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AV
KNUT A. MAGNUSSEN AND TERJE SKJERPEN

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Preface

In the Norwegian large scale macroeconomic models MODAG and KVARTS (annual and quarterly respectively), the specification of consumer demand has changed considerably over the last years. In former versions of the models total consumption expenditure was determined by real disposable income and credit expansion, while the allocation to different groups of durables and non-durables took place in a static expenditure system. Now, the demand for durables are modelled separately by single equation error-correction models which allow for a stock adjustment process. A single equation error correction model in which disposable income is the main explanatory variable is used in the determination of total consumption of non-durables. As earlier there are no wealth effects present in the consumption model. Furthermore the allocation of total expenditure of non-durables to different consumption categories is modelled by means of a two stage dynamic expenditure system. The two stage approach is adopted in order to introduce durable stock effects on the demand for different groups of energy and transport consumption. It should also be noted that the new versions of the two models are more similar than before, both with regard to the aggregation level and the econometric specification.

This report describes in detail the structure and the properties of the 1989-version of the models. Both estimation and simulation results are discussed and the models are also compared with large scale macroeconomic models of other countries.

The report has been written by the authors in common, but Knut A. Magnussen has had the main responsibility for the modelling of demand for durables and the consumption function for non-durables, while Terje Skjerpen has had the main responsibility for the estimation of the demand systems.

Central Bureau of Statistics, Oslo, 14 August 1992

Svein Longva

CONTENTS

1 Introduction[1]

The consumption blocks in the Norwegian macroeconomic models MODAG and KVARTS consisted in former versions of the models, cf. Cappelen and Longva (1987) and Bowitz and Eika (1989), of two main parts: a macro consumption function and a static linear expenditure system. The explanatory variables in the macro consumption functions were households' real disposable income and real increase in loans from financial institutions. In KVARTS, total consumption was allocated to seven sub-groups in the linear expenditure system while fourteen consumption groups, consumption of housing services included, were present in MODAG. In KVARTS, consumption of housing services was determined in a separate equation, depending on the capital stock of houses. Consumption of cars, furnitures and other durable consumer goods were included in the expenditure systems in both models.

The modelling of the consumption blocks was based upon a variant of the Extended Linear Expenditure System (ELES), cf. Lluch (1973). In this approach the households are assumed to optimize an intertemporal separable utility function. Because of time separability, two step budgeting can be justified and moreover the estimation of a static expenditure system can be argued for.

In early work on the consumption block in KVARTS, Biørn and Jensen (1983) also investigated DELES-models, see Dixon and Lluch (1977), which offer a special treatment of durable goods within the ELES framework. One variant of the DELES-models was included in the first version of KVARTS, but since problems arose when combining the consumption block with the rest of the model, see Biørn, Jensen and Reymert (1987), the less general ELES model was chosen. However, the main features of the two variants were not significantly different according to Biørn and Jensen (1983).

The parameters of the entire consumption block in KVARTS were estimated by aggregate time series data. However, this was not the case for the expenditure system in MODAG, see Cappelen and Longva (1987), whose parameters were calculated from income elasticities, mainly estimated by cross-section data. Cross-section data were also used to estimate marginal propensities to consume for three sosioeconomic groups: wage-earners, self- employed and pensioners. For two energy categories, electricity and fuel, a CES-aggregate was utilized to take possibilities for substitution into account.

In the early 1980's, the credit market and the market for housing were deregulated. These events were influential in the marked consumer boom in 1985 and 1986, followed by a recession, especially for durable goods, in 1987-89. The macro consumption function totally failed to predict this development and the supply

[1]The authors would like to thank Erik Biørn and Ådne Cappelen for useful comments on an earlier version of the report.

of credit could no longer be seen as exogenous to the household sector. Therefore the macro consumption function was taken out of use and the work on a new consumption model started.

Since the consumer boom in particular affected purchases of durables and the prediction failures were most severe for these goods, we decided to remove durables from the expenditure system. In doing this we can treat durables more in accordance with relevant investment theory and include variables which can explain more of the short run fluctuations in purchase of durables than within an expenditure system. Since we found small cross-price effects from durables to non-durables in KVARTS, the consequences of removing durables for the expenditure systems are minor. On the other hand, this way of modelling consumption behaviour implies that the link to utility theory is somewhat relaxed.

This paper presents the entire consumption models in MODAG and KVARTS in the 1989-version of the models, and discuss both theoretical assumptions and the empirical results. In particular, we try to compare the features of the two models. The fact that the level of aggregation is the same for both models makes this possible. In section 2 we present the teoretical background and the empirical results for durables, while section 3 deals with modelling of non-durable goods and services. In section 4 the simulation properties of the estimated relations are investigated and in section 5 we compare our consumption models with other macroeconomic models.

2 Durable goods

Durable goods are divided into three groups; houses, transport equipment and other durables. Transport equipment consists of cars, motorcycles and bicycles. The group other durables consists of furnitures, electric household equipment and durable leisure goods. Consumption of services from durable goods is, in accordance with the Norwegian national accounts, treated in different ways depending of the kind of good. Housing services ($C50$) depends on the capital stock of houses. The consumption of services from transport equipment and other durables are conventionally set equal to the purchase of these goods in each period, denoted as $C30$ and $C40$ respectively. For these goods, we model the purchase and not the actual consumption of services, even if the distribution of services also is of interest. We do not analyse housing investment in this report.

The rest of this section is divided into two parts, one dealing with housing consumption and the other with demand for transport equipment and other durable goods.

2.1 Consumption of housing services

Housing services are, as mentioned above, modelled in accordance with the way the national accounts measure the consumption. This implies a connection between the capital stock and consumption of services and is an accounting relationship rather than a usual demand function. It is simular in spirit to the user cost of capital concept, but there are some minor deviations from this scheme as repair work etc. also counts as consumption of housing services.

After some estimation experiments, we found that a log-linear function described data in a better way than a linear one. Estimation results also showed that a constant term has to be included in addition to the level of the capital stock. However, real disposable income has no significant effects on the consumption of housing services. The chosen equation in KVARTS includes the capital stock in the current period and four quarters ago, and in MODAG the capital stock in current and previous year, in both equations bounded by the restriction that the marginal effects are the same in both periods. Since capital stocks are measured at the end of the year, this can be interpreted as an effect from the stock in the middle of the period.

The estimated equation in KVARTS is

$$\begin{aligned} log(C50)_t &= \underset{(86.8)}{-4.90} + \underset{(283.3)}{0.53}[log(K83)_t + log(K83)_{t-4}] \\ DW &= 0.64, R^2 = 0.999, SER = 0.008. \end{aligned} \tag{1}$$

The similar equation in MODAG is:

$$\begin{aligned} log(C50)_t &= \underset{(35.1)}{-3.62} + \underset{(156.2)}{0.53}[log(K83)_t + log(K83)_{t-1}] \\ DW &= 0.73, R^2 = 0.999, SER = 0.008 \end{aligned} \tag{2}$$

The estimation period is from 1970 to 1989 and $C50$ denote consumption of housing services and $K83$ the capital stock of houses. The results imply an elasticity of housing services with respect to housing capital of slightly more than 1. In addition, the equations suffer from severe autocorrelation problems and t-values are not to be taken seriously. Considering that the equations are supposed to reproduce the way the national accounts measure consumption of housing services, we have put it into use, despite the problems with autocorrelation as attempts with various dynamic specifications showed that better statistical specifications are far from the "true" accounting rules used in the national accounts.

2.2 Personal transport equipment and other durable goods

In modelling the demand for transport equipment and other durables, we want to take account of the fact that it is the capital stock of the good (and not the purchase in each period) that generates utility to the consumer. It is therefore reasonable to assume that the purpose of consumer behaviour is to reach a desired level of the capital stock even though there may be deviations between the actual level and the desired level in the short run. For a more detailed discussion of the demand for durables, see Magnussen (1990).

The theoretical framework is an error-correction model (ECM) which can be interpreted as a flexible version of the traditional stock-adjustment model cf. Stone and Rowe (1957). An important feature of this model is that it takes time to reach the desired level of stocks of a particular good. The reasons for this adjustment process are transaction costs which can be a consequence of for instance lack of information or financial problems. Let us start with the simple stock-adjustment equation

$$HC_{it} - HC_{it-1} = \lambda(HC^*_{it} - HC_{it-1}) \tag{3}$$

where HC_{it} is capital stock of durable good i in period t, HC^*_{it} is desired capital stock, λ is an adjustment parameter, $0 < \lambda < 1$, $i = 30, 40$.

Equation (3) then says that only a part of the discrepancy between actual and desired stock in each period is closed. To see the connection between the stock-adjustment model and the more flexible ECM, let us add and subtract λHC^*_{it-1} on the right hand side, which gives

$$HC_{it} - HC_{it-1} = \lambda[HC^*_{it} - HC^*_{it-1}] - \lambda[HC_{it-1} - HC^*_{it-1}] \tag{4}$$

If we in addition remove the restriction that the coefficients on the right hand side are equal, we get the ECM, which can be written

$$\Delta HC_{it} = \beta \Delta HC^*_{it} - \lambda[HC_{it-1} - HC^*_{it-1}] \tag{5}$$

where Δ denote the first difference.

The interpretation of the ECM is that discrepancies between desired and actual capital stocks, which can be created by shocks in the short run, will be eliminated in the long run. The long-run properties of the model are connected to the last term on right hand side of (5).

Since HC^* is an unobservable variable, it has to be modelled in some way. According to consumer theory, the desired capital stock should depend on real disposable income and relative prices. In particular, the user cost of capital should be an important price variable in this model. In our case only disposable income deflated by the price index for the respective group of goods has turned out significant. A priori it is likely to assume that the elasticity of the capital stock wrt. income has been declining through the estimation period. To take this into account, we have chosen the following linear function for desired capital stock.

$$HC^{*}_{it} = a + b(RC/PCi)_t, \quad a < o \tag{6}$$

where RC is disposable income and PCi is a price index for the durable good.

Purchases are determined by using the definition between stock, depreciation and purchase

$$C_{it} = HC_{it} - HC_{it-1} + D_{it} \tag{7}$$

where C_{it} is purchase (consumption) of good i in period t, and D_{it} is depreciation of good i in period t.

Equation (7) says that the discrepancy between capital stock in period t and $t-1$ is equal to purchase in period t less depreciation in the same period. Since the depreciation rate has been fairly constant over the last years, for forecasting purposes depreciation is set to be a constant fraction of the capital stock lagged one period

$$D_{it} = \delta_i \cdot HC_{it-1} \tag{8}$$

where δ_i is the rate of depreciation for good i.

The combination of equations (5) and (6) gives the equation

$$\begin{aligned} \Delta HC_{it} \; &= \beta b \Delta(RC/PCi)_t \\ &- \lambda[HC_{it-1} - a - b(RC/PCi)_{t-1}] \end{aligned} \tag{9}$$

which is the basis for the estimated equations for both groups of durables. Equation (9) was estimated with the two-step procedure described in Engle and Granger (1987). In the first step, the following long run equations were estimated

$$HC_{it} = a + b(RC/PCi)_t \tag{10}$$

When the estimated value of a is negative, the income elasticity will decline towards 1 as income grows. Using this method we can easily verify this assumption in the first step. In the second step, equation (9) is estimated using the lagged residuals from (10), RES_{it-1}, as an approximation for the last term in brackets of equation (9). In this equation the relevant short run dynamics is determined. The estimated relations are generally written

$$\begin{aligned} \Delta HC_{it} \; &= \alpha_0 + \alpha_1(L)\Delta(RC/PCi)_t + \alpha_2(L)\Delta HC_{it-1} \\ &- \lambda \cdot RES_{it-1} + \alpha_3 DVAT + \textstyle\sum_{i=1}^{3} \gamma i DSi \end{aligned} \tag{11}$$

where DVAT is a dummy which takes care of the effects of introducing VAT in 1970. DSi are seasonal dummies. In the annual equation $\gamma i = 0,\ i = 1,2,3$.

The estimated equations are presented in table 1 and 2. We do not include seasonal dummies in the long run relations since it seems unlikely that seasonal variations should effect the desired level of the capital stock. The lag specification of the short run variables is determined by starting out with many lags, and remove insignificant variables.

Since our quarterly data are seasonally unadjusted, we add dummies which are supposed to take care of seasonal variations in data when estimating the equations in KVARTS. Each dummy has the value 1 in one quarter, 0 in others. We also included a variable aimed at taking account of changes in the seasonal pattern due to changes in national accounting practice, but it did not turn out to be significant. As usual in ECM models, we have experimented with the short run specification of the model. This resulted in inclusion of lagged values of the left hand side variable. Changes in the uemployment rate, which is supposed to represent expectations of and uncertainty about future income, turned out as a significant variable, but the effect was unreasonably large in MODAG.

Since the estimated long-run equations are linear with negative constant terms, the elasticities are not time invariant but declining towards 1 as income grows. The elasticity for capital stock of personal transport equipment in KVARTS starts at about 4.0 declining to about 1.7 by the end of the estimation period, while the elasticity for capital stock of other durable goods are declining from about 1.6 to about 1.1. The similar elasticities in MODAG are for personal transport equipment declining from above 7 in 1962 (just after the end of the car sales rationing period), to 2.8 in 1966 and 1.6 in 1989 and for other durable goods declining from 1.7 to 1.1 during the estimation period. This results indicate that cars have been and still are more a kind of luxury good than furnitures etc., but both groups of goods are not luxury goods to the same extent as 20 years ago. In addition we have shown that the long-term elasticities for each consumption group are about the same for both models.

As can be seen from table 2, all adjustment parameters are highly significant, but the values are rather small especially in the quarterly model. Among the short-run variables we can see that the change in the endogenous variable lagged one period is significant for all four equations. For other durable goods in KVARTS the same variable lagged 2, 3 and 4 periods are significant as well. The first lag has the largest coefficient and the total effect (the sum of the coefficients) is 0.86. The change in real disposable income in the present period is significant in all equations except from the equation for transport equipment in MODAG. If this variable is removed, there is no income effect in the first year. This may seem as a strange result but is in line with the equation for non-durables, see chapter 3.1. For the group other durable goods in KVARTS the change in income lagged 5 periods also turned out to be significant, but no similar approximation of income expectations were found for transport equipment. The constant terms in these equations have no economic interpretation and all dummy variables are significant.

As can be seen from the test-statistics in table 2, there are some problems connected to three of the equations. For other durable goods the only significant test statistic is for the misspesification test in the annual equation. Compared to the quarterly equation, this may be caused by one or more omitted lag variables. For transport equipment, the normality test turns out to be significant for both the quarterly and the annual model. In addition, the quarterly equation suffers from heteroskedasticity problems which may be connected to the specification of the seasonal dummy variables.

The stability properties of equation (11) are examined by recursive estimation from 1970 to 1989. In appendix B, figures of both short run coefficients and the adjustment parameters are presented.

We will start to comment on the parameters for transport equipment in the quarterly model fairly. As can be seen, all parameters are stable through most of the period after 1975, except for a jump upwards in 1985. The upward raise in 1985 seems to be most pronounced for the short run parameter for the first difference of income. However, all parameters are stabilizing again in the period after 1985/86. The instability problems in 1985/86 are similar for the annual model but there are some differences cf. fig. 16-18. The adjustment parameter jumps upwards but returns to the former level in 1988/89, while the parameter for change of the stock of transport equipment remains at the higher level after 1985. Another pattern is due to the parameter of the income variable whose value falls considerably in 1985/86 and is growing somewhat in the period after.

The properties of the equations for other durable goods are in general better than for transport equipment see fig. 4-11 and 19- 21. Despite some minor trends for some of the parameters, the main impression is that the parameters are stable. The adjustment parameter in the quarterly model is declining somewhat after 1978. The same pattern is due both to the third coefficient of income change and for the coefficient connected to the lagged endogenous variable, while a slightly upward trend is connected to the first parameter for change of income. In the annual model, the adjustment parameter is also declining while the coefficient for change in income is growing somewhat. However, the parameter for the lagged endogenous variable remains stable through the period after 1978.

To sum up the analysis of durable goods, we are to a large extent satisfied with the results for consumption of housing services and other durable goods, but the same can not be said about the estimation results for transport equipment. The long run relationship between income and the capital stock for the latter group seems reasonable and the stock adjustment approach contributes to a good tracking of the underlying development of purchase of transport equipment, see chapter 4. However, the short run fluctuations are not satisfactorily modelled for transport equipment. Later investigations have shown that a real interest rate variable contribute to a somewhat better tracking through the estimation period. If we in addition accept "large" marginal effects of changes in unemployment, it is possible to capture most of the fluctuations for this group as well.

Table 1: Estimated long-run equations for Personal transport equipment (30) and Other durable goods (40). t-values in brackets.

Model	KVARTS		MODAG	
Left hand side variable	HC30	HC40	HC30	HC40
Constant term	-746927 (6.4)	-225429 (9.5)	-735912 (5.6)	-201567 (11.6)
RC/PC30	2.50 (15.1)		0.63 (12.6)	
RC/PC40		2.31 (54.4)		0.58 (69.4)
SER	202776	59396	16978	30111
DW	0.14	1.55	0.27	0.88
R^2	0.72	0.97	0.86	0.99
Period	67.1-89.4	67.1-89.4	62-89	62-89

Table 2: Estimated equations for Personal transport equipment (30) and Other durable goods (40). t-values in brackets.

Model	KVARTS		MODAG	
Left hand side variable	ΔHC30	ΔHC40	ΔHC30	ΔHC40
Const.term	-2029	10016	14839	1039
	(1.72)	(5.5)	(1.2)	(0.2)
Δ(RC/PCi)	0.06	0.04	0.04	0.11
	(3.14)	(3.08)	(0.9)	(3.8)
Δ(RC(-1)/PCi(-1))		-0.07		
		(4.38)		
Δ(RC(-5)/PCi(-5))		0.02		
		(1.66)		
ΔHCi(-1)	0.85	0.58	0.56	0.78
	(15.81)	(5.98)	(2.9)	(8.4)
ΔHCi(-2)		-0.28		
		(2.70)		
ΔHCi(-3)		0.29		
		(2.98)		
ΔHCi(-4)		0.27		
		(2.95)		
RESi(-1)	-0.01	-0.03	-0.13	-0.20
	(3.27)	(4.54)	(3.6)	(4.5)
DS1	6164	-15780		
	(3.99)	(6.8)		
DS2	12571	-7795		
	(8.54)	(2.99)		
DS3	-5115	-10215		
	(2.48)	(4.28)		
DVAT	17119	4059	27023	9046
	(4.90)	(2.51)	(1.5)	(2.0)
SER	4.99	2188	25918	6387
DW	1.91	1.77	1.72	1.64
R^2	0.85	0.94	0.64	0.84
Period:	68.1-89.4	68.2-89.4	64-89	64-89
Test for:				
Autocorrelation (Harvey (1981))	F(1.78) 1.29	F(1.72) 3.60	F(1.20) 1.63	F(1.20) 0.53
	F(4.72) 2.14	F(4.66) 2.20	F(2.17) 2.76	F(2.17) 0.86
Heterosced. (Engle (1982))	F(1.78) 16.1*	F(1.72) 0.11	F(1.19) 0.96	F(1.19) 0.06
	F(4.72) 5.07*	F(4.66) 0.27		
Misspecific. (Ramsey (1969))	F(1.79) 1.11	F(1.73) 3.59	F(1.20) 1.05	F(1.20) 9.88*
Normality (Jarque and Bera (1980))	$X^2(2)$ 24.1*	$X^2(2)$ 0.15	$X^2(2)$ 15.58*	$X^2(2)$ 2.88

* - significant at 5%-level

3 Non-durable goods and services

Nondurable goods and services are divided into the following eleven groups in KVARTS and MODAG;

Food	$C00$	
Beverages and tobacco	$C11$	
Electricity	$C12$	
Fuel	$C13$	
Operation of personal transport equipment	$C14$	
Other nondurable goods	$C20$	(12)
Clothing and footwear	$C21$	
Other services	$C60$	
Public transport services and communication	$C61$	
Consumption of health services	$C62$	
Consumption abroad by resident households	$C66$	

Total consumption of non-durables except for consumption of health services is determined in a consumption function for non-durables and allocated to the above groups in the linear expenditure systems. Consumption of health services is determined exogenously in both MODAG and KVARTS. The reason is that this category is mainly financed by government transfers in kind so that only a small portion of it is decided by the consumers individually. An alternative route, which has not been tried, is to include health services in the concept of total consumption of non-durables and accordingly include health service expenditures in the definition of total expenditure on non-durables. Following this route, it is still possible to stick to the assumption that health consumption is exogenously determined. The rest of this section is divided into two parts, the first dealing with the consumption function for non-durables and the other with the expenditure systems.

