Tools for Cyclical Assessment

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1. INTRODUCTION AND SUMMARY

Up-to-date knowledge about the current cyclical position is a key element in assessing the state of the economy and in economic-policy planning. In the event of an economic slowdown, with lower output growth and higher unemployment, it may be necessary to ease economic policy in order to stabilise the economy, provided that the necessary scope exists. Conversely, if there are indications of excessive pressure on the production resources, entailing a risk of unsustainable wage and price inflation, it may be necessary to tighten economic policy. In both cases a precise picture of the current cyclical position is called for as the basis for possible stabilisation-policy initiatives. This applies especially in connection with strong cyclical reversals, such as after the financial crisis, when major economic-policy measures need to be considered.

Much time is invested in producing an accurate description of the current cyclical position in connection with the preparation of multi-annual economic forecasts. In simplified terms, we need to know where we are before we know where we will go. This includes an assessment of the capacity pressures in the economy. Is there, for example, a labour shortage, and is the production capacity of firms ample or under pressure? In addition, an analysis of the momentum or driving forces of the economy is also needed, for instance growth abroad boosting exports and hence output and employment.

Cyclical assessments may draw on quite extensive statistics, although some economic statistics are available only with a certain time lag. A case in point is the national accounts, as the first version is released around 60 days after the reference quarter. Economic statistics on a monthly basis can be used to draw an earlier, but obviously less complete picture.

The NARES model is a key element of Danmarks Nationalbank's conjunctural analysis. The purpose of this model, which is described in detail in this article, is to summarise economic statistics in a consistent manner.

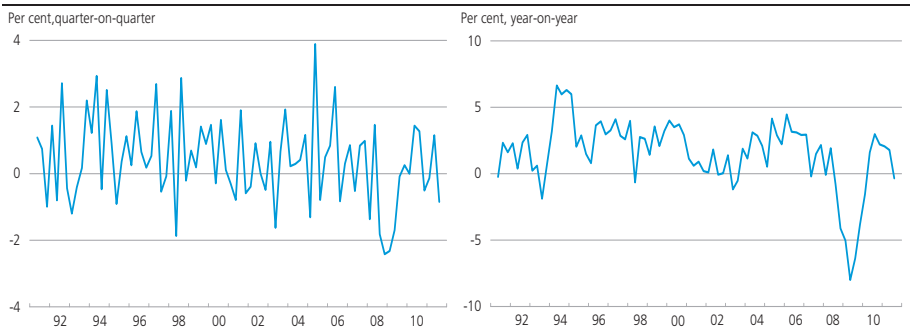
The NARES results provide the foundation for assessing the current economic situation. Moreover, the model also proved its worth when, during the financial crisis in 2009, Statistics Denmark postponed the release of the first version of the quarterly national accounts from 60 to 90 days after the reference quarter. The reason was that the deadline for VAT payments from firms was extended, and VAT data is a central source of input for the quarterly national accounts. At the time there was strong demand for updated assessments of the current economic development, not least for economic policy planning, and models such as NARES were particularly useful in that situation.

The available information about macroeconomic developments range from actual statistics on economic activity, such as the retail sales index, over payment data, e.g. Dankort payments, to sentiment indicators, e.g. the consumer confidence indicator. To this should be added statistics on price and wage developments, interest rates, stock prices and exchange rates, etc.

The focus is often on growth in the gross domestic product, GDP, as a key economic indicator summarising current cyclical developments in one figure, cf. Chart 1.1. Despite quarterly fluctuations, this indicator shows cyclical upturns and downturns, e.g. the weak years immediately after the millennium, the subsequent upswing and the dive in connection with the financial crisis. Besides GDP estimates, other parameters that may be interesting to monitor are e.g. the components of aggregate demand: private and public consumption, investment and exports. Another useful breakdown is to view output by industry.

The necessary extent and degree of detail in a cyclical assessment naturally depend on its purpose. If, for example, the analysis is to be used as the basis for a projection, statistics throwing light on all aspects of the economic situation are called for, corresponding to the quarterly nation-

GDP GROWTH — Chart 1.1



Source: Statistics Denmark.

al accounts. Since the analysis is most often summarised as estimates of one or more target variables, it is also relevant to consider whether the estimates should be point estimates or probability distributions.

The analyses in this article show that NARES contains suitable indicators of the most central elements of the national accounts. Consequently, it is possible to produce approximate national accounts on the basis of economic statistics. The positive results are consistent with the experience from regular use of the model at Danmarks Nationalbank.

The article presents a number of other model approaches as alternatives to NARES, and a Real-Time Forecasting System, RTFS, is constructed for estimation of quarterly GDP growth. This model is compared with a technical application of the NARES model and the first preliminary version of the national accounts. A comparison of the three estimates with the final national accounts shows that the smallest deviations are found in the preliminary national accounts, while the greatest are found in NARES. In practice, NARES is not used in this technical manner. Instead, the model's estimates are used as the basis for assessing the components of the national accounts at a detailed level. Overall, the NARES model is regarded as a useful tool for assessments of the current state of the economy and economic projections. At the same time, the NARES results provide a foundation for insight into and analysis of the quarterly national accounts from Statistics Denmark.

Section 2 of this article describes the general principles of Danmarks Nationalbank's NARES system for summarising economic statistics as quarterly national accounts. Section 3 reviews the indicators used for calculating the key national accounts figures and analyses the consistency with Statistics Denmark's official national accounts. Section 4 presents a number of alternative models developed for the purpose of throwing light on the cyclical position on the basis of available statistics. One of these models is used in section 5 to construct an alternative estimate of quarterly GDP growth in Denmark. Section 6 compares the growth estimates produced by this alternative model, the NARES model and the first preliminary version of the national accounts with the final quarterly national accounts.

2. NARES

NARES is a system for constructing indicator-based national accounts. One of NARES's most important objectives is to provide earlier estimates than the official quarterly national accounts from Statistics Denmark. NARES is used at Danmarks Nationalbank in connection with cyclical assessments and as a basis for forecasting.

The original purpose of NARES was to provide quarterly national accounts that were consistent with the national accounts from Statistics Denmark, which were then available only on an annual basis, cf. Christensen (1989). In addition to being used for an overall assessment of the current cyclical position and the economic outlook, the NARES calculations were also used in the preliminary work on MONA, cf. Danmarks Nationalbank (2003). Since Statistics Denmark began to release quarterly national accounts, they have been used in the modelling work.

The statistical information about developments in a given quarter is regularly increased, so it is important to specify when an estimate is made. An assessment of the current cyclical position could, for example, mean the development in the current quarter. But an assessment of the development in the preceding quarter and the coming quarter could also be relevant. Estimates of the current quarter are often called "nowcasts", while estimates of the preceding and coming quarters are called "backcasts" and "forecasts", respectively. NARES is normally used for backcasting, but can also be used for nowcasting.

One of the basic principles of NARES is that it uses only "hard" indicators, i.e. statistics on economic activity. Examples are retail sales and turnover in manufacturing. Thus, the model does not include confidence indicators such as consumer and business confidence indicators, which are based on households' and firms' qualitative *assessments* of their finances.

The absence of estimated relations is another fundamental principle. Instead, indicators are aggregated to produce a national accounts figure based on each indicator's share of the national accounts variable. For example, retail sales are included in the calculation of private consumption with the weight attributed to consumption of retail goods in total private consumption, and household purchases of vehicles are included with the weight attributed to vehicle consumption in total private consumption.

A general problem in the calculation of estimates for the most recently completed quarter is that observations are missing for one or more indicators due to the time lags between the period under review and the publication of the statistics. In NARES, this is overcome by applying a technical projection e.g. based on growth in the most recent quarters. If other information is available, an alternative estimate of the missing observation may be entered manually. The earlier the NARES calculation is performed, the greater the problem of missing data obviously is. This applies especially if the system is used for nowcasting the current quarter.

The choice of scope and degree of detail in NARES should be viewed, inter alia, in the context of the MONA model used for forecasting in Danmarks Nationalbank. The trade-off between the degree of detail and the complexity of a model depends on what is needed and not on a fixed template. It is by no means given beforehand that the choice will be the same for a model for assessment of recent developments, such as NARES, and for a projection model like MONA. But the advantage of coordinating the two models is that the NARES estimate for the most recent quarter can be used as the basis for projections in MONA if the quarter is not yet covered by the quarterly national accounts prepared by Statistics Denmark.

In the practical application of NARES, the focus is on developments in the most recent quarter. The quarterly national accounts are used to the extent that they are available, and the national accounts are projected by one quarter based on the growth in the NARES indicators. Consequently, any differences in levels between the indicators and the equivalent national accounts figures are not essential when it comes to the usefulness of the NARES model.

NARES contains indicators of the demand components of the national accounts, including e.g. consumption and investment. Total output, GDP, is then calculated based on the supply-demand balance, i.e. as the difference between demand and imports. No GDP indicator is calculated from the supply side. The NARES presentation of output on the demand side deviates from the approach of the quarterly national accounts, where GDP is calculated on the basis of indicators on the supply side.

In NARES, the domestic sector is divided into a public and a private section. As regards income and net lending, this division is not applied in the first version of the quarterly national accounts. On the basis of direct and indirect taxes paid, among other things, NARES presents indicators of payments between the private and the public sectors to provide for such division.

The focus in NARES is on seasonally adjusted values. Many indicators show clear seasonal variation; retail sales, for instance, are considerably higher in December than in any other month of the year. That is why the indicators are subject to seasonal adjustment before the actual NARES calculation where the indicators are aggregated to national accounts level.

Basically, the aim is to develop indicators in volume terms, and the NARES calculation in value terms is typically achieved by inflating the volume by a suitable price index. As an example, the volume index of retail sales is included in the indicator of private consumption in volume terms. The value of private consumption is then calculated by inflating

the volume by the consumer price index. In other cases, e.g. for exports and imports, the current statistics are available in value terms only. Volumes are then obtained by deflating by a relevant price index. Also for the price indexes, the level of aggregation is often considerably higher than the level applied in Statistics Denmark's national accounts. This could lead to bias in connection with changes in weights.

In NARES, the aim is for the volume indicators to match the chained values in the national accounts.[1] For aggregation, the chain formula is used, weighting the quantities with the prices applicable in the previous year. The prices applicable in the previous year are sourced from Statistics Denmark's national accounts. Normally, missing data will not give rise to problems when NARES is used solely for calculation on the most recent completed quarter, since prices from the previous year will be available when estimates for the first quarter of a new year are to be calculated.

