DANMARKS NATIONALBANK

DANMARKS NATIONALBANK WORKING PAPERS

2010 • 66

Maria Carlsen

and

Peter E. Storgaard

Danmarks Nationalbank

Dankort payments as a timely indicator of retail sales in Denmark

March 2010

The Working Papers of Danmarks Nationalbank describe research and development, often still ongoing, as a contribution to the professional debate.

The viewpoints and conclusions stated are the responsibility of the individual contributors, and do not necessarily reflect the views of Danmarks Nationalbank.

As a general rule, Working Papers are not translated, but are available in the original language used by the contributor.

Danmarks Nationalbank's Working Papers are published in PDF format at www.nationalbanken.dk. A free electronic subscription is also available at this Web site.

The subscriber receives an e-mail notification whenever a new Working Paper is published.

Please direct any enquiries to
Danmarks Nationalbank, Communication Desk, Havnegade 5, DK-1093 Copenhagen K Denmark
Tel.: +45 33 63 70 00 (direct) or +45 33 63 63 63
Fax : +45 33 63 71 03
E-mail:info@nationalbanken.dk

Nationalbankens Working Papers beskriver forsknings- og udviklingsarbejde, ofte af foreløbig karakter, med henblik på at bidrage til en faglig debat.

Synspunkter og konklusioner står for forfatternes regning og er derfor ikke nødvendigvis udtryk for Nationalbankens holdninger.

Working Papers vil som regel ikke blive oversat, men vil kun foreligge på det sprog, forfatterne har brugt.

Danmarks Nationalbanks Working Papers er tilgængelige på Internettet www.nationalbanken.dk i pdf-format. På webstedet er det muligt at oprette et gratis elektronisk abonnement, der leverer en e-mail notifikation ved enhver udgivelse af et Working Paper.

Henvendelser kan rettes til :
Danmarks Nationalbank, Kommunikation, Havnegade 5, 1093 København K.
Telefon: 33 63 70 00 (direkte) eller 33 63 63 63
E-mail: info@nationalbanken.dk

ISSN (trykt/print) 1602-1185

ISSN (online) 1602-1193

Abstract

The paper examines whether electronic payments by card (Dankort) provides a useful indicator for retail sales in Denmark. Dankort transactions data is available about one week after the reference month, while the retail sales index is only published about three weeks later. We add to previous work by setting up a model for the seasonally adjusted volume index for retail sales. The extensions considered are meant to further enhance the usefulness of the nowcasting model for conjunctural analysis. The out-of-sample forecasting ability of the model compares favourably with a benchmark autoregression.

Resumé

En væsentlig del af betalingerne i den danske detailhandel foregår med dankort, som er et elektronisk debetkort. Dankortbetalinger kan anvendes som en tidlig indikator for detailomsætningen, da dankortomsætningen for en given måned er tilgængelig omkring en uge efter månedens udløb, mens detailomsætningen først offentliggøres ca. 30 dage efter referencemåneden.

I Danmarks Nationalbank, Kvartalsoversigt 2. kvartal 2005, s. 17 opstilles en simpel regressionsmodel, der forklarer år-til-år væksten i værdiindekset for detailomsætningen ud fra år-til-år væksten i dankortomsætningen.

Til brug for konjunkturvurdering er det særligt det sæsonkorrigerede mængdeindeks for detailomsætningen, der har interesse. I dette papir udvides den eksisterende model derfor i to dimensioner: modellering af sæsonmønstret og korrektion for prisudviklingen. Der opstilles to modeller til forklaring af det sæsonkorrigerede mængdeindeks for detailomsætningen ud fra dankortbetalinger. Den ene model er i årlige vækstrater (model 1), mens den anden er baseret på en kointegreret vektor autoregressiv model i månedlige vækstrater (model 2).

Såvel model 1 som model 2 er bedre til at forudsige den sæsonkorrigerede detailomsætning end en AR(4)-model. Det viser, at dankortbetalingerne bidrager med væsentlig information til forklaring af detailomsætningen. Sammenlignes de to modeller ved RMSE, er forudsigelsesfejlene tydeligt mindre for model 2 end for model 1.

1 Introduction

Economic statistics take time to compile and there is often a considerable time lag between the reference period and the time of publication of "hard" economic data. This is unfortunate as having a precise knowledge of the current economic situation is essential for forecasting and economic policy-making.

In this paper we investigate an example of how electronic transactions data may be used to provide a timely indicator of "hard" data. In particular, we examine whether electronic payments by card (Dankort) provides a useful indicator for retail sales in Denmark.

The Dankort is a debit card developed jointly by the Danish banks and introduced in 1983. The Dankort is free of charge to the customers, and the card is extensively used by households. The payments data is compiled by a single source (PBS A/S), and it is available soon after the expiry of a month.

To be useful for nowcasting, the relationship between Dankort payments and retail sales has to be sufficiently stable over time. We argue in this paper that a relatively stable share of the retail sales is paid for with Dankort. However, we also discuss various factors that may disturb this relationship. One example is that after the introduction of the Dankort, people's payment habits changed, and at least at the beginning of the period, there was a strong growth in the adoption of the new card. In addition, the ongoing technological development has led to various new ways to use the Dankort, e.g. internet shopping is growing.

In the end, it is an empirical question whether the relationship is sufficiently stable to be used for the purpose of nowcasting. This will be examined further in this paper, where the objective is to set up a model which is able to nowcast retail sales from electronic transactions data.

The first model using Dankort payments as an indicator for retail sales was, to the best of our knowledge, presented in Danmarks Nationalbank (2005a). In this article the nowcasting ability of Dankort transactions was demonstrated in a simple model explaining annual growth in the value of retail sales.

In this paper we extend the analysis in two dimensions. First, we set up a model for the volume index for retail sales which is often of more interest for economic analysis. Second, we consider nowcasting the seasonally adjusted volume index for retail sales to further enhance the usefulness of the model for conjunctural analysis.

Related papers are scarce, but Galbraith and Tkacz's (2007) analysis of electronic transactions as indicators of economic activity in Canada is an exception. One part of their paper explores the ability to nowcast GDP and consumption from debit card transaction data. It is found that using this data one can potentially improve consensus forecasts of real GDP and consumption growth.

The paper is structured as follows. In the next section we review the Dankort payments data. Then we turn to the relationship between payments made by Dankort and retail trade, discussing in some detail the differences in coverage. In section 4 we take a closer look at the time-series properties of the data, before we estimate and assess two indicator models in section 5.

