testing of economically sensible restrictions. In line with Banerjee *et al* (1986), who suggest that when the sample size is small the long run variables (levels) should be regressed together with the variables that describe the short run dynamics (differences), we model the long run relationship simultaneously with the short run. Having obtained the preferred model, the Johansen procedure is used to estimate the cointegrating relationship and the number of cointegrating vectors. In order to evaluate the long run properties of the model and the dynamic response to shocks in the exogenous variables, a system of simultaneous equations containing the preferred equation and a disaggregated form of the savings identity are used for a number of simulations.

[1] Perhaps the most well known example of this is the evidence provided by Nobel Prize winner Simon Kuznets in the 1940’s that the savings ratio had not changed much since the middle of the nineteenth century despite the large rise in per capita income.

The new National Accounts (NA) involve a number of changes in the classification and definition of items which requires that a consumption model be estimated based on this new data set.[2] In addition to this, considerable effort has been put into the calculation of more reliable stock variables. The decision to use annual data was taken with consideration to the superior quality of this data compared to quarterly or semi-annual figures, used in all of the previous Swedish studies mentioned in Section 1.1.

1.4 Disposition

Section 2 deals with the theory underlying the consumption function. In order to identify important variables in determining present and future consumption, a two period consumption function based on the life-cycle hypothesis is derived. In the following section, the data issues that follow from the theoretical identification of important variables are examined. Section 4 briefly discusses the principles of econometric modelling before the variables included in the general model are tested for stationarity and a preferred model is derived. In Section 5, the model is tested and evaluated and both recursive estimates of the parameters and forecasts are presented. In order to evaluate the long run properties of the model and the dynamic response to shocks in the exogenous variables, a number of simulations are carried out using a system of simultaneous equations in Section 6. Finally, Section 7 concludes with the main results of the study.

Used variables are defined at the position of their first occurrence. In addition to this, a complete list of definitions is given in Appendix A. Appendix B contains graphs of the used variables along with a discussion of how each series was obtained.

2 A Derived Consumption Function

The permanent income and life-cycle hypotheses were originally regarded as competing theories but the general view today is that they are complementary [Darby (1987)]. The main difference between them is their respective time horizon, with the life-cycle hypothesis having a finite time horizon and the permanent-income hypothesis assuming that the horizon is indefinitely long.

The first consumption function based on the life cycle-hypothesis was published by Ando and Modigliani (1963). Their model starts from the individual consumer whose utility is assumed to be a function of her aggregated consumption in current and future periods. The individual maximizes this utility with respect to her budget constraint, i.e. current wealth plus current income and net present value of expected future income. Two fundamental assumptions are made:

(I) The utility function is homothetic with respect to consumption at different points in time.
(II) The individual neither expects to receive nor desires to leave any inheritance.

As Ando and Modigliani (1963) do not specify a utility function, it is not possible for them to obtain an intertemporal effect of the interest and personal subjective discount rates on consumption. In order for us to study these intertemporal effects, we derive a two period consumption function in a fashion analogous to that of Muellbauer and Lattimore (1995). In doing this we use the framework of Ando and Modigliani (1963).

[2] For a discussion of the new NA, see Appendix B.

A person's life-cycle wealth is defined as current wealth (accumulated savings) plus the discounted value of her present and future income. The assumption that individuals neither expect to receive nor desire to leave any inheritance implies that life-cycle wealth is fully consumed. Hence,

$$W_1 + Y_1 + \frac{1}{1+R_1^e} Y_2^e = C_1 + \frac{1}{1+R_1^e} C_2 \equiv W_{L1}, \qquad (2.1)$$

where W_1 is wealth in period 1, Y_1 is real income in period 1, Y_2^e is the expected real value of period 2 income, R_1^e is the expected real interest rate, C_1 and C_2 are real consumption in each respective period and W_{L1} is life-cycle wealth.

Following most consumption literature [see e.g. Muellbauer and Lattimore (1995) or Romer (1996)], we assume that intertemporally additive preferences in some increasing monotonic transformation of life time utility is the sum of the subutilities of consumption in each period, discounted using some subjective discount rate. Thus the utility function can be expressed as

$$U = u(C_1) + \frac{1}{1+\delta} u(C_2), \qquad u' > 0,\ u'' < 0 \text{ and } \delta \geq 0, \qquad (2.2)$$

where U is life time utility, $u(C_1)$ and $u(C_2)$ are the subutilities of consumption in each respective period and δ is the subjective discount rate. The combination of additivity and homotheticity implies that $u(C_i)=C_i^{-\rho}$ so that the utility function can be written as

$$U = C_1^{-\rho} + \frac{1}{1+\delta} C_2^{-\rho}, \qquad (2.3)$$

where the elasticity of substitution is $\sigma = 1/(1+\rho)$. σ measures how responsive the ratio of consumption in the two periods is to the opportunity cost, $1/(1+R_1^e)$.

A solution to the consumption function can be obtained by maximizing life-cycle utility with respect to consumption in each period, subject to the period to period budget constraint using the Lagrangian method:

$$\text{Max } L = \max\left[U(C_1, C_2) + \lambda\left(C_1 + \frac{1}{1+R_1^e} C_2 - W_L\right)\right]. \qquad (2.4)$$

The first order conditions (F.O.C.s) are:

$$\frac{\partial L}{\partial C_1} = 0 = \frac{\partial U}{\partial C_1} + \lambda$$

$$\frac{\partial L}{\partial C_2} = 0 = \frac{\partial U}{\partial C_2} + \frac{1}{1+R_1^e} \lambda .$$

If preferences are homothetic, the F.O.C.s yield

$$C_1^{-(1+\rho)} = \frac{1+R_1^e}{1+\delta} C_2^{-(1+\rho)}. \qquad (2.5)$$

Using (2.5) and the life cycle wealth identity (2.1), the following consumption function is obtained

$$C_1 = \frac{W_{L1}}{k_1} = \frac{1}{k_1}\left(W + Y_1 + \frac{1}{1+R_1^e} Y_2\right), \tag{2.6}$$

where k_1 is the inverse of the marginal propensity to consume (MPC) out of lifetime wealth. Since lifetime wealth is an additive function of current wealth and the net present value of income, the MPC out of lifetime wealth ($1/k_1$) equals the MPC out of current wealth. In general, the MPC out of lifetime wealth depends on the real interest rate and the subjective discount rate. Assuming constant elasticity of substitution preferences, the inverse of the MPC out of lifetime wealth can be written as

$$k_1 = 1 + \left(\frac{1}{1+d}\right)^{s} \left(\frac{1}{1+R_1^e}\right)^{1-s} \tag{2.7}$$

and for small values of d and R_1^e approximately as

$$k_1 \approx 1 + \frac{1}{1 + s\,d + (1-s)R_1^e}\,. \tag{2.8}$$

As can be seen from (2.7) and (2.8), an increase in either R_1^e or d will decrease k_1, i.e. increase the MPC out of lifetime wealth. A *ceteris paribus* increase in d will increase present consumption while the effect of an increase in R_1^e is ambiguous and depends on the relative sizes of W and Y_2^e. Introducing income uncertainty in the two period model, the utility function can be written as

$$U^* = u(C_1) + \frac{1}{1+d} Eu(C_2)\,, \tag{2.9}$$

where U^* is life time utility under uncertainty and $Eu(C_2)$ is the expected utility in the second period. Using this utility function instead of (2.2), it can be shown that the saving decision is to a near approximation equivalent to that of a problem with income certainty, in which expected income is reduced by a discount factor reflecting uncertainty.[3] Hence an increase in uncertainty about future income will increase savings and reduce current consumption.

The two-period model can be expanded to a multi-period model with n periods, for which the derivation is similar to the two period model, but more tedious. In the n period model derived by Muellbauer and Lattimore (1995), the MPC out of lifetime wealth also depends on the time horizon. An increase in the time horizon will reduce the MPC as lifetime wealth must 'last' for more periods. This implies that older people, with a shorter time horizon, have a larger MPC out of lifetime wealth than younger people. Under the assumption that the subjective and the market discount rates both are five percent, Muellbauer and Lattimore (1995) have shown that in the context of the multi-period model, the MPC out of lifetime wealth is 0.056 with a time horizon of 40 years while it is 0.062 with a time horizon of 30 years. We assume that on an aggregated level the time horizon in Sweden has been fairly constant from the 1970's and forward and we will therefore ignore it. However, different time horizons can be an important variable in comparing different countries' consumption functions.

Consequently, it is evident that present and future income, current wealth, expected interest rate, subjective discount rate and income uncertainty are important variables in determining present and future consumption.

[3] See Muellbauer and Lattimore (1995, pp. 249-255).

3 Data

The variables shown in Section 2.2 to be important in determining present and future consumption can be divided into two different types: Wealth variables and intertemporal variables. The former type consists of present and future income and current wealth while the expected interest rate, subjective discount rate and income uncertainty are all intertemporal variables. However, knowledge of the theoretically appropriate variables does not solve the entire estimation problem as these variables can be difficult or even impossible to measure empirically. Therefore, proxy variables are needed. This section discusses the proxies used in the estimations, starting with the dependent variable, consumption.

3.1 Consumption

3.1.1 Household Consumption Expenditure

Private consumption is here defined as total real household consumption expenditure according to NA. The proper measure of consumption in estimating a consumption function is pure consumption. It is this term that both the permanent-income and the life-cycle hypotheses set out to explain by optimal allocation of present and future resources over time. Pure consumption corresponds to the value of nondurable goods and services as well as the value of the flow of services from durable goods. However, in consumption expenditure as measured by NA, durable goods are treated as if they were immediately consumed upon purchase. If purchases of durables are spread out evenly over time and in the population, there is reason to believe that the difference between the two consumption measures may in fact not be large at an aggregated level. Examination of data shows that durables are a relatively constant share of total consumption expenditure, which at least does not contradict this view.

3.2 Wealth Variables

According to the life-cycle theory, a person's life-cycle wealth is defined as the sum of current wealth, present income and the discounted value of expected future income. The two former variables are fairly straightforward to measure. For the latter variable, future income, a proxy is needed. We therefore assume that future income is a function of present income, current wealth and the expected real interest rate.