NARES is a dynamic system, in the sense that it is subject to ongoing adjustment, e.g. when new statistics are released. A case in point is that the use of the statistics of firms' purchases and sales has increased after the change from a quarterly to a monthly frequency. To this should be added the work of developing and improving the model.

3. INDICATORS IN NARES

This section describes the building blocks of NARES, particularly the main components of the supply-demand balance.

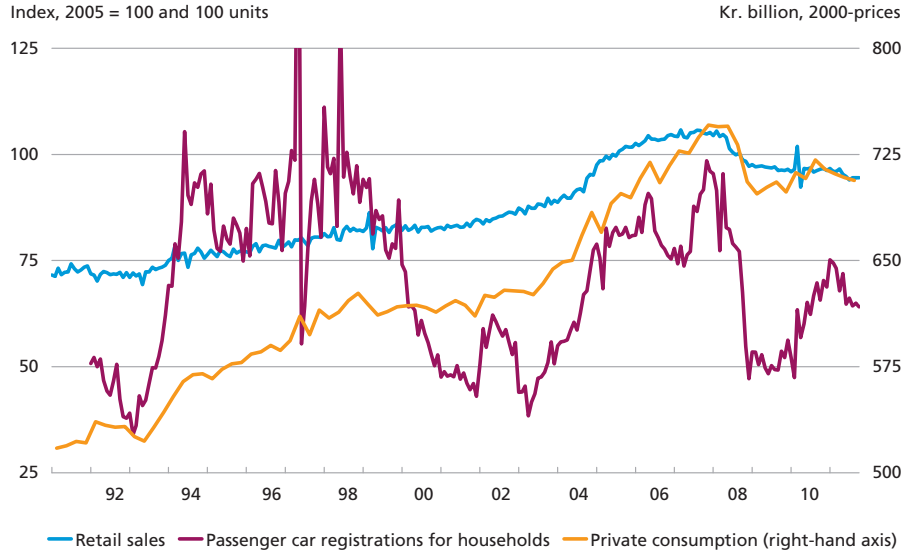
Private consumption

The value of private consumption is roughly equivalent to half of GDP in Denmark. Hence, it plays a key role in analysing the current state of the economy and the economic outlook. Services account for around half of private household consumption, while the remainder is made up of consumption of goods, which is generally well covered by indicators. The retail sales index, new motor vehicle registrations for households and energy supply items have almost identical counterparts in the breakdown of consumption in the national accounts.

The slowdown in 2008-09, which also affected private consumption, was evident in both retail sales and household purchases of vehicles, cf. Chart 3.1. Purchases of vehicles showed a similar pattern in connection with the economic slowdown around the millennium rollover. But the

[1] Chained values mean a calculation in volume terms for which the weighting basis rests on the prices of the previous year.

RETAIL SALES, PURCHASES OF VEHICLES AND PRIVATE CONSUMPTION Chart 3.1



Note: Seasonally adjusted figures. The number of new passenger car registrations for households was 18,535 in May 1997 and 13,366 in June 1998. New registrations in the two months are not indicated in the chart.
Source: Statistics Denmark.

drop in retail sales was unusual. While purchases of vehicles have increased since then, retail sales have remained almost unchanged since the beginning of 2009.

The indicator coverage in NARES of household services consumption, of which housing accounts for just over 40 per cent, is less extensive, although more indicators have been included in the latest version of the model. For instance, parts of the consumption of services are now sourced from VAT statistics, including catering. But some of these indicators are also affected by firms' consumption of goods and services. This presents a potential problem in the event of diverging developments in the consumption of households and firms, respectively.

The sub-components of total private household consumption are aggregated on the basis of fixed weights reflecting the value of the consumption components in 2000, cf. Table 3.1.

The indicators are very different, covering consumption of both goods and services. They have been selected primarily using an empirical criterion, and, generally, an indicator is only included if it improves the estimate of the actual consumption component relative to a simple technical projection. For parts of the consumption of services, no sufficiently good indicators are available, so they are subject to technical projection. Non-residents' consumption in Denmark is subtracted from the estimate of consumption in Denmark, while Danish residents' con-

PRIVATE CONSUMPTION INDICATOR — Table 3.1

Indicator	Value in 2000, kr. billion	Covered by indicator
Retail sales	221.7	Yes
Electricity consumption	14.7	Yes
Heating consumption (degree days)	21.8	Yes
Fuels and lubricants	18.2	Yes
Purchase of vehicles	26.6	Yes
Maintenance and repairs of motor vehicles	14.2	Yes
Catering	27.7	Yes
Accommodation services	3.4	Yes
Post and telecommunications	11.9	Yes
Car rental, etc.	7.0	Yes
Hairdressing salons, etc.	5.8	Yes
Package holidays	5.7	Yes
Housing	125.5	Yes
Other services	114.4	No
Non-residents' consumption in Denmark	-30.3	Yes
Danish residents' consumption abroad	29.0	Yes

Note: If an item is not covered by an indicator, a technical projection has been applied.
Source: Statistics Denmark and own calculations.

sumption in the rest of the world is added. The result is the indicator of Danish residents' total private consumption. The individual indicators are described in more detail in Box 3.1.

INDICATORS FOR THE COMPONENTS OF PRIVATE CONSUMPTION — Box 3.1

Retail sales

Retail sales consist of food and other everyday commodities, clothing, etc. The consumption of these goods accounts for the major share of the consumption of goods. The indicator applied is Statistics Denmark's volume index of retail sales, which is released monthly. Retail sales accounted for just over 35 per cent of private household consumption in 2000.

Electricity consumption

The applied electricity consumption indicator is the monthly statistics of the Danish Energy Agency on electricity supply in Denmark. These monthly statistics are calculated as the net production at Danish plants, including wind power and hydropower, less net exports of electricity and losses. Electricity consumption accounted for just over 2 per cent of private household consumption in 2000.

Heating consumption (degree days)

NARES applies the number of shadow degree days[1] as an indicator of the consumption groups of gas, liquid fuels and district heating, etc. in the national accounts. This number is published in monthly reports from the Danish Meteorological Institute. The concept is that since these consumption groups are primarily associated with heating of homes, they are closely correlated with outdoor temperatures – measured here as the sum of shadow degree days. Part of the energy consumption does not

CONTINUED Box 3.1

depend on outdoor temperatures. This applies to e.g. consumption for heating water, cooking, etc. This is taken into account by adding a constant to the number of degree days in each period. The national accounts consumption groups of gas, liquid fuels and district heating, etc. made up approximately 3.5 per cent of private consumption in 2000.

Fuels and lubricants

The NARES indicator of fuels and lubricants is the Danish Energy Agency's monthly statistics of sales of engine fuels. This item accounted for just under 3 per cent of private household consumption in 2000.

Purchases of vehicles

The indicator of purchases of vehicles is the number of new motor vehicle registrations for households and a share of new registrations for business purposes. A share of new registrations for business purposes is included because household purchases of vehicles from the corporate sector are also included in private consumption. The number of new registrations is published monthly by Statistics Denmark. New registrations are closely correlated with purchases of vehicles in the national accounts, although the number of new registrations does not take into account e.g. the composition of purchases of vehicles, including vehicle size. Purchases of vehicles totalled just over 4 per cent of private household consumption in 2000.

Maintenance and repairs of motor vehicles

The applied indicator of maintenance and repairs of motor vehicles is the Danish Road Directorate's traffic indicator of the number of kilometres travelled on Danish roads. The idea is that the number of kilometres travelled entails some wear and tear on the vehicle fleet, resulting in repairs. This indicator is also used in the quarterly national accounts, cf. Graversen et al. (2008).

Car rental, etc.

The source of car rental, etc. is Statistics Denmark's statistics of firms' domestic sales, also called VAT statistics. NARES uses the sum of sales under *Rental and leasing of cars and light motor vehicles* and *Driving schools* deflated by the relevant item from the consumer price index. Car rental, etc. accounted for just over 1 per cent of private household consumption in 2000.

Catering

The NARES indicator of catering in the national accounts is domestic sales in restaurants, deflated by the corresponding price index from the consumer price index. This item made up approximately 4.5 per cent of private household consumption in 2000.

Accommodation services

The applied indicator of household consumption of hotels is Statistics Denmark's statistics of the number of overnight stays at hotels, holiday resorts, etc. This item accounted for around 0.5 per cent of private household consumption in 2000.

CONTINUED Box 3.1

Post and telecommunications

The indicator of the consumption of postal services and telecommunications, etc. is firms' domestic sales in the categories of *Postal and courier activities* and *Telecommunications*. In the national accounts, the consumption of postal services and telecommunications, etc. accounted for almost 2 per cent of private household consumption in 2000.

Hairdressing salons, etc.

The applied indicator of hairdressing salons, etc. in the breakdown of consumption in the national accounts is domestic sales under *Hairdressers, laundries and other services*. This item accounted for almost 1 per cent of private consumption in 2000.

Package holidays

The indicator is Statistics Denmark's statistics of the number of international charter/taxi flights out of Copenhagen Airports. The consumption of package holidays accounted for just under 1 per cent of private household consumption in 2000.

Housing

The NARES indicator of housing is housing in the preceding quarter deflated by a rate of wear and tear of dwellings plus completed all-year dwellings. The coefficient of completed all-year dwellings is greater than one, reflecting that the quality of newly built dwellings is assumed to be higher than the quality of the existing housing stock. Housing accounted for around 20 per cent of private household consumption in 2000.

Other services

In the absence of suitable indicators of the remainder of private consumption of services, a technical projection is applied. Other services, such as insurance and financial services, made up almost 19 per cent of private household consumption in 2000.

Non-residents' consumption in Denmark

The above indicators cover consumption in Danish territory. Part of this is non-residents' consumption in Danish territory. Since the aim of NARES is the private consumption of Danish households, non-residents' consumption in Danish territory is subtracted. Non-residents' consumption in Danish territory is based on the balance of payments statistics deflated by the total consumer price index, excluding housing and fuels.