2 The Dankort

The Dankort is a nationwide debit card developed by the Danish banks in a joint venture.[1] The Dankort was launched in 1983 as a voucher system using only manual imprinters and the electronic Dankort system, by which the Dankort was to be used online, was launched nationwide in 1985.[2]

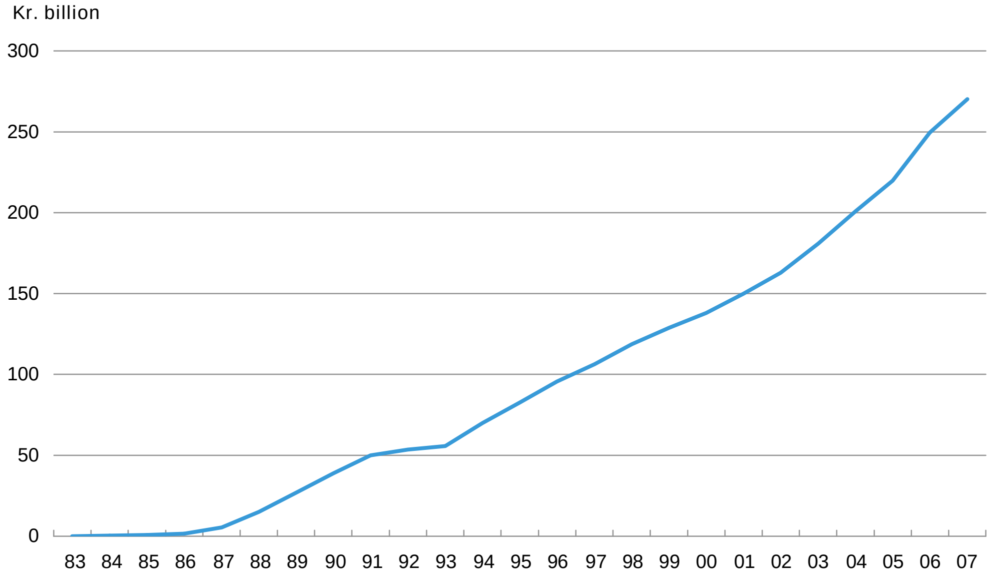
The Dankort is free of charge to all customers.[3] There have been two short periods

[1] See also Danmarks Nationalbank (2005b) and Schou (2006).

[2] The first outdoor ATM was introduced in 1984, enabling Dankort holders to withdraw cash 24 hours a day.

[3] Special fees do, however, apply to payments on the internet.

VALUE OF DANKORT TRANSACTIONS PER YEAR — Chart 1



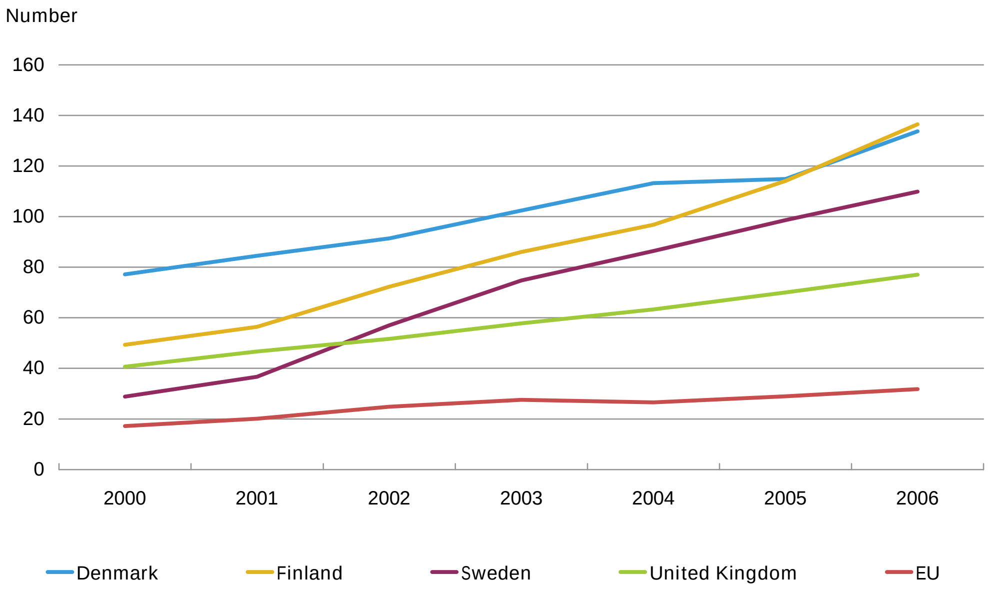
Source: PBS A/S.

where the card holders were charged a fee of kr. 0.50 for each transaction, the first period was from the introduction in 1983 to 1 January 1985 and the second was from 1 January 2005 to 1 March 2005. The introduction of the fee led to a considerable fall in the number of Dankort transactions in January and February 2005.

Since the introduction in 1983 the value of Dankort transactions has increased substantially, cf. Chart 1. The value of card transactions naturally increases in a growing economy. However, a part of the increase in the value of transactions is attributable to growth in the adoption of the new card, at least at the beginning of the period.By the end of 2007, more than 3.86 million Dankort had been issued, which may be compared with the Danish population of 5.4 million. The number of payments increased from 81 million in 1990 to 737 million in 2007.

Denmark had the highest number of debit card transaction per capita in EU in the

ANNUAL DEBIT CARD TRANSACTIONS PER CAPITA Chart 2



Source: ECB and Eurostat.

period 2000-2004, where Finland reached approximately the same number in 2005-2006, see Chart 2. Also if we include other card payments, Denmark had the highest and second highest number of transactions in 2000-2004 and 2005-2006, respectively. The card payments in Denmark are to a very large extent made by Dankort, as the value of transactions with other payment cards constitutes only 6 per cent of the value of total card transactions.[4] There has been a slight upward trend in Danish credit-card use, but the incentive for Danish consumers and retailers to use credit cards have been low due to the strong position of the Dankort as a widely accepted national payment card.[5]

[4] This is the average share in the period 2001-2006, based on data from PBS A/S and the Danish Competition Authority.

[5] From mid-2005 the shops have to pay an annual subscription determined on the basis of their size, i.e. the number of Dankort transactions.

3 Transactions data and retail trade

Households may pay for their purchases of retail goods by cash, cheques or card. As mentioned above, payment cards – other than the Dankort – are only used to a limited extent in Denmark. Also, the use of cheques in retail payments has been reduced significantly, and it has been estimated to be only approximately 2 per cent of retail payments in 2004.[6] The two remaining means of payment, cash and Dankort, are thus used in most transactions linked to retail sales.[7]

The value of Dankort payments and the value index of retail sales are highly correlated, cf. Chart 3. The value of Dankort transactions has however been increasing more than retail trade, which indicates that ever more purchases of goods by households are paid for using the Dankort.

