

Preface

This master thesis is the final work of the two-year master program in economics at the Department of Economics at the Norwegian University of Science and Technology (NTNU).

I would like to thank my supervisor, Kåre Johansen, for all his useful comments and constructive criticism.

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August 29, 2011

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1 Introduction

This master thesis estimates dynamic models for the demand for durable goods in Norway. In Norway, demand for total consumption goods has been extensively studied ¹, whereas this has not been the case for durable goods. The relatively few studies that has been done include studies on consumption of the durable good cars, for instance Harilstad and Nymoene (1993), Magnussen (1990), and Vennes (2010). This thesis has been influenced by these papers.

The development in consumption of goods is important in economic analysis. Jansen (2010, p. 4) argues that "since private consumption constitutes about half of the domestic absorption in modern economies, it is imperative for policy makers to have a firm grip on the driving forces behind aggregate consumption". Having well established and correctly specified models for the consumption of goods is crucial for policy makers such as national treasury divisions and central banks when making policy decisions regarding matters such as taxes, interest rates, and public spending. Thus, knowing whether or not, to what extent, and at what point in time different economic "shocks" or policy alterations potentially affect consumption obviously provides valuable information to policy makers.

Modeling consumption of durables may yield different results than for total consumption. A durable good is a good providing services to a consumer across time, for instance a car or a piece of furniture. There are two main differences between durable and normal goods. First, demand for durable goods will be affected by the stock owned by consumers at each point in time, which is more difficult to quantify than the actual purchases of goods. Second, because the purchases of durables can be postponed in bad times or expedated in better times, these goods might be more sensitive to economic shocks. This second characteristic is, in my opinion, what makes them particularly interesting to work with.

How variables such as income, wealth, interest rates, prices, and unemployment affect demand, as well as how fast changes in these variables yield effects on consumption will be the main focus of this master thesis. In figure 1 below, we can see the seemingly high

¹See Jansen (2009) for an overview on these studies.

correlation between the movements in real private disposable income, y , wealth, w , total consumption, c_{tot} , and consumption of durable goods, c_{dur} in Norway (1978-2008). The durable goods used for the analysis in this paper are furniture and household articles².

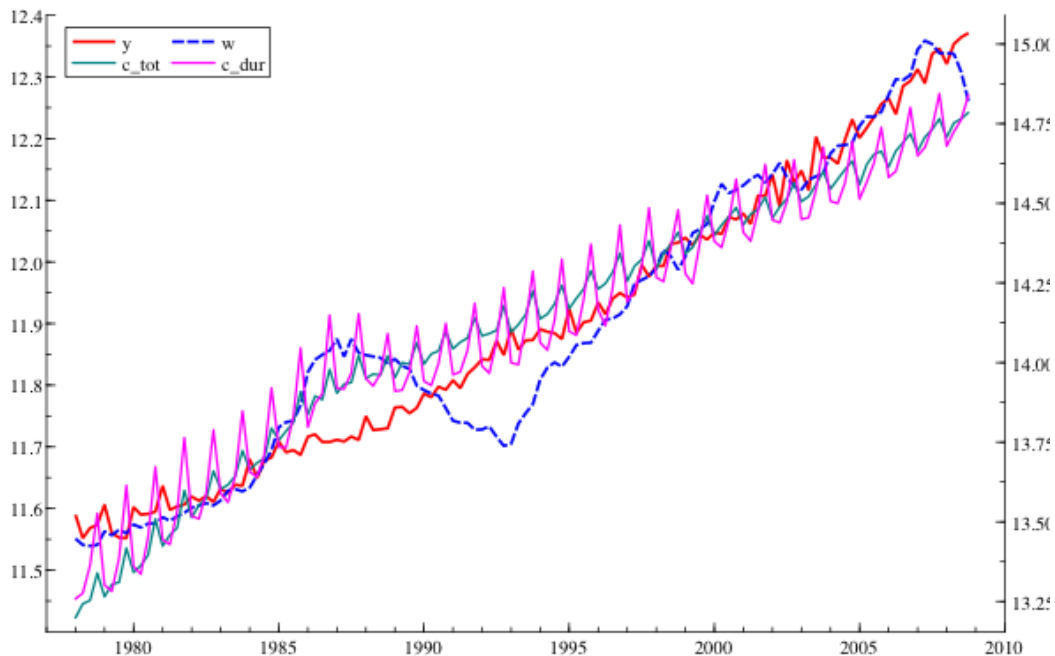


Figure 1: Norwegian income, wealth, and consumption of goods (1978-2008)

As can also be seen in Figure 1, is that the consumption of durable goods has been more volatile than both real private disposable income and total consumption, whereas wealth has been the most volatile of the four.

Models used to describe the Norwegian economy broke down in the mid-eighties, failing to explain the huge consumption growth taking place at the time. Magnussen (1990) argues that one possible explanation is that durable goods in the models weren't treated differently than normal goods. Eitrheim et al. (2000) notes that the ex post prediction abilities of the models were more successful after the inclusion of a wealth variable.

Previous studies on the effect of wealth on consumption in Norway thus suggest that the wealth effect is highly relevant in explaining consumption³. Given the scarce research on the consumption of durable goods, it will be interesting to examine the effect of wealth

²All values are real values and measured on a logarithmic scale. A more thorough description of the variables will be given in chapter 3

³See for instance Jansen (2009).

when modeling the purchases of durable goods. The other variables that are expected to affect the demand for goods include level, lagged and differenced values of relative prices, private disposable income⁴, private wealth, the real interest rate, and the unemployment rate. The unemployment rate will be used as a proxy for uncertainties in the future. To model the relative prices, I will construct price indices for each group of goods.

Dynamic modeling normally comprises three steps, including formulation, estimation and evaluation (Doornik and Hendry, 2007). The formulation should be based on economic theory and should be expressed according to the variables' time series properties. Based on economic theory and previous studies, I attempt to construct a dynamic model for consumption of durable goods. I will apply the general-to-specific method. Thus by gradually reducing a general model, I will try to determine the major drivers behind the consumption decision regarding durable goods.

The rest of the thesis is structured as follows. Chapter 2 describes the theoretical framework for demand analysis, and gives a brief overview of the relevant literature on dynamic modeling of demand for durable and non-durable goods. Chapter 3 will be dealing with the empirical data used. General properties of time series econometrics data will be described, and the time series properties of the variables used will be tested. Based on this analysis, the models used for estimation in chapter 4 will subsequently be specified. The empirical results will be reported in chapter 4. The chapter attempts to discriminate between competing model formulations on consumption of durable goods, and also compares the results with an equivalent model for total consumption. Chapter 5 summarizes and concludes.

⁴The effect of taxes can indirectly be seen through changes in private disposable income.

2 Theoretical framework

According to Brooks (2008), Hendry's approach to econometric modeling is that the models should be consistent with the data and economic theory. In this chapter, relevant economic theories concerning consumption will be reviewed. The main goal of this chapter is to identify the relevant variables and restrictions to enter into the dynamic consumption functions which will be estimated in Chapter 4.

Standard demand theory states that a consumer will maximize his or her utility bounded by some budget constraint. The possible choices depend on prices and the consumers' budget, which generally is defined as a function of income and relative prices (Rødseth, 1997). Chapter 8 in Rødseth (1997) builds a model based on the intertemporal budget constraint, where the net present value of consumption cannot exceed the net present value of income. Durable goods, however, are goods providing services to the consumer over time, and thus one cannot simply use standard consumer theory in order to describe the demand for such goods. It is generally assumed that the utility obtained from durable goods depend on the stock of the good rather than the purchase in each period, because durables yield utility across time.

The optimal stock, or the desired level of a durable good will in the following be labeled K_t^* . It will be determined by income, relevant prices, and other variables (Magnussen, 1990). The model assumes that the consumer owns the good one period at the time to a given price. This price is expressed as a "rental" cost, assuming the goods are debt-financed. The price is calculated as the sum of the purchase price of the good and the interest rate, and the potential selling price at the end of the period is subtracted to find the implicit price of owning a durable good in one period. This equals the purchase price of the good, multiplied with the sum of the interest rate and the depreciation rate. The initial stock of a durable good, K_{t-1} , is included as a central factor in all models explaining the purchases of such goods (Harilstad and Nymoën, 1993).

According to Rødseth (1997), the variables explaining the demand for durable goods are income, relative prices, the interest rate, and the stock of durables in the previous period.

As I will show in my empirical analysis in chapter 4, the lagged changes in consumption of durables will be very important determinants for consumption of durables, as well as for total consumption.

2.1 Modeling the demand for durable goods

Because previous models for consumption in Norway had failed to explain the demand for goods in general⁵, and particularly weak in explaining demand for durables, Magnussen (1990) derived a model for the demand for durable goods to be incorporated into a new version of the Norwegian macroeconomic model KVARTS⁶. In doing so, he analysed the demand for two groups of durables, namely private means of transportation (mainly cars), and furniture, electrical household articles and durable leisure goods, using quarterly data. He used the traditional model for demand for durable goods as introduced by Stone and Rowe in their influential article from 1957.

Magnussen (1990) assumes the stock of durables to be a function of private disposable income and relative prices, in accordance with Stone and Rowe (1957). As previously mentioned, the utility from durable goods is related to the stock of the good rather than the purchase. Behind the traditional model lies the assumption that the consumers have a desired level of the stock of the durable goods, given their income and the relative prices (Magnussen, 1990). Because the acquisition of the goods can be time-consuming due to difficulties with financing, information gathering etc., the relation is expressed through a "partial adjustment" equation, where only some of the deviation from the desired level of the stock of the good in the previous period is corrected in the following period.

If K_t is the stock of the good at time t , the desired stock level is expressed as K_t^* , and γ is the adjustment parameter, the partial adjustment equation can be expressed as follows

⁵This will be discussed further in Chapter 2.2.

⁶KVARTS is a macroeconomic model for the Norwegian economy, based on quarterly data, used for short and medium term analysis of economic policies. Read more at <http://www.ssb.no/forskning/modeller/kvarts/index.html> (in Norwegian).

$$(1) \quad K_t - K_{t-1} = \lambda(K_t^* - K_{t-1})$$

Some proportion $0 < \lambda < 1$ of the deviation from the desired level of K , that is $K_t^* - K_{t-1}$, will be corrected each period. Theoretically, the partial adjustment equation can be justified by solving the cost minimization problem for a quadratic cost function, as specified by Stewart and Wallis (1981) in equation (2).

$$(2) \quad C(K_t) = a_1(K_t^* - K_t)^2 + a_2(K_t - K_{t-1})^2$$

Here, the first term represents the cost of being in disequilibrium compared to the desired stock level. The cost of adjusting is given in the second term. Minimizing equation (2) with respect to K , yields equation (1) if we let $\lambda = \frac{a_1}{a_1 + a_2}$. An increase in a_2 will lead to a decrease in λ , which means the deviation from equilibrium will be corrected at a lower pace.

Magnussen (1990) also defines the relationship between the stock, the purchases, and the depreciation of the durable goods as given in equation (3),

$$(3) \quad K_t = K_{t-1} + C_t - D_t$$

where C and D are the purchases and the depreciation at time t , respectively. Thus, the change in stock from one period to the next is last period's stock plus new purchases minus depreciation. There will usually be a close association between depreciation and the stock, which can be modeled by letting the depreciation be a constant fraction of lagged stock; i.e. $D_t = \delta K_{t-1}$, where $0 < \delta < 1$ is the constant rate of depreciation. If we include this in equation (3) we get equation (4).

$$(4) \quad K_t = (1 - \delta K_{t-1}) + C_t$$

By inserting equation (4) into equation (1) and performing a few transformations, we get equation (5).

$$(5) \quad C_t = \lambda K_t^* - (\lambda - \delta) K_{t-1}$$

This equation shows directly how lagged stock of durable goods is included as a determinant for purchases of durable goods. We see that if the adjustment parameter λ exceeds the rate of depreciation δ , then, assuming $K_{t-1} < K_t^*$, then past period's stock will be negatively correlated with the purchases of the goods in the next period. That means that the larger the stock in the past period, the lower will next period's purchases be. This is empirically sound according to Magnussen (1990), even though he also argues that the effect often has shown to be somewhat weak. We note that if $K_{t-1} = K_t^*$, that is, the consumers stock of durable goods equals the consumer's desired level, then new purchases will merely equal the depreciation of the stock from last period.

My data set lacks information on the stock of durables. Obtaining this information would be a very tedious and possibly inachievable task, and is thus too comprehensive for this thesis. In chapter 4, I will instead construct a model based on equation (1) transformed into an error correction model. In equation (5), this would imply $\lambda = \delta$, making K_{t-1} drop out of the equation. The transformation will be demonstrated and discussed in the next section.

The stock adjustment model and ECM

The stock adjustment was presented in section 2.1 as a central model for explaining the consumption of durable goods. Still, previous studies have mainly relied on error correction representations⁷. The two models are closely related, and Magnussen (1990) shows how the stock adjustment model can be transformed into an error correction model. The stock adjustment model can be derived as follows.