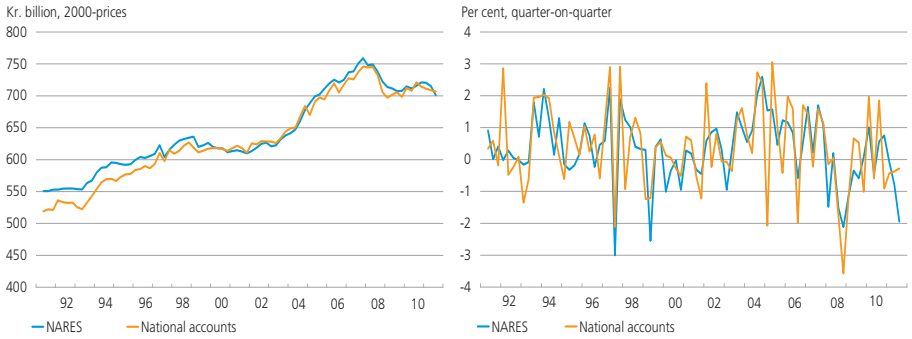
Danish residents' consumption abroad

Correspondingly, the above indicators do not include the consumption of Danish residents in the rest of the world, so this consumption is added in the indicator equation for private consumption.

[1] Shadow degree days = 17 less the mean temperature for a 24-hour period.

Chart 3.2 shows the technical estimate of the development in private consumption achieved after purely mechanical application of NARES, together with private consumption in chained values according to the

PRIVATE CONSUMPTION Chart 3.2



Source: Statistics Denmark and own calculations.

national accounts. The *Other services* item is projected on the basis of the national accounts for the most recent quarter using a growth rate equal to a moving average of the growth rates of the last four quarters.[1] Relative to a constant growth rate the moving average means that there is no significant deviation in growth between the consumption of other services in NARES and the trend in the national accounts viewed over a number of years, such as after the financial crisis. On the other hand, the reversal is captured slightly later due to the high growth rates in the preceding years.

The indicator follows the overall development in private consumption, and substantial deviations from consumption growth in the national accounts are seen only in a few quarters, cf. Chart 3.2. The fluctuations in the private consumption indicator are less pronounced that the fluctuations in the national accounts series.

According to Table 3.2, the average deviation between the consumption growth estimate in NARES and the private consumption figure in the national accounts in the period 1991-2008 is -0.05 percentage points. Consequently, the underestimation of consumption growth in NARES in this period is very modest. The correlation with the private consumption figure in the national accounts is high throughout the period, and the deviation measured in terms of RMSE[2] is less pronounced than if two simple benchmark models had been used: one based on the trend (average quarterly growth) in the period 1991-99 and an AR(4) model[3]. As a result, the precision is higher for the relatively disaggregated calculation of private consumption relative to the simple benchmarks.

1 The same approach has been applied to other variables that are subject to technical projection on the basis of known figures from the national accounts.
2 See the note to Table 3.2.
3 An AR(4) model is an autoregressive model with four lags. This model seeks to explain growth in private consumption in terms of growth in private consumption in the four preceding quarters.

PRIVATE CONSUMPTION — Table 3.2

	1991-99	2000-08	1991-2008
Average error	-0.11	0.02	-0.05
Average absolute error	0.77	0.75	0.76
RMSE	0.98	1.01	1.00
Correlation coefficient	0.64	0.70	0.67
RMSE, trend 1991-99		1.42	
RMSE, AR(4) model		1.51	

Note: The average error is calculated as the growth estimate in NARES less the growth in the national accounts figure. RMSE, root mean square error, is the square root of the average of the squared errors and is also a measure of estimation errors. The estimation period for the AR(4) model is 1991-99. All calculations are made on quarterly growth rates in per cent.
Source: Statistics Denmark and own calculations.

Public consumption

The value of public consumption corresponds to just over one fourth of the value of GDP in Denmark. Quarterly statistics of public finances are released around 80 days after the end of the reference quarter, i.e. after the first version of the preliminary national accounts. In NARES, public consumption is broken down by compensation of employees in the public sector, public purchases of goods and depreciation (consumption of fixed capital).

Wages, etc.

The expenditure for wages, etc. accounts for more than 60 per cent of total public consumption. The NARES indicator of compensation of employees in the public sector is constructed as the number of employees in the public sector multiplied by working hours per employee. The latter figure changes, e.g. in the event of changes in working hours due to collective bargaining. The source of the number of employees in the public sector is Statistics Denmark's employee statistics based on employers' reporting to SKAT (the Danish tax authority). Before 2008, the ATP statistics were used as an indicator of employment in the public sector.

Public purchases of goods, etc.

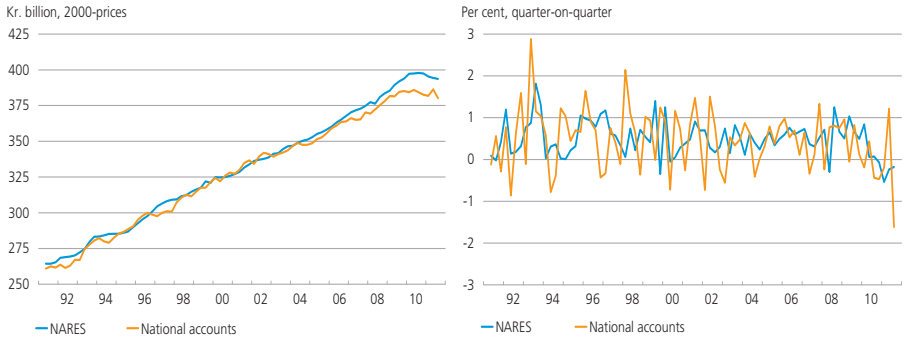
In value terms, public purchases of goods correspond to around one fourth of public consumption. In NARES, purchases of goods are the result of a technical projection based on public purchases of goods in the preceding quarter.

Consumption of fixed capital

In the absence of suitable indicators, a technical projection is applied.

The NARES estimate of public consumption captures the development in the national accounts figure only to a low degree, cf. Chart 3.3. The

PUBLIC CONSUMPTION Chart 3.3



Source: Statistics Denmark and own calculations.

average rate of growth in the indicator is close to that of the national accounts, but the correlation is quite low viewed over the entire period 1991-2008, cf. Table 3.3. In the period 2000-08, the indicator is no more precise than the simpler alternatives, which naturally reflects merely that there are not enough indicators of public consumption.

Gross fixed capital formation

In value terms, gross fixed capital formation accounts for approximately 20 per cent of GDP in Denmark. In NARES, gross fixed capital formation has been broken down by residential investment, building and construction investment excluding residential investment, investment in machinery and equipment and other investment.

Residential investment

The indicator of residential investment includes relative weights for all-year dwellings under construction and other buildings under construction. The source is Statistics Denmark's construction statistics.

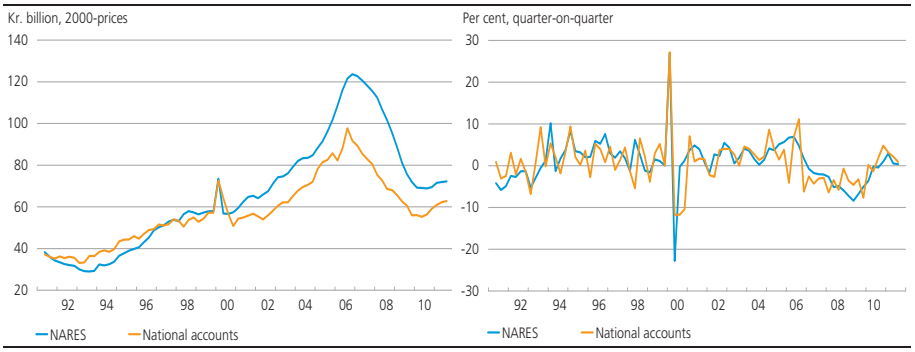
PUBLIC CONSUMPTION Table 3.3

	1991-99	2000-08	1991-2008
Average error	-0.04	0.04	0.00
Average absolute error	0.76	0.51	0.63
RMSE	0.93	0.64	0.79
Correlation coefficient	0.02	0.10	0.05
RMSE, trend 1991-99		0.60	
RMSE, AR(4) model		0.64	

Note: The average error is calculated as the growth estimate in NARES less the growth in the national accounts figure. RMSE, root mean square error, is the square root of the average of the squared estimation errors and is also a measure of estimation errors. The estimation period for the AR(4) model is 1991-99. All calculations are made on quarterly growth rates in per cent.

Source: Statistics Denmark and own calculations.

RESIDENTIAL INVESTMENT — Chart 3.4



Note: A dummy has been introduced in the indicator for the 1st quarter of 2000, taking into account that the surge in residential investment in the wake of the storm in December 1999 was not reflected in construction activity to the same extent.
Source: Statistics Denmark and own calculations.

The residential investment indicator overestimates the increase in residential investment since 2000. This reflects a strong rise in dwellings under construction, which is not offset to the same extent by increased residential investment, cf. Chart 3.4. A possible reason is variations in construction time. Moreover, major repairs of dwellings are included in residential investment in the national accounts, but not in the NARES indicator. In NARES, average quarterly growth is 0.91 percentage points higher than in the national accounts in the period 2000-08, cf. Table 3.4. The average absolute error of just over 3 percentage points over the entire period reveals considerable errors in the quarters. But the correlation coefficient is high, and RMSE is lower relative to the simple alternatives.

Building and construction investment, excluding residential investment

Total building and construction investment in NARES is calculated as the sum of indicators of building investment and construction investment,

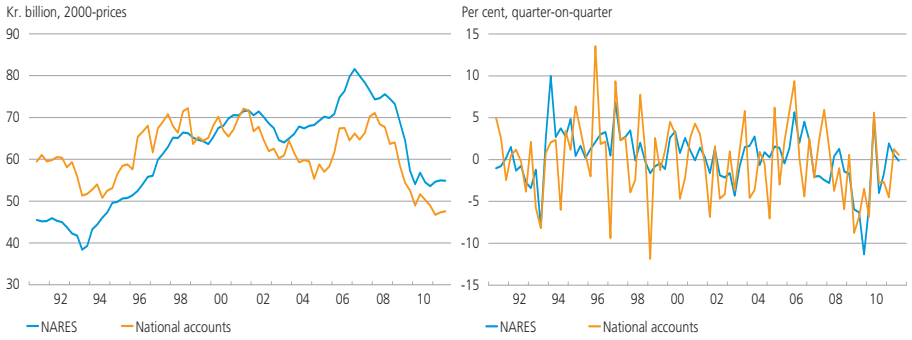
RESIDENTIAL INVESTMENT — Table 3.4

	1991-99	2000-08	1991-2008
Average error	-0.19	0.91	0.37
Average absolute error	2.99	3.18	3.09
RMSE	3.90	4.65	4.30
Correlation coefficient	0.46	0.78	0.70
RMSE, trend 1991-99		6.98	
RMSE, AR(4) model		7.79	

Note: The average error is calculated as the growth estimate in NARES less the growth in the national accounts figure. RMSE, root mean square error, is the square root of the average of the squared estimation errors and is also a measure of estimation errors. The estimation period for the AR(4) model is 1991-99. All calculations are made on quarterly growth rates in per cent. The dummy introduced in the indicator for the 1st quarter of 2000 reduces the deviations and increases the correlation in the period 2000-08.
Source: Statistics Denmark and own calculations.