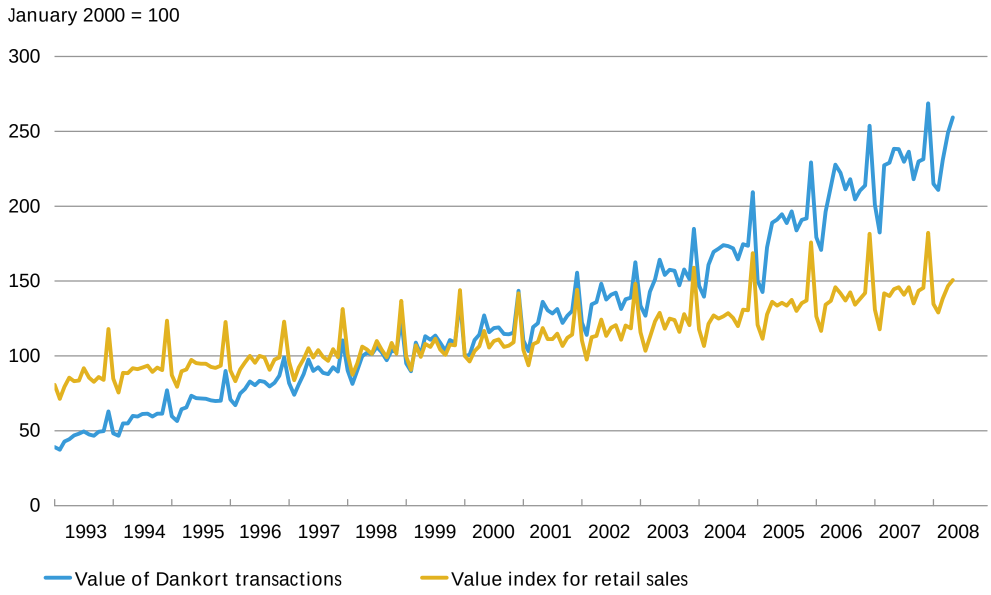
ATM cash withdrawals are not included in the payments data, so there is no discrepancy in coverage stemming from this. But it is possible to withdraw more money than the amount of the bill in most shops. It is likely that this withdrawn amount is used for other retail payments and thus does not lead to noise in the relationship between Dankort payments and retail sales. Another noticeable feature in Chart 3 is that the seasonal pattern in the value index for retail sales and Dankort transactions is very similar with peaks in December, due to Christmas shopping, and troughs in February.

The growth in Dankort transactions is higher than the growth in retail sales, cf. Chart 4. Before 1998 the difference in growth rates was considerably higher. But from then on the annual growth rates indicate that the use of the Dankort had reached a mature state in terms of adoption, as the downward trend seems to vanish. After 1998 we therefore expect the relationship between Dankort payments and the retail trade index to have stabilised which should improve Dankort-based nowcasts of the retail trade. However,

[6] Cf. Carlsen and Riishøj (2006).

[7] In 2004, the share of cash payments was about 40 per cent of retail payments; see also Carlsen and Riishøj (2006).

DANKORT TRANSACTIONS AND RETAIL SALES Chart 3



Source: Statistics Denmark and PBS A/S.

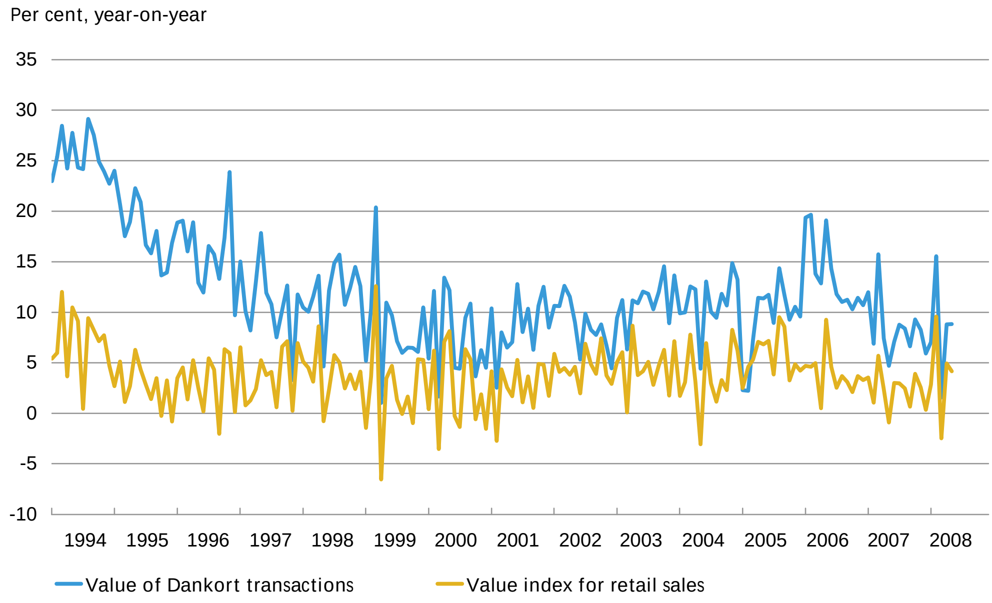
the growth rate in Dankort transactions is generally higher than the growth rate in retail sales. This may indicate that the adoption of the Dankort is still ongoing and/or that some purchases are paid for with Dankort but not included in the retail trade index. Since variation in Dankort payments which are not retail sales may disturb the relationship we seek to exploit for nowcasting, they will be discussed in more detail in the next section.

3.1 Dankort payments not related to retail trade

Dankort transactions data may be split into three groups: 1) Face-to-face payments (physical trade), 2) Internet payments (non-physical trade), and 3) Other payments.

A large part of the payments in the first group is related to retail sales. There are, however, exceptions such as purchases of bus and train tickets, theatre tickets and taxi,

DANKORT TRANSACTIONS AND RETAIL SALES, ANNUAL GROWTH RATES Chart 4



Note: The annual growth rates in Dankort transactions in January and February 2005 and 2006 are affected by the fee mentioned in the main text.

Source: PBS A/S and Statistics Denmark.

hotel and restaurant payments. To the extent that consumption of these items increase more than retail sales, this may explain at least part of the observed difference in the growth rates in Chart 4. As long as these differences are stable, their destabilising effect on the Dankort/retail sales relationship may be limited. One may pay large-value items like cars (which are not considered to be retail sales) with Dankort, but it is not considered to be common.

The third group, other payments, includes transactions in payment machines not served by a person, e.g. payments on a petrol station, parking meters, and bridge toll, neither of which are included in the retail trade index. The value of these other payments has increased from kr. 0.7 billion in 2003 to kr. 19 billion in 2007, where the latter constitute 7 per cent of the total Dankort payments.[8] Some of this increase may be ascribed to the bridge toll.[9] This illustrates that new payment methods are continuously developed which potentially could disturb the Dankort/retail sales relationship.[10] The second group of Dankort transactions, internet payments, will be discussed in the next section together with retail trade and internet shopping.