3.2.1 Real Disposable Income

Income is here defined as real disposable income according to NA. This is obtained by adding positive transfers from both public and private sectors to factor income. From this measure negative transfers such as taxes are deducted. The income term corresponding to pure consumption would be the sum of disposable income (according to NA), the return (alternative revenue) on durables and capital gains minus losses on household wealth. According to the permanent-income hypothesis, this 'pure income' measure can in turn be regarded as the sum of permanent and transitory income. Permanent income is that part of income which people expect to persist into the future and transitory income is a temporary increase in income arising from windfall gains. If an increase in income is regarded as permanent, consumption will rise by much more than if it is regarded as transitory. However, since a measure of 'pure income' is not easily obtained, and even less so divided into a permanent and transitory component, we henceforth treat real disposable income from NA as an approximation to permanent income.

3.2.2 Household Wealth

On the basis of liquidity characteristics, household wealth can be disaggregated into two main components, financial wealth, derived by deducting financial liabilities (hereafter referred to as debt) from financial assets, and housing wealth. Typically housing wealth has accounted for the larger share of total wealth, between 94 percent in 1977 and 52 percent in 1998 (see Appendix B). Illiquid assets in general are burdened by indivisibility, capital uncertainty, transaction costs and sometimes even transaction restrictions. However, housing wealth differs from other illiquid assets in one important aspect: It enters into the utility function. Some 20 percent of household consumption expenditure consists of housing expenditure.

In our estimates we include financial assets and net housing wealth, i.e. housing wealth minus debt, as two separate wealth variables. However, it should be pointed out that the prevalent way of including wealth in the estimation of a consumption function is to include net financial wealth, i.e. financial assets minus debt, and housing wealth as the two separate wealth variables.[4] Ideally we would like to include the three wealth terms as separate regressors but in doing this, debt does not come out significant. Therefore we must choose from which type of asset the debt should be deducted. In our view, debt has more in common with housing wealth than financial assets and should therefore be deducted from housing wealth. Firstly, just as housing wealth, most of household debt is illiquid in the sense that it runs with a fixed interest rate for a predetermined fixed period of time. Of course this is not strictly true for all debt, but both the issuing of a loan and advance repayment are associated with costs which add to the illiquidity of debt. Also, the absolute majority of household debt pertains to housing and it therefore seems reasonable to deduct it from housing wealth.

3.3 Intertemporal Variables

As discussed in Section 2, the interest and subjective discount rates enter the consumption function under the assumption of intertemporally additive and homothetic preferences. The assumption that the time horizon in Sweden has been fairly constant from the 1970's and forward implies that the subjective discount rate also ought to be rather stable during the period in question and thus can be disregarded. In order to capture the effects of income uncertainty, unemployment is included so as to reflect what in the literature is called precautionary saving. Lyhagen (1997) found in his study that consumption in Sweden decreased with 1.7 percent during the years 1988-1992 as a result of households' reaction to an increase in uncertainty.

3.3.1 Unemployment

An increase in income uncertainty operates like a higher real interest rate: it decreases consumption in the first period. For the currently unemployed, an increased unemployment rate is probably interpreted as a smaller possibility of finding new employment. For the majority of the labor force, those currently employed, an increase in the unemployment rate may be interpreted as an increased possibility of unemployment also for them.

In the sample period there is a large shift in the unemployment level during the years 1991 to 1993. Perhaps then the unemployment variable is not only accounting for income uncertainty but also accounting for effects of the 1990-91 tax reform, the increase in government debt that

[4] See e.g. Berg (1990), Barot (1995) or Berg and Bergström (1995). With regards to the housing stock, it should be mentioned that the one used by Barot (1995) differs from that of the other two studies. Our stock is similar but not identical to that of Berg (1990) and Berg and Bergström (1995).

took place in the early 1990's and the 1992 switch to a floating exchange rate.[5] If the unemployment variable is insignificant while a dummy variable with a successive level shift during the turbulent years 1991-1993 is significant, unemployment is in fact capturing other effects than the desired one.

3.3.2 Interest Rate

According to Muellbauer and Lattimore (1995, p. 221 and footnote 1), real interest rates have often been found insignificant and hence have been omitted from the consumption function. Still, the interest rate enters the solution to the individual's intertemporal utility optimization problem in the life-cycle hypothesis and thus is a justifiable variable. An increase in the interest rate has both an income and a substitution effect. The substitution effect is negative, making today's consumption more costly relative to tomorrow's. Assuming the individual is a net borrower, the sign of the income effect is also negative but if the individual is a net lender, the income effect is positive.[6] At an aggregate level, the sign of the interest rate is ambiguous. The interest rate used in our estimates is the real after tax short interest rate.[7]

4 Empirical analysis

4.1 Econometric Modelling

In order to minimize the amount of data mining in deriving a consumption function we use Hendry's general to specific approach, i.e. we start with a general 'overparametized' model, reducing it by a sequence of tests of economically sensible restrictions.

A time series can be regarded as a single or particular realization of a stochastic process. For a stochastic process to be stationary in the weak sense, its mean and variance must be constant over time and the value of the covariance between two time periods must only depend on the distance between the time periods, and not on the actual time at which the covariance is considered. If one or more of these conditions is not fulfilled, the process is said to be nonstationary. Generally, a variable is said to be integrated of an order d, denoted I(d), if it must be differenced d times in order to achieve stationarity.[8] Hence a nonstationary variable with a stationary first difference is denoted I(1). If nonstationary series are regressed on each other the ensuing model may be based on spurious correlation.

Simply differencing all I(1) series to make them I(0) can result in the loss of valuable information from economic theory concerning the long run equilibrium properties of the variables, which if supported by the data would result in a misspecified model. However, if there is a linear combination of nonstationary variables that is stationary, this can be used in parallel with the differences of the I(1) variables. If such a linear combination exists, the series are said to be cointegrated. Another way of explaining this is to say that cointegrated series drift together in time, albeit with short run deviations.

The difference between the long run equilibrium relationship and the actually observed relationship in each time period is referred to as the 'equilibrium error'. The process describing the adjustment towards equilibrium is referred to as the *ECM*. However, short run

[5] The 1990-91 tax reform reduced capital income taxes to 30 percent and set the deductibility tax rate of capital losses and interest rate expenses to 30 percent.

[6] According to the new NA, the effect of interest rates and dividends on disposable income has been both positive and negative during our sample period [National Institute of Economic Research (1999a, p.46)].

[7] Using the real after tax long interest rate does not significantly effect the estimation results.

[8] Another way of saying this is that it has d unit roots.

fluctuations also need to be modelled. This is why non-stationary variables appearing in the long run relationship, are often incorporated into the short run part of the model in their stationary (differenced) form, including lags. In addition to the differenced long run variables, other differenced variables can be incorporated into the short run part. These variables may affect the short run variation in consumption but their cumulative (long run) effect is zero.

A commonly used test for cointegration is the one developed by Engle and Granger (1987). The first step in their procedure is to regress the dependent variable on all the variables assumed to appear in the long run relationship. Thereafter, residuals from the estimated equation are tested for stationarity. If the residuals are stationary this implies that the variables are cointegrated.[9] Engle and Granger have shown that cointegrated series have an error correction representation. This means that the cointegrating vector can be incorporated into a short run model where both sides of the equation are stationary. Unfortunately, Monte Carlo studies have shown that estimation of the long run cointegrating relationship has considerable small-sample bias. Banerjee *et al.* (1986) suggest that in small samples, the long run variables should be regressed together with the variables that describe the short run dynamics. The residuals from this regression should thereafter be tested for stationarity. If they are stationary, there exists a cointegrating relationship between the long run variables. As our sample consists of only 29 observations, we will use this procedure. An additional problem with the both the Engle-Granger and the Banerjee method is that it only allows for one cointegrating vector. The number of cointegration vectors will be tested for using the Johansen procedure.

4.2 Integration Analysis

Simulations have shown that the power of the majority of unit root tests is low, especially when the number of observations is small. Thus the tests will too often indicate that a series contains a unit root [Enders (1995, pp. 251-254)]. Therefore, results must be interpreted with the utmost care. The power decreases even more if the estimated regression does not correctly mimic the actual data-generating process, i.e. incorrectly includes or omits deterministic regressors. Augmented Dickey-Fuller tests are in addition to this sensitive to nonlinear transformations of the data [Kennedy (1998, p. 286)].

In testing for the order of integration of our variables we have followed the procedure of testing for a unit root when the form of the data-generating process is unknown as described in Enders (1995, pp. 254-258). The test does not imply that the true data-generating process is uncovered. In fact, there is no way to be sure that the appropriate deterministic regressors are included in the model. Test results are displayed in *Table 4.1*.

[9] For a more detailed description of this test procedure, see e.g. Charemza and Deadman (1997, pp. 127-131) or Enders (1995, pp. 373-377).

Table 4.1 Augmented Dickey-Fuller tests for the order of integration

Variable	H0	Test with…	Number of augmentations	DF-statistic	Critical Value	Integration order
cons	I(1)	…	1	-1.96	-1.95	
	I(2)	intercept	0	-3.30	-3.00	I(1)[10]
fa	I(1)	…	0	-1.58	-1.95	
	I(2)	intercept, trend	1	-4.74	-3.60	I(1)
fl	I(1)	...	2	-0.59	-1.95	
	I(2)	...	0	-2.47	-1.95	I(1)
			0			
hs	I(1)	intercept, trend	0	-1.43	-1.96	
	I(2)	intercept, trend	0	-6.17	-3.60	I(1)
inc	I(1)	…	1	-1.56	-1.95	
	I(2)	intercept	0	-3.28	-3.00	I(1)
nhs	I(1)	…	1	-0.67	-1.95	
	I(2)	intercept	0	-3.61	-3.00	I(1)
rhp	I(1)	intercept, trend	1	-4.07	-3.60	I(0)
RS	I(1)	intercept, trend	0	-4.29	-3.60	I(0)[11]
UNP	I(1)	…	…	…	…	I(0)[12]

Note: Critical values are for 5% significance level and *n*=25 from Dickey & Fuller (1981). The inclusion of an intercept and/or trend does not imply that these are significant.

Upper case letters refer to variables in levels while lower case letters refer to variables in natural logarithms. *CONS* is real household consumption expenditure, *FA* is real financial assets of households, *FL* is real financial liabilities of households, *HS* is the housing stock, *INC* is real disposable income, *NHS* is the net housing stock (housing stock minus debt), *RHP* is the relative house price, *RS* the real after tax short interest rate and *UNP* the open unemployment rate.[13] The reasons for testing the housing stock, net housing stock and relative house price, will be disclosed in Section 4.3.

It is reasonable to expect that consumption, financial assets, debt, housing stock, net housing stock and income all trend while the relative house price, interest rate and unemployment do not. This was confirmed by the test results displayed in *Table 4.1*.