BUILDING AND CONSTRUCTION INVESTMENT, EXCLUDING RESIDENTIAL INVESTMENT

Chart 3.5



Source: Statistics Denmark and own calculations.

respectively. The applied indicator of construction investment is employment in the construction sector. The source is Statistics Denmark's statistics of employees in building and construction. Building investment, excluding residential investment is based on building activity.

In addition to the breakdown by type, investment is also broken down by sector in NARES, i.e. by energy extraction, public and private excluding energy extraction. The distribution between the public and private shares of e.g. construction investment is based on a projection of the public share of total construction investment. A technical projection of the building and construction investment of the energy sector has been applied.

The general trends in building and construction investment are partly captured by the indicator, cf. Chart 3.5, and there is some correlation with the national accounts series throughout the period, cf. Table 3.5. But NARES overestimates the average growth during the period and

BUILDING AND CONSTRUCTION INVESTMENT, EXCLUDING RESIDENTIAL INVESTMENT

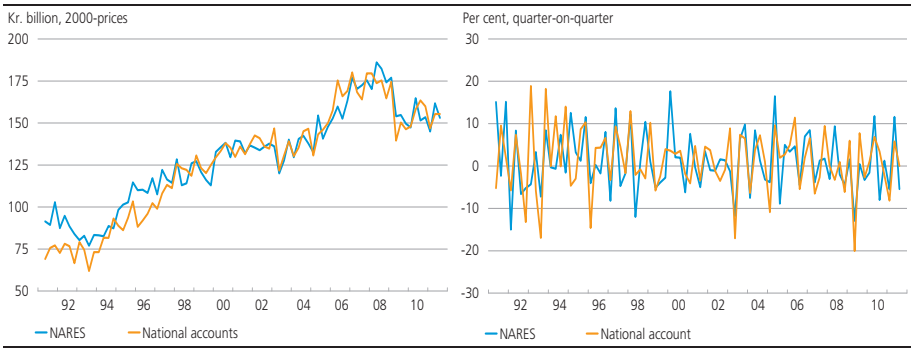
Table 3.5

	1991-99	2000-08	1991-2008
Average error	0.45	0.44	0.45
Average absolute error	3.50	3.39	3.44
RMSE	4.75	4.08	4.43
Correlation coefficient	0.39	0.29	0.35
RMSE, trend 1991-99		4.14	
RMSE, AR(4) model		4.70	

Note: The average error is calculated as the growth estimate in NARES less the growth in the national accounts figure. RMSE, root mean square error, is the square root of the average of the squared estimation errors and is also a measure of estimation errors. The estimation period for the AR(4) model is 1991-99. All calculations are made on quarterly growth rates in per cent.

Source: Statistics Denmark and own calculations.

INVESTMENT IN MACHINERY AND EQUIPMENT, ETC. Chart 3.6



Source: Statistics Denmark and own calculations.

produces considerable average absolute errors, as was also the case for residential investment. However, this indicator performs marginally better than simpler alternatives.

Investment in machinery and equipment, excluding vessels and aircraft

This indicator consists of the sum of investment in transport equipment, machinery and fixtures and investment in software, etc. Investment in transport equipment is broken down further by purchases of lorries, vans and passenger cars for business purposes as well as investment in railway equipment and drilling rigs. As regards vehicles, the source is Statistics Denmark's statistics of new motor vehicle registrations. As regards investment in railway vehicles and drilling rigs, one of the sources is net imports thereof according to the external trade statistics, deflated by a relevant sub-index from the price index of turnover in manufacturing as compiled by Statistics Denmark.

The indicator of investment in machinery, etc. is made up of both direct imports of machinery and supplies from the domestic manufac-

INVESTMENT IN MACHINERY AND EQUIPMENT, ETC. Table 3.6

	1991-99	2000-08	1991-2008
Average error	-0.61	0.46	-0.07
Average absolute error	7.79	4.61	6.17
RMSE	9.66	5.81	7.94
Correlation coefficient	0.31	0.57	0.40
RMSE, trend 1991-99		6.08	
RMSE, AR(4) model		5.33	

Note: The average error is calculated as the growth estimate in NARES less the growth in the national accounts figure. RMSE, root mean square error, is the square root of the average of the squared estimation errors and is also a measure of estimation errors. The estimation period for the AR(4) model is 1991-99. All calculations are made on quarterly growth rates in per cent.

Source: Statistics Denmark and own calculations.

turing sector. The relative weights of these elements reflect the import share of investment in machinery and equipment according to the input/output tables of Statistics Denmark. As regards domestic supplies, which are covered by e.g. the index of turnover in manufacturing, it is taken into account that investment goods account for only a minor share of turnover in manufacturing, while a major share can be attributed to semi-manufactures, etc.

The indicator of investment in software, etc. is based on Statistics Denmark's statistics of employees based on employers' reporting to SKAT. Employment statistics were previously based on ATP statistics.

In line with building and construction investment, investment in machinery and equipment is broken down by sectors. The distribution on public and private investment is based on a projection of the public sector's share of total investment in machinery and equipment.

The indicator of investment in machinery and fixtures matches the national accounts figure well in level terms, cf. Chart 3.6. In terms of growth rates, there is reasonable correlation in the period 2000-08, cf. Table 3.6. However, the indicator has a positive bias in that period, and there are substantial absolute errors in the entire period 1991-2008. In terms of RMSE, the indicator does not perform any better than a simple AR(4) model.

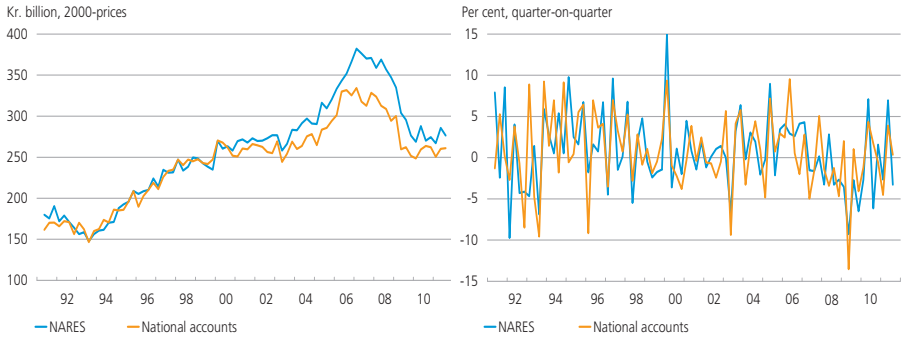
Other investment

In NARES, investment in livestock is based on changes in the stocks of sows and cows, etc. The indicator of investment in vessels and aircraft, etc. is sourced from Statistics Denmark's statistics of sales by Danish iron shipyards deflated by a relevant series for the price index from turnover in manufacturing as well as net imports of vessels and aircraft, etc. deflated by projected price indexes from the national accounts.

Together, the above types of investment make up gross fixed capital formation. Chart 3.7 shows the developments in gross fixed capital formation in NARES and the national accounts. NARES's overestimation of residential investment and building and construction investment in the late 2000s naturally materialises in total gross fixed capital formation.

The overestimated gross fixed capital formation in NARES after 2000 represents an average deviation of 0.59 percentage points per quarter over the period 2000-08, cf. Table 3.7. However, the correlation between this indicator and the national accounts series is relatively high in this period, and in terms of RMSE the indicators are more accurate than the simple alternatives.

GROSS FIXED CAPITAL FORMATION — Chart 3.7



Source: Statistics Denmark and own calculations.

Inventory investment

The value of inventory investment is very low compared with the other components of demand, but the contribution from inventories to GDP growth is often quite substantial. Moreover, the national accounts figures may be subject to considerable revision from the first to the final version. NARES breaks down inventory investment by agriculture, energy extraction and inventory investment excluding energy and agriculture. Inventory investment in energy is compiled as the change in a calculated fuel store achieved by weighting various fuel components. As regards agriculture, inventory investment is calculated as a weighted average of changes in pig and cattle stocks from Statistics Denmark. Inventory investment in the private non-agricultural sector constitutes the remainder of inventory investment, as the public sector has no inventory investment. Inventory investment in the private non-agricultural sector is sourced from Statistics Denmark's value-based inventory statistics for manufacturing and wholesale trade.

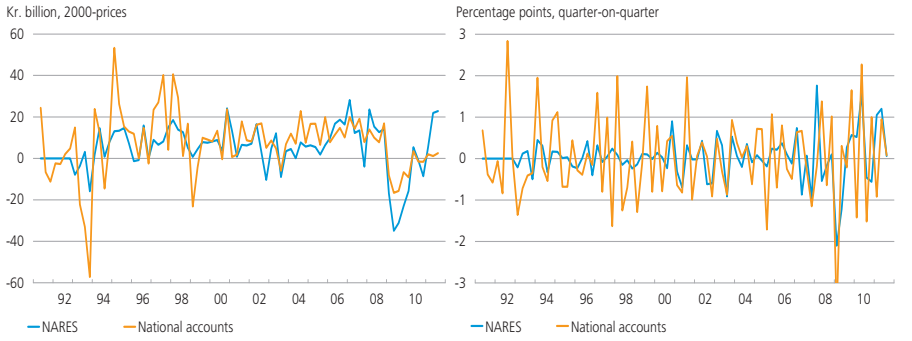
GROSS FIXED CAPITAL FORMATION — Table 3.7

	1991-99	2000-08	1991-2008
Average error	-0.20	0.59	0.20
Average absolute error	4.32	2.71	3.51
RMSE	5.39	3.25	4.44
Correlation coefficient	0.39	0.68	0.51
RMSE, trend 1991-99		4.16	
RMSE, AR(4) model		4.43	

Note: The average error is calculated as the growth estimate in NARES less the growth in the national accounts figure. RMSE, root mean square error, is the square root of the average of the squared estimation errors and is also a measure of estimation errors. The estimation period for the AR(4) model is 1991-99. All calculations are made on quarterly growth rates in per cent.

Source: Own calculations.

INVENTORY INVESTMENT Chart 3.8



Note: The right-hand chart shows contributions to quarterly GDP growth. Before 1993, in the absence of inventory value statistics for the manufacturing and wholesale sectors, inventory investment is equal to zero in NARES.
Source: Statistics Denmark and own calculations.