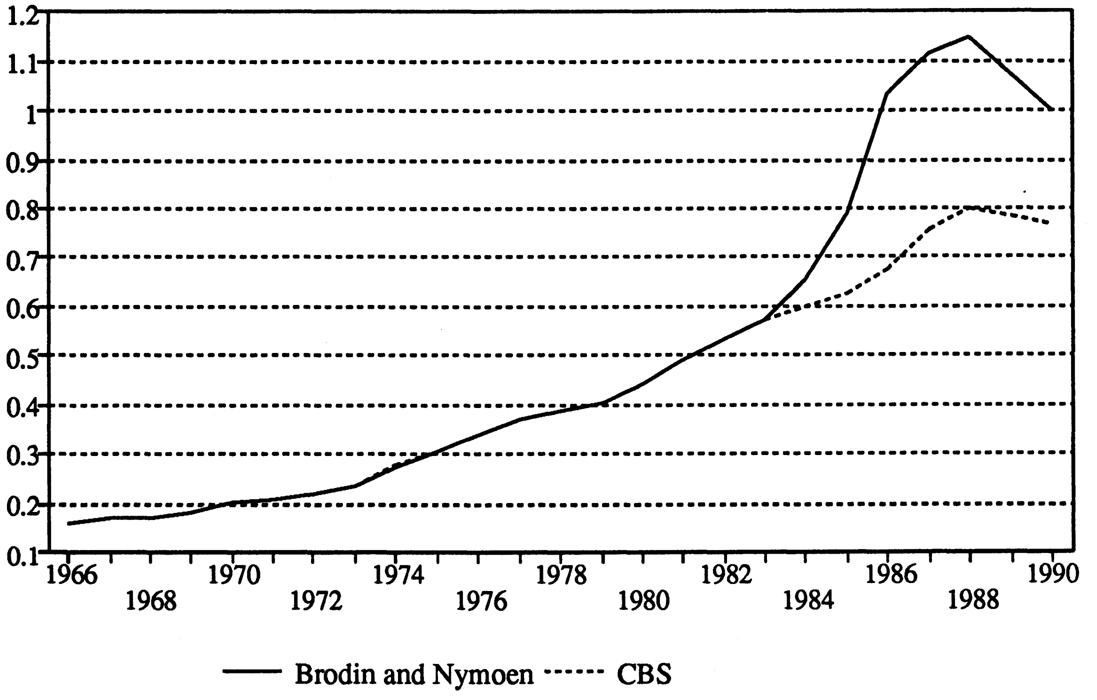
3.1 A consumption function for non-durables

In the first versions of MODAG and KVARTS the macro consumption functions included both real disposable income and the real value of the increase in credits to the household sector. Credit supply was until 1984 more or less rationed and could therefore be viewed as exogenous to consumers. By 1984 there were few regulations left in the credit market. The macro consumption functions totally failed to predict the consumer boom that followed in the period 1985-86. The upswing in private consumption in the middle of the 1980s and especially the downturn from 1987 to 1989 was more pronounced for (purchases of) durable goods than for non-durables. We have so far not found any specification of the consumption function that can explain the development of private consumption well through the whole estimation period. In this section we first discuss some of the specifications that failed and then we present the estimated consumption function for non-durables that we use as our "working-horse" until a more satisfactory model has been found.

The separation of total consumption into non-durables and durables can be justified by assuming weak separability between total consumption of non-durables and durables. Maximizing the overall utility function will generate demand functions for both groups of goods in which the relative price between durables and non-durables is included. On this theoretical background, we tested the effect of this relative price variable in the demand function for non-durables. The effects turned out to be insignificant. Another price variable that failed as an explanatory variable was the rate of inflation, measured as the annual increase in the consumer price index. It can be argued that higher inflation increases uncertainty and should thereby affect consumption negatively or inflation can be seen as an approximation for wealth effects, see e.g. Hendry and Ungern-Sternberg (1981). However, we could not find any effects of inflation in the quarterly or the annual consumption functions. Another variable that could represent uncertainty, the increase of unemployment, was not significant either.

The life-cycle hypothesis attributes an important role for wealth effects in consumption functions. Consumer demand should depend on total resources available to the consumer through his remaining life-time. In general these resources consist of the present stock of wealth (except for human capital) and the expected future income stream. The wealth variable can however be defined in different ways. In our analysis we tried two main specifications of real wealth: the sum of net liquid assets and the housing stock and the housing stock alone. A crucial point is however how to value the housing stock. The national account price index measures the costs of building a new house and does not represent the actual market value of houses. This is the main reason for why the wealth variables in our analysis did not contribute to explain the development of private consumption through the last part of the 1980s. Brodin and Nymoen (1989, 1992) have constructed a housing price series that in a better way reflect the market value of the housing stock. In figure 1 we have displayed this series together with the price index from the national accounts. The series are similar until 1983. As can be seen the growth in 1984-86 is significantly more rapid in the Brodin and Nymoen index and the downturn in 1986-90 is also more pronounced. The wealth effect in the Brodin and Nymoen analysis is highly significant and contribute to a very good tracking of total private consumption through the 1980s. Moreover, they argue that the omission of wealth variables in former consumption functions led to misspecifications and that the consumer boom in the middle of the 1980s cannot be seen as a structural break in consumer behaviour. However, there are problems connected to the price index used by Brodin and Nymoen. In Magnussen and Moum (1992) it is shown that other indicators point to a quite different development of second hand housing prices through the beginning of the 1980s. Further, it is shown that the results in Brodin and Nymoen change considerably, in directions of unstable parameters, if their price index is replaced by (from our point of view) a more reasonable indicator. The questions related to wealth effects should therefore be analysed in more detail in later studies.

Figure 1. Price indices for housing investment.



From our point of view, the deregulation of the credit market through the first part of the 1980s seems to have had a major impact on private consumption through the last part of the 1980s. Before 1984, the banks lending possibilities were (more or less) limited but from that year there were few regulations of the total credit volume. In 1985 and 1986 there were in practice no restraints on private borrowing but private banks have later on been more restrictive in their lending policy. On this background we can argue that until 1984 there was to a large extent credit rationing, in 1985 and 1986 there was hardly any rationing of credit at all and in the period after 1986 there has been a kind of "market" rationing by the banking sector. One strategy in modelling these changes in the credit market is outlined in Cappelen (1991). By utilizing a life-cycle model with credit rationing he gives a teoretical explanation of the consumer boom in the moddle of the 1980s. When credit constraints where removed, rationed consumers were able to consume more through borrowing. This model could be combined with a model for non-rationed households and be analyzed empirically. However, relevant information about the share of consumers who are rationed is missing through the estimation period and this makes it difficult to aggregate the consumption functions for the two groups of consumers. In a related model Steffensen (1989) analyse empirically total private consumption by dividing households into the same two groups; one rationed in the credit market and the other not. Assuming that the former group receive a constant share of total disposable income, he constructs a macro consumption function which incorporate the behaviour of both groups of consumers. The estimated model is however not able to explain the consumer boom in 1985/86 well and this may be a result of the assumptions related to aggregation. Another approach is utilized in Nesbakken (1990) who estimated annual consumption functions for non-durables over the period 1963-87. By adjusting household income (for instance by including income from the stock of private transport equipment) and including household borrowing and housing capital as explanatory variables, relatively stable consumption functions are estimated. A major problem with this analysis is however to defend that households loans were exogenous to the households in the period after 1984. In addition, it seems that the results are somewhat dependent on the specification of a demographic variable; the proportion of the population between 25 and 45 years. On this background we have in later analysis chosen another assessment to represent the effects from the credit market. By combining the nominal interest variable already included in MODAG as a relevant variable in the rationing period with a real after tax rate of interest variable which seems to be an important variable after 1984 it seems possible to track non-durable consumption in a better way. This approach will be continued.

Let us then turn to the chosen equations which is error correction models in the logarithms of non-durable consumption and real disposable income

$$\Delta logCPIV_t = \alpha_0 + \alpha_1(L)\Delta logCPIV_{t-1} + \alpha_2(L)\Delta log(RC/PCIV)_t +$$
$$\alpha_3(L)\Delta logRENBG300_t + \alpha_4 logCPIV_{t-1} + \alpha_5 log(RC/PCIV)_{t-1} + \quad (13)$$
$$\gamma_0 DVAT + \sum_{i=1}^{3} \gamma_i DSi$$

where

RC	is nominal disposable income
$CPIV$	is consumption of non-durables
$PCIV$	is the price index for non-durables
$RENBG300$	is the average interest rate on loans from private and public banks to households
$DVAT$	is a dummy for the introduction of VAT in 1970
DSi	is seasonal dummies.

The short run dynamics was established through the estimation process. In the short run dynamics lagged differentials of consumption plays a major part. In the quarterly model lagged income is also present as a short run variable and the annual relation also includes the nominal interest rate. An increase in interest rates will decrease consumption in the short run. The interest variable is included to account for the fact that interest rate changes can give both substitution and income effects while the real disposable income variable is only able to represent income effects. The more relevant real interest rate was however not significant. Both models include a dummy variable for introduction of VAT in 1970 and the quarterly model also contains seasonal dummy variables. The estimated equations are presented in table 3.

From the estimation results we can calculate long-run income elasticities for both equations. The elasticity according to the annual equation is estimated to 0.88 and for the quarterly relation 0.93. Combined with the elasticities for durables (that exceeds 1) these values are in accordance with a hypothesis of a long-run elasticity of total consumption wrt. income of approximately 1.

The main problem with these equations is the failure to fit the actual values of consumption through the 1980s (see figure 6A and 6B in appendix C for the results of dynamic simulation). The equations overestimate the true values before 1985 and underestimate the values from 1985 to 1989. These problems are closely connected to instability properties of the estimated coefficients which should not be surprising since no special treatment is offered to explain the boom in 1985/86.

To investigate the stability properties of the long-run coefficients (the income elasticities), we have undertaken recursive estimation through the last part of the estimation period. Figure 15 and 25 in appendix B display the results of this

Table 3: Estimated consumption functions for non-durable goods in MODAG and KVARTS. t-values in brackets.

Model	MODAG	KVARTS
Left hand side variable	log(CPIV/CPIV(-1))	log(CPIV/CPIV(-1))
Const.term	0.43 (1.92)	0.19 (1.25)
log(CPIV(-1)/CPIV(-2))	0.71 (3.88)	-0.42 (5.04)
log(CPIV(-3)/CPIV(-4))	-0.27 (1.40)	
log(CPIV(-4)/CPIV(-5))		0.30 (3.47)
log(RC/PCIV)/(RC(-1)/PCIV(-1))		0.14 (2.13)
log(RENBG300/RENBG300(-1))	-0.22 (2.95)	
log(CPIV(-1))	-0.26 (3.01)	-0.15 (3.04)
log(RC(-1)/PCIV(-1))	0.23 (2.72)	0.14 (2.75)
DVAT	0.02 (2.25)	0.05 (3.60)
DS1		-0.12 (4.72)
DS2		-0.11 (6.70)
DS3		-0.05 (4.31)
SER	0.015	0.019
R^2	0.72	0.97
DW	2.18	2.09
Period	66-89	67.2-89.4
Test for:		
Autocorrelation (Harvey (1981))	F(1.15) 1.68 F(2.13) 1.73	F(1.79) 0.81 F(4.73) 1.17
Heteroscedasticity (Engle (1982))	F(1.15) 0.18	F(1.79) 1.87 F(4.73) 3.53
Misspecification (Ramsey (1969))	F(1.16) 0.47	F(1.80) 0.06
Normality (Jarque and Bera (1980))	$X^2(2)$ 0.08*	$X^2(2)$ 0.57*

* - significant at 5%-level

estimation procedure. As can be seen, the coefficients are reasonably stable until 1985, but then there is an upward tendency for both coefficients. For the annual equation it seems that the value of the elasticity reachs a peak in 1986 and returns to the level from the first part of the 1980s in 1989. The standard deviation, calculated by the method described in Bårdsen (1989), is very large in periods of instability. The pattern of the estimated coefficients in the quarterly equation is somewhat different. The rise of the coefficient in 1985/86 is smaller than for the annual model and the value remains at the higher level in the last part of the 1980s. The deviation of the development of the coefficients is related to the difference of specification, in particular it seems that the inclusion of the interest rate variable in the annual model contributes to bring the value of the coefficient down again. This effect is not present in KVARTS since the nominal interest rate turned out to be insignificant.

In a similar manner we have investigated the stability properties of the short run coefficients in the quarterly model, see figures 12-14. They reveal a trend-like development through the 1970s, but all seem to stabilize more through the 1980s and there are no marked shifts in the values of the coefficients in 1985/86. For the annual equation the picture is less encouraging, see figures 22-24. The first coefficient for the lagged endogenous variable shows an upward trend through the last part of the 1980s, while the second coefficient seems more or less stable until 1986 when the value drops significantly. The interest rate coefficient is also mainly stable through most of the 1980s but a significant upward tendency appears in 1988 and 1989.

To sum up, we can say that there are some instability problems for the long-run coefficients (which are of most importance) connected to the period 1985/86. Even if the instability of the estimated coefficients looks severe, the values in the period of instability do not deviate much from former values (especially in the quarterly equation), and seems to return to the level of the former values after the effects of the shocks in 1985/86 (in particular in the annual equation).

3.2 On the allocation of non-durable consumption to subcategories

3.2.1 The treatment of foreigners' consumption in Norway

Before constructing the distributional system, the consumption figures have been adjusted for foreigners' consumption in Norway. Total consumption by foreigners, $C70_t$, is endogenous in both KVARTS and MODAG and determined in an export equation. To correct for this export also at the disaggregate level, we use constant shares. If we let CPi_t denote consumption of category i in period t by Norwegian citizens and Ci_t the sum of CPi_t and export category to foreigners in period t, we can write down the following two equations which have been applied in KVARTS and MODAG respectively

$$CPi_t = (1 - s_i)Ci_t/10000 \tag{14}$$

$$CPi_t = (1 - s_i)Ci_t \tag{15}$$

The normalization in equation (14) is done because our estimation procedure requires not too different levels for the data series to work well. A companion normalization has not been undertaken on annual data because the allocation system in MODAG is based on a per capita framework. The following values for s_i are applied: $s_{00} = 0.1; s_{11} = 0.04; s_{14} = 0.15; s_{20} = 0.08; s_{21} = 0.08; s_{60} = 0.49$ and $s_{61} = 0.06$. For the other consumption categories no consumption of foreigners is assumed. The fractions add to one. Our choice of weights is to a large extent in line with Cappelen (1985) who calculated weights to be used in the national accounts. It should be noted that aggregating the price indices using the same constant shares produces a price index for total consumption by foreigners which differs somewhat from the official one, which is based on a much more detailed commodity level. Thus implicitly there is a discrepancy between the value of foreigners' consumption from the official national accounts and the definition used in our analysis.

3.2.2 A submodel for the allocation of energy consumption to electricity and fuel in MODAG.

It is well known that in the static LES-system with positive "necessity quantities" all commodities are alternative provided certain regularity conditions are fulfilled. Although we are working within the framework of a dynamic LES-system, we want to give special attention to alternativity in energy consumption. Because of this energy consumption is modelled as a two step decision. The theoretical point of departure at the lower decision level, where the value of energy consumption is allocated to electricity ($CP12_t$) and fuel ($CP13_t$) respectively, is the maximization of a CES-function.

The following equation has been estimated on annual data using ordinary least squares

$$log(\frac{CP12_t}{CP13_t}) = f_0 + f_1 \cdot log\left(\frac{HC40_{t-1}}{BEF_{t-1}}\right) + f_2 \cdot log(\frac{PC12_t}{PC13_t}) + f_3 \cdot log(\frac{CP12_{t-1}}{CP13_{t-1}}) + v_t \quad (16)$$

In this equation the log of the ratio between consumption of electricity and fuel depends on the log of the lagged stock of other durable goods divided by the lagged size of the population, $\frac{HC40_{t-1}}{BEF_{t-1}}$, the log of the price ratio between electricity and fuel and the lagged left hand side variable. The reason for incorporating the first variable is to pick up effects which influence the consumption ratio but which cannot be accounted for by changes in relative prices. In fact heating is the only area in which changes in relative prices have substitution effects. For the capital stock of other durable goods to yield utility, input of electricity is necessary in Norway. Thus our prior is that the sign of f_1 in (16) is positive. The lagged endogenous variable in (16) is introduced in order to model the sluggishness of the adjustment of the consumption ratio coming from a change in relative prices. The size of the parameter f_3 is rather important because it contains information with respect to how fast consumers adapt. If we let ^ denote an estimated value, we may write the long run solution connected to the above equation as

$$log(\frac{CP12_t}{CP13_t}) = \frac{\hat{f}_0}{1-\hat{f}_3} + \frac{\hat{f}_1}{1-\hat{f}_3} log\left(\frac{HC40_{t-1}}{BEF_{t-1}}\right) + \frac{\hat{f}_2}{1-\hat{f}_3} log(\frac{PC12_t}{PC13_t}) + \frac{\hat{v}_t}{1-\hat{f}_3} \quad (17)$$

To introduce a more convenient notation let

$$\hat{f}_i^* = \frac{\hat{f}_i}{1-\hat{f}_3}, \quad i = 0, 1, 2 \quad (18)$$

$$\hat{v}_t^* = \frac{\hat{v}_t}{1-\hat{f}_3} \quad (19)$$

Inserting this into (17) yields

$$log(\frac{CP12_t}{CP13_t}) = \hat{f}_0^* + \hat{f}_1^* log\left(\frac{HC40_{t-1}}{BEF_{t-1}}\right) + \hat{f}_2^* log(\frac{PC12}{PC13}) + \hat{v}_t^* \quad (20)$$

This equation can be deduced from a situation where the households maximize a CES-aggregate of energy goods, $CPCU_t$, given total expenditure on energy consumption. The following function is assumed

$$CPCU_t = (\delta_t^*(\frac{CP12_t}{\delta_t^*})^{-\zeta} + (1-\delta_t^*)(\frac{CP13_t}{(1-\delta_t^*)})^{-\zeta})^{-\frac{1}{\zeta}} \tag{21}$$

From the first order condition for internal maximum one gets the following equation

$$log(\frac{CP12_t}{CP13_t}) = log(\frac{\delta_t^*}{1-\delta_t^*}) - \frac{1}{1+\zeta} log(\frac{PC12_t}{PC13_t}) \tag{22}$$

The question is now how we can identity δ_t^* and ζ from the estimated long-run parameters from equation (16). Again we start by some simplification of the notation

$$\hat{f}_t^* = \hat{f}_0^* + \hat{f}_1 \cdot log\left(\frac{HC40_{t-1}}{BEF_{t-1}}\right) + \hat{v}_t^* \tag{23}$$

Setting terms equal to each other in equation (20) and (22) yields

$$log(\frac{\hat{\delta}_t^*}{1-\hat{\delta}_t^*}) = \hat{f}_t^* \quad , \quad \hat{f}_2^* = -\frac{1}{1+\hat{\zeta}} \tag{24}$$

Equation (24) can be solved for $\hat{\delta}_t^*$ which gives

$$\hat{\delta}_t^* = \frac{e^{\hat{f}_t^*}}{1+e^{\hat{f}_t^*}} \tag{25}$$

It should be noted that this parameterization ensures that δ_t^* lies within the unit interval. The parameter ζ is identified by

$$\hat{\zeta} = -\frac{1}{\hat{f}_2^*} - 1 \tag{26}$$

From relations (20) and (23) it can be seen that the long-run residual term v_t^* enters in the expression of $ln(\frac{\hat{\delta}_t^*}{1-\hat{\delta}_t^*})$. The reason for this is that unless this calibration is undertaken the following equation will not hold for every period of time

$$PCCU_t \cdot CPCU_t = PC12_t \cdot CP12_t + PC13_t \cdot CP13_t \tag{27}$$

In this equation $PCCU_t$ is the price of the energy aggregate and it can be found from the dual optimization problem where expenditure on energy consumption is minimized given $CPCU_t$. The formula for the dual price is

$$PCCU_t = [\hat{\delta}_t^* PC12_t^{\frac{\hat{\zeta}}{1+\hat{\zeta}}} + (1-\hat{\delta}_t^*) PC13_t^{\frac{\hat{\zeta}}{1+\hat{\zeta}}}]^{\frac{\hat{\zeta}+1}{\hat{\zeta}}} \tag{28}$$

For simulation purposes equations (16), (21), (27) and (28) have been implemented in MODAG. The idea is now the following. The variable $CPCU_t$ enters an allocation system on a higher level and may be labeled demand for energy. The dual price can be determined from the prices of electricity and fuel. For given values of $CPCU_t$ and $PCCU_t$, $CP12_t$ and $CP13_t$ can be determined from the equations (17) and (27).

The estimation results are given in table 4 below

Table 4: Estimation results for the parameters in the subsystem of energy consumption in MODAG.

Parameter	Value	t-statistic
f_0	0.657	1.670
f_1	0.197	1.545
f_2	-0.131	-1.661
f_3	0.749	5.626
f_2^*	-0.522	
R^2	0.950	
SER	0.094	
DW	1.677	

Estimation period: 1963-1989

As it can be seen from the estimation results f_1 has the right sign but the coefficient is not very significant. The long-run elasticity of substitution is the negative of f_2^*. The size of this parameter is somewhat lower than obtained in some other studies but this may be due to the real capital variable which tends to take away a part of the price effect.

The within sample forecasting properties for $CP13_t$ has been disappointing when simulating the consumption block. Much of the variation in fuel consumption cannot be accounted for by the estimated model. Several explanations can be given. All the variables, apart from the fuel variable, show a positive trending behaviour through most of the sample period. This is driven by the real income growth of the household sector. The real income growth has also a partial positive effect on fuel consumption. However the income effect has been counteracted by a change in the relative price between electricity and fuel in disfavour of fuel over the sample period as a whole.

At the microeconomic level the consumption of fuel is closely related to the choice of the type of capital equipment in the households. The choice of capital equipment may be regarded as a function of contemporaneous and expected future values of the relative price between electricity and fuel and a real income measure. Given the choice of capital equipment, the type of energy input may be considered as given. The effect of changes in energy prices given these assumptions are twofold. In the first place changes in relatively prices may initiate an investment decision based on another technology which has now become relatively cheaper. In the second place changes in energy prices may change the degree of utilization of the existing equipment. Since the fuel price has been rather volatile over the sample period, it is of great interest to know how agents at the micro level change their expectations when the relative price between electricity and fuel changes substantially. The decisive point is whether the change is viewed as permanent or temporary. Because of this rather complex structure it is difficult to pick up the macroeconomic consequences of changes in relative prices using only aggregate time series.

In modelling energy consumption it may also be important to pick up effects associated with changes in the temperature. Since the average temperature influences the demand for energy it should have been introduced directly into the expenditure system. Furthermore, since it can be argued that temperature influences electricity and fuel consumption differently, temperature effects should be included at both the upper and the lower level in the expenditure system. However, this will reduce the degrees of freedom beyond an already strained situation.

The temperature aspect is even more accentuated when working with quarterly data. In the last part of the 1980's Norway experienced unusual high middle temperatures in the first and fourth quarter of the calendar year ("mild winters"). This last feature has the potential to contaminate the interpretation of the seasonal parameters in the estimated allocation system.