We begin with the partial adjustment equation from equation (1), $K_t - K_{t-1} = \lambda(K_t^* - K_{t-1})$. By adding $0 = \lambda K_{t-1}^* - \lambda K_{t-1}^*$ to the equation, we get

$$(6) \quad K_t - K_{t-1} = \lambda(K_t^* - K_{t-1}^*) - \lambda(K_t - K_{t-1}^*)$$

Allowing for differing coefficients of λ , we can now write the equation on the form

$$(7) \quad \Delta K_t = \lambda_1 \Delta K_t^* - \lambda_2 (K_t - K_{t-1}^*)$$

where the Δ s are used to describe changes in the variables. The change in K from period $t - 1$ to period t is thus expressed as ΔK_t . The derivation shows that the error correction model in this simple form can be viewed as a more flexible version of the stock adjustment model, where the first part shows the short term effects and the second shows the long term effects. In other words, equation (7) shows the error correction from time $t - 1$ to time t .

We've seen the derivation of a stock adjustment model, which is often used to model consumption of durable goods. It has also been demonstrated how this model can be transformed into the more flexible error correction model, where one can easily separate between short- and long-term effects.

⁷The error correction model (ECM) will be explained in section 3.1.4

Since this thesis' main objective is to determine the drivers behind consumption of durable goods, the following chapters will review some relevant theories and empirical research on these drivers.

2.2 The macroeconomic consumption function

Previous studies can give important information with regards to methodology and interpretation of estimation results. This section presents a selection of some relevant literature on dynamic modeling of consumption.

The consumption function has been debated ever since John Maynard Keynes first described the idea of such an empirical relationship (Jansen, 2010). The Keynesian consumption function assumes that consumption is almost entirely based on current income (Keynes, 1936), whereas classical economists generally assumed that an increase in income would lead to an equal increase in consumption.

Modern macroeconomists have relied on New Keynesian DSGE⁸ models which build on a set of Euler equations. Hall (1978) used Euler equations to model consumption, and showed using the rational expectations hypothesis that the stochastic life-cycle theory would imply that consumer expenditure would evolve by a random walk (Molana, 1991). The developments would only be affected by non-predicted changes in the explanatory variables. Halls random walk hypothesis from 1978 was created as a response to the Lucas critique.⁹ However, the use of Euler equations in modeling consumption has been criticized as they have fallen short of explaining the recent financial crisis (Jansen, 2009). The Lucas critique would say the reason behind this is that the models have failed to take into account some consumer preference variables such as, for instance, the intertemporal elasticity of substitution.

2.2.1 The life cycle hypothesis

It might be appropriate to base the discussion of the effects on consumption from wealth and income changes on a life cycle model. An important hypothesis in standard economic

⁸Dynamic Stochastic General Equilibrium models, which are based on the interaction between rational agents.

⁹The "Lucas critique" is the name of Nobel Prize winner Robert E. Lucas, who was a pioneer in the rational expectations econometrics. Lucas formulated his critique as "given that the structure of all econometric model consists of optimal decision rules of economic agents, and that optimal decision rules vary systematically with changes in the structure of series relevant to the decision maker, it follows that any change in policy will systematically alter the structure of econometric models." (Lucas, 1976, p. 41)

theory states that most consumers wish to have a relatively smooth consumption pattern throughout their life cycle. Two important theories include the permanent income hypothesis developed by Milton Friedman, as presented in Friedman (1957), and the life cycle hypothesis as presented in Ando and Modigliani (1963). The main idea behind these theories are inter temporal decision making, based on the simplifying assumptions of certainty with regards to future income, perfect capital markets, and constant interest rates.

In real life, neither of these assumptions will hold. The assumption of unrestricted access to capital at a constant interest rate for all consumers throughout their lifetimes is, of course, is a bold simplification of reality. A typical individual will to a greater or a lesser extent be liquidity constrained. When this is the case, consumption might depend more heavily on the consumer's income relative to the consumer's wealth. This is probably one of the reasons why earlier models explaining consumption which only included income as the regressor broke down after the deregulation of the credit markets in Europe in the 1980's. Additionally, in periods with for instance rising unemployment, some individuals might increase savings on a precautionary note. This motivates the use of the unemployment rate as a proxy for uncertainty.

The permanent income hypothesis is based on the theory that consumers prefer smooth consumption over volatile. The hypothesis states that the choices consumers make with regards to consumption depends not on their current income, but on some measure of a longer-term expectation of income. The theory concludes that short-term changes in income will have little effect on consumer spending behaviour because the permanent income is unaffected by transitory changes in income. The key determinant of consumption might then be the consumers real wealth rather than his or her current disposable income.

To summarize, the life cycle hypothesis says that consumption in all periods is approximately equal and predetermined by the consumers based on their expectations towards their lifetime income.

2.2.2 The effect of real wealth on consumption

Financial turmoils of the past century raised the debate on the effect of changes in real wealth on consumption. Previous studies on the Norwegian economy have struggled with predicting for instance the large growth in the Norwegian economy in the late 1980's following the deregulation of the credit market (Jansen, 2009). The deregulation, which also found place in other European countries, led to forecast failure both when using consumption functions and by the use of Euler equations (Eitrheim et al., 2000). Consequently, Eitrheim et al. (2000) found support in a model including wealth effects.

According to Jansen (2010), the drastic fall in household income following the banking crisis in Norway in 1990-1992 led to a significant increase in savings. This reduction in savings and the simultaneous growth in consumption in Norway in the mid 1980's has been attempted explained by many researchers. Brubakk (1994) suggests it was a wealth effect following the increase in housing prices, perhaps in a combination with deregulated credit markets. Halvorsen (2003) argues that the housing prices alone could not explain the drastic fall in savings. She suggests it was the deregulation of the credit market and the increased access to credit for people who had previously been rationed. When some households took out higher mortgages because the housing prices were increasing, this probably led to an even greater reduction in savings.

A new consumption function in Statistics Norway's macroeconomic model KVARTS shows that real wealth has a significant effect on household consumption (Jansen, 2010)¹⁰. The new consumption function is homogeneous of degree one in income and wealth and has been superior to alternative models in explaining the development in Norwegian aggregate consumption over the past few decades (Jansen, 2010).

The deregulation of the credit market in the eighties led the banks to increase the lending capacity and competition between the banks to win market shares¹¹. Housing prices were increasing, and because housing constitutes a large part of Norwegian private real

¹⁰See Jansen (2009) for a summary on the recent literature on the Norwegian consumption function.

¹¹Source: <http://www.regjeringen.no/nb/dep/fin/dok/nouer/2009/nou-2009-10.html?id=558836>.

wealth, wealth was increasing. This, coupled with low inflation at the time, led to a large increase in private consumption. In the late eighties, however, economic policies were tightened, consumption decreased, and when the international economy slowed down a large number of Norwegian banks needed to be rescued by the government. This is one of the financial crises the traditional consumption function without wealth effects has struggled to model. "A change in the correlation pattern between real interest rates and wealth, which is related to a change in the monetary policy regime, is the reason why both variables need to be included in the long run relationship" (Jansen, 2010).

We have now discovered some variables which are potentially important determinants for the consumer's decision making. These include income, wealth, prices, and previous stock of goods. Additionally, uncertainties about the future are expected to affect consumption today. If uncertainty increases, we can assume that consumer's will increase their savings as a safety measure (Brubakk, 1994). Assuming that the unemployment rate is negatively correlated with changes in income, the unemployment rate may be included in the consumption function as a proxy for uncertainties in the future (Harilstad and Nymoene, 1993).

3 Empirical Specification

Relevant theories and literature on consumption have been reviewed, and a set of potential explanatory variables has been identified. The next step lies in specifying the theories through observable variables. However, we need to be aware of the pitfalls in econometric modeling when using time series data. Brodin and Nymo en (1992) lists challenges such as aggregation problems, simultaneity bias, the "Lucas critique", genuine structural breaks, and integrated variables.

This chapter deals with the listed empirical challenges and the empirical data used to estimate the Norwegian consumption function. Chapter 3.1 will present the data set at hand, which will be used in the subsequent analysis. The time series econometric properties of the variables will be evaluated, followed by a description of cointegration and error correction models. Finally, the time series profiles of the variables will be examined, and cointegration will be tested. Chapter 3.2 presents the theory behind building econometric models, and chapter 3.3 discusses model testing and the procedures used to discriminate between competing models.

3.1 The variables and time series properties

This chapter describes the data set, and will consider the econometric properties of the variables presented. The time series econometrics part builds mainly on Brooks (2008). The notational convention will be such that capitalized letters express the observed variable, whereas lower case letters express the logarithmic transformation of the variable, i.e. $a = \ln(A)$.

3.1.1 The data set

The variables which will be analyzed are total consumption in Norway and consumption of a group of durables including furniture and household articles. The data comprises quarterly data from 1978 through 2008, and thus consists of 120 observations. The numbers are

drawn from Statistikkbanken at Statistics Norway. In the data set from Statistikkbanken, the variable "furniture and household articles" is the variable which inhibits most of the features of durable goods compared to the other groups of goods. In order to simplify the notation, the variables "total goods" and "durable goods" are labeled C_{tot} and C_{dur} , respectively.

Some of the most important right hand side variables are obtained from Jansen (2009). The income variable, Y , is the real value of private disposable income after tax exclusive of equity income. The wealth variable, W , is real net wealth, defined as the sum of household's housing values, stocks, bonds, insurance claims, and other liquid claims less of debt.¹² The data for the real interest rate RRa is also obtained from Jansen (2009). The Norwegian credit market was deregulated in the 1980's; thus there are no recorded values of RRa from before the first quarter of 1984. The unemployment rate URR is extracted from the Norwegian Labour and Welfare Administration (NAV), and denominate the unemployed as a percentage of the labour force¹³. To obtain the relative price of durables, P_{dur} , I will use a price index which is obtained by dividing durable consumption in current prices by the corresponding fixed price values. To obtain the relative price, this index is then divided by a price index for total consumption. These numbers are also drawn from Statistikkbanken¹⁴. The price of durables is thus defined as the real price.

As mentioned, lower-case letters express the logarithmic values of the variables. The variables are thus defined as follows: $\ln(C_{tot}) = c_{tot}$, $\ln(C_{dur}) = c_{dur}$, $\ln(Y) = y$, $\ln(W) = w$, and $\ln(P_{dur}) = p_{dur}$ will be used in the analysis.

3.1.2 Stationarity and unit root testing

When dealing with time series data, it's important to distinguish between stationary and non-stationary variables. A stationary variable has constant mean and variance across

¹²The wealth variable does not include the stock of durable goods.

¹³Monthly data can be extracted from http://www.nav.no/0m+NAV/Tall+og+analyse/Arbeidsmarked/Statistikk/_attachment/196148?=true&_ts=120ecfb6e50.

¹⁴The numbers can be extracted from http://statbank.ssb.no/statistikkbanken/Default_FR.asp?PXSid=0&nvl=true&PLanguage=0&tilside=selectvarval/define.asp&Tabellid=06144.

time (Brooks, 2008). Non-stationary data has means and variances which vary over time, which means standard inference is invalid. This is because the t- or F-statistics for the non-stationary variables don't follow the normal t- or F-distributions¹⁵. The critical value will also depend on whether the model in the alternative hypothesis has a constant and/or a trend. Also, if the data is non-stationary, this can lead to spurious regressions¹⁶.

A weakly stationary variable¹⁷ has constant mean and variance, as well as zero autocovariances over time. The term stationarity will for the remainder of this paper be used in the sense of weak stationarity, with the properties:

$$(8) \quad E(y_t) = \mu$$

$$(9) \quad Var(y_t) = \sigma^2$$

$$(10) \quad Cov(y_t, y_{t-s}) = \gamma_s$$

where equation (8) assumes constant mean, equation (9) assumes the variance to be constant, and equation (10) assumes that the covariance depends only on the time interval s between the observations.

Provided that the data is stationary and a shock occurs, the effect will eventually die out. If the shock is persistent, the variable is not stationary, and is said to contain a unit root. A variable y_t containing d unit roots is said to be integrated of order d , $y_t \sim I(d)$. This means that y_t needs to be differenced d times in order to become stationary. Differencing means looking at the change in a variable from each time period to the next, instead of looking at the level values.

Many economic time series will be non-stationary, and will usually have to be differenced once to become stationary. We'll consider the general case of an $AR(1)$ -process:

¹⁵The t- and F-distributions for non-stationary variables are generally wider i.e. has higher kurtosis, than for stationary variables, thus the critical values should be higher for non-stationary data.

¹⁶This can happen if two unrelated variables are trending over time, making them appear as related.

¹⁷A variable is strictly stationary when its distribution is independent of time.

$$(11) \quad y_t = \mu + \phi y_{t-1} + u_t,$$

where μ is a constant¹⁸ and u_t follows a white noise process¹⁹. For values $\phi < 1$, the process will be stationary. If $\phi = 1$, then the process has one unit root, and is thus an $I(1)$ variable. By subtracting y_{t-1} from both sides we get $\Delta y_t = \mu + \psi y_{t-1} + u_t$, where $\psi = (\phi - 1)$. To test for stationarity, we use a Dickey-Fuller test. The null hypothesis is $\psi = 0$, which implies $\phi = 1$ and thus a random walk process. The alternative hypothesis is $\psi < 0$, implying $\phi < 1$ which means that shocks will gradually die out. Since the null hypothesis is non-stationarity, the test statistics will not follow the standard t-distribution. The problem is solved by using lower²⁰ critical values.

However, there are some weaknesses in the basic Dickey-Fuller test. The test has low power when ϕ is close to one, which means that there is increased probability of over-rejecting the null of a unit root when it is in fact true.

