Danmarks Nationalbank

Monetary Review 3rd Quarter Part 2

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MONETARY REVIEW 3rd QUARTER 2011, Part 2

The small picture on the front cover shows the "Banker's" clock, which was designed by Arne Jacobsen for the Danmarks Nationalbank building.

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Real Economic Consequences of Financial Crises

Kim Abildgren, Economics, Birgitte Vølund Buchholst and Atef Qureshi, Financial Markets, and Jonas Staghøj, Statistics[1]

1. INTRODUCTION AND SUMMARY

The Danish economy has been characterised by substantial fluctuations in recent years. The years prior to the Financial Crisis saw considerable overheating and soaring prices of both commercial and residential properties. The strong increases in house prices throughout the first part of the 2000s were to a large extent driven by the introduction of new loan types (adjustable-rate loans and deferred amortisation), and from the middle of the decade, the housing market became so frenzied that it can justly be described as a genuine house price bubble with unrealistic expectations of future house prices, cf. Dam et al. (2011).

The downturn in the housing market and an economic slowdown started in late 2007. In the 4th quarter of 2007 both house prices and seasonally adjusted quarterly real GDP fell. This means that the Danish economy was already slowing down before the global financial crisis and the recession in the world economy really took off. The global financial crisis originated in the USA, which had also seen a strong increase in house prices and a build-up of imbalances in the economy in the pre-crisis years. The same applied in several other countries.

The decline in the Danish housing market reinforced the contractive effects of the global financial crisis. Part of the banks' lending is collateralised on real property, and a number of banks have had to make substantial impairment charges on property-related exposures in step with the reversal of property prices. Many banks had also increased their lending far beyond the level of their deposits prior to the crisis, thereby accumulating considerable customer funding gaps. This meant that Danish banks had to rely on the financial markets as a source of financing, which made them particularly vulnerable in connection with the erup-

1 The authors would like to thank Heino Bohn Nielsen, Department of Economics at the University of Copenhagen, for valuable suggestions and comments in connection with the preparation of the analyses in this article. Any inaccuracies in the article as well as the views and conclusions presented are attributable to the authors alone.

tion and global spreading of the international liquidity crisis. During the financial crisis in recent years, four out of Denmark's 15 largest banks have ceased to exist as independent firms, and the government has intervened extensively to support financial stability.

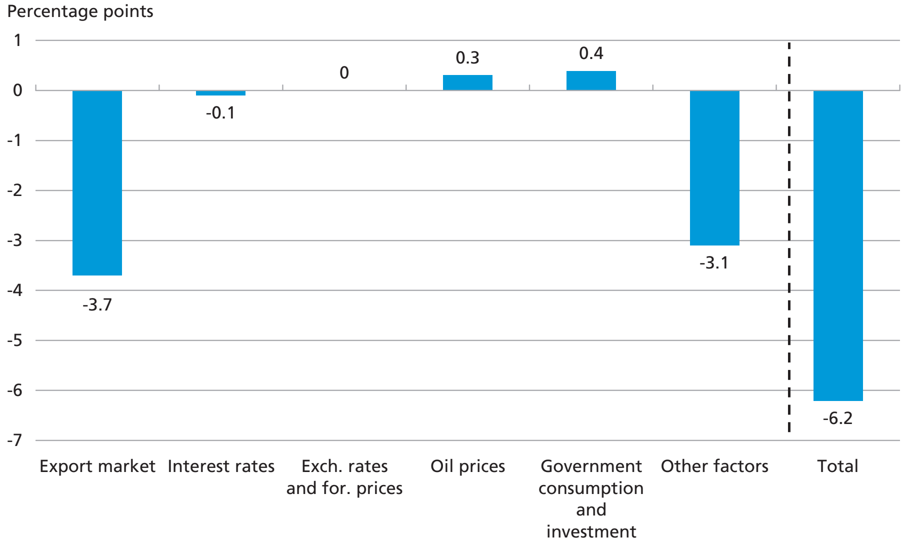
Due to the sharp aggravation of the international financial crisis in the autumn of 2008, real GDP growth in Denmark was around 6 percentage points lower in 2009 than forecast by Danmarks Nationalbank in the 1st quarter of 2008, cf. Chart 1.1. While around half of the forecast error could be attributed to lower export market growth, the other half primarily reflected "other factors". The "other factors" item covers many different circumstances, including those related to the Financial Crisis. They may include e.g. changes in private-sector consumption and investment behaviour in the wake of the global financial crisis that generally increased the uncertainty concerning the economic outlook and undermined confidence in the financial system. The "other factors" item may also reflect the effect of the banks' need to tighten their credit terms and widen their interest margins in view of the cyclical reversal. This should be viewed not least in light of the lenient credit standards prior to the Financial Crisis. Finally, the "other factors" item covers the effect of all other impacts on the economy and changes in the economic structure that cannot be attributed to changes in the other elements shown separately in the decomposition in Chart 1.1.

Historical experience from many other countries shows that economic downturns that coincide with financial crises are longer and deeper than other economic downturns, and that economic upswings following a banking crisis are weaker than normal, cf. Reinhart and Rogoff (2009a) and Reinhart and Reinhart (2010). The analyses in this article can be seen as an attempt to gain an impression of the extent to which financial crises have a negative impact on the Danish economy compared with business cycles without a financial crisis.

Section 2 in this article presents an overview of banking crises in Danish economic history. They include the Monetary Crisis 1857-58, the Savings Bank Crisis 1876-78, the Liquidity Crisis 1885, the Construction and Banking Crisis 1907-09, the Banking Crisis 1920-33, the Kronebank Crisis 1984-85, the seven-year slump 1987-93 and the Financial Crisis from 2007/08 onwards. Most of those crises were characterised by a substantial increase in the banks' write-down ratios and the resulting undermining of the banks' capital bases. This was the case in the 1920s in particular, and in accumulated terms more than 20 per cent of loans and guarantees were written down in the period 1920-33.

Section 3 compares the length and depth of economic downturns with and without banking crises in the past 200 years. Like studies from other

DECOMPOSITION OF FORECAST ERROR CONCERNING GDP GROWTH IN 2009 Chart 1.1



Note: Decomposition of the forecast error concerning real GDP growth in 2009 as estimated in Danmarks Nationalbank's forecast from the 1st quarter of 2008.
Source: Danmarks Nationalbank.

countries, our findings show a clear pattern of economic downturns with banking crises being deeper and longer than downturns without banking crises. The reason may be that economic downturns are aggravated by banking crises, but it may also merely reflect the fact that banking crises occur during deep economic downturns. Sections 5-7 will further discuss the extent to which effects of the former type apply.

Based on a number of summary calculations, section 4 discusses the size of the gross output loss suffered by the economy during an economic downturn with a banking crisis compared with a normal economic downturn. Furthermore, the size of the net output loss is calculated, deducting the higher output created during a prior credit expansion if the latter was at the root of the actual banking crisis. It is estimated that while the accumulated gross output loss during the economic downturn 2007-09 characterised by the Financial Crisis amounted to around 3.6-4.2 per cent of the gross domestic product, GDP, the net output loss was in the range of 2.2-4.2 per cent of GDP.

Section 5 seeks to quantify the extent to which recent years' financial crisis has had a negative impact on the business cycle. The calculations are based on a quarterly model for the Danish economy since 1948 that comprises a number of selected real economic as well as monetary and financial variables. The calculations indicate that in the period 2009-13 real GDP is on average 2.25-2.5 per cent below what it would have been in the absence of the Financial Crisis. This corresponds to a total accumulated output loss of around 12 per cent of GDP over the period 2009-13. An important question when reviewing the transmission process of the Financial Crisis is whether there have been periods showing signs of a general "credit crunch". A credit crunch may occur if the banks reduce the supply of credit considerably more than the weak economic development would warrant, making it difficult for creditworthy borrowers to obtain financing. This question cannot be answered on the basis of the above model calculation, as it requires supplementary information. Based on Statistics Denmark's confidence indicators, only a limited number of firms, particularly in manufacturing industry and building and construction, have reported financial constraints as impediments to production in recent years. This indicates that the Financial Crisis was not accompanied by a general credit crunch. Accordingly, the output loss caused by the Financial Crisis is, on the whole, attributable to the more general negative impact of the Financial Crisis on the economy. The calculations also show that the output loss occurred at the beginning of the crisis, i.e. at the end of 2008 and in the 1st half of 2009, followed by stabilisation. It would be natural to regard this stabilisation as an effect of the economic-policy measures (including the bank rescue packages).

The analyses in sections 2-5 are based on macroeconomic data. Sections 6-7 discuss the conclusions concerning the impact of banking crises that can be drawn from analyses of individual firms' financial statements.

Based on a failure-rate model, section 6 reviews whether the financial health of a firm's bank affected the firm's survival during the most recent financial crisis. The analysis indicates that the default risk for firms with a "weak" bank was higher in 2008-09 than for similar firms with a "sound" bank. The question is how those results should be interpreted. Firstly, the calculations are based on the assumption that the explanatory variables in the failure-rate model (return on assets, debt ratio, auditors' qualification, etc.) fully allow for the fact that the probability of default is higher for firms with "poor" finances than for firms with "healthy" finances. Where this is not the case, the impact of having a "weak" bank on a firm's probability of default will be overestimated because "weak" banks tend to have a higher share of "bad" customers. In such cases it cannot be ruled out that the calculations simply reflect the default of unprofitable firms during the Financial Crisis and that those firms were mainly customers of "weak" banks. Secondly, the calculations assume that in terms of the probability of default, the effect of having a "weak" bank is the same for all firms. In view of the fact that only a small number of firms in recent years have reported financial constraints as impediments to production, these results might indicate that dependence on "weak" banks affected only the probability of default for a small share of firms, while the probability of default for the majority of firms was not affected by the state of their banks.

To illustrate this issue, section 7 focuses on whether a negative effect of having a "weak" bank can be seen on the return on assets for the majority of non-defaulting firms during the Financial Crisis. There are no indications that the return on assets for non-defaulting firms during the Financial Crisis was dependent on the "soundness" of their banks. This is consistent with Statistics Denmark's confidence indicators, which indicate that only a limited number of firms have reported financial constraints as impediments to production during the Financial Crisis.

The analyses in sections 3-7 focus on the real economic consequences of banking crises in the short and medium term. Section 8 discusses the consequences of banking crises to economic growth and the income level in the economy in the longer term. For Denmark as well as other countries it is difficult to see any direct effect of previous banking crises on the long-term economic growth rate or income level per capita. Obviously, this does not mean that banking crises may not have any consequences for the long-term economic growth rate or income level. But it does imply that factors other than banking crises may be decisive for the economic growth rate and income level in the longer term.

In summary, the analyses in this article show that a financial crisis has a substantial negative impact on the real economy in the short and medium term. This highlights the importance of an economic policy aiming for stable economic development to avoid a massive build-up of imbalances in the economy followed by a crisis when the bubble bursts and the imbalances are redressed. The costs of financial crises should also be borne in mind when assessing the proposals for future regulation of the banking sector that are currently being prepared in international forums. Depending on the pace, the phasing-in of new capital and liquidity requirements may have some minor transitional consequences for the economy, cf. Christensen (2011). But, as shown by the analyses in this article, there will be large potential gains for the economy if the future regulation contributes to fewer and less serious financial crises in the future.

2. IDENTIFICATION AND DATING OF BANKING CRISES IN DANISH ECONOMIC HISTORY

An empirical analysis of the real economic consequences of banking crises requires identification of the periods during which crises and instabil-

BANKING CRISES IN DANISH ECONOMIC HISTORY SINCE 1857 Table 2.1

Crisis	Brief description	Extraordinary government measures	International dimension?
The Monetary Crisis 1857-58	Liquidity problems of Danish banks and trading houses that were dependent on foreign financing.	The government established a "Temporary Loan Fund", which provided loans to banks and commercial businesses.	International liquidity crisis that spread from the USA to Europe.
The Savings Bank Crisis 1876-78	Several savings banks and a few commercial banks experienced a crisis during a recession.	Danmarks Nationalbank had to provide extraordinary loans to a few banks.	In 1873 the global economy was hit by a prolonged recession.
The Liquidity Crisis 1885	During a wave of bankruptcies the banks' liquidity comes under pressure.	Liberal lending policy on the part of Danmarks Nationalbank.	No
The Construction and Banking Crisis 1907-09	Several medium-sized commercial banks and Denmark's largest savings bank experienced difficulties.	The government, Danmarks Nationalbank and a number of large private banks established a Banking Committee with a view to providing guarantees for depositors and other creditors in crisis-stricken banks. Denmark's largest savings bank is reconstructed with government help.	A US banking crisis in 1907 impeded international financing.
The Banking Crisis 1920-33	A large number of Danish banks, including the five largest, experienced difficulties.	Several large banks, including Scandinavia's largest bank – Landmandsbanken – received capital and/or liquidity support from the government and Danmarks Nationalbank.	The late 1920s and the early 1930s were characterised by financial, banking and currency crises in many countries (cf. the US stock market crash in 1929 and the collapse of the international gold standard system in 1931).
The Kronebank Crisis 1984-85	Denmark's seventh largest bank, Kronebanken, experienced difficulties.	Danmarks Nationalbank and a number of large banks provided a guarantee aimed at depositors and other creditors in Kronebanken.	No
The seven-year slump 1987-93	A number of banks encountered difficulties, including Denmark's ninth largest bank, Varde Bank.	The government and Danmarks Nationalbank were involved in finding solutions for five distressed banks. In addition, the Faroe Islands experienced a banking crisis.	Currency crisis in the European Monetary System 1992-93. Systemic banking crises in Norway, Sweden and Finland.
The Financial Crisis from 2007/08 onwards	A number of banks experienced difficulties and had to cease as independent firms, including four of the 15 largest banks.	The government provided a safety net for the banks by way of a comprehensive government guarantee for depositors etc. In addition, the government provided capital injections to a large number of credit institutions and gave credit institutions the opportunity to purchase an individual government guarantee on debt issues. Danmarks Nationalbank established additional credit facilities and expanded the collateral base.	An international liquidity crisis spread from the USA to Europe in the second half of 2007, developing into a genuine global credit crisis in 2008.

ity in the financial sector may potentially have had a significant negative impact on the economy.

In the literature, several different approaches have been used to identify periods of such "systemic" banking crises. Reinhart and Rogoff (2009b) delimit banking crises to situations in which the government has intervened in various ways, while Bordo et al. (2001) classify banking crises as situations in which a large part of the banking sector's capital base is undermined.

In the literature, different approaches have also been used to pinpoint the start and end times of the banking crises. For example, some studies define the start of a banking crisis based on the timing of a significant drop in the stock indices for banks, the timing of a substantial fall in bank deposits or the timing of government intervention to support financial stability. In some studies the end time of a banking crisis is determined as the time when output growth is back at the pre-crisis trend level or as the time when government support measures expire.

Using the above methods of determination, it may often be difficult or even impossible to determine exactly when a banking crisis begins or ends. For example, there is the question of what is "significant" or "substantial". Furthermore, a banking crisis may have started well before the government intervenes. There may also be cases in which a crisis becomes critical after government intervention (or after the first intervention). Ultimately, the identification and delineation of periods of banking crises will always have elements of subjectivity and estimates, and often an "expert opinion" is also seen as a method of delineation.

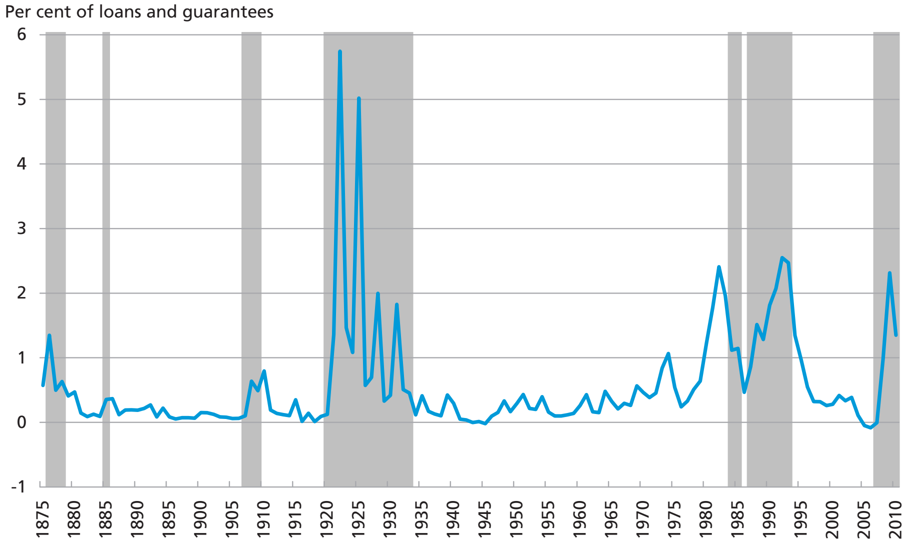
Moreover, the impact of a banking crisis on the real economy may depend on the specific circumstances, e.g. whether it is an isolated banking crisis or a dual crisis combining a banking crisis and a currency crisis. It may also be of significance whether the crisis is national (a banking crisis in a single country) or international. Finally, the extent of government intervention to address the crisis is also relevant.

Table 2.1 provides a summary overview of the periods identified in Danmarks Nationalbank's "Monetary History of Denmark"[1] as periods of banking crises on which the analyses in this article will be based.

An impression of the extent of the individual crises can be gained by looking at the write-down ratios of the banking sector since 1875, cf. Chart 2.1. The chart should be used with some caution when comparing the write-down ratio levels over extended periods of time due to changes in accounting principles, etc. However, the chart clearly shows that most

[1] Cf. Hansen and Svendsen (1968); Hoffmeyer and Olsen (1968); Mordhorst (1968); Mikkelsen (1993); and Abildgren et al. (2010). The most recent financial crisis is discussed in Abildgren and Thomsen (2011).

THE BANKS' WRITE-DOWNS 1875-2010 Chart 2.1



Note: The grey markings indicate periods of banking crises, cf. Table 2.1.
For the period from 1921 onwards, the compilation covers all commercial banks and savings banks.
For the period 1893-1920, the table shows a weighted average of the write-down ratios for all savings banks and the write-down ratios for the three main commercial banks (Privatbanken, Landmandsbanken and Handelsbanken). The weightings used are the loans provided by all savings banks and all commercial banks, respectively. On average, the savings banks and the three main commercial banks accounted for around 80 per cent of the loans provided by all commercial banks and savings banks in the period 1893-1920.
For the period 1875-1892, the table shows a weighted average of the write-down ratios for the three main commercial banks and the write-down ratio for Den Lollandske Landbostands Sparekasse. The weightings used are the loans provided by all commercial banks and all savings banks, respectively. On average, the four banks accounted for around 27 per cent of the loans provided by all commercial banks and savings banks in the period 1875-1892.
Negative write-down figures indicate that previous write-downs are reversed as revenue.

Source: Calculated on the basis of data from Abildgren (2008, 2010b); Banktilsynet (1945); Christiansen et al. (1945); Hansen (1996); Hansen (1969); Statistics Denmark, *Statistical Yearbook*, various editions; and the website of the Danish Financial Supervisory Authority.

of the banking crises since 1875 (marked in grey in the chart) were characterised by a substantial increase in the banks' write-down ratios.

The highest write-down ratios could be seen in the 1920s, and in accumulated terms more than 20 per cent of loans and guarantees were written down in the period 1920-33. At the other end of the spectrum is the liquidity crisis in 1885, which was not characterised by any significant increase in the banks' write-downs.

Furthermore, it is worth noting that the period from the end of World War II until the early 1980s was characterised by pronounced stability in the Danish banking sector. The same trend is seen in a larger international perspective. Globally, there were no major banking crises during the Bretton Woods period from 1945-71, apart from a single banking crisis in Brazil in 1962, cf. Allen and Carletti (2008). For the period 1970-2007, on the other hand, a total of 42 systemic banking crises in 37 countries can be listed, cf. Laeven and Valencia (2008).

3. COMPARISON OF BUSINESS CYCLES WITH AND WITHOUT BANKING CRISES 1821-2009

This section compares the business cycles in Denmark with and without banking crises in the past almost 200 years.

In the USA[1] and the euro area[2] special committees have established and are maintaining a historic chronology of the troughs and peaks of the economy. Such a chronology is not available for Denmark and many other small countries. For those countries it is common to identify the business cycles based on the cyclical component of real GDP calculated using various statistical filtering techniques.

In this article the business cycles have therefore been identified based on the cyclical component of real GDP calculated using a filter, cf. Box 3.1. The quality of the historical national accounts data is questionable, cf. e.g. Mogensen (1987), but they are currently the best basis for assessment of the cyclical fluctuations in Danish economic history.

Table 3.1 shows the chronology calculated for the length and amplitude of Danish business cycles in the past almost 200 years. As illustrated, there are large variations in business cycle volatility over time. The inter-war period and the periods of the two world wars were characterised by particularly large cyclical fluctuations, whereas the fluctuations were relatively moderate during the gold standard period. This pattern is also seen in many other countries, cf. Bergman et al. (1998).

Since World War II, the Danish business cycles have tended to be longer on average, especially since the mid-1970s. Moreover, it should be noted that while the economic upturns and downturns prior to World War I were of more or less equal length, the economic downturns have been considerably shorter than the upturns during the subsequent period. The situation for the USA is fairly similar.

According to Zarnowitz (1992), the dampening of the cyclical fluctuations in the USA in the first four decades after World War II can be attributed to several factors, including a shift in the business structure from the more volatile primary and secondary sectors towards the less cyclically sensitive tertiary sectors (including public services) and the growing importance of automatic stabilisers[3]. Similar conditions may have contributed to the dampening of the cyclical fluctuations in Denmark in the post-war period compared with the inter-war period.

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1 NBER's Business Cycle Dating Committee.

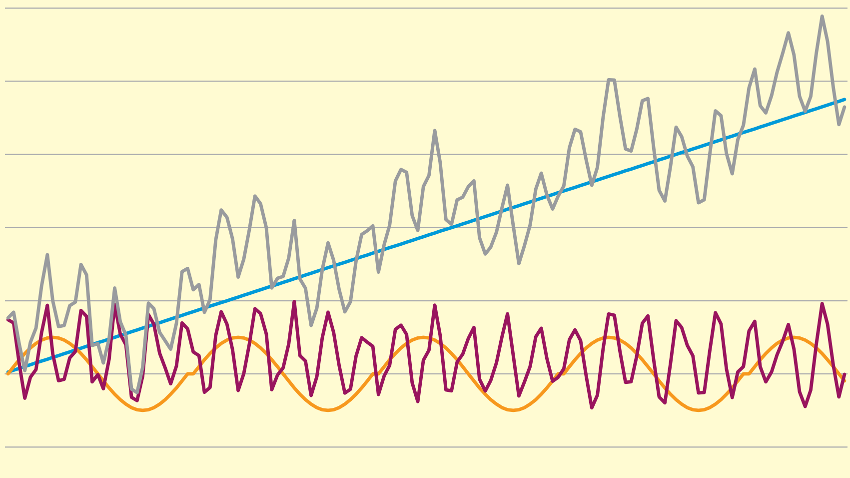
2 CEPR's Euro Area Business Cycle Dating Committee.