The indicator captures only to a low degree the substantial fluctuations in the national accounts series in the 1990s, cf. Chart 3.8. The two series show more similar patterns in the 2000s.

Exports

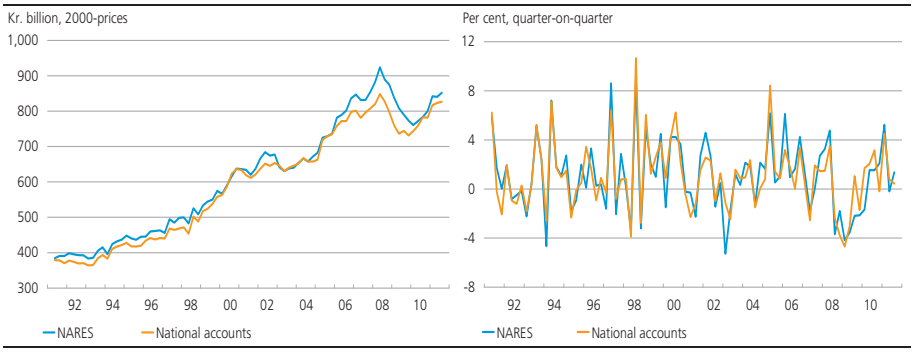
In value terms, exports of goods and services correspond to just over half of GDP in Denmark. NARES breaks down total exports into goods and services.[1] The indicator of total exports of goods is calculated on the basis of the external trade statistics. The calculation incorporates the sum of total exports of goods, excluding vessels and aircraft, exports of vessels and aircraft and a transition item accounting for differences between the compilations of exports of goods in the external trade statistics and the national accounts.[2] Each sub-item is deflated by a relevant price index – primarily unit value indexes. Exports of services are calculated as the value of exports of services from the balance of payments statistics, deflated by a price index reflecting container freight rates. The indicator value of freight rates should be viewed in light of sea freight's large share of total exports of services in value terms.

The most important difference between NARES and the national accounts as regards compilation of exports is the higher degree of simplicity in the price indexes used as deflators in NARES. In summary, exports of goods and services are generally well covered by indicators, as illustrated by the precision of the indicator in Chart 3.9. Both levels and quarterly growth are captured well by the indicator.

[1] Exports of goods are broken down by types, e.g. manufactured exports and exports of fuels, etc. on the basis of the external trade statistics.

[2] The transition item takes into account the different definitions of goods in the external trade statistics and the national accounts. On the export side, the external trade statistics add repairs, etc., but subtract returned goods. On the import side, general trade in the external trade statistics is supplemented with victualling, bunkering and repairs, while returned goods and freight are subtracted.

EXPORTS Chart 3.9



Source: Statistics Denmark and own calculations.

The difference in levels in the second half of the 2000s is attributable to errors in estimating the deflators of exports of both goods and services. On the goods side, this reflects lower growth in the unit value indexes relative to the deflator of the national accounts during the period. On the services side, the collapse of freight rates in late 2008 results in a considerably stronger fall in the services exports deflator in NARES relative to the national accounts. The overall result is an average deviation, relative to export growth in the national accounts, of just under 0.2 percentage points per quarter in the period 2000-08, cf. Table 3.8. Export growth in NARES shows hardly any bias before 2000. The average absolute error is somewhat greater over the entire period, but RMSE is considerably lower than would have been the case with the more simple benchmarks, and the correlation is very high.

Imports

In value terms, imports of goods and services correspond to almost half of GDP in Denmark. The indicator of imports is compiled using the same template as for exports. Imports of services from the balance of pay-

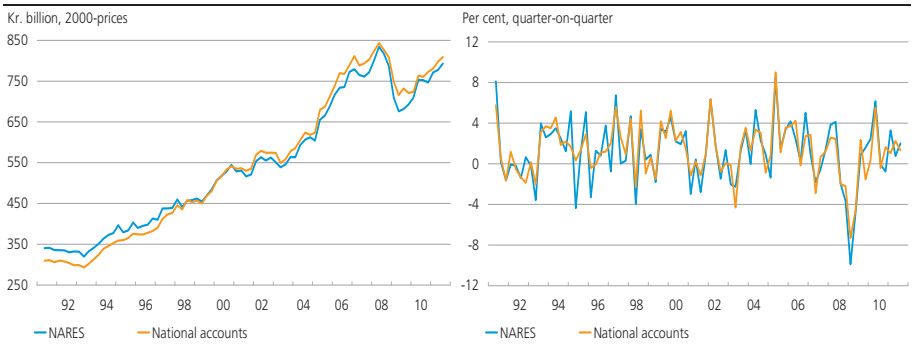
EXPORTS Table 3.8

	1991-99	2000-08	1991-2008
Average error	0.04	0.18	0.11
Average absolute error	0.97	1.26	1.12
RMSE	1.26	1.53	1.41
Correlation coefficient	0.92	0.82	0.88
RMSE, trend 1991-99		2.44	
RMSE, AR(4) model		2.77	

Note: The average error is calculated as the growth estimate in NARES less the growth in the national accounts figure. RMSE, root mean square error, is the square root of the average of the squared estimation errors and is also a measure of estimation errors. The estimation period for the AR(4) model is 1991-99. All calculations are made on quarterly growth rates in per cent.

Source: Statistics Denmark and own calculations.

IMPORTS Chart 3.10



Source: Statistics Denmark and own calculations.

ments statistics are deflated by a projected price index from the national accounts for the most recent quarter, as no suitable indicator is available for this deflator. On the goods side, imports are divided into imports of goods excluding vessels and aircraft, bunkering, imports of vessels and aircraft and a transition item. The deflators for imports of goods correspond to those for exports of goods.

The indicator of imports is very precise, cf. Chart 3.10, with only a small deviation in the average quarterly growth rate relative to the national accounts series, cf. Table 3.9. The correlation is high, and in terms of RMSE the indicator performs considerably better than the simple benchmarks.

GDP

After compilation of the individual demand components and imports, total output can be determined. Compiled in chained values, GDP is calculated on the basis of the preceding year's prices in the national accounts. Consequently, the deviations between the GDP estimate in

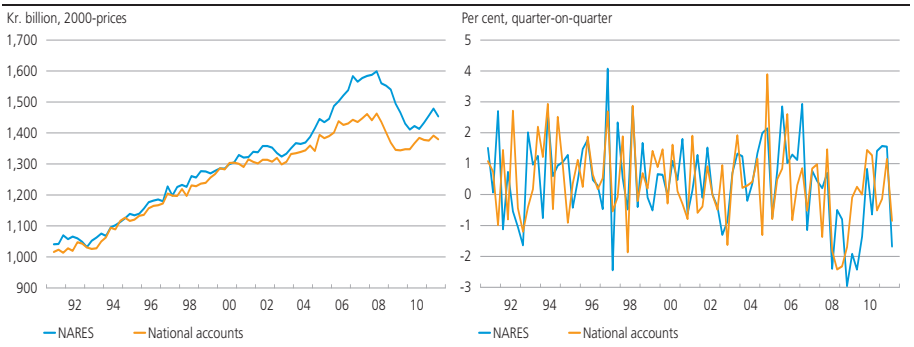
IMPORTS Table 3.9

	1991-99	2000-08	1991-2008
Average error	-0.17	-0.09	-0.13
Average absolute error	1.31	1.03	1.16
RMSE	1.71	1.26	1.50
Correlation coefficient	0.82	0.89	0.85
RMSE, trend 1991-99		2.60	
RMSE, AR(4) model		2.80	

Note: The average error is calculated as the growth estimate in NARES less the growth in the national accounts figure. RMSE, root mean square error, is the square root of the average of the squared estimation errors and is also a measure of estimation errors. The estimation period for the AR(4) model is 1991-99. All calculations are made on quarterly growth rates in per cent.

Source: Statistics Denmark and own calculations.

GDP — Chart 3.11



Source: Statistics Denmark and own calculations.

NARES and the final GDP figure in the national accounts are the result of the inaccuracies in the estimates of the individual demand components and imports.

The left-hand side of Chart 3.11 shows that GDP in 2007-08 is markedly higher in NARES than in the national accounts. This reflects the overestimation in NARES of gross fixed capital formation, particularly in those years. The same applies to exports in volume terms, as the deflators for exports of both goods and services are lower, cf. above. The difference in levels is, as such, not a determining factor for the model's usefulness in practice, given the focus on developments in the most recent quarter only, as mentioned earlier, but the difference reflects the accumulated errors.

The right-hand side of Chart 3.11 shows large errors in a few quarters, but the GDP indicator in NARES is reasonably successful in capturing the general economic trends over the entire period. A positive bias is observed in the period 2000-08, cf. the average errors in Table 3.10. In terms of RMSE, the deviations in the period 2000-08 are slightly less

GDP — Table 3.10

	1991-99	2000-08	1991-2008
Average error	-0.03	0.27	0.12
Average absolute error	1.16	0.95	1.05
RMSE	1.49	1.26	1.38
Correlation coefficient	0.35	0.48	0.41
RMSE, trend 1991-99		1.33	
RMSE, AR(4) model		1.37	

Note: The average error is calculated as the growth estimate in NARES less the growth in the national accounts figure. RMSE, root mean square error, is the square root of the average of the squared estimation errors and is also a measure of estimation errors. The estimation period for the AR(4) model is 1991-99. All calculations are made on quarterly growth rates in per cent.

Source: Own calculations.

GROWTH CONTRIBUTIONS Table 3.11

	Average, NARES	Average, national accounts	Average error	Average absolute error
Private consumption	0.18	0.20	-0.02	0.38
Public consumption	0.15	0.15	0.00	0.16
Gross fixed capital formation	0.17	0.12	0.05	0.70
Inventory investment	0.02	0.04	-0.02	0.71
Exports	0.47	0.42	0.05	0.49
Imports	-0.40	-0.45	0.06	0.46
GDP	0.59	0.48	0.12	1.06

Note: All figures are based on the contributions to GDP growth. The average errors are calculated as growth estimates according to NARES less growth according to the national accounts. The period is Q2 1991-Q4 2008.
Source: Statistics Denmark and own calculations.

pronounced than for the simple benchmarks. The correlation between GDP growth in NARES and the national accounts is relatively high throughout the period.