[10] Is barely I(1) but clearly so when I(1) is against I(0) tested at a 1% significance level and I(2) against I(1) is tested at a 5% significance level.

[11] Is I(0) on theoretical grounds, intercept and trend doubtful but significant and excluding them 'makes' variable I(1).

[12] Visual inspection of unemployment indicates the possibility of a stationary variable with a structural shift 1992-1993. To test for this we used a Perron test described in Charemza and Deadman (1997, pp. 115-122).

[13] *RHP* is the ratio of the real estate price index (*PH*) and the implicit deflator for household consumption expenditure (*P*).

4.3 The General Model

From Section 3, we conclude that consumption in the long run ought to be a function of income, current wealth, interest rate and unemployment, i.e.

$$CONS = f(INC, W, RS, UNP, e) \qquad \text{where } e \sim \text{i.i.d}(0, s^2)\,. \tag{4.1}$$

When testing for the order of integration, we found that both the interest rate and unemployment are stationary variables. This implies that the *ECM* should be determined by income and wealth.

Wealth is the sum of financial and housing assets, minus debt. Under the assumption that the long run ratio between house prices and the implicit consumption deflator is constant, the long run development of the housing stock should be identical to that of housing wealth.[14] The integration test of the relative house price indicated that the series was stationary. As the housing stock series also has better long run properties, i.e. less short run fluctuation than the housing wealth series, we include the housing stock minus debt (*NHS*) in the *ECM*. This means that (4.1) can be written as

$$CONS = f(INC, FA, NHS, RS, UNP, e)\,. \tag{4.2}$$

Since we are interested in the relative effect that a percentage change in an explanatory variable has on the dependent variable, the consumption function is expressed in its exponential form. Omitting the stochastic error term, consumption in each period can be expressed as

$$CONS_t = A(1+RS_t)^{a_1}(1+UNP_t)^{a_2}(FA_t)^{a_3}(NHS_t)^{a_4}(INC_t)^{a_5} \tag{4.3}$$

where A is a constant scale term. The coefficients $\alpha_{1\ldots}\ \alpha_5$ are each variable's elasticity and should be interpreted as the effect that a one percent change in that variable has on the dependent variable.

According to the life-cycle hypothesis, consumption in each period is a function of lifetime wealth. If preferences are homothetic, an increase in lifetime wealth with one percent will increase consumption in each period proportionally. Hence, in (4.3), ($a_3 + a_4 + a_5$) should equal one. This is known as the homogeneity constraint, or unit elasticity. If this condition is satisfied, (4.3) can be written as

$$\frac{CONS_t}{INC_t} = A(1+RS_t)^{a_1}(1+UNP_t)^{a_2}\left(\frac{FA_t}{INC_t}\right)^{a_3}\left(\frac{NHS_t}{INC_t}\right)^{a_4}. \tag{4.4}$$

In estimating our model, we use the ordinary least squares (OLS) method. One of the conditions for an OLS estimation to yield a best linear unbiased estimate (BLUE) is that it is linear in the parameters.[15] By transforming an exponential equation to its logarithmic form, linearity in the parameters is obtained. Hence, (4.4) is expressed as

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[14] This assertion is based on Tobin's *q* of investment. *q* is the ratio of the market value of a unit of capital to the replacement cost of capital, i.e. the profitability of producing a new house. In times of shortage, $q > 1$, it is profitable to build new houses while in times of surplus, $q < 1$, it is not profitable to build since old houses are cheaper than building new ones. With $q = 1$ in the long run, the market clears and housing wealth deflated by production prices is the same as the housing stock. Assuming that in the long run the ratio between house prices and the implicit consumption deflator is one, thus has the implication that real housing wealth is measured by the housing stock.

[15] The OLS estimator is the BLUE in the classical linear regression (CLR) model. For the assumptions of the CLR model, see e.g. Kennedy (1998, pp. 42-53).

$$\log\frac{CONS_t}{INC_t} = a_0 + a_1\log(1+RS_t) + a_2\log(1+UNP_t) + a_3\log\frac{FA_t}{INC_t} + a_4\log\frac{NHS_t}{INC_t} \qquad (4.5)$$

where log refers to the natural logarithm. Under the assumption that $(1+RS_t)$ and $(1+UNP_t)$ are close to one, a near approximation to $\log(1+RS_t)$ and $\log(1+UNP_t)$ is RS_t and UNP_t which means that (4.5) is approximately equal to

$$\log\frac{CONS_t}{INC_t} \approx a_0 + a_1 RS_t + a_2 UNP_t + a_3\log\frac{FA_t}{INC_t} + a_4\log\frac{NHS_t}{INC_t}. \qquad (4.6)$$

In the general model, we assume that the interest and unemployment rates can be entered as in (4.6). Unit elasticity is also assumed and tested for later. The general model thus has the following form

$$\Delta cons_t = a_0 - a_1 Dcons_{t-1} + a_2 Dinc_t + a_3 Dinc_{t-1} + a_4 Dfa_t + a_5 Dfl_t + a_6 Dhs_t + \qquad (4.7)$$

$$a_7 rhp_t - a_8 rhp_{t-1} - a_9 D9193_t - a_{10} UNP_t + a_{11} RS_t -$$

$$a_{12}[\log(CONS_{t-1}/INC_{t-1}) - b_1\log(FA_{t-1}/INC_{t-1}) - b_2\log(NHS_{t-1}/INC_{t-1})],$$

where Δ refers to the first difference of a variable and *D9193* is the dummy variable discussed in Section 3.3.1, equal to 0 in 1970-1990, 0.33 in 1991, 0.66 in 1992 and 1 thereafter. The expected signs are indicated for most parameters. However, the parameters a_3, a_4, a_5, a_8 and a_{11} are uncertain in sign. $[\log(CONS_{t-1}/INC_{t-1}) - b_1\log(FA_{t-1}/INC_{t-1}) - b_2\log(NHS_{t-1}/INC_{t-1})]$ is the *ECM*.

The dependent variable is expressed in differenced form in order to obtain stationarity. A constant is included in order not to force the regression through the origin. The lagged dependent variable is included to account for habit persistence. Differenced income measures the MPC out of income in the short run. The reason for including a lagged differenced income term is to account for possible sluggishness in the dynamic adjustment, positive or negative.

The effect of an increase in financial assets in the short run is ambiguous and depends on whether the increase is caused by increased saving or whether the asset value has increased, caused e.g. by higher stock market prices. If an increase in financial assets is mainly due to higher savings, lower consumption coincides with high asset values. However, if valuation gains are the principal reason behind the higher value of assets, higher consumption coincides with high asset values. Due to the large valuation increase of the stock market in the 1980's and 1990's, it is primarily this latter effect we expect to capture when including this variable in the short run part of the estimated consumption function.

The short run effect of debt is also ambiguous. In the long run, a persistently higher level of debt implies lower consumption. However, in the short run, this is not necessarily the case. An increase in debt means 'more money to spend' and a temporary increase in consumption is therefore entirely possible.

The change in the housing stock is included in the short run part of the equation in order to capture the effect on non-housing consumption due to an increased housing stock. It is mainly the purchases of semi-durables and durables that can be expected to rise, as people buy furniture and major household appliances when furnishing homes.

Since we have assumed that the ratio between the house price and the implicit consumption deflator is constant in the long run (cf. Section 4.2 and footnote 14), the relative house price is included only in the short run part so as to measure the transitory wealth effect from house-owners. The intuition is that house-owners in the short run have rules of thumb for the preferred amount of mortgage relative to their housing wealth. When they see an increase in the relative price of housing they feel wealthier and increase their consumption. Prospective house-owners who do not already own houses are also affected by high relative prices and either consume or save more depending on whether the price acts as a deterrent or not. This variable most likely also reflects the Swedish business cycle. In times of boom, the relative price is likely to be above its long run value as the supply of houses in the short run is fixed.

As mentioned in Section 3.3.1, it is possible that the unemployment variable captures something else or something more than just the effect of unemployment. We therefore include a dummy, resembling the shape of unemployment to account for possible effects of the tax reform, increased government debt and the switch to floating exchange rate. In contrast to unemployment, the dummy does not drop at the end of the sample period. If in fact unemployment measures the effect of unemployment and nothing else, it should be at least as significant as the dummy.

4.4 Estimation Results

Table 4.2 reports the results of the general to specific methodology, from left to right. The dependent variable is the differenced value of the logarithm of real household consumption expenditure, $\Delta cons$.

Table 4.2 General to specific modelling of household consumption expenditure

Model	A	B	C	D	E
constant	-0.026 (1.489)	-0.013 (1.758)	-0.011 (1.397)	-0.008 (1.165)	…
$\Delta cons_{t-1}$	-0.090 (0.866)	…	…	…	…
Δinc_t	0.272 (3.433)	0.265 (3.870)	0.292 (3.978)	0.296 (4.030)	0.369 (4.560)
Δinc_{t-1}	0.227 (2.227)	0.125 (1.880)	0.144 (1.980)	0.132 (1.880)	…
Δfa_t	0.073 (3.887)	0.063 (4.194)	0.064 (3.902)	0.059 (3.927)	0.047 (2.788)
Δfl_t	-0.037 (0.747)	…	…	…	…
Δhs_t	-0.115 (1.847)	-0.114 (1.817)	…	…	…
$rhp_{\mathbf{t}}$	0.235 (4.861)	0.180 (8.120)	0.172 (7.364)	…	…
rhp_{t-1}	-0.179 (5.971)	-0.150 (6.431)	-0.156 (6.190)	…	…
Δrhp_t	…	…	…	0.166 (7.651)	0.171 (7.287)
$D9193_t$	-0.090 (2.566)	-0.057 (8.404)	-0.049 (8.031)	-0.047 (8.640)	-0.043 (6.4642)
UNP_t	-0.493 (0.783)	…	…	…	…
RS_t	0.100 (1.615)	0.098 (1.614)	…	…	…
$\log(CONS_{t-1}/INC_{t-1})$	-0.577 (7.881)	-0.553 (8.853)	-0.474 (8.311)	-0.455 (8.897)	-0.413 (7.491)
$\log(FA_{t-1}/INC_{t-1})$	0.115 (5.704)	0.098 (5.744)	0.091 (4.960)	0.080 (6.922)	0.066 (6.662)
$\log(NHS_{t-1}/INC_{t-1})$	0.021 (3.284)	0.016 (3.260)	0.018 (3.576)	0.015 (4.504)	0.016 (5.244)
R^2 adjusted	0.914	0.912	0.894	0.896	0.841
Standard error	0.0057	0.0057	0.0063	0.0062	0.0076
Durbin Watson	2.126	2.401	2.590	2.669	2.089
Akaike Information Criterion	15.57	15.10	14.64	14.53	13.89

Note: *t*-values in parentheses.