The Dickey Fuller test is only valid as long as u_t is a white noise process, i.e. the error terms are assumed not to be serially correlated (Brooks, 2008). With first-order serial correlation, the errors in one time period are correlated directly with errors in the ensuing time period; $u_t = \rho u_{t-1} + \epsilon_t$, with coefficient ρ and a stochastic "shock" ϵ_t (Hendry and Juselius, 2000a).

In order to remove potential serial correlation, we include the lagged first differences in the equation:

$$(12) \quad \Delta y_t = \mu + \psi y_{t-1} + \sum_{i=1}^n \alpha_i \Delta y_{t-i} + u_t$$

¹⁸If y_t is non-stationary, i.e. $\phi \geq 1$, then $\mu = 0$ implies a random walk process and $\mu \neq 0$ implies a random walk with drift.

¹⁹A white noise process has constant mean and variance, as well as zero autocovariance (Brooks, 2008, p. 209)

²⁰in absolute value

Because we are augmenting the test by including more lags, this is called an augmented Dickey Fuller (ADF) test. In order to determine the optimal number of lags, one can utilize one of the information criteria²¹ or by examining the significance of the lagged values of y_t . The more lags you include, the less precise will the estimates be. However, it's important to identify and get rid of the serial correlation. A rule of thumb is to use as many lags as the frequency of your data (Brooks, 2008). When dealing with quarterly data, one should generally use four lags to augment the test, because there might be correlation between the seasons. The formal results from the ADF-test will be presented in Chapter 3.1.5.

3.1.3 Cointegration

Any linear combination of $I(1)$ variables is typically spurious. However, there exists some special cases in which a long-term relationship between $I(1)$ variables produce error terms that are $I(0)$. If two or more series are themselves non-stationary, but a linear combination of them is stationary, the series are said to be cointegrated (Granger, 1981). If the long-term relation between y and the explanatory variables is given by

$$(13) \quad y_t = \beta_0 + \sum_{i=0}^n \beta_i x_{i,t} + u_t$$

and y and x are cointegrated, then the residuals from regressing (13), u_t , are stationary. This means that the cointegrating variables might deviate from a long term equilibrium path in the short run, but gradually move towards it over time. We can define z_t as this deviation.

$$(14) \quad z_t = y_t - \beta_0 - \sum_{i=0}^n \beta_i x_{i,t}$$

²¹See chapter 6 in Brooks (2008) for definitions.

Now if there exists such parameter values so that $z_t \sim I(0)$, even though y and x are $I(1)$, we can now say that y and x are cointegrated, and the long term relationship is given by

$$y_t = \beta_0 + \sum_{i=0}^n \beta_i x_{i,t} .$$

To test for cointegration, we can apply Engle and Granger's two step procedure (Engle and Granger, 1987). The first step is to estimate the static regression of consumption, c , on y , and w by applying the standard OLS method. We store the residuals. The second step is to test whether or not the errors are stationary. In order to do this, we run an augmented Dickey-Fuller unit root test as described in section 3.1.2. If the residuals are stationary, this suggests that the variables are cointegrated. However, because the residuals are estimated in a regression, the augmented DF-test has low power in small samples. This means that the null hypothesis of unit roots will be rejected less frequently. Engle and Granger (1987) propose seven test statistics for testing the null hypothesis of no cointegration versus the alternative of cointegration²². However, I will use the critical values given in Table A2.8 in Brooks (2008). The results from the formal testing of cointegration is found in section 3.1.6.

3.1.4 Error correction models (ECM)

When a set of variables are cointegrated, there exists a so-called equilibrium correction relationship between them and vice versa (Brooks, 2008, p. 339). This property is known as the Granger representation theorem. The connection between cointegration and error correction models was first suggested by Clive Granger in Granger (1981) and later proved in Engle and Granger (1987). In this model, we look at the deviations from the long term equilibrium relationship between the variables and how they move towards it across time.

An appealing feature of these models is the possibility to include both differenced and leveled values of the variables provided they are all $I(0)$ variables (Hendry and Juselius, 2000b). In this way, one can investigate both the short-term and the long-term effects in one single model. This holds because the deviations from the long term association of the

²²These include CRDW, DF, ADF, restricted VAR, etc. See page 266 in Engle and Granger (1987) for further explanation.

variables will be stationary, and so will the differenced values of the variables included in the model. Inclusion of level variables will still yield a balanced equation as long as they are stationary. This means that OLS will produce non-spurious results and unbiased estimates. In the case of two cointegrated variables, an error correction model (ECM) can be expressed as:

$$(15) \quad \Delta y_t = \gamma_0 + \gamma_1 \Delta x_t - \alpha(y_{t-1} - \beta_0 - \beta_1 x_{t-1}) + v_t$$

If x and y are cointegrated with cointegrating coefficient β_1 , then $y_{t-1} - \beta_0 - \beta_1 x_{t-1}$ ²³ is known as the error correction term. This is the deviation from the long term equilibrium. The error correction term will be $I(0)$ even though x and y are $I(1)$. α is known as the speed of adjustment. If $-\alpha$ is significantly negative, it means that cointegration exists, i.e. there is a long term relationship between the variables. Thus, if α is close to 1 it means that a large proportion of the disequilibrium from one period is corrected in the next period (if α is 1, it means the equilibrium will be fully restored). $\gamma_1 \Delta x(t)$ is describing the short run effects y from changes in x .

There are, however, weaknesses in the Engle Granger two-step procedure. Brooks (2008) discusses problems such as the low power of the cointegration test in small samples, the possibility that the equation is biased due to simultaneity,²⁴ and the lack of possibility to perform any hypothesis tests on the cointegration relationship that was estimated at the first stage of the procedure.

The long term equilibrium

A long term equilibrium or so-called steady state is generally defined by constant rates of growth. Thus, we can express Δy and Δx as

²³We recognize this term as the deviation from the long term equilibrium, z_{t-1} , from equation (14) for $n=1$.

²⁴Simultaneity bias is the occurrence of cross-causality between the dependent and the independent variables. See (Brooks, 2008, p. 342) for further discussion.

$$\Delta y_t = \delta_y$$

$$\Delta x_t = \delta_x$$

If we insert these growth rates into the error correction model given in equation (15), we get

$$(16) \quad \delta_y = -\alpha(y - \beta_0 - \beta_1 x) + \gamma_1 \delta_x + \gamma_0$$

We can now solve for the long term solution for y .

$$(17) \quad y = \beta_0 + \beta_1 x + \frac{\gamma_0 + \gamma_1 \delta_x - \delta_y}{\alpha} = \beta_1 x + \text{constant}$$

The parameter β_1 can now be interpreted as the long term effect of a permanent change in x on y .

One-step error correction models

To deal with the problem of the low power Dickey Fuller test in step one of the Engle Granger two-step procedure, Kremers et al. (1992) propose an alternative solution towards estimating the error correction model. The procedure involves skipping the first stage in the Engle Granger two-step procedure, and directly include the lagged level values into the equation. This can be done by formulating a new model, like the one in equation (18):

$$(18) \quad \Delta y_t = \gamma_0 + \gamma_1 \Delta x_t - \alpha y_{t-1} + \lambda x_{t-1} + v_t$$

In the static or steady state solution, the difference variables will be constants. Solving for y , we get the steady state solution given by

$$(19) \quad y = \frac{\lambda}{\alpha} x + \text{constant}$$

We can thus estimate the parameters in equation (18) without first having to test for cointegration. If $-\alpha$, is significantly negative, and λ is significantly different from zero, this indicates that cointegration exists between y and x .

According to Kremers et al. (1992)²⁵, the method is preferable because it utilises the available information more efficiently than does the Dickey-Fuller test. The method has been called a one-step ECM. The one-step ECM will be applied in chapter 4, as an alternative error correction model.

The error correction term in the Engle Granger two-step approach requires little explanation because it is simply the residual from the cointegration test. It is explicitly included in the model formulation, and the error is expected to be zero in the long term if a cointegrating relationship exists. The error correction term in the one-step ECM, on the other hand, calls for a more thorough investigation. The long term equilibrium in the one-step ECM is derived as follows.

3.1.5 The time profiles of the variables

Here, we will consider the development in the variables over time. In figure 2, we see the level values of the variables y , w , RRa , c_{tot} , and c_{dur} . Except in the cases of RRa

²⁵Page 325.

and URR , there is seemingly an upward trend in the data suggesting that these variables might contain one or more unit roots.

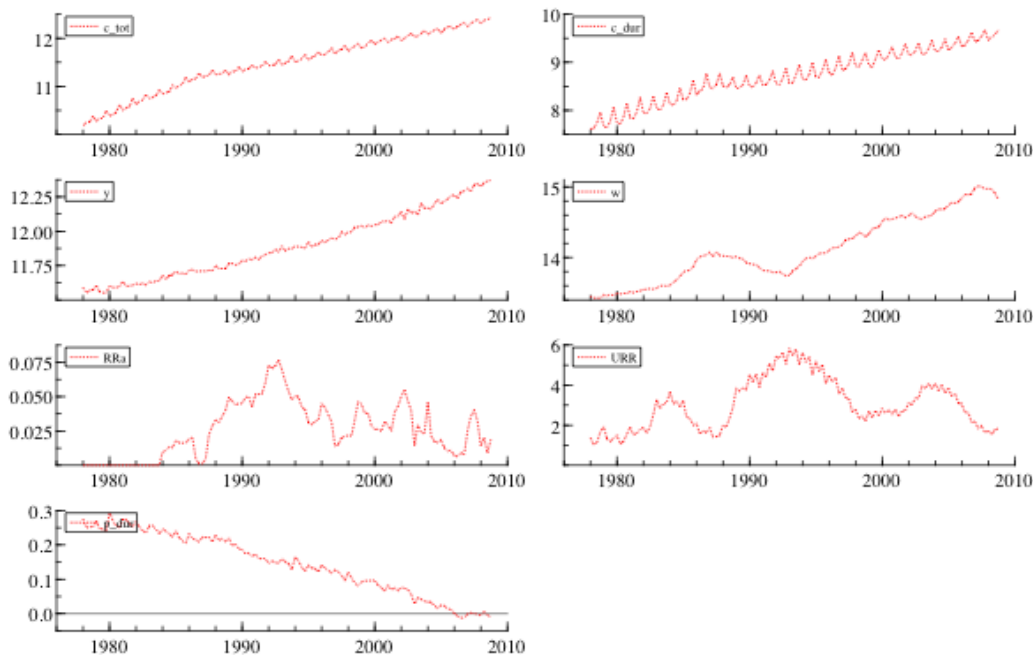


Figure 2: Graphs of level variables

The first difference of the variables y , w , c_{tot} , and c_{dur} are depicted in figure 3. The development in the differenced variables seem to be moving around a constant mean with a constant variance, thus they now appear to be stationary. Whether this is correct or not will be tested more formally by use of augmented Dickey Fuller tests.

In table 1, both the lag length according to Akaike's information criteria, and the lags with the highest ADF t-value have been included. Together with the graphical evidence from figure 2 and figure 3, I will conclude that y and w are $I(1)$ variables. Total consumption and consumption of durable goods are not so obvious, but considering the graphical evidence, I will assume that they are also $I(1)$ variables. In the case of the unemployment rate, the unit root hypothesis is strongly rejected, and we thus conclude that the variable is stationary in levels.

The ADF test for unit roots in the real price of durables, p_{dur} , is not rejected, whereas the test of the first difference, Δp_{dur} is strongly rejected. Supported by the graphical evidence in figure 2 and 3, I conclude that p_{dur} is $I(1)$. The logarithmic value of the real price of

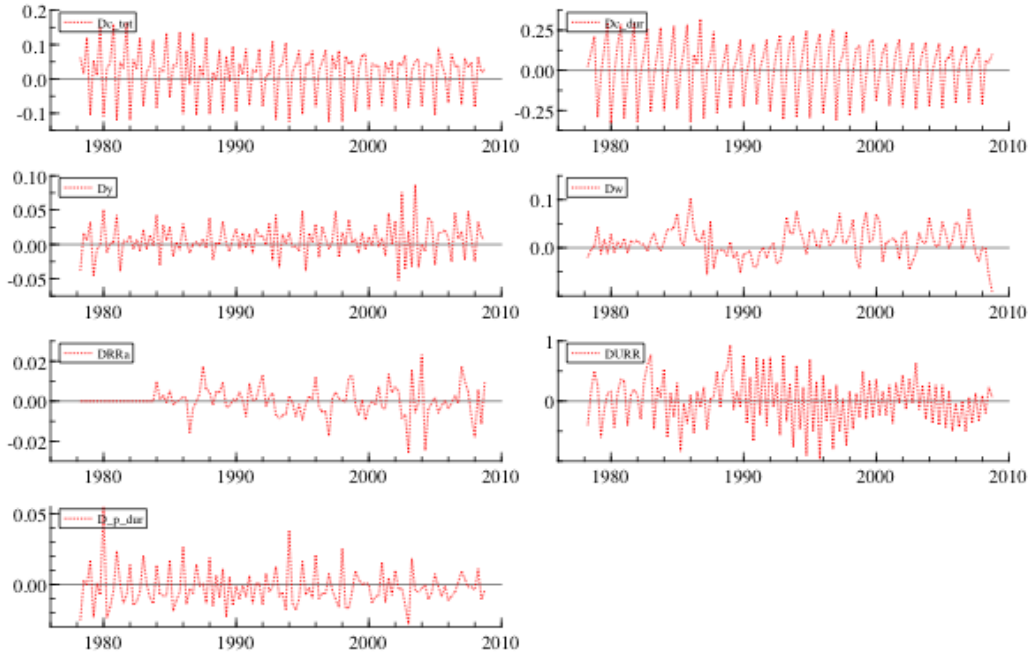


Figure 3: Graphs of differenced variables

Table 1: Results from ADF-test

Variable	t-ADF (Akaike)	D-lag	t-ADF (significance)	D-lag
y	4.004**	3	0.2366	0
w	-1.733	4	-1.733	4
RRa	-1.847	4	-2.379	2
c_{tot}	-3.183*	4	-7.662**	3
c_{dur}	-1.984	4	-2.911*	3
p_{dur}	0.6531	4	-0.3282	0
URR	-3.850**	4	-3.850**	4
Δy	-4.733**	4	-21.62**	0
Δw	-2.572	4	-7.352**	0
ΔRRa	-7.443**	3	-10.75**	0
Δc_{tot}	-2.440	4	-29.46**	2
Δc_{dur}	-3.659**	4	-58.99**	2
Δp_{dur}	-6.421**	3	-15.33**	0
ΔURR	3.191*	4	-18.83**	0

* Significant at the 5 per cent level (CV=-2.89), ** Significant at the 1 per cent level (CV=-3.49)

durable goods shows a clear downward trend in figure 2, suggesting that durable goods have become less costly relative to other goods over the past thirty years.