3 Automatic stabilisers refer to the fact that fiscal policy is automatically eased during an economic downturn as expenditure for e.g. unemployment benefits increases with rising unemployment. Furthermore, taxes are reduced when corporate and household earnings decline. On the other hand, fiscal policy is automatically tightened during an economic upturn by increased tax revenue and reduced expenditure for transfer payments.

IDENTIFICATION OF BUSINESS CYCLES Box 3.1

An economic time series can, by means of a filter, be broken down into a trend and a number of cyclical components that can be viewed as deviations from the trend, cf. Chart 3.1. The cyclical component corresponding to the business cycle is typically delimited to cycles lasting from 2 to 8 years.

ILLUSTRATION OF BUSINESS CYCLES IDENTIFIED ON THE BASIS OF THE CYCLICAL COMPONENT IN THE LOGARITHM OF REAL GDP Chart 3.1



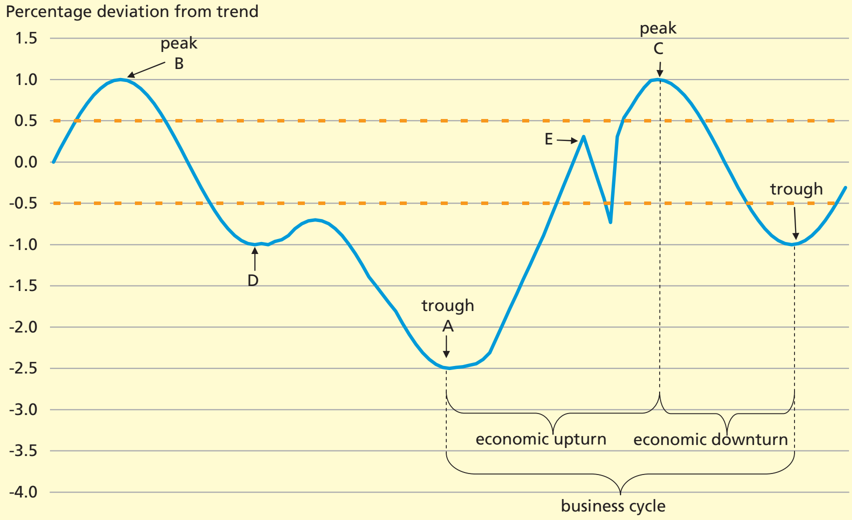
In this article the business cycles are identified by first calculating the cyclical component in the logarithm of annual data for real GDP since 1815.[1] The business cycles are subsequently identified based on the cyclical component using the following algorithm, cf. Chart 3.2:

- An economic upswing starts at a trough in the time series and ends at a peak.
- An economic downturn starts at a peak in the time series and ends at a trough.
- A business cycle consists of an economic upswing followed by an economic downturn.
- A trough is a negative global minimum located between two peaks and represents a negative output gap of minimum 0.5 per cent of GDP.
- A peak is a positive global maximum located between two troughs and represents a positive output gap of minimum 0.5 per cent of GDP.[2]

In Chart 3.2, for example, point A is a trough in the business cycle. It constitutes a global minimum between the two peaks, B and C, and represents a negative output gap of 2.5 per cent of GDP, which exceeds the required threshold value. Point D, on the other hand, is not a trough as it is a local rather than a global minimum between the two peaks, B and C. Point E is not a peak, as the positive output gap is not above the threshold value of 0.5 per cent of GDP.

CONTINUED Box 3.1

ILLUSTRATION OF BUSINESS CYCLES IDENTIFIED ON THE BASIS OF THE CYCLICAL COMPONENT IN THE LOGARITHM OF REAL GDP Chart 3.2



[1] The calculations use a Baxter-King (1999) filter with the cyclical component delimited as fluctuations at a frequency of 2-8 years. The filter applies 3 observations on each side of the symmetrical average. By transforming the time series logarithmically before filtering, the cyclical component (when multiplied by 100) can be interpreted as the percentage deviation from the trend and thereby as an output gap. Applying a business cycle length of 2-10 years and 4 observations on each side of the symmetrical average does not provide substantially different results.

[2] The condition that a trough or a peak must be located +/- 0,5 per cent from the trend is arbitrary, but it is consistent with e.g. Artis et al. (2003). The relevant literature talks about "amplitude censoring".

In Table 3.1 the business cycles characterised by the banking crises identified in Table 2.1 are highlighted in bold.

There is a clear pattern of economic downturns with banking crises being deeper or longer than economic downturns without banking crises:

- The economic downturn of 2007-09, which was characterised by the Financial Crisis, was the deepest downturn since World War II.
- The economic downturn of 1855-58, which included the Monetary Crisis, was the deepest downturn in the period 1821-1915.
- The economic downturn of 1876-77, which was characterised by the Savings Bank Crisis, was the deepest downturn in the gold standard period.
- The economic downturn of 1986-93, during which a number of banks experienced a crisis, is unique in that it was the longest economic downturn (7 years) since 1821. On the other hand, it was not much deeper than the average depth of the downturns since 1975.

CHRONOLOGY OF DANISH BUSINESS CYCLES 1821-2009 TABLE 3.1

Turning points			Length (years)			Amplitude (% of GDP)	
Trough	Peak	Trough	Upswing	Down-turn	Cycle	Strength of upswing	Depth of downturn
...	1821	1823	...	2	...	...	2.4
1823	1824	1825	1	1	2	1.7	1.3
1825	1828	1833	3	5	8	2.7	3.7
1833	1834	1836	1	2	3	3.7	3.3
1836	1840	1842	4	2	6	2.1	3.5
1842	1845	1847	3	2	5	4.0	4.3
1847	1850	1854	3	4	7	7.3	7.2
1854	**1855**	**1858**	1	**3**	4	8.8	**8.8**
1858	1859	1861	1	2	3	4.9	3.5
1861	1863	1864	2	1	3	4.1	3.3
1864	1865	1868	1	3	4	1.9	3.6
1868	1870	1871	2	1	3	3.6	2.1
1871	1872	1873	1	1	2	2.5	2.4
1873	**1876**	**1877**	3	**1**	4	2.0	**4.3**
1877	1879	1881	2	2	4	3.3	1.6
1881	1883	1885	2	2	4	2.6	3.1
1885	**1887**	1889	**2**	2	4	**2.6**	2.8
1889	1890	1894	1	4	5	3.0	2.9
1894	1896	1898	2	2	4	2.7	2.2
1898	1903	1906	5	3	8	2.6	2.1
1906	**1911**	1912	**5**	1	6	**2.3**	2.4
1912	1914	1915	2	1	3	6.0	7.0
1915	1916	1918	1	2	3	4.8	10.5
1918	1920	1921	2	1	3	10.3	8.0
1921	**1923**	**1925**	**2**	**2**	4	**10.9**	**8.7**
1925	**1930**	**1932**	**5**	**2**	7	**6.5**	**5.8**
1932	1939	1941	7	2	9	12.4	20.1
1941	1944	1945	3	1	4	15.4	12.8
1945	1950	1952	5	2	7	10.2	4.5
1952	1954	1958	2	4	6	2.9	3.1
1958	1961	1963	3	2	5	2.9	2.9
1963	1965	1966	2	1	3	3.0	2.3
1966	1973	1975	7	2	9	3.8	5.8
1975	1979	1981	4	2	6	5.3	4.5
1981	**1986**	**1993**	**5**	**7**	12	**5.0**	**5.1**
1993	2000	2003	7	3	10	3.9	2.8
2003	**2007**	**2009**	4	**2**	6	3.9	**6.1**
Average of monetary regimes:							
1823-1842 ("Rigsdaler's return to par") ...			2.3	2.5	4.8	2.6	3.0
1842-1873 ("Silver standard")			1.8	2.1	3.9	4.6	4.4
1873-1912 ("Gold standard")			2.8	2.1	4.9	2.6	2.7
1912-1945 ("Wars and inter-war period")			3.1	1.6	4.7	9.5	10.4
1945-1975 ("Bretton Woods")			3.8	2.2	6.0	4.6	3.7
1975-2009 ("Post-Bretton Woods")			5.0	3.5	8.5	4.6	4.6
Total 1823-2009			2.9	2.2	5.2	4.9	4.9

Note: The depth of an economic downturn is measured from peak to trough. The strength of an economic upturn is measured from trough to peak. The monetary regimes are stated in quotation marks as the breakdown into periods is based on whole business cycles and therefore may not coincide fully with the monetary regimes. The business cycles characterised by banking crises are highlighted in bold.

Source: Calculated on the basis of Hansen (1983), Hansen and Svendsen (1968), Abildgren (2010a), and Statistics Denmark. The data for 2011-12, which are included in the calculation of the cyclical component for 2008-09, are based on Danmarks Nationalbank's forecast.

Furthermore, with regard to the above four economic downturns it should be noted that while the two deepest downturns (1855-58 and 2007-09) were characterised by international financial crises, the banking crises in the two other periods (1876-77 and 1986-93) were of a more national (or Nordic) nature.

Table 3.1 paints a more mixed picture in terms of the length and strength of economic upturns following downturns with banking crises. For example, the economic upturn in the period 1993-2000 following the seven-year slump was very long, but it was weaker than the average economic upturns since World War II. On the other hand, the economic upturn 1877-79 following the Savings Bank Crisis was shorter but stronger than the average economic upturns during the gold standard period.

Finally, it should be noted that the banking crisis in the 1920s and the early 1930s lasted for a very long time, and that the economy was characterised by strong upturns as well as deep downturns during this period.

The above results are generally in line with international studies in this field. For example, Bordo et al. (2001) analyse data for 21 countries for the period 1880-1997. They find that, on average, economic downturns characterised by banking and currency crises have been deeper and lasted longer than economic downturns without banking crises. Kannan et al. find similar results for 21 industrialised countries for the period 1960-2008 and also point out that upswings following economic downturns with banking crises tend to be weaker than normal.

As previously stated, it should be noted that the causality between economic trends and banking crises can go either way. So in principle, based on the above analysis, it may simply be concluded that economic downturns with banking crises are longer and deeper than normal. The reason may be that economic downturns are aggravated by banking crises, but it may also merely reflect the tendency for banking crises to occur during deep economic downturns. Sections 5-7 will further discuss the extent to which effects of the former type apply.

4. SUMMARY COMPILATION OF GROSS AND NET OUTPUT LOSSES DURING AN ECONOMIC DOWNTURN WITH A BANKING CRISIS

One of the methods to quantify the output loss in connection with banking crises is to compare the development in actual real GDP during a period characterised by a banking crisis with the development in hypothetical real GDP if there had been no banking crisis. This can be done in several ways.

Some studies define output loss in connection with banking crises as the accumulated difference between actual real GDP and potential real GDP during the course of the banking crisis while disregarding the impact, if any, of the banking crisis on potential GDP. Such a method is used in e.g. Hoggarth et al. (2002).

However, the above types of calculations tend to overestimate the output loss caused by banking crises because they disregard the fact that banking crises often occur during recessions where the output level is usually lower than the potential level – even if there is no banking crisis. Some of the calculations in Hoggarth et al. (2002) seek to address this problem by calculating the output loss based on the difference between the actual development in real GDP during the banking crisis and the development expected in economic forecasts one year prior to the onset of the crisis. The weakness of this method is that it will attribute all unexpected shocks to the economy that were not included in the pre-crisis forecast to the banking crisis – even if they are not actually related to the banking crisis.

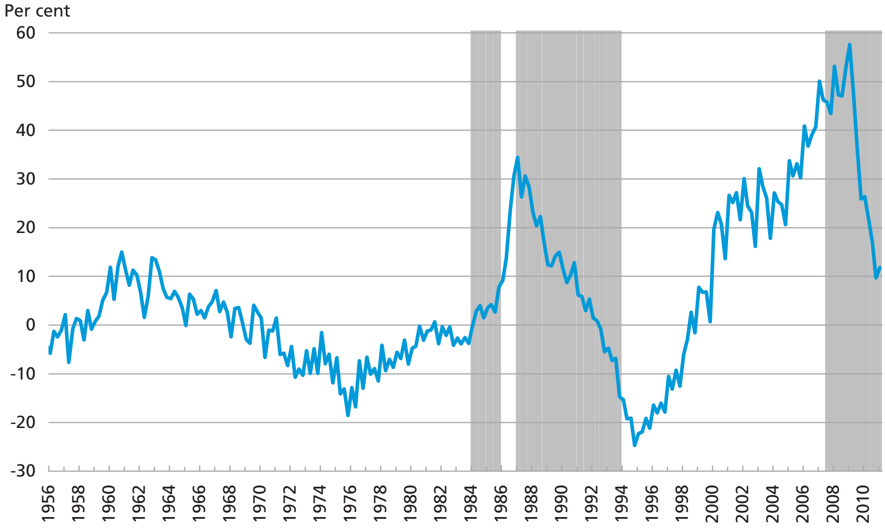
Serwa (2010) summarises a number of studies in this field. The studies find an average accumulated output loss during a banking crisis of 4-20 per cent of GDP. The methods applied in the studies vary, however, so these estimates should be used with some caution. The wide interval of the estimated losses also reflects that calculations of this type are subject to great uncertainty and should be regarded as rough estimates only.

Schwierz (2004) argues that studies should not be restricted to review the lower output that may result from a distressed financial sector's reluctance to provide loans (gross output loss). Calculations of the output loss should set off the higher output created during a prior credit expansion if the latter was at the root of the actual banking crisis, thereby producing the net output loss of the banking crisis. This approach might also be motivated with reference to Chart 4.1, which shows the development in lending by banks as a ratio of GDP since the mid-1950s. There are only two periods during which lending as a ratio of GDP increased to a level considerably above the trend. This was the case in the 2nd half of the 1980s prior to the seven-year slump 1987-93 and in the years after the millennium rollover prior to the Financial Crisis from 2007/08 onwards.

The terms gross and net output losses can be illustrated as in Chart 4.2. Here, the net output loss figures are based on two calculations of the development in real GDP. One calculation concerns the actual development in real GDP, while the other concerns the development in real GDP, assuming that the banking crisis did not occur (the counter-factual development). The gross output loss is then calculated as the accumulated

LENDING BY BANKS AS A RATIO OF GDP 1956-2011, DEVIATION FROM TREND

Chart 4.1

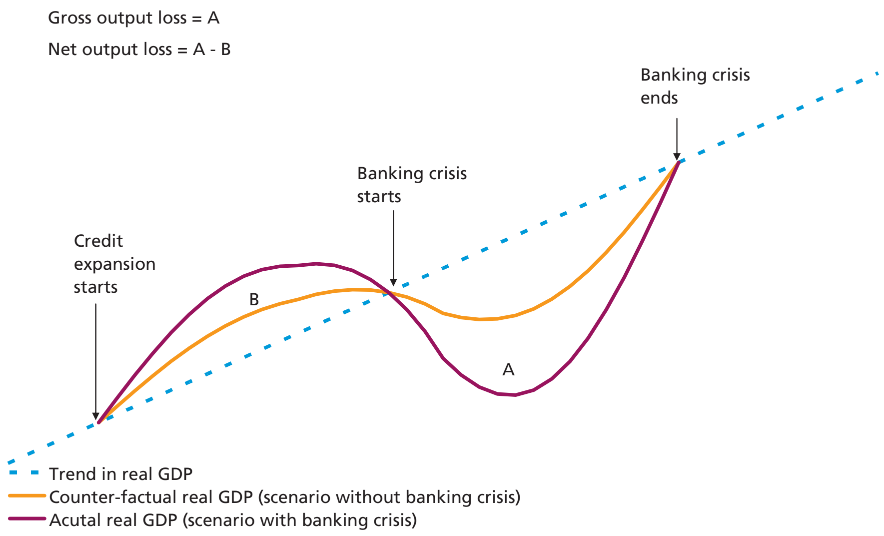


Note: The grey markings indicate periods of banking crises, cf. Table 2.1. Lending concerns the banks' domestic loans to non-MFIs. Lending and GDP are in current prices. The trend is calculated as a 32-quarter moving average.
Source: Abildgren (2010b) updated with new and revised figures.

difference between counter-factual real GDP and actual real GDP during the banking crisis years (area "A" in Chart 4.2). The net output loss is calculated as the gross output loss less the accumulated percentage dif-

GROSS AND NET OUTPUT LOSS IN A BANKING CRISIS

Chart 4.2



OUTPUT LOSS DURING THE ECONOMIC DOWNTURN IN 2007-09 CHARACTERISED BY THE FINANCIAL CRISIS

Table 4.1

Per cent of GDP	Gross output loss	Net output loss
Benchmark: The period since World War II	4.2	4.2
Benchmark: The period since 1973................................	3.6	2.2

Source: See main text.

ference between actual real GDP and counter-factual real GDP during the boom years prior to the banking crisis (area "A – B" in Chart 4.2).

Table 4.1 shows the result of a number of summary calculations of gross and net output losses during the most recent economic downturn 2007-09, which was characterised by the Financial Crisis. The calculations compare the length and depth of the economic downturn with a "normal" economic downturn without a banking crisis based on the cyclical component of real GDP as described in section 3. This means that the calculations are based on the implied assumption that the Financial Crisis was the only reason why the economic downturn 2007-09 became deeper than normal. It is therefore a very "broad" definition of the "effects of the Financial Crisis".

The length of the economic downturn from 2007 to 2009 (2 years) was more or less in line with the average for economic downturns without banking crises since World War II (2.3 years). In the period 2007-2009 the average annual decline in the cyclical component of real GDP was 3.0 per cent. If the annual decline had been in line with the average for economic downturns without banking crises since World War II, the average annual decline would only have been 1.6 per cent. The gross output loss in connection with the Financial Crisis can thus be stated at 3.0 - 1.6 = 1.4 per cent of GDP in the first year and 1.4 + (3.0 - 1.6) = 2.8 per cent of GDP in the second year, or 1.4 + 2.8 = 4.2 per cent of GDP in total. The length and strength per boom year of the previous cyclical upswing in 2003-07 were largely in line with the average for other economic upturns since World War II (excluding economic upturns prior to banking crises). As a consequence, the net output loss corresponds to the gross output loss of 4.2 per cent of GDP.

The strength per boom year of the cyclical upswing in 2003-07 exceeded the average for other economic upturns since 1973 (excluding economic upturns prior to banking crises). Moreover, the average annual decline in the cyclical component of real GDP has been slightly larger for economic downturns since 1973 than for economic downturns after World War II. If the period after 1973 rather than the period after World War II is used as a benchmark, calculations in line with the above will produce slightly lower gross and net output losses during the economic downturn, cf. Table 4.1.

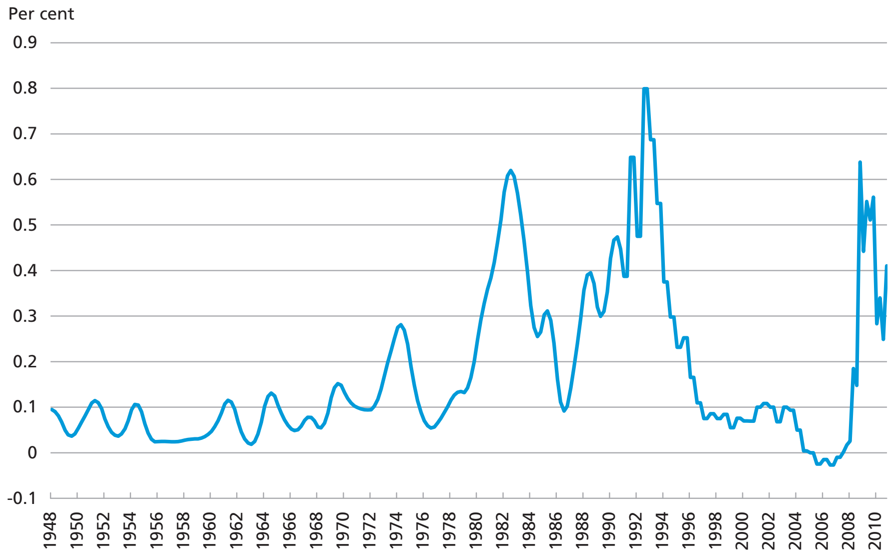
It should be noted that the calculations in Table 4.1 are restricted to the output loss during the actual economic downturn in 2007-09. In order to calculate the total output loss relating to a banking crisis, it is necessary to consider the question of whether an economic upswing immediately after a downturn with a banking crisis is weaker or stronger than normal. It must also be considered whether a banking crisis has any impact on growth and income levels in the longer term. These questions will be discussed in more detail in sections 5 and 8, respectively.

5. MACROECONOMIC ANALYSIS OF THE REAL ECONOMIC CONSEQUENCES OF FINANCIAL CRISES

Due to the complicated interaction between the real and financial parts of the economy it is difficult to quantify the extent to which a financial crisis aggravates a business cycle compared with a business cycle without a financial crisis.

This can be illustrated on the basis of Chart 5.1, which shows the banks' write-down ratio since 1948. Usually, the banks' write-downs

THE BANKS' QUARTERLY WRITE-DOWN RATIO 1948-2010 — Chart 5.1



Note: Write-downs as a ratio of loans and guarantees.
The quarterly write-down ratio is not annualised and before the 3rd quarter of 2007 it is interpolated on the basis of half-year and full-year data.
Negative write-down figures indicate that previous write-downs are reversed as revenue.
Source: Abildgren (2010b) and the Danish Financial Supervisory Authority.

increase in connection with a recession – whether there is a banking crisis or not. Accordingly, write-downs rose in connection with the first oil crisis in the mid-1970s, in connection with the downturn related to the second oil crisis in the late 1970s and early 1980s, during the seven-year slump in the late 1980s and early 1990s and finally in the period from 2008 onwards.

The write-downs increase in connection with a downturn because poor sales opportunities and rising unemployment reduce the earnings base of firms and households and thus their ability to service their bank loans. Furthermore, downturns may be accompanied by falling stock and house prices, which reduces the value of the collateral for the bank loans. They may also lead to a higher level of write-downs in the banking sector. Finally, write-downs may rise during a slump if the banks become more cautious in their lending portfolio quality assessment.

Normally, a downturn will also be accompanied by a decline or low growth in the demand for credit due to weak development in consumption and investment ("demand effect"). To counter the risk of losses on loans, the banks will often widen their interest-rate margins and tighten their credit standards in connection with a slump. Viewed in isolation, this also reduces bank lending ("supply effect").

Therefore, a slump typically implies increasing write-downs in the banking sector and lower lending volumes, regardless of whether there is a financial crisis or not.

During a financial crisis, however, the banks' write-downs may increase more than warranted by the general economic development. Thus, the write-downs are indicators of the impact of the financial crisis on the economy. For example, the write-downs may grow more than warranted by the general cyclical development because a financial crisis leads to extraordinarily high uncertainty about the future economy and thereby the future finances of bank customers. Write-downs may also increase more than usual because the banks become extra cautious in their lending portfolio quality assessment.

A calculation of the real economic effects corresponding to such "extraordinary" increases in the banks' write-downs during a financial crisis can be interpreted as an expression of the negative impact of the financial crisis, viewed in isolation, on the business cycle. Below, such a calculation will be made on the basis of a summary model (a vector autoregressive (VAR) model) for the Danish national economy.