3.1.1 Internet payments

The number of Dankort payments in Danish internet shops has increased considerably since 2000, cf. Chart 5. Dankort payments on the internet as a share of total Dankort payments have increased from below 0.5 per cent in 2000 to approximately 4 per cent in 2007. Looking at the value of the Dankort transactions, the share is a bit higher and was around 6 per cent in 2007. Thus, although internet shopping has increased in recent years, it still constitutes a relatively small share of the total Dankort payments in numbers as well as value. As long as the retail trade index captures internet shopping in the same way as the total value of Dankort transactions, the increasing internet shopping will not take away the usefulness of Dankort payments as an indicator for retail sales.

The retail trade index includes internet shopping. The population of firms behind the retail trade index consists of firms who have their main or secondary activity within the sectors of retail trade. However, if a wholesale firm has expanded by opening a retail store without registering under the sectors of retail trade, the internet sale will not enter into the retail trade index. Unfortunately, there is no measure of this lack of coverage.

The category "retail sale via mail order houses" in the retail trade index contains retail trade with goods ordered by mail, internet, telephone, etc. which are sent to

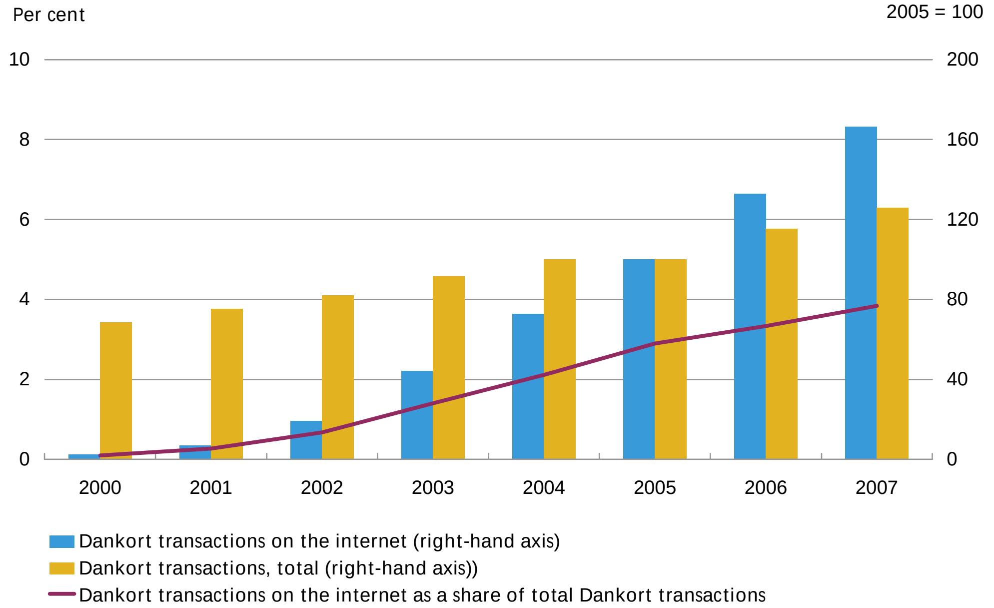
[8] Cf. the Danish Competition Authority (2008).

[9] The bridge to Sweden, Øresundsbroen, was opened in 2000. The bridge between Sealand and Funen was opened in 1997/1998.

[10] A similar issue arises with Dankort payments on the internet. A recent example (outside our sample period) is that since the end of 2009 it has been possible to pay outstanding tax by Dankort.

NUMBER OF DANKORT PAYMENTS IN DANISH INTERNET SHOPS AND TOTAL DANKORT TRANSACTIONS

Chart 5



Note: Dankort includes Visa/Dankort and eDankort.
Source: PBS A/S and The Danish Bankers Association.

the customer. Thus, the category contains only part of the internet shops but the development over time may reflect the increased use of the internet. "Retail sale via mail order houses" has increased 26 per cent from 2000 to 2007, very similar to the increase of 25 per cent in the total retail trade index. One might have expected internet shopping to be expanding at a faster rate than total retail trade. But as explained above, some of the internet shopping may be included via one of the other categories in the retail sales index.

One possible difference in coverage between retail sales and Dankort payments is that the most popular items bought on the internet are travel products and other entertainment products, which are not included in retail sales, but may be paid with Dankort. If internet shopping continues to rise quickly in the future, it is possible that the discrepancy between the retail trade and Dankort payments increases.

In sum, the difference in growth rates seen in Chart 4 can probably be explained by the introduction of new payment methods and increased purchases of goods not included in retail sales. Whether the relationship between Dankort payments and the retail trade index is stable enough to be used for nowcasting is ultimately an empirical question which we now turn to.

4 Data

As shown and discussed above, Dankort payments covary quite closely with the value index for retail sales. But for economic analysis a real measure of households' retail purchases is often of more interest. Therefore we will focus on the volume index for retail sales in the following. The sample period begins in 1998, where as noted in Section 3 the relationship between Dankort payments and retail sales appears to have stabilised, and ends in May 2008.

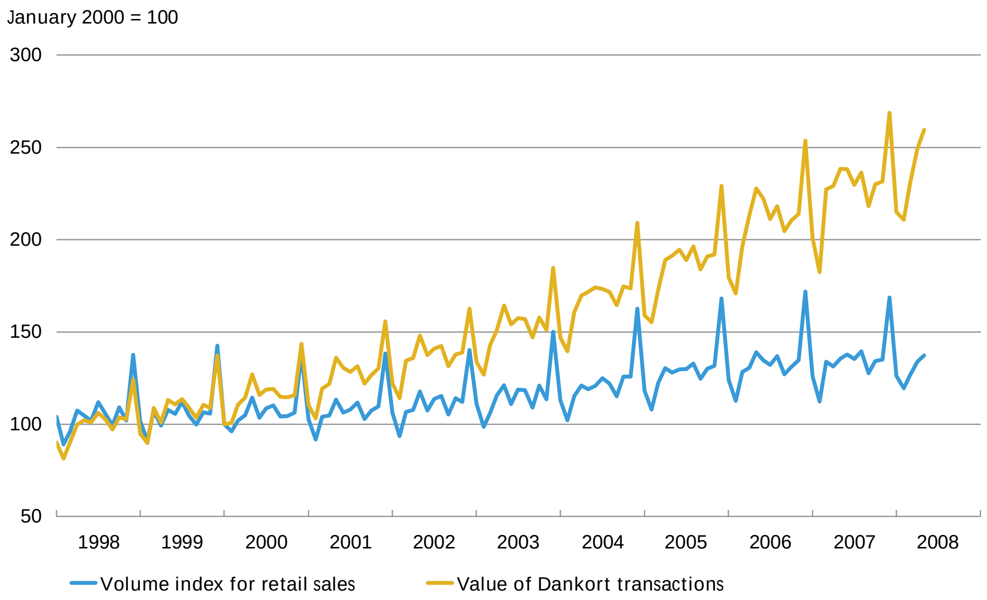
The value of the monthly Dankort transactions are shown together with the volume index for retail sales in Chart 6.[11] The two series are visibly time dependent with an upward trend, and they both contain clear seasonal patterns. Given the importance of seasonal variation for the data and to guide our choice of model, we will consider the nature of the seasonality in some detail.