3.2.3 A submodel for the allocation of energy consumption to electricity and fuel in KVARTS

To model the allocation of energy consumption using quarterly data we initially tried to treat energy consumption as we do with annual data. An equation corresponding to (16) with longer lags and deterministic dummies was estimated. However, the estimated elasticity of substitution was over 3, which seems unrealistically high. We decided to follow another approach where the connection to economic theory was somewhat relaxed. The following general specification is postulated

$$\begin{aligned} W12_t &= E_0^* + \textstyle\sum_{i=1}^4 E_i^* W12_{t-i} + \sum_{i=0}^4 E_{5+i}^* \log\left(\frac{PC12_{t-i}}{PC13_{t-i}}\right) \\ &+ \textstyle\sum_{i=0}^4 E_{10+i}^* \log\left(\frac{VCEN_{t-i}}{PCEN_{t-i}}\right) + \sum_{i=1}^5 E_{15+i}^* (DSi_t - DS4_t) + \varepsilon_{12t}^* \end{aligned} \tag{29}$$

In equation (27) $W12_t$ is the share of electricity expenditure out of total energy expenditure ($VCEN_t$), whereas $PCEN_t$ is the price of total energy consumption which is defined in the following manner

$$PCEN_t = \frac{VCEN_t}{CP12_t + CP13_t} = \frac{VCEN_t}{CPEN_t} \tag{30}$$

The parameters are labeled E_i^* and the error term ε_{12t}^*. The DSi_t-variables are seasonal dummies. After having omitted insignificant variables the following equation is retained

$$\begin{aligned} W12_t &= E_0 + E_1 W12_{t-1} + E_2 W12_{t-3} + E_3 \cdot W12_{t-4} + E_4 \log\left(\frac{PC12_t}{PC13_t}\right) \\ &+ E_5 \log\left(\frac{PC12_{t-4}}{PC13_{t-4}}\right) + E_6 \log\left(\frac{VCEN_t}{PCEN_t}\right) + E_7 \cdot \log\left(\frac{VCEN_{t-1}}{PCEN_{t-1}}\right) \\ &+ E_8 \cdot \log\left(\frac{VCEN_{t-3}}{PCEN_{t-3}}\right) + E_9 \cdot (DS2_t - DS4_t) + \in_{12t} \end{aligned} \tag{31}$$

Equation (31) was estimated by ordinary least squares and the results are given in table 5.

The following long-run solution is obtained from (31) when disregarding the stochastic error term

$$W12_t = \text{Deterministic part} - 0.097 \log\left(\frac{PC12_t}{PC13_t}\right) + 0.222 \log\left(\frac{VCEN_t}{PCEN_t}\right) \tag{32}$$

According to equation (32) a one percent partial increase in the total expenditure on energy, $VCEN_t$, gives a 1.3 percent increase in the long run consumption of electricity, $CP12_t$, whereas a one percent partial increase in the price of electricity, $PC12_t$, gives a long run decrease of 1.1 percent. Both elasticities are calculated at the sample mean value of $W12_t$ (0.076).

Table 5: Estimation results for the parameters in the subsystem of energy consumption in KVARTS

Parameter	Value	t-statistic
E_0	0.036	0.829
E_1	0.295	3.420
E_2	0.186	2.345
E_3	0.447	5.071
E_4	0.072	4.651
E_5	-0.079	-4.957
E_6	-0.111	-4.458
E_7	0.162	4.660
E_8	-0.035	-1.795
E_9	-0.080	-3.795
R^2	0.930	
DW	1.99	
SER	0.020	

Estimation period 1967.1 to 1989.4

3.2.4 The sub-system for non-durable transport consumption in MODAG.

This second subsystem contains the variables $CP14_t$ and $CP61_t$ which is directly connected to a further decomposition of the variable $CP61_t$ which has been done in Magnussen and Stoltenberg (1991). In this subsystem we allocate total expenditure on non-durable transport activities by resident households to operation of personal transport equipment ($CP14_t$) and consumption of public transport services and communication ($CP61_t$) using a dynamic linear expenditure system formulated on per capita basis and extended with effects from the capital stock of cars, $HC30_t$. The reason for including this variable is the belief that an increase in the stock of cars reflects a preference change in favour of private transport services. The subsystem is

$$\frac{CPi_t}{BEF_t} = \gamma_{it} + \frac{\beta i}{PCi_t}[\frac{VCTR_t}{BEF_t} - \sum_k PCi_t\gamma_{it}] \tag{33}$$

where $i, k \in \{14, 61\}$

$$\gamma_{14t} = \gamma_{14.0} + \gamma_{14.1}\frac{CP14_{t-1}}{BEF_{t-1}} + \gamma_{14.2}\frac{HC30_{t-1}}{BEF_{t-1}} \quad \forall t \tag{34}$$

$$\gamma_{61t} = \gamma_{61.0} + \gamma_{61.1}\frac{CP61_{t-1}}{BEF_{t-1}} \quad \forall t \tag{35}$$

$$VCTR_t = PC14_t \cdot CP14_t + PC61_t \cdot CP61_t \tag{36}$$

In equation (33) $VCTR_t$ is total expenditure on non-durable transport consumption whereas BEF_t is the population size. Equation (33) may be derived from a utility-maximization problem but the subsequent estimation results gave coefficients which to some extent could not be reconciled with the necessary regularity conditions and for that reason the dual price index could not be calculated in every period of the sample. Because of this a more pragmatic route of action was taken. At the upper stage the following variables were used

$$CPTR_t = CP14_t + CP61_t \tag{37}$$

$$PCTR_t = \frac{PC14_t \cdot CP14_t + PC61_t \cdot CP61_t}{CPTR_t} \tag{38}$$

However, this means that it is impossible to solve for the variables at the upper level first and thereafter solve for the variables $CP14_t$ and $CP61_t$. For simulation purposes the following equations are implemented: The equation for $CP14_t$ in (33), equation (36), equation (37) and finally the following equation

$$PCTR_t = \frac{VCTR_t}{CPTR_t} \tag{39}$$

which can be deduced by combining (36) and (38).

The parameters in (33) were estimated by applying FIML to the first equation of this system. Since the estimated value of $\gamma_{61.0}$ was highly insignificant it was restricted to zero. The estimation results are given in table 6 below.

The positive value of $\gamma_{14.2}$ means that an increase in the stock of cars reallocates consumption in favour of operation of personal transport equipment. This result is in accordance with our apriori belief, but the coefficient is not very significant. In the model which has been implemented in MODAG the value of $\gamma_{61.0}$ has been restricted to zero because of its insignificance. Furthermore $\gamma_{61.1}$ is very close to unity which indicates very slow adjustment and stability problems.

Table 6: Estimation results for the subsystem of non-durable transport consumption in MODAG

Parameter	Value	t-statistic
β_{14}	0.741	15.441
$\gamma_{14.1}$	0.003	1.279
$\gamma_{14.2}$	0.042	1.385
$\gamma_{14.3}$	0.375	1.193
$\gamma_{61.1}$	0.999	13.871
R^2	0.997	
SER	0.001	
DW	1.974	

Estimation period: 1963-1989

3.2.5 The expenditure system in KVARTS and at the upper level of MODAG

In this section the allocation system at the top level of KVARTS and MODAG are presented. For both models the underlying theoretical assumption of behaviour is based on consumers maximizing a utility function given total expenditure on non-durables. Assuming weak separability between non-durables and durables allows to model consumption of the different non-durable categories as functions of only prices on non-durables and total expenditure on non-durables. The exact form of the implemented equations are somewhat different in KVARTS and MODAG which necessitates a separate treatment. We start out by describing the upper level allocation system in KVARTS and proceed later to that of MODAG.

The expenditure system in KVARTS

To allocate total expenditure on non-durables to different subcategories our point of departure is a parameter-varying version of the Stone-Geary utility function (cf. Stone (1954) and Frisch (1954)). The utility function in period t can be written as

$$U_t = \sum_{i \epsilon I} \beta_i ln(CPi_t - \phi_{it}) \tag{40}$$

In equation (40) the β_i's represent the Engel derivatives which are assumed to be constant parameters and scaled such that $\sum \beta_i = 1$. For the ϕ_{it}'s, which are often referred to as "necessity quantities", we operate with different assumptions which will be described below. The reason for this is that we are interested in studying a possible habit formation behaviour. Furthermore it may take time to adjust consumption of the different categories to changes in the exogenous variables (cf. Phlips (1972)). Maximization of (40) given the budget constraint leads us to the following expenditure system written out in volume form after allowance for seasonal and stochastic effects

$$\begin{aligned} CPi_t = \; & \phi_{it} + (\beta_i / PCi_t) \cdot [VCIV_t - \textstyle\sum_{i \epsilon I} PCi_t \cdot \phi_{it}] + \\ & \tfrac{PCIV_t}{PCi_t} \textstyle\sum_{k \epsilon I} \sum_{j=1}^{3} (Sj_k + SSj_k \cdot S_t)[DSj_t - DS4_t]/10 + ui_t \end{aligned} \tag{41}$$

The character I denotes a set containing the consumption category suffixes: $I = \{00, 11, \text{en}, 14, 20, 21, 60, 61, 66\}$. Using equation (41) we can then calculate $CP00_t, CP11_t, CPEN_t, CP14_t, CP20_t, CP21_t, CP60_t, CP61_t$ and $CP66_t$. In addition we also have the following formulas

$$PCen_t = \frac{PC12_t \cdot CP12_t + PC13_t \cdot CP13_t}{CP12_t + CP13_t} \tag{42}$$

$$CPen_t = CP12_t + CP13_t \tag{43}$$

$$VCIV_t = \sum_{i \epsilon I} PCi_t \cdot CPi_t \tag{44}$$

$$PCIV_t = \frac{VCIV_t}{\sum_{i \epsilon I} CPi_t} \tag{45}$$

Furthermore the seasonal dummy variables DSj_t takes the value 1 in the j'th quarter and zero otherwise. The variable S_t is a dummy variable which is 1 until 1978.1 and 0 thereafter. The reason for including this variable is possible changes in the seasonal pattern due to changes in national accounting practice. Sj_i and SSj_i are parameters connected to the seasonal dummy variables and to the variable S_t. The variables ui_t are error terms.

From the adding-up condition in value it follows that

$$\sum_{i \epsilon I} \beta_i = 1 \tag{46}$$

$$\sum_{i \epsilon I} Sj_i = 0 \quad \text{for } j = 1, 2 \text{ and } 3 \tag{47}$$

$$\sum_{i \epsilon I} SSj_i = 0 \quad \text{for } j = 1, 2 \text{ and } 3 \tag{48}$$

$$\sum_{i \epsilon I} PCi_t ui_t = 0 \tag{49}$$

In this paper we operate with five different variants with respect to the modelling of the ϕ_{it}'s to capture habit formation and sluggish adjustment behaviour. These five options are labelled

$$\begin{array}{ll} I) & \phi_{it} = \phi_{i1} \quad \text{for all } t \\ II) & \phi_{it} = \phi_{i1} + \phi_{i2} VCIV_{t-1} \\ III) & \phi_{it} = \phi_{i1} + \phi_{i2} VCIV_{t-1} + \phi_{i3} VCIV_{t-4} \\ IV) & \phi_{it} = \phi_{i1} + \phi_{i4} CPi_{t-1} \\ V) & \phi_{it} = \phi_{i1} + \phi_{i4} CPi_{t-1} + \phi_{i5} CPi_{t-4} \end{array} \tag{50}$$

The models have been estimated by full information maximum likelihood using the sample 1967.2 to 1990.4. Because of the adding up condition singularity is introduced in the variance covariance matrix. This is usually handled by omitting one of the equations and this route of action has also been followed here. The invariance property of the estimation procedure with respect to which equation omitted, has not been investigated. Pollak and Wales (1969) used a stochastic parameter approach in their maintained stochastic specification which fulfilled the invariance condition. Barten (1969) proved the invariance property within another type of expenditure system but did not allow for dynamic effects in the model. Let u_t be the column vector which consists of the residual terms in the first eight equations in (41). The stochastic assumptions are then:

$$E(u_t) = 0_{8*1} \quad \text{for all } t \tag{51}$$

$$E(u_t u_t^T) = \Gamma_{8*8} \quad \text{(symmetric and unrestricted) for all } t \tag{52}$$

$$E(u_t u_s^T) = 0_{8*8} \quad \text{for all } t \text{ and } s, \text{ where } t \text{ is different from } s. \tag{53}$$

In the expenditure system we use seasonal dummies to pick up deterministic seasonal effects. In model V where the endogenous variables lagged four periods are introduced, we also allow for stochastic seasonal effects. The relative prices ($PCIV_t/PCi_t$) have been included multiplicatively to the seasonal variables to preserve the homogeneity of zero property in prices and total expenditure.

Table 7. Estimation results for the expenditure system implemented in KVARTS (model V) with t-values in brackets.

Consumption category	Parameters									
	β_i	$\varphi_{i,1}$	$\varphi_{i,4}$	$\varphi_{i,5}$	$S1_i$	$S2_i$	$S3_i$	$SS1_i$	$SS2_i$	$SS3_i$
00	0.242 (17.429)	1.677 (2.677)	0.163 (2.511)	0.524 (9.623)	0.615 (0.358)	-0.578 (0.826)	-1.364 (-2.858)	1.861 (-4.174)	-1.585 (-3.281)	1.993 (3.347)
11	0.110 (8.706)	0.612 (1.813)	0.261 (3.943)	0.350 (5.147)	-1.175 (-1.916)	1.490 (2.967)	-1.029 (-2.365)	0.919 (1.437)	1.086 (2.390)	0.509 (1.187)
en	0.045 (5.748)	0.805 (6.826)	0.155 (2.753)	0.586 (8.771)	5.463 (7.179)	-5.777 (-4.600)	-4.672 (-6.563)	-2.514 (-4.436)	2.919 (3.628)	2.336 (4.166)
14	0.075 (8.412)	-0.205 (-2.125)	0.474 (6.876)	0.333 (5.157)	1.066 (2.287)	0.292 (0.746)	-1.175 (-3.578)	0.367 (0.828)	4.000 (7.714)	-2.892 (-5.426)
20	0.118 (20.702)	-0.236 (-1.337)	0.409 (10.823)	0.443 (11.268)	-5.242 (-7.504)	0.722 (2.089)	-0.374 (-1.323)	3.518 (8.690)	-1.598 (-4.427)	2.337 (6.453)
21	0.143 (19.060)	1.224 (4.185)	0.213 (4.106)	0.269 (4.883)	-4.025 (-4.003)	-0.585 (-1.122)	-3.774 (-8.430)	-1.671 (-3.334)	0.692 (1.480)	0.519 (1.103)
60	1.113 (10.307)	-0.591 (-2.139)	0.446 (6.257)	0.460 (6.404)	2.844 (5.317)	0.097 (0.228)	2.370 (5.634)	-1.313 (-2.451)	-2.409 (-4.589)	-1.416 (-2.842)
61	0.027 (7.507)	-0.112 (-1.615)	0.515 (6.537)	0.438 (5.390)	-0.008 (-0.029)	0.870 (3.321)	-0.060 (-0.287)	0.392 (1.281)	0.256 (0.849)	1.400 (4.348)
66	0.127	-1.018 (-4.173)	0.483 (7.424)	0.408 (6.360)	*)	*)	*)	*)	*)	*)

*) The parameter can be estimated from the adding up restriction.

Table 8: Single equation statistics for model V; the model implemented in KVARTS

Consumption category	RSQ	CRSQ	SSR	SER	DW	RRSME*)
00	0.986	0.978	3.372	0.243	1.816	1.730
11	0.872	0.797	4.747	0.289	1.888	6.403
en	0.973	0.957	4.175	0.271	2.001	
14	0.977	0.964	1.489	0.162	2.020	9.650
20	0.996	0.993	0.827	0.120	2.462	1.796
21	0.978	0.965	2.089	0.191	1.990	3.462
60	0.975	0.961	2.953	0.228	1.798	4.372
61	0.976	0.963	0.645	0.106	2.446	3.756
....						
12				7.139		
13				19.780		
66				10.440		

*) RRSME is calculated on basis of dynamic simulation of the expenditure system, i.e. the variable VCIV is treated as exogenous. The simulation period starts in 1968.2 and ends in 1990.4

The estimation results are given in tables 7 and 8. Using a FIML-approach it is possible to do some testing applying the LR-test. However the LR-statistic can only be used when a "restrictive" model is nested within a more general model. For the expenditure models investigated in this paper we have a combined nested/non-nested structure. Models I, II and III are hierarchically nested whereas the same is true for models I, IV and V. Let l_i denote the log-likelihood value attached to model i and let furthermore l_j denote the log-likelihood value to model j which is nested within model i. The statistic $T = -2[l_j - l_i]$ is then asymptotically χ^2 distributed with the number of degrees of freedom corresponding to the number of restrictions when going from the general to the more restricted model. The log-likelihood value for the different models are $l_I = 217.73, l_{II} = 308.04, l_{III} = 327.015, l_{IV} = 310.84$ and finally $l_V = 387.431$. From this we can draw the conclusion that model I and II are both rejected against model III, and model I and IV are both clearly rejected against model V. Thus evidence is found for inclusion of dynamic effects in the expenditure system. As noted earlier model III and V are non-nested and cannot be tested against each other by the LR-principle. Because model V picks up dynamic effects somewhat more flexible than model III, the former has been preferred. Model V may also be tested against models where the deterministic dummy variables have been omitted and the conclusion seems to be that these variables cannot be omitted without a significant loss of explanatory power.

When $CPi_t < \phi_{it}$ for any combination of i and t we get problems with the interpretation of the demand system since it no longer can be asserted that the estimated equations can be deduced from utility maximization. This problem suggests the application of some constrained optimization routine where the parameters are restricted to lie in a set which fulfill $CPi_t > \phi_{it}$ for every i and t. The applied estimator does not take such constraints under consideration. In all the five estimated models there are some occurrence of the problem stated above. However for model V which is our preferred model and which will be used in the (deterministic) simulation part of the paper, $CPi_t < \phi_{it}$ occurs only in a few cases.

It can be seen from table 7 that all the short-run Engel derivatives are positive in all the models. Short-run Engel and Cournot elasticities can be calculated for instance in some point describing the sample mean. Because of the dynamic effects and because of the functional form medium- and long-run elasticities will deviate substantially from the short-run effects. Instead of calculating analytical expressions for the medium- and long-run elasticities, we calculate elasticities by simulations later in this paper. It is of great interest to investigate the stability properties of the chosen dynamic model. However, we are confronted with a model that is non-linear in the variables since the lagged endogenous variables enter multiplicatively to the prices. As a simplification assume that all prices are equal to 1 as in the base year. Under this assumption we can write down the expenditure system with the last equation and the error term omitted as

$$CP_t = A_4 CP_{t-1} + A_5 CP_{t-4} + A_x X_T + \phi_1^T + \beta\phi_1 \qquad (54)$$

where

$$CP_t = [CP00_t; CP11_t; CPen_t; CP14_t; CP20_t; CP21_t; CP60_t; CP61_t]^T \qquad (55)$$

$$A_i = A_i^* - \beta\phi_i;\ i = 4, 5 \qquad (56)$$

$$A_i^* = DIAG[\phi_{00,i}; \phi_{11,i}; \phi_{en,i}; \phi_{14,i}; \phi_{20,i}; \phi_{21,i}; \phi_{60,i}; \phi_{61,i}];\ i = 4, 5 \qquad (57)$$

$$\beta = (\beta_{00}; \beta_{11}; \beta_{en}; \beta_{14}; \beta_{20}; \beta_{21}; \beta_{60}; \beta_{61})^T \qquad (58)$$

$$\phi_i = (\phi_{00,i}; \phi_{11,i}; \phi_{en,i}; \phi_{14,i}; \phi_{20,i}; \phi_{21,i}; \phi_{60,i}; \phi_{61,i})\ i = 1, 4, 5 \qquad (59)$$

$$A_x = \begin{bmatrix} -\beta_{00}\phi_{66,4} & -\beta_{00}\phi_{66,5} & \beta_{00} & S1_{00} & S2_{00} & S3_{00} & -\sum_{j=1}^{3} Sj_{00} \\ -\beta_{11}\phi_{66,4} & -\beta_{11}\phi_{66,5} & \beta_{11} & S1_{11} & S2_{11} & S3_{11} & -\sum_{j=1}^{3} Sj_{11} \\ -\beta_{en}\phi_{66,4} & -\beta_{en}\phi_{66,5} & \beta_{en} & S1_{en} & S2_{en} & S3_{en} & -\sum_{j=1}^{3} Sj_{en} \\ -\beta_{14}\phi_{66,4} & -\beta_{14}\phi_{66,5} & \beta_{14} & S1_{14} & S2_{14} & S3_{14} & -\sum_{j=1}^{3} Sj_{14} \\ -\beta_{20}\phi_{66,4} & -\beta_{20}\phi_{66,5} & \beta_{20} & S1_{20} & S2_{20} & S3_{20} & -\sum_{j=1}^{3} Sj_{20} \\ -\beta_{21}\phi_{66,4} & -\beta_{21}\phi_{66,5} & \beta_{21} & S1_{21} & S2_{21} & S3_{21} & -\sum_{j=1}^{3} Sj_{21} \\ -\beta_{60}\phi_{66,4} & -\beta_{60}\phi_{66,5} & \beta_{60} & S1_{60} & S2_{60} & S3_{60} & -\sum_{j=1}^{3} Sj_{60} \\ -\beta_{61}\phi_{66,4} & -\beta_{61}\phi_{66,5} & \beta_{61} & S1_{61} & S2_{61} & S3_{61} & -\sum_{j=1}^{3} Sj_{61} \end{bmatrix} \quad (60)$$

$$X_t = [CP66_{t-1}; CP66_{t-4}; VCIV_t; DS1_t/10; DS2_t/10; DS3_t/10; DS4_t/10]^T \quad (61)$$

For the vector-process CP_t to be stationary it is necessary that the roots of the following equation all lie outside the unit circle

$$|I - A_4B - A_5B^4| = 0 \quad (62)$$

where B is the backward operator. The matrices A_4 and A_5 can be estimated from the available data and the length of the roots can be calculated given the estimated matrices giving an indication of a possible presence of unit or explosive roots. Equation (62) has 32 roots. The Troll programme Limo (1983) has been applied to calculate the roots[1]. The magnitude of the five lowest roots, which all are real, are 1.022, 1.047, 1.074, 1.093 and 1.104. Thus we have roots almost on the unit circle. These low roots mean that the adjustment following exogenous shocks takes very long time. Furthermore the calculated roots are subject to sampling and it is possible that for instance a 95 percent confidence interval would cover the unit root and even some part of the explosive area. Since the expenditure system is non-linear in the variables the model must be linearized before calculating the roots. From this it follows that the magnitude of the roots may depend on in which sample point one choose to linearize the model. A natural extension, which has not been undertaken, may therefore be to linearize in different points to see how robust the roots are with regard to the non-linearities.