Abildgren (2010b) estimates a VAR model based on quarterly data for Denmark for the period 1948-2010, cf. Box 5.1. Chart 5.2 shows the development in real GDP, house prices and lending corresponding to an "extraordinary" increase in the Danish banking sector's write-down ratios

VAR MODEL FOR THE DANISH ECONOMY 1948-2010 Box 5.1

VAR models appear to be particularly suited for illustrating the complicated interaction between the financial sector and the real economy due to the few *a priori* restrictions imposed on such models. In recent years, VAR models have been applied to illustrate how the macroeconomy is affected by shocks to the robustness of the banking sector, cf. Anari et al. (2005), Kupiec and Ramirez (2008), Marcucci and Quagliariello (2008), Österholm (2010), Monnin and Jokipii (2010), Berrospide and Edge (2010) as well as Puddu (2010).

In general terms, an unrestricted, reduced-form VAR model can be written as

$$Y_t = CD_t + A_1 Y_{t-1} + \ldots + A_p Y_{t-p} + E_t \ , \quad (5.1)$$

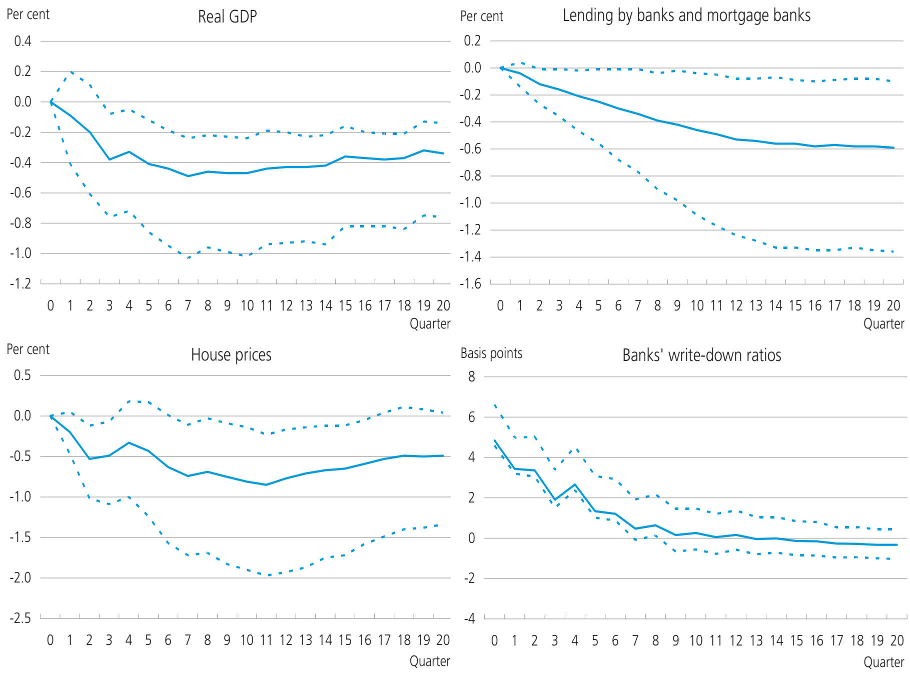
where Y_t is a vector of endogenous variables; A_i (i=1,...,p) are coefficient matrices; and E_t is a vector of serially uncorrelated residuals (unexpected "shocks") with zero means and a time-invariant variance-covariance matrix. Constant terms, time trends and seasonal dummies are included on the right-hand side of equation (5.1) via the term CD_t. The model assumes a linear relationship between the variables, and the coefficients are assumed to be constant over time. Once (5.1) has been estimated, it is possible to analyse how an unexpected shock to one of the endogenous variables at time t affects the other variables in the system at time t, t+1, t+2, etc. (impulse response analysis).

Abildgren (2010b) estimates a VAR model like (5.1) based on quarterly data for Denmark for the period 1948-2010. The model includes the following nine endogenous variables: real GDP, consumer prices, short-term interest rates (Danmarks Nationalbank's discount rate), yields on long-term government bonds, share prices, the money supply (M2), domestic credit provided by Danish banks, house prices and the banks' write-down ratios. The endogenous variables are included with five lags in the model, which also contains constant terms, time trends and seasonal dummies, and all the endogenous variables are included in levels (possibly following logarithmic transformation). The impulse response functions shown in this article are based on residuals orthogonalised via a Cholesky decomposition where the variables are included in the above order. This means that the block of monetary and financial variables is placed after the block of real economic variables, whereby the model allows the monetary and financial variables to react immediately to shocks to the real side of the economy. Including the banks' write-down ratios at the end of the causal structure also ensures that the estimated effects of a shock to the banks write-downs are, insofar as possible, "adjusted" for shocks to and movements in the other endogenous variables in the model. This provides the most conservative estimates of the effect that shocks to the banks' write-down ratios has on the other variables in the model.

Abildgren (2010b) describes a number of robustness checks for the model. For example, estimations of the model have been made on the basis of first differences of seasonally adjusted series, and the impact of alternative orderings of the endogenous variables has also been examined. The model results are generally robust to such alternative model specifications. Furthermore, the model seems to be econometrically well-specified on the basis of different misspecification tests and tests for structural breaks.

The data basis of the model version used for the calculations in this article has been revised and updated compared with Abildgren (2010b).

DEVELOPMENT IN REAL GDP, HOUSE PRICES AND LENDING CORRESPONDING TO AN EXTRAORDINARY INCREASE IN THE BANKS' WRITE-DOWN RATIOS Chart 5.2

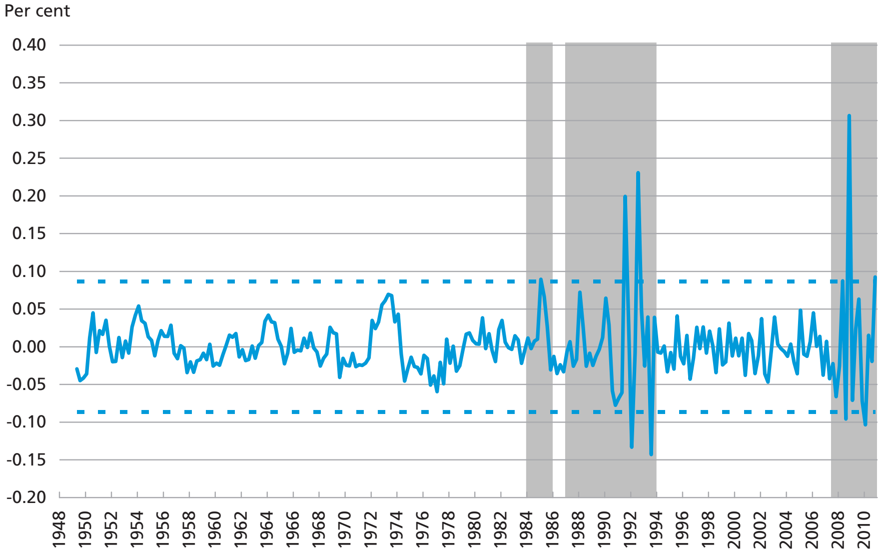


Note: The charts show the response in case of an extraordinary increase in the write-down ratio of a single standard deviation. For real GDP, lending and house prices, the charts show the deviations from the baseline scenario in per cent. For write-downs, the chart shows the deviation from the baseline scenario in basis points.
Source: Abildgren (2010b) updated with new and revised figures.

as indicated by historical experience. The solid curves show the estimated consequences (responses) of the increase (impulse), and therefore the curves are also called impulse responses. The broken curves show 95 per cent confidence bounds for the estimated impulse responses. Viewed in isolation, the extraordinary rise in the banks' write-down ratios coincides with a prolonged fall in lending, house prices and real GDP.

The question is how often such extraordinary increases in the Danish banking sector's write-down ratios have occurred, and how large they have been. This is illustrated in Chart 5.3. The chart shows that since the late 1940s the Danish banking sector has only experienced two periods of such extraordinary growth in their write-down ratios that clearly differ significantly from zero when calculated at a significance level of 5 per cent. One was in the early 1990s – a period characterised by banking and currency crises. The other occurred in 2008 during the Financial Crisis. On the other hand, according to the model the only cause of the majority of the high write-down ratios in the early 1980s was the negative economic development in the wake of the second oil crisis. In early

EXTRAORDINARY INCREASES IN THE WRITE-DOWN RATIO OF DANISH BANKS 1949-2010 Chart 5.3



Note: Stated as percentages of loans and guarantees. The dotted lines indicate two standard deviations and may be seen as 95 per cent confidence bounds around 0. The grey markings indicate periods of banking crises, cf. Table 2.1.

Source: Calculated on the basis of Abildgren (2010b) updated with new and revised figures.

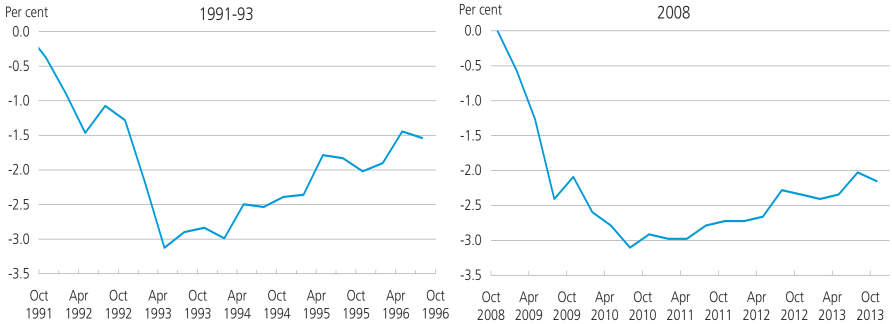
1985, however, the minor extraordinary increase in write-downs coincided with the Kronebank Crisis.

Chart 5.3 also shows a very substantial extraordinary hike in the banking sector's write-downs in the 4th quarter of 2008, i.e. just after the suspension of payments by the US investment bank Lehman Brothers in September 2008. The crisis in the early 1990s, on the other hand, was characterised by a higher number of smaller extraordinary increases in write-downs dispersed over a number of years.

Chart 5.4 estimates the development in real GDP five years ahead, corresponding to the extraordinary increases in the Danish banking sector's write-downs in 1991-93 and 2008. Viewed in isolation, the extraordinary growth in the banks' write-downs in 2008 was equivalent to real GDP in the 1st half of 2010 being around 3 per cent lower than in a baseline scenario without a financial crisis. Similarly, the extraordinary increases in the banking sector's write-downs in 1991-93 became – over a few years – equivalent to a level of real GDP that was around 3 per cent lower than in the baseline scenario.

A VAR model of the above nature does not involve explicit modelling of all the economic correlations that are assumed to exist. Instead, it is a time series model which summarises the correlations and cross correlations that can be drawn from a historical data set. As the period since

DEVELOPMENT IN REAL GDP CORRESPONDING TO THE EXTRAORDINARY INCREASES IN THE BANKS' WRITE-DOWN RATIOS IN 1991-93 AND 2008 — Chart 5.4



Note: The charts show the deviations from the baseline scenario in per cent. The left-hand chart concerns the effects corresponding to the extraordinary increases in the banks' write-down ratios in the period from the 3rd quarter of 1991 to the 3rd quarter of 1993, while the right-hand chart concerns the effect corresponding to the extraordinary increase in the banks' write-down ratios in the 4th quarter of 2008. The effects shown are related to non-seasonally adjusted variables.

Source: Calculated on the basis of Abildgren (2010b) updated with new and revised figures.

1948 has been characterised by very few banking crises, caution should be exercised when drawing conclusions from projections based on the model. With these reservations, the model calculations in Chart 5.4 indicate that in the period 2009-13 real GDP is on average 2.25-2.5 per cent below what it would have been in the absence of the Financial Crisis. This corresponds to a total accumulated output loss of around 12 per cent of GDP over the period 2009-13.

The transmission mechanism involved in connection with the Financial Crisis cannot be derived from the simple model, so the transmission mechanism is open to interpretation. A possible ("supply-related") interpretation of the development in Chart 5.2 might be that an extraordinary increase in the banks' write-down ratios is followed by a period of lending restraint with a view to restoring capital adequacy in the banking sector. The lending reduction affects the rest of the economy via lower consumption and investment and thereby lower output. Another possible ("demand-related") interpretation is that the extraordinary increase in the banks' write-downs reflects the growing uncertainty about the future economy and the economic outlook for households and the corporate sector caused by the Financial Crisis, which has led to lower consumption and investment and thus lower house prices, output and demand for credit.

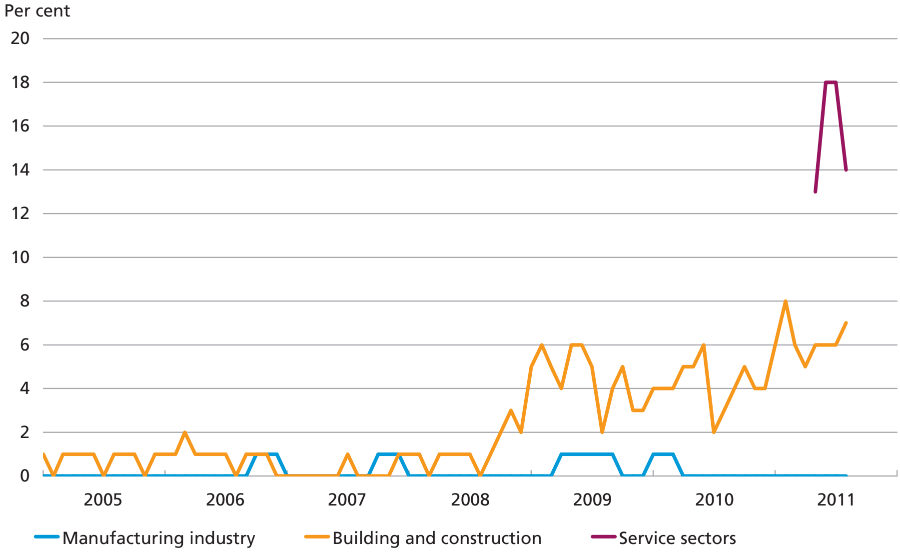
An important question when interpreting the calculation results is whether there have been periodic signs of a general credit crunch during the Financial Crisis. A credit crunch may occur if the banks reduce the supply of credit considerably more than the weak economic development would warrant, making it difficult for creditworthy borrowers to obtain financing, cf. Danmarks Nationalbank (2009).

This question cannot be answered on the basis of the above model calculation. Firstly, it is not possible to decompose the results of the calculations into impacts caused by changes in the supply of and demand for credit, respectively. Secondly, the customers' creditworthiness is not part of the calculation basis. Supplementary information is therefore necessary to assess the credit crunch issue. Based on Statistics Denmark's confidence indicators, only a limited number of firms, particularly in manufacturing industry and building and construction, have reported financial constraints as impediments to production in recent years, cf. Chart 5.5. This indicates that the Financial Crisis was not accompanied by a general credit crunch. Accordingly, the output loss caused by the Financial Crisis according to Chart 5.4 is on the whole attributable to the more general negative impact of the Financial Crisis on the economy. A case in point is the extraordinary impact of the crisis on the saving behaviour of households and firms due to weakened confidence in the banking sector.

This does not mean that some firms or firm segments have not found it more difficult to raise bank loans during the financial crisis in recent years. According to a study from Statistics Denmark, the share of rejected loan applications from small and medium-sized enterprises increased from 4 per cent in 2007 to 23 per cent in 2010, while the share

SHARE OF FIRMS REPORTING FINANCIAL CONSTRAINTS AS IMPEDIMENTS TO PRODUCTION

Chart 5.5



Source: Statistics Denmark.

of partially rejected loan applications from small and medium-sized enterprises increased from 6 to 24 per cent during the same period, cf. Statistics Denmark (2010). The Danish Ministry of Economic and Business Affairs (2011) made a more detailed analysis of these figures by linking them with the firms' financial results. The analysis shows that the firms whose credit applications were granted in full were characterised by higher profit ratios, higher returns on equity and lower gearing than the firms that obtained only part of the credit they applied for or none at all. Also Statistics Denmark's survey of small and medium-sized enterprises' access to financing seems therefore not to indicate the existence of a general credit crunch where creditworthy borrowers were unable to obtain loan financing. If anything, it reflects that the banks tightened their credit standards during the Financial Crisis in view of the customers' reduced payment ability as a consequence of the weak economic development.

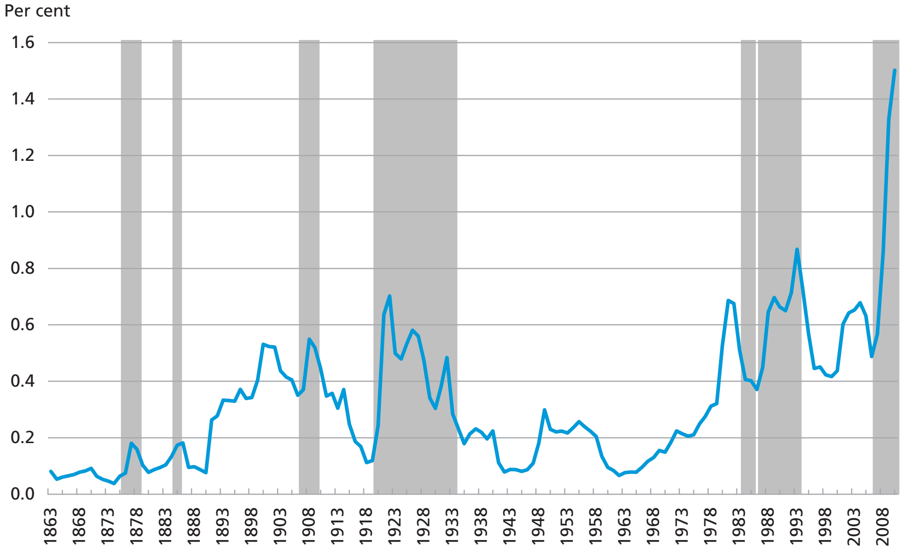
Both before and after the most recent financial crisis, Denmark's real economy has been in a better state than in the early 1990s. According to the calculations in Chart 5.4, the financial crisis in recent years has caused an output loss of the same magnitude as seen as a result of the banking and currency crises in the early 1990s. This covers two opposite effects. The financial crisis from 2007-08 onwards was of a completely different nature and far more serious than the crisis in the early 1990s. This is offset, however, by the fact that the economic-policy measures (including the bank rescue packages) introduced during the most recent financial crisis were much more comprehensive than the crisis intervention in the early 1990s.

The calculations also show that the output loss caused by the Financial Crisis occurred at the beginning of the crisis, i.e. at the end of 2008 and in the 1st half of 2009, after which the development stabilised. It would be natural to regard this stabilisation as an effect of Bank Rescue Package 1 (a general government guarantee for depositors and unsecured claims in banks) and Bank Rescue Package 2 (public capital injections in credit institutions) in October 2008 and February 2009, respectively.

6. BANKS AND DEFAULTING FIRMS DURING THE FINANCIAL CRISIS FROM 2007/08 ONWARDS

Chart 6.1 shows the failure rate in the Danish business sector over the past 150 years. Although adjustment has been made for various data breaks resulting from differences in the compilation methods used in the underlying statistics, experience shows that caution should be exercised when comparing levels over time in a long time series such as this

FAILURE RATE OF DANISH FIRMS 1863-2010 Chart 6.1



Note: The grey markings indicate periods of banking crises, cf. Table 2.1.
The failure rate is calculated as the number of defaulting firms as a ratio of the total number of firms.
The total number of firms is calculated on the basis of VAT statistics since 1969. The total number of firms prior to 1969 is interpolated from business counts, census information on the heads of small and medium-sized enterprises in trade and industry, and the number of agricultural establishments. Adjustment has been made for a number of data breaks.

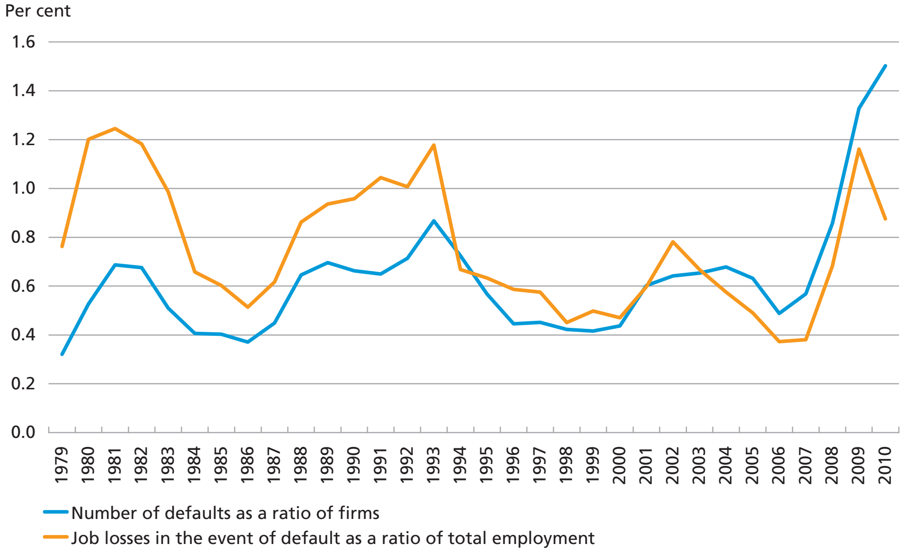
Source: Statistics Denmark, Hastrup (1979), Johansen (1985), and Olsen (1962).

one. In addition, the failure rate level over time will depend on the development in the structure of the business sector, e.g. the classification of firms by industry or legal form of ownership (sole proprietorships, limited liability companies, etc.). However, the chart clearly shows that the failure rate (i.e. the number of defaulting firms as a ratio of the total number of firms) is high during periods characterised by banking crises.

The financial crisis in recent years has greatly affected the Danish business sector, which has experienced the highest failure rates over a number of years. This applies to the failure rate and the number of jobs lost as a result of defaults as a ratio of total employment (the share of job losses), cf. Chart 6.2. While the share of job losses declined in 2010, the failure rate increased. The reason is that, on average, the firms that defaulted in 2010 had fewer employees than the ones that defaulted in 2009.

Danmarks Nationalbank's lending surveys indicate that during the most recent financial crisis the banks needed to tighten their credit standards, particularly for corporate customers, in order to adjust to the cyclical reversal, cf. Nielsen (2010). The question is whether the high failure rate in the last few years was caused by cyclical developments

FAILURE RATE AND JOB LOSSES IN CONNECTION WITH DEFAULTS
1979-2010 Chart 6.2



Note: Job losses in connection with defaults are measured by the number of employee claims submitted to the Employees' Guarantee Fund (Lønmodtagernes Garantifond – LG).
Source: Statistics Denmark and LG.

alone, or if part of the increase can be attributed to the tightening of credit standards and the lower propensity to provide credit for some banks that have been under financial pressure.

The literature comprises several studies indicating that firms with a "weak" bank perform less well than firms with a "sound" bank. For example, some studies show that firms with a "weak" bank have fewer real economic investments (Gibson (1995, 1997); Minamihashi (2011)), fewer direct investments (Klein et al. (2002); Ushijima (2008)), and higher failure rates (Joeveer (2004); Akashi et al. (2009)) than firms with a "sound" bank. A "weak" bank may have fewer options to meet the credit and liquidity needs of corporate customers than a bank with "sound" finances, and for individual firms it may be both difficult and costly to switch to another bank at short notice, because the bank's knowledge of the individual firm is important in connection with the extension of credit. Unlike a potential new bank, the firm's existing bank has such knowledge. In the academic literature on banks this is referred to as "asymmetrical information".