While the seasonality may be of a simple deterministic nature, it could also be stochastic with seasonal unit roots. With stochastic seasonality, an observation in a specific month would be related to current and past disturbances which occurred in that specific month, but independent of the other months.[12] The presence of seasonal unit roots

[11] The Dankort data has been corrected in January and February 2005 for the estimated influence of the fee mentioned earlier in the text.

[12] That is, a shock to retail sales in December – perhaps to Christmas shopping – affect retail sales in December the following years but have no effect in the other months.

DANKORT TRANSACTIONS AND VOLUME INDEX OF RETAIL SALES — Chart 6



Source: Statistics Denmark and PBS A/S.

also implies that seasonality may have long-run implications, meaning for instance that "summer can become winter".

We consider two seasonality hypotheses to get at which data transformation is necessary to obtain stationary series suitable for modelling.[13] The first hypothesis is that the transformation required to get stationary time series is annual differencing. This entails that first differencing is not sufficient to remove the non-stationarity in the series because the underlying process is seasonally integrated of order one, denoted SI(1). With monthly data, a simple SI(1) process may be written as

$$\Delta_{12} y_t = \kappa + \text{lags of } \Delta_{12} y_t + \varepsilon_t, \tag{1}$$

[13] This follows Osborn (2002).

where κ is a constant and ε_t is i.i.d. In this case there are implicitly 12 unit-root processes which are related to each of the 12 months of the year. Hence, annual differencing is required to remove the non-stationarity in the process. The constant, κ, allows for drift in the data.

The second hypothesis is that after first differencing, i.e. monthly differencing, the stochastic process is stationary around a constant underlying seasonal pattern. A simple process with deterministic seasonality can be written as

$$\Delta_1 y_t = \lambda_i SD_{it} + \text{lags of } \Delta_1 y_t + u_t, \quad (2)$$

where SD_{it} for $i = 1, ..., 12$ are seasonal dummy variables with corresponding coefficients λ_i and u_t is i.i.d. In this case there is only one unit-root process and first differencing removes the non-stationarity in the process. A deterministic linear trend in y_t is allowed through the inclusion of seasonal dummy variable terms.

In order to throw light on this issue, we conduct HEGY-tests to investigate the presence of seasonal unit roots in the volume index for retail sales and the value of Dankort payments.[14] Both series are in log levels, and the estimation equations include a constant, a trend, and seasonal dummies.[15] The main HEGY-test results are shown in Appendix A1. We reject seasonal unit roots at most but not all seasonal frequencies at the 5 per cent level for both data series. The test for frequency zero corresponds to a conventional unit-root test, and we can not reject the unit-root hypothesis for either series.

In the HEGY-tests no lags of the dependent variables have been included. Even though there is no problem with autocorrelation in the residuals, we have as a robustness check rerun the tests with different choices of lags, and the results are basically

[14] See Hylleberg et al (1990). Beaulieu and Miron (1993) extend the HEGY procedure to monthly data.

[15] As in Beaulieu and Miron (1993) we allow for seasonal dummies in all tests.

unchanged.[16]

All in all, we can not entirely rule out the presence of seasonal unit roots, but we do reject at most of the seasonal frequencies. Hence, the tests point for the most part to the use of a model with first differences and deterministic seasonality.

From an economic perspective, we do not expect the presence of seasonal unit roots in the data series under consideration. It is hard to argue that a shock to retail sales in for example July 2006 will affect retail sales in July 2007 but not August 2006.

Without a completely clear conclusion from the HEGY-test, it remains an open (and empirical) question which model is the best for the purpose of nowcasting; a model with annual differences or monthly differences. In building our preferred model, we will therefore consider one model with annual differences and another with monthly differences.[17]

5 Estimation

In the following we set up and estimate two models of the seasonally adjusted volume index for retail sales. The estimation sample is January 1998-December 2006 and the remaining 17 months are saved for out-of-sample nowcasts.

5.1 A model with annual differences

In this section we assume that the appropriate transformation of the data is annual differencing. The general model can be written as

[16] The set of lags was determined by first estimating the equation with two years of lags and then excluding the lags which did not enter significantly.

[17] We refrain from considering models with a combination of roots/differences.

$$\Delta_{12}Vol_t = \Delta_{12}D_t + \Delta_{12}P_{t-1} + \text{lags of } \Delta_{12}Vol_t,\ \Delta_{12}D_t \text{ and } \Delta_{12}P_{t-1} + \text{deterministic terms} + \varepsilon_t, \quad (3)$$

where Vol is the (log) seasonally adjusted volume index for retail trade and D is the (log) value of Dankort payments. P is the (log) implicit price deflator included to deflate the value of Dankort payments.[18] The deterministic terms consist of a constant, i.e. we allow for trends in the data, and the deterministic terms include calendar dummies: $\Delta_{12}\text{Tuesday}_t, \ldots, \Delta_{12}\text{Sunday}_t, \Delta_{12}\text{Easter}_t$.[19]

The estimation results are shown in Table 1 (with graphs in Appendix A2). The model explains about 80 per cent of the variation in the annual change in the volume index. Standard diagnostic tests indicate that the model is well specified and that one lag is sufficient.

A one percentage increase in Dankort payments in a given month leads to a 0.68 percentage increase in the volume index in the same month. The coefficient is less than one, which reflects that Dankort payments include more items than retail sales and the ongoing advance of the Dankort as a means of payment as discussed above.

The Friday and Easter dummies are the only significant calendar dummies. In addition to the immediate effect, dynamic effects are also significant, and the static long-run solution is given by

$$\Delta_{12}Vol_t = -0.006 + 0.47\Delta_{12}D_t - 1.06\Delta_{12}P_{t-1} + \text{dummies.}$$

[18] We only include the lagged value of the implicit price deflator as its current value is not in the information set when forecasting in real time.

[19] The "day dummies" measure the number of days in a given month compared to the same month a year before and take on the value 1, 0 or -1. Only six of the seven "day dummies" are included in the estimation in order to avoid the dummy variable trap. The Easter-dummy measures whether Easter lies in the same month as the year before and takes on the value 1, 0 or -1.