We started by estimating the general model (Model A). Altogether there are 15 parameters in this model. With only 29 available observations, the regression results are not very reliable.

Model reduction must be guided by economic theory. Restrictions were tested using the Lagrange Multiplier statistic in its *F* distribution form (*LMF*).[16] The high R^2 of Model A was to be expected but nevertheless there are several insignificant variables, albeit with the expected sign. The lagged dependent variable is insignificant which is hardly surprising with annual data since adjustment is on a yearly basis. The debt variable is also dropped due to its low *t*-value. This does not contradict theory, which predicts ambiguous short run effects from an increase in debt. The insignificant *t*-value of unemployment indicates that it is in fact playing the role of a dummy variable and therefore should be dropped as argued in Section 3.3.1. The remaining insignificant variables are kept. As shown in *Table 4.3*, the *LMF* test supports our restriction.

After the restrictions are implemented, we are left with Model B with an Akaike Information Criterion (*AIC*) which is slightly lower than that of the previous model. This indicates that Model B fits better than Model A, i.e. no information is lost in the model reduction. The R^2 value of Model B is of the same size as that of Model A and all variables have the same signs and magnitudes. As mentioned in Section 3.3.2, interest rates are difficult to incorporate into a consumption function and therefore we are not surprised that the variable does not appear significant. A possible reason for the insignificance of the interest rate is that it covaries with the relative house price. However, the correlation between the two variables is 0.68, which although high is no cause for alarm. We were expecting the coefficient of the housing stock to be positive but this is not the case. However, as it is not significant it is dropped along with the interest rate. This restriction is supported by the *LMF* test.

In Model C, the *AIC* is somewhat better than before and R^2 is only slightly lower than in the previous model. All variables except for the intercept are significant at the 5% level. As in the two previous estimated models, the terms rhp_t and rhp_{t-1} have coefficients of almost equal size but of opposite sign. We therefore test this restriction and find it valid.[17]

The intercept, being of small size and insignificant in all models estimated, is removed before our final model is estimated.[18] In light of the few number of available observations, the lagged income variable is also removed from the model. This leaves us with our preferred equation, Model E, which has a somewhat lower *AIC* than the former models. The R^2 is not as high as in the former models but in return it only has seven estimated parameters. Having reached our final equation, variables that dropped out at an earlier stage of the process were reintroduced to test for significant effects.

To once more check if unemployment should enter the model or not, we regressed unemployment on a constant and *D9193* and added the residuals of this regression as an additional explanatory variable to Model E. Since the residuals were not significant, we conclude that unemployment does not belong in the model. Using the total unemployment rate (including persons in programs) instead of the open does not either effect the estimation results.

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[16] For a description of this test see Charemza and Deadman (1997, p. 66-67).

[17] For a description of the procedure for testing the equality of two regression coefficients, see e.g. Gujarati (1995, pp. 254-255). Our estimated t-value is -0.0025 and we can therefore not reject the null hypothesis that the two coefficients are of equal size.

[18] Including the intercept in Model E makes virtually no difference to the equation. The value of the intercept is –0.003 and it's *t*-value is 0.358. For this reason test statistics should not be seriously biased.

The homogeneity constraint is tested by adding inc_{t-1} as an explanatory variable and checking whether its elasticity is zero [Barot (1995)]. With a *t*-value of 0.37, the test shows that the constraint is clearly satisfied.

Table 4.3 Testing restrictions using the *LMF* test

Model reduction	Number of restrictions	*LMF*-statistic	Critical Value (df_{num}, df_{denom})
A–>B	3	1.12	3.49 (3,12)
B–>C	2	2.71	3.68 (2,15)
A–>C	5	1.78	3.11 (5,12)
C–>D	1	0.99	4.45 (1,17)
A–>D	6	1.62	3.00 (6,12)
D–>E	2	3.17	3.55 (2,18)
A–>E	8	2.17	2.85 (8,12)

Note: Critical values are for 5% significance level.

4.5 Cointegration and Implied Long Run Solution

To test for the stationarity of the residuals of Model E, an integration test is performed. The *LMF* test indicates that no augmentations are necessary. The null hypothesis is that the residuals are non-stationary, i.e. not cointegrated. The t-value is 6.68, which is larger than the critical value of 4.23.[19] The null hypothesis is therefore rejected. This suggests that $\log(CONS_t/INC_t)$, $\log(FA_t/INC_t)$ and $\log(NHS_t/INC_t)$ are cointegrated.

The long run relationship is

$$0.413 \cdot \log \frac{CONS_t}{INC_t} = 0.066 \cdot \log \frac{FA_t}{INC_t} + 0.016 \cdot \log \frac{NHS_t}{INC_t} . \tag{4.8}$$

Rearranging terms gives us the cointegrating relationship

$$cons_t = 0.80 \cdot inc_t + 0.16 \cdot fa_t + 0.04 \cdot nhs_t . \tag{4.9}$$

The interpretation of this is that an increase in income with one percent increases consumption by 0.8 percent. The parameters for financial assets and the net housing stock are interpreted in the same way. We find the size of the parameters reasonable. Financial assets are generally more liquid than the net housing stock and therefore the former should influence consumption more. The income parameter is close to one, as expected. Knowledge of the cointegrating vector enables us to write Model E as

$$\Delta cons_t = 0.37\Delta inc_t + 0.05\Delta fa_t + 0.17\Delta rhp_t - 0.04D9193_t - 0.41ECM_{t-1} + e_t, \tag{4.10}$$

where e_t is the estimated residual and

$$ECM = cons - 0.80 \cdot inc - 0.16 \cdot fa - 0.04 \cdot nhs.$$

The parameter a_{12} of (4.7) in front of the *ECM* indicates the speed of the long run adjustment. According to (4.10), 41 percent of the adjustment towards equilibrium takes place in the first period. In levels, (4.10) can be expressed as

[19] Critical value for the cointegration test is from Charemza and Deadman (1997, p. 292) for 5% significance level, test with intercept, m=2.

$cons_t = 0.59cons_{t-1} + 0.37inc_t – 0.04inc_{t-1} + 0.05fa_t + 0.02fa_{t-1} +$ (4.11)

$0.02nhs_{t-1} + 0.17\Delta rhp_t – 0.04D9193_t + e_t.$

As pointed out in Section 4.1, the above estimation method assumes the existence of only one cointegrating vector. To test for the validity of this assumption, we use the Johansen procedure, which is based on maximum-likelihood estimation of a vector autoregressive model (VAR).[20] With n long run variables the basic VAR model can be formulated as

$$\Delta Z_t = \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi \cdot Z_{t-k} + e_t \qquad (4.12)$$

where Z_t is a n ´ 1 vector of observations on all long run variables in the model, X_t is a vector containing all variables appearing in the short run part of the model, and k is the number of lags. Π is a n ´ n matrix which can be expressed as the product of two matrices ***a*** ×***b***' where ***a*** and ***b*** are n ´ r matrices and r is the number of cointegrating vectors. The number of cointegrating vectors can be obtained by checking the significance of the characteristic roots of Π. In practice only estimates of Π and the characteristic roots are obtained. To test for the number of characteristic roots that are different from unity the trace and max test statistics, λ_{trace} and λ_{max}, are used. The trace statistic tests the null hypothesis that the number of cointegrating vectors is less than or equal to r against a general alternative. The max statistic tests the null that the number of cointegrating vectors is r against the alternative of $r+1$ cointegrating vectors. In our case we estimate a VAR with three long run (log($CONS_{t-1}/INC_{t-1}$), log(FA_{t-1}/INC_{t-1}), log(NHS_{t-1}/INC_{t-1})) and four short run (Δinc_t, Δfa_t, Δrhp_t, $D9193_t$) variables. The Johansen procedure confirms our results from the Engle-Granger/Banerjee procedure.

Table 4.4 Test for the number of cointegrating vectors according to Johansen procedure

	Trace statistic			Max statistic		
r	Ordinary	Small-sample correction	Critical value	Ordinary	Small-sample correction	Critical value
0	46.03**	41.1**	17.9	52.51**	46.89**	24.3
1	5.15	4.60	11.4	6.48	5.79	112.5
2	1.34	1.94	3.8	1.34	1.94	3.8

Note: Critical values are for 5% significance level from the computer package PcFiml 9.0 for Windows.
** implies that the test result is significant at 1% significance level.

As can be seen from *Table 4.5*, the only estimate of the adjustment matrix ***a*** that is significantly different from zero is the one belonging to log(*CONS/INC*).[21]

Table 4.5 Standard error of ***a***

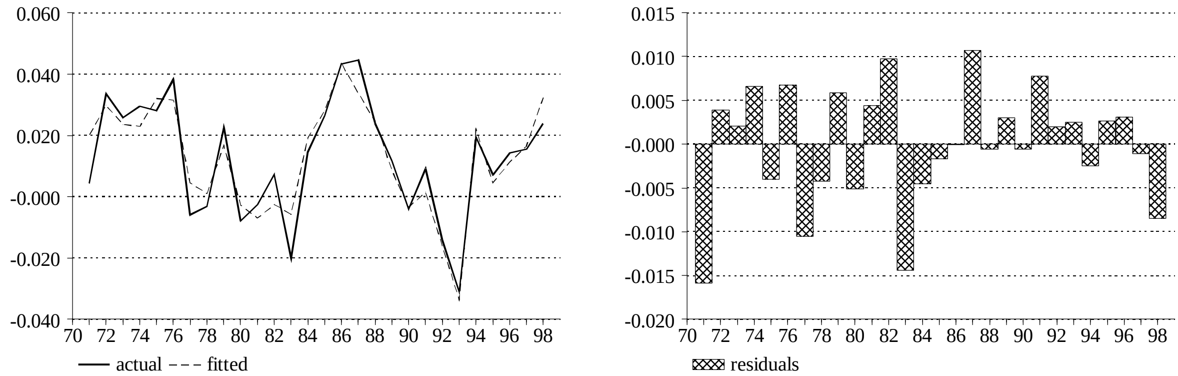
Variable	α	Standard error of α
log(*CONS/INC*)	-0.41065	0.042149
log(*FA/INC*)	0.00003	0.00004
log(*NHS/INC*)	1.1371	1.5002

[20] For more information on VAR modelling see e.g. Charemza and Deadman (1997, ch. 6) or Doornik and Hendry (1997).
[21] The estimated α is asymptotically normally distributed [Johansen (1995, pp. 181-182)].