This issue will be discussed below, based on the analysis in Abildgren, Buchholst and Staghøj (2011), whose point of departure is a modified version of Danmarks Nationalbank's failure-rate model[1]. On this basis,

[1] Cf. Danmarks Nationalbank (2003, 2007), Lykke et al. (2004), and Dyrberg (2004).

the article examines whether the failure rate for Danish firms with a "weak" bank has tended to be higher during the financial crisis in recent years than for similar firms with a "sound" bank.

The data basis of the analysis is a database consisting of all published financial statements for non-financial public or private limited liability companies (excluding holding companies, agricultural establishments and government-guaranteed entities) with a balance sheet exceeding kr. 150,000, compiled by Experian A/S. Sole proprietorships are not comprised by the database. Around 50 per cent of the firms in the database state the name of their main bank, and this part of the database forms the basis for the estimations below. The result is a data set consisting of around 550,000 financial statements presented by 37,000 firms on average for the financial years 1995-2009. The number of defaulting firms presenting their last financial statement as an active firm in 2009 is based on preliminary data.[1]

The basic model describes the probability that firm j will default in year t ($PD_{j,t}$) based on information on the firm's return on assets, debt, etc. in year t-1 ($X_{1,j,t-1}$,..., $X_{k,j,t-1}$). As explanatory variables the model also includes a number of other firm-specific details such as age, geographical location, etc. in year t as well as industry-specific time dummy variables intended to capture cycles and more structural development trends for the individual industries ($Z_{1,j,t}$,..., $Z_{m,j,t}$). More formally, this can be written as:

$$PD_{j,t} = F\left(b_0 + \sum_{i=1}^{k} b_i X_{i,j,t-1} + \sum_{i=1}^{m} a_i Z_{i,j,t} \right), \qquad (6.1)$$

where b_0 is a constant term, and b_1, ..., b_k, a_1, ..., a_m are parameters. The explanatory variables in the basic model are described in more detail in Table 6.1.

The analysis uses a "broad" definition of the term "default". A firm is regarded as having defaulted if one of the following events has occurred: (a) The firm is being liquidated or is subject to compulsory liquidation; (b) the firm has been compulsorily dissolved or is in a process towards compulsory dissolution; (c) the firm has been granted a write-down of debt by confirmation of compulsory composition or is subject to compulsory composition; or (d) the firm has been subject to an enforced sale.

[1] This is not expected to significantly influence results, unless the breakdown of firms by firms with "weak" and "sound" banks for not yet registered defaulting firms with 2009 as the last financial year differs systematically from the breakdown of already registered defaulting firms with 2009 as the last financial year.

EXPLANATORY VARIABLES IN (6.1)-(6.2) Table 6.1

Explanatory variables	Expected impact on failure rate	Description
Included with a lag:		
Return on assets	-	The firm's return on assets less the median return on assets for the relevant sector. The return on assets is calculated as the firm's profit for the year before interest (primary operating result) as a ratio of its total assets at year-end.
Debt ratio (short-term)	+	Short-term debt as a ratio of total assets at year-end.
Debt ratio (long-term)	+	Long-term debt as a ratio of total assets at year-end.
Size	-	The logarithm of total assets at year-end deflated by the GDP deflator (1995=1).
Capital base reduction	+	The dummy variable is set at 1 if the firm has had a deficit in the last year, and if a repetition thereof would lead to the firm's equity capital falling below the statutory capital adequacy requirement for new firms. Otherwise, the dummy variable is set at 0.
Critical auditors' qualification..........................	+	The dummy variable is set at 1 if the annual financial statements include one or more critical auditors' qualifications. Firms without auditors' qualifications constitute the reference group for which the dummy variable is set at 0.
Included without a lag:		
Form of ownership	+	The dummy variable is set at 1 if the firm is a private limited liability company at the beginning of the year. Public limited liability companies constitute the reference group (at value 0). The statutory capital adequacy requirement is higher for the establishment of public limited liability companies than for private limited liability companies.
Age	-	Dummy variable representing the age of the firms measured as the number of whole years at the beginning of the year. The reference group (at value 0) is made up of newly-established firms that are less than 1 year old.
Municipality group	-	Dummy variables ranking the firms' registered offices at the beginning of the year by municipality group with Greater Copenhagen as the reference group (at value 0). Greater Copenhagen is normally more sensitive to economic fluctuations than other districts.
Time dummies for each sector	+/-	The time dummy variables for each of the seven industries in the data basis (manufacturing industry is the reference category). These dummy variables are to capture the cyclical development as well as more industry-specific trends in each industry.

As regards the timing of defaults in the data base used for the estimated equations in this section, the following should be noted: All defaults are attributed to the year immediately after the end of the year for which the firm presented its last financial statements as an active firm. On average, however, 1.5 years elapse from the time a firm presents its last financial statement as an active firm until its default is officially confirmed, cf. Lykke et al. (2004). In effect, several of the defaults attributed to year t in the data basis therefore concern the following year.

In purely econometric terms the basic model in equation (6.1) is estimated as a logistic regression model[1], and the result appears from Table 6.2. The response variable is the logarithm of the so-called odds ratio, i.e. the probability of "exit by default" relative to the probability that the firm "will continue as an active firm". This "relative default risk" is simply referred to as "default risk" in the following.

In view of the large number of observations, it can be argued that the coefficient estimates should be assessed at a significance level lower than the traditional 5 per cent. All the estimated coefficients shown in the basic model are significant at a significance level of 1 per cent, and the signs are as expected, cf. also Table 6.1. The model illustrates e.g. that the larger a firm's return on assets and the lower its debt, the lower its default risk will be.

Table 6.2 also shows the change in the odds ratio in case of a one-unit change in the explanatory variable. Table 6.2 shows e.g. that the default risk of a firm with a critical auditors' qualification is around three times higher than the default risk of a similar firm without a critical auditors' qualification.

In order to assess whether a firm's dependence on a "weak" bank during the financial crisis increased its probability of default, a number of dummy variables are added to the basic model in equation (6.1) as follows:

$$PD_{j,t} = F\left(b_0 + \sum_{i=1}^{k} b_i X_{i,j,t-1} + \sum_{i=1}^{m} a_i Z_{i,j,t} + d_{04} D04_{j,t} + \ldots + d_{10} D10_{j,t} \right). \qquad (6.2)$$

For example, the dummy variable $D10_{j,t}$ in equation (6.2) is 1 in 2010 if firm j had a "weak" bank at the beginning of 2010. For other years the variable is 0. The other dummy variables are defined in the same way. A

[1] The model has been estimated using maximum likelihood. The estimation uses a multinomial logit model with four outcomes ("active firm", "exit by default", "exit by voluntary liquidation" and "exit by merger"). The base category of the model is "active firm", cf. Abildgren, Buchholst and Staghøj (2011) for further details.

ESTIMATION OF FAILURE-RATE MODEL (6.1) – THE BASIC MODEL Table 6.2

	Coefficient estimate	Standard error	Change in the odds ratio in case of a one-unit change in the explanatory variable
Constant term	-2.816***	0.0857	...
Return on assets	-0.00125***	0.000205	0.999
Debt ratio (short-term)	0.359***	0.0132	1.431
Debt ratio (long-term)	0.322***	0.0297	1.380
Size	-0.217***	0.00753	0.805
Critical auditors' qualification	1.168***	0.0218	3.214
Form of ownership	0.354***	0.0228	1.425
Capital base reduction	1.281***	0.0218	3.599

Note: The response variable in the estimated equation is the logarithm of the so-called odds ratio, i.e. the probability that a firm will "exit by default" divided by the probability that it will "continue as an active firm". The figures in the column under the heading "Change in the odds ratio in case of a one-unit change in the explanatory variable" are produced by taking the antilogarithm of the figures in the column of coefficient estimates.
In addition to the variables shown in the table, the estimated model includes dummy variables for municipality group and age. Other variables include time dummies for each industry. The model is estimated on the basis of 554,425 annual financial statements for the period 1995-2009.
* indicates that a coefficient is significantly different from zero at a significance level of 10 per cent.
** indicates that a coefficient is significantly different from zero at a significance level of 5 per cent.
*** indicates that a coefficient is significantly different from zero at a significance level of 1 per cent.
Source: Abildgren, Buchholst and Staghøj (2011).

positive value of e.g. the parameter d_{10} reflects that a firm with a "weak" bank was more likely to default in 2010 than a similar firm with a "sound" bank. Parameters of the other dummy variables for the firms' banks in equation (6.2) can be interpreted in the same way.

If the estimated dummy variable parameters for the firms' banks in the period from 2007/08 onwards differ significantly from zero and are positive, this may indicate that firms with a "weak" bank have been subject to a higher default risk during the Financial Crisis than similar firms with a "sound" bank. As a robustness check, equation (6.2) also includes a number of additional dummy variables for the firms' banks relating to the years preceding the Financial Crisis. *A priori* the parameters for those dummy variables must be expected not to differ significantly from zero.

How to operationalise the term "weak" bank is a different matter. This can be done in several ways.

One possibility is to take as a starting point the "Supervisory Diamond" for banks introduced by the Danish Financial Supervisory Authority (FSA) on the basis of the common features characterising banks in difficulties during the most recent and previous banking crises, cf. Danish Financial Supervisory Authority (2010). The Supervisory Diamond includes a number of benchmarks for what must be defined as banking activity subject to heightened risk. The benchmarks of the Supervisory Diamond concern lending growth, property exposure, large exposures, excess liquidity cover and funding ratio. Against this background, a bank

ENDOGENEITY PROBLEMS IN RELATION TO EQUATION (6.2) Box 6.1

Reverse causality

The model assumes that the causality goes from the dummy variables for a "weak" bank to the probability of default of the individual firm – and not vice versa – so reverse causality will not be a problem. This seems to be a fair assumption if the default of an individual firm has no impact on whether its main bank is classified as "weak" or not. The degree to which this assumption is fulfilled in practice depends on the specific definition of a "weak" bank. If a "weak" bank is defined on the basis of data relating to the period prior to the financial crisis, the firms' probabilities of default during the crisis (which are the object of the analysis) will not affect the definition of a "weak" bank. This means the problem of reverse causality is avoided. However, this is not the case for definitions of a "weak" bank based on data relating to the period during the financial crisis.

The definitions of a "weak" bank according to the Supervisory Diamond for banks or to excess capital adequacy based on data for the period preceding the financial crisis from 2007/08 onwards do not give rise to any problems of reverse causality because defaulting firms during the financial crisis using these definitions do not influence whether a bank is classified as "weak" or not.

Parameter estimation bias as a result of leaving out variables

Another problem concerns the risk of leaving out variables of relevance to a firm's probability of default which are also correlated with the dummy variables for a "weak" bank. Assume that there is a tendency for firms with a high debt ratio to be customers mainly of "weak" banks. Furthermore, assume that while a high debt ratio increases the probability of default of a firm, the strength of its bank has no influence on its default risk. If the debt ratio is not among the explanatory variables, the high debt ratio's effect on the default risk when estimating equation (6.2) will be misattributed to the "weak" bank. It is sought to address this risk of *parameter estimation bias as a result of omitting variables* by including all those variables in equation (6.2) which impact the firm's probability of default according to Danmarks Nationalbank's failure-rate model. This is a way to ensure that any positive and significant dummy variable parameters for "weak" banks during the years of financial crisis in equation (6.2) are not merely a reflection of "weak" banks having "weak" firms with high probabilities of default as their customers.

The vast majority of firms stick with the same bank year after year. Of the firms that have switched to other banks over time, several firms tended to switch to "weak" banks during the period leading up to the Financial Crisis, and several firms tended to leave the "weak" banks during the Financial Crisis. Model (6.2) is not affected by firms switching between "sound" and "weak" banks over time if the explanatory variables include all the firm characteristics that are key to the firm's probability of default. If, on the other hand, relevant explanatory variables are left out, there is a risk of parameter estimation bias as a result of the firm switching to another bank. The vast majority of firms have remained with the same bank before and during the Financial Crisis, however.

might be defined as being "weak" if, based on data from the period immediately prior to the most recent financial crisis (i.e. mid-2007), the bank exceeded the FSA threshold values for four out of the five variables in the Supervisory Diamond. Of the slightly more than 100 Danish banks stated by the firms as their banks, 14 banks would be defined as "weak" according to that definition, including 3 medium-sized and 11 small banks.

Another possibility is to perceive a bank as "weak" if it is among the 10 per cent of the banks having the lowest excess solvency ratio (relative to the individual capital need) in 2007. Of the slightly more than 100 Danish banks stated by the firms as their banks, 11 banks would thus be defined as "weak", including 3 medium-sized banks. Only 2 of the 11 banks coincide with those described as "weak" according to the Supervisory Diamond. Therefore, it may be useful to make estimations of equation (6.2) using more alternative definitions of the term "weak" bank in order to check the robustness of the results.

If the parameter estimates for the bank variables in equation (6.2) are to be interpreted as an expression of how a firm's dependence on a "weak" bank impacts its probability of default, the model must take fully into account the differences in the firms' credit quality. If not, the positive coefficient dummy variables for a "weak" bank may merely reflect that "weak" banks have a customer portfolio characterised by a predominance of unprofitable firms with a high probability of default. For this reason it must be ensured that the explanatory variables reflect all the financial and structural differences between the firms that affect the probability of default of the individual firm, and adjustment must be made accordingly. For example, the failure rate of a firm with a high debt ratio must be expected to be higher than that of a firm with a low debt ratio. However, this should be captured by the explanatory variables in equation (6.2), so the effect of a high debt ratio on the probability of default is not misattributed to the dummy variable for the firm's bank, cf. the discussion of endogeneity problems in Box 6.1.

Table 6.3 shows a comparison of a number of key ratios for firms with "sound" or "weak" banks – weak banks being defined on the basis of the Supervisory Diamond for banks and excess capital adequacy, respectively (both definitions are based on data from mid-2007). In the period 2007-09, the failure rate for firms with a "weak" bank was, on average, higher than that for firms with a "sound" bank, but this was also the case before the Financial Crisis, although to a lesser extent. "Weak" banks thus tend to have a higher share of "bad" customers. Moreover, there are several systematic differences between firms with a "sound" and "weak" bank, respectively. Firms with a "weak" bank are generally

COMPARISON OF KEY RATIOS FOR FIRMS WITH A "SOUND" AND "WEAK" BANK, RESPECTIVELY

Table 6.3

	Average 1995-2006				Average 2007-09			
	"Weak" bank defined on the basis of the Supervisory Diamond		"Weak" bank defined on the basis of excess capital adequacy		"Weak" bank defined on the basis of the Supervisory Diamond		"Weak" bank defined on the basis of excess capital adequacy	
	Sound bank	Weak bank	Sound bank	Weak bank	Sound bank	Weak bank	Sound bank	Weak bank
Failure rate (per cent)	2.5	3.8	2.6	2.8	2.9	4.5	2.9	5.3
Return on assets (per cent) .	5.6	3.8	5.4	6.2	4.8	3.6	4.7	4.8
Primary operating result (kr. million)	2.1	0.5	2.1	0.8	3.1	0.5	2.9	1.0
Assets (kr. million)	36.2	12.0	35.3	11.9	67.0	19.4	65.1	16.6
Equity capital (kr. million) ...	15.4	3.6	15.0	4.1	27.5	6.4	26.7	6.2
Short-term debt as a ratio of assets (per cent	54.0	60.2	54.4	52.9	59.8	65.4	60.1	60.1
Long-term debt as a ratio of assets (per cent)	12.2	12.5	12.2	15.2	10.5	10.7	10.4	13.5
Number of employees	25.6	11.2	25.0	12.6	34.0	14.5	33.1	15.8
Age of firm (years)	17.5	15.3	17.4	16.1	21.2	18.3	21.0	19.5
Capital base reduction (share of firms, per cent)	14.3	18.8	14.5	15.0	16.3	21.3	16.5	18.2
Critical auditors' qualification (share of firms, per cent)	7.8	10.1	7.9	9.6	11.0	14.8	11.1	13.5
Geographical location of firms (per cent)								
Copenhagen and Frederiksberg	13.4	28.3	14.5	5.2	12.2	28.4	13.5	4.6
County of Copenhagen ...	11.6	23.1	12.5	2.8	10.5	23.0	11.7	1.7
Counties of Frederiksborg and Roskilde	12.7	24.4	13.7	2.7	11.8	23.2	12.9	3.1
Other urban municipalities	19.8	5.3	18.8	21.7	20.8	7.1	19.8	19.6
Rural districts....................	42.6	18.9	40.5	67.7	44.7	18.2	42.1	71.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Break-down of firms by industry (per cent)								
Trade, etc.	32.3	31.0	32.3	29.8	34.9	32.0	34.9	30.5
Construction	12.4	14.4	12.5	15.3	14.0	15.7	14.1	16.9
Real estate	23.0	25.8	23.2	21.1	20.5	25.5	20.9	19.0
Manufacturing	18.1	14.7	17.9	19.9	17.6	13.6	17.3	20.3
Transport, etc.	5.3	4.2	5.2	4.9	8.9	8.5	8.9	8.0
Other	8.9	9.9	8.9	9.0	4.1	4.5	4.0	5.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Number of observations	430,843	27,662	446,627	11,878	89,435	6,485	93,293	2,627

Source: Calculated by Abildgren, Buchholst and Staghøj (2011) on the basis of data from Experian A/S.

smaller than firms with a "sound" bank in terms of the value of their total assets, equity capital and number of employees. On average, firms with a "weak" bank are also slightly younger than firms with a "sound" bank.

All in all, table 6.3 highlights the need to adjust for systematic differences between the firms when attempting to estimate the effect of having a "weak" bank rather than a "sound" bank on their financial performance during the most recent financial crisis.

Table 6.3 also illustrates that the geographical location of firms with "weak" banks is highly dependent on the definition of a "weak" bank. If the Supervisory Diamond is used to define "weak" banks, firms with a "weak" bank will to a great extent be located in large towns. On the other hand, if excess capital adequacy is used to define "weak" banks, firms with a "weak" bank will to a great extent be located in rural districts. This highlights the need to make estimations of the model (6.2) using several different definitions of the term "weak" bank in order to ensure the robustness of the results.

Table 6.4 shows the results of estimations of equation (6.2) using two different definitions of a "weak" bank. If a "weak" bank is defined on the basis of the Supervisory Diamond in mid-2007, the parameters of the dummy variables *D08-D09* differ significantly from zero at a 1 per cent significance level, and the sign is as expected. According to the calculations, and all other things being equal, the default risk in 2008-09 for firms with a "weak" bank was around 40 per cent higher than for similar firms with a "sound" bank. The parameter estimates relating to the period prior to the Financial Crisis (D04-D06) do not differ significantly from zero, which is also in accordance with expectations. In the years prior to the Financial Crisis, the firms' choice of bank did not affect their probabilities of default.

The results based on excess capital adequacy in mid-2007 indicate more or less the same pattern, although the bank variable has a somewhat stronger effect on the probability of default. It should also be noted that with this definition of a "weak" bank, the effect on the probability of default in 2007 differs significantly from zero at a 1 per cent significance level. This may seem to be a very early stage of the Financial Crisis, but the effect should be seen in the light of the fact that, on average, 1.5 years elapse from the time a firm presents its last financial statement as an active firm until its exit by default is officially confirmed. So in effect, several of the defaults attributed to 2007 in the data basis concern the following year.

It is also worth noting that there are no indications of the strength of a firm's bank having had any impact on its probability of default in 2010. This applies regardless of the definition of a "weak" bank. Accordingly, the effect of a "weak" bank can only be traced in the crisis years up to and including 2009. This is consistent with the results in section 5, which indicated that the negative impact on real GDP caused by the

ESTIMATION OF FAILURE-RATE MODEL (6.2) INCLUDING DUMMY VARIABLES FOR THE FIRMS' BANKS

Table 6.4

	Coefficient estimate		Standard error		Change in the odds ratio in case of a one-unit change in the explanatory variable	
	"Weak" bank defined on the basis of the following:					
	The Supervisory Diamond	Excess capital adequacy	The Supervisory Diamond	Excess capital adequacy	The Supervisory Diamond	Excess capital adequacy
Constant terms	-2.825***	-2.821 ***	0.0857	0.0857	...	...
Return on assets	-0.00126***	-0.00126 ***	0.000205	0.000205	0.999	0.999
Debt ratio (short-term)	0.358***	0.358 ***	0.0132	0.0132	1.431	1.431
Debt ratio (long-term)	0.322***	0.321 ***	0.0297	0.0297	1.379	1.379
Size	-0.217***	-0.217 ***	0.00753	0.00753	0.805	0.805
Critical auditors' qualification	1.167***	1.167 ***	0.0218	0.0218	3.211	3.214
Form of ownership ..	0.354***	0.353 ***	0.0228	0.0228	1.424	1.424
Capital base reduction	1.280***	1.282 ***	0.0218	0.0218	3.596	3.602
D10	-0.00842	0.195	0.170	0.241	0.992	1.216
D09	0.337***	0.763 ***	0.106	0.147	1.400	2.144
D08	0.323***	0.711 ***	0.105	0.152	1.382	2.035
D07	0.302**	0.752 ***	0.128	0.174	1.352	2.122
D06	-0.121	0.268	0.160	0.233	0.886	1.307
D05	0.124	0.219	0.133	0.212	1.132	1.245
D04	0.108	0.011	0.122	0.195	1.114	1.011

Note: For a further description of the two definitions of a "weak" bank, see the main text.
The response variable in the estimated equation is the logarithm of the odds ratio, i.e. the probability that a firm will "exit by default" divided by the probability that it will "continue as an active firm". The figures in the column under the heading "Change in the odds ratio in case of a one-unit change in the explanatory variable" are produced by taking the antilogarithm of the figures in the column of coefficient estimates.
In addition to the variables shown in the table, the estimated model includes dummy variables for municipality group and age. Other variables include time dummies for each industry. The model is estimated on the basis of 554,425 annual financial statements for the period 1995-2009.
* indicates that a coefficient is significantly different from zero at a significance level of 10 per cent.
** indicates that a coefficient is significantly different from zero at a significance level of 5 per cent.
*** indicates that a coefficient is significantly different from zero at a significance level of 1 per cent.

Source: Abildgren, Buchholst and Staghøj (2011).

Financial Crisis occurred at the beginning of the crisis, after which the development stabilised in parallel with the implementation of Bank Rescue Packages 1 and 2.

In summary, the above analysis indicates that the default risk for firms with a "weak" bank was higher in 2008-09 than that for similar firms with a "sound" bank. The question is how these results should be interpreted. Firstly, the calculations are based on the assumption that the explanatory variables in the failure-rate model (return on assets, debt ratio, auditors' qualification, etc.) fully allow for the fact that the probability of default is higher for firms with "poor" finances than for firms with "healthy" finances. Where this is not the case, the impact of having a "weak" bank on a firm's probability of default will be overestimated. The reason is that, as mentioned above, "weak" banks tend to have a higher share of "bad" customers. In such cases it cannot be ruled out that the calculations simply reflect the default of unprofitable firms during the financial crisis and that those firms were mainly customers of "weak" banks. Secondly, the calculations assume that in terms of the probability of default, the effect of having a "weak" bank is the same for all firms. In view of the fact that, as mentioned in section 5, only a small number of firms in recent years have reported financial constraints as impediments to production, it would be natural to see this result as indicating that dependence on "weak" banks affected only the probability of default for a small share of firms, while the probabilities of default of the majority of firms were not affected by the state of their banks. To illustrate this issue, section 7 below focuses on whether a negative impact of having a "weak" bank can be seen on the return on assets for the non-defaulting firms during the Financial Crisis.