The development in the real interest rate needs some extra attention. Because of the deregulation in the credit market in 1984, there are no observations of the real interest rate until 1984(1). Even though the formal testing implies it is $I(1)$ ²⁶, I will assume for now that RRa is $I(0)$.

3.1.6 Formal testing for cointegration

In this section, the results from the formal testing for cointegration will be presented. Cointegration tests will be run for total consumption and consumption of durables with income and wealth. The possible cointegration relationships between consumption of durables and the unemployment rate and the relative price of durables are also included.

Engle and Granger's two step method is used to test for cointegration. In the first step, the simple static equation with no lags provided in equation (13) in section 3.1.3 is estimated using the basic OLS method. The estimated parameters describing the potential long-term relationships between the mentioned variables is shown in equations (20)-(22). First, for total consumption we obtain the following results:

$$(20) \quad c_{\text{tot}} = -14.73 + 1.823 y_t + 0.3202 w_t$$

Equation (20) shows the estimated positive long term effects of income and wealth on total consumption. The equation also contains a constant term. We read this equation such that one unit change in income gives 1.8 units change in consumption of total goods in the long run, given constant wealth. Similarly, a unit change in wealth gives 0.3 units

²⁶We cannot reject H_0 that there exists one or more unit roots in the level value of RRa . We can do so for the first difference, namely ΔRRa , which generally means we are dealing with an $I(1)$ variable. However, as discussed in section 3.1.3, the Dickey-Fuller test has low power. This means we can possibly have under-rejection of the null hypothesis.

change in consumption, income held constant. Both variables will affect consumption positively, in line with expectations. When long-term income or wealth increase, you have more to spend on consumption.

$$(21) \quad c_dur = -13.72 + 1.438 y_t + 0.3779 w_t$$

$$(22) \quad c_dur = 7.891 - 0.3958 y_t + 0.4403 w_t \\ - 4.641 p_dur_t$$

In the above equations for consumption of durables, we see that income is a less important determinant, and wealth is slightly more central in explaining the long-term path for consumption of durables. We also notice that the price seems to be crucial in determining consumption of durable goods. This is probably because durable goods are generally not necessities, because the existing stock could in most cases provide sufficient utility.

When these equations have been estimated, the residuals should be stored. The second step is then to test whether these residuals from the estimated equations are stationary. If I reach the conclusion that the residuals are stationary, the results in equations (20)-(22) can be interpreted as estimated cointegrated relationships. Then the estimated parameters estimates can be interpreted as the long term effects on the left hand side variable of increased values of the included explanatory variables.

Before I progress, however, we notice that in equation (22), the income parameter value is negative. This is not the expected sign; income should theoretically be positively correlated with consumption. I'll rerun the estimation without the income variable, yielding the new estimation result given in equation (23).

$$(23) \quad \begin{array}{ccccccc} c_dur & = & 3.888 & + & 0.3826 & w_t & - & 3.886 & p_dur_t \\ & & (1.38) & & (0.0928) & & & (0.487) & \end{array}$$

All the parameters now shows the expected signs.

I now proceed to the second step of the Engle Granger test, which is to test the residuals from the estimated static equations (20), (21), and (23). The results from the augmented Dickey Fuller tests are summarized in table 2.

Table 2: Results from Engle Granger test step 2

Variable	t-ADF (Akaike)	D-lag	t-ADF (significance)	D-lag
<i>equation(20)</i>	-2.324	4	-4.428**	0
<i>equation(21)</i>	-2.226	4	-8.548**	0
<i>equation(23)</i>	-2.830	4	-7.476**	0

T=119; Critical values: 5 per cent level=-2.89, 1 per cent level=-3.49.

Based on the results from table 2, there is weak evidence in favour of cointegration between consumption, private disposable income, and private wealth. Additionally, the real price of durables also seems to be cointegrated with consumption of durables, and private wealth. The zeroth lag strongly suggests stationarity, with rejection of the unit root hypothesis in all three cases. When using Akaike's information criterium and looking at up to four lags, on the other hand, we cannot reject the null. I will, however, assume cointegration for now, and use these results in building an error correction model in chapter 4.

3.2 Building an econometric model

When building an econometric model, the objective should be to build a statistically adequate empirical model satisfying the classical linear regression model assumptions²⁷, has the appropriate theoretical interpretation, is parsimonious, and has correct sizes and signs on its coefficients (Brooks, 2008). The method I will apply in reaching this goal is the General-to-Specific method, in which you start out with a very general model which is both consistent with the data and is based on relevant economic theory. I will then gradually reduce the model until I arrive at a parsimonious final formulation. This is known as Hendry's approach, as described in Gilbert (1989).

An econometric model builds on the relevant economic theory, and has to fit the data in the best way possible. Hendry and Richard (1982) suggest six criteria that should be satisfied for a final model;

1. It should be logically plausible
2. It should be consistent with underlying theory
3. It should have regressors uncorrelated with the error terms
4. The parameter estimates should be stable across the entire sample
5. The residuals should be white noise
6. The model should explain the results better than all other competing models

These criteria will be tested after we've arrived at the final model specification.

In the general-to-specific approach, the first step is to form a model with "all" possibly relevant right hand side (RHS) variables. The choice of variables should be based on economic theory, and one should include all variables expected to influence the dependent variable along with an appropriate numbers of lags. The model formed by this approach is known as a general unrestricted model (*GUM*) (Brooks, 2008, p. 193).

²⁷1. $E(\epsilon_t) = 0$, 2. $Var(\epsilon_t) = \sigma^2 < \infty$, 3. $Cov(\epsilon_i, \epsilon_j) = 0$, 4. $Cov(\epsilon_i, x_i) = 0$, 5. $\epsilon_i \sim N(0, \sigma^2)$ (Brooks, 2008)

The next step is to reparameterise the model by gradually excluding the least significant variables.

The model will be on double logarithmic form, which means that the right hand side (RHS) and the left hand side (LHS) variables are natural logarithms. When using the log-log specification the estimated parameters can conveniently be interpreted as elasticities.

3.3 Model testing and discrimination

As mentioned, there is no guarantee that you end up with the best model by applying the General-to-Specific method. For instance, variables that were not significant at an early stage of the reduction process might have become more significant if we had rather excluded some other variable. A good model should pass the misspecification tests, have stable parameters throughout the data set, and forecast the development in the variables in a decent way. There are various tests which should be run in order to ensure the model fulfills the appropriate criteria as listed in section 3.2.

Comparing estimated standard deviations, residual sum of squares, the models' predictive abilities, parameter stability and encompassing tests can be used to discriminate between the models.

Misspecification tests

The AR(1) test is a test for autocorrelation of the first order. The AR(1) test is the most important test. Significance implies the errors are not white noise, which means standard inference is no longer valid and the estimators will not be efficient. Serialcorrelation often means that the model has been misspecified (Doornik and Hendry, 2007, p. 280)

The HETERO test is a test for heteroscedasticity, where the null is unconditional homoscedasticity. Thus, a rejection of this test implies the errors don't exhibit constant variance (Doornik and Hendry, 2007, p. 282).

ARCH(1) (AutoRegressive Conditional Heteroskedasticity) tests for heteroscedasticity of the first order (Brooks, 2008, p. 389).

NORMALITY tests for deviations from normality in the residuals (Doornik and Hendry, 2007, p. 258).

The "regression specification error test" (RESET) is a test for misspecified functional form (Doornik and Hendry, 2007, p. 283).

Parameter stability

A good model should give stable parameter estimates throughout the sample period. Models with parameter stability is preferred both statistically and because they are more easily interpreted economically. Additionally, stability in the parameter estimates are important if the results are to be used for forecasting purposes (Harilstad and Nymoen, 1993, p. 29). Graphical representations of recursive estimation will be a good indicator on whether or not this is the case. When using recursive estimation, the observations are added one by one following an initial period where a number of observations are used. In the graphical representations, plus and minus 2 standard deviations are also shown.

Parameter stability can also be tested using a Chow test (Doornik and Hendry, 2007). The most aggressive Chow test begins with a short base period, and then adds the following observations one by one. If one uses the 1 per cent critical value, the parameter is considered stable as long as all the observations fall below this level.

In-sample forecasting

In-sample forecasting is done by retaining some of the data from the full data set (Doornik and Hendry, 2007). The forecasting abilities will be displayed graphically in section 4.3.

When discriminating between competing models, one can compare the models' predictive abilities formally by evaluating their "root mean squared error" (*RMSE*) and "mean

absolute percentage error” (*MAPE*), and then pick the model which yields the lowest values on these tests.

The *RMSE* expresses the average squared²⁸ deviation between the predicted and actual values. A low *RMSE* is therefore preferred. The *RMSE* is defined by Doornik and Hendry (2007) as:

$$(24) \quad RMSE = \left[\frac{1}{H} \sum_{t=1}^H (y_t - f_t)^2 \right]^{1/2}$$

H is the number of periods predicted for. In this paper, forecasting has been carried out using $H=20$, which equals $\frac{20}{4} = 5$ years.²⁹

The second measure is given by

$$(25) \quad MAPE = \frac{100}{H} \sum_{t=1}^H \left| \frac{y_t - f_t}{y_t} \right|$$

expressing the mean absolute value of the discrepancy between predicted and actual values as the percentage of the actual value.

Encompassing tests

In the general-to-specific approach which will be applied in the empirical specification process in this thesis, one might end up with different specifications depending on how the reduction process is executed. Encompassing tests can then be used to discriminate between these specifications which are said to be nested within the general model.

If we formulate a general model, where Model 1 and Model 2 ($M1$ and $M2$ hereafter) are seen as special cases of the general model, the general model is said to nest $M1$ and $M2$. Thus, all the variables from both $M1$ and $M2$ are included in the general model. We can

²⁸We use squared values so that the positive and negative deviations do not cancel each other out.

²⁹Quarterly data is used, the frequency of the data is thus 4 per year. 20 periods thus equal 5 years.

then use encompassing tests when attempting to identify the superior specification. We test whether or not the variables from the special cases are redundant in the joint model by using F-tests.

For instance, $M1$ is affected by changes in A , but not from changes in B , and $M2$ is affected by changes in B , but not from changes in A . These models are then said to be non-nested. The joint or general model will include both A and B , and can be written as $X = \beta_0 + \dots + \beta_i A + \beta_j B$. We then test the restriction that $\beta_i = 0$, which would mean that the variable A is redundant, and $\beta_j = 0$, which would mean that B is redundant.

We will now be facing four possible outcomes. Either $M1$ is rejected, and $M2$ accepted, suggesting $M2$ is a valid simplification of the general model. We would thus prefer $M2$ over $M1$. The opposite outcome would obviously lead to the opposite conclusion. The third possibility is rejection of of both models. The last possible outcome is one in which both models are valid simplifications of the general model. In this case, we cannot on statistical grounds conclude on which model is better. ³⁰

³⁰See pages 115-116 in Brooks (2008) for a more thorough description of the method.

4 Empirical Analysis

The theoretical framework for modeling consumption of durable goods has been specified, and the time series properties of the variables have been investigated. Based on the insights gained in the previous chapters, this chapter attempts to model the consumption of durable goods by use of error correction models. I first tried to estimate error correction models using the Engle Granger two-step method. We recall the rather weak evidence in favor of a cointegration relationship from section 3.1.6. Because the results from the second step were not very convincing either, I chose to focus on the one step ECM method. I will, however, briefly present the results from the two-step Engle Granger procedure in section 4.5.

Section 4.1 constructs a general model for consumption, including the relevant variables identified in the theoretical and literature review. The general model will then be gradually reduced until a parsimonious model has been specified. I end up with three competing model specifications using the one-step ECM method. Through various tests, chapter 4.3 tries to discriminate between the models in order to identify the model best fit to describe the data. In section 4.4, I then specify and estimate a model for total consumption for comparison.

4.1 The general model specification

This section constructs a general model for the consumption of durable goods based on the insights gained in the previous chapters.