The expenditure system at the upper level in MODAG

In contrast to KVARTS, MODAG has a dynamic consumer allocation system formulated on a per capita basis and for that reason the way of modelling the allocation of non-durable consumption is more in accordance with a representative

[1] We thank Martin Moe for having performed the necessary calculations

consumer approach. (To be consistent we should also have used the per capita formulation when modelling the quarterly data. However, while population variables play an important role in MODAG, the same is not true for KVARTS. Furthermore, there are no official quarterly population data so we need to apply linear interpolation to calculate quarterly population series.) The equations to be estimated may be considered to be deduced from maximization of the following Stone-Geary utility function

$$U_t = \sum_{i \in J} \beta_i ln(\frac{CPi_t}{BEF_t} - \phi_{i,t}) \tag{63}$$

where $J = \{00, 11, cu, tr, 20, 21, 60, 66\}$

Special attention should be paid to the third and fourth element of this set since these variables are directly related to the allocation system at the lower stage. As in the quarterly model "the necessity quantities" are given a dynamic formulation to take account of habit formation properties

$$\phi_{i,t} = \phi_{i,o} + \phi_{i,1} \frac{CPi_{t-1}}{BEF_{t-1}} \tag{64}$$

The maximization problem described above gives us the following system of demand equations written out in volume form after addition of stochastic terms

$$\frac{CPi_t}{BEF_t} = \phi_{it} + \frac{\beta_i}{PCi_t}(\frac{VCIV_t}{BEF_t} - \sum_{i \in J} PCi_t \cdot \phi_{it}) + \epsilon_{it}$$

The adding-up condition

$$\sum_{i \in J} PCi_t \cdot CPi_t = VCIV_t \tag{65}$$

implies that

$$\sum_{i \in J} \beta_i = 1 \tag{66}$$

and

$$\sum_{i \in J} PCi_t \epsilon_{it} = 0 \tag{67}$$

This system has been estimated by full information maximum likelihood. The assumptions for the distribution of the errors correspond to what was assumed for the quarterly data. The estimation results for the parameters in the systematic part of the system are displayed in tables 9 and 10.

The β_i's which are the short run derivatives of the implicit expenditure variables with respect to total expenditure, or equivalent the short run marginal budget shares, can be found in the first column of table 9. The estimated values may be compared to the values obtained for the quarterly model in the first column of table 7. The comparison reveals important differences between the quarterly and the annual model. For instance in the annual model β_{00} and β_{60} are much lower than in the implemented quarterly model, whereas for β_{66} the opposite conclusion can be drawn. Note however that β_{en} in table 7 and β_{cu} in table 9 are not very different even if the way of modelling total energy consumption is quite different in the two models. For the quarterly model some comments were devoted to the long-run properties of the model. Pollak (1970) was interested in the steady state solution of a dynamic linear expenditure system and gave formulas for the calculations of the implicit long-run parameters. Further he stressed in the context of our annual model, that if $\phi_{i,1}$ exceeds one, instability is introduced. From the third column of table 9 it can be seen that $\phi_{cu,1}$ exceeds one which is an indication of the above mentioned problem. Further comments on this will be given in the next section where we calculate different elasticities by simulation.

Table 9: Estimation results for the parameters in the top level expenditure system of MODAG with t-values in brackets.

Consumption category	Parameters		
	β_i	$\varphi_{i,0}$	$\varphi_{i,1}$
00	0.157 (6.750)	0.135 (2.554)	0.735 (13.096)
11	0.085 (3.533)	0.015 (0.437)	0.702 (8.030)
cu	0.024 (1.711)	-0.037 (-1.102)	1.007 (23.814)
TR	0.124 (6.445)	-0.089 (-2.828)	0.877 (23.990)
20	0.126 (10.912)	-0.072 (-2.422)	0.855 (29.998)
21	0.146 (7.238)	0.122 (3.283)	0.376 (4.484)
60	0.172 (4.967)	-0.184 (-2.051)	0.912 (15.016)
66	0.166	0.126 (-2.808)	0.779 (12.482)

Estimation period 1964 to 1989.

Table 10: Single equation statistics for the expenditure system of MODAG.

Consumption category	RSQ	CRSQ	SSR	SER	DW	RRSME*)
00	0.989	0.971	0.004	0.019	2.959	1.095
11	0.900	0.739	0.008	0.028	1.251	6.162
cu	0.975	0.935	0.004	0.019	2.220	6.190
tr	0.995	0.986	0.002	0.015	1.038	4.652
20	0.999	0.996	0.001	0.008	2.016	1.728
21	0.961	0.898	0.003	0.016	1.153	2.674
60	0.977	0.941	0.006	0.024	1.747	3.529
...						
66						7.166
12						8.393
13						9.497
14						8.293
61						5.371

*) RRSME is calculated on basis of dynamic simulation of the expenditure system, i.e. the variable $VCIV_t$ is treated as exogenous. The simulation period starts in 1966 and ends in 1990.

4 Simulation properties and calculation of elasticities

Historic dynamic simulation on the entire consumption blocks has been undertaken for the sample period 1966 to 1990 for MODAG and 1968.2 to 1990.4 for KVARTS. The figures in Appendix C display the graphs for the actual time series together with their simulated values, while table 11 reveals the RRMSE (Relative Root Mean Square Error) attached to the dynamic simulation results for all the endogenous variables. Before commenting on the simulation results in more detail, it should be noted that dynamic simulation only gives limited information of how appropriate the model is. This comes from the fact that in a model with lagged endogenous variables the prediction errors have a tendency to accumulate.

The simulation results for purchase of personal transport equipment, C30, are given in figures 3A and 3B respectively. For this variable a clear cyclical pattern has been experienced over the sample period. Periods of growth have been followed by periods of recessions. This feature is most pronounced in the middle and last part of the 1980's where very high growth occured in 1984, 1985 and 1986 and a significant decrease in the subsequent years. This special development has frequently been associated with the credit liberalization which took place in Norway through the beginning of the 1980's. The termination of the credit rationing regime made it possible to close the gap between the actual and the desired capital stock more quickly than before which very likely initiated the substantial capital accumulation. Gradually the need for a continued accumulation ceased because the gap became smaller. The consumption models fail to predict this pattern. A much smoother behaviour for the simulated series than for the historical ones gives underprediction in the years of high growth and overprediction in the years with recession. As can be seen from the figures, the models also have some problems of explaining the behaviour connected to the minor peak in the second half of the 1970's. For purchase of other durable goods, C40, the dynamic simulation results look much better than for purchase of personal transport equipment. From figures 6A and 6B it can be seen that total consumption of non-durables, CPIV, in both MODAG and KVARTS shows a satisfactory tracking performance over most of the sample period. However, in the second half of the 1980's when total consumption of non-durables as durables first experienced an unusual high growth and thereafter declined, underprediction occurs. The prediction error for total consumption of non-durables is transmitted to the different non-durable consumption groups. Accordingly the prediction errors for the non-durable consumption groups can be decomposed in two parts. The first part is due to the specification of the allocation system itself whereas the other is linked to the prediction errors of total consumption of non-durables. The contributions from these two effects may be calculated by using tables 8,10 and 11. The contribution from the prediction errors of total consumption of non-durables can be calculated by subtracting the RRMSE in the situation where CPIV is endogenous from the RRMSE in the situation where CPIV is viewed as exogenous.

Regarding the subgroups of non-durables, special attention should be devoted to the variables modeled in two stages. This is the case for consumption of electricity, CP12, and consumption of fuel, CP13, in both the annual and quarterly model and for operation of personal transport equipment, CP14, and consumption of public transport services, CP61, in the annual model. From figures 9A, 9B, 10A and 10B it can be seen that consumption of electricity shows a positive trend over the sample period, whereas consumption of fuel seems to be rather stationary and volatile over the sample period. The relation between the actual and simulated data for the consumption of fuel is not encouraging. Both in MODAG and KVARTS huge prediction errors are present and the models fail to explain important features of the actual series. For consumption of electricity the situation is somewhat better, but for substantial periods of time continuous over- and underprediction occur. From figure 9B it seems however, that the clear seasonal pattern is picked up by the quarterly model.

For consumption of public transport services and operation of personal transport services in MODAG significant prediction errors emerge at the end of the sample period. In KVARTS these variables were modeled in only one stage. From table 11 it can be seen that the RRMSE's do not differ substantially between the annual and the quarterly model. Some comments are required for the actual seasonal pattern of these two variables. As can be seen from figures 11B and 15B the quarterly historic time series appear very different before and after 1978.1. After the introduction of new calculation methods in the quarterly national accounts, the actual variables seem to be much smoother because the seasonal fluctuations are more moderate. Even if we have tried to take account of this feature by introducing a dummy variable, we have not succeeded in picking up the seasonal pattern in the first part of the sample for the first variable and the second part of the sample for the other variable. After the structural break, a systematic underprediction occurs for operation of personal transport equipment. On the other hand the model seems to pick up the seasonal movement somewhat better. For consumption of public transport services it is hard to detect a stable seasonal pattern at all after 1978.1.

The prediction results for consumption of clothing and footwear, CP21, are displayed in figures 13A and 13B. Even if the RRMSE's are rather low it is evident that the simulated series behave much smoother than the historical ones.

From tables 8 and 10 it can be seen that R^2 is much lower for consumption of tobacco and beverages, CP11, than for the other consumption groups at the allocation system at the upper level. This goes together with some substantial prediction errors as can be seen from figures 8A and 8B. Especially, the models do only to a limited extent explain the significant drop it the actual series from 1980 to 1982. In the fall of 1982 Norway experienced a strike at the State wine and liquor monopoly. Thus a dummy variable picking up this effect would probably account for a part of the substantial decrease in consumption of tobacco and beverages.

Both in MODAG and KVARTS consumption abroad, CP66, is determined residually from the respective adding-up conditions. One consequence of this is that predictions errors for the other consumption groups, if they all go in the same direction, will to some extent have to be counteracted by significant prediction errors for this consumption group. This may explain why RRMSE, especially in the quarterly model, is rather high.

Table 11: RRMSE statistics for the entire consumption block in KVARTS and MODAG.

Endogenous variables	RRMSE	
	KVARTS	MODAG
CP00	2.5	1.4
CP11	7.1	6.6
CP12	6.7	8.6
CP13	18.1	9.4
CP14	9.6	7.3
CP20	4.2	2.9
CP21	5.1	3.5
CP60	7.4	5.2
CP61	4.9	6.1
CP66	15.7	8.7
C30	25.2	20.2
C40	7.9	6.1
HC30	6.4	5.4
HC40	1.7	1.6
C50	0.9	1.0
CPIV	3.7	2.5

Dynamic simulation over the period 1968.2-1990.4 for KVARTS and 1966-1990 for MODAG

To calculate various elasticities we utilize the above simulated series as a baseline projection and carry out sustained increases in each exogenous variable by 1 percentage from 1975 in MODAG and 1975.1 in KVARTS. The new trajectories may then be compared to the baseline projection and short-, medium- and long-run elasticities can be calculated. The simulated elasticities are given in tables (12) and (13). These tables only contain income elasticities and direct price elasticities. The cross price elasticities have not been tabulated, but they are to some extent commented on below.

From table 12 it can be seen that the immediate effect of an increase in nominal income on non-durable consumption is zero. This property is due to the fact that the term corresponding to such an effect was not found significant in the estimation. In KVARTS, however, an income increase has an immediate effect. After 15 years the income elasticity of non-durables is less than 1, whereas it is over 1 for both durable consumption groups. In this paper we have treated the capital stock of houses as an exogenous variable, but of course this capital stock will also react to income changes through an investment equation. With such an extension we could have deduced the effects on financial savings of an income increase. A reasonable development of the financial saving should be a greatly prized goal for the consumption model.

Table 12 reveals substantial differences between MODAG and KVARTS with respect to medium- and long-run income elasticities for consumption of fuel, CP13. In MODAG the elasticities after 8 and 15 years are -0.09 and 0.42, respectively, whereas the corresponding values in KVARTS are -0.05 and - 0.33. As explained earlier the way of modelling energy consumption is rather different in MODAG and KVARTS. In MODAG a sustained increase in income will have a direct positive effect and an indirect negative on the consumption of fuel, CP13. The positive effect may be associated with the positive, although small, short-run Engel derivatives of energy at the upper level in the allocation system. The negative effect is due to adjustment of the capital stock of other durables, HC40, coming from the increase in income. This reallocates energy consumption in the disfavour of fuel. For consumption of electricity, CP12, both effects work in the same, positive direction. In the long-run, approximated with elasticities after 15 years, it is evident that the direct effect is stronger than the indirect one giving a positive long-run effect on consumption of fuel from a sustained increase in income. In KVARTS the stock variable is not introduced, but even there it is possible to distinguish between two kind of effects from an income increase. An increase in income will increase the expenditure on energy, VCEN. However, at the same time an income increase will decrease the share of fuel expenditure out of total energy consumption. In the long-run the second effect is the most important one.

In KVARTS, changes in the prices of durables have no effects on the consumption of non-durables and changes in the prices of non-durables have no effect on the purchase of durables. Besides, the cross-price elasticities within the group of non-durables are generally of small magnitude both in the short and long-run. In the annual model MODAG it has however been allowed for some influences on the consumption of non-durables from price changes on durables, since the stock variables enter at the second stage of the expenditure system. This introduces a kind of asymmetry since we do not allow for price impulses in the opposite direction. In our two submodels in the allocation system of non-durables the stocks of durable goods, HC30 and HC40 respectively, has been introduced in order to reallocate the consumption within each group. Since the stocks depend on their respective prices, PC30 and PC40, changes in these variables will influence the magnitude of the stocks which again influence the allocation within each subgroup of non-durables.

A one percentage sustained increase in PC30 in 1975 resulted in a long-run cross-price elasticity at -0.83 for the operation of personal transport equipment, CP14. The reduction in consumption of this group was followed by an increase in the consumption of public transport services and communication, CP61, which led to a long-run elasticity of 0.87. Thus an increase in the price of personal transport equipment affects the consumption within this subgroup in the expected direction out of theoretical considerations. In the subgroup for consumption of energy we have earlier explained the reason for incorporating the stock of other durable goods, HC40. The introduction of this stock variable in the allocation systems means that a price change of the variable PC40 will change the distribution within the group. The long-run cross-price elasticities on electricity, CP12, and fuel, CP13 are -0.11 and 0.58 respectively. As for the other subgroup the elasticities again have the expected sign with a moderate magnitude. It can be seen that the elasticity for electricity is much lower than for fuel in absolute value. The reason for this feature is that expenditure on fuel amounts for only a minor part of total expenditure on energy.

Table 12 and 13 also support us with some information concerning the stationarity aspects within the framework of an allocation system. For some of the consumption groups the income and direct price elasticity show a rapid growth, which may be due to stationarity problems, but it is important to keep in mind that the elasticities themselves are functions of the levels of the variables. To look further into this issue, let us discuss the elasticities for the consumption group other consumption services, CP60. From table 13 it can be seen that the income elasticity is growing rapidly in both KVARTS and MODAG. This increase is accompanied by an increase in the absolute value of the direct price elasticity which in MODAG reaches the magnitude of 2.4 at the terminal point. The stationarity feature should have been more thoroughly investigated. One rather easy way to do this is to keep on with dynamic simulation post sample. This requires explicit assumptions about the post sample paths of the exogenous variables.

For the purchase of durable goods a kind of overshooting pattern is revealed in the sense that the short run elasticities are much higher than the elasticities after 8 and 14 years. It should also be noted that the elasticities connected to durables show a stronger tendency to converge than what is the case for non-durables. This feature is linked to the choice of functional form in the single equations. Furthermore the functional form also explains the similiar pattern for the development of the absolute value of the income and price elasticities of the durable goods.

The direct and cross price elasticities connected to changes in prices of non-durables cannot be given a pure Cournot-interpretation. This feature comes from the fact that we have implemented an adding-up condition both in value and volume for the expenditure system. Adding up in value follows from the expenditure system itself, whereas adding up in volume is required to link the expenditure system to the consumption function for non-durables. To reconcile these two conditions the price index for non-durables, PCIV, has to be determined simultaneously with the volume variables in the model. An increase in one of the prices of the non-durables increases the aggregate price index and decreases the total consumption of nondurables, in such a way that the product, i. e. VCIV, increases somewhat. This introduces some compensation for the households.

It is interesting to compare the elasticities obtained from the quarterly and annual data respectively. Out of theoretical considerations the long run elasticities should not diverge substantially. However, especially for the non-durable goods the choice of data frequency seems to have important effects. This fact is of course somewhat disturbing, but one explanation may be that the divergence is due to special effects connected to the startperiod of the KVARTS calculations, the first quarter, which in the model for the annual data is weighted down because effects from the other quarters also are incorporated. One way of tackling this problem may be to use an estimation and calibration approach in which the quarterly data are only utilized to determine the seasonal pattern and deduce the other parameters in the quarterly model from what has been obtained for the annual model. In a dynamic setting this approach is however not straightforward.

Table 12. Percentage effect from a one percent sustained increase in nominal income taking place in 1975 in MODAG and KVARTS[1].

Endogenous variables	Elasticities after									
	0 year		1 year		2 years		8 years		15 years	
	MODAG	KVARTS	MODAG	KVARTS	MODAG	KVARTS	MODAG	KVARTS	MODAG	KVARTS
CP00	0.00	0.11	0.13	0.32	0.32	0.45	0.26	0.50	0.31	0.48
CP11	0.00	0.17	0.21	0.47	0.51	0.65	0.37	0.59	0.43	0.55
CP12	0.00	0.02	0.08	0.06	0.24	0.09	0.83	0.18	1.25	0.28
CP13	0.00	0.03	0.04	0.05	0.09	0.06	-0.09	-0.05	0.42	-0.33
CP14	0.00	0.20	0.44	0.73	1.01	0.94	1.00	1.22	1.03	1.05
CP20	0.00	0.13	0.24	0.45	0.60	0.71	0.78	1.11	0.86	1.07
CP21	0.00	0.18	0.29	0.49	0.60	0.60	0.12	0.47	0.22	0.46
CP60	0.00	0.13	0.35	0.47	0.88	0.77	1.51	1.39	1.77	1.47
CP61	0.00	0.07	0.13	0.28	0.36	0.47	0.99	0.99	1.09	1.17
CP66	0.00	0.36	0.52	1.23	1.17	1.75	1.03	1.68	1.06	2.97
CPIV	0.00	0.13	0.23	0.43	0.57	0.65	0.66	0.90	0.81	0.92
HC30	0.14	0.05	0.44	0.35	0.75	0.66	1.50	1.44	1.46	1.45
HC40	0.23	0.02	0.60	0.22	0.97	0.58	1.30	1.34	1.08	1.04
C30	0.79	1.25	1.81	1.99	2.16	2.18	1.55	1.57	1.49	1.54
C40	1.54	0.72	2.56	2.23	2.85	3.03	0.53	0.80	1.31	1.29

[1] In KVARTS the increase took place in 1. quarter of 1975.

Table 13. Direct price elasticities following from a one percent sustained increase in the different proices taking place in 1975 in MODAG and 1975 1. in KVARTS.

Endogenous variables	Direct price elasticities after									
	0 years		1 year		2 years		8 years		15 years	
	MODAG	KVARTS	MODAG	KVARTS	MODAG	KVARTS	MODAG	KVARTS	MODAG	KVARTS
CP00	-0.14	-0.14	-0.29	-0.31	-0.43	-0.44	-0.58	-0.62	-0.63	-0.64
CP11	-0.26	-0.20	-0.46	-0.39	-0.61	-0.53	-0.84	-0.66	-0.88	-0.66
CP12	-0.13	-0.17	-0.26	-0.20	-0.37	-0.23	-0.77	-0.30	-1.26	-0.31
CP13	-0.13	-0.54	-0.23	-0.53	-0.32	-0.58	-0.66	-0.97	-0.80	-1.35
CP14	-0.28	-0.31	-0.48	-0.68	-0.61	-0.93	-0.55	-1.32	-0.45	-1.27
CP20	-0.29	-0.13	-0.54	-0.39	-0.77	-0.61	-1.30	-1.10	-1.44	-1.16
CP21	-0.33	-0.12	-0.51	-0.33	-0.61	-0.44	-0.59	-0.52	-0.63	-0.54
CP60	-0.40	-0.18	-0.76	-0.46	-1.07	-0.71	-2.13	-1.37	-2.39	-1.54
CP61	-0.11	-0.10	-0.25	-0.25	-0.41	-0.41	-1.12	-1.01	-1.49	-1.26
CP66	-0.63	-0.49	-1.04	-1.03	-1.31	-1.38	-1.91	-2.48	-1.88	-2.78
HC30	-0.13	-0.05	-0.43	-0.34	-0.75	-0.65	-1.48	-1.42	-1.44	-1.43
C30	-0.79	-1.24	-1.80	-1.97	-2.14	-2.16	-1.54	-1.55	-1.47	-1.53
HC40	-0.23	-0.05	-0.59	-0.32	-0.96	-0.57	-1.29	-1.04	-1.07	-1.06
C40	-1.53	-0.71	-2.54	-2.21	-2.82	-3.00	-0.53	-0.80	-1.30	-1.28

5 Comparisons with consumer demand in other macroeconomic models

This section provides a comparison of the consumption blocks in MODAG and KVARTS with consumer demand in three other large scale macroeconometric models. The models to be examined are; ADAM, an annual model of the Danish economy, HERMES, an annual model of the Belgium economy and The London Business School econometric model of the UK economy.