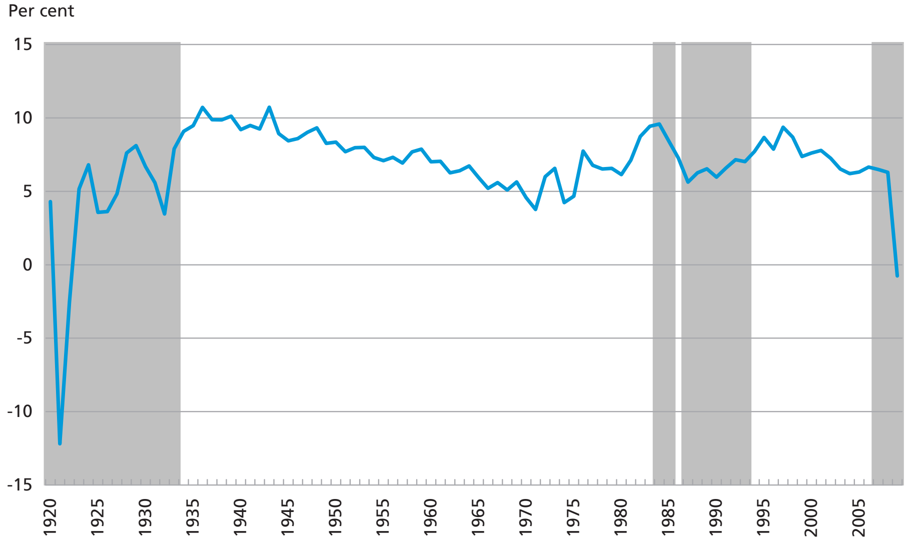
7. BANKS AND THE RETURN ON ASSETS OF NON-DEFAULTING FIRMS DURING THE FINANCIAL CRISIS FROM 2007/08 ONWARDS

The financial strength of a firm's bank may not only affect the firm's survival during a financial crisis. In more general terms, the bank may also affect the financial performance of non-defaulting firms. As mentioned in section 6, a "weak" bank may have fewer options to meet the credit and liquidity needs of corporate customers than a bank with "sound" finances. If a firm with a "weak" bank finds it difficult to obtain alternative funding, it may have to reduce its activity level, divest assets or refrain from making profitable investments. This may have a negative impact on the firm's financial performance, even if it does not cause it to fail. While credit constraints may cause firms with poor liquidity to default in the short term, it may be argued that a potential impact on the return on assets of non-defaulting firms will only be seen in the slightly longer term.

Chart 7.1 shows the return on assets in the Danish industrial sector over the past 80 years. The return on assets is a measure of a firm's primary operating result (i.e. the profit for the year before interest) as a ratio of its total assets. It thus reflects the firm's ability to generate a return on assets which is used to pay taxes and to achieve a return on the firm's liabilities, including its equity capital.

The development in the return on assets over time is not affected by the business cycle alone, but also by structural changes in the business

RETURN ON ASSETS IN MANUFACTURING INDUSTRY 1920-2009 Chart 7.1



Note: The grey markings indicate periods of banking crises, cf. Table 2.1.
The return on assets is calculated as the firm's profit for the year before interest ("primary" or "ordinary" operating profit) as a ratio of its total assets at year-end. Data for the period 1920-75 are based on all industrial firms organised as public limited liability companies (A/S) or private limited liability companies (ApS) with minimum 20 employees. Data for the period 1990-94 are based on all industrial firms (excluding oil extraction) with minimum 20 employees. Since 1995, the series has been based on all industrial firms (excluding oil extraction). Adjustment has been made for various data breaks.

Source: Statistics Denmark and Experian A/S.

sector (e.g. shifts between individual industrial sectors). Furthermore, a shift in the statutory accounting rules implies that caution should be exercised when comparing levels over time.[1]

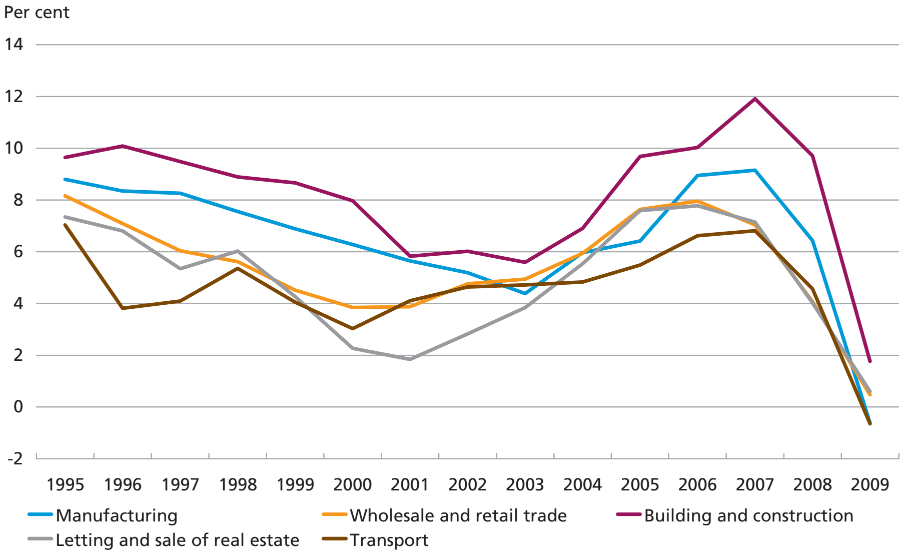
However, the chart clearly shows that the return on assets during the most recent financial crisis was characterised by an extraordinarily strong decline. The question is, however, whether this decline was caused by cyclical developments alone, or if part of the decline in the return on assets can be attributed more directly to the tightening of credit standards and the lower propensity to provide credit of some banks that have been under financial pressure during the Financial Crisis.

This issue is discussed below based on an analysis in Abildgren, Buchholst and Staghøj (2011). The analysis is based on the same firm-specific data from Experian A/S as those used in connection with the failure-rate analysis in section 6.

Chart 7.2 shows the average return on assets for different industries in the period 1995-2009 in the data base used for the analysis. The devel-

[1] The accounting principles actually applied may also impede comparisons over time. During periods of high inflation, for example, there will be a tendency to underestimate firms' return on assets if capital gains on the firm's assets are not fully recognised in the operating result, cf. Waagstein (1985).

RETURN ON ASSETS IN SELECTED INDUSTRIES 1995-2009 Chart 7.2



Note: A simple average of returns on assets for firms in the various industries. The return on assets is calculated as the firm's profit for the year before interest ("primary" or "ordinary" operating profit) as a ratio of its total assets at year-end.

Source: Calculated on the basis of data from Experian A/S.

opment is characterised by a substantial decline in the return on assets for all industries in the period 2008-09. Moreover, a tendency towards level differences in the return on assets across industries is noted. Among other factors, this can be attributed to industry-related differences in capital intensity and corporate structure.

The analysis focuses on the financial statements for non-defaulting firms.[1] A simple basic model is estimated for firm *j*'s return on assets in year t, $Y_{j,t}$, based on information about the size, debt ratio, etc. of the firm in year t-1 ($X_{1,j,t\text{-}1}$,..., $X_{k,j,t\text{-}1}$). As explanatory variables the model also includes a number of other firm details such as exports, geographical location in year t as well as industry-specific time dummy variables intended to capture cycles and more structural development trends in the individual industries ($Z_{1,j,t}$,..., $Z_{m,j,t}$), cf. equation (7.1):

$$Y_{j,t} = b_0 + \sum_{i=1}^{k} b_i X_{i,j,t-1} + \sum_{i=1}^{m} a_i Z_{i,j,t}, \qquad (7.1)$$

where b_0 is a constant term, and b_1, ..., b_k, a_1, ..., a_m are parameters.

1 The financial statements of defaulting firms that presented their last financial statements as an active firm in year t are included in the data material with financial statements up to and including year t-1.

In addition, an extended model is estimated with dummy variables indicating whether the firm's bank is "weak" or not, cf. equation (7.2):

$$Y_{j,t} = b_0 + \sum_{i=1}^{k} b_i X_{i,j,t-1} + \sum_{i=1}^{m} a_i Z_{i,j,t} + d_{05} D05_{j,t} + \ldots + d_{09} D09_{j,t}. \tag{7.2}$$

The dummy variable $D09_{j,t}$ in equation (7.2) is 1 in 2009 if firm j had a "weak" bank at the end of 2009. For other years the variable is 0. The other dummy variables for the firms' banks are defined in the same way. A significant, negative value of e.g. d_{09} indicates that a firm with a "weak" bank had a lower return on assets in 2009 than a similar firm with a "sound" bank.

The explanatory variables in (7.1) and (7.2) are stated in Table 7.2 and seek to adjust for differences in the firms' characteristics.[1] As largely the same variables are included in the failure-rate model in section 6, this means that adjustment is also made for differences in the firms' credit quality. This is a way to ensure that a significant, negative value of e.g. d_{09} in model (7.2) is not merely a reflection of the "weak" banks having "weak" firms as their customers.

Equation (7.2) also includes a number of dummy variables for the firms' banks relating to the period preceding the financial crisis. They act as a robustness check of whether a possible difference in the return on assets caused by a "weak" bank only had an effect during the crisis, or whether this was also the case before the Financial Crisis.

It should also be noted that the analysis is based on a comparison of the differences in the return on assets of firms with "weak" and "sound" banks, respectively. In this way the analysis seeks to identify a possible negative effect on the return on assets during the banking crisis of having a "weak" bank as compared to having a "sound" bank. On the other hand, this analysis approach cannot be used to estimate the negative effects, if any, of a general tightening of credit standards during the financial crisis by "weak" and "sound" banks alike.

Table 7.3 shows the results of a basic model estimation (7.1).[2] The results show e.g. that the return on assets of a firm with a critical auditors'

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[1] The variables "debt ratio (short-term)", "debt ratio (long-term)", "size" and "capital base reduction" are included with a lag in (7.1) and (7.2) to avoid any endogeneity issues. The first three variables include the firm's total assets, which is also used to calculate the return on assets. The capital base reduction variable includes information on the profit for the year and therefore cannot be included contemporaneously in the model.

[2] The model is estimated using pooled ordinary least squares (OLS). This means that the error term is considered to be independent between different observations, conditional on the explanatory variables. It has been sought to model the heterogeneity of firms by including a large number of explanatory variables.

EXPLANATORY VARIABLES IN EQUATIONS (7.1) AND (7.2) Table 7.2

Explanatory variables	Description
Included with a lag:	
Debt ratio (short-term)	Short-term debt as a ratio of total assets at year-end.
Debt ratio (long-term)	Long-term debt as a ratio of total assets at year-end.
Size	The logarithm of total assets at year-end deflated by the GDP deflator (1995 = 1).
Capital base reduction	The dummy variable is set at 1 if the firm has had a deficit in the last year, and if a repetition thereof would lead to the firm's equity capital falling below the statutory capital adequacy requirement for new firms. Otherwise, the dummy variable is set at 0.
Included without a lag:	
Critical auditors' qualification	The dummy variable is set at 1 if the annual financial statements include one or more critical auditors' qualifications. Firms without auditors' qualifications constitute the reference group for which the dummy variable is set at 0.
Form of ownership	The dummy variable is set at 1 if the firm is a private limited liability company at year-end. Public limited liability companies constitute the reference group (at value 0). The statutory capital adequacy requirement is higher for the establishment of public limited liability companies than for private limited liability companies.
Age	Dummy variable representing the age of the firms measured as the number of whole years at year-end. The reference group is made up of firms that are 1 year old.
Exports	The share of the firm's revenue made up by exports.
Municipality group	Dummy variable ranking the firms' registered offices at year-end by municipality group with Greater Copenhagen as the reference group (at value 0). Greater Copenhagen is normally more sensitive to economic fluctuations than other districts.
Time dummies for each industry	The time dummy variables for each of the seven industries in the data basis (manufacturing is the reference category). These dummy variables are to capture the cyclical development as well as more industry-specific trends in each industry.

qualification is around 5 percentage points lower than that of a similar firm without a critical auditors' qualification.

Table 7.4 shows the results of model (7.2) for the firms' return on assets, including dummy variables for the firms' banks in the period 2005-09. The estimated parameters of the explanatory variables do not change noticeably when incorporating dummy variables for "weak" banks in the model. The model is estimated separately for two different definitions of a "weak" bank on the basis of the Supervisory Diamond and excess capital adequacy, respectively (both definitions are based on data from mid-2007), cf. section 6.

ESTIMATION OF MODEL (7.1) FOR RETURN ON ASSETS – THE BASIC MODEL Table 7.3

	Coefficient	Standard error
Constant	2.792***	0.484
Critical auditors' qualification	-4.870***	0.137
Form of ownership	0.582***	0.085
Exports	0.018***	0.002
Size	-0.239***	0.029
Debt ratio (short-term)	0.051***	0.001
Debt ratio (long-term)	0.033***	0.002
Capital base reduction	-13.194 ***	0.123

Note: The response variable in the estimated equation is the return on assets calculated as the firm's profit for the year before interest ("primary" or "ordinary" operating profit) as a ratio of its total assets at year-end. In addition to the variables shown in the table, the estimated model includes dummy variables for municipality group and age. Other variables include time dummies for each industry. The model is estimated on the basis of 463,158 annual financial statements for the period 1995-2009.
* indicates that a coefficient is significantly different from zero at a significance level of 10 per cent.
** indicates that a coefficient is significantly different from zero at a significance level of 5 per cent.
*** indicates that a coefficient is significantly different from zero at a significance level of 1 per cent.
Source: Abildgren, Buchholst and Staghøj (2011).

The results in Table 7.4 give no indications that the return on assets for non-defaulting firms during the Financial Crisis was dependent on the "soundness" of their banks. This may reflect that non-defaulting firms

ESTIMATION OF MODEL (7.2) FOR THE RETURN ON ASSETS INCLUDING DUMMY VARIABLES FOR THE FIRMS' BANKS Table 7.4

	"Weak" bank defined on the basis of			
	The Supervisory Diamond		Excess capital adequacy	
	Coefficient	Standard error	Coefficient	Standard error
Constant	2.811***	0.484	2.791***	0.484
Critical auditors' qualification	-4.869***	0.137	-4.869***	0.137
Form of ownership	0.583***	0.085	0.583***	0.085
Exports	0.018***	0.002	0.018***	0.002
Size	-0.239***	0.029	-0.239***	0.029
Debt ratio (short-term)	0.051***	0.001	0.051***	0.001
Debt ratio (long-term)	0.033***	0.002	0.033***	0.002
Capital base reduction	-13.194***	0.123	-13.194***	0.123
D09	0.286	0.602	-0.328	0.937
D08	-0.929	0.572	-0.679	0.887
D07	-0.440	0.552	1.474*	0.858
D06	-0.901 *	0.539	-0.883	0.838
D05	-0.455	0.532	-0.071	0.824

Note: The response variable in the estimated equations is the return on assets calculated as the firm's profit for the year before interest ("primary" or "ordinary" operating profit) as a ratio of its total assets at year-end. In addition to the variables above, the estimated model includes dummy variables for municipality group and age. Other variables include time dummies for each industry. The model is estimated on the basis of 463,158 annual financial statements for the period 1995-2009.
* indicates that a coefficient is significantly different from zero at a significance level of 10 per cent.
** indicates that a coefficient is significantly different from zero at a significance level of 5 per cent.
*** indicates that a coefficient is significantly different from zero at a significance level of 1 per cent.
Source: Abildgren, Buchholst and Staghøj (2011).

with "weak" banks were not affected by a possible tightening of credit standards by those banks during the financial crisis, or that the firms had no difficulties finding alternative funding sources where the "weak" banks were unable to meet the firms' credit needs in a satisfactory manner.

Obviously, it cannot be ruled out that a potential effect of having had a "weak" bank during the Financial Crisis on the return on assets will affect the firms that did not default during the crisis only in the slightly longer term. A firm which is prevented from expanding or making the desired investments due to credit constraints may thus possibly obtain a lower return on assets in the slightly longer term without this necessarily having any effect on the return on assets in the short term, as illustrated by model (7.2). On the other hand, the result that the strength of the firms' banks has not affected the firms' return on assets is consistent with Statistics Denmark's confidence indicators mentioned in section 5, which indicate that only a limited number of firms have reported financial constraints as impediments to production during the Financial Crisis.

8. CONSEQUENCES OF BANKING CRISES FOR LONG-TERM GROWTH AND INCOME LEVEL

The previous sections focused on the real economic consequences of banking crises in the short and medium term. This section discusses the effects of banking crises in the longer term.

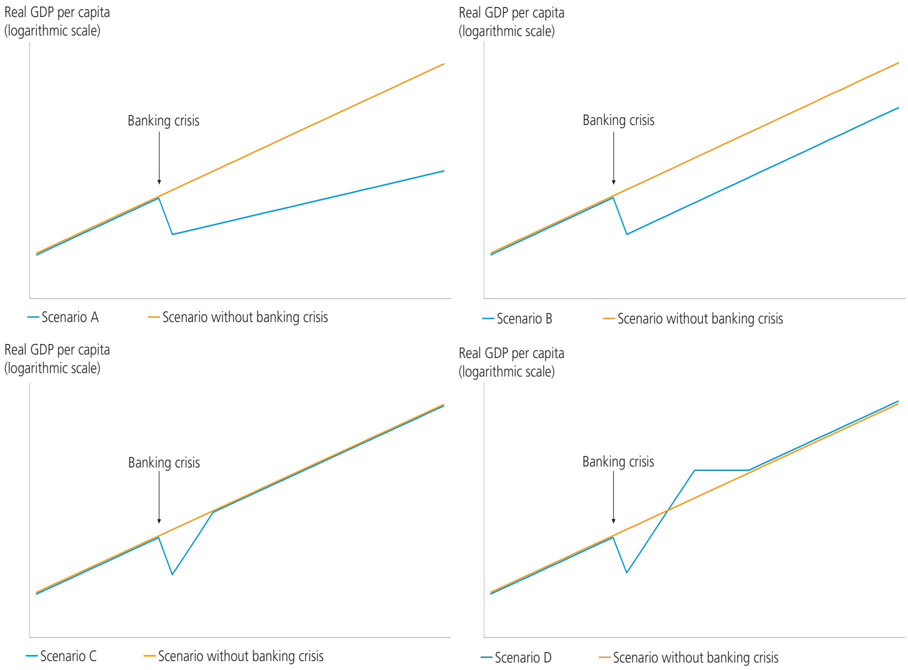
In principle, there are (at least) four possible scenarios for the development in real GDP per capita after a banking crisis, cf. Chart 8.1. In scenario A the trend growth after the banking crisis is permanently lower than before the crisis. This not only implies that it will never be possible to recover the output loss suffered during the banking crisis; it also means that the loss will increase over time compared to a situation without a banking crisis.

In scenario B the trend growth reverts to the pre-crisis level. The output loss suffered during the crisis is never recovered, however, and the income level after the banking crisis is permanently lower than it would have been if there had been no banking crisis.

In scenario C the trend growth reverts to the pre-crisis level in the long term, and, during a transition period, the growth level is higher than the pre-crisis trend growth. The long-term level of real GDP per capita in scenario C is not affected by the banking crisis, but there will still be a period of output loss during the banking crisis.

Finally, scenario D illustrates a situation where the trend growth reverts to the pre-crisis level in the long term, while, during a transition

ALTERNATIVE GROWTH DEVELOPMENT FOLLOWING A BANKING CRISIS Chart 8.1



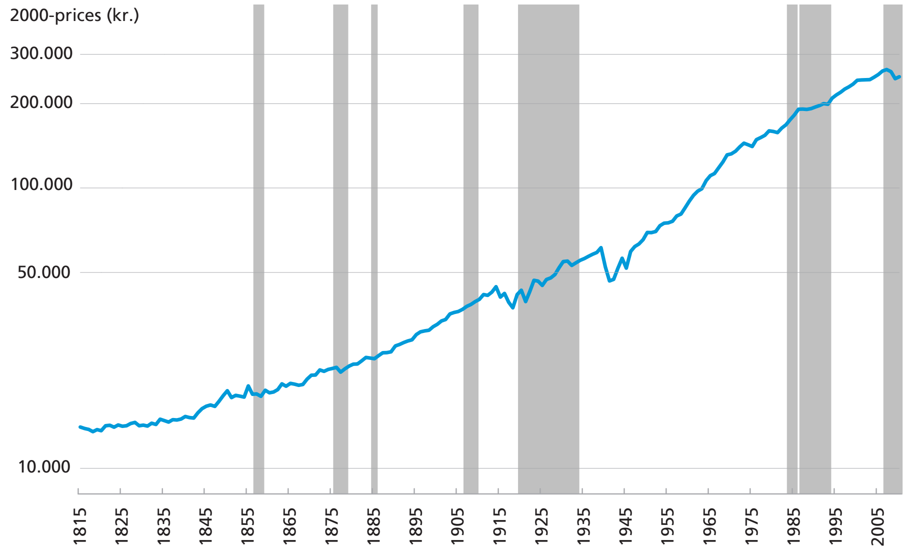
period, the growth level is sufficiently higher than the pre-crisis trend growth to compensate for the temporary loss of income during the banking crisis.

An empirical analysis of the long-term real economic consequences of banking crises can take as its starting point Chart 8.2, showing real GDP per capita in Denmark for the period after 1815. As illustrated, it is difficult to see any direct effect of previous banking crises on the long-term economic growth rate or income level per capita. Obviously, this does not mean that banking crises may not have any consequences for the long-term economic growth rate or income level. But the chart implies that factors other than banking crises may be decisive for the economic growth rate and income level in the longer term.

Chart 8.3 gives the same impression, showing the development in real GDP per capita in 22 other countries since 1870. Those 22 countries accounted for just under half of the worldwide output in 2008. As was the case for Denmark, it is also difficult to see any effect of major international financial crises on the long-term economic growth or income level per capita.

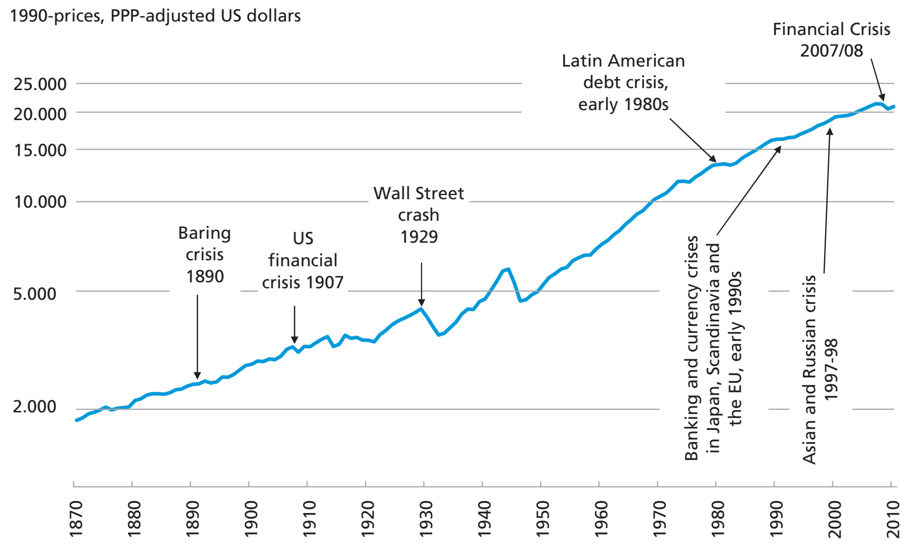
A more detailed analysis of the impact of the financial crisis in recent years on Denmark's potential output can be found in Andersen and Rasmussen (2011).