In the general dynamic model, I will include both difference and level values of the variables. In the ECM we can separate between long term and short term partial effects. In equation (26), Δc_{dur} is the difference value of the natural logarithm of consumption of durable goods, which includes furniture and household articles. y and w are the logarithms of private disposable income and wealth, respectively. p_{dur} is the real price of durables. Because we are working with quarterly data, we should use dummies to control

for seasonal variations in consumption.

First, I will estimate a model where all the expected short term effects from lagged income, lagged wealth, lagged real interest rate, and lagged consumption are included. This is the one-step ECM method, as discussed in section 3.1.3. Then the appropriate restrictions will be applied until we end up with a reduced model. Further, the results from the cointegration test run in section 3.1.6 will be used for estimation, by use of the two-step Engle-Granger procedure.

The general model is given in equation (26)³¹.

$$\begin{aligned}
(26) \quad \Delta c_{dur_{t-1}} = & \beta_0 + \sum_{i=1}^4 \beta_{1,i} \Delta c_{dur_{t-i}} + \sum_{i=0}^4 \beta_{2,i} \Delta y_{t-i} + \sum_{i=0}^4 \beta_{3,i} \Delta w_{t-i} \\
& + \sum_{i=0}^4 \beta_{4,i} \Delta RRa_{t-i} + \sum_{i=0}^4 \beta_{5,i} \Delta p_{dur_{t-i}} + \beta_6 y_{t-1} + \beta_7 w_{t-1} + \beta_8 RRa_{t-1} \\
& + \beta_9 c_{dur_{t-1}} + \sum_{i=0}^2 \beta_{9,i} seasonal_{i,t} + \beta_{10} RRa_{dummy} + u_t
\end{aligned}$$

where I have included 4 lags of the difference values of c_{dur} , y , w , RRa , and the real price of durables, p_{dur} . These variables are capturing the short term effects on consumption. I have also included the first lag of c_{dur} , y , w , RRa , and p_{dur} to investigate the long run dynamics, a set of seasonal dummy variables to capture seasonal fluctuations throughout the year, and a dummy for the interest rate before the deregulation in 1984, given by RRa_{dummy} .

The estimation results for the general model for durables are given in Appendix A, table 11.

The reported results show low significance for most of the variables. This is probably due to the high number of variables included in the regression and multicollinearity³² between these variables. The remaining variables are thus expected to obtain increased

³¹In the case of total consumption, the price variable is not included.

³²Multicollinearity occurs when the explanatory variables are correlated. Read more about multicollinearity on page 170 in Brooks (2008)

significance throughout the simplification process.

However, we note that some of the variables are already significant, including the first, second, and third lagged differences of the left hand side variable, as well as one seasonal dummy. The lagged left hand side variable is also somewhat significant at this stage, with a t-value of -2.18. This indicates negative autocorrelation in consumption of durables.

As it appears from the results in Section 3.1.6 that there is possible cointegration between the consumption variables and income, wealth, and in the case of durables; the real price, we know from Granger's Representation theorem that there exists an error correction relationship or long term equilibrium association between the variables.

4.2 One-step ECM for consumption of durable goods

Because the cointegration results from section 3.1.6 were somewhat inconclusive, the one-step ECM procedure as described in section 3.1.3 will first be applied.

When estimating the model for durable goods, I find the long term income effect to be insignificant. Suspecting that this is a result of multicollinearity between income and wealth, I have constructed an alternative model specification where I include income instead of wealth. I then find the income variable to be significant. Additionally, I have estimated a model where I take the effects of the unemployment rate into account.

I have estimated three different models for the consumption of durable goods. When deciding upon which model is better, various criteria will be applied. This will be discussed further in section 4.3.

For simplicity, I will name the three main reduced models *RM1* (Reduced Model 1), *RM2* (Reduced Model 2), and *RM3* (Reduced Model 3). The models are summarized in the table 3.

Table 3: The three competing models for durable goods

Model	Long term effects
<i>RM1</i>	w_{t-1}
<i>RM2</i>	y_{t-1}
<i>RM3</i>	w_{t-1} , URR_t , and URR_{t-4}

4.2.1 *RM1*: Consumption of durables with long term wealth effects

As explained in Section 3.2, the general-to-specific method is carried out by gradually reducing the model by eliminating the least significant variables at each stage.

At the first stage I have estimated the general error correction model for consumption. In the first elimination I exclude all variables with t-values lower than the absolute value of 0.7 This includes Δy_{t-1} , Δy_{t-2} , Δw_{t-2} , Δw_{t-4} , ΔRRa_{t-3} , $\Delta p_{durable_{t-1}}$, $\Delta p_{durable_{t-3}}$, $\Delta p_{durable_{t-4}}$, y_{t-1} , RRa_{t-1} , $p_{durable_{t-1}}$, and a constant term. What might be most surprising in this round of elimination is that last period's income was actually the least significant variable, contradicting standard consumption theory.

Further, we eliminate the least significant variable at each level, and end up with a parsimonious model where all variables are significant at least at the 5 per cent level. The significance tests are based on the regular t-values as found for instance in Brooks (2008).

The specific model for durable goods resulting from the the general-to-specific process is given in table 4.

All the variables in the model are significant at least at the 5 per cent level. We see that the variables affecting the demand for durable goods³³ includes the four lagged differences of consumption of durables, the third lag of the difference of income, the difference and first lagged difference value of wealth, the first and fourth lag of the difference value of the real interest rate, consumption of durables in the past quarter, wealth in the past quarter, and two seasonal dummy variables.

In the short run, consumption of durable goods is negatively affected by changes in previous consumption³⁴. The negative autocorrelation is expected, implying convergence

³³That is, consumption of furniture and household articles in Norway between 1978(1) through 2008(4)

³⁴Except from consumption four quarters ago.

Table 4: RM1

Variable	Parameter estimate	t-value	Part. R^2
$\Delta c_{dur_{t-1}}$	-0.4442	-5.43**	0.2177
$\Delta c_{dur_{t-2}}$	-0.3634	-4.41**	0.1553
$\Delta c_{dur_{t-3}}$	-0.4716	-6.52**	0.2861
$\Delta c_{dur_{t-4}}$	0.2436	2.77**	0.0676
Δy_{t-3}	0.4096	2.61*	0.0602
Δw_t	0.2367	2.23*	0.0447
Δw_{t-1}	0.2798	2.56*	0.0582
ΔRRa_{t-1}	-0.8444	-2.28*	0.0469
ΔRRa_{t-4}	-0.9336	-2.37*	0.0504
w_{t-1}	0.0349	4.65**	0.1692
$c_{dur_{t-1}}$	-0.0476	-4.09**	0.1360
$Seasonal_t$	-0.1258	-3.95**	0.1284
$Seasonal_{t-1}$	-0.0907	-2.69**	0.0638
$AR(1 - 5)$	$F(5, 101) = 1.7817[0.1233]$	$ARCH(1 - 4)$	$F(4, 111) = 1.2086[0.3113]$
$Normality$	$Chi^2(2) = 4.7694[0.0921]$	$Heterotest$	$F(24, 94) = 1.3179[0.1746]$
$HeteroX - test$	$F(79, 39) = 1.1249[0.3486]$	$RESET23$	$F(2, 104) = 1.1765[0.3124]$

* Significant at the 5 per cent level. ** Significant at the 1 per cent level.

Read more about the tests in section 3.3.

towards the long-term equilibrium level of consumption. The real interest rate also affects consumption of durables negatively. We recall from chapter 2 that the real interest rate can be interpreted as a price through acting as a rental cost³⁵. This might explain why I do not find significance from the price variables. Past changes in income and wealth give positive effects. There are also large seasonal fluctuations in the model, as can be seen through the high significance of the seasonal dummies.

In the long run, we see a significant effect from lagged consumption and lagged wealth. These effects should be further investigated.

The long term equilibrium

First, we notice that the parameter for lagged consumption of durables $c_{dur_{t-1}}$, is significantly negative at -0.0476 , corresponding to our expectations. This means that current consumption of durables will be negatively correlated with last period's consumption,

³⁵We might assume that the purchase of durable goods in many cases could be debt financed, which means that the cost of money can act as an indirect price of durables.

which is in line with the stock adjustment theory.

We notice that the parameter of lagged wealth w_{t-1} is significantly positive at 0.0349, confirming the hypothesis that last period's wealth will be important in determining current consumption of durables. Additionally, the short-term wealth elasticity, Δw_t and Δw_{t-1} , are also significant. These results are interesting, adding to the discussion about wealth as a determinant for consumption. Lagged income, y_{t-1} , is not significant in explaining the consumption of durables, i.e. there are no long-run income effects in the model.

We recall that when using the one-step ECM method, one needs to calculate the long term parameter values in order to be able to evaluate the long term dynamics of the model. Thus, in order to be able to quantify the long term effects, we need to perform the calculations as described in section 3.1.4. We assume the steady state level of constant growth rates, thus all the differenced variables $\Delta A_{t-i} = \delta_A = \text{constant}$. The seasonal dummies will not affect the long term solution. The long term equilibrium will be given by

$$(27) \quad -0.0476c_{dur} + 0.0349w + \text{constant} = 0$$

which gives

$$(28) \quad c_{dur} = \frac{0.0349}{0.0476}w + \text{constant} = 0.7332w + \text{constant}$$

The long term effect of a permanent change in wealth on consumption of durables is 0.7332, which is significantly positive. A 10 per cent increase in wealth will give 7.33 per cent increase in consumption of durables.

The level part of the model can be written as $-0.0476(c_{durt-1} - 0.7332w_{t-1} - \text{constant})$,

where the expression within the parentheses is the error correction term, showing the deviation from the long term equilibrium, and -0.0476 is the speed of adjustment, as discussed in Section 3.1.3. The adjustment towards the long term static solution is rather slow, where only about 5 per cent of the disequilibrium from the previous period will be restored in the following quarter. This means it will take approximately 20 years to reach the long term equilibrium level.

From the final model presented in table 4 it seems like cointegration exists between consumption of durables and wealth. Wealth is a long term determinant for consumption of durable goods, affecting consumption of durables positively.

4.2.2 *RM2*: Consumption of durables with long term income effects

The fact that income is not included in the long run effects in the final specification of the model might seem to oppose most theories of consumption. The reason why income is insignificant might be due to multicollinearity with wealth. To test this hypothesis, we can run the specific model again, using lagged income in stead of lagged wealth. My hypothesis is accepted; lagged income now has a t-value of 4.29.

Lagged wealth, w_{t-1} , has been excluded from the formulation, and lagged income, y_{t-1} , has been inserted instead. The long term effect of income on consumption of durables is now significant, with a parameter value 0.0278. In *RM2* less than three percent of last period's disequilibrium will be restored as the speed of adjustment is estimated to be 0.0295. This is lower compared with the speed of adjustment in *RM1* of -0.0476 .

Δw_t has been excluded in *RM2*, but the rest of the model remains the same. It looks like the exclusion of the wealth variable has led to increased impact from short-term real interest rates. Lagged consumption also shows increased significance through a higher parameter value in absolute terms.

Table 5: RM2

Variable	Parameter estimate	t-value	Part. R^2
$\Delta c_{dur_{t-1}}$	-0.4154	-5.01**	0.1899
$\Delta c_{dur_{t-2}}$	-0.3412	-4.06**	0.1335
$\Delta c_{dur_{t-3}}$	-0.4359	-5.98**	0.2506
$\Delta c_{dur_{t-4}}$	0.2732	3.08**	0.0813
Δy_{t-3}	0.4782	3.03**	0.0791
Δw_{t-1}	0.3715	3.49**	0.1024
ΔRRa_{t-1}	-0.9738	-2.63**	0.0605
ΔRRa_{t-4}	-1.1000	-2.80**	0.0681
y_{t-1}	0.0278	4.29**	0.1466
$c_{dur_{t-1}}$	-0.0295	-3.53**	0.1040
$Seasonal_t$	-0.1182	-3.64**	0.1100
$Seasonal_{t-1}$	-0.0859	-2.48**	0.1466
$AR(1 - 5)$	$F(5, 102) = 2.1448[0.0660]$	$ARCH(1 - 4)$	$F(4, 111) = 1.1660[0.3298]$
$Normality$	$Chi^2(2) = 1.7721[0.4123]$	$Heterotest$	$F(22, 96) = 1.3104[0.1849]$
$HeteroX - test$	$F(67, 51) = 1.3546[0.1296]$	$RESET23$	$F(2, 105) = 1.9300[0.1503]$

* Significant at the 5 per cent level. ** Significant at the 1 per cent level.

Read more about the tests in section 3.3.

The long term equilibrium

The long term equilibrium is given as

$$(29) \quad c_{dur} = \frac{0.0295}{0.0278}y = 1.0612y$$

The effect of income on consumption of durable goods is significantly positive. A 10 per cent increase in income will give a 10.6 per cent increase in consumption of durables when all other variables are held constant. The long term elasticity of consumption of durables with regards to income is approximately unity, meaning that consumption of durable goods is linked to income by roughly a one-to-one relationship.

4.2.3 RM3: Consumption of durables with long term effects from wealth and unemployment

Consumption theories suggest that consumption is affected by consumer's expectations towards the future because uncertain times might call for increased saving³⁶, leading to decreased consumption. In *RM3*, the unemployment rate is included as a proxy for uncertainty. The reduced model including unemployment, *URR*, is given in table 6.