Let us start with ADAM which has much in common with the Norwegian models. The model is e.g. described in Dam (1986) and Heinesen (1988). Private consumption expenditure in ADAM is determined in a hierarchic system. Total consumption is determined in a macro consumption function, formulated as an error-correction mechanism. The explanatory variables are households disposable income and wealth. Earlier versions of MODAG and KVARTS also contained a macro consumption function, but as durable goods have been removed from the expenditure system, this is no longer the case. The consumption function for non-durables has however some common features with the macro consumption function in ADAM. The most important difference is that we have not found any significant wealth effects by using official data in this function.

Gross rents is determined separately in a stochastic technical relationship in ADAM where gross fixed capital of houses is the important explanatory variable. This is in common with the new consumption blocks in MODAG and KVARTS.

Total consumption less gross rents, is in ADAM allocated to several expenditure groups in a dynamic linear expenditure system. The system is dynamic since both lagged consumption and lagged prices are included. For two groups some extra variables are present in the system. The group electricity and fuel is influenced by frost-days, and the group other durable goods is determined by the expected rate of interest on bank loans. Both the use of a linear expenditure system and the allocation to expenditure groups are much the same as in MODAG and KVARTS. One of the consumption groups in the demand system in ADAM is an aggregate of three sub groups; gasoline and oils for transport equipment, personal transport equipment and purchased transport and communication. The reason for this aggregation is that the consumption of these groups are either strong substitutes or complements. Both gasoline etc. and personal transport equipment are determined in more traditional specifications outside the system and the group purchased transport and communication is finally determined as a residual.

Let us then turn to the model HERMES, a model for Belgium economy presented in Bossier et. al. (1989). As is the case in ADAM, total consumption is determined in a macro consumption function. Explanatory variables are net liquid assets and real disposable income adjusted for inflation losses on net liquid assets as in Hendry and von Ungern-Sternberg (1981).

In addition to the macro consumption function, durable goods are determined separately in this model. Explanatory variables in the determination of durables are real disposable income, relative prices (durables vs. non-durables) and a long term real rate of interest. Non-durables are determined residually as total consumption less consumption of durables. The distinction between durables and non-durables is the same as in KVARTS and MODAG but durables goods are divided into three subgroups in the Norwegian models. In addition we are not able to find significant price and interest effects for the Norwegian economy for any of the two groups of durables presented in section 2.

In HERMES, both durable goods and non-durables are allocated by demand systems to smaller expenditure groups, assuming a separable utility function. Durables are first divided to clothing, transport, and furniture and household equipment by a dynamic linear expenditure system. The same kind of system is further used to divide transport to vehicles, fuel for personal transport and transport services. Eventually fuel is spread on petrol, diesel and oils within an almost ideal demand system. Compared to this, clothing are in KVARTS and MODAG treated as a non-durable good. More interesting is the separation of transport where a similar specification is chosen in MODAG, but transport is however divided into two groups and not three as in HERMES and a linear expenditure system is utilized in the Norwegian model. Non-durables less rent, domestic services and medical care are in HERMES allocated to subgroups by an almost ideal demand system. The reason for not including these groups is that they are not likely to be substituted for each other. Except for services this seems reasonable in the short run. As in KVARTS and MODAG a demand system is applied to non-durables but the type of system is different. For instance, power and fuel appear as an aggregate at the upper level of the systems but are separated in sub-systems at a lower level. In HERMES, fuel and power are separate groups in the demand system, but fuel is decomposed into coal, gas and petroleum.

The last model which we take a closer look at is The London Business Schools quarterly model of the UK economy (LBS). The model is described in Dinesis et. al. (1989). Unlike KVARTS and MODAG, but in the same way as both ADAM and HERMES, total consumption is modeled in a macro consumption function in the LBS model. As in HERMES durable goods are determined in a stochastic equation and the third econometric equation in the consumption block determine retail sales. However, there is no expenditure system in the LBS model.

The explanatory variables in the macro consumption function are disposable income, a real interest rate, the rate of inflation and wealth. Wealth is real net financial wealth plus the real value of the housing stock. In this way both flow influences, represented by income, and stock effects, represented by wealth, are present. Explanatory variables in the determination of consumption of durables are in addition to income and a real interest rate a minimum "deposit rate" for durables.

From table 14, which displays the main differences between the four models, we can draw some conclusions. LBS is the only model without a hierarchic system, while KVARTS and MODAG is the only not containing a macro- consumption function. Stock-adjustment approaches for durables combined with demand systems for non-durables are common for ADAM and the Norwegian models.

Table 14: Main differences between the consumption blocks in ADAM, HERMES, KVARTS/MODAG and LBS.

	Model			
	ADAM	HERMES	KVARTS/MODAG	LBS
Hierarchic structure	Yes	Yes	Yes	No
Macrocons. function	Yes	Yes	No	Yes
Wealth-effect	Yes	Yes[1]	No[2]	Yes
Inflation effect	No	No[3]	No[2]	Yes
Stock-adjustment modelling of durables	Yes[4]	No	Yes	No
Demand systems				
Durables	No	Yes	No	No
Non-durables	Yes	Yes	Yes	No

[1] Wealth is here equal to net liquid assets
[2] In the function for non-durables
[3] Real disposable income is however adjusted for inflation losses on net liquid assets
[4] Only personal transport equipment

6 Concluding remarks

From the point of view of economic theory a consistent treatment of consumption of non-durables, purchases of durables and financial savings is highly warranted. In principle this may be obtained by formulating and solving a dynamic optimization problem allowing for a detailed commodity/service classification. However, this must be modified so it is possible to estimate the structural equations corresponding to the solution of the optimization problem. These modifications should always be stated explicitly.

A usual assumption in applied demand work is to impose intertemporal separability in the intertemporal utility function. Such a structure rationalise decentralisation and thereby estimation of one-period allocation systems. Very often estimation of static demand systems on aggregate time series gives a model in which the residuals are not well-behaved. The interpretation of this is that the the pure static system is unable to pick up important features of data. Thus the intertemporal separability assumption should perhaps be replaced by an other assumption which allows for dynamic effects in the allocation systems itself.

In our modelling exercise we have to some extent taken account of this objection since we have allowed for dynamic effects both in the single equations for durables and in the allocation systems for non-durables. However, with regard to the allocation system it is important to bear in mind that allowing for a dynamic structure through the "necessity quantities" implies vital constraints on how the dynamics operates. This suggests that a fruitful route may be to allow for dynamic effects within the framework of flexible functional forms. There is a comprehensive literature on demand systems and flexible functional forms, but usually a static framework, not leading to data congruency, is very often chosen (cf. Leighton 1987). Anderson and Blundell (1983 and 1984) have given important contributions to the dynamic modelling of non-durable demand systems (cf. also Chambers (1990)). They found that their data was not in conflict with a model having the property that the original AIDS-model (cf. Deaton and Muellbauer (1980)) was only valid in the long run. Besides the ability to pick up a substantial part of the dynamic behaviour in data, another important feature of their model is that the long run solution is easily obtained because of the error correcting formulation of the model. However, the AIDS-model extended with short-run dynamics are very demanding in terms of numbers of parameters. Anderson and Blundell using Canadian national accounts data had only four non-durable consumption categories, whereas the numbers of categories in our allocation system for non-durables are ten. A way out of this problem may be to utilize some hierarchical structure allowing multi-stage budgeting. Thus taking account of time non-separability may necessitate intratemporal separability.

A natural extension of the dynamic AIDS-system is to include durable goods and financial assets and to take account of the interactions of these variables both in the short and in the long run. In our consumption modelling the relative price between durables and non-durables was tried both in the consumption function for non-durables and in the the equations for durables, but because of insignificance it was left out of the implemented equations. Thus except that we, for pragmatic reasons, allow for reallocating effects at the second stage in the allocation system in MODAG, there are no price impulses from durables to non-durables or the other way around. However the allocation system and the single equations for durables have not been deduced from a unified optimization problem. A result of this may be that effects from relative prices have been hidden. Besides introducing only relative prices between aggregates we implicitly assume separability between durables and nondurables, again abstracting from the modelling at the second stage of the allocation system of non-durables. This assumption may not be valid and may hide the fact that there are substantial relative price effects between individual non-durables and durables.

For durable goods it is usual to distinguish between purchases and consumption. The consumption of durables is linked to the stock of durables and it is these variables which enter the utility function. This means that purchase of durables may be viewed as a reaction to changes in the optimal stock of different durables. In the modelling of durables two aspects should be stressed. The first aspect is that purchases of durables is closely connected to financial adjustment since they usually are financed by running down net financial assets. Because of this, the functioning of financial markets will be of great importance for how fast the consumers can adapt to changes in the optimal stocks. The other aspects is linked to the possibility that the second hand market of durables contains valueable information about what is happening in the first hand market since the two markets are closely interrelated. Both these aspects influence the dynamic behaviour of purchase of durables. However, for instance in the case of automobiles there are no official data concerning the second hand market. Thus we are unable to take account of the interrelation between the first and second hand market.

To solve the dynamic optimization problem hinted at in the beginning of this chapter, a very important part is to clarify the budget constraint confronting the households when deciding on consumption, real investment and financial savings/dissavings. Theoretically two different situations may be distinguished. In the first situation it is assumed that consumers may lend and borrow at given interest rates. At the other extreme households are rationed with regard to credit. The two hypotheses imply different financial adjustment since in the first case the consumption path can be separated from the income path, whereas this is not so under rationing. It seems reasonable to assume that within a credit- rationing regime, not all consumers are effectively rationed in the credit market. Thus intertemporal adjustment because of changes in the real interest rate should have a role to play. However, neither in MODAG nor KVARTS we find any support for long-run effects of interest rates in the consumption function for non-durables. The failure to detect substitution effects can therefore come from problems attached to aggregation. Some effort has been undertaken to study the aggregation problem when it is assumed that a proportion of households is rationed whereas the other part is unrationed. However, this approach introduces important problems connected to data and it is not clear whether the proxy variables utilized to pick up changes in the above mentioned proportion over time is adequate.

References

Anderson, G. and R. Blundell (1983): Testing Restriction in a Flexible Dynamic Demand System: An Application to Consumers' expenditure in Canada. *Review of Economic Studies. 50, 391-40*

Anderson, G. and R. Blundell (1984): Consumer non-durables in the UK - a dynamic demand system. *Economic Journal 94.* Supplement 35-44

Barten, A.P. (1969): Maximum likelihood estimation of a complete system of demand equations. *European Economic Review 1, 7-74.*

Biørn, E. (1989): Taxation, technology and the user cost of capital. North-Holland Amsterdam.

Biørn, E. and M. Jensen (1983): Varige goder i et komplett system av etterspørsels-funksjoner. (Durable goods in a complete system of demand functions). Rapporter 83/16. Central Bureau of Statistics.

Biørn, E., M. Jensen and M. Reymert (1987): KVARTS - a quarterly model of the Norwegian economy. Economic Modelling.

Bossier et. al. (1989): HERMES: a macrosectoral model for the Belgian economy. *Economic Modelling Vol. 6 No.4.*

Bowitz, E. and T. Eika (1989): KVARTS-86. A quarterly macroeconomic model. Formal structure and empirical characteristics. Rapporter 89/2. Central Bureau of Statistics.

Brodin, P.A. and R. Nymoen (1989): The consumption function in Norway: Breakdown and reconstruction. Working paper No. 1989/7.

Brodin, P.A. and R. Nymoen (1992): Wealth effects and Exogeneity: The Norwegian Consumption Function 1966(1) - 1989(4). Forthcoming in Oxford Bulletin of Economics and Statistics.

Bårdsen, G. (1989): Estimation of Long Run Coefficients in Error Correction Models. Oxford Bulletin of Economics and Statistics 51.2.

Cappelen, Å. (1980): Inntektsfordeling og konsum 1962- 78. (Income distribution and consumption 1962-78). Artikkel nr. 123. Central Bureau of Statistics.

Cappelen, Å. (1985): Fordelingen av utlendingers konsum i Norge på hovedgrupper av konsumposter. (The distribution of foreigners consumption in Norway on main consumption groups). Unpublished paper. Central Bureau of Statistics.

Cappelen, Å. and S. Longva (1987): MODAG A: A medium-term macroeconomic model of the Norwegian economy. In Bjerkholt and Rosted (eds.) Macroeconomic medium term models in the nordic countries. North-Holland.

Cappelen, Å. (1991): Kredittrasjonering og konsumentatferd. (Credit rationing and consumer behaviour). I Moum (red.) Husholdningens sparing. Rapporter 91/16. Central Bureau of statistics.

Chambers, M.J. (1990): Forecasting with Demand Systems. A Comparative Study. *Journal of Econometrics 9, 165-191.*

Dam, P.U. (1986): The Danish macroeconomic model ADAM: a survey. *Economic Modelling Vol.3 No.1.*

Deaton, A.S. and J. Muellbauer (1980): An almost ideal demand system. *American Economic Review, 70, 312-26.*

Dinesis et. al. (1989): The London Business School econometric model: some recent developments. *Economic Modelling Vol.6 No.3.*

Dixon, P.B and C. Lluch (1977): Durable goods in the Extended Linear Expenditure System. *Riview of Economic Studies, 44, 381 - 384.*

Engle, R. (1982): Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation. Econometrica 50, 982-1008.

Engle, R. and C.W.J Granger (1987): Cointegration and error correction: Representation, estimation and testing. *Econometrica Vol. 55 No. 2.*

Frisch, R (1954): Linear Expenditure Functions: An expository Article. *Econometrica Vol. 22 No. 4.*

Heinesen, E. Red. (1988): Privat forbrug og boliginvesteringer i ADAM. (Private consumption and housing investments in ADAM). Arbejdsnotat Nr. 24. Danmarks Statistik.

Harvey, A. (1981): The Econometric Analysis of Time Series. London. Philip Allan.

Hendry, D.F. and T. von Ungern-Sternberg (1981): Liquidity and inflation effects on consumers' expenditure. In A. Deaton, ed. Essays in the theory and measurement of consumers behaviour. Cambridge Uni-versity Press.

Jarque, C.M. and A. K. Bera (1980): Efficient Tests for Normality, Homoscedasticity and Serial Independence of Regression Residuals. Economic Letters 6.

Leighton, R.L (1987): Applied demand analysis. Longman Group UK Limited.

Lluch, C. (1973): The Extended Linear Expenditure System. *European Economic Rewiev, 4, 21-32.*

Magnussen, K.A. and J. Stoltenberg (1991): En disaggregert ettermodell for offentlig transport i MODAG/MSG (A disaggregated model for public transport services and communication in MODAG/MSG). Rapporter 91/11. Central Bureau of Statistics.

Magnussen, K. A. (1990): Etterspørselen etter varige konsumgoder. (The demand for durable consumer goods). Rapporter 90/16. Central Bureau of Statistics.

Magnussen, K. A. and K. Moum (1992): Konsum og boligformue: Tar Eilev Jansen likevel feil? Sosialøkonomen nr. 6.

Moum, K. (red.) (1991): Husholdningens sparing. Begrepsavklarings dataproblemer og analyse. (Household savings. Concepts, data and analysis). Rapporter 91/16. Central Bureau of Statistics.

Nesbakken, R. (1990): Husholdningenes konsum av ikke- varige konsumgoder. (Households consumption of non-durable consumer goods). Rapporter 90/-14. Central Bureau of Statistics.

Phlips, L. (1972): A dynamic version of the linear expenditure model. *Review of Economics and Statistics, 54, 450-458.*

Pollak, R.A. (1970): Habit formation and dynamic demand functions. *Journal of Political Economy 78, 745- 761.*

Pollak, R.A and T.J Wales (1969): Estimation of the Linear Expenditure System. *Econometrica 37, 611-628.*

Ramsey, J. B (1969): Test of specification Errors in Classical Linear Regression Analysis. Journal of the Royal Statistical Society. B. 31 350-371.

Steffensen, E. R. (1989): Konsumetterspørselen i Norge estimert ved hjelp av Euler-likninger på årsdata 1962-1987. (Consumer demand in Norway estimated by Euler-equations using annual data from 1962 to 1987.) Arbeidsnotat Nr. 20/1989. SNF.

Stone, R. (1954): Linear Expenditure Systems and Demand Analysis: An Application to the Pattern of British Demand. *Economic Journal 64, 511-527.*

Stone, R. and D.A. Rowe (1957): The market demand for durable goods. *Econometrica Vol.25 No.3*

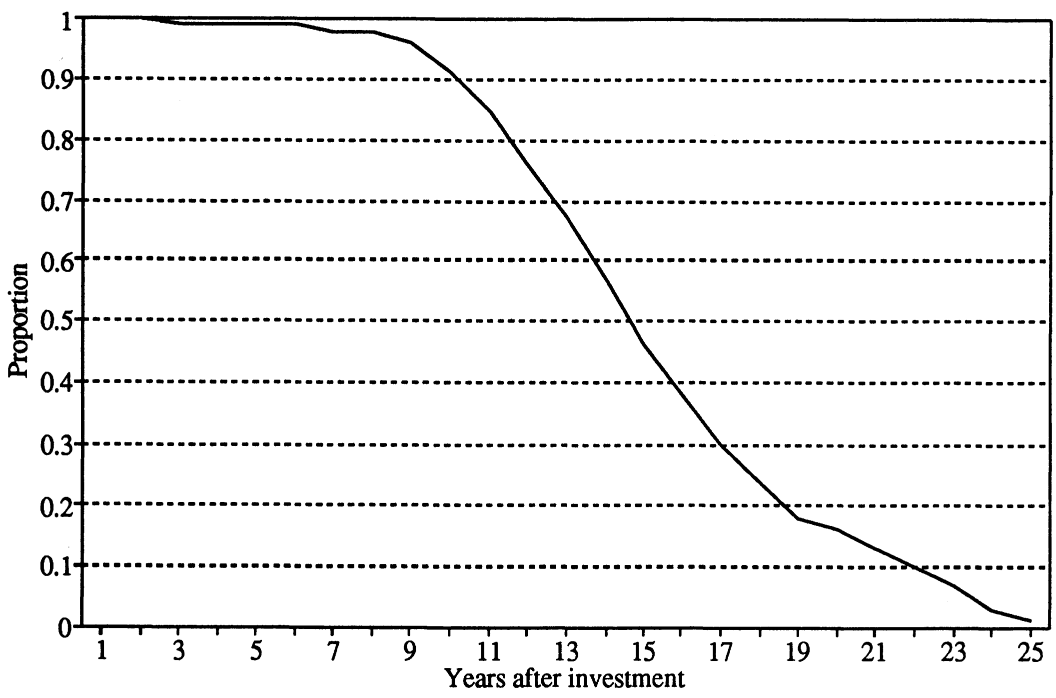
Troll program Limo (1983): Technical Report No. 34. Massachusetts Institute of Technology.

A Data Appendix

From the national accounts, annual and quarterly data on consumption, price indices and income variables are available for the period 1966 (1962 for annual data) to 1990. Households disposable income is defined as a sum of wage income, households' share of net operating surplus, net interest receipts, dividends and transfers from public sector less direct taxes.

The construction of capital stock of personal transport equipment and other durable goods are based on consumption data from the national accounts and figures showing the age composition of cars in each year from 1978 to 1988, see Manussen (1990). Age data are used to create a survival function $B(s)$, showing the proportion of an investment made s years ago which still exists. The survival function was calculated by dividing the number of cars in period t of one vintage, with the initial number of cars in the same vintage. Tests confirmed that the function, presented in figure A1, is reasonably stable over the relevant period.

Figure A1. The survival function for cars in Norway.



By using the function $B(s)$, the purchase data C_t and a real rate of interest it is possible, by making certain assumptions, to create the net capital value of the goods concerned. The method is described in detail in Biørn (1989). Net capital is a wealth concept which expresses the market value of the capital goods reflecting its remaining service flow. The definition is

$$V_t = \sum_{s=0}^{T} p_{t,s} B(S) \cdot C_{t-s} \tag{A.1}$$

where V_t is the net capital in period t, $p_{t,s}$ is the price of one capital unit of age s at time t. C_{t-s} is the volume of investments $t-s$ years ago.

The summation has to be done over all vintages which still exists. Our data showed that up to 25 years old capital units (cars) have to be included. Even though the survival function is calculated on basis of data for cars, we also apply this function (and the same age of living) on the group other durable goods. The main reason for this application is that no registration data are available for these goods. Having the survival function, the main problem in calculating HC_t is to determine the second hand price, $p_{t,s}$.

Despite some kind of second hand markets for the capital goods, no official second hand price index exists in Norway. We are therefore forced to make the assumption that the law of indifference holds between different vintages, which means that a household buying a capital unit of age s at time t, pays the same price per unit of discounted prospective capital as a household which buy a new capital unit at time t. This means that we can write $p_{t,s}$ as a product of the price of a new capital unit p_t and the relationship between two terms of discounted prospective capital services

$$p_{t,s} = p_t \cdot J(s)/J(o) \quad \text{where } J(s) = 1/B(s) \sum_{z=s}^{T} B(z)/(1+r)^{z-s} \tag{A.2}$$

In this way the survival function is also used to measure the expected capital services. In our case, we choose $r = 0$, which gives the following expression for V_t:

$$V_t = p_t \sum_{t=0}^{T} [\sum_{z=s}^{T} B(z) / \sum_{z=0}^{T} B(z)] C_{t-s} \tag{A.3}$$

From this we easily find the real capital value $HC_t = V_t/p_t$, and the depreciation by using equation (4).

To obtain quarterly data series, we assume that the relation between depreciation in each quarter and the capital stock in the beginning of the quarter is the same within each year.The annual depreciation rate is calculated by iteration, and then it is easy to calculate both the capital stock and depreciation in each quarter.