REAL GDP PER CAPITA IN DENMARK 1815-2010 Chart 8.2



Note: The grey markings indicate periods of banking crises, cf. Table 2.1. Adjustment has been made for the return of Southern Jutland to Denmark in 1920.
Source: Calculated on the basis of data from Hansen (1983), Hansen and Svendsen (1968), Abildgren (2010a), and Statistics Denmark.

REAL GDP PER CAPITA IN 22 COUNTRIES 1870-2010 Chart 8.3



Note: The countries include Austria, Belgium, Finland, France, Germany, Italy, Netherlands, Norway, Sweden, Switzerland, UK, Portugal, Spain, Australia, New Zealand, Canada, USA, Brazil, Chile, Uruguay, Japan and Sri Lanka.
Source: Balakrishnan et al. (2009), IMF (2010) and Maddison (2010).

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Potential Output in Denmark

By Asger Lau Andersen and Morten Hedegaard Rasmussen, Economics[1]

1. INTRODUCTION AND SUMMARY

In Denmark as well as in all other countries, economic developments are characterised by fluctuations in the short term. Growth in the gross domestic product, GDP, is high in some years, while other years see low – sometimes even negative – growth.

Disentangling such short-term movements from the underlying long-term trend in the economy's productive capacity is an important issue in macroeconomic studies. The concepts of *potential output* and *output gap* play a key role in this context. Potential output is the output level that the economy can sustain without inflationary pressures arising in the longer term. The output gap is the deviation of actual output from this level.

These concepts are relevant in many areas of economic policy. The development in potential output is typically regarded as an indicator of long-term economic trends and is often used as a measure of the effects of structural policy steps. The output gap, on the other hand, is regarded as a summary indicator of the cyclical position of the economy and is probably the most frequently used measure of this. Consequently, output gap estimates play a decisive role in macroeconomic forecasts and in the conduct of macroeconomic stabilisation policies. Moreover, the output gap is often seen as an indicator of the balance between supply and demand in the economy and hence of the pressure on the economy's resources. A positive output gap provides an indication of macroeconomic imbalances which will generate inflationary pressures and which are not sustainable in the longer term. This indicator property is especially relevant for central banks that use the output gap as a tool for monitoring inflationary developments. Finally, the size of the output gap is central to assessments of the long-term perspectives of fiscal policy, since the output gap is a central element of the calculation of the underlying fiscal position.

1 In writing this article, we have benefited from comments and suggestions by Christian Møller Dahl. The views and conclusions expressed in this article are strictly those of the authors. Any errors or omissions remain the responsibility of the authors.

The key challenge when using the concepts of potential output and the output gap is that they are *theoretical* concepts and therefore not directly observable. This means that, as opposed to *actual* output, *potential* output cannot be calculated by systematic collection of statistical information. Instead, potential output and the output gap must be estimated. Over the years, economists and econometricians have developed a variety of estimation methods for this exact purpose.

In this article we estimate the development in potential output and the output gap in the Danish economy since 1985. The estimations are based on the production function method, in which the economy's total output is modelled as a function of capital, labour and productivity. The production function method is one of the most frequently used methods for measuring potential output, and it is used by e.g. the OECD, the European Commission and the Danish Ministry of Finance, cf. Beffy et al. (2006), D'Auria et al. (2010) and Ministry of Finance (2004).

The calculations in this article – which are based on the latest national accounts statistics – show that the Danish economy experienced a severe overheating in the years leading up to the financial crisis. A low unemployment rate and strong capacity pressures in Danish firms contributed to a GDP level that was considerably higher than potential GDP in these years. As a result of the intense labour market pressures, wage growth was markedly higher than warranted by labour productivity growth.

The economic crisis that followed the 2008 global financial crisis led to a dramatic acceleration of the slowdown that had hit the Danish economy already in late 2007, and resulted in large negative output gaps in 2009 and 2010. The distance to potential output has since narrowed considerably, however, and we estimate the output gap to be -1.6 per cent of potential GDP in the 2nd quarter of 2011.

The negative output gap is first and foremost expressed by a participation rate that is somewhat below its structural level, while net unemployment is close to the level that is consistent with stable medium-term development in wages and prices. So if labour demand should increase, a sustainable rise in employment would require a relatively quick expansion of the labour force. The large number of persons in active labour market programmes and jobseeking students indicates that such an expansion could be feasible, since it can reasonably be assumed that many of these persons would be both willing and able to return to the labour market, should employment opportunities improve.

Productivity in the Danish economy, measured in terms of total factor productivity, TFP, fell strongly in the wake of the financial crisis in 2008 and 2009. The TFP level has recovered somewhat since the trough in

2009, but remains below the 2006 peak. Since the spare capacity in Danish firms has now almost returned to its historical average, we find that productivity is again close to its structural level.

In sum, our overall assessment is that there is currently modest spare capacity in the Danish economy. The gap between actual and potential output has narrowed considerably since 2009, and despite the outlook for limited growth in the current half-year we expect this gradual closing of the negative output gap to continue in the coming years.

It is important to bear in mind, however, that the exact size of the output gap will always be subject to great uncertainty, and the analyses in this article show that the estimates may be considerably revised at a later date – due to revision of existing national accounts figures or new data releases. This applies especially to the estimates of the elements of greatest interest, i.e. the current size of the output gap and its near-term development. Hence, output gap estimates can never stand alone in assessments of the current cyclical position, but should be integrated as an important element of the overall assessment.

This article continues as follows: Section 2 presents various views of the concept of potential output and specifies how the concept is used in this article. Section 3 describes our general estimation approach in this article, i.e. the production function method. In sections 4-6 we describe estimation methods and results for the structural level of each sub-component in the production function. In section 7, these results are put together to construct estimates of potential output and the output gap in the Danish economy since 1985. Section 8 discusses the sensitivity of the results to alternative unemployment measures, while section 9 focuses on the uncertainty associated with estimates of the current size of the output gap when the future course of the economy is unknown. Section 10 discusses how the financial crisis in 2008 and 2009 may have impacted the potential output level in Denmark. In section 11, we proceed to illustrate one of the most important uses of output gap estimates, i.e. for calculations of the structural fiscal balance. The results and principal conclusions of this article are summarised in Part 1 of this Monetary Review.

2. WHAT IS POTENTIAL OUTPUT?

Potential output and the output gap are key concepts in discussions of macroeconomic policy, for academic economists as well as practitioners. But despite their central role, the precise meaning of these concepts is often only vaguely defined. The reason is that different economists apply the concepts in different ways. One contributory factor has been the evolution of macroeconomic theory, leading to several changes in the view of how potential output can and should be defined. The latest novelty is the increased use of DSGE models, which has enabled a number of model-based definitions of the concept, cf. Box 2.1.

The original definition of the concept of potential output, which can be traced back to Okun (1962), referred to the output level that can be achieved under full employment, the latter being interpreted as a situation with very low unemployment. This definition implies that actual output can exceed potential output only under rare circumstances.

However, this original definition of the concept has been superseded. The most popular view today is that potential output is the output level that is consistent with stable inflation. Contrary to Okun's original characterisation, this definition implies that actual output can and will deviate, both positively and negatively, from potential output. But a prolonged period of positive output gaps will result in uncontrollable inflation hikes. Ultimately, this will harm the future growth potential in the economy so that the actual output level is reduced. According to this view, potential output is equal to the economy's *sustainable* output level.[1]

Another popular view is that potential output can be interpreted as the *trend* of actual output. According to this view, the potential output level can be viewed as an indicator of the development in actual output in the longer term, e.g. over a 10-year period. The interpretation of potential output as closely related to the trend output level also entails that the *output gap*, i.e. the relative deviation between actual and potential output, may be regarded as an expression of the cyclical position. As a result, potential output is sometimes also referred to as the output level achieved in a "normal" state of the business cycle.

Although the latter two definitions of potential output are conceptually different, they often appear concurrently, cf. e.g. Arnold (2009). This reflects the implicit view that output may deviate from the sustainable, inflation-neutral level for a short time only. So if this level evolves smoothly over time, it will coincide with the trend of the actual output level.

In an economy characterised by frequent, temporary shocks to the supply side, the inflation-neutral output level will *not* evolve smoothly, however, so the two notions of potential output will not necessarily

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[1] According to Okun's original representation, a high output level would, over time, lead to *high*, but not *rising* inflation. The theory that only one output level is consistent with stable inflation stems from two almost contemporaneous articles by Friedman (1968) and Phelps (1967). These articles focused on the relation between *unemployment* and inflation and led to the theory of the *natural unemployment level*. Hence, the modern view of potential output can also be characterised as the output level achieved when unemployment is at its natural level, cf. also Congdon (2008).

POTENTIAL OUTPUT IN NEW-KEYNESIAN DSGE MODELS Box 2.1

The development of new-Keynesian DSGE (*Dynamic Stochastic General Equilibrium*) models has entailed a number of new, model-consistent definitions of potential output, each related to the traditional definitions described in the main text. The DSGE literature distinguishes between three definitions of potential output, cf. Vetlov et al. (2011):

Trend output is the level towards which output would converge in the absence of all temporary shocks, corresponding to a long-term steady-state development. In DSGE models, trend output normally follows a stable course over time and is probably the model-consistent concept that is related most closely to traditional definitions of potential output.

Natural output is the level of output that would be achieved with full flexibility of all prices in the product and labour markets. Given the slow adaptation, due to nominal rigidities, of prices and wages to their long-term equilibrium values in these models, the level of actual output will generally deviate from this level. This concept is closely related to the traditional view of potential output as an inflation-stabilising level of output: In many new-Keynesian models, the deviation of output from its natural level is decisive for inflation dynamics, and stabilisation of inflation requires stabilisation of output at its natural level. As opposed to the traditional view of potential output, this natural level is also volatile in the short term, since it is impacted by a large number of potential shocks to the economy. Moreover, the changes in the natural output level will typically show a positive correlation with changes in actual output, even within the time horizons that are normally associated with the duration of the business cycle. Consequently, the deviation from the natural level is a suitable indicator of short-term inflationary pressures, but not suitable as a measure of the cyclical position.[1]

Efficient output is defined as the output level that would be achieved with full price flexibility and *perfect competition* in all markets. It is the optimum output level in a welfare context. Due to market imperfections, the actual output level will, however, always be lower than the efficient level, and the concept is thus related to Okun's original definition of the potential output level as the "best achievable". But where Okun saw deviations from the potential level as a consequence of insufficient demand, the DSGE literature offers another conclusion: Deviations between the efficient and the natural output levels are due to imperfect competition in the product, service and labour markets and should therefore be addressed via *structural policy*. Conversely, persistent attempts to press output upwards to the efficient level via demand-stimulating policy will only result in higher inflation. These policies should therefore not aim at *minimising* the gap between actual and efficient output, but at *stabilising* it.

[1] The business cycle is here envisaged as lasting 2-8 years, in accordance with the general view in the literature.

coincide. A sudden, short-lived oil price increase, for example, will exert upward pressure on prices, resulting in a reduction of the output level that can be sustained without inflationary pressures arising. Since the increase is short-lived and the effect on output therefore only temporary, *trend* output will, by definition, not change. Hence, in order to ensure consistency between the two concepts, potential output is often defined as *the output level that is consistent with stable inflation in the absence of temporary supply shocks.*

In the remainder of this article, the concept of potential output refers to this latter definition. Consequently, we focus on potential output as a phenomenon that usually evolves smoothly over time. This implies that the resulting output gap estimates can be seen as measures of the cyclical position, making the estimates particularly relevant from a fiscal point of view, cf., among others, Basu and Fernald (2009): In the longer term, fiscal developments are closely related to developments in the output *trend*, and when the output gap expresses a measure of the deviation from this trend, the gap can be used to calculate indicators of the underlying fiscal position, cf. also section 11.

Moreover, the output gap estimates in this article may be interpreted as indicators of the inflationary pressures in the Danish economy in the *longer* term. Hence, persistently positive output gaps over several years will be a clear indication of mounting risk of overheating of the economy and rising inflationary pressures, while persistently negative output gaps will be an indication of falling inflationary pressures. However, it is important to bear in mind that the estimated output gaps are not necessarily accurate indicators of inflationary pressures in the *short* term, and that, accordingly, they do not represent a suitable benchmark for short-term inflation stabilisation. Such a benchmark would require estimation of another concept of potential output, which would allow a higher degree of volatility in the short term in the event of temporary supply shocks.

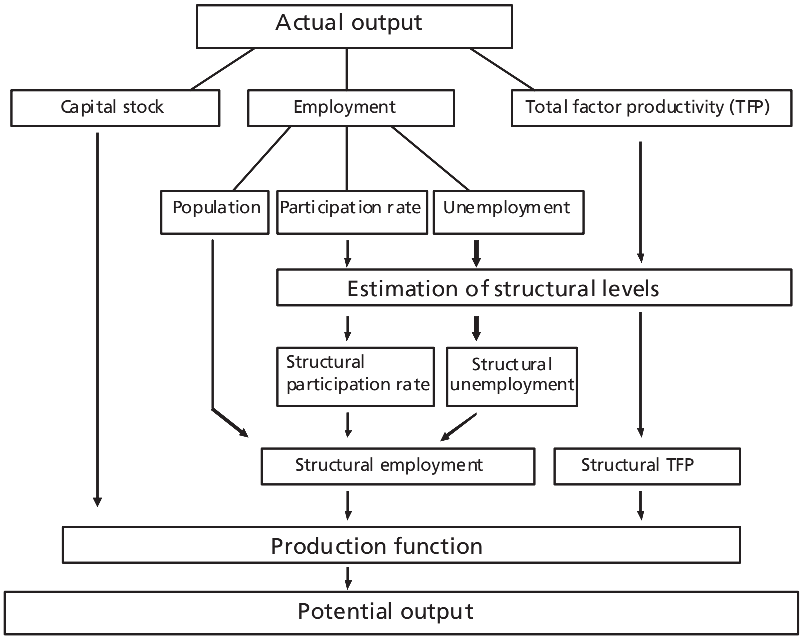
3. ESTIMATION OF POTENTIAL OUTPUT: THE PRODUCTION FUNCTION METHOD

In this article, the potential output level in Denmark is estimated using the production function method. Under this approach, total output in the economy, measured by GDP, is modelled as a specific function of measurable input factors (typically capital and labour) and total factor productivity, TFP. The latter is an overall measure of how efficienctly the production factors are used in the production process. Potential output is then calculated as the output level achieved when each input factor is at its structural level, cf. Chart 3.1.

The principal advantage of the production function method is that it allows decomposition of the output gap into the deviations of the underlying production factors from their structural levels. Similarly, the rate of growth in potential output can be decomposed into the growth

THE PRODUCTION FUNCTION METHOD FOR CALCULATION OF POTENTIAL OUTPUT

Chart 3.1



rates for the structural levels of the input factors. Hence, this method provides for economic interpretation of developments in potential output and the output gap, thereby contributing to enhanced insight into the supply side of the economy. Such insight cannot be gained by methods estimating potential output solely by looking at the development in GDP, cf. also Box 3.1.

However, the production function method also has certain weaknesses: Firstly, the method requires specific assumptions regarding the form of the production function, and these assumptions influence the final estimate of potential output. Secondly, the method imposes substantial demands on the data, which can be difficult to meet. This applies especially to data for the size of the capital stock, which is typically subject to considerable uncertainty.

Finally, it is worth emphasising that the production function method as such is not an actual estimation method, but rather a framework that allows decomposition of potential output and the output gap into contributions from the underlying factors. The final estimate of potential output ultimately depends entirely on how the structural level of each

ALTERNATIVE METHODS FOR ESTIMATION OF POTENTIAL OUTPUT Box 3.1

The production function method is the most widespread method for estimation of potential output and the output gap, but it is far from being the only method. The most popular methods can be divided into the following main categories:

Univariate filters reflect statistical methods dividing GDP into a trend component and a cyclical component solely by means of mechanical transformations of actual GDP data. The Hodrick-Prescott filter (Hodrick and Prescott 1997) and the Baxter-King filter (Baxter and King, 1999) are popular examples. The principal advantage of these methods is that they are easy to use. But these filters are rarely anchored in economic theory, and the exact nature of what is estimated may be unclear. Moreover, the methods are subject to an *end point problem*, which makes it difficult to estimate the trend near the start and end points of the series. As regards the Hodrick-Prescott filter, the end point problem entails, for example, that the estimate of the trend in the last period of the time series will often be too close to the actual value in that period. This is problematic, given that the last period of the time series is typically the *present* period. In economic-policy planning, the estimate of the last period of the time series will therefore be of greatest interest.

Unobserved Components Models, UCM, reflect a more complex model approach where the trend in GDP is estimated by including information from other economic time series besides the GDP series itself. This approach is based on known macroeconomic relationships, often inspired by economic theory. The typical example is an expectations-augmented Phillips curve establishing a link between the output gap (or the unemployment gap) and inflation in the short term. The fundamental idea is that high and rising inflation indicates that output is above its potential level, while falling inflation indicates the opposite. In combination with a fully specified statistical model for the development in potential output, such relationships may be used for estimation of the level of potential output by means of recursive estimation methods, such as the frequently used Kalman filter. Kuttner (1994) and Apel and Jansson (1999) are examples of estimations of potential output based on the UCM approach. Theoretically, the UCM approach is considerably more satisfactory than simple, univariate filtering methods. But in practice, it can be difficult to apply this method in a satisfactory way, and the results will often be sensitive to detailed assumptions about the underlying statistical processes.

Estimates based on DSGE models constitute the newest type of estimates of potential output and the output gap and are not yet widely used. The European Central Bank, ECB, estimates potential output for the euro area within the framework of the *New Area Wide Model*, cf. Vetlov et al. (2011). DSGE-based estimates are fully model-consistent and therefore the theoretically most well-founded. In addition, this approach provides for a sophisticated distinction between various theoretical definitions of potential output, cf. also Box 2.1. The main drawback of this approach is that it requires development of a full DSGE model, which is highly time-consuming. Moreover, the estimates produced by such a model will be entirely dependent on the underlying model properties, and they will be more difficult to communicate to outsiders than estimates based on simpler and more well-known methods.

It is worth noting that several of these estimation methods can be used directly or in combination with the production function method. Previously, a widely used method was to use the framework of the production function method to decompose

CONTINUED Box 3.1

actual GDP into capital, labour and TFP, followed by application of the HP filter for cyclical adjustment of each of these components. However, simple HP filtering is increasingly found to be unsatisfactory, and more advanced methods are gaining ground, such as the UCM approach to estimation of the structural components within the framework of the production function approach. This type of combined approach is used in this article.

input factor is estimated. Sections 4-6 provide further descriptions of the methods used in this article to estimate these structural levels.

Application of the production function method in this article

The aggregate production function we use is a standard Cobb-Douglas function with constant returns to scale. Consequently, output in quarter *t* is modelled as:

$$Y_t = TFP_t \cdot L_t^{\alpha} K_t^{1-\alpha}, \tag{3.1}$$

where Y is GDP in volume terms, K is capital in volume terms, L is labour input and *TFP* is total factor productivity.

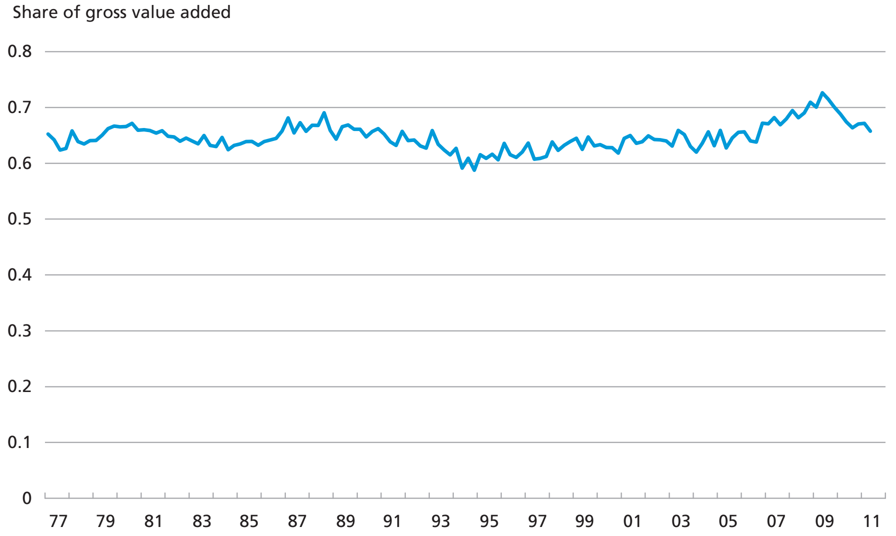
The main motivation for choosing the Cobb-Douglas function as our aggregate production function is simplicity. However, the specification also has a number of characteristics that are broadly consistent with empirical macroeconomic observations. For example, assuming perfect competition and profit maximisation, a production technology as in (3.1) will result in a constant wage share, equal to the elasticity of output with respect to labour, α. This is consistent with the fact that the wage share has been relatively constant over a large number of years, with limited fluctuations around an average of approximately 65 per cent, cf. Chart 3.2. In light of this observation, the parameter α is assumed to be equal to 0.65 in all periods.

Labour input is measured as the number of persons in employment, decomposed as:

$$L_t = B_t \cdot E_t \cdot (1 - u_t), \tag{3.2}$$

where B is the number of persons in the population in the 16-66 age group, E is the participation rate, and u is the unemployment rate. The unemployment rate is measured here as net unemployment, in full-time equivalents, divided by the number of persons in the labour force. The labour force is defined as the number of employed plus unemployed

WAGE SHARE IN THE PRIVATE NON-AGRICULTURAL SECTOR Chart 3.2



Source: Statistics Denmark and own calculations.

persons. The participation rate is defined as the number of persons in the labour force divided by the number of persons in the population in the 16-66 age group.[1]

The size of the capital stock is based on annual national accounts data. It is measured as the net stock of fixed real capital in 2000 prices, chained values, covering all industries and all types of capital[2]. The figures are converted to quarterly frequency by combining information about the size of gross fixed investment from the quarterly national accounts with an assumption of constant depreciation rates within the same year.

The TFP level is calculated residually on the basis of equations (3.1) and (3.2) as:

$$TFP_t = \frac{Y_t}{K_t^{1-\alpha}(B_t \cdot E_t \cdot (1-u_t))^{\alpha}} .$$

[1] Ideally, labour input should be calculated as the number of hours worked rather than the number of employed. However, since the available time series for the number of hours worked in Denmark are burdened with considerable measurement problems, calculations based on them would generate noise in the estimates of structural employment and potential output. When labour input is measured as the number of employed, as is the case here, fluctuations in the average number of hours worked per employed person will be reflected in fluctuations in the TFP estimate.