Table 3.11 shows descriptive statistics of the contributions from the main components of the supply-demand balance to GDP growth. The decomposition reveals the impact of the errors in estimating e.g. private consumption on the precision of the total GDP estimate. The average errors in the growth contributions of the components are generally modest, reflecting the mutually offsetting effect of positive and negative errors. The absolute errors for the growth contributions are thus considerably greater. Although in NARES public consumption is covered by indicators only to a very limited extent, and, as mentioned, the errors are not lower than those resulting from the simple alternatives, this component has less of an impact on errors in the GDP estimates, cf. the modest average absolute error. Private consumption, imports and exports are sources of greater errors, even though these components are well covered by indicators in NARES. But the largest contributions to errors in the GDP estimates are attributable to gross fixed capital formation and inventory investment despite the relatively small shares of these components in overall demand.

The performance of NARES in a purely mechanical run is illustrated above. It is important to emphasise that these technical estimates are used as an early element of the cyclical assessment process, which also involves a number of other elements. For example, supplementary information can be used in the determination of the technical projections in order to improve the model estimates. But the most significant difference relative to actual application of NARES is that the model results are not used directly, but rather as the basis for a detailed assessment of the national accounts components, cf. the example in Box 3.2.

APPLICATION OF NARES IN THE 2ND QUARTER OF 2011 — Box 3.2

This box illustrates how the final estimates for the 2nd quarter of 2011, produced before the release of the quarterly national accounts at the end of August 2011, were determined on the basis of the NARES calculations.

Calculated on the basis of the NARES indicators, cf. Table 3.12, quarterly growth in private consumption was -0.8 per cent. A review of the individual indicators disclosed receding growth in retail sales and some of the minor consumption items. But in light of a considerable fall in consumption of services in the 1st quarter of 2011, the technical projection of consumption of other services was found to be too negative. For this reason, among others, the estimate of private consumption was increased to quarterly growth of -0.1 per cent. The national accounts figure for private consumption in the 2nd quarter of 2011 also shows a moderate decline, cf. the last two columns of Table 3.12.

As regards public consumption, the NARES calculations resulted in quarterly growth of -0.3 per cent. A key contributing factor was that the technical projection was affected by declines in previous quarters, and, in view of such factors as the Finance Act and local and regional government budgets, growth in public consumption was estimated at 0.8 per cent. This estimate is slightly lower than the figure in the national accounts.

On the basis of the indicators, NARES estimated quarterly growth in gross fixed capital formation at 9.3 per cent. A review of the indicators prompted a lowering of private investment in building and construction relative to the NARES result. The estimated quarterly growth of just over 7 per cent is somewhat higher than the national accounts figure.

The growth contribution from inventory investment was estimated at 0.3 per cent in the 2nd quarter of 2011. According to the NARES indicators, the growth contribution from inventory investment was 1.4 percentage points. This figure was not found to be credible, however. The revised national accounts figure is a negative growth contribution of 0.1 percentage points.

The export estimate was unchanged from the previous quarter, i.e. slightly higher than the NARES figure, where the indicators pointed to a small decline. The national accounts showed a good increase in exports in the 2nd quarter of 2011.

ESTIMATES FOR THE 2ND QUARTER OF 2011 — Table 3.12

Per cent, quarter-on-quarter	NARES	Estimate	Flash NA	NA
Private consumption	-0.8	-0.1	-0.3	-0.4
Public consumption	-0.3	0.8	0.9	1.2
Gross fixed capital formation	9.3	7.3	4.5	3.9
Inventory investment[1]	1.4	0.3	0.4	-0.1
Exports	-0.2	0.0	0.2	0.8
Imports	0.8	2.4	1.4	2.2
GDP	2.0	0.5	1.0	1.2

Note: "Flash NA" is the first preliminary version of the quarterly national accounts. "NA" is the latest version of the national accounts, released at the end of November 2011. The NARES estimates in the table are actual real-time predictions.

Source: Statistics Denmark and own calculations.

[1] Contribution to GDP growth.

CONTINUED Box 3.2

Import growth was 0.8 per cent according to the indicators. The review of the NARES result gave rise to adjustment of the import price development, and the estimated increase in volume terms was determined at 2.4 per cent. This estimate is in line with the latest version of the national accounts.

Overall, GDP growth was estimated at 0.5 per cent in the 2nd quarter of 2011, which was considerably lower than the NARES estimate of 2.0 per cent. This reflects the significant element of assessment in the calculation of the estimates. The adjusted estimates of the components of the supply-demand balance are, in general, closer to the national accounts figures than the mechanical NARES estimates. Quarterly GDP growth is estimated at 1.2 per cent in the latest version of the national accounts.

Wages and income

In addition to the items of the supply-demand balance, NARES also calculates a number of wage and income items. Indirect taxes are subtracted from output at current prices, and subsidies are added in order to produce an estimate of the gross domestic product at factor cost. Indirect taxes are primarily VAT income, published monthly by SKAT with a lag of approximately 60 days. Total residual income is determined residually as gross domestic product at factor cost less wages and salaries. Compensation of employees is compiled including employer contributions to various social schemes. The wages and salaries items as such are broken down by the private and the public sector. In both cases, wages are determined as a weighted wage rate multiplied by the number of employees. The development in the number of employees is based on Statistics Denmark's statistics of employees from reporting to SKAT. Employer contributions are determined on the basis of developments in the ATP rates and employer contributions to unemployment insurance.

Private disposable income is calculated as the private gross domestic product at factor cost plus private net interest income and private net transfers less contributions to social schemes and direct taxes. Transfers are based on e.g. data on the number of recipients of unemployment benefits and early retirement benefits. The indicator of direct taxes is sourced from SKAT.

Sectoral balances

NARES also calculates net lending for the private sector, the public sector and in relation to the rest of the world. The balance of goods and services is given as the value of exports minus imports, cf. above. If investment income and current transfers are added, the result is the current account of the balance of payments. Addition of capital trans-

fers, net, results in net lending in relation to abroad, which is thus covered directly by the balance of payments statistics.

Net lending for the public sector is the sum of public sector revenue less expenditure for public investment, public consumption, subsidies and transfers. The value of public consumption and investment is given by the indicators in volume terms, cf. above, together with the relevant prices. As regards public transfers, the information, besides indicators of early retirement and unemployment benefits, includes EU transfers and development aid from the balance of payments statistics. The main items on the revenue side are direct and indirect taxes, which are partially covered by indicators.

Net lending for the private sector is determined as private disposable income, cf. above, less private consumption expenditure, the value of private investment and capital taxes, plus net capital expenditure and net capital transfers.

4. ALTERNATIVE MODELS

There are various other approaches to assessing the current economic situation. Like NARES, they apply information from economic statistics with a view to mapping general economic trends. Statistical models are typically used to summarise relevant cyclical indicators, resulting in an estimate of recent developments in major variables of interest, such as GDP growth or other national accounts components. This section gives an overall description of some of the models, while the next section contains a description and an analysis of a Real-Time Forecasting System.

A simple approach is to use models that explain e.g. quarterly GDP growth in terms of monthly indicators – or "bridge equations". The name refers to the bridge-building in such models between the different frequencies of the target variables and indicators. Rünstler and Sédillot (2003) present an example:

$$\rho(L)\Delta y_t = \sum_{j=1}^{k} \delta_j(L)\Delta x_{j,t} + \varepsilon_t, \tag{4.1}$$

where Δy_t is GDP growth and $\Delta x_{j,t}$ is (changes in) the monthly indicators. $\rho(L)$ and $\delta_j(L)$ are lag polynomials to enable GDP growth in previous quarters or previous changes in the monthly indicators to contribute to explaining the current GDP growth.

The monthly variables are often aggregated to a quarterly frequency before model estimation, in order to keep the lag structure simple, among other reasons. In the aggregation, the same weight is usually applied to the three months. A highly relevant practical problem is that

data may be missing for one or more months as regards the indicators. If that is the case, it is not possible to perform the aggregation to quarterly data, so the model cannot be used for estimation in the first instance.

The solution is to incorporate estimates of the observations that are missing for the indicators. One approach is to construct "auxiliary models" to generate an estimate for a third month based on data for two months for a variable.[1] This provides for calculation of a (partially estimated) quarterly observation for the indicator, and the model (4.1) is used for estimation on the quarterly variable in question.

For the euro area, Rünstler and Sédillot (2003) find that bridge equations based on quantitative activity indicators, such as industrial production, retail sales and vehicle registrations, improve the estimate of GDP growth in the relevant quarter relative to benchmark models that do not include the information from the indicators.

The basic concept of bridge equations – to use early monthly indicators for calculating relevant quarterly data – is the same as in NARES. The most important difference is that bridge equations use estimated coefficients for aggregation of indicators, while NARES is based on aggregation of indicators for the sub-components of a variable using weights reflecting the relevant indicator's share of the variable. While estimated weights per construction provide for better aggregation of indicators in the historical period (estimation period), it is an empirical question which method is better for nowcasting and forecasting.

Bridge equations are typically single-equation models that explain a quarterly variable in terms of one or more indicators. A different model approach – vector autoregressive, VAR, models – describes the dynamics of the quarterly variables and indicators in one model. A simple example is a VAR model with GDP and monthly industrial production aggregated to a quarterly frequency.

It is possible to include more indicators by estimating a number of bivariate VAR models, and then use the average estimate, or by expanding the VAR model. However, many parameters often need to be estimated in multivariate VAR models with a rich lag structure. Bayesian estimation methods based on an *a priori* parameter distribution may reduce the dimensionality problem and improve the efficiency of the estimates, cf. Banbura et al.

Recent years have seen considerable focus on models that use the information from a very large number of indicators for producing a nowcast or forecast of e.g. GDP growth. Stock and Watson (2002) argue that

[1] Such auxiliary models are typically univariate autoregressive models.

it may be more useful to summarise the information in a large number of indicators rather than applying e.g. VAR models for which the number of indicators is limited to perhaps 10.

The Stock and Watson model describes the variable, y_{t+1}, to be forecast, as explained by a number of dynamic factors f_t:

$$y_{t+1} = \beta(L)f_t + \gamma(L)y_t + \varepsilon_{t+1}, \tag{4.2}$$

where $\beta(L)$ and $\gamma(L)$ are lag polynomials. The relation between the indicators X_i and the factors is given as:

$$X_{it} = \lambda_i(L)f_t + e_{it}, \quad i = 1,\ldots,N. \tag{4.3}$$

The fundamental idea is that cyclical developments are driven by a limited number of factors that are not directly observable. At the same time, these factors are assumed to explain the development in the indicators, cf. equation (4.3), and they can be determined by exploiting the information contained in a large number of indicators. The estimated factors – called *diffusion indexes* by Stock and Watson – are then used in the forecast equation (4.2).