B Recursive Parameter Estimates

B.1. Parameters in the equations for transport equipment, other durable goods and non-durables in KVARTS

Figure 1. The change in the capital stock in the equation for transport equipment.

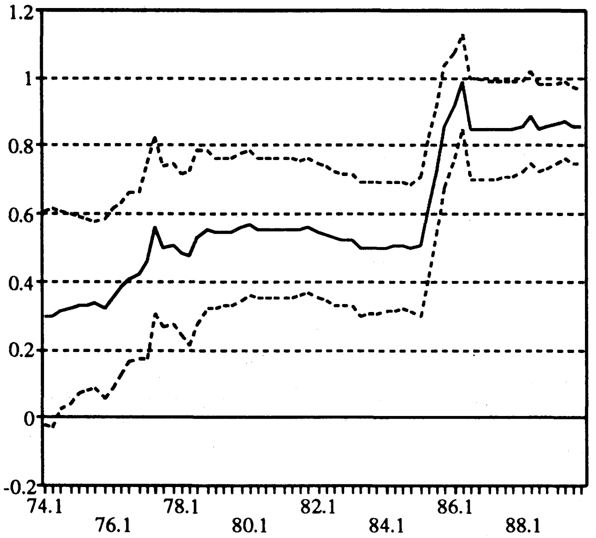


Figure 2. The adjustment coefficient in the equation for transport equipment.

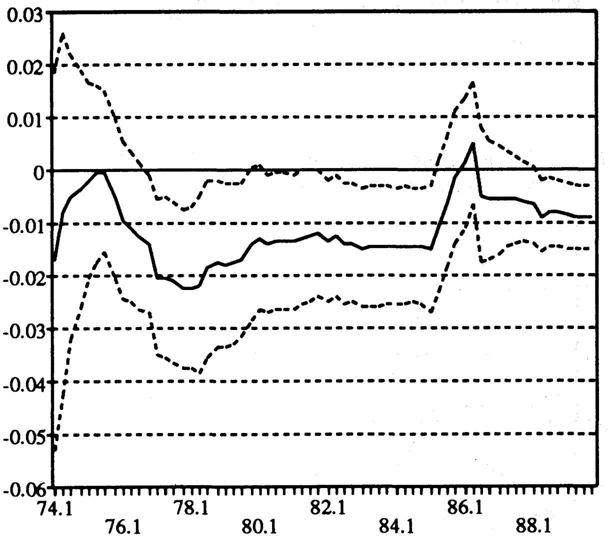


Figure 3. The change in disposable income in the equation for transport equipment.

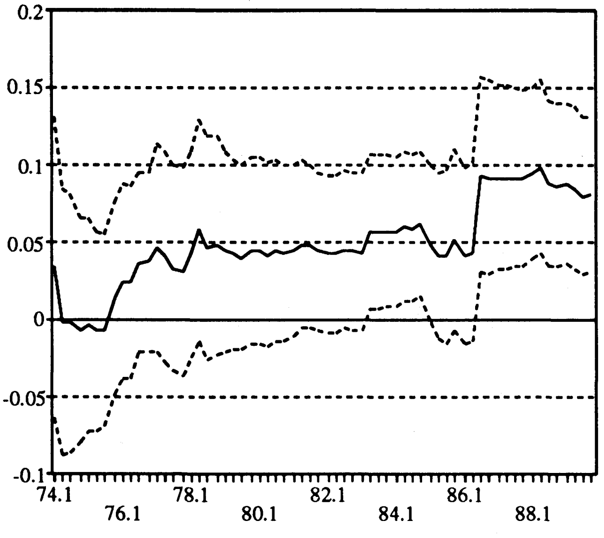


Figure 4. The change in the capital stock (1. lag) in the equation for other durable goods.

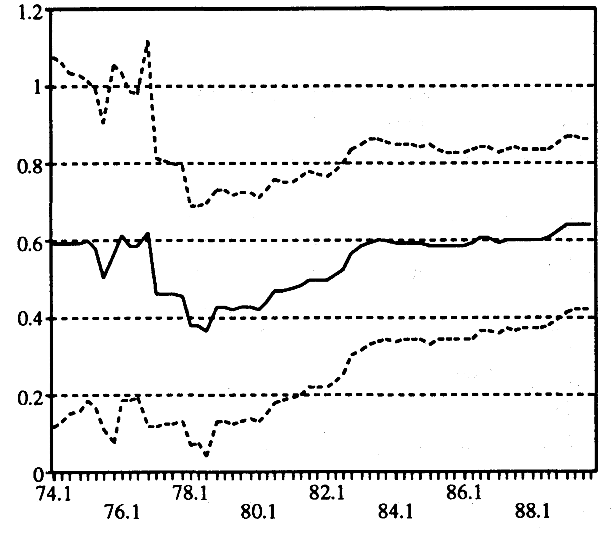


Figure 5. The change in the capital stock (2. lag) in the equation for other durable goods.

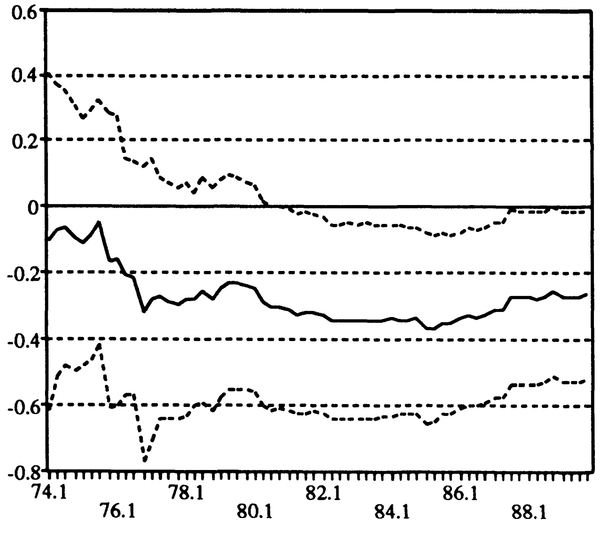


Figure 6. The change in the capital stock (3. lag) in the equation for other durable goods.

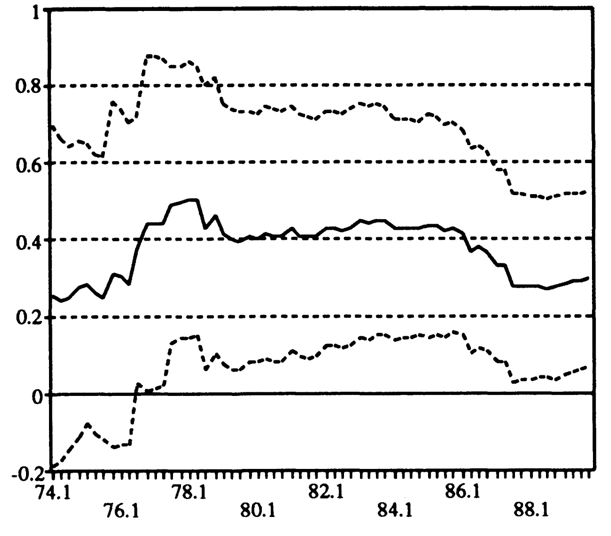


Figure 7. The change in the capital stock (4. lag) in the equation for other durable goods.

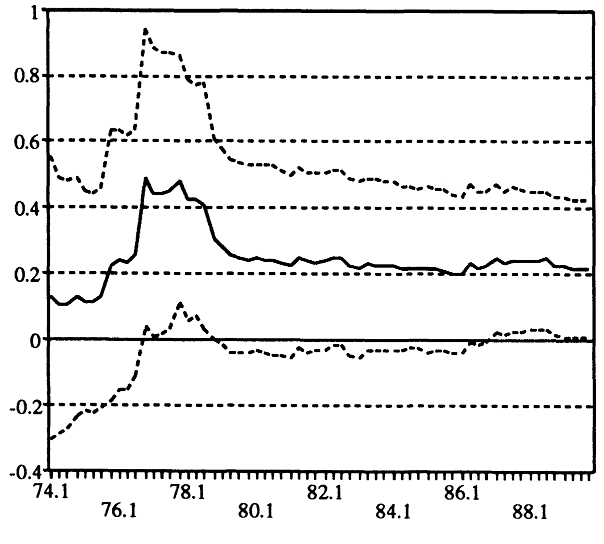


Figure 8. The adjustment parameter in the equation for other durable goods.

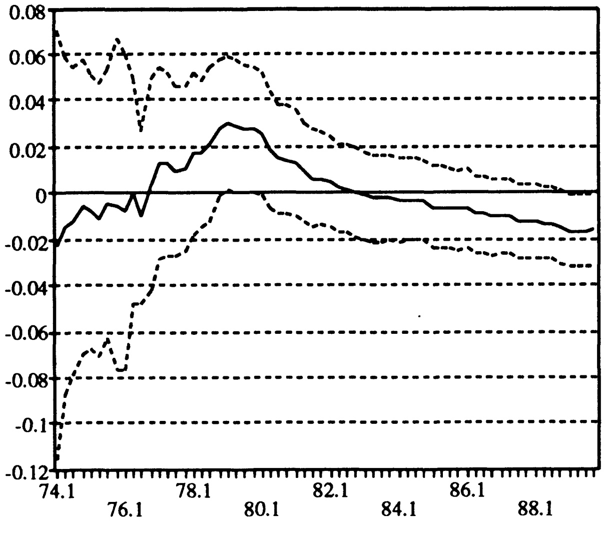


Figure 9. The change in disposable income (1. lag) in the equation for other durable goods.

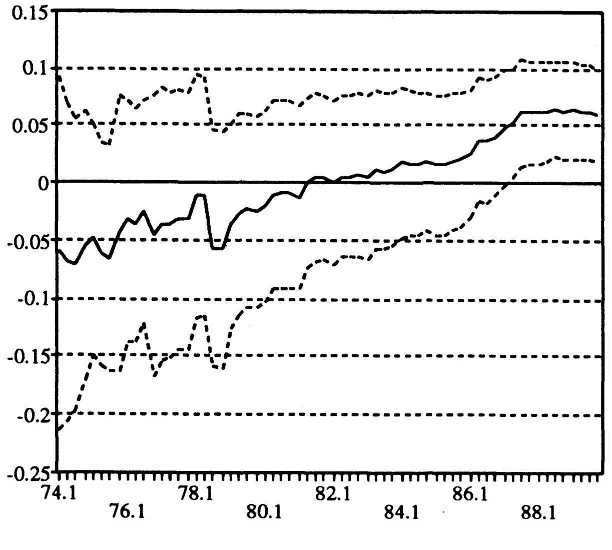


Figure 10. The change in disposable income (2. lag) in the equation for other durable goods.

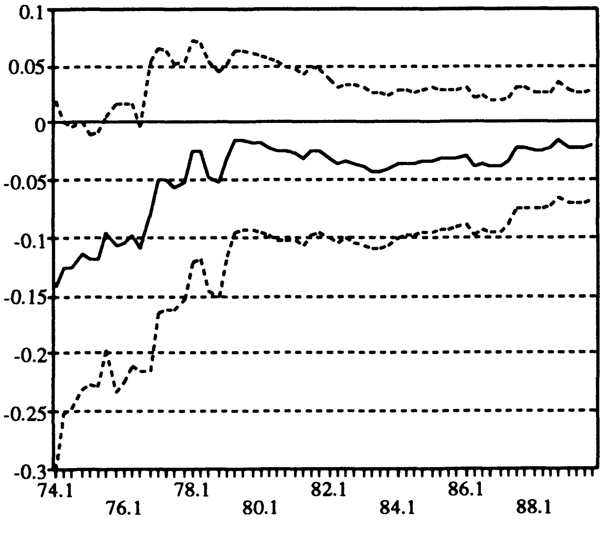


Figure 11. The change in disposable income (3. lag) in the equation for other durable goods.

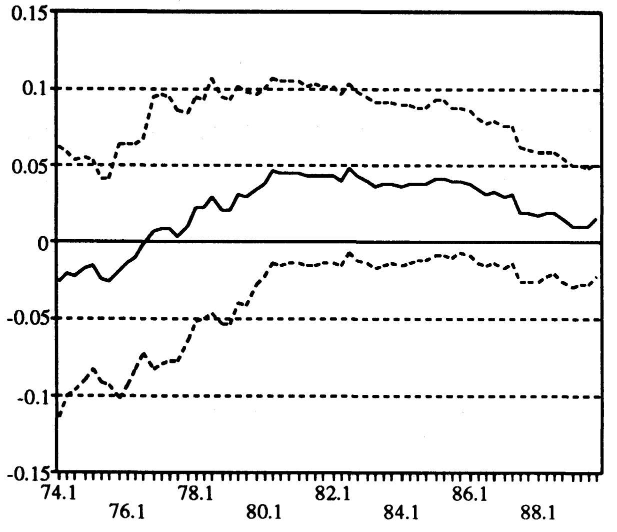


Figure 12. The change in consumption of non-durables (1. lag) in the equation for non-durables.

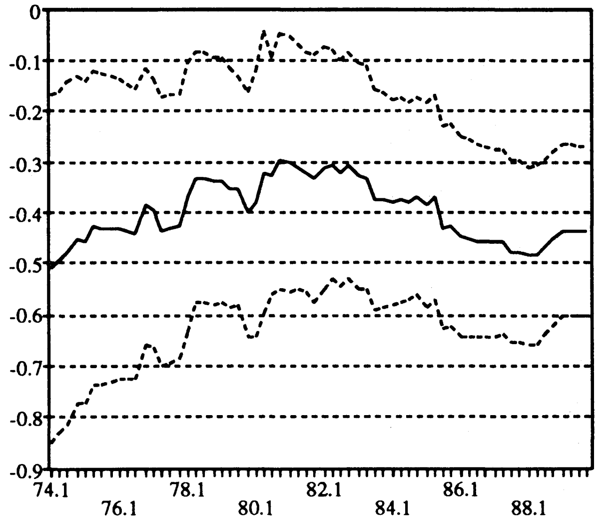


Figure 13. The change in consumption of non-durables (2. lag) in the equation for non-durables.

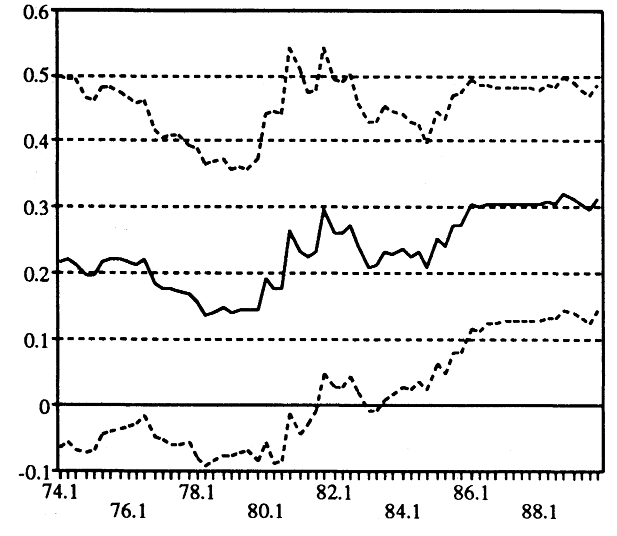


Figure 14. The change in disposable in the equation for non-durables.

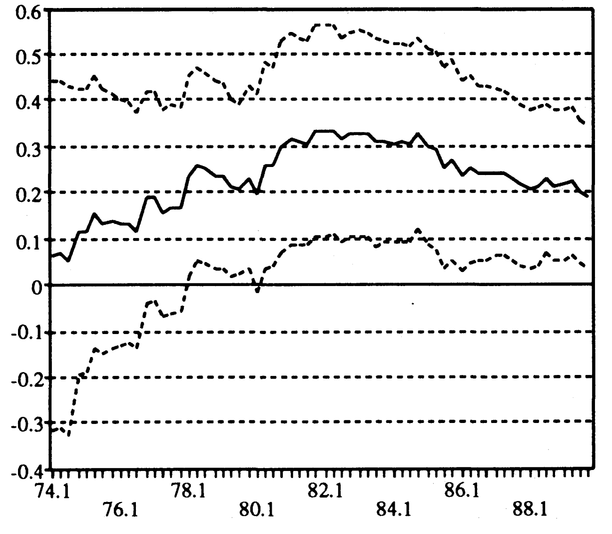
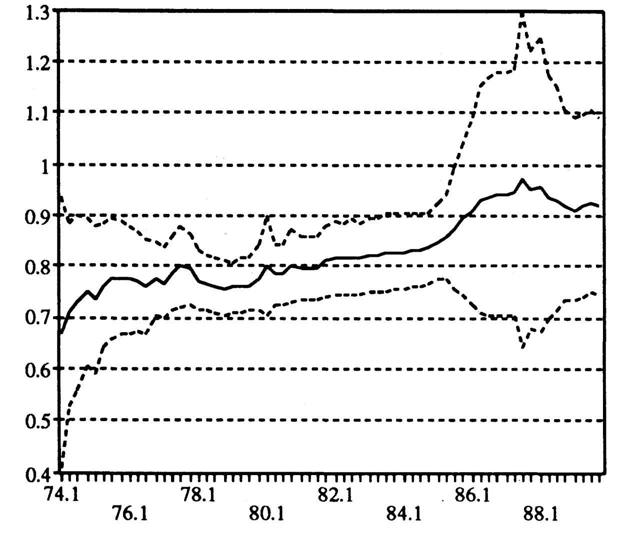


Figure 15. The long-run coefficient (income elasticity) in the equation for non-durables.



B.2. Parameters in the equations for transport equipment, other durable goods and non-durables in MODAG

Figure 16. The adjustment coefficient in the equation for transport equipment.

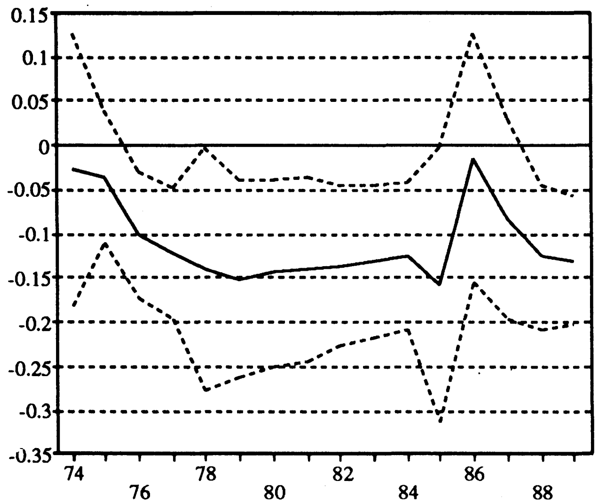


Figure 17. The change in disposable income in the equation for transport equipment.

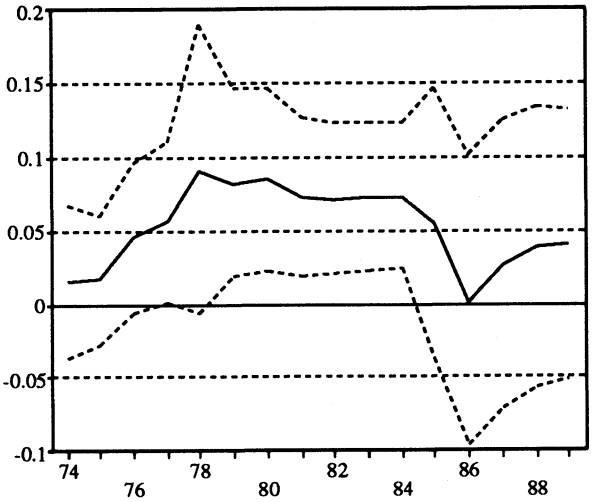


Figure 18. The change in the capital stock in the equation for transport equipment.

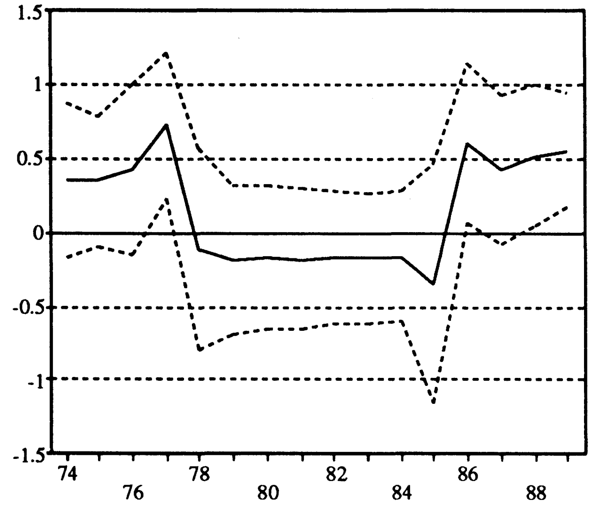


Figure 19. The adjustment parameter in the equation for other durable goods.

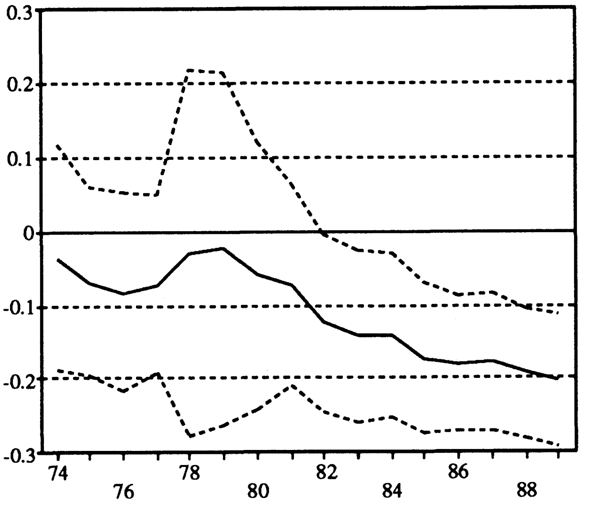


Figure 20. The change in disposable income in the equation for other durable goods.