[2] The national accounts distinguish between gross and net stocks. In the gross stock, the value of a capital good is calculated as the replacement cost, disregarding the age dimension. Consequently, capital equipment of a given quality is assumed to have the same value, irrespective of its remaining lifetime. The net stock, on the other hand, takes into account the deterioration over time of the value of capital equipment due to wear and tear and a diminishing remaining lifetime. It remains an open question whether the gross stock would be a better measure of the productive capacity of the capital stock. However, we use the net stock, with a view to comparability with Danmarks Nationalbank's macroeconometric model, MONA.

This implies that all factors, other than capital and labour, that contribute to total output are included in TFP. Similarly, any measurement errors in the calculations of capital and labour will impact on the TFP measure. Moreover, fluctuations in the utilisation rate of the capital stock will be reflected in the TFP estimate, cf. also later.

Potential output, Y^*, is defined as the output level achieved when all components of the production function are at their structural levels. We then get:

$$Y_t^* = TFP_t^* \cdot (B_t^* \cdot E_t^* \cdot (1-u_t^*))^{\alpha} (K_t^*)^{1-\alpha}, \quad (3.3)$$

where an asterisk indicates the structural level of the variable in question.

For the number of people in the population in the 16-66 age group and the size of the capital stock, the structural quantities are defined as being equal to the actual quantities. Hence, by definition, it applies that $B^* = B$ and $K^* = K$. As regards the population, this definition reflects that demographic changes are regarded as fully structural and therefore independent of the business cycle.[1] As regards the capital stock, the definition mainly reflects that the time series for the size of the capital stock is relatively smooth already at the point of departure, despite the strong volatility of investment in fixed real capital. The reason is that, in a given quarter, net investment is very small relative to the size of the accumulated capital stock. Conceptually, the definition $K^* = K$ implies that the estimate of potential output should be regarded as *conditional* on the current size of the capital stock. Consequently, the final result for potential output may be seen as an estimate of the sustainable output level of the economy, *given* the present volume of available capital.[2]

In contrast, the time series for TFP, the participation rate and unemployment are affected by both cyclical and structural movements, and it requires formal estimation to separate them. In sections 4-6 we describe how we define and estimate each of these structural components.

The output gap, Y^g, is defined as the relative deviation between the actual output level and potential output. Combining equations (3.1),

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1 In this way, the potential cyclical effects on the volume of immigration and emigration are ignored. Conversely, smoothing out the time series for the number of persons in the 16-66 age group would remove a considerable amount of the variation in the series that should be regarded as structurally driven, i.e. the variation attributable to the number of births and deaths.

2 This interpretation is parallelled in the new-Keynesian DSGE literature, in which a distinction is made between *conditional potential output* and *unconditional potential output*. The former is the output level that would be achieved if all nominal rigidities in the economy ceased to exist as from today, while the latter is the level that would be achieved in the absence of nominal rigidities in all past and future periods. The difference is that the size of the capital stock is taken as given in the first definition, while the definition of *unconditional potential output* implies that the potential level of the capital stock may deviate from the actual level.

(3.2) and (3.3) and the definitions $B^* = B$ and $K^* = K$, the ouput gap can then be approximated:

$$\begin{aligned} Y^g &= \ln Y_t - \ln Y_t^* \\ &\approx \ln TFP_t - \ln TFP_t^* + \alpha \cdot (\ln E_t - \ln E_t^* - (u_t - u_t^*)). \end{aligned} \quad (3.4)$$

This shows that the output gap is given by the sum of a TFP gap and a participation rate gap less an unemployment gap. The latter two are weighted using the parameter α, which is assumed to be equal to 0.65 as mentioned previously.

In this article, we use the expressions in (3.3) and (3.4) to calculate estimates of potential output and the output gap in the Danish economy for each quarter since 1985. The motivation for the choice of starting year is that the introduction of the fixed-exchange-rate policy in the autumn of 1982 represented a change of regime in the Danish economy, which resulted in permanent shifts in key economic mechanisms, including the formation of prices, wages and expectations. Since it is more than likely that the transition to the new regime happened gradually over several years, it makes sense to choose 1985 as the starting year for the estimation period.

The data are based on official statistics from Statistics Denmark for the period from the 1st quarter of 1985 to the 2nd quarter of 2011. These statistics have been supplemented with Danmarks Nationalbank's latest forecast for the Danish economy until end-2013. We have included the forecast-based data for two reasons: to calculate estimates of the development in the output potential and the output gap in the near future, and to improve the accuracy of the estimates of the current output gap, cf. section 9. The forecast itself is described in more detail in "Recent Economic and Monetary Trends" in Part 1 of this Monetary Review.

4. STRUCTURAL UNEMPLOYMENT

Structural unemployment is an important component in the determination of potential output. But it also attracts interest in its own right, since the theory of a structural or *natural* level of unemployment is a key element of understanding the labour market and the relationship between unemployment on the one hand and wage and price developments on the other.

Generally, structural unemployment can be defined as the level of unemployment that is *sustainable* in the long term. In this case, sustainability is typically interpreted as stable inflation. This reflects the predominant view that a trade-off exists between unemployment and inflation in the *short term*. Consequently, when unemployment is low, inflation is high and vice versa. In the *long* term, however, there is no such trade-off, meaning that a low level of unemployment will, over time, not only entail high but also *rising* inflation. But persistent increases in inflation are not sustainable in the long term and will ultimately lead to higher unemployment. Accordingly, structural unemployment is often defined as the level of unemployment that is consistent with stable inflation. As a result, structural unemployment is often referred to as *NAIRU,* which stands for *Non-Accelerating Inflation Rate of Unemployment.*

But in a small, open economy like Denmark, pursuing a fixed-exchange-rate policy against a major currency, stable inflation *per se* is not a sufficient criterion for sustainability. The level at which inflation is stabilised is also important. Hence, for the fixed-exchange-rate policy to be sustainable, inflation must not persistently exceed inflation in the currency anchor. Structural unemployment in Denmark can therefore be defined as the level of unemployment ensuring that price developments in Denmark mirror those in the euro area in the medium term.

Just like potential output, structural unemployment is a theoretical concept that is not directly observable. This entails uncertainty as to how much unemployment can fall without inflationary pressures arising. The structural level may change over time, further reinforcing the challenge. Possible reasons are e.g. changes in the unemployment benefit system (where the degree of compensation, in particular, is considered an important factor), the relative balance between the organisations in the labour market, or the degree of match between the qualifications of the unemployed and the qualifications demanded by the employers. The list of factors that may potentially affect structural unemployment is long, and it must be borne in mind that there is considerable uncertainty as to which factors determine its level.

Estimation method in this article

In this article, structural unemployment is determined by means of an *Unobserved Components Model,* UCM. The UCM approach was first applied to estimation of structural unemployment in the USA by Staiger, Stock and Watson (1996) and Gordon (1997, 1998). The method has been used increasingly since then and is currently applied by the OECD, the European Commission and the Danish Ministry of Finance, among others.

The UCM approach requires no explicit assumptions regarding the specific factors causing changes in the unobservable variables – in this case structural unemployment and the unemployment gap. Instead, the values of the unobservable variables are inferred from assumed relations between the unobservables and some observable variables. These observation relations are typically inspired by economic theory. At the same time, a full statistical model is constructed to account for developments in the unobservable variables, where changes over time are attributed to unspecified, stochastic shocks. On the basis of the full model, the values of the unobservable variables can then be estimated using the Kalman filter, a mathematical method for deriving information on the true values of variables that can only be observed subject to measurement error and other random influences.

In UCM estimations of structural unemployment, an expectations-augmented Phillips curve is often used as the key economic relation. This curve states a negative relation between the unemployment gap and the *change* in inflation.[1] The rationale is that rising inflation, everything else being equal, indicates that unemployment is below its structural level, implying a negative unemployment gap. Falling inflation, on the other hand, indicates a positive unemployment gap. This rationale is evident, given the general definition of structural unemployment as the level of unemployment at which inflation is constant.

However, this approach is problematic when applied to Danish quarterly data. The reason is that, as a result of the fixed-exchange-rate policy, price developments in Denmark are anchored in price developments in the euro area in the medium term. This means that price developments are less governed by internal factors, including influences from the labour market. Moreover, in the short term, price developments in a small, open economy like Denmark are driven by fluctuations in e.g. energy and food prices, which can be very volatile. The outcome of these factors together is that the observed correlation between unemployment and inflation is not strong and stable enough to be used for identification of the size of the unemployment gap in the Danish economy.

Developments in the Danish labour market, on the other hand, play a decisive role in wage developments. Consequently, this article's estimations of structural unemployment are, instead, based on a negative correlation between the unemployment gap and the development in the *wage share* in the private non-agricultural sector. If the unemployment rate is below its structural level, the resulting pressure on the

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[1] Such formulation of the expectations-augmented Phillips curve rests on the assumption that expected inflation can be approximated by lagged inflation.

labour market will lead to higher wage inflation. Given that domestic prices are, as mentioned, anchored to price developments in the euro area, higher wage inflation will entail a faster pace of real wage inflation compared with productivity. This will cause the wage share to rise and the profit ratio to fall.

Consequently, the development in the wage share, which is an observable variable, may be used to extract information on the size of the unemployment gap: A high and rising wage share indicates, everything else being equal, that unemployment is below its structural level, whereas a low and falling wage share indicates that unemployment is higher than its structural level.

The relation between unemployment and the wage share prompts the following equation:

$$\Delta ws_t = \sum_{i=1}^{4}\left(\delta_i (ws_{t-i} - ws^*)\right) - \gamma \cdot u_{t-1}^{c} + \mathbf{x}_t'\beta + \varepsilon_t \, , \qquad (4.1)$$

where ws is the logarithm of the wage share in the private non-agricultural sector, u^c is the unemployment gap, i.e. the deviation between actual and structural unemployment, and $\mathbf{x}$ is a vector of control variables, capturing the effect of temporary supply shocks. These comprise commodity price inflation, changes in the effective exchange rate and the growth in average labour productivity in the private non-agricultural sector. All control variables are expressed as deviations from their respective sample means and are included both contemporaneously and with one and two lags. The error term ε is assumed to be normally distributed with a mean of zero.

Equation (4.1) describes a dynamic process for the logarithm of the wage share. The change in the share is modelled as a function of the wage share level in the preceding quarters, unemployment in the preceding quarter and a number of temporary supply shocks. If unemployment is maintained at its structural level, whereby the unemployment gap is zero, the wage share, in the absence of temporary supply shocks, will, over time, converge towards its long-term level, ws^*, which is here assumed to be constant. The idea behind the equation is described in more detail in Box 4.1, while the Technical Appendix contains a more formal description of the theoretical basis.

The wage share equation in (4.1) is combined with a statistical model of the developments in structural unemployment and the unemployment gap. The full model is estimated using the Kalman filter and an iterative maximum likelihood procedure. The model and the estimation method are described in more detail in the Appendix.

THE RELATIONSHIP BETWEEN THE UNEMPLOYMENT GAP AND THE WAGE SHARE Box 4.1

The wage share is defined as the share of value added that is used for compensation of wage earners and can be calculated as total wage compensation divided by gross value added. The change in the logarithm of the wage share can be written as:

$$\Delta ws_t = \Delta w_t - \Delta p_t - \Delta y_t$$

where w is average nominal hourly wages, p is a measure of the price level (in producer prices), and y is average productivity per hour worked, all in logarithms. It follows that the relative change in the wage share is given by growth in real wages less growth in average hourly productivity.

In the long term, the wage share will typically be determined by structural factors on the supply side of the economy, including firms' production technology and competition climate. Assuming perfect competition and Cobb-Douglas production technology, the firms' profit maximisation will, for instance, entail a wage share equal to the elasticity of output with respect to labour input. The assumption of a constant, long-term equilibrium value for the wage share is supported by relatively constant wage shares in Denmark and a number of other countries over long periods, cf. also section 3.

In the short and medium term, however, the wage share may deviate from its long-term equilibrium value, possibly due to a certain lag in firms' adjustment to new conditions. For example, rigid nominal prices and wages may entail that real wages do not adjust immediately to cyclical fluctuations in productivity, so these fluctuations will cause the wage share to change. The wage share can also be changed as a result of temporary fluctuations in factors that can affect firms' pricing. These factors include commodity price inflation and the effective exchange rate.

Finally, fluctuations in unemployment may cause the wage share to deviate from its long-term level. A low rate of unemployment will typically generate an upward pressure on wages. In a small, open economy like Denmark, pursuing a fixed-exchange-rate policy against a major currency, price dynamics tend to be more closely linked to price developments in the currency anchor, and the pass-through of the higher wage inflation to price inflation will thus be less than complete. For a given rate of increase in productivity, this entails a higher wage share. Conversely, the wage share tends to fall when unemployment is high.

Structural unemployment is the level of unemployment that is consistent with convergence of the wage share, in the medium term, towards its equilibrium level. Actual unemployment may deviate from this level in the short and medium term. If unemployment is below its structural level, entailing a negative unemployment gap, the wage share will, all other things being equal, rise, while the profit ratio will fall. The result is deterioration of the competitiveness of Danish firms, which will eventually lead to lower demand for labour and higher unemployment, until the wage share returns to a normal level. Consequently, unemployment cannot deviate permanently from its structural level.

The relationship between the unemployment gap and the wage share is reflected by the inclusion of the unemployment gap on the right-hand side of equation (4.1). In addition, the formulation of the equation explicitly takes into account the developments

CONTINUED	Box 4.1

in productivity, commodity prices and the effective krone rate, respectively, which may all influence the course of the wage share, cf. above. Finally, lagged values of the wage share level are included. This reflects an error correction mechanism prompted by the possible impact on hourly wages of the historical ratio between real wages and productivity, cf. e.g. Blanchard and Katz (1999).

Estimation results: Structural unemployment in Denmark since 1985

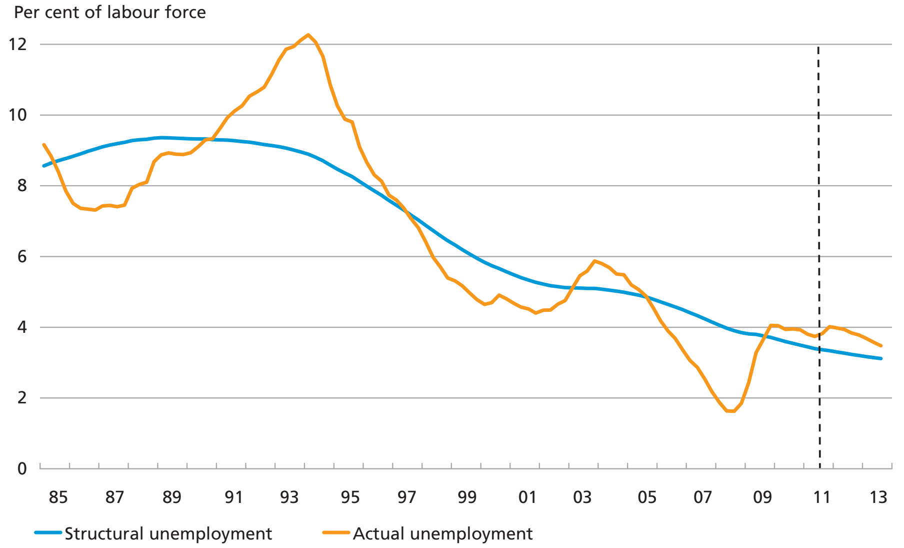
Table 4.1 shows estimates of the coefficient parameters in equation (4.1). The results show a clear and significant negative relation between the change in the wage share and the estimated unemployment gap. An increase in the unemployment gap by 1 percentage point is, all else equal, associated with a relative drop in the wage share of approximately 0.4 per cent in the subsequent quarter. Furthermore, for a given unemployment gap, a 1 percentage point increase in average labour productivity is associated with an average drop in the wage share of 0.6 per cent. This reflects a limited initial reaction in the growth rate of real wages, which increases less than one-for-one with the growth rate of productivity. Moreover, higher commodity price inflation causes the wage share to decline, but with a lag of a few quarters.

The coefficients on the lagged values of the wage share indicate a certain persistence. A short-lived increase in unemployment, for example, continues to impact the wage share for several quarters. However, in the absence of new shocks, the wage share will, over time, converge towards its long-term value, estimated here at 0.65. This is well

ESTIMATION OF EQUATION (4.1) — Table 4.1

Variable	Coefficient	Standard error
Unemployment gap (t-1)	-0.40	(0.16)
Wage share gap (t-1)	-0.67	(0.09)
Wage share gap (t-2)	0.30	(0.09)
Wage share gap (t-3)	0.01	(0.09)
Wage share gap (t-4)	0.26	(0.07)
Commodity price inflation (t)	-0.03	(0.03)
Commodity price inflation (t-1)	0.08	(0.03)
Commodity price inflation (t-2)	-0.10	(0.03)
ΔEffective krone rate (t)	0.02	(0.12)
ΔEffective krone rate (t-1)	0.47	(0.12)
ΔEffective krone rate (t-2)	-0.14	(0.12)
Productivity growth (t)	-0.62	(0.08)
Productivity growth (t-1)	-0.33	(0.10)
Productivity growth (t-2)	-0.05	(0.10)
Long-run equilibrium wage share	0.65	

ACTUAL AND STRUCTURAL UNEMPLOYMENT Chart 4.1



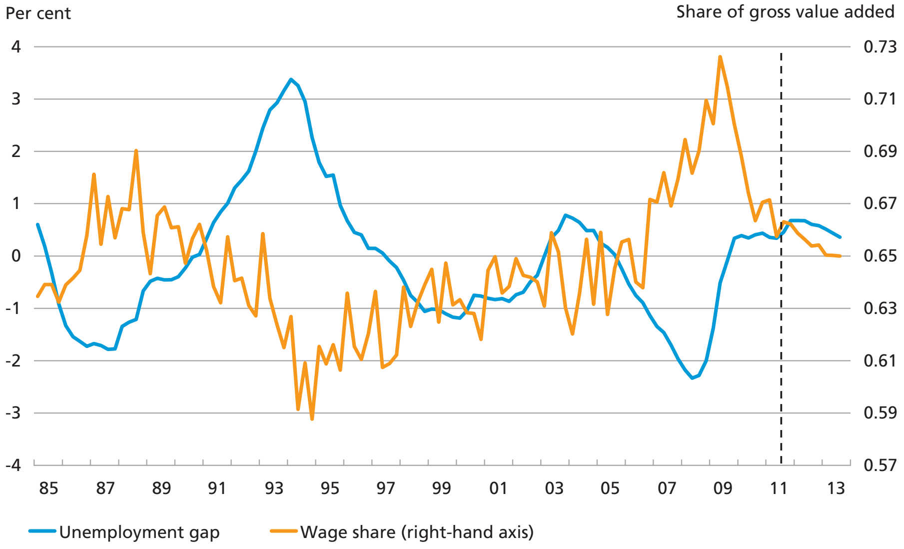
Note: Unemployment is calculated as registered net unemployment. The labour force is calculated as the number of employed persons plus net unemployed persons. The figures to the right of the dashed line are based on Danmarks Nationalbank's latest forecast of the Danish economy.
Source: Statistics Denmark and own calculations.

in accordance with the assumption that the parameter α in the aggregated Cobb-Douglas production function is equal to 0.65, cf. section 3.

Overall, structural unemployment has shown a remarkable decline over the period under review, cf. Chart 4.1. While structural net employment was more than 9 per cent of the labour force, corresponding to more than 260,000 persons, at the beginning of the 1990s, the current level is approximately 3.4 per cent of the labour force, or just under 100,000 full-time equivalents. The principal driver of this development is the labour market reforms – implemented particularly in the 1990s – which *inter alia* reduced the unemployment benefit entitlement period while also launching a far more active labour market policy than previously pursued. Before the reforms, the focus was on securing income support for the unemployed, but with the reforms, it shifted to ensuring their return to employment. The result of this reform drive was a notable and sustained drop in structural unemployment.

Compared with the development in actual unemployment, the development in structural unemployment prompts the assessment that the unemployment gap was positive over a prolonged period in the 1990s, but became negative just before the millennium rollover, cf. Chart 4.2. The recession in the early 2000s gave rise to a short-lived positive unemployment gap, while the most recent boom caused unemployment to plummet to far below its structural level. The recent economic crisis

UNEMPLOYMENT GAP AND WAGE SHARE | Chart 4.2



Note: The figures to the right of the dashed line are based on Danmarks Nationalbank's latest forecast of the Danish economy.
Source: Statistics Denmark and own calculations.

saw a considerable rise in unemployment, closing the negative gap. The estimate for the 2nd quarter of 2011 indicates a positive unemployment gap of around 0.3 per cent of the labour force, or about 8,500 full-time equivalents.

The described development in the unemployment gap is closely related to the dynamics of the wage share, cf. Chart 4.2. During the recession in the early 1990s, for example, the wage share fell to a level far below its historical average. Conversely, the strong overheating of the labour market in 2006-07 brought the wage share to new historical peaks, before the financial crisis triggered the abrupt reversal in the labour market.

5. STRUCTURAL PARTICIPATION RATE

In this article, the participation rate is defined as the number of persons in the labour force divided by the number of persons in the population in the 16-66 age group. The labour force is defined as the sum of the number of employed persons and the number of registered full-time unemployed persons. Consequently, jobseekers who are not included in registered unemployment, including persons in active labour-market programmes, self-supporting unemployed and jobseeking students, are not counted in the labour force.

A fall in employment during an economic slowdown will, however, result in a rising number of not only registered unemployed persons, but also persons in each of the groups mentioned above. This means that more people will disappear from the registered labour force, causing the participation rate to fall. Conversely, the participation rate tends to increase during a boom.

The increased use of foreign labour in recent years also contributes to this pattern. The reason is that foreigners employed at Danish firms count in employment and hence in the labour force, but not in the population figure. Since the number of foreigners employed at Danish firms is strongly dependent on the business cycle, this will also contribute to a procyclical participation rate.

The structural participation rate is the level that would be obtained in the absence of such cyclical fluctuations. In this article, we estimate the structural participation rate using an Unobserved Components Model, as was also the case with structural unemployment. The central observation equation of the model is given as

$$shortage_t = \eta_0 + \eta_1 \cdot E_t^c + \varepsilon_t \ , \qquad (5.1)$$

where *shortage* is the share of industrial firms reporting a shortage of labour (seasonally adjusted), E^c is the deviation between the actual and structural participation rate, and ε is an error term that is assumed to be normally distributed with a mean of zero. The rationale behind the equation is that when the participation rate is higher than its structural level, the amount of spare labour in the economy will be limited, and more firms will experience a labour shortage. Conversely, a participation rate below the structural level will be associated with substantial reserves of potential labour, and fewer firms will experience a labour shortage.