Table 6: RM3

Variable	Parameter estimate	t-value	Part. R^2
$\Delta c_{dur_{t-1}}$	-0.5834	-8.02**	0.3775
$\Delta c_{dur_{t-2}}$	-0.5299	-6.75**	0.3007
$\Delta c_{dur_{t-3}}$	-0.6479	-12.1**	0.5784
Δy_{t-3}	0.4447	2.84**	0.0705
Δw_{t-1}	0.3256	3.04**	0.0801
ΔRRa_{t-1}	-0.8484	-2.30*	0.0475
ΔRRa_{t-4}	-0.9370	-2.38*	0.0507
w_{t-1}	0.0500	6.40**	0.2788
$c_{dur_{t-1}}$	-0.0703	-5.44**	0.2184
$Seasonal_t$	-0.1490	-5.48**	0.2206
$Seasonal_{t-1}$	-0.0900	-2.67**	0.0630
$URR(t)$	-0.0160	-3.15**	0.0856
$URR(t-4)$	0.0174	3.20**	0.0881
$AR(1-5)$	$F(5, 101) = 0.5743[0.7195]$	$ARCH(1-4)$	$F(4, 111) = 0.8121[0.5200]$
$Normality$	$Chi^2(2) = 0.6335[0.7785]$	$Heterotest$	$F(24, 94) = 1.0837[0.3770]$
$HeteroX-test$	$F(79, 39) = 1.0810[0.4022]$	$RESET23$	$F(2, 104) = 1.8906[0.1561]$

* Significant at the 5 per cent level. ** Significant at the 1 per cent level.

Read more about the tests in section 3.3.

$\Delta c_{dur_{t-4}}$ is excluded, and Δw_t is now insignificant. The insignificance of this short-term wealth effect is probably a result of multicollinearity between wealth and unemployment. Economically, this makes sense. In bad times, the unemployment rate is generally increasing, and vice versa if the economy is expanding. This is typically accompanied by reductions and increases in wealth, respectively. The negative correlation pattern is shown in figure 4.

When including up to four lags of the unemployment rate, we find that the current and the fourth lag are both significant, with t-values of -3.15 and 3.20 , accordingly. We notice

³⁶"Saving for the rainy days".

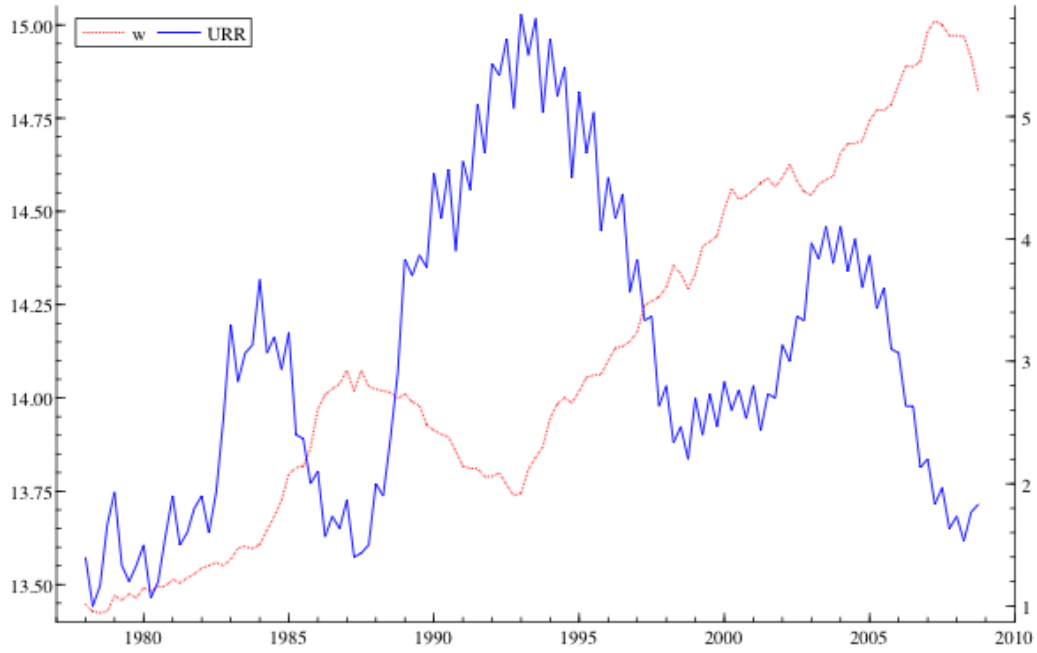


Figure 4: The development in real private wealth and the unemployment rate (1978-2008).

the result that URR_{t-4} affects consumption of durables positively with a parameter value of 0.0174. The two unemployment rate parameter values are similar, but with opposite signs. This can be interpreted such that an increase in unemployment leads to a decrease in the purchases of durables, whereas the level of unemployment does not show any long term effects. I construct a new variable defined as $DAURR = URR_t - URR_{t-4}$, and rerun the regression. Now, I get a significantly negative effect of -0.02397 from this yearly increase in unemployment, with a t-value of -4.73 . However, the new model shows fail both the autocorrelation test and the RESET test at the 1 per cent level.

The long term equilibrium

The long term equilibrium is given as

$$(30) \quad c_{dur} = 0.7112w - 0.2276URR_t + 0.2475URR_{t-4}$$

The long term elasticity with regards to wealth in $RM3$ is 0.7112. There is a positive long term effect of wealth, as before, and a negative long term effect from the unemployment

rate at time t .

4.3 Model properties and discrimination

This chapter will evaluate and compare the three models' properties and by use of different criteria attempt to discriminate between the models.

Mis-specification tests

None of the tests show significance, which means all tests are accepted. I thus conclude that models $RM1$, $RM2$, and $RM3$ are well specified.

Parameter stability

The initial period used when testing for parameter stability is set to 40 observations. Because short initial periods can give very high standard deviations seen as spikes in the graphs due to the low degrees of freedom, I have chosen to use ten years.

The recursive estimation is used to check for structural breaks in the long term variables in the three alternative models. From figure 5, it seems that the long term parameters of $RM1$ are stable across time, as there are no indications of structural breaks. This is also the case for both $RM2$ and $RM3$, and the graphic evidence is included in appendix B.

The Chow test for $RM1$ shown graphically in figure 6. The test is carried out through adding the observations one by one after the initial period of 40 observations. The Chow test shows stability throughout the sample period. The same is found for $RM2$ and $RM3$. The graphic results can be found in appendix B.

In-sample forecasting

The forecasting period has been set to 20 quarters, i.e. 5 years. We thus retain the last five years of the sample set for forecasting, in order to be able to evaluate the model's

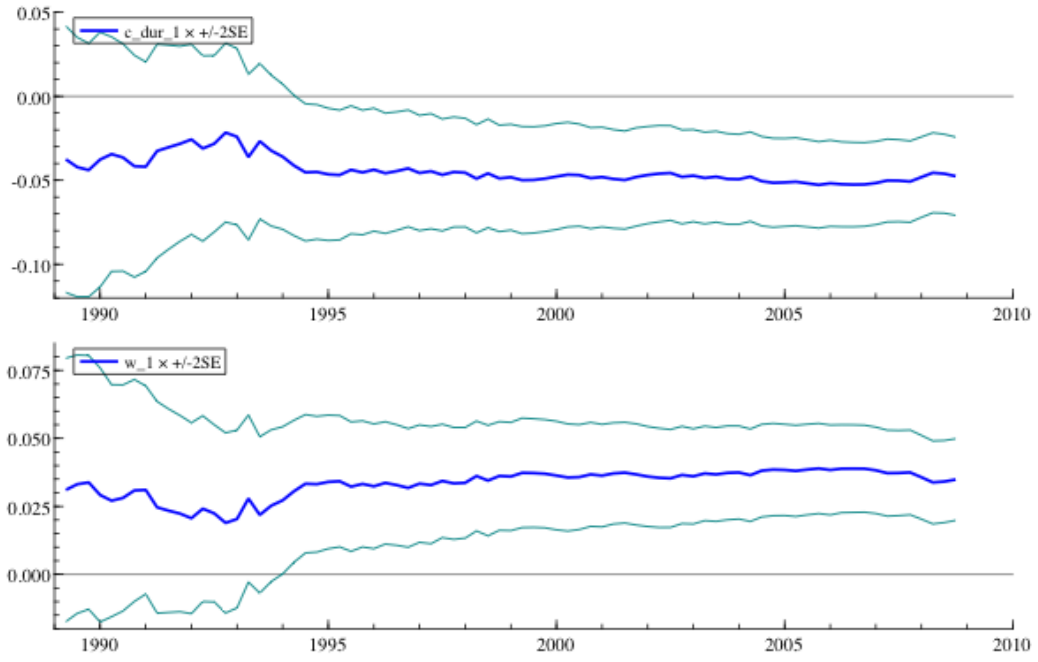


Figure 5: Recursive estimation $RM1$

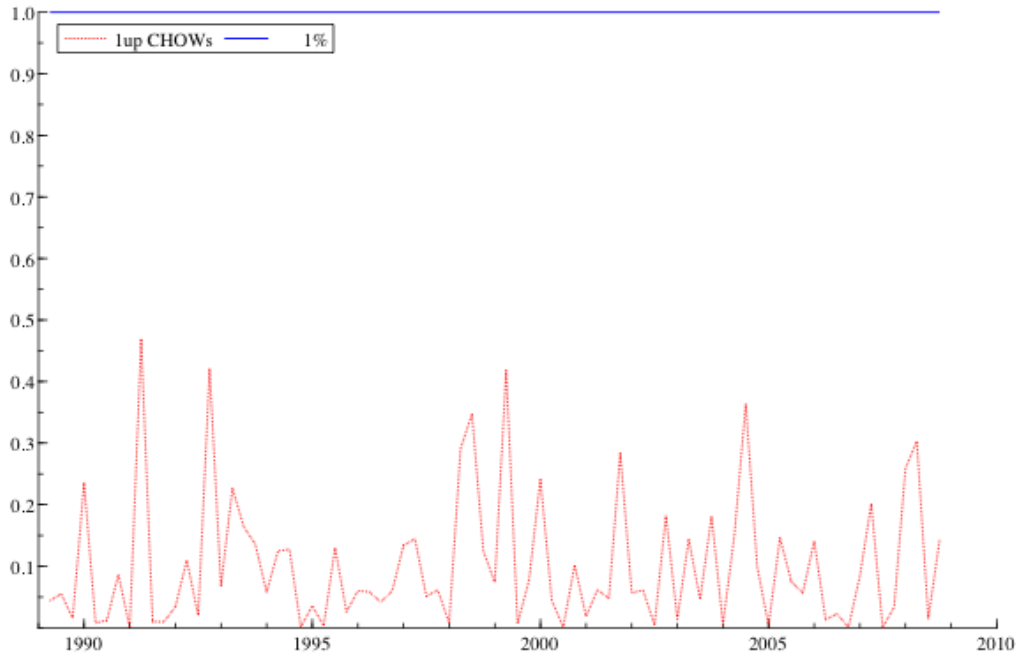


Figure 6: Chow test for $RM1$

forecasting abilities by comparing it with the actual observations. We see from figure 7 that $RM1$ predicts quite well the development throughout the forecasting period. The model slightly overpredicts consumption in the second quarter of each year, but predicts the downturns with high precision.

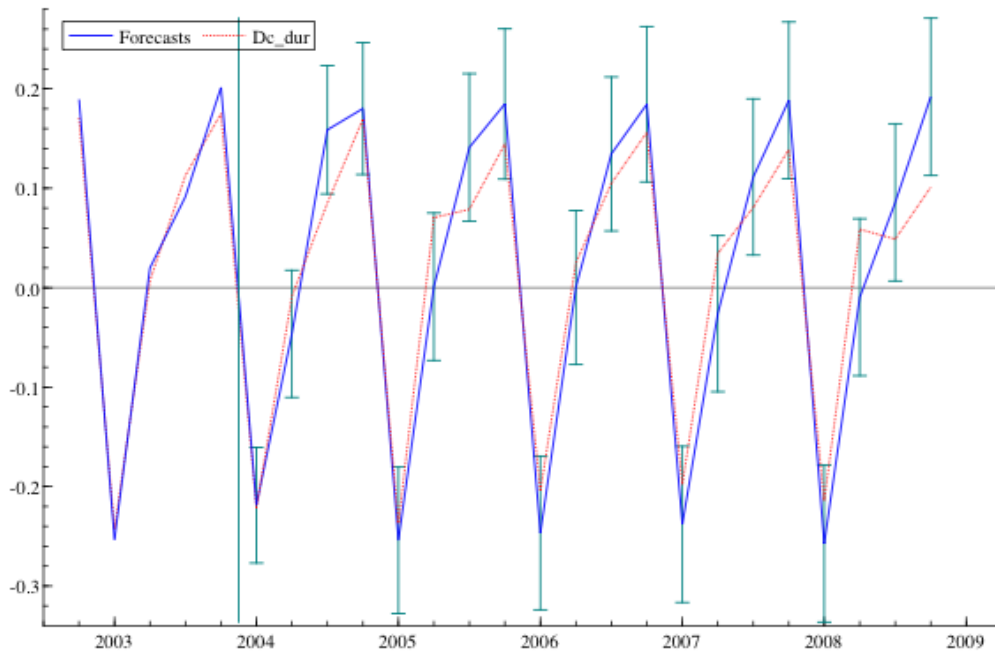


Figure 7: 5 year in-sample forecast of $RM1$.