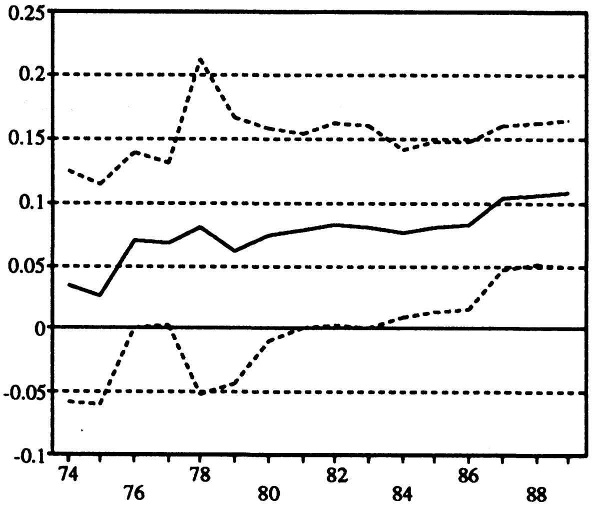


Figure 21. The change in the capital stock in the equation for other durable goods.

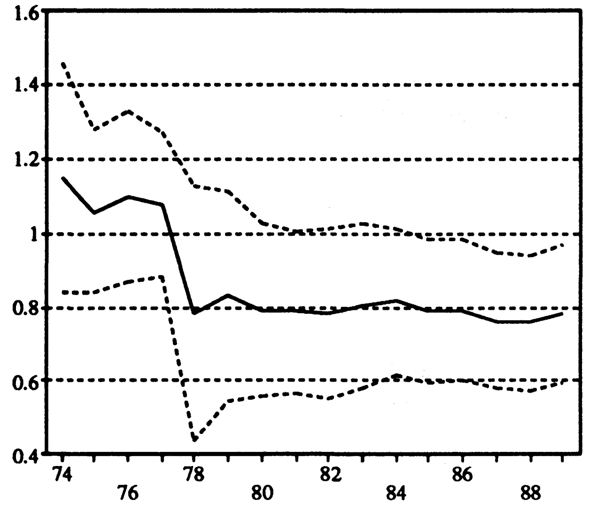


Figure 22. The change in consumption of non-durables (1.lag) in the equation for non-durables.

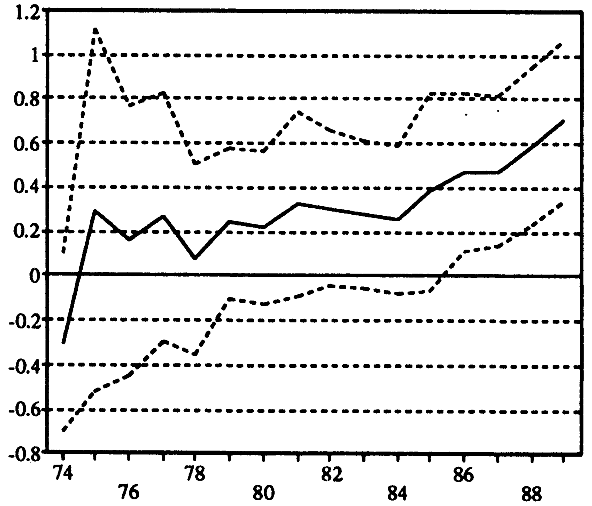


Figure 23. The change in consumption of non-durables (2.lag) in the equation for non-durables.

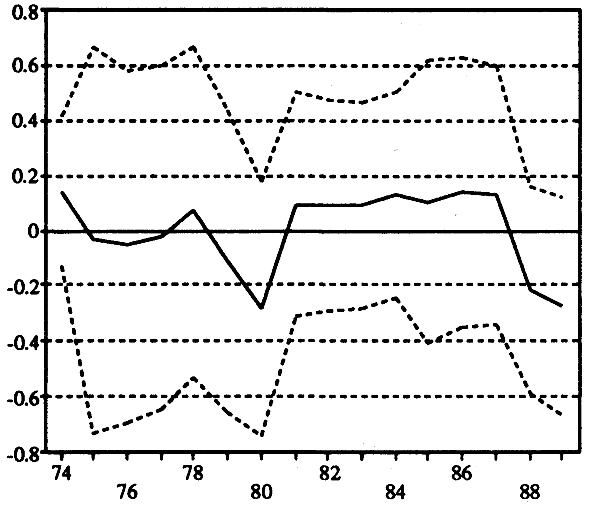


Figure 24. The change in nominal interest rate in the equation for non-durables.

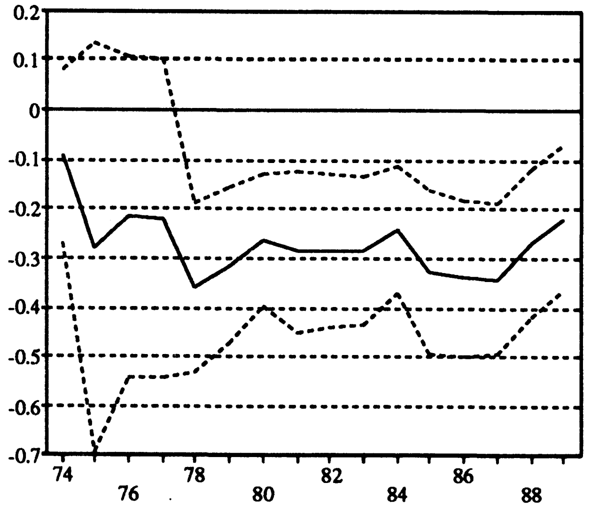
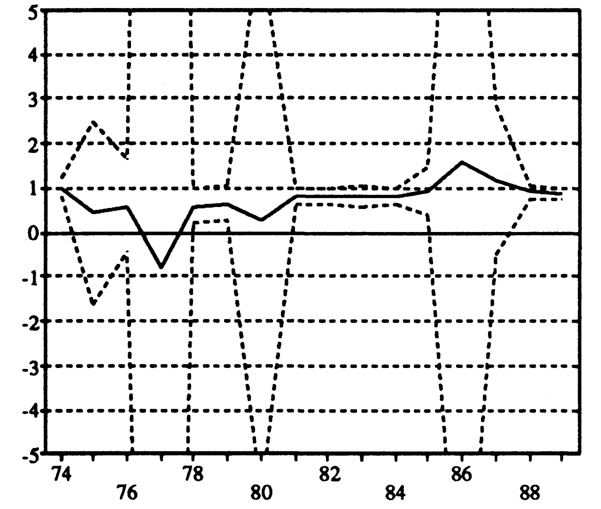


Figure 25. The long-run coefficient (income elasticity) in the equation for non-durables.



C Simulation results.

Observed and simulated values for consumption groups in MODAG (A) and KVARTS (B).

FIGURE 1A. CONSUMPTION OF HOUSING SERVICES
Billion 1989-kroner.

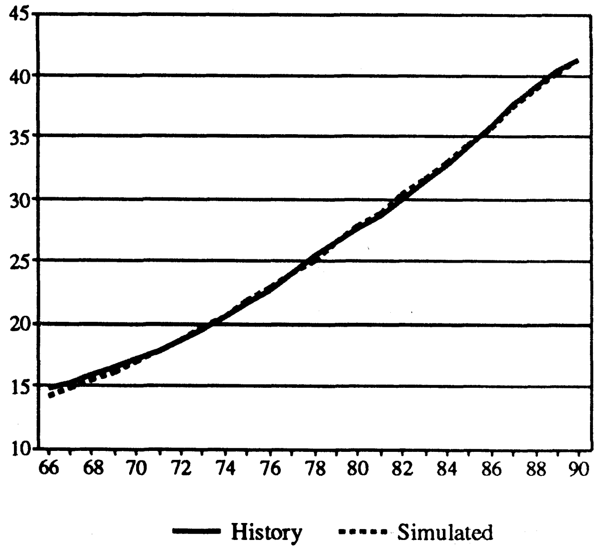


FIGURE 1B. CONSUMPTION OF HOUSING SERVICES
Billion 1989-kroner.

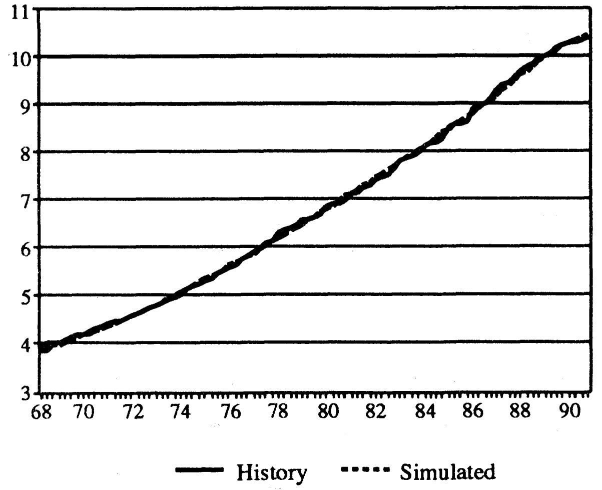


FIGURE 2A. CAPITAL STOCK OF TRANSPORT EQUIPMENT. Billion 1989-kroner.

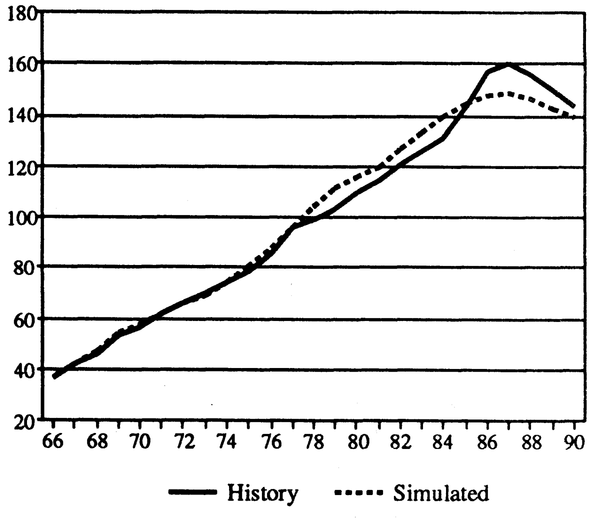


FIGURE 2B. CAPITAL STOCK OF TRANSPORT EQUIPMENT. Billion 1989-kroner.

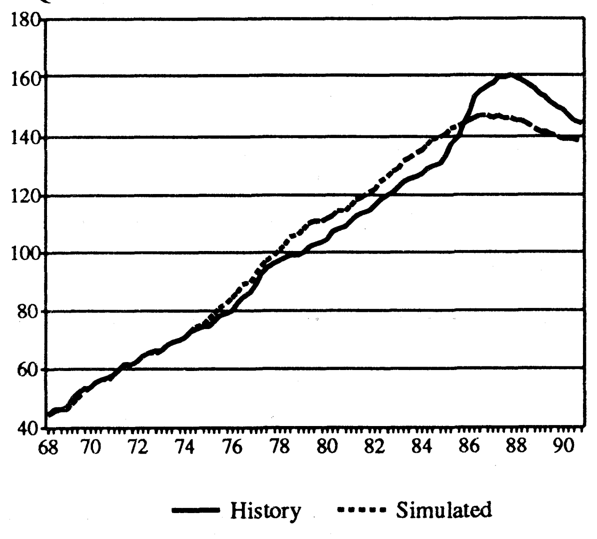


FIGURE 3A. PURCHASE OF TRANSPORT EQUIPMENT. Billion 1989-kroner.

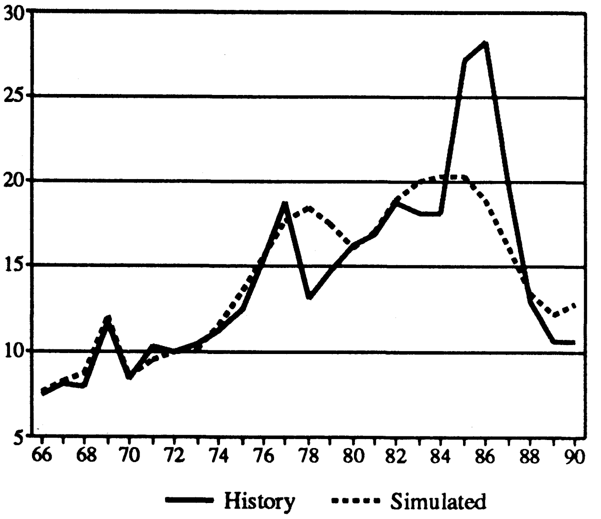


FIGURE 3B. PURCHASE OF TRANSPORT EQUIPMENT. Billion 1989-kroner.

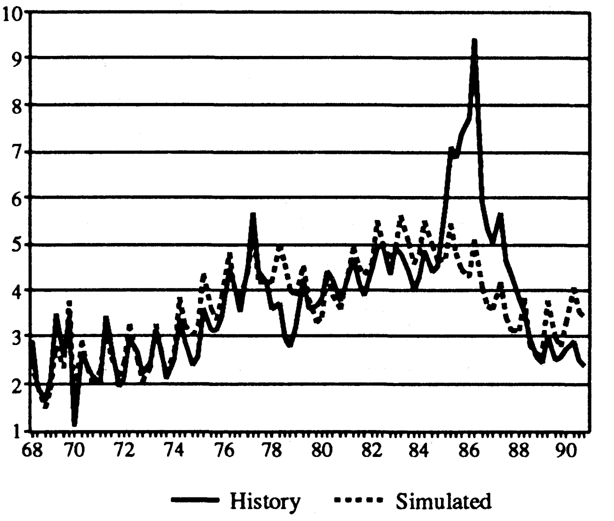


FIGURE 4A. CAPITAL STOCK OF OTHER DURABLE GOODS. Billion 1989-kroner.

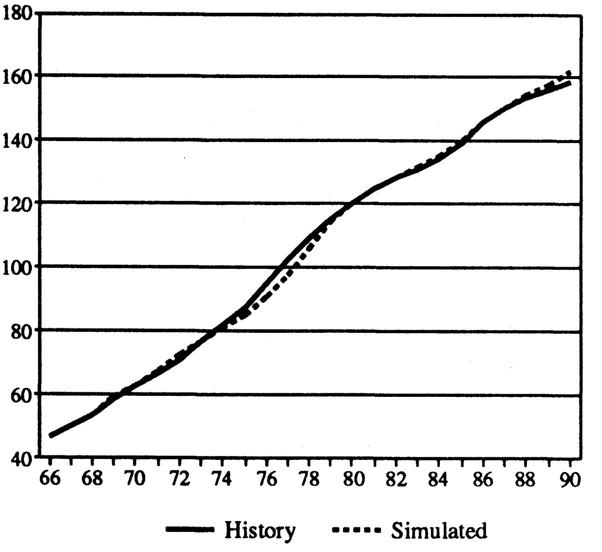


FIGURE 4B. CAPITAL STOCK OF OTHER DURABLE GOODS. Billion 1989-kroner.

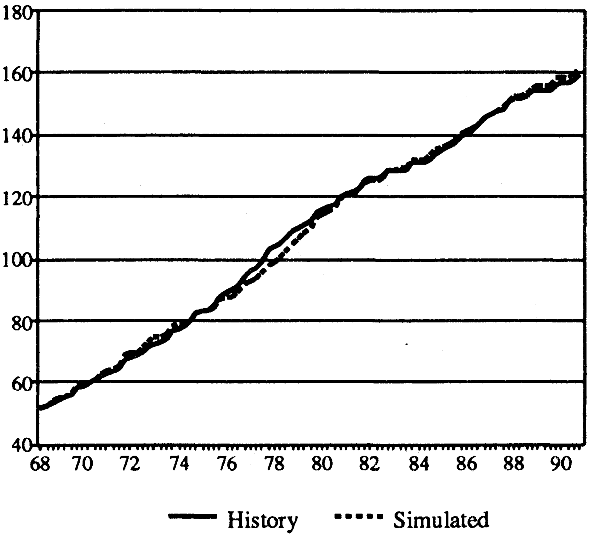


FIGURE 5A. PURCHASE OF OTHER DURABLE GOODS Billion 1989-kroner.

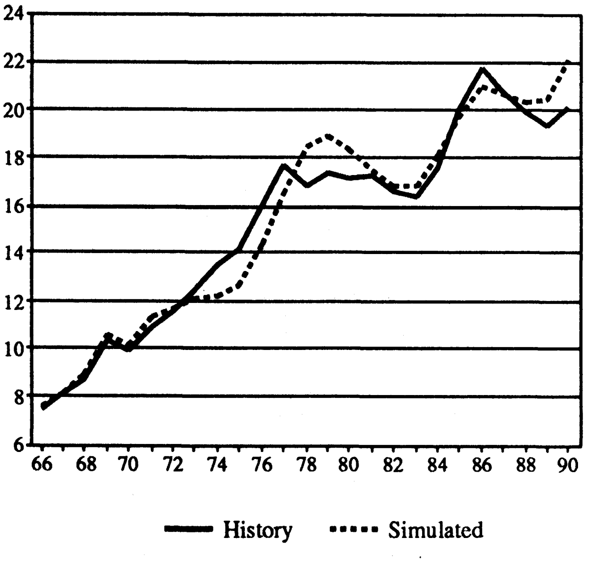


FIGURE 5B. PURCHASE OF OTHER DURABLE GOODS Billion 1989-kroner.

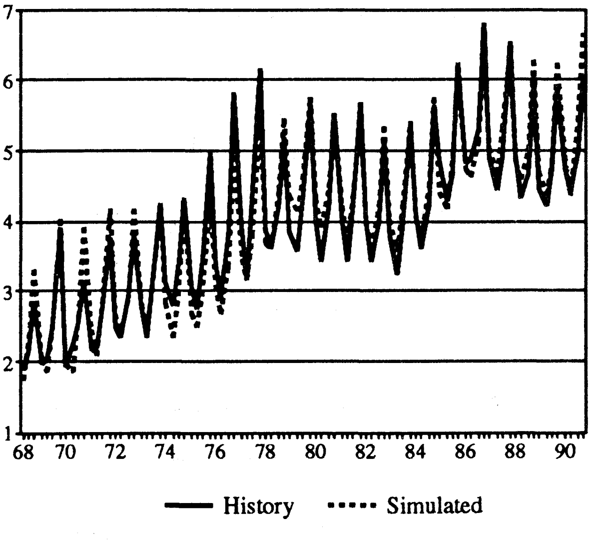


FIGURE 6A. CONSUMPTION OF NON-DURABLES
Billion 1989-kroner.

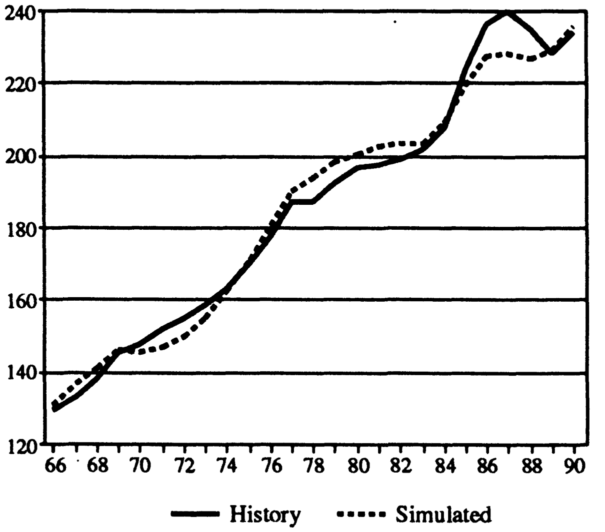


FIGURE 6B. CONSUMPTION OF NON-DURABLES
Billion 1989-kroner.

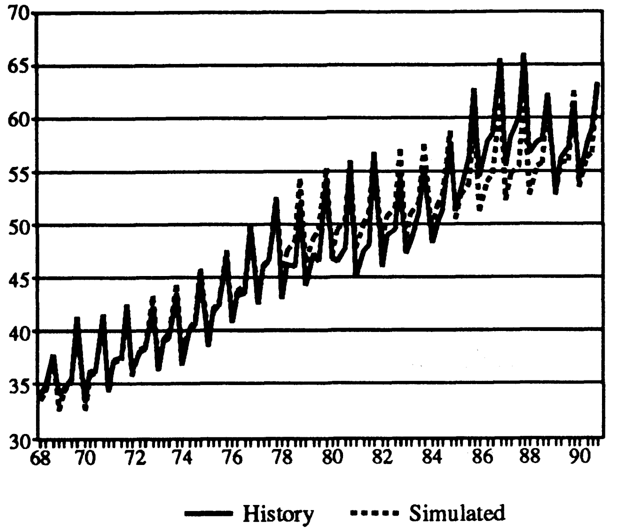


FIGURE 7A. CONSUMPTION OF FOOD
Billion 1989-kroner.

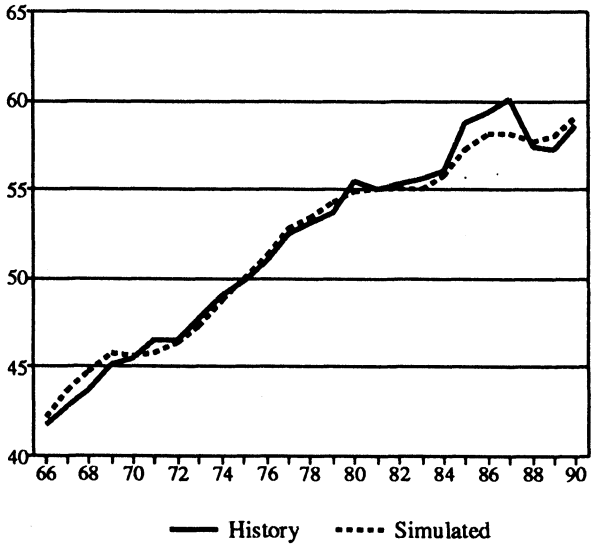


FIGURE 7B. CONSUMPTION OF FOOD
Billion 1989-kroner.