Dahl et al. (2005) use this model type with Danish data to predict unemployment, turnover in manufacturing and net retail prices 6 and 12 months ahead on the basis of diffusion indexes. The results are not as good as those produced by other studies for other countries, but the use of filtered data reduces forecast errors compared with the use of a standard autoregressive model. To our knowledge, no institutions in Denmark are using diffusion indexes for forecasting or nowcasting on an ongoing basis.

The wealth of information included in diffusion indexes is at the same time both an advantage and a disadvantage of the model. The advantage is that all indicators are taken into account, including soft ones such as confidence indicators. The weakness is that inclusion of all indicators also results in substantial noise, and that the model may be perceived as a "black box", because an economic interpretation based on the diffusion indexes is not easily given.

More recent literature contributions have sought to address these weaknesses of the model framework, now mostly referred to as factor models. Bai and Ng (2008) demonstrate that the model estimates can be improved by selecting indicators in advance on the basis of the variable to be predicted. This removes noisy indicators and indicators driven by factors with only a weak correlation with the relevant variable.

Another improvement is related to the use of factor models for ongoing nowcasting and backcasting of e.g. GDP as more and more indicators become available. In order to ease interpretation, Banbura et al. (2010b) decompose the ongoing changes in the GDP estimate into the extent of the innovation in the indicator and the importance of the indicator in relation to the GDP estimate. Given the model's simultaneous descriptions of the GDP estimate and the indicators, the innovation in the indicator can be calculated on the basis of the model. Intuitively, this is done by using the model to estimate the expected indicator value, on the basis of the existing information, before the release. The difference between this expected value of the indicator and its realised value is the novelty in the indicator. Using this decomposition as the foundation makes it easier to determine the drivers of changes in the GDP estimate.

It is often possible to improve the precision of the estimates by combining estimates from several models. This would also increase the robustness against instability in the individual models, cf. Timmermann (2006). An example of a system that combines many of the different models mentioned above is SAM at Norges Bank, cf. Aastveit et al. (2011). This system includes e.g. more than 200 models for estimation of GDP growth. In addition to point estimates of GDP growth, SAM is also used to derive distributions of growth estimates, providing for an assessment of the uncertainty associated with the central estimate.

5. THE RTFS MODEL

As an alternative forecasting tool in the cyclical assessment process, this section sets out a Real-Time Forecasting System, RTFS, which was developed and used by the US Department of the Treasury, cf. Kitchen and Monaco (2003). The Ministry of Economic and Business Affairs (2007) uses a Danish version of RTFS for nowcasting GDP growth in Denmark.

RTFS uses a number of early monthly indicators for nowcasting quarterly real growth in GDP. As opposed to NARES, which applies only hard indicators, RTFS also includes soft indicators.[1] The relation between each of these indicators and GDP growth is given as:

$$\Delta GDP_t = \alpha^j + \beta_0^j \cdot X_t^j + \cdots + \beta_4^j \cdot X_{t-4}^j + \varepsilon_t^j \,, \qquad (5.1)$$

[1] The following 19 indicators are currently used: Unemployment (net), vehicle sales to households and firms, short-term interest rate (3-month), long-term interest rate (10-year), spread between long-term and short-term interest rates, consumer confidence, confidence indicators for construction, services and manufacturing, effective krone rate, job vacancies advertised on the Internet (Jobindex), OMXC20, imports and exports of goods, industrial production, new orders, retail sales and Dankort payments.

where it applies to all j indicators that X is the indicator (or a transformation thereof), α is a constant, βs are the coefficients of the indicator and their lags, while ε is the error term. ΔGDP indicates quarterly growth in seasonally adjusted real GDP. The optimal number of lags is determined for each indicator separately by means of the Akaike information criterion[1], which weighs higher explanatory power against increased complexity. Estimation of (5.1) using the method of ordinary least squares results in estimated parameters for α and β and thus an estimate of quarterly GDP growth for each indicator as well as an R^2, which is a measure of the explanatory power. The system's growth estimate is an R^2-weighted average of the predictions of the individual indicators. This means that the growth estimate of each relation is given a weight that reflects the relation's ability to explain historical GDP growth.

The system bridges the gap between indicators with a monthly frequency and GDP with a quarterly frequency by generating simple averages of the indicators on the basis of data for the months available. As a result, e.g. an (estimated) quarterly figure for consumer confidence in the 1st quarter of the year is available already when the consumer confidence indicator for January is released. Data for more and more months is included in step with the releases.

Each time a new statistic is released, the system is re-estimated and the weights are updated. This usually gives rise to adjustment of the GDP estimate. The revision impacts the predicted GDP growth through two channels – a direct contribution from the new information in the statistic and an indirect contribution from re-estimation of (5.1) for the individual indicator. The re-estimation causes the weights between the individual indicators to shift if the explanatory power of the indicator in question changes. Re-estimation may also imply a change in the coefficients of the relation for the indicator.

RTFS is different from NARES in several respects. The RTFS model also uses soft indicators, which can presumably e.g. capture economic reversals earlier than the hard indicators can. Moreover, the system allows free estimation of coefficients, meaning that the weight of an indicator corresponds to its explanatory power.

The ongoing re-estimation means that the system is continuously using the available information for determining data relations. But re-estimation also has certain drawbacks. The ongoing adjustment of the coefficients in the individual relations and of the relative weights between the indicators could make it more difficult to identify the reasons for a change of the GDP estimate, cf. above. This makes it potentially more

[1] No more than four lags are allowed.

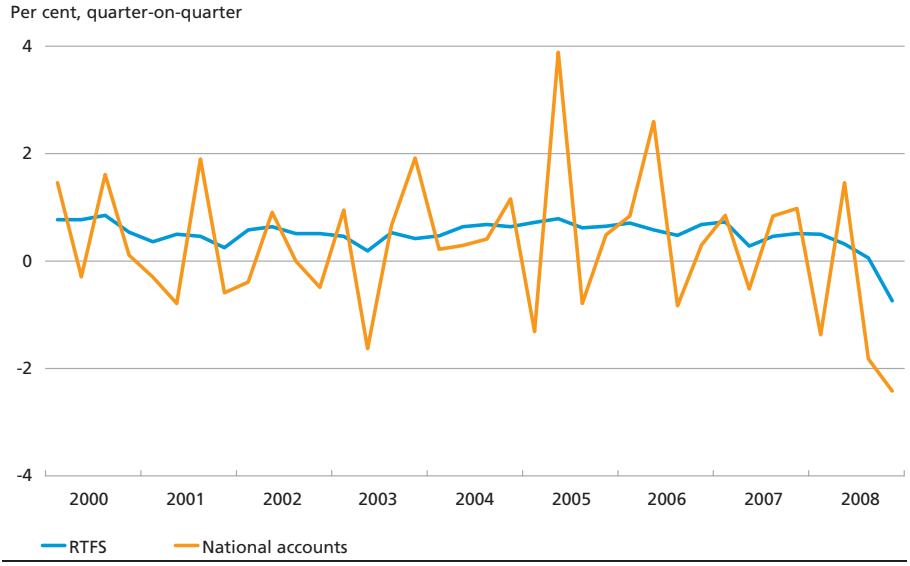
difficult to communicate the results of the system to the outside world. A case in point is the effect of revisions of the national accounts, cf. the illustration of use of the model in Box 5.1. Revisions of the GDP series will change the estimated relations and thus the growth estimate for the quarter in question even though no, as such, new updated information has been released.

In NARES, the more disaggregated GDP estimation method ensures a kind of consistency between the weights of the various indicators. This is not necessarily the case in RTFS, given the principle of free estimation, because the individual estimations do not take into account any correlation between two series. For example, if there is strong correlation between two indicators because they have roughly the same coverage, their individual explanatory power will be almost the same. This would almost correspond to including only one of these indicators but with twice the weight

Chart 5.1 shows quarterly GDP growth according to the final national accounts and the estimates produced by the RTFS model in the period 2000-08. In general, RTFS is unable to capture the strong fluctuations in the highly volatile GDP pattern, including especially in the mid-2000s. However, it does, to some extent, capture the economic reversals towards the end of the period.

QUARTERLY GDP GROWTH, ESTIMATES FROM RTFS AND FINAL NATIONAL ACCOUNTS

Chart 5.1



Note: For each RTFS estimate of GDP growth, the underlying data set includes only information available at the time. Revisions of indicators have not been taken into account, however, so the predictions are not actual real-time predictions.

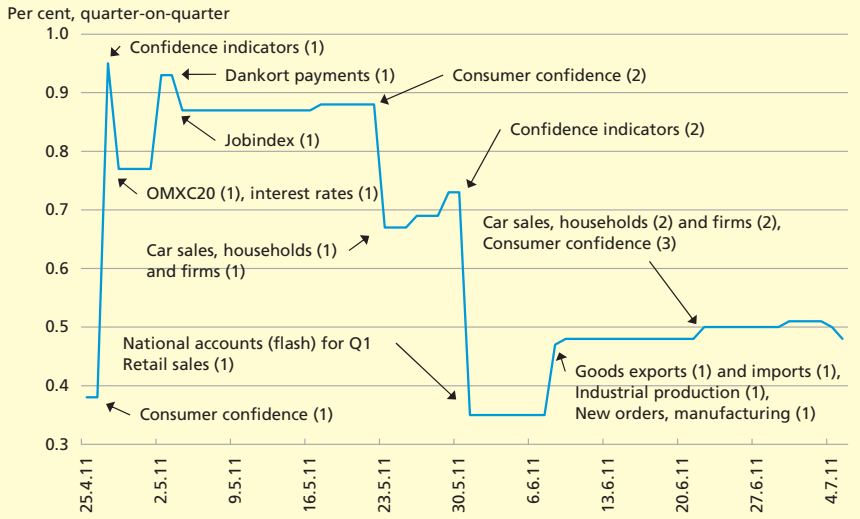
Source: Statistics Denmark and own calculations.

THE DEVELOPMENT IN THE RTFS MODEL ESTIMATE OF THE 2ND QUARTER OF 2011 — Box 5.1

This box illustrates the dynamics of the RTFS estimate of quarterly GDP growth for the 2nd quarter of 2011. Data releases are systematic during a quarter. At the beginning of the quarter, the model primarily consists of confidence indicators and high-frequency financial series, including e.g. interest rates and stock prices, but also Dankort payments. The harder data is released from the middle of the quarter, e.g. car sales and retail sales.