As in the case of $RM1$, both $RM2$ and $RM3$ predicts quite well the development throughout the forecasting period. These models also slightly overpredict consumption in the second quarter of each year, and also predict the downturns with high precision. The graphical representations of the $RM2$ and $RM3$'s forecasts can be found in figures 14 and 15 in Appendix B.

4.3.1 Prediction criteria

All the models were well specified according to the mis-specification tests. Additionally, the models seem to have stable parameters across time, and good forecasting abilities³⁷.

Thus far, we don't have any strong evidence in favor of either model. We therefore proceed

³⁷With exception of a somewhat weaker Chow test for $RM1$.

to the prediction criteria $RMSE$ and $MAPE$ as described in section 3.3, and finally hand out the encompassing tests described in the same section.

Table 7: Prediction criteria

Prediction criteria	$RM1$	$RM2$	$RM3$
$RMSE$	0.049937	0.050348	0.052634
$MAPE$	78.061	79.343	74.290

As discussed, a lowest possible value of these criteria is preferred. The results from table 7 suggests that $RM1$ is the better model based on $RMSE$, whereas $RM3$ is the preferred specification judging by the $MAPE$ criterion.

4.3.2 Encompassing tests

Here, I will apply the encompassing test as described in section 3.3. I will test $RM1$ versus $RM2$, and $RM1$ versus $RM3$.

Wealth versus income

In this case, the joint model includes both wealth and income. $RM1$ includes the lagged wealth variable, and $RM2$ includes lagged income. $c_{t-1} = \dots + \beta_1 w_{t-1} + \beta_2 y_{t-1}$. $RM1$ is tested for the restriction that $\beta_1 = 0$, and $M2$ for whether or not $\beta_2 = 0$.

Table 8: Encompassing test $RM1$ vs $RM2$

Test	$RM1$ vs. $RM2$	$RM2$ vs. $RM1$
Joint Model	$F(1, 103) = 0.041175[0.8396]$	$F(1, 103) = 1.1270 [0.2909]$

The test suggests that both models are valid simplifications of the general model. We can thus draw no conclusions about which is the better model.

With versus without the unemployment rate

If $c_{t-1} = \dots + \beta_1 \Delta c_{durt} - 4 + \beta_2 w_{t-1} + \beta_3 URR_t + \beta_4 URR_{t-4}$, then $RM1$ is tested for the restriction that $\beta_3 = \beta_4 = 0$, whereas $RM2$ is tested for $\beta_1 = \beta_2 = 0$.

Table 9: Encompassing test $RM1$ vs $RM3$

Test	$RM1$ vs. $RM3$	$RM3$ vs. $RM1$
Joint Model	$F(2, 104) = 2.0652[0.1320]$	$F(2,104) = 3.2853 [0.0728]$

The test suggests that both models are valid simplifications of the general model.

Because neither model is rejected, we cannot draw any conclusions on which model is better. We can, however, examine the models' estimated standard deviations. The estimated standard errors are low and almost equal in all three models, with $\sigma_{RM1} = 0.02834$, $\sigma_{RM2} = 0.02866$, and $\sigma_{RM3} = 0.02868$. Relying on these estimated standard errors would lead to a slight preference towards $RM1$ over the other two.

4.4 One-step ECM for total consumption

For comparison, I have estimated a model for total consumption. I have applied the same approach as for durable goods of constructing a one-step ECM using the general-to-specific method.

When estimating the EMC for total consumption³⁸, I have eliminated the variables with t-values lower than 0.7 in the first stage, including Δy_t , Δy_{t-1} , Δy_{t-2} , Δw_t , Δw_{t-3} , ΔRRA_t , ΔRRA_{t-1} , ΔRRA_{t-2} , w_{t-1} , and RRA_{t-1} . We note that in this case, last period's income is significant at this first stage, whereas last period's wealth is eliminated.

The final model specification is given in Table (10).

The unemployment rate is found to be insignificant in the consumers' decisions towards the purchase of total goods.³⁹ This is probably because the purchases of total goods is less flexible time-wise than purchases of durables which can be postponed or expedited according to economic outlooks⁴⁰.

Another interesting observation is that I don't find any significant effect from the interest

³⁸The general model is similar to the general model for durables, which be found in Appendix A, except there are no prices included in the model.

³⁹The result suggests that there are other factors taken into consideration when deciding upon total consumption of goods.

⁴⁰Total goods include all goods, and amongst them are necessary good etc.

Table 10: Reduced model for total consumption

Variable	Parameter estimate	t-value	Part. R^2
$\Delta c_{tot,t-1}$	-0.4007	-5.81**	0.2380
$\Delta c_{tot,t-2}$	-0.1903	-2.69*	0.0630
$\Delta c_{tot,t-4}$	0.3916	5.55**	0.2219
Δy_{t-3}	0.3348	3.43*	0.0982
Δy_{t-4}	0.3670	3.76**	0.1158
Δw_{t-1}	0.2314	3.90**	0.1232
y_{t-1}	0.0319	5.89**	0.2434
$c_{tot,t-1}$	-0.0272	-5.27**	0.2047
<i>Seasonal</i> _t	-0.0810	-6.05**	0.2528
<i>Seasonal</i> _{t-1}	-0.0696	-6.61**	0.2877
<i>Seasonal</i> _{t-2}	-0.0611	-4.68**	0.1687
<i>AR</i> (1 - 5)	$F(5, 103) = 2.5236[0.0338]*$	<i>ARCH</i> (1 - 4)	$F(4, 111) = 1.3471[0.2571]$
<i>Normality</i>	$Chi^2(2) = 0.9724[0.6150]$	<i>Heterotest</i>	$F(19, 99) = 0.5923[0.9039]$
<i>HeteroX - test</i>	$F(47, 71) = 0.7991[0.7923]$	<i>RESET</i> 23	$F(2, 106) = 4.0237[0.0207]*$

* Significant at the 5 per cent level. ** Significant at the 1 per cent level.

Read more about the tests in section 3.3.

rates, and the lack of long term effects from wealth.

Both the test for serial correlation and the RESET test for mis-specified functional form are rejected, suggesting this is not necessarily a well-specified model.

The long term equilibrium is given as

$$(31) \quad c_{tot} = \frac{0.0319}{0.0272}y + constant = 1.1728y + constant$$

The model suggests there is a long term elasticity of income on consumption of total goods such that a 10 per cent increase in income will lead to an 11.73 per cent increase in consumption. This long term elasticity is close to unity, suggesting an approximately one-to-one relationship between income and total consumption in the long run.

Parameter stability

The Chow test shows stable parameters throughout the sample.

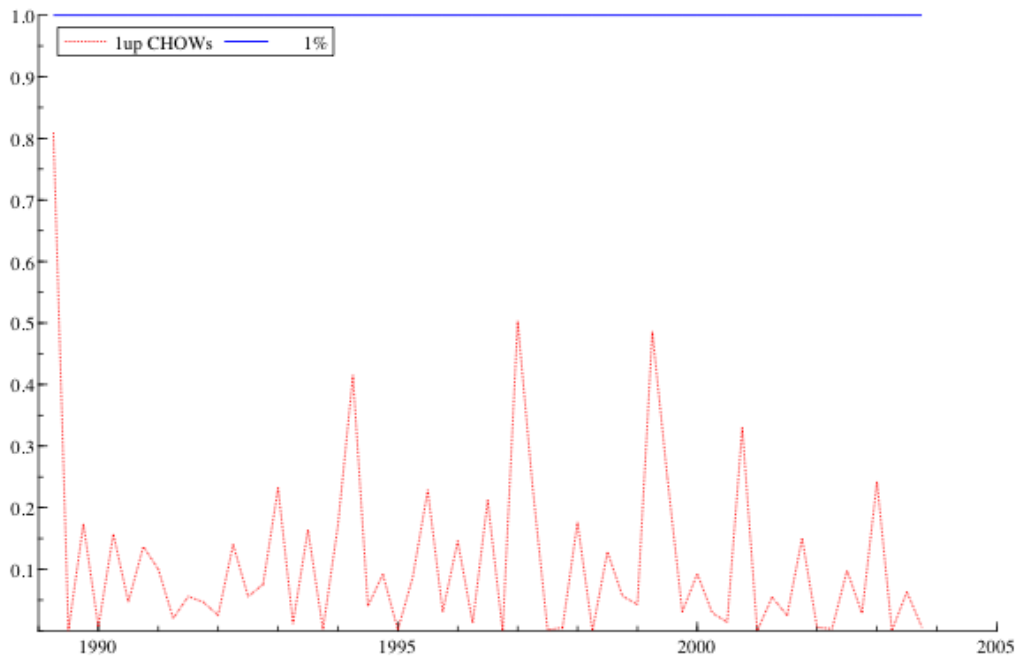


Figure 8: Chow test for total goods

In-sample forecasting

The model, as was the case with $RM1$, $RM2$, and $RM3$, hits the bottoms with high precision. However, this model underestimates quite badly the consumption growth in the first quarter of each year, and overestimates the third quarter consumption growth even more. There are obviously weaknesses in the model, as expected from the rejection of two of the mis-specification tests.

4.5 Engle Granger two-step procedure

In this section, the results from the cointegration tests in section 3.1.6 will be used in constructing the error correction model. We recall that the cointegration test is step one in the Engle Granger two-step procedure. This section thus describes the second step of the test, where we utilise the residuals from the first step of the estimation to describe the long term association between the relevant variables. We also recall that the cointegration tests in the first step were inconclusive.

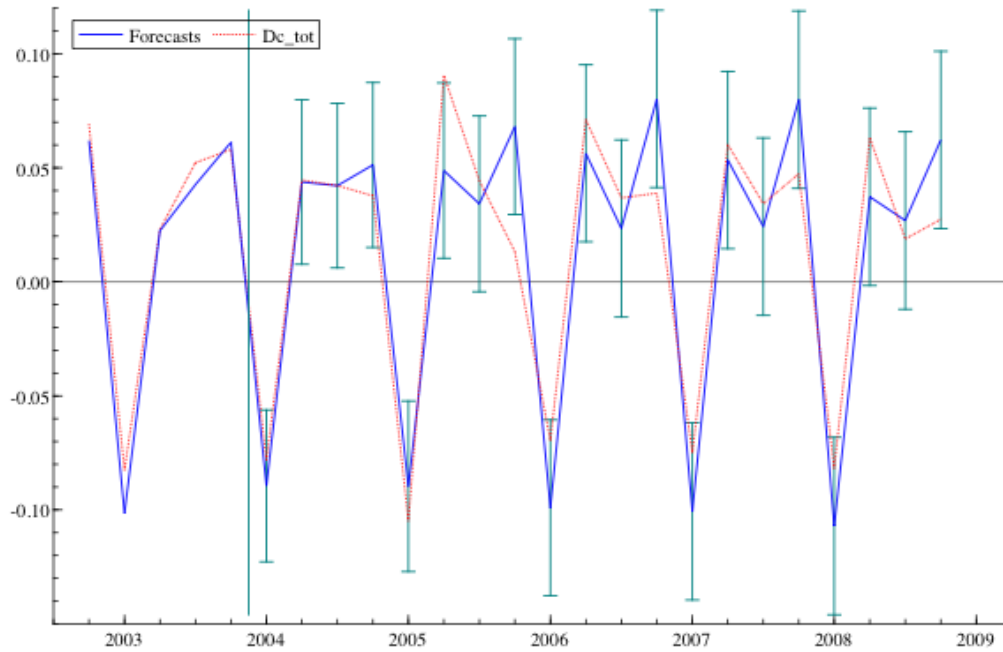


Figure 9: 5-year in-sample forecast

Consumption of durable goods based on the possible cointegration relationship from equation (20)

First, the reduced model using the potential cointegration relationship between total consumption, wealth, and income as tested in section 3.1.6 is estimated. Unfortunately, the short term effects through the cointegration test residual is excluded early on in the reduction process due to low significance. The residual obtains higher significance when included in the final specification, but is still only significant at the 20 per cent level, with a t-value of -1.29 . Additionally, the normality and hetero tests are rejected.

Inclusion of up to four lags of the unemployment rate URR into the final specification does not change the result, as none of the lags are significant.

According to the lack of long term effects in the error correction model derived in step two of the Engle Granger procedure, and the inconclusive results from step one of the test, the hypothesis of cointegration is not supported.

Consumption of durable goods based on the cointegration relationship from equation (21)

Here, an error correction model based on the potential cointegration relationship between consumption of durables, wealth, and income as tested in section 3.1.6 was estimated.

In this case the price, and not income, was included in the long term dynamics. However, as in the previous case where we used price and not income to explain the short term dynamics, this effect is not significant with a t-value of -1.19 . The reduced model using the residuals from this equation does not find the residual significant.

Consumption of durable goods based on the cointegration relationship from equation (23)

We recall that equation (23) looked at the potential cointegration relationship between consumption of durables, wealth, and the price of durables. Once again, the result does not support the cointegration hypothesis, as the long term cointegration relationship is, due to low significance, not included in the final model specification.

To summarize, neither of the estimated models utilizing the residuals from step one of the Engle Granger two-step procedure supports the cointegration hypothesis.