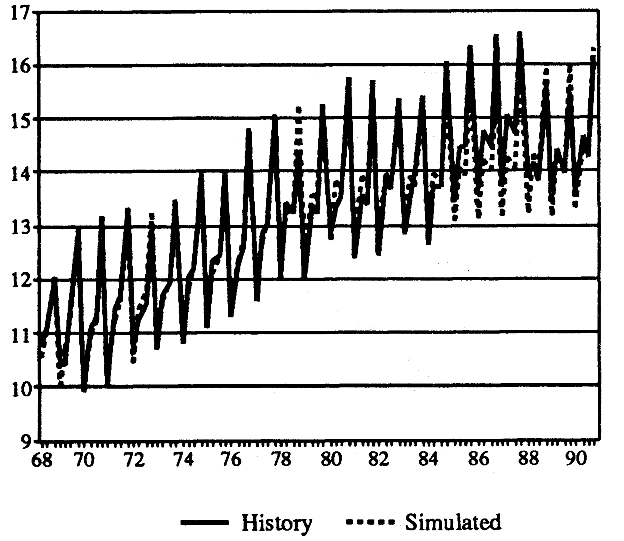


FIGURE 8A. CONSUMPTION OF TOBACCO AND BEVERAGES. Billion 1989-kroner.

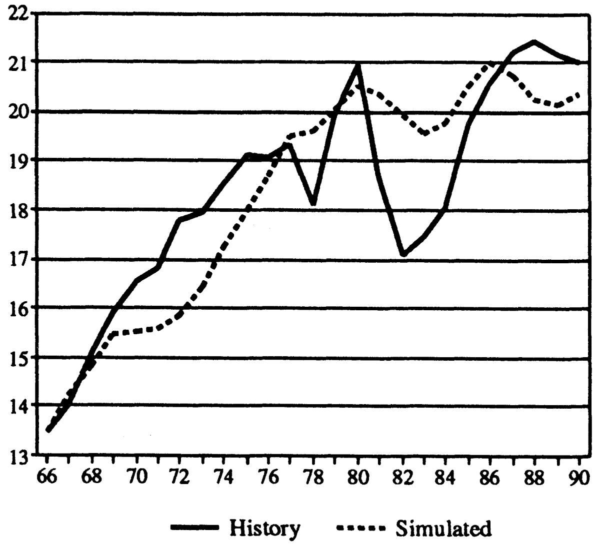


FIGURE 8B. CONSUMPTION OF TOBACCO AND BEVERAGES. Billion 1989-kroner.

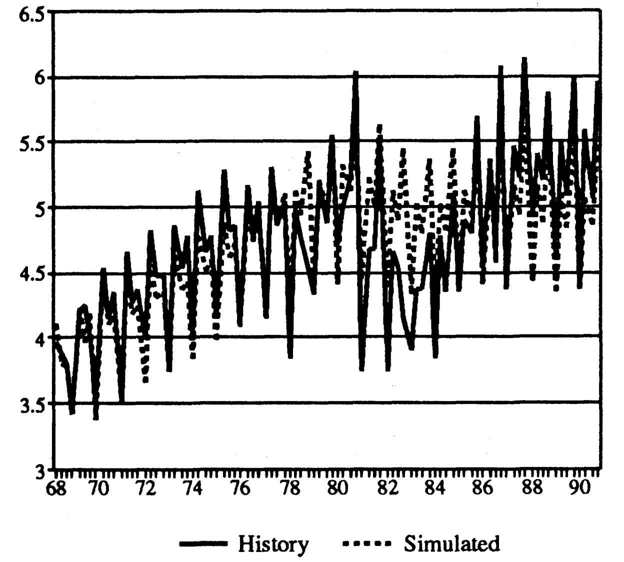


FIGURE 9A. CONSUMPTION OF ELECTRICITY
Billion 1989-kroner.

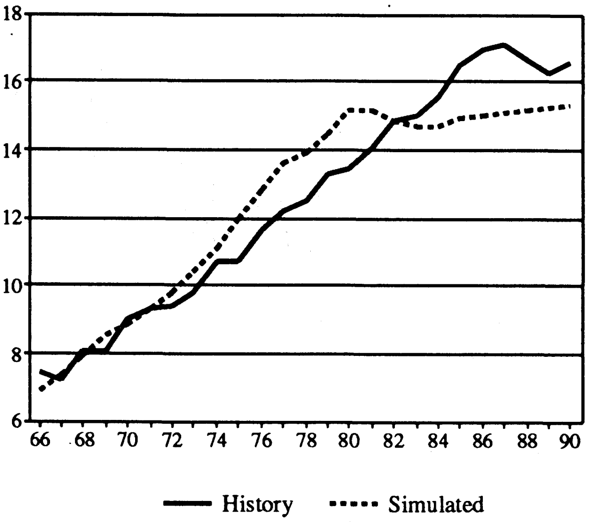


FIGURE 9B. CONSUMPTION OF ELECTRICITY.
Billion 1989-kroner.

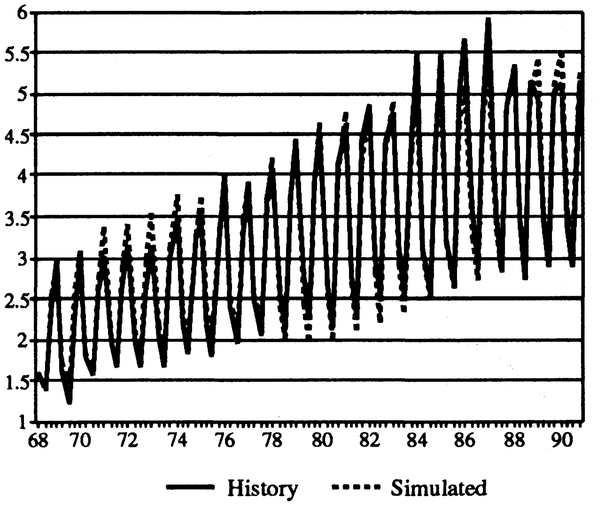


FIGURE 10A. CONSUMPTION OF FUEL
Billion 1989-kroner.

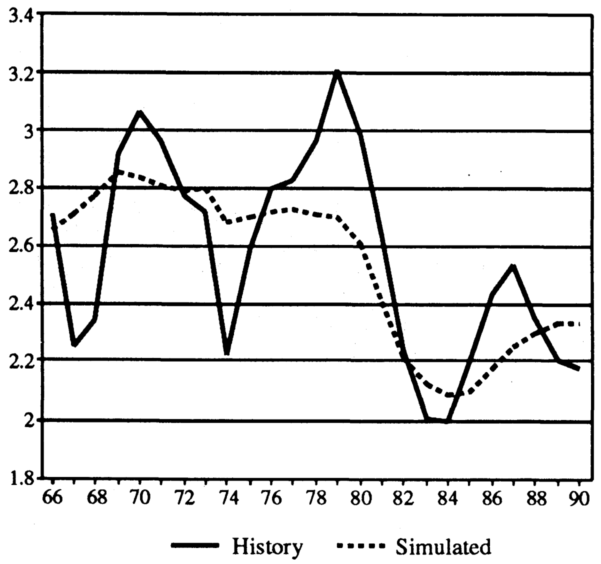


FIGURE 10B. CONSUMPTION OF FUEL
Billion 1989-kroner.

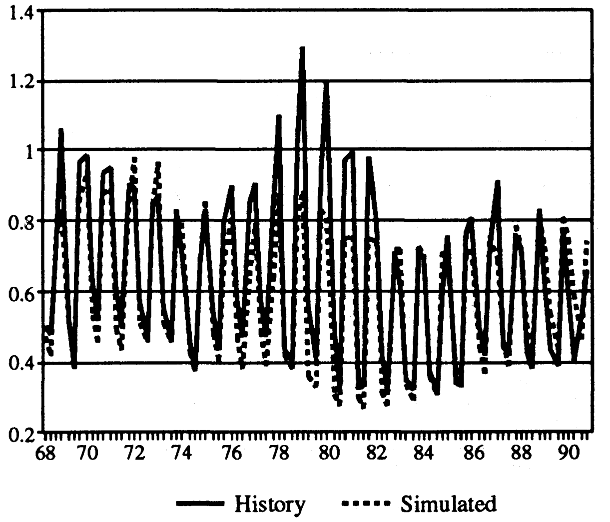


FIGURE 11A. OPERATION OF PERSONAL TRANSPORT EQUIPMENT. Billion 1989-kroner.

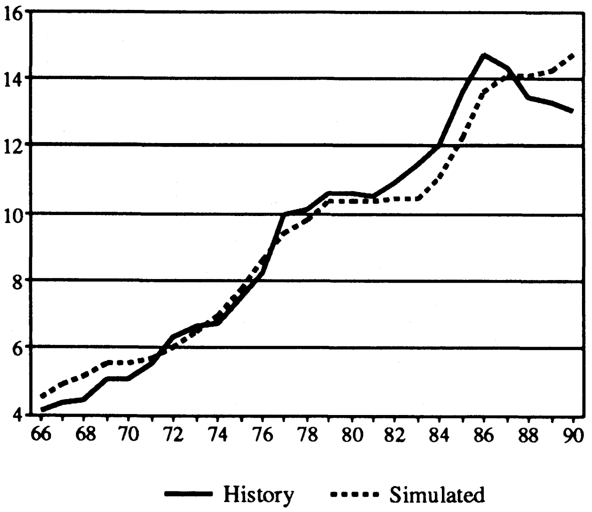


FIGURE 11B. OPERATION OF PERSONAL TRANSPORT EQUIPMENT. Billion 1989-kroner.

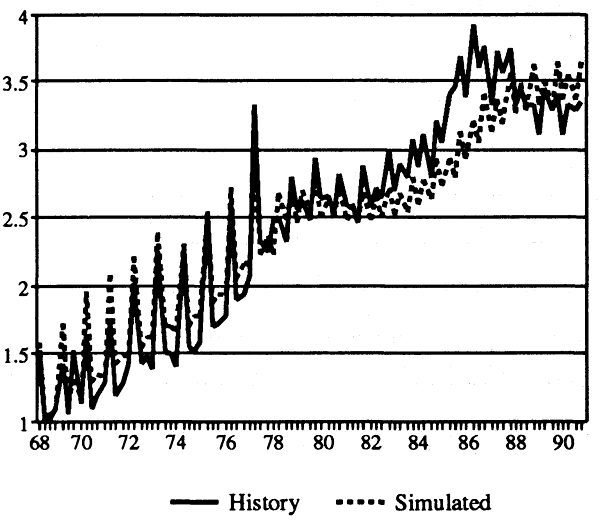


FIGURE 12A. CONSUMPTION OF OTHER NON-DURABLE GOODS . Billion 1989-kroner.

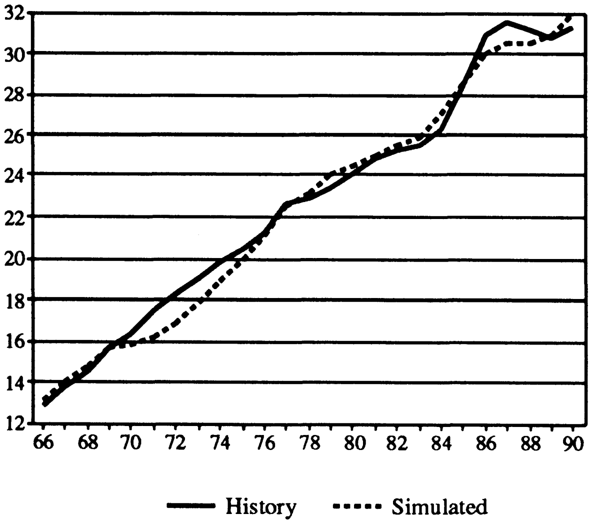


FIGURE 12B. CONSUMPTION OF OTHER NON-DURABLE GOODS. Billion 1989-kroner.

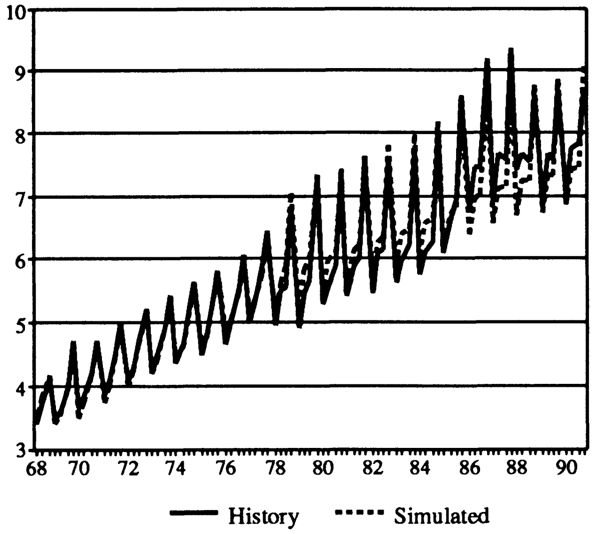


FIGURE 13A. CONSUMPTION OF CLOTHING AND FOOTWEAR. Billion 1989 -kroner.

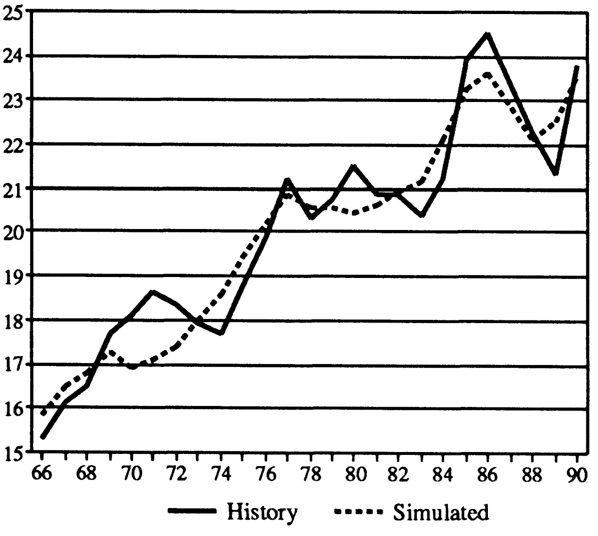


FIGURE 13B. CONSUMPTION OF CLOTHING AND FOOTWEAR. Billion 1989-kroner.

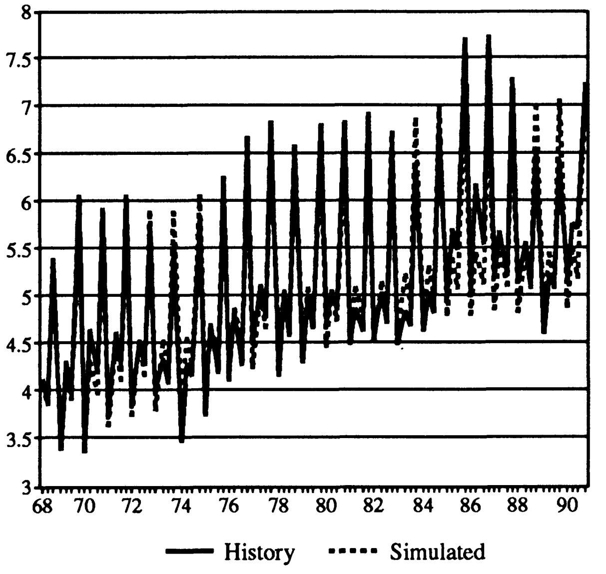


FIGURE 14A. CONSUMPTION OF OTHER SERVICES Billion 1989-kroner.

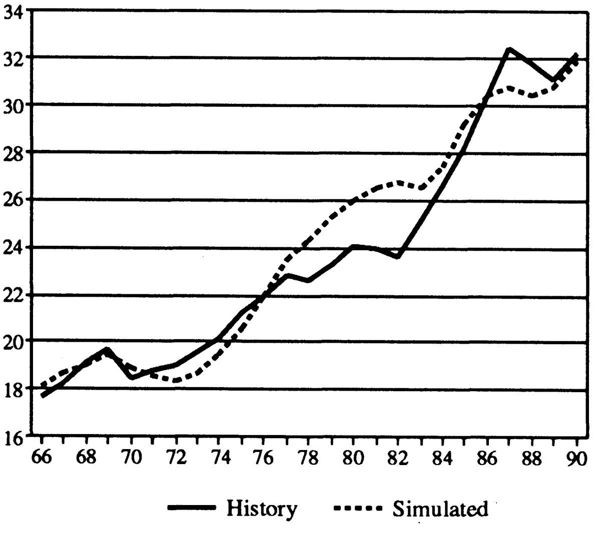


FIGURE 14B. CONSUMPTION OF OTHER SERVICES Billion 1989-kroner.

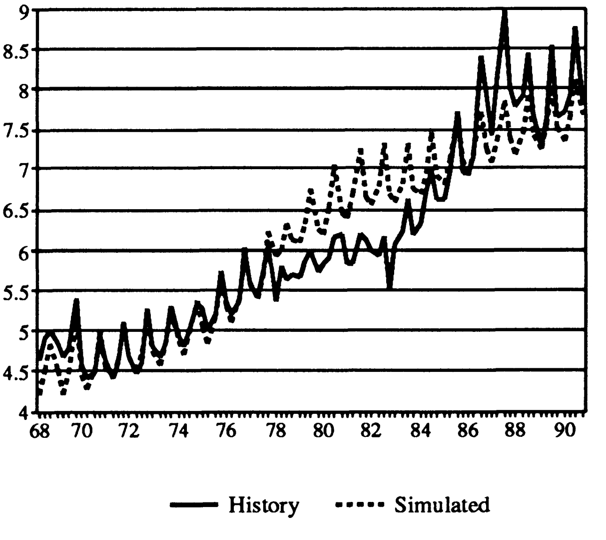


FIGURE 15A. CONSUMPTION OF PUBLIC TRANSPORT SERVICES. Billion 1989-kroner.

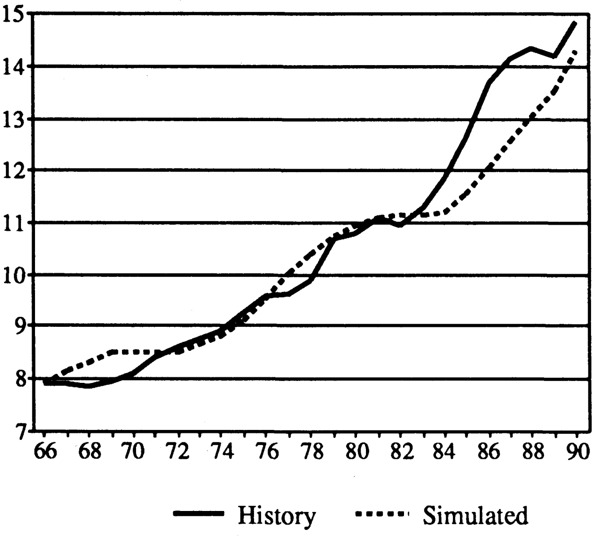


FIGURE 15B. CONSUMPTION OF PUBLIC TRANSPORT SERVICES. Billion 1989-kroner.

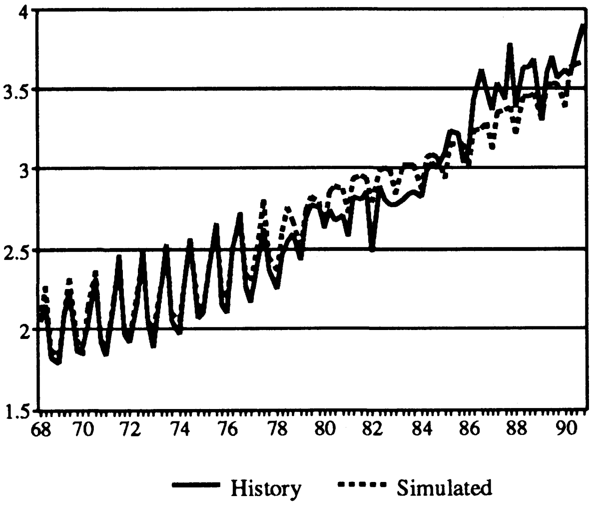


FIGURE 16A. CONSUMPTION ABROAD Billion 1989-kroner.

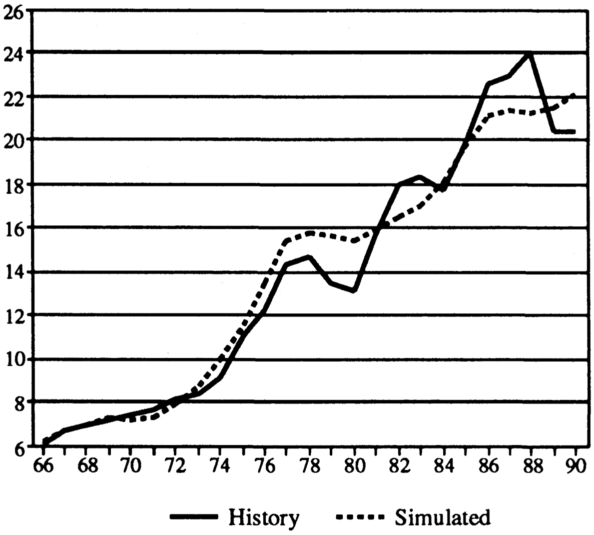
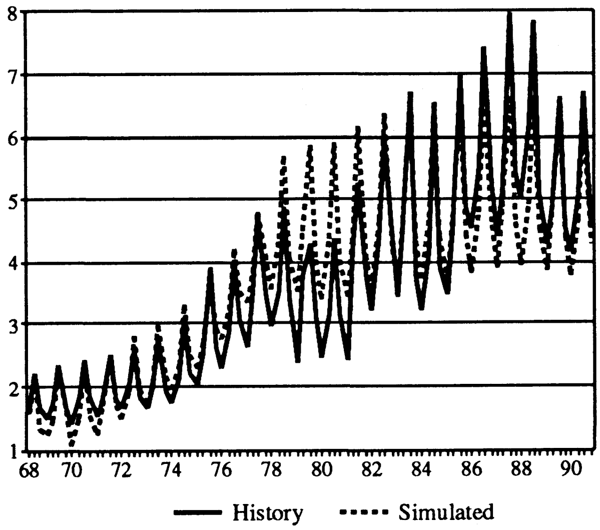


FIGURE 16B. CONSUMPTION ABROAD Billion 1989-kroner.



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