OLS REGRESSION OF THE ANNUAL CHANGE IN THE SEASONALLY ADJUSTED VOLUME INDEX FOR RETAIL TRADE (MODEL 1) — Table 1

	Coefficient	Standard error
Constant	-0.003	-0.007
Dankort transactions (D_t)	0.679	0.051
Volume index (Vol_{t-1})	0.508	0.084
Dankort transactions (D_{t-1})	-0.447	0.069
Price deflator (P_{t-1})	-0.520	0.147
Tuesday	-0.001	0.004
Wednesday	-0.005	0.003
Thursday	0.000	0.003
Friday	-0.011	0.003
Saturday	0.003	0.003
Sunday	0.006	0.004
Easter	-0.010	0.005

Number of observations: 95 R^2: 0,82 σ: 0.0127 AR 1-6: F(6,77) = 2.11
Normality test: $\chi^2(2)$ = 3.16 Hetero test: F(22,60) = 0.96 RESET test: F(1,82) = 2.48

Note: Monthly observations. The variables are in log and annual differences. The volume index is seasonally adjusted, whereas the other variables are not.

An increase in the value of Dankort payments by 1 per cent is associated with an increase in retail sales of approximately 0.5 per cent. Notice that the coefficient to the price variable is close to 1. This is as expected since the left hand side is a real measure and the value of Dankort payments is a nominal measure.

Turning to the model's nowcast abilities out of sample, we find that the root mean square error (RMSE) for the 17 one-step-ahead forecasts is 0.0218.[20] The inclusion of Dankort payments is indeed useful for nowcasting retail sales as a benchmark univariate AR(4) model in annual growth rates yields a RMSE of 0.0314.

Next we consider an extended model which includes an estimate P_t^* of the implicit price deflator in the model.[21] The estimate is calculated from a subset of the prices in the consumer price index, which is published ten days after the end of a month. Hence,

[20] All reported RMSEs have been computed based on the forecast error made in predicting the month-on-month change in the retail index to make them comparable across models.

[21] Specifically, we include $\Delta_{12} P_t^*$ as an additional regressor.

D_t and P_t^* is available about three weeks before the retail trade index which is only published thirty days after the end of the reference month. If prices are stable over time, the inclusion of P_t^* in the model should not add much more information than the lagged actual deflator P_{t-1}, but the estimated deflator might be able to capture some high-frequency variation in prices.

The estimation is based on a smaller sample because the estimate of the implicit price deflator is only available since 2000. The RMSE of the 17 out-of-sample nowcasts is reduced to 0.0177, indicating that it is useful to include the estimate of the annual price change in the model.

5.2 A model with monthly differences

The unit-root tests in the HEGY-tests above indicated that retail sales and Dankort transactions are integrated of order one. Also, we have argued that households' extensive use of the Dankort when purchasing retail goods should lead to a (long-run) relationship between the two. To investigate this further, still with the objective of finding a model useful for nowcasting the volume index for retail sales, a cointegrated VAR is set up in the following.

We include the seasonally adjusted volume index and Dankort payments as endogenous variables and the implicit deflator as unmodelled, all in logs. An unrestricted constant and a trend restricted to the cointegration space is included to allow for deterministic trends in the data and, possibly, in the cointegration relations. Also we condition on the set of calendar dummies introduced above (in level form) and a full set of monthly seasonal dummies. Formally, the model may be written in error-correction form as

$$\Delta Y_t = \alpha + \Pi Y_{t-1}^* + \sum_{j=1}^{k} A_i \Delta Y_{t-j} + B\Delta Z_t + \text{dummies} + \varepsilon_t, \tag{4}$$

where Y contains the endogenous I(1) variables, Y^* is Y together with the time trend and the unmodelled variable, k is the lag length of the VAR, Z is the unmodelled variable and it is assumed that ε_t is i.i.d.$N(0, \Omega)$.

A lag length of 5 is chosen. The model generally passes standard tests for misspecification, although normality of the errors is rejected, cf. Table 2. The problem with non-normality is found to be due to outliers in March and April 1999, but in the following we continue with the full sample.

DIAGNOSTIC TESTS (SYSTEM) Table 2

	AR 1-6	ARCH 1-6	Hetero.	Normality
Test statistic distribution	F(6,66)	F(6,60)	F(24.47)	$X^2(2)$
Volume index	0.85	4.03**	1.46	21.2**
Dankort	1.01	1.42	1.16	9.74**
Test statistic distribution	F(24,118)	..	F(72,135)	$X^2(4)$
System...	1.34	..	0.88	8.89

Note.: * and ** denotes rejection at a respectively 5 and 1-per-cent significance level.

Test for cointegration rank points to one cointegrating relationship, cf. Table 3. After imposing a cointegration rank of one, we consider the theoretical restrictions that follow from the discussion above. First we expect that changes in the marginal process for Dankort transactions should not affect the conditional process for the volume index given Dankort transactions. Second, we expect a long-run relationship between (log) Dankort transactions and the (log) value index for retail sales. This implies equal coefficients on the volume index and the implicit deflator. The two overidentifying restrictions (Dankort transactions weakly exogenous and equal coefficients on the volume index and the deflator) are rejected by the LR test on a 5 per cent significance level, but accepted on a 1 per cent level (P-value = 0.03). When the restriction that the trend does not enter the cointegrating relation is added, the overidentifying restrictions are no longer rejected at a 5 per cent significance level (P-value = 0.07).

COINTEGRATION TESTS				Table 3
Rank	Trace	Max	Trace (T-nm)	Max (T-nm)
0	34.47**	22.68*	31.12**	20.48*
1	11.79	11.79	10.64	10.64

Note: * and ** denotes rejection at a respectively 5 and 1 per cent significance level.

The final cointegrating relation reads

$$ecm_t = Vol_t + P_t - 0.43D_t.$$

In the long run a one per cent increase in Dankort payments is thus found to lead to an increase in the volume of retail sales of 0.43 per cent (standard error 0.01). The adjustment coefficient in the volume index equation is estimated to be -0.32 (with a standard error of 0.09). Accordingly, about one third of a deviation from the long-run equilibrium will be corrected in the next month.

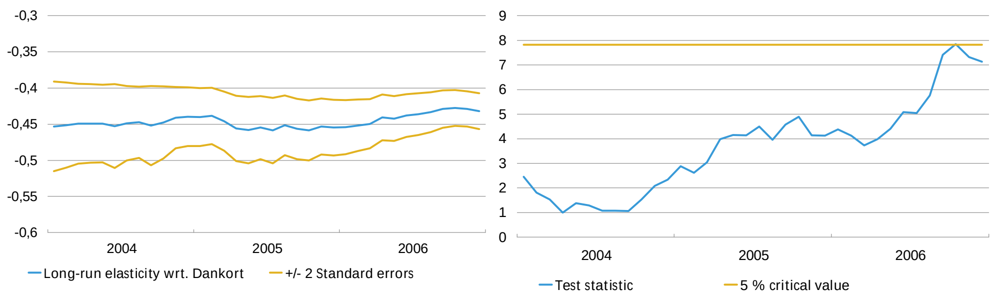
The long-run elasticity with respect to the Dankort transactions has been relatively stable over time, cf. the recursive graphics in Chart 7. The chart also shows that the overidentifying restrictions would not have been rejected on virtually any sample ending in 2004 and later.