5 Conclusion

In this thesis, I have done an empirical analysis of demand for durable goods in Norway between the years 1978 and 2008. The goal was to see which variables were most important in explaining the consumption of these goods, and was motivated by the scarcity of the existing empirical literature on the subject. The research might provide new insights on the drivers behind the demand for an important group of consumer goods, which may again prove to be valuable information for policy makers.

Previous studies on the effect of wealth on consumption suggests that it is an important determinant, especially on the consumption of durable goods (Jansen, 2009). The other variables used in this study were relative prices, real disposable income, the real interest rate, and the unemployment rate.

I attempted to prove cointegration between some of the variables listed above. But the results from the Engle Granger two-step method did not support my hypothesis. An alternative approach to examine the long and short term associations between the variables were handed out instead.

The one-step ECM method was applied on a general demand model⁴¹ based on macroeconomic theory. The model was gradually reduced by use of the general-to-specific approach until I ended up with a specified model with all variables significant at the five per cent level. This model was named *RM1* and shows significant estimates of lagged consumption and wealth whereas the estimated level effect of income was insignificant. This results means that private wealth can be seen as the main long run determinant of durable goods consumption. Previous consumption growth, changes in the real interest rate⁴² as well as past changes in income and wealth, are important short term determinants. Thus, we have positive short term effects from these variables, but they don't affect the long term solution.

Since no significant long term effect from income was found in *RM1*, I chose to construct

⁴¹As given in equation (26).

⁴²Recall that the interest rate might act as a "rental cost", or an implicit price of durables.

an alternative model where income replaced wealth as a long term determinant⁴³. This model is known as *RM2*. As expected, income is now found to be significant.

Economic theory suggests that consumption is affected by consumers' expectations towards the future. A third model was therefore constructed, *RM3*, where the unemployment rate was included as a proxy for uncertainty. The unemployment rate shows a negative short term effect on consumption of durable goods in this model. The effects from the remaining variables are the same as in *RM1*.

I thus ended up with three different model specifications, namely *RM1*, *RM2*, and *RM3*. All three models seem to be valid specifications of the general model, and there are no signs of misspecification in neither model. No indications of structural breaks were found in the recursive estimations, and all models pass the Chow test at the one per cent level. The models show good forecasting abilities, and predict the downturns with high precision. They do, however, all slightly overestimate third quarter growth in consumption of durable goods. The prediction criteria RMSE and MAPE favor *RM1* and *RM3*, respectively.

The various tests and criteria give somewhat opposing results, albeit most tests are inconclusive. Based on the specification tests, prediction criteria, or encompassing tests, no strict conclusions can be drawn. However, the estimated standard deviations lead to a slight preference of *RM1*, which can be interpreted such that *RM1* fits the data marginally better than the other two models.

For comparison, a model for total consumption was derived in the same way as the three models for consumption of durables. In this case, both the unemployment rate and wealth are insignificant. On the other hand, income was found to have a significant long term effect. There are no significant short term effects from the interest rates. These results deviate from what I found in the case of consumption of durables, which is probably due to the special characteristics of durable goods. Because purchases of durables can be postponed or expedited according to economic outlooks, wealth and unemployment may be a more important determinant for consumption of durables than is the case for total

⁴³Suspecting this result might be due to multicollinearity between income and wealth.

consumption. However, the model for total consumption shows signs of mis-specification, and gives less efficient forecasts than the other models.

A weakness in this paper is the inability of including the actual stock of goods in the analysis. Stock data for the group of goods evaluated in this thesis does not exist at this point in time, and the construction of such data is a task too comprehensive for this paper. Future research is encouraged to construct data for the stock of durable goods and repeat the analysis including this data.

Additionally, future research could be carried out testing a greater number of specific models against the models provided in this thesis. For instance, one could try to include more lags of all the variables. Tests with a higher number of lags on the cointegration residuals might yield different results than the tests carried out in this thesis.

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A Estimation results

Table 11: Estimation results from general model for durable goods

Variable	Parameter estimate	t-value	Part. R^2
$\Delta c_{dur_{t-1}}$	-0.4254	-3.65**	0.1356
$\Delta c_{dur_{t-2}}$	-0.3565	-2.98*	0.0944
$\Delta c_{dur_{t-3}}$	-0.4419	-3.76**	0.1425
$\Delta c_{dur_{t-4}}$	0.1245	1.13	0.0148
<i>Constant</i>	0.3848	0.16	0.0003
Δy_t	0.1747	0.79	0.0073
Δy_{t-1}	-0.0356	-0.10	0.0001
Δy_{t-2}	0.2375	0.66	0.0051
Δy_{t-3}	0.6399	2.01	0.0452
Δy_{t-4}	0.2301	0.94	0.0103
Δw_t	0.1951	1.51	0.0260
Δw_{t-1}	0.2440	1.86	0.0389
Δw_{t-2}	0.0445	0.34	0.0014
Δw_{t-3}	0.1167	0.85	0.0084
Δw_{t-4}	0.0817	0.59	0.0041
ΔRRa_t	0.7166	1.49	0.0256
ΔRRa_{t-1}	-0.8881	-1.77	0.0355
ΔRRa_{t-2}	-0.7149	-1.45	0.0242
ΔRRa_{t-3}	-0.1960	-0.42	0.0020
ΔRRa_{t-4}	-0.6061	-1.26	0.0184
Δp_{dur_t}	-0.6305	-1.64	0.0307
$\Delta p_{dur_{t-1}}$	0.1749	0.33	0.0013
$\Delta p_{dur_{t-2}}$	0.4654	0.98	0.0111
$\Delta p_{dur_{t-3}}$	0.3101	0.70	0.0057
$\Delta p_{dur_{t-4}}$	0.2578	0.64	0.0048
y_{t-1}	0.0089	0.04	0.0000
w_{t-1}	0.0475	0.93	0.0101
RRa_{t-1}	0.1191	0.30	0.0011
$p_{dur_{t-1}}$	-0.2404	-0.511	0.0031
$c_{dur_{t-1}}$	-0.1174	-2.11	0.0497
RRa_{dummy}	-0.0153	-0.79	0.0073
$Seasonal_t$	-0.1793	-3.96**	0.1558
$Seasonal_{t-1}$	-0.1175	-2.39	0.0627
$Seasonal_{t-2}$	-0.0421	-0.93	0.0100

T= 119, k=34 (number of regressors), $F(33, 85) = 136.5[0.000]**$, RSS=0.0709386

B Parameter stability and in-sample forecasts

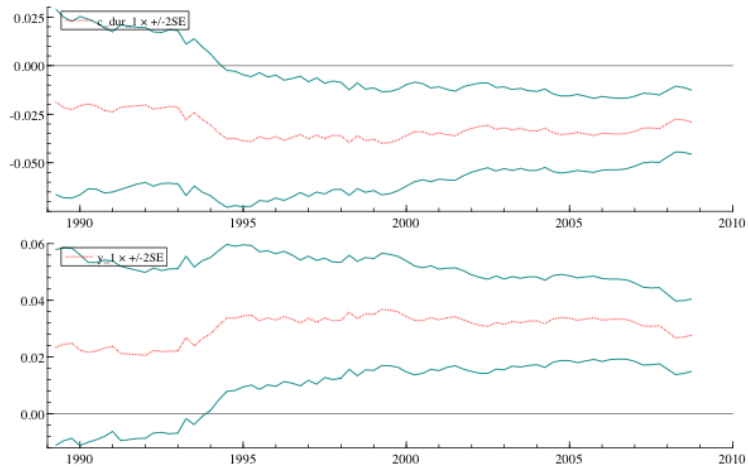


Figure 10: Recursive estimation $RM2$

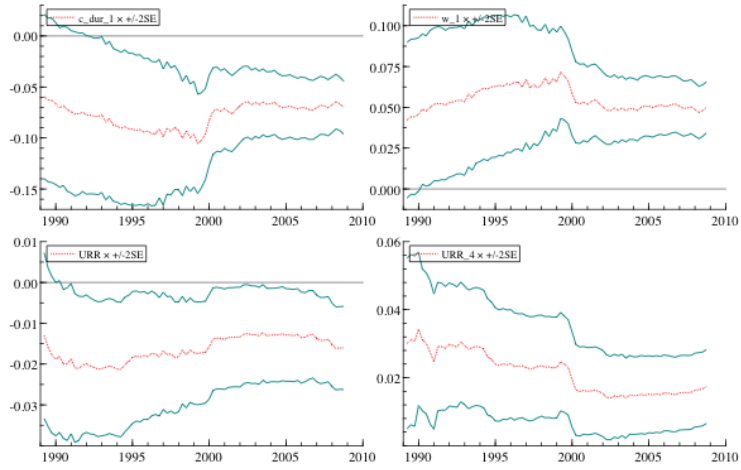


Figure 11: Recursive estimation $RM3$

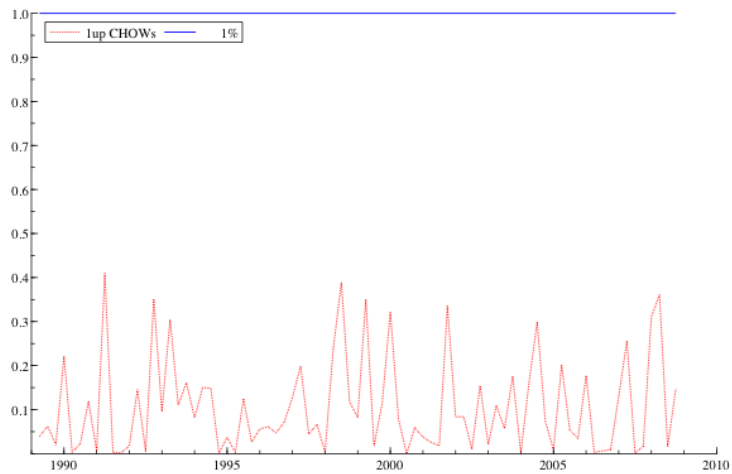


Figure 12: Chow test for $RM2$

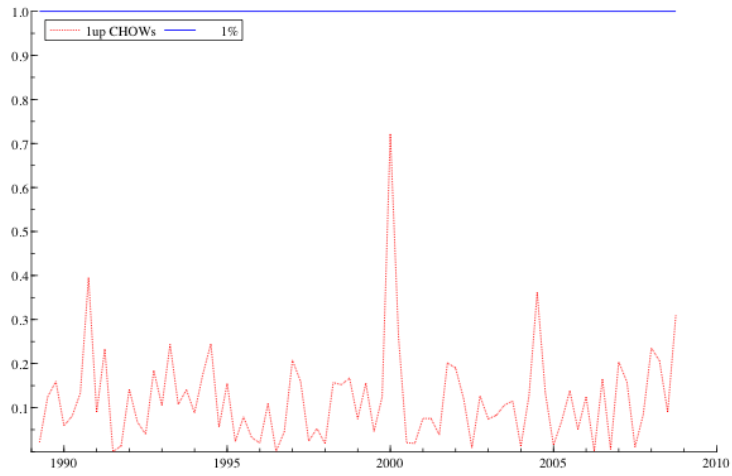


Figure 13: Chow test for $RM3$

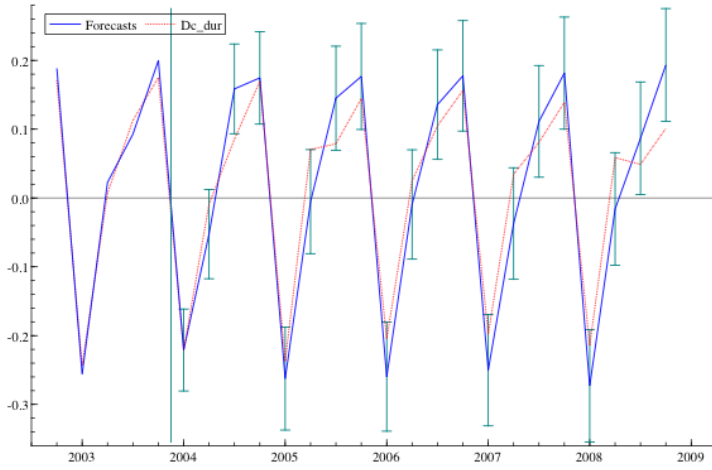


Figure 14: 5 year in-sample forecast of $RM2$.

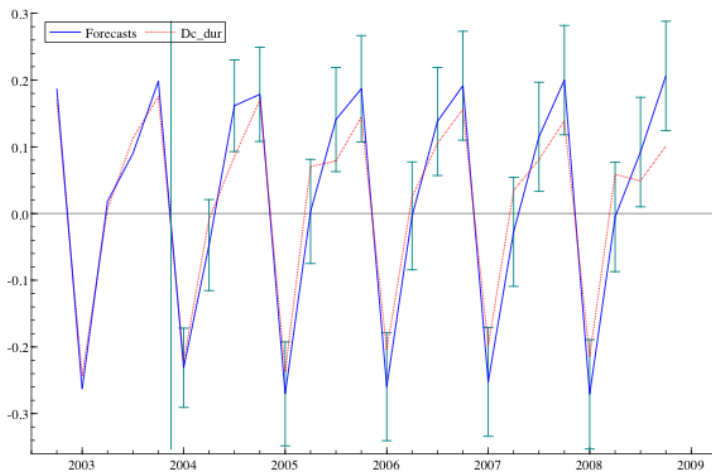


Figure 15: 5 year in-sample forecast of $RM3$.