The development in the structural participation rate, E^*, is described in terms of the following equation:

$$E_t^* = E_{t-1}^* - \Delta ogy_t + \mu \cdot \Delta leave_t - 0{,}5 \cdot \Delta sh6066_t + \zeta_t \,. \qquad (5.2)$$

According to the equation, the structural participation rate is specified as a random walk with drift. The drift changes over time, depending on the development in the observable variables Δogy, $\Delta leave$ and $\Delta sh6066$. The variable Δogy denotes the change in the number of participants in an early retirement programme known as *transitional allowance*, while $\Delta leave$ denotes the change in the number of participants in leave schemes. These variables are included with a view to explicitly taking into account the impact of a number of labour market policy measures that were implemented in the 1990s and caused the participation rate to plummet. One of these measures was the introduction of transitional allowance. This retirement scheme was introduced in 1992 and later extended in 1994, bringing the number of participants in the scheme to just under 47,000. The scheme was closed for admissions in 1996, and the participation rate for the age group in question then rose in step with the phasing out of the scheme. From the 1st quarter of 1992 to the 1st quarter of 1996, the variable Δogy is equal to the quarterly change in the number of recipients of transitional allowance, divided by the number of persons in the 16-66 age group. Outside this period, the value of Δogy is zero. The coefficient on Δogy is set at -1. This restricttion represents the assumption that for each person admitted to the transitional allowance scheme, the structural labour force is also reduced by 1 person.

Another labour market policy measure in the 1990s was the implementation (and subsequent phasing out) of leave schemes for childminding, education and sabbaticals. At the beginning of 1995, the total number of participants in these schemes peaked at just over 87,000 people. The variable $\Delta leave$ takes the value of zero until 1992, when the number of participants in the schemes is registered for the first time. After this time, $\Delta leave$ equals the change in the number of participants in the leave schemes, divided by the number of persons in the 16-66 age group. The coefficient on $\Delta leave$ is not subject to restrictions. The reason is that part of the variation in the number of participants in the leave schemes must be assumed to be cyclical, whereby the relationship between the number of participants and the reduction of the structural labour force is less than 1:1.

The variable $\Delta sh6066$ denotes the change in the ratio between the number of persons in the 60-66 age group and the 16-66 age group. This variable is included in order to take into account that a larger share of 60-66 year-olds in the population will result in a lower structural participation rate, since this age group, irrespective of the cyclical position, has a lower participation rate than the rest of the population of working age. One of the reasons is access to the early retirement scheme. The coefficient on $\Delta sh6066$ is set at -0.5, reflecting that the average difference in the participation rate between the 16-59 age group and the 60-66 age group was approximately 50 percentage points in the period 1985-2005.

The development in the cyclical component of the participation rate, E^c, is described by the equation:

$$E_t^c = \phi_1 \cdot E_{t-1}^c + \phi_2 \cdot E_{t-2}^c + \chi \cdot u_{t-1}^c + \kappa_t \ , \tag{5.3}$$

PARAMETER ESTIMATES IN THE MODEL FOR STRUCTURAL PARTICIPATION RATE		Table 5.1
Parameter	Estimate	Standard error
μ	-0.76	(0.36)
φ_1	0.84	(0.11)
φ_2	0.04	(0.11)
χ	-0.04	(0.05)
η_0	0.02	(0.00)
η_1	1.32	(0.55)

Source: Own calculations.

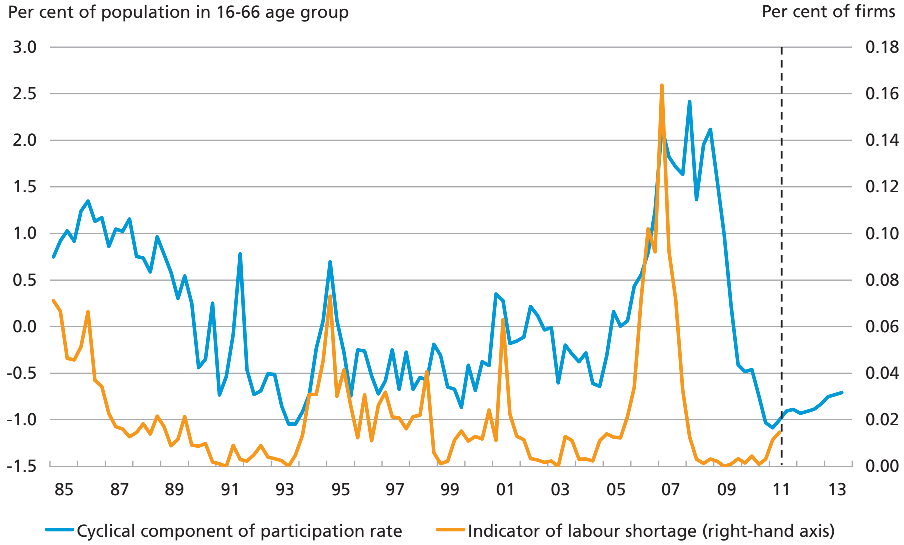
where u^c is the unemployment gap and κ is a noise term that is assumed to be normally distributed with a mean of zero. The lagged values of E^c on the right-hand side capture persistence in the cyclical component of the participation rate. One reason for such persistence is that persons who leave the labour force temporarily due to lack of job opportunities become engaged in other activities, e.g. studying. Once they have left the labour force, there is a certain probability that they will remain outside the labour force in the following quarters. The unemployment gap in the preceding quarter is included on the right-hand side of the equation to capture a "discouraged worker" effect, since higher unemployment can result in more people not finding employment and leaving the labour force. The unemployment gap is estimated as described in the preceding section. It is then treated as an exogenous, observable variable in the estimation of the structural participation rate.

The model is estimated using the Kalman filter.[1] All parameter estimates have the expected signs, cf. Table 5.1. The coefficient on $\Delta leave$ in equation (5.2) is -0.76, i.e. 76 per cent of the inflow to and outflow from the leave schemes of the 1990s is counted as structural changes in the labour force. The coefficient on the unemployment gap in equation (5.3) has the expected negative sign, in accordance with a discouraged worker effect, but is not statistically significant. Finally, the coefficient on the cyclical component of the participation rate in equation (5.1) is positive and clearly significant. Thus, as expected, there is a positive relationship between the shortage of labour in manufacturing and the estimated cyclical component of the participation rate, cf. Chart 5.1.

The estimated series for the structural participation rate shows a strong drop in the period 1992-96, cf. Chart 5.2. This is directly attributable to the sudden growth in the number of persons in leave schemes and on transitional allowance in those years. Subsequently, the gradual phasing out of the leave schemes prompted small, abrupt increases in the

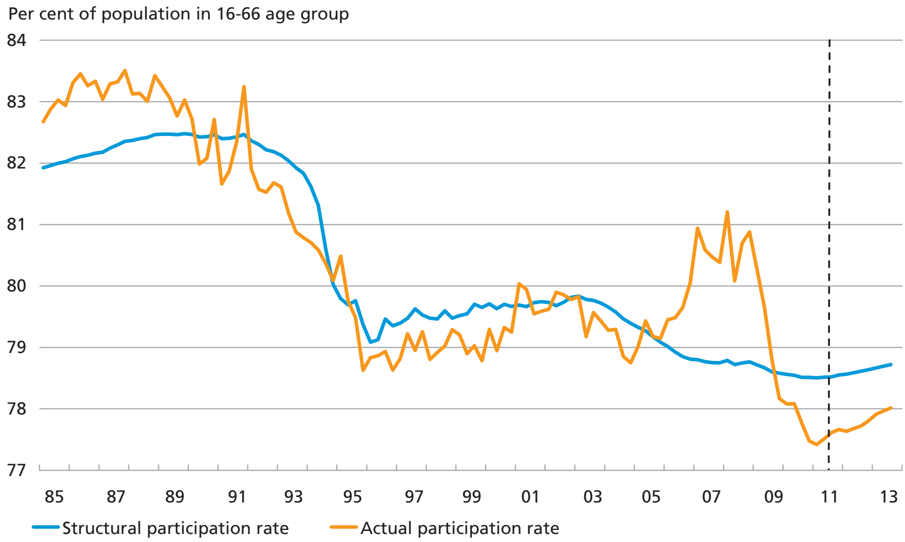
[1] The model and the estimation method and results are described in more detail in the Appendix.

CYCLICAL COMPONENT OF THE PARTICIPATION RATE AND LABOUR SHORTAGE IN MANUFACTURING INDUSTRY Chart 5.1



Note: The indicator of labour shortage indicates the share of firms in manufacturing industry, weighted by number of employees, reporting labour shortage as a production constraint. The figures to the right of the dashed line are based on Danmarks Nationalbank's latest forecast of the Danish economy.
Source: Statistics Denmark and own calculations.

ACTUAL AND STRUCTURAL PARTICIPATION RATE Chart 5.2



Note: The participation rate is calculated as the number of persons in the labour force divided by the number of persons in the population in the 16-66 age group. The figures to the right of the dashed line are based on Danmarks Nationalbank's latest forecast of the Danish economy.
Source: Statistics Denmark and own calculations.

structural participation rate in the following years in step with the reduction of the number of participants in the schemes.

From 2003 until today, the structural participation rate has fallen gradually by just over 1 percentage point in total, whereby it is estimated to be 78.5 per cent in the 2nd quarter of 2011. This fall can be attributed to an increasing share of 60-66-year-olds in the total population of working age.

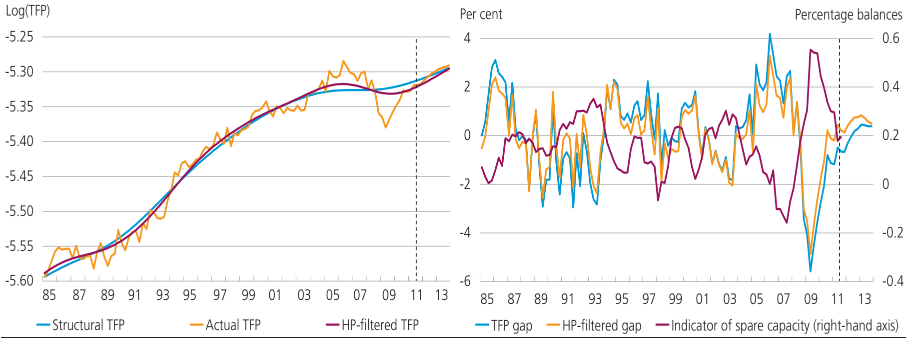
Given the actual development in the participation rate, the described development in the structural participation rate results in large, positive estimates of the cyclical component of the participation rate between the 1st quarter of 2006 and the 4th quarter of 2008, cf. also Chart 5.1. The participation rate then plummeted, as the effects of the economic crisis intensified, and the estimated cyclical component is strongly negative from the 4th quarter of 2009 onwards. In the 2nd quarter of 2011, the participation rate is approximately 1 percentage point below its structural level, corresponding to a negative labour force gap of just over 37,000 persons.

6. STRUCTURAL TOTAL FACTOR PRODUCTIVITY

The structural TFP level is estimated using an extended HP filter. The extended HP filter is based on the standard univariate HP filter that estimates the trend in a time series on the basis of a trade-off between smoothness in the estimated trend and minimisation of deviations between the actual values in the series and the trend. While the standard HP filter estimates are based solely on the development in the actual series, the extended HP filter also includes information from one or more external variables. Hence, this method can be regarded as a compromise between the simplicity of the HP filter and the higher degree of complexity in multivariate estimation methods, including the UCM approach. A formal description of the extended HP filter is given in the Appendix.

The estimation of structural TFP utilises information on the degree of spare capacity in manufacturing industries. The rationale behind this approach is that the firms' capacity utilisation is strongly dependent on cyclical factors. The reason is that after a cyclical turning point, it typically takes some time for firms to adapt their input of capital and labour. Consequently, during a demand-driven economic upturn, firms will respond to the increased demand by e.g. letting their employees work longer hours and more intensively and by utilising machinery and buildings more intensively. This results in higher capacity utilisation. On the other hand, an economic downturn will typically be accompanied by falling capacity utilisation.

STRUCTURAL TFP AND TFP GAP — Chart 6.1



Note: The indicator of spare capacity is the share of firms (weighted by number of employees) reporting more than sufficient production capacity, less the share of firms (weighted by number of employees) reporting less than sufficient production capacity. The figures to the right of the dashed line are based on Danmarks Nationalbank's latest forecast of the Danish economy.

Source: Statistics Denmark and own calculations.

But such fluctuations in the degree of utilisation of the input factors are not captured sufficiently by the applied measures of capital and labour. Instead, they are reflected in the TFP estimate. For example, an increase in the amount of overtime will, other things being equal, result in a higher TFP estimate when the total labour input is measured by the number of persons, as is the case here. Hence, the TFP estimate can be seen as an imperfect measure of true total factor productivity where cyclical fluctuations in capacity utilisation generate measurement error. This necessitates cyclical adjustment of the estimated TFP series, and information on the degree of spare capacity can be exploited for this purpose.

The estimated series for structural TFP based on the extended HP filter follows the latest development in the actual TFP less closely than is the case for the series based on the standard HP filter, cf. Chart 6.1. The former series results in larger TFP gaps during the most recent boom and numerically larger negative gaps during the subsequent crisis. This reflects that the extended HP filter – as opposed to the standard HP filter – takes into account the unusually high capacity utilisation rates during the boom, as well as the extraordinarily high number of firms reporting spare capacity during the subsequent crisis, cf. Chart 6.1.[1]

Against this background it can be argued that the estimates of structural TFP based on the standard HP filter attach too much weight to

[1] We have also experimented with an UCM approach estimating structural TFP by means of the Kalman filter. The central observation equation in the model is a positive correlation between the TFP gap and capacity utilisation in manufacturing industries, while we have experimented with a number of different assumptions regarding the statistical model for structural TFP. In all of our experiments, the Kalman filter estimates resulted in *even* larger positive TFP gaps in the years 2005-07 than was the case with the extended HP filter.

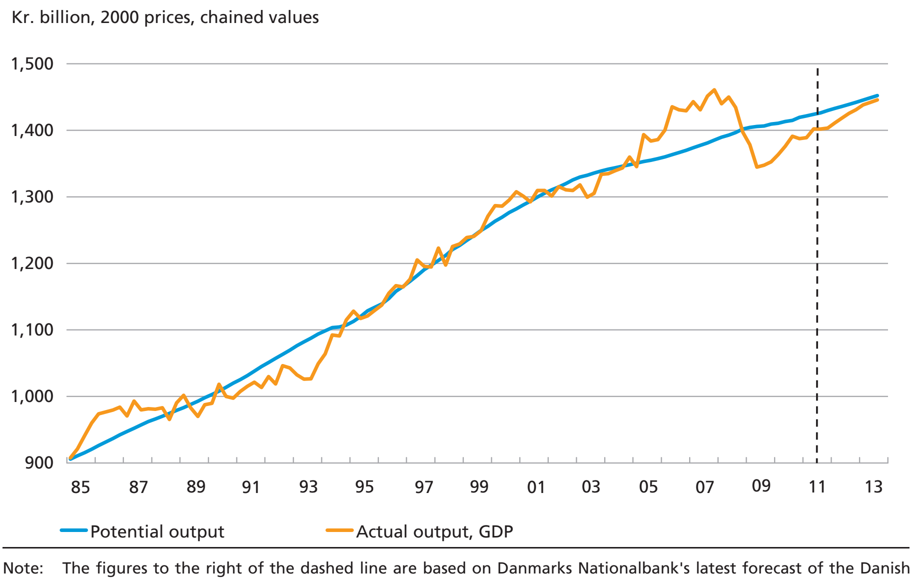
the actual TFP development, and that the development in the HP-filtered series is less credible than the corresponding development in the series based on estimates using the extended HP filter.

7. POTENTIAL OUTPUT AND THE OUTPUT GAP

On the basis of the estimates of the structural levels of unemployment, the participation rate and TFP, the level of potential output can be calculated as described in section 3. Chart 7.1 shows the resulting series. It is noteworthy that the rate of increase in potential output in recent years has been lower than in the preceding decades. In particular, the curve flattened in the early 2000s when growth in potential output seems to decline. Another "kink" can be observed in the autumn of 2008 in the wake of the global financial crisis, cf. also section 10.

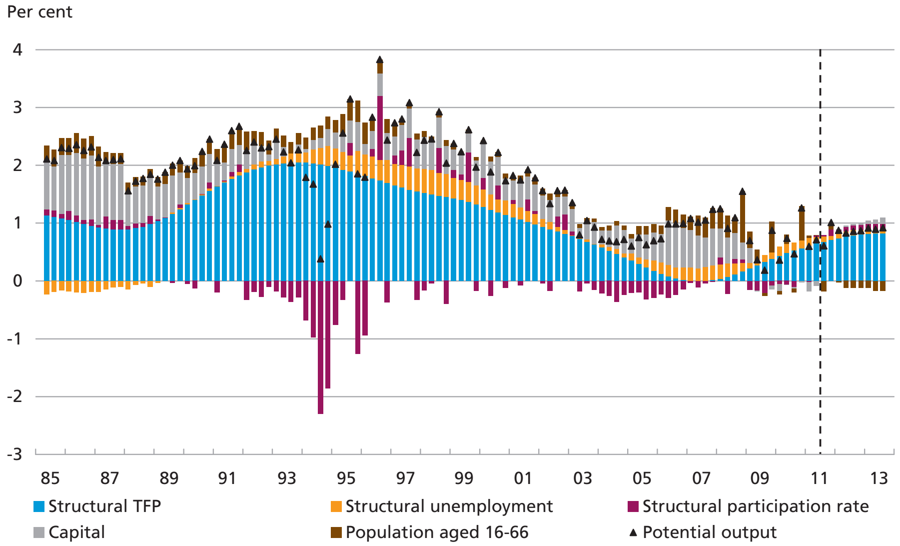
Chart 7.2 shows a decomposition of the growth rates in potential output. The declining growth since the mid-1990s can be primarily attributed to weaker development in TFP. A drop in the structural participation rate, combined with slower capital accumulation, contributed further to the fall in the growth rate in potential output seen around 2003. Capital accumulation contributed substantially to potential output growth during the most recent boom, however, but then declined to almost zero when the financial crisis caused a collapse in investment levels.

ACTUAL AND POTENTIAL OUTPUT — Chart 7.1



Note: The figures to the right of the dashed line are based on Danmarks Nationalbank's latest forecast of the Danish economy.
Source: Statistics Denmark and own calculations.

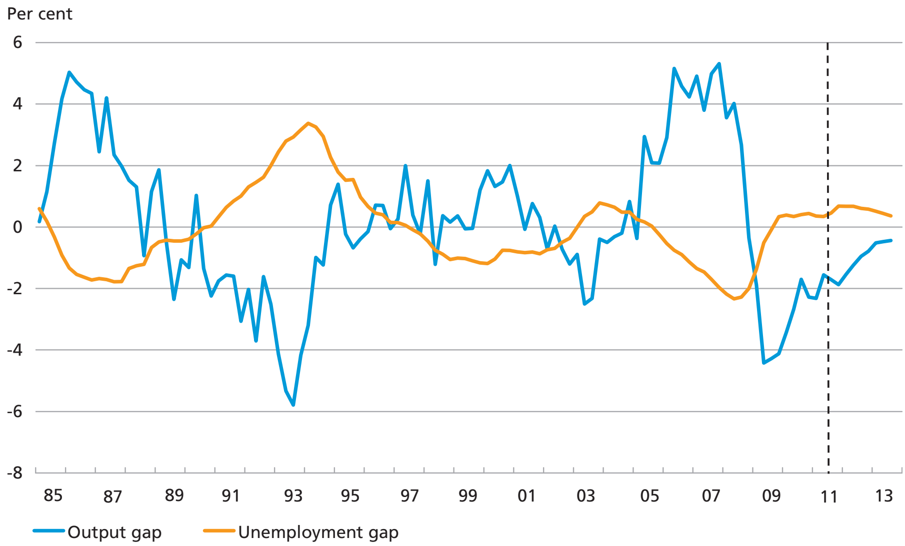
DECOMPOSITION OF GROWTH IN POTENTIAL OUTPUT — Chart 7.2



Note: The growth rates for each quarter have been converted to annual growth rates. The figures to the right of the dashed line are based on Danmarks Nationalbank's latest forecast of the Danish economy.
Source: Statistics Denmark and own calculations.

The estimated series for the output gap is shown in Chart 7.3 together with the estimated series for the unemployment gap. There is a strong negative correlation between the output gap and the unemployment gap. Moreover, the unemployment gap tends to lag the output gap by a

OUTPUT GAP AND UNEMPLOYMENT GAP — Chart 7.3



Note: The figures to the right of the dashed line are based on Danmarks Nationalbank's latest forecast of the Danish economy.
Source: Statistics Denmark and own calculations.

couple of quarters. This is a well-known cyclical phenomenon. The explanation is that, at the beginning of a demand-driven cyclical turning point, firms tend to respond to changed sales opportunities by adjusting the rate of capacity utilisation and the size of their inventories. It takes a couple of quarters for them to adjust the demand for labour, as reflected in unemployment.

According to the estimates, the output gap was large and positive at the beginning of the period, followed by a marked economic slowdown in the early 1990s. The decade ended with a substantial boom, which was then replaced by a short-lived downturn in the first years of the 2000s. In the years 2005-07, the Danish economy experienced a strong boom and overheating, which resulted in output gaps exceeding 4 per cent and considerable pressure on the labour market. But a cyclical turning point set in at the end of 2007, and the incipient slowdown escalated dramatically after the outbreak of the financial crisis in 2008 and the resulting sudden braking of the world economy. The recession bottomed out in the 2nd quarter of 2009, when GDP was more than 4 per cent below its potential level.

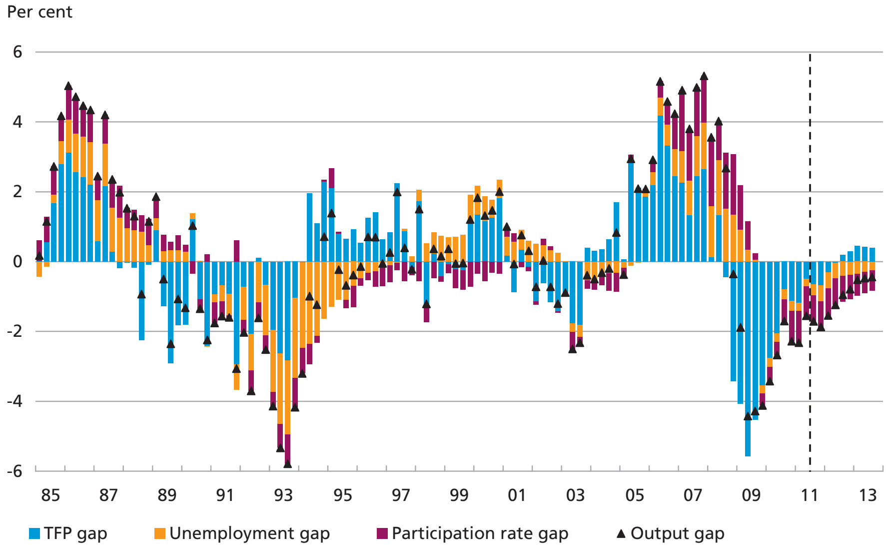
However, the GDP level has rallied since the abrupt falls in 2008 and 2009. Compared with modest growth rates in the level of potential output, this has led to considerable narrowing of the output gap, which is estimated to be -1.6 per cent of potential output in the 2nd quarter of 2011. Against the backdrop of Danmarks Nationalbank's forecast for the Danish economy, described in "Recent Economic and Monetary Trends" in Part 1 of this Monetary Review, our assessment is that the output gap will widen a little in the remainder of 2011, followed by a resumed narrowing in the coming years.

The output gap can be decomposed into contributions