Given the weak exogeneity of the Dankort transactions we continue the analysis towards a nowcasting model for the volume index in a single equation framework. The general equation from which we start is specified as follows

$$\begin{aligned} \Delta Vol_t &= \Delta D_t + \Delta P_{t-1} + \text{lags of } \Delta Vol_t,\ \Delta D_t \text{ and } \Delta P_{t-1} + ecm_{t-1} \\ &\quad + \text{deterministic terms} + \varepsilon_t, \qquad (5) \end{aligned}$$

where the deterministic terms include a constant, the same calendar dummies as above

RECURSIVE COINTEGRATION RESULTS Chart 7



and a full set of seasonal dummies.

We start with five lags and then eliminate insignificant lags to arrive at the model in Table 4 with graphical analysis given in Appendix A2. The model explains more than 80 per cent of the variation in the monthly change in the volume index. Test for misspecification generally look fine, although the RESET test indicate that there may be a problem with the functional form of the regression equation.[22]

Turning to the nowcast abilities of model 2, we find a RMSE of 0.0103 for the 17 out-of-sample nowcasts. Adding the estimate of (the monthly growth in) the implicit price deflator to the model, the RMSE is reduced to 0.0089. This may be compared to a benchmark AR(4) model in monthly growth rates which has a RMSE of 0.0136.

Finally, we depict the out-of-sample nowcasts from the two models in Chart 8. Both models seem to carry information about the volume of retail sales as was also found in the comparison with univariate AR(4) models. Based on RMSE, model 2 yields the lowest forecast errors in the period under consideration, cf. Table 5.

The mean forecast errors show that model 1 delivers unbiased forecasts for the period under consideration, while model 2 has a small positive bias.

[22] When the estimate of the implicit price deflator is added to the model (see below), no specification problems are detected by the tests.

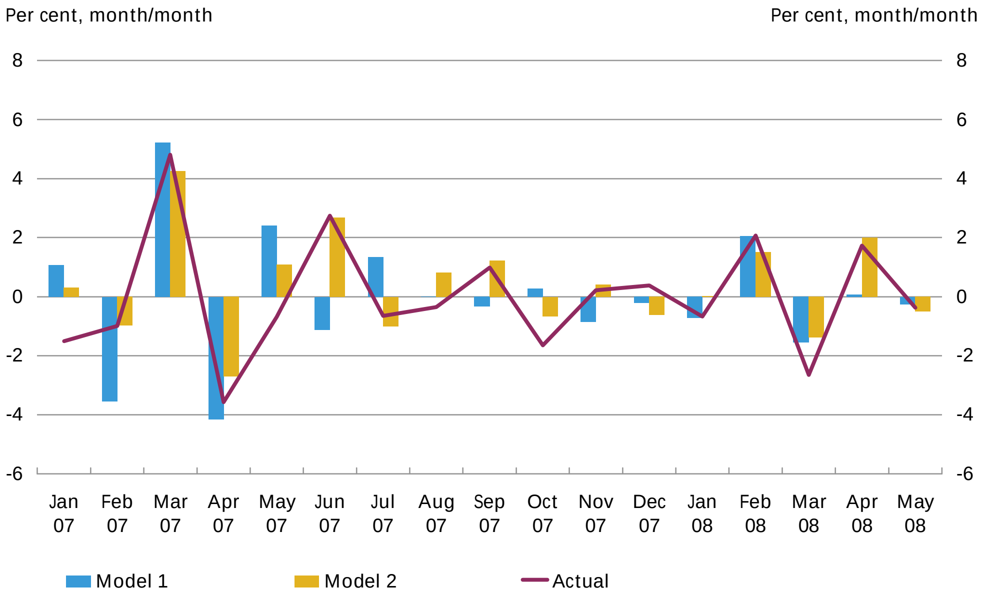
OLS REGRESSION OF THE MONTHLY CHANGE IN THE SEASONALLY ADJUSTED VOLUME INDEX FOR RETAIL TRADE (MODEL 2) Table 4

	Coefficient	Standard error
Constant	0.180	0.062
Dankort transactions (D_t)	0.544	0.045
Volume index (Vol_{t-1})	-0.277	0.121
Dankort transactions (D_{t-1})	0.169	0.085
Price deflator (P_{t-1})	0.254	0.312
Volume index (Vol_{t-2})	-0.142	0.102
Dankort transactions (D_{t-2})	0.018	0.072
Price deflator (P_{t-2})	-0.791	0.307
Error-correction term (ECM_{t-1})	-0.307	0.107

Number of observations: 102 R^2: 0,85 σ: 0.0087 AR 1-6: F(6,69) = 1.97
Normality test: $\chi^2(2)$ = 2.61 Hetero test: F(41,33) = 0.86 RESET test: F(1,74) = 6.04*

Note: Monthly observations. The variables are in log and monthly differences. Coefficient estimates for calendar and seasonal dummies not shown. The volume index is seasonally adjusted, whereas the other variables are not. * and ** denotes rejection of the null hypothesis at a respectively 5 and 1 per cent significance level.

MONTHLY CHANGES IN THE SEASONALLY ADJUSTED VOLUME INDEX OF RETAIL SALES AND THE TWO NOWCASTS Chart 8



Note: Based on models which include the estimate of the implicit price deflator, P^*.

OUT-OF-SAMPLE FORECAST ACCURACY Table 5

Jan 2007 – May 2008	Model 1	Annual AR(4)	Model 2	Monthly AR(4)
RMSE	0.0177	0.0314	0.0089	0.0136
Mean error[1]	-0.0001	0.0004	0.0039	0.0069

Note: Model 1 and 2 include the estimate of the implicit price deflator, P^*.

[1] Model forecast minus actual value.

6 References

Beaulieu, J. Joseph and Jeffrey A. Miron (1993), Journal of Econometrics, 55 (305-328).

Carlsen, Maria og Johanne Dinesen Riishøj (2006), Brug af kontanter i Danmark, Danmarks Nationalbank, Working Paper, 41.

Danish Competition Authority (2006), Konkurrenceforholdene på betalingskortmarkedet 2006.

Danish Competition Authority (2008), Konkurrenceforholdene på betalingskortmarkedet 2008.

Danmarks Nationalbank (2005a), Recent Economic and Monetary Trends, Monetary Review, 2nd Quarter.

Danmarks Nationalbank (2005b), Payment Systems in Denmark.

Galbraith, John W. and Greg Tkacz (2007), Electronic Transactions as High-Frequency Indicators of Economic Activity, Bank of Canada Working Paper, 58.