Until the middle of the 2nd quarter, confidence indicators and data with higher frequencies pointed to good GDP growth of just under 1 per cent, cf. Chart 5.2. A drop in the number of new motor vehicle registrations in April then led to a reduction of the model estimate by approximately 0.2 percentage points. Subsequently, the flash estimate of GDP in the 1st quarter of 2011, among other factors, led to a change in the estimated relations of a magnitude that resulted in a further reduction of the GDP estimate for the 2nd quarter by 0.4 percentage points to just over 0.3 per cent. This was not changed to any significant degree after the subsequent releases, and at the end of the quarter, the model estimate of GDP was around 0.5 per cent. According to the most recent national accounts, released at the end of November 2011, GDP growth was 1.2 per cent in the 2nd quarter of 2011. This is slightly higher than the first indications of the RTFS model at the beginning of the quarter, but quite far from the final model estimate.

REAL-TIME DEVELOPMENT IN ESTIMATE FOR THE 2ND QUARTER OF 2011 — Chart 5.2



Note: The figures in brackets indicate the month of the quarter that is covered by the release.
Source: Own calculations.

In connection with the strong drop in GDP growth in 2008-09, the relative weights of the individual indicators shifted. The weights of the indicators that demonstrated explanatory power in respect of the down-

RTFS Table 5.1

	2000-08
Average error	0.22
Average absolute error	0.95
RMSE	1.17
Correlation coefficient	0.54

Note: The average error is calculated as the growth estimate according to RTFS less growth according to the national accounts. RMSE, root mean square error, is the square root of the squared estimation errors and is also a measure of estimation errors. All calculations are made on quarterly growth rates in per cent.
Source: Own calculations.

turn increased, while the weights of other indicators with no explanatory power were reduced. A notable feature is that interest rates have lost almost their entire weight in the model in recent years, while the weights of e.g. stock prices, confidence indicators and consumer confidence have increased. Otherwise, the indicator weights in the model have been relatively stable, with no strong fluctuations from quarter to quarter. The experience with the RTFS model since 2009, in a period of large fluctuations in GDP, is described in Box 6.1 on p. 35.

The average deviation between GDP according to the national accounts and the RFTS estimate of GDP is 0.22 percentage points, cf. Table 5.1. Consequently, the model tends to overestimate growth. Despite the less volatile GDP growth according to RTFS, compared with the national accounts, the correlation coefficient is still reasonable at 0.54.

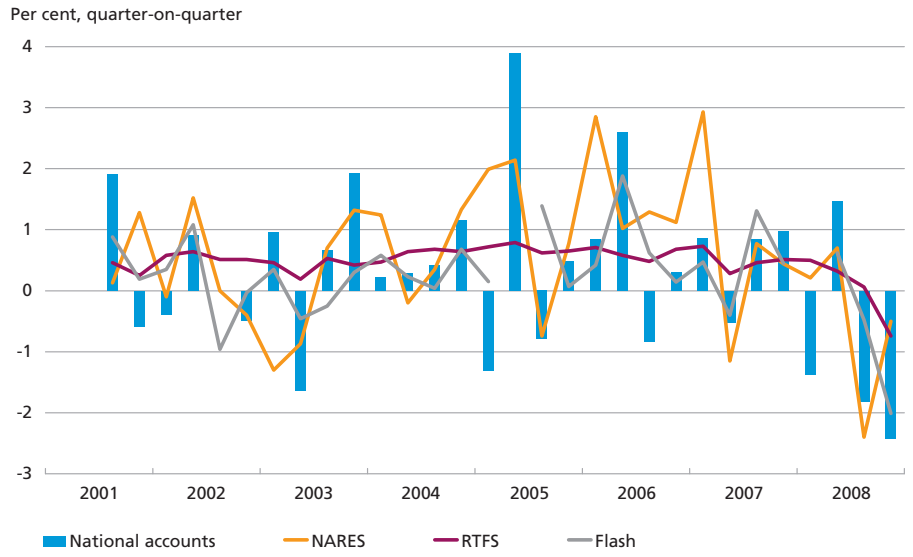
6. COMPARISON

This section compares a technical application of the NARES model with the RTFS model and Statistics Denmark's flash release of the quarterly national accounts. The basis for comparison is the final national accounts that are available around three years from the reference year.

From time to time there are strong deviations between quarterly GDP growth according to the final national accounts and the three estimates, cf. Chart 6.1. The NARES estimates show stronger fluctuations than the final national accounts and also stronger fluctuations than the other two estimates. In most quarters, the RTFS estimates are between 0 and 1 per cent, i.e. they are considerably more stable than quarterly GDP growth according to the final national accounts.

Table 6.1 compares the precision of the three estimates. In terms of RMSE, the flash estimate of the national accounts shows the smallest deviations from the final national accounts. In the period under review, the technical application of the NARES model shows the greatest deviations. The average error is close to zero for the flash estimate, while

QUARTERLY GDP GROWTH, MODEL ESTIMATES AND FINAL NATIONAL ACCOUNTS 2001-08 Chart 6.1



Note: "Flash" means the first preliminary version of the quarterly national accounts. Statistics Denmark did not release flash estimates for the 2nd quarter of 2005 and the 1st quarter of 2008.
Source: Statistics Denmark and own calculations.

both RTFS and NARES have a positive bias. The correlation between the estimates and the final national accounts is positive for all three estimates, and higher for RTFS and the flash estimate than for NARES.

The data basis of the quarterly national accounts is considerably more extensive and detailed than the basis of the NARES and RTFS models. Moreover, there is a very high degree of methodological overlap between the compilation of the flash estimate and the final national accounts. Therefore, it is no surprise that the flash estimate and the final national accounts are more consistent.

QUARTERLY GDP GROWTH, THREE MODEL ESTIMATES RELATIVE TO FINAL NATIONAL ACCOUNTS Table 6.1

	NARES	RTFS	Flash
Average error	0.29	0.25	0.06
Average absolute error	0.96	0.87	0.74
RMSE	1.29	1.07	0.89
Correlation coefficient	0.43	0.53	0.65

Note: The period is 2001-08. For reasons of comparability, quarters not covered by flash estimates are excluded here. The flash estimate is the first version of the preliminary national accounts. The average error is calculated as the growth estimate according to NARES, RTFS and flash less growth according to the final national accounts. RMSE, root mean square error, is the square root of the average of the squared estimation errors and is also a measure of estimation errors. All calculations are made on quarterly growth rates in per cent.
Source: Statistics Denmark and own calculations.

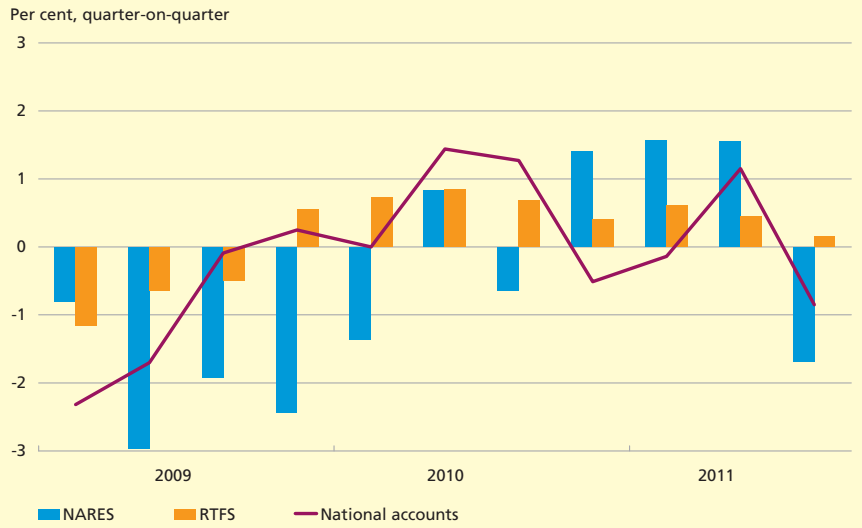
MODEL PERFORMANCE IN RECENT YEARS — Box 6.1

Recent years have seen large fluctuations in GDP growth, and, as already mentioned, Statistics Denmark postponed for a period the release of the flash version of the quarterly national accounts from 60 to 90 days after the end of the reference quarter. This box takes a closer look at the ability of the NARES model and the RTFS model to capture the large fluctuations in GDP. The basis for comparison here is the preliminary quarterly national accounts released at the end of November 2011.

Both RTFS and NARES point to considerable declines in GDP in the first two quarters of 2009, which is consistent with the national accounts, cf. Chart 6.2. The models fail to capture the reversal from the 2nd to the 3rd quarter of 2009. In NARES, one of the reasons is that the technical projection is based on developments in previous quarters. In the two subsequent quarters, NARES underestimates growth, while the RTFS model is more consistent with the preliminary national accounts. For the two quarters around the turn of the year 2010/11, for which the national accounts show a fall in GDP, the two models indicate positive growth. Finally, in the two most recent quarters, NARES is closer to the national accounts figure than RTFS is.

Overall, the reversal from negative to positive growth is reflected in the two models, while the weakening of the economy at the end of 2010 and the beginning of 2011 according to the national accounts is less clear in NARES and RTFS.

QUARTERLY GDP GROWTH, ESTIMATES FROM NARES AND RTFS AND PRELIMINARY NATIONAL ACCOUNTS — Chart 6.2



Source: Statistics Denmark and own calculations.

One of the key differences between NARES and RTFS concerns the use of estimated coefficients.[1] As described above, the weighting of indicators in NARES reflects each indicator's share of the national accounts

[1] As mentioned, the RTFS model is re-estimated on an ongoing basis in step with the release of new economic statistics.

variable. This implies a restriction on NARES, which does not exist in statistical models like RTFS, where parameters are estimated freely. The fixed coefficients in NARES are a possible reason why the NARES GDP estimates are less precise than the RTFS estimates. Box 6.1 describes the experience with the two models in recent years with large GDP fluctuations, for which final national accounts are not yet available.

The practical use of NARES differs from the technical application illustrated here. A key difference is that the NARES result for a given quarter is not regarded as the final estimate, but as the basis for a detailed assessment of the national accounts components. It is thus possible to include supplementary information or estimates in the technical projecttions.

The NARES model provides estimates of a large number of variables, which distinguishes it from the RTFS model and many other models. At the same time, the system ensures that the estimates are consistent and in accordance with the definitions and relations in the national accounts. Both the wide extent and inherent consistency of the NARES model are regarded as great advantages in the ongoing cyclical assessment and projection work.

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