4.6 Model Fit

The left part of *Figure 4.1* shows the actual values of $\Delta cons$ as well as the fitted values from the estimation of Model E and the right part shows the residuals from the equation. As can be seen, the fit is quite good and the estimated equation seems to capture the major turning points. The residuals of 1971 and 1983 are the only ones of a size worth mentioning.

Figure 4.1 Actual versus fitted values and residuals



5 Testing and Evaluating the Preferred Model

Visual examination of the residuals shows that they appear to be normally distributed and that there are no obvious signs of autocorrelation or heteroscedasticity. In this section we make use of standard tests, recursive estimates of the parameters and forecasts in order to further diagnose our preferred model.

5.1 Tests

The standard test for first order serial correlation is the Durbin Watson (DW) test. Our DW value indicates that there is a possibility of negative serial correlation but we cannot say whether this is actually the case as the estimated value lies in the indecisive range ($4\text{-}d_U = 1.948 \leq 2.08 \leq 4\text{-}d_M = 3.157$).[22] It should however be noted that the DW statistic assumes the presence of an intercept in the regression.

To test for higher order serial correlation we used a test developed by Godfrey (1978). This test can be used for different specifications of the error process. The null hypothesis is that there is no serial correlation. The test statistic is $n \times R^2$ and it has a χ^2 distribution with p degrees of freedom, where p is the number of lagged residuals included in the regression. Test results are reported in *Table 5.1*.

Table 5.1 Godfrey test for serial correlation

Null hypothesis	Test statistic	Critical Value (df)
$\rho_2 = 0$	3.31	3.84 (1)
$\rho_3 = 0$	3.12	3.84 (1)
$\rho_4 = 0$	2.52	3.84 (1)

Note: Critical values are for 5% significance level.

[22] Critical values are for 5% significance level, n=29 and k=7 from Gujarati (1995, pp. 818-819) and Farebrother (1980) who gives tables for models with no intercept term. Gujarati (1995, pp. 420-425) also has a description of the test procedure.

The test indicates no signs of serial correlation. We conclude that serial correlation is not a serious problem in the model.

The Jarque-Bera test for the normality of residuals has the null hypothesis that the residuals are normally distributed. The test statistic is χ^2 distributed with two degrees of freedom. The null hypothesis cannot be rejected at the 5% significance level (*p*-value: 0.146).

To test for heteroscedasticity we used the Breusch-Pagan-Godfrey heteroscedasticity test. The null hypothesis is that the residuals are homoscedastic. The test statistic is asymptotically χ^2 distributed with (m–1) degrees of freedom where m is the number of variables in the original regression. The null hypothesis cannot be rejected at the 5% significance level (*p*-value: 0.212).

If one (or several) of the explanatory variables is endogenous, it is likely to be correlated with the error term, and a simultaneity problem arises. If there is simultaneity, the OLS estimators are not consistent. To test for simultaneity, we used the Hausman specification test.[23] The null hypothesis is that there is no simultaneity. For each explanatory variable, a two step procedure is performed. First the explanatory variable is regressed on the other explanatory variables. In the second step, $\Delta cons$ is regressed on the explanatory variable and the obtained residuals from the first regression. If the coefficient of the residual used as a regressor in this second step is significant, the null hypothesis is rejected. *Table 5.2* reports the test results.

Table 5.2 Hausman specification test

Variable	*t*-value of residual in second step regression
inc	1.091
fa	0.475
rhp	0.258
nhs	0.537

Note: The variables were tested in their first difference form.

As can be seen from *Table 5.2*, the null hypothesis of no simultaneity can not be rejected for any of the explanatory variables. Hence there is no evidence that the error term is correlated with the dependent variable.

5.2 Stability of Parameters

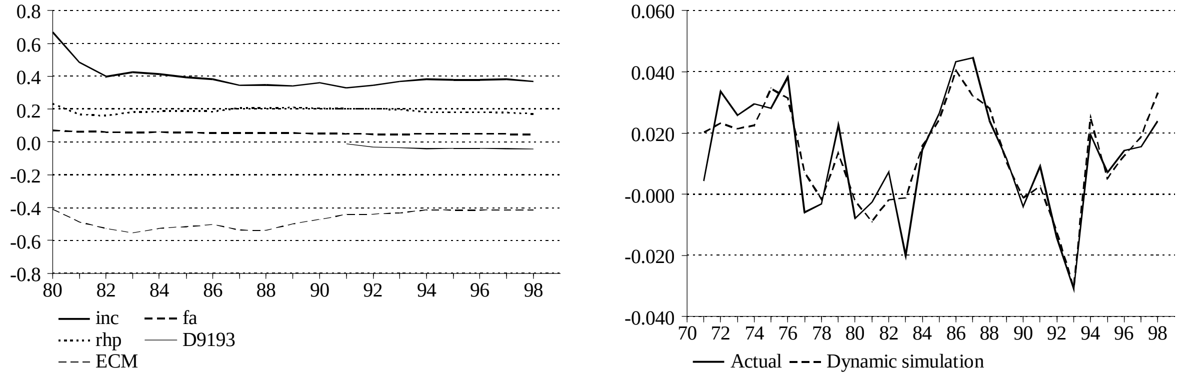
A plot of the recursive least squares coefficients is shown to the left in *Figure 5.1*. Initial instability merely reflects the few number of observations with which the equation is estimated. The parameters seem to be stable over time. This indicates that the model is robust and that there are no structural changes.

Another sign of stability is resemblance of the fitted values of the dynamic dependent variable estimates of the model to the actual values. We started from the actual value of the dependent variable year 1970 and used this for the estimation of the 1971 value of $\Delta cons$. Thereafter the estimated 1971 value of consumption is used to estimate the 1972 value of $\Delta cons$ and so on.

[23] For a description of this test, see e.g. Gujarati (1995, pp. 670-671).

All explanatory variables are actual values. Our simulation indicates that the model is robust, see the right part of *Figure 5.1*.

Figure 5.1 Recursive least squares estimates of parameters and dynamic simulation of $\Delta cons$



5.3 Forecasts

In order to perform an *ex ante* forecast, Model E was re-estimated using data for the period 1970-1994. Then a dynamic forecast for the years 1995-2000 was made in a similar fashion to that described in Section 5.2. Actual data for the explanatory variables were used until 1998 after which the forecast values of *Table 5.3* were used. *Figure 5.2* shows that the fit is good for the whole period, perhaps with the exception of 1998. For reference, NIER's forecasted values for the years 1999 and 2000 are also included in the figure [National Institute of Economic Research (1999b, p. 19)].

Table 5.3 Percentage change in explanatory variables

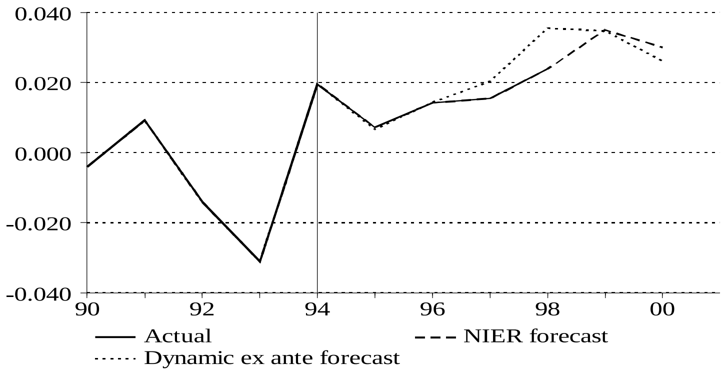
Variable	1999	2000
INC^{ξ}	3.4	3.3
FA^{ψ}	10.0	10.0
PH^{φ}	8.0	3.0
P^{ξ}	0.7	1.9
HS^{ψ}	3.0	3.0
FL^{ψ}	10.0	10.0

ξ From NIERs august 1999 forecast with consideration taken to information as of 1999-10-08.

ψ Own values.

φ Based on actual data for first half of 1999 from Statistics Sweden.

Figure 5.2 Dynamic *ex ante* forecast of $\Delta cons$



A forecast for the years 1999-2000 based on the estimation of Model E for the whole period 1970-1998 produces similar results. The values from *Table 5.3* were used also for this forecast. The forecast values of $\Delta cons$ from the model, 0.036 and 0.028 respectively, are similar to those published in the August forecast of the NIER, 0.035 and 0.030.

6 Simulations

To evaluate the long run properties of the preferred model and the dynamic response to shocks in the exogenous variables, a number of simulations are carried out. The first subsection below presents the framework for the simulations and deals with the adjustment towards equilibrium. The subsection thereafter first introduces different shocks in disposable income and then in the other exogenous variables.

6.1 Framework and Adjustment Towards Equilibrium

The study of adjustment towards equilibrium and the effects of exogenous shocks requires, in addition to the use of the preferred equation itself, the use of the familiar savings identity:

$$S \equiv INC - CONS. \qquad (6.1)$$

Furthermore, total savings in each period must be distributed between the two wealth variables. Can a constant long run ratio between the two be assumed? Examination of data shows that the average ratio of financial to total assets during our sample period is 0.84. However, the borrowing restrictions of the 1970's and first half of the 1980's and the tax reform of 1990-91 have most likely changed the distribution of wealth and we therefore use the ratio of 1997, 0.80.[24] This means that 80 percent of savings in each period is distributed to financial assets while 20 percent is attributed to the net housing stock. Hence, financial wealth and net housing assets in each period are calculated as

$$FA_t = FA_{t-1} + 0.80 \cdot (INC_t - CONS_t) \qquad (6.2)$$

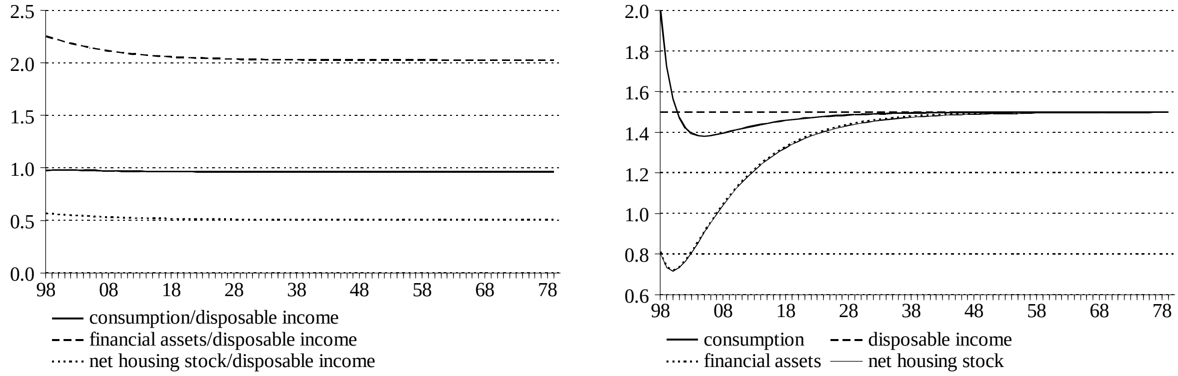
$$NHS_t = NHS_{t-1} + (1 - 0.80) \cdot (INC_t - CONS_t). \qquad (6.3)$$

The average yearly growth rate in disposable income has been 1.1 percent during the sample period, but we assume that the steady state growth rate is slightly higher, namely 1.5 percent.[25] Using the actual values of our variables for the years 1997 and 1998, the adjustment towards steady state has been simulated using (6.2), (6.3) and Model E. Assuming there is a steady state solution, it will be reached as time approaches infinity. However, as the simulation technique requires a final period to be set, steady state will only be approximated.

Figure 6.1 shows the ratios of consumption, financial assets and the net housing stock to disposable income as well as the growth rate of each respective variable as a steady state is approached.

[24] This is close to the ratio of the 1990's, which is 0.79. The ratio for the period 1970-1979 is 0.89 and for the period 1980-1989 it is 0.82.
[25] This is the same growth rate as used by Barot (1995, p.35).

Figure 6.1 Adjustment towards steady state
Left: ratios to disposable income, right: growth rate (in percent)



As can be seen to the left in *Figure 6.1*, the long run ratios of consumption, financial assets and the net housing stock to disposable income are all above their equilibrium values to begin with. The stock of financial assets relative to disposable income is 2.25 in 1998 and the ratio slowly adjusts to its equilibrium value of approximately 2.0. The net housing stock relative to disposable income is 0.58 in 1998 and the equilibrium ratio is approximately 0.5 which is one fourth of that of financial assets to disposable income. This is to be expected as savings are distributed in the proportion one to four. For both variables, 50 percent of the adjustment takes place in the first nine years. The ratio between consumption and disposable income is 0.98 in 1998 and 50 percent of the adjustment towards the equilibrium ratio of roughly 0.96 takes place in the first seven years. The steady state ratios are close to the average ratios observed in the 1990's.[26] However, the low saving ratio during the sample period is most likely policy induced.[27]

The high ratios of consumption, financial assets and the net housing stock to disposable income in the first period of the simulation are the reason for the slow growth rates in these variables during the first 30 years of the simulation, as shown to the right in *Figure 6.1*. Subsequently, the growth rate of all variables is approximately 1.5 percent. The initial drop in the growth rates is due to the high starting values, i.e. actual data for 1997 and 1998.

6.2 Shocks

To evaluate the effects of exogenous shocks in the model, we have simulated such *ceteris paribus* (positive) shocks when the economy is in equilibrium. In Section 6.2.1, different types of income shocks are simulated. The effects of a temporary increase in the relative price of housing and increases in financial assets and the net housing stock are studied in Section 6.2.2.

6.2.1 Shocks in Disposable Income

Three different types of shocks in disposable income have been simulated. The first is a temporary shock in the level of disposable income, which has no permanent effect. One possible cause for such a shock could be 'too high' wage contracts in one period, which in the

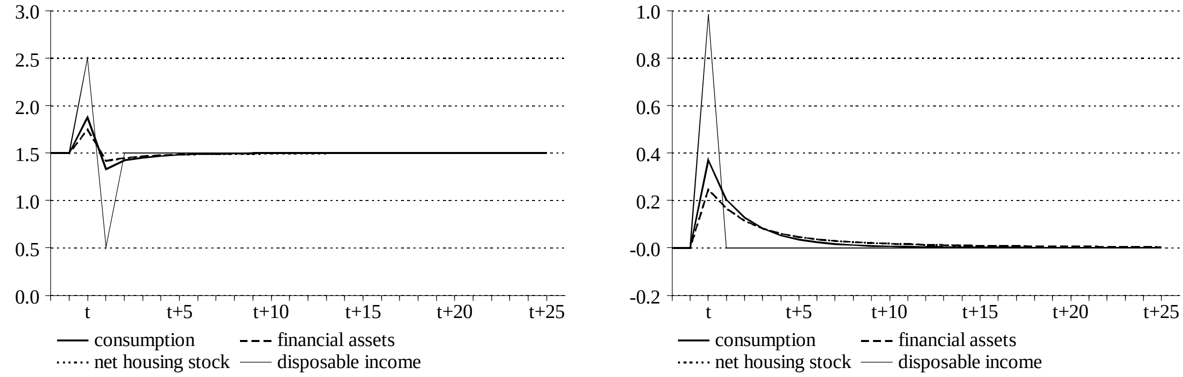
[26] The average savings ratio during the 1990's is 0.034 while the average ratios of financial assets and the net housing stock to disposable income are, respectively, 1.82 and 0.48. Respective figures for the whole sample period are 0.027, 1.61 and 0.32.

[27] Due to generous tax rate deductions on interest payments, the real after tax interest rate was for long periods very low and even negative. This factor stimulated consumption and suppressed savings.

next period are adjusted for by lower wage increases. The second type of shock in disposable income is a permanent level shock which could be caused by a permanent income tax cut. The third shock is a permanent increase in the growth rate of disposable income, perhaps caused by new technology, the removal of the remaining trade barriers or institutional rationalization.

The effects of a temporary shock in the level of disposable income are displayed in *Figure 6.2*.

Figure 6.2 A temporary one percent level shock in disposable income in period *t*
Left: growth rates (in percent), right: percentage difference in levels compared to baseline



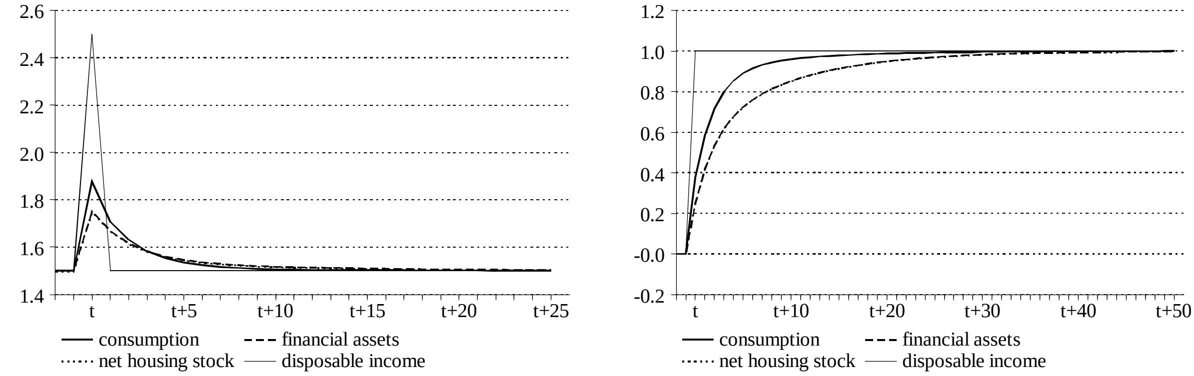
Note: The plotted line for the net housing stock coincides with that of financial assets.

As can be seen from the left part of *Figure 6.2*, the increase in disposable income in period *t* is followed by a decrease of equal size in period *t+1*. This is also evident from the right hand part of the figure where there is only a difference in disposable income between the shock and the baseline scenario in period *t*. The growth rates in consumption and the stocks follow the same pattern as income. The reason why the growth rates in the stocks also increase in period *t* is that as income increases, so do savings. The decrease in income in the following period also reduces the growth rates in consumption and the stocks, but by less than their increase in period *t*. This is due to the short run dynamics of the model.

The short run MPC out of income of Model E is 0.37 (cf. *Table 4.2*), which is evident from studying the right part of *Figure 6.2*. The remaining part of the income increase in period *t* is saved and according to the initial assumptions 80 percent of this savings is invested in financial assets and 20 percent in the net housing stock. Hence, both stocks will increase by the same percentage amount, i.e. by 0.25 percent, as financial assets constitute 80 percent out of total assets while the net housing stock constitutes 20 percent. The total effect of the income increase in period *t* can thus be calculated as each component's ratio to income times its percentage effect ($1 \approx 0.37 \cdot 0.96 + 0.25 \cdot 2 + 0.25 \cdot 0.5$). When ten years have elapsed, almost no growth effects of the temporary income shock remain and the initial income increase will be consumed.

The effect of a permanent one percent level shock in disposable income is illustrated in *Figure 6.3*, in a manner analogous to that of the temporary shock.

Figure 6.3 A permanent one percent level shock in disposable income in period *t*
Left: growth rates (in percent), right: percentage difference in levels compared to baseline

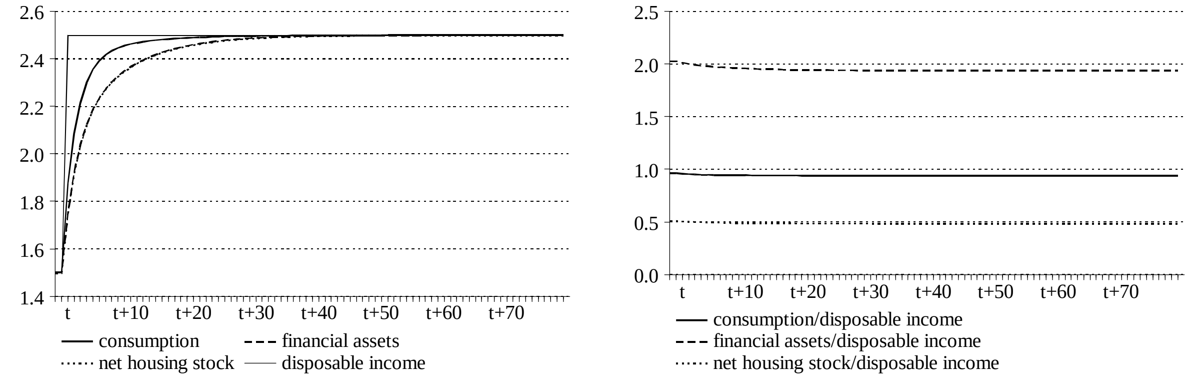


Note: The plotted line for the net housing stock coincides with that of financial assets.

As can be seen in the left part of *Figure 6.3*, there is an initial growth increase in all variables but they eventually return to the growth rate of the baseline scenario. However, the levels of all variables are permanently affected by the shock. As can be seen in the right hand part of the figure, when 30 years have passed, all levels are one percent above baseline.

Figure 6.4 shows the effect of a permanent increase in the growth rate of disposable income.

Figure 6.4 A permanent one percentage point increase in the growth rate of disposable income induced in period *t*
Left: growth rates (in percent), right: ratios to disposable income



Note: The plotted line for the net housing stock coincides with that of financial assets.

Consumption adjusts more quickly than financial assets and the net housing stock, which adjust by the same rate. In 30 years the adjustment is virtually complete. The new equilibrium ratios of the stocks to disposable income, shown to the right in the figure, are slightly lower than the ones observed in the baseline scenario, 1.94 for financial assets and 0.48 for the net housing stock. The increase in the savings rate ratio, however, is dramatic, from approximately four percent of disposable income to six. The reason for this is that a higher income growth rate requires increased savings in order to maintain the desired ratios between the stocks and disposable income.

6.2.2 Shocks in the Relative Price of Housing and the Stock Variables

We have assumed that the ratio between the house price and the implicit consumption deflator is constant in the long run (cf. Section 4.2 and footnote 14). However, short run fluctuations (for example house price bubbles) are possible and therefore the effect of a temporary house price shock is simulated here. Also, the effects of equal shocks on the two stocks are compared. To do this, we have simulated a one billion SEK shock to each of them. One may imagine some new technology increasing the net present value of the shares owned by households. A sudden shock in the net housing stock is somewhat harder to rationalize but could be induced by an investment subsidy.

According to Model E, one would expect a temporary increase in the relative price of housing to have a positive effect on consumption in that same period, but to have the opposite effect in the next period.

Figure 6.5 A temporary one percent shock in the relative price of housing in period *t*
Percentage difference in levels compared to baseline

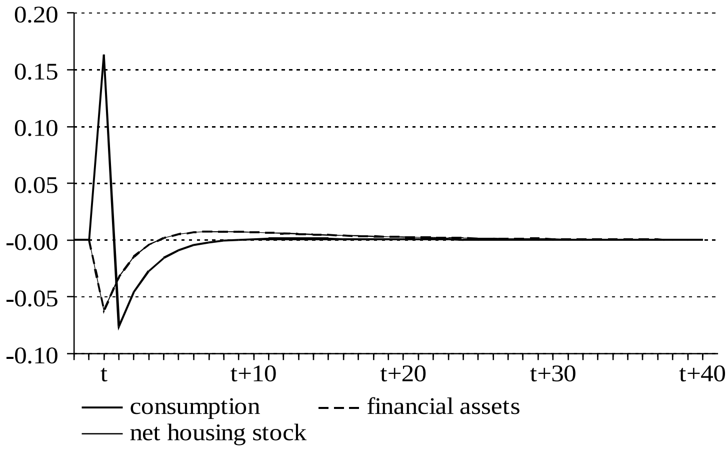
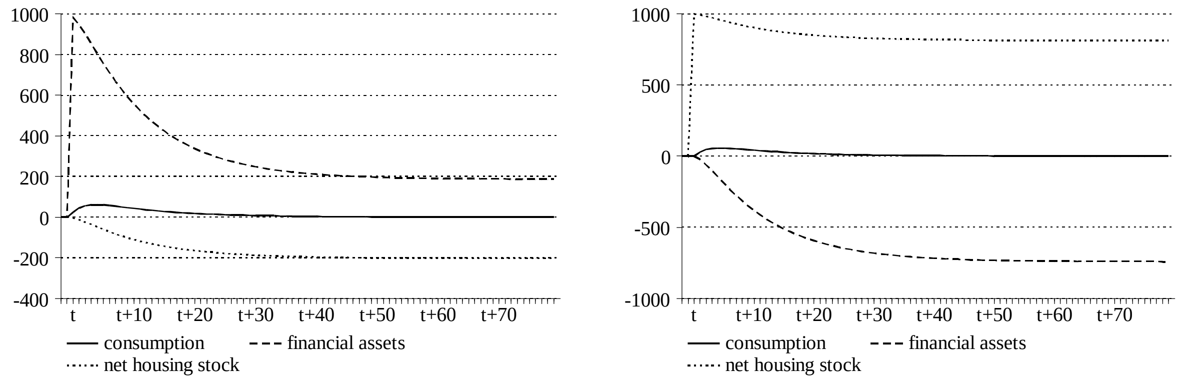


Figure 6.5 shows that the adjustment back to equilibrium after a temporary shock in the relative price of housing is not as straightforward as one might initially expect. The immediate positive effect on consumption is to some extent offset by a decrease in savings, which affects financial assets and the net housing stock negatively. Next period's consumption decrease relative the baseline scenario is not as large as the initial increase due to the positive effect of lagged consumption. Subsequently, consumption and the two stocks adjust towards the steady state. Consequently, the net effect on consumption is approximately zero after ten years.

The left hand side of *Figure 6.6* shows the effect of a one billion SEK increase in financial assets in period *t* and to the right we see the effect of an equal sized shock in the net housing stock.

Figure 6.6 A one billion SEK increase in financial assets/net housing stock in period *t*
Difference in levels compared to baseline



The immediate effect on consumption from the increase in financial assets is a 20 million increase compared to the baseline scenario. After roughly nine years fifty percent of the initial increase has been consumed, i.e. the accumulated total difference between consumption in the baseline and the simulated scenario is around 500 million. Financial assets are one billion above the baseline scenario in period *t* and it takes roughly 40 years until they settle to a new equilibrium level of 200 million above the baseline scenario. During this time the net housing stock gradually approaches its new equilibrium value of 200 million below the baseline scenario. The reason why financial assets during this period decrease four times as much as the net housing stock is that the decrease in savings caused by the higher consumption is distributed four to one between the stocks. Although the steady state stocks are permanently changed compared to the baseline scenario, the relationship between financial assets and the net housing stock asymptotically reaches four to one as they both increase with time (due to savings). Given that households have a preferred distribution of wealth, it seems realistic that when this differs from their actual distribution, they reallocate their savings until the preferred distribution is reached once again. If such a behavioural change were introduced to the model, the new steady state levels would be the same as those of the baseline scenario, i.e. all extra wealth would be consumed. However, such a simulation will not be done here.

To the right in *Figure 6.6*, we see the effect of a permanent one billion SEK increase in the net housing stock. There is no immediate effect on consumption as the net housing stock only enters the long run part of the model. It takes roughly eleven years for half of the initial increase to be consumed. Hence, an increase in the net housing stock by a certain amount does not affect consumption as much as an increase in financial assets of equal size. The reallocation of wealth is larger than in the previous simulation. In period $t+40$, the net housing stock is 800 million above the baseline while financial assets are as much below.

The results of all of the above simulations all seem reasonable. Half of the adjustment towards steady state in the baseline solution takes place in less than ten years and the implied stocks and savings rate all adjust to a reasonable level. Total net wealth (financial assets plus the net housing stock) is approximately two and a half times as large as disposable income in steady state. During our sample period the ratio between total net wealth and disposable income has varied between 2.9 (in 1997 and 1998) and 1.2 (in 1977). In all scenarios, the model behaves in a manner consistent with how we intuitively would expect consumption to react to the different types of shocks. This serves as an indicator of robustness. Furthermore, the model behaves in accordance with the life-cycle hypothesis where an increase in wealth is only gradually consumed over the lifetime.

7 Summary and Conclusions

The purpose of this thesis was to specify and estimate a consumption function to be used for medium term forecasts. Considerable effort has been put into the reliability of the variables used, in particular the housing stock, which differs from that used in previous Swedish studies. Including disposable income, financial assets and the net housing stock as long run variables, our preferred model was derived using Hendry's general to specific approach. We found that in the short run, financial assets and the relative house price are significant and important explanatory variables.

The estimated long run coefficients are in line with theory and we find them to be of a reasonable magnitude. The long run marginal propensities to consume out of disposable income, financial assets and the net housing stock are, in turn, 0.80, 0.16 and 0.04. Hence, a one percent increase in disposable income, will increase consumption by 0.80 percent. Tests show that the homogeneity constraint is satisfied, i.e. an increase in disposable income and wealth by one percent will increase consumption as much. The preferred model (E) performed well in standard tests and recursive estimates showed that the parameters are stable over time. Forecasted values for 1999 and 2000 are close to those of the National Institute of Economic Research.

The last section of this thesis was devoted to dynamic simulations in order to evaluate the long run properties of the preferred model and the dynamic response to shocks in the exogenous variables. In order to perform such simulations, a system of simultaneous equations containing the estimated consumption function and a disaggregated form of the savings identity was used. We found that half of the adjustment towards steady state in the baseline solution takes place in less than ten years and the implied stocks and savings rate all adjust to a reasonable level. In the shock scenarios, the model behaves in a manner consistent with how we intuitively would expect consumption to react. Temporary shocks do not have lasting effects and all variables adjust back to their equilibrium values with reasonable speed. As expected from theory, a permanent rise in the income growth rate leads to a higher savings rate.

Appendix A List of Definitions

Throughout, upper case letters refers to variables in levels while lower case letters refers to variables in natural logarithms. All constant price series are expressed in millions of SEK, 1998 prices.

C_t	Consumption in period *t*
CONS	Real household consumption expenditure
D9193	Dummy variable equal to 0 before 1991, 0.33 in 1991, 0.66 in 1992 and thereafter 1.
Δ	First difference
d	Subjective discount rate
E(…)	Expected value of …
e	i.i.d. error with an expected value of zero and a constant, finite variance.
FA	Real financial assets of households (deflated by *P*)
FL	Real financial liabilities of households (deflated by *P*)
HS	Housing stock (nominal value of housing wealth divided by *PH*)
INC	Real disposable income (deflated by *P*)
κ	The inverse of the marginal propensity to consume
log	Natural logarithm
MPC	Marginal propensity to consume
NHS	Net housing stock (housing stock minus financial liabilities)
P	Implicit deflator for household consumption expenditure, 1998=1
PH	Real estate price index, 1998=1
R_t	Real interest rate in period *t*
R^e_t	Expected real interest rate in period *t*
RHP	Relative house price (*PH*/*P*)
RS	Real after tax short interest rate
r	Substitution parameter in the utility function
s	Elasticity of substitution between consumption in periods 1 and 2
U	Life time utility of consumption
*U**	Life time utility of consumption under income uncertainty
$u(C_t)$	Subutility of consumption in period *t*
UNP	Open unemployment
W_L	Life-cycle wealth
W	Current wealth
Y_t	Disposable income in period *t*
Y^e_t	Expected disposable income in period *t*

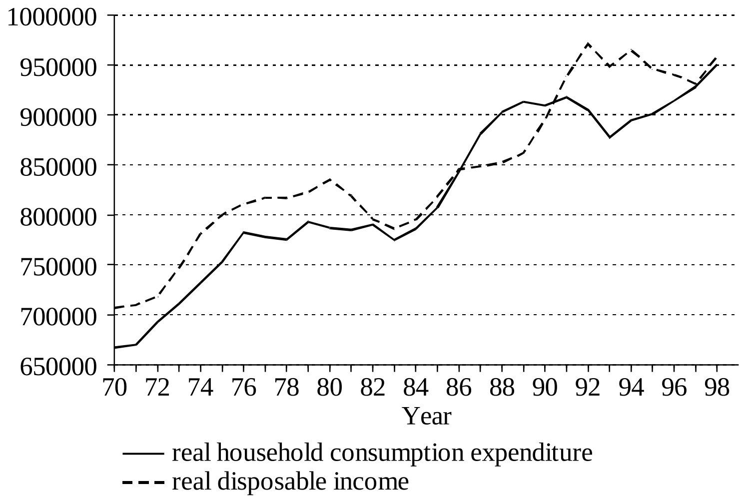
Appendix B Graphs and Definitions of Variables

NA published in May 1999, were the first to be prepared in accordance with the guidelines of the new revised European System of Accounts, ESA 95. This in turn is a more explicit version of the System of NA, SNA 93, endorsed by the UN, OECD etc. The new system involves changes in the classification of items, definitions and terminology. Sources and methods of calculation have also been reviewed and chain indeces have been introduced. The calculations published so far are for the years 1993 to 1998.

Below we present graphs of the used variables along with a description of how each series was obtained. All series are plotted together with real disposable income.

Household consumption expenditure and real disposable income

Figure B1 Household consumption expenditure and real disposable income
Millions of SEK



Source: NIER.

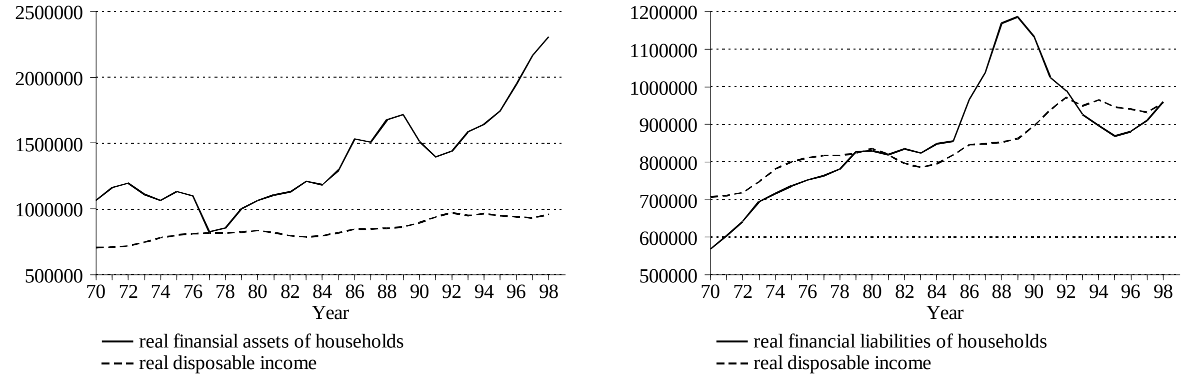
In terms of household consumption expenditure, the level is largely the same as under the previous method of calculation but there has been some redistribution among different categories of consumption and the share of household consumption expenditure in services is higher than before. In order to splice the new household consumption expenditure series with the old, the old level has simply been lifted.

Included in total household consumption expenditure are both net foreign travel and the consumption of goods and services of non-profit institutions. The latter is a fairly constant share of total consumption over time and thus should not affect the estimates much but the share of the net foreign travel does vary over time and thus could influence our results. However, the share of net foreign travel relative to total consumption is so small (varying between 2 and 0.04 percent for the period 1980 to 1998) that in fact it should not be a problem.

Real disposable income was obtained by deflating the nominal series by the implicit deflator for private consumption. According to the new NA, net savings in labor-contract pension schemes have been transferred from the corporation sector to households and is yet another item in the calculation of household net lending. This makes household net lending considerably higher than before. Other components of net lending which have been considerably affected by new definitions, adjustments for accruals, and reclassifications of both income and expenditure calculations are the direct yield on insurance saving, transfer payments received, taxes and interest. At the same time, a new definition of operating surplus on owner-occupied homes is a factor that lowers households' disposable income. The new level of disposable income is between one and two percent lower than the former for the available years. The level for previous years' data has been lowered in order to splice the new and old data series.

Real financial assets and liabilities of households

Figure B2 Real financial assets and liabilities of households and real disposable income
Millions of SEK

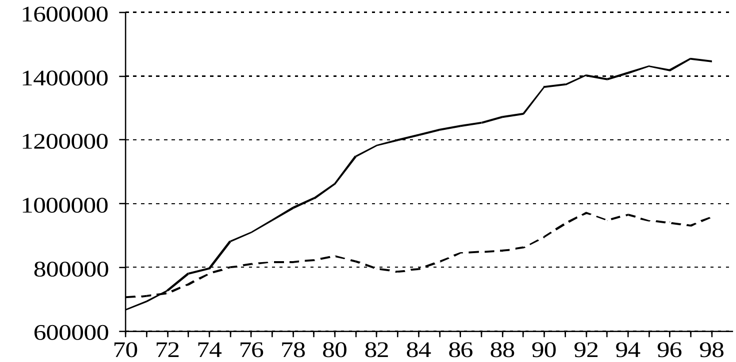


Source: NIER and Statistics Sweden.

The nominal financial variables of this study, assets and liabilities, were obtained directly from the financial accounts at Statistics Sweden. With the exception of 1975 and 1970, annual stock figures were not available before 1980 so earlier data were constructed using transaction data. Inconsistency between data published in different years leads us to question the quality of the data, and in particular the quality of earlier data is most likely rather poor. Annual data according to ESA 95 are not yet available. The nominal financial variables were deflated using the implicit deflator for private consumption.

Housing stock

Figure B3 Housing stock and real disposable income
Millions of SEK



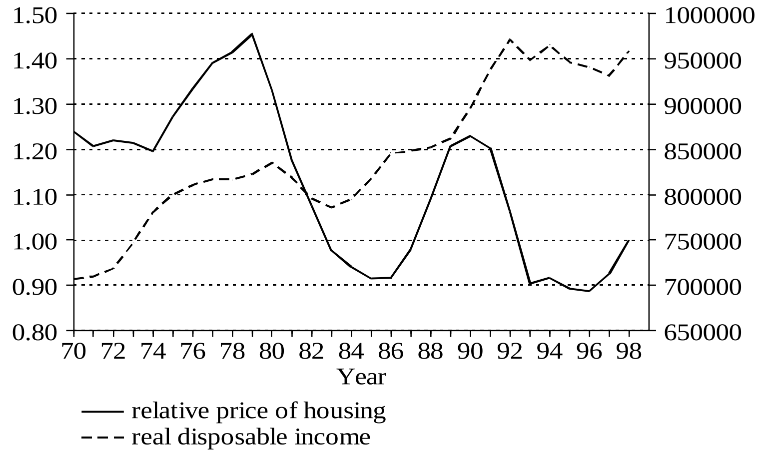
Source: NIER and Statistics Sweden.

Nominal housing wealth was constructed by multiplying the assessed value of owner-occupied one- and two-dwelling buildings and buildings for seasonal and secondary use owned by households by a purchase-price coefficient. This coefficient is a measure of the purchase-price relative to assessed value. Consideration has been taken to an unpublished revision of the purchase-price coefficient for the years 1970-1974 obtained from Statistics Sweden.

Real housing wealth was obtained by deflating the nominal housing wealth series by the implicit deflator for private consumption. The housing stock was obtained by deflating the nominal housing wealth series by the real estate price index. This in turn was obtained as a weighted average of the corresponding indices for owner-occupied one- and two- dwelling buildings (90 percent) and buildings for seasonal and secondary use owned by households (10 percent).

Relative price of housing

Figure B4 Relative price of housing and real disposable income
Right axis: millions of SEK, left axis: ratio



Source: NIER.

The relative price of housing is simply the ratio of the real estate price index to the implicit deflator for household consumption expenditure. The real estate price index was obtained as a weighted average of the corresponding indices for owner-occupied one- and two- dwelling buildings (90 percent) and buildings for seasonal and secondary use owned by households (10 percent).

Real after tax short interest rate

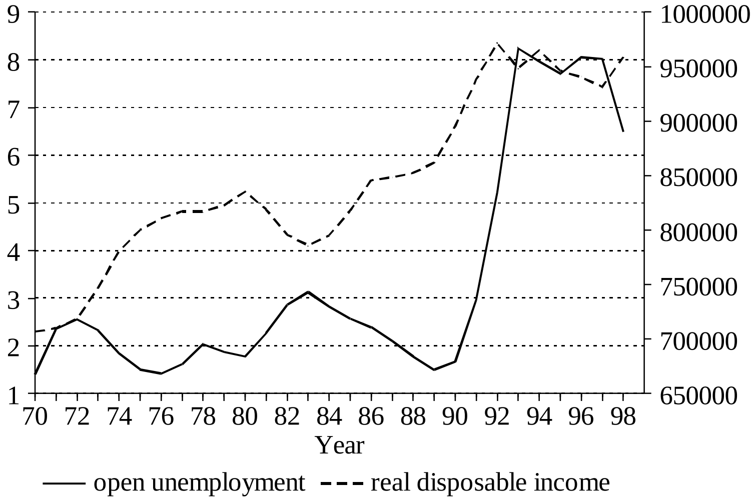
Figure B5 Real after tax short interest rate and real disposable income
Right axis: millions of SEK, left axis: percent

Source: NIER.

To obtain the real after tax short run interest rate, the yield of the Swedish three month treasury bill was adjusted for inflation and tax deductions.

Open unemployment

Figure B6 Open unemployment and real disposable income
Right axis: millions of SEK, left axis: percent



Source: NIER.

The unemployment variable used is open unemployment.

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