Ghysels, Eric, Hanh S. Lee and Jaesum Noh (1994), Testing for unit roots in seasonal time series, Journal of Econometrics, 62 (415-442).

Hylleberg, S., R.F. Engle, C.W.J. Granger, and B.S. Yoo (1990), Seasonal integration and cointegration, Journal of Econometrics, 44 (215-238).

Osborn, Denise R. (2002), Unit-Root Versus Deterministic Representations of Seasonality for Forecasting, chapter 18 in A Companion to Economic Forecasting edited by Michael P. Clements and David F. Hendry, Blackwell Publishers.

Schou, Peter (2006), Dankortet – udvikling og perspektiv, chapter 10 in Den finansielle sektor - Udvikling og perspektiver, Festskrift til professor Morten Balling edited by Michael Christensen and Anders Grosen.

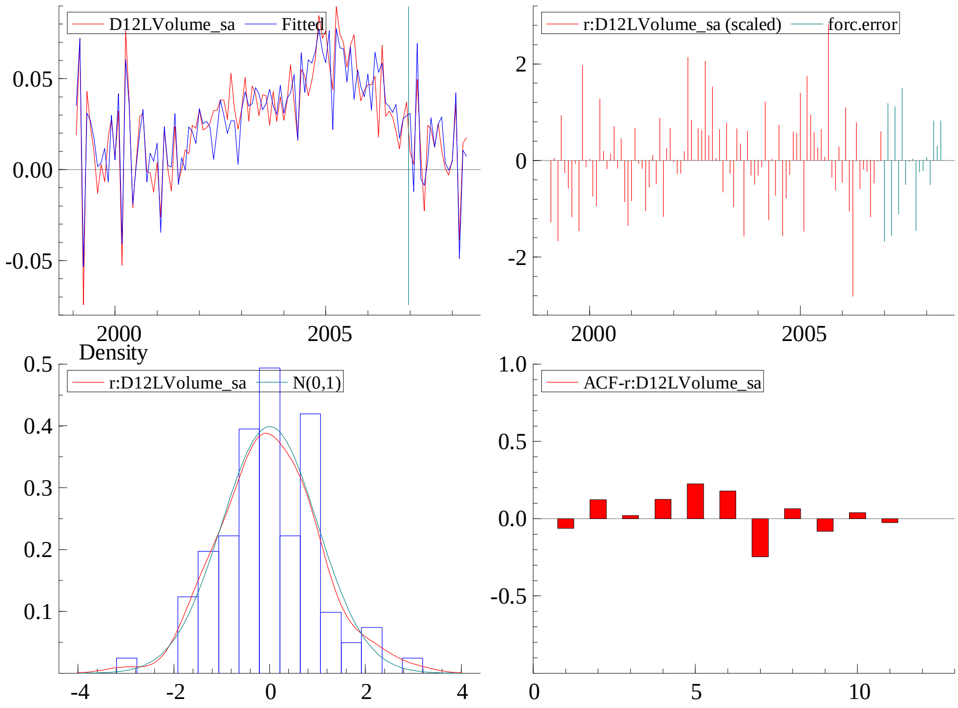
7 Appendix A1: HEGY tests

t-tests	0	π	$\pi/2$		$2\pi/3$		$\pi/3$		$5\pi/6$		$\pi/6$	
	π_1	π_2	π_3	π_4	π_5	π_6	π_7	π_8	π_9	π_{10}	π_{11}	π_{12}
Retail sales (volume)	0.85	-3.38	1.28	-3.03	1.15	2.59	3.21	-1.45	-3.34	2.24	2.79	-6.26
Dankort transactions	0.52	-3.11	1.13	-3.57	-0.34	3.26	2.35	-2.85	-2.86	2.28	1.09	-2.88
Critical value (5 per cent level)	-3.28	-2.75	-3.24	-2.18	-3.24	2.19	-3.24	-2.18	-3.24	2.19	-3.24	-2.18
Critical value (10 per cent level)	-2.99	-2.47	-2.95	-1.85	-2.95	1.86	-2.95	-1.85	-2.95	1.86	-2.95	-1.85

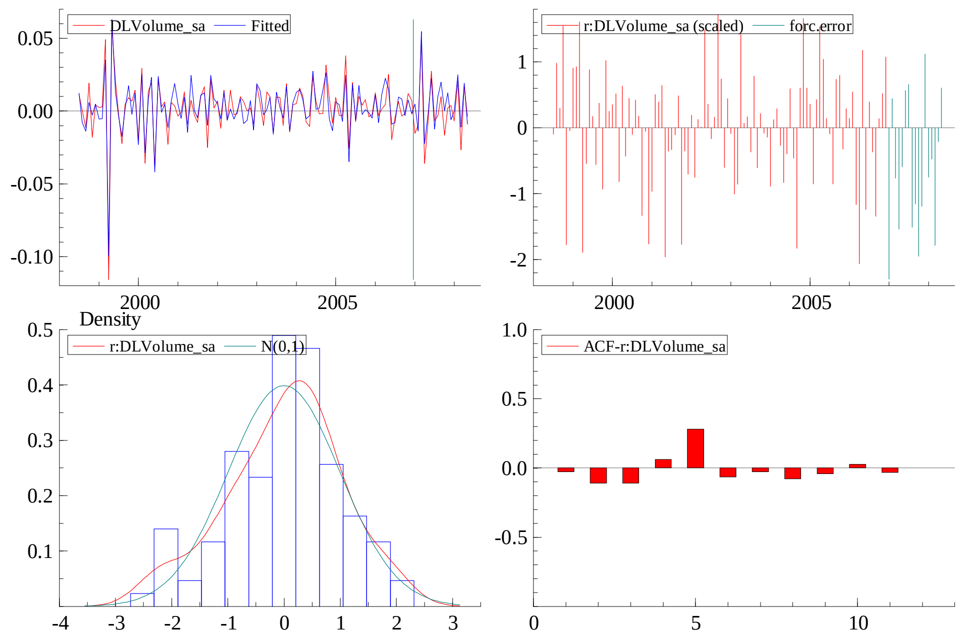
F-tests	$\pi/2$	$2\pi/3$	$\pi/3$	$5\pi/6$	$\pi/6$
	F(3, 4)	F(5, 6)	F(7, 8)	F(9, 10)	F(11, 12)
Retail sales (volume)	5.56	4.23	6.56	8.10	20.99
Dankort transactions	7.19	5.32	7.01	6.58	4.39
Critical value (5 per cent level)	6.23	6.23	6.23	6.23	6.23
Critical value (10 per cent level)	5.25	5.25	5.25	5.25	5.25

Note: Period 1999:1-2008:5. OLS standard errors. Series in log levels and the estimation equations include a constant, a trend and seasonal dummies.

8 Appendix A2: Graphs



Model 1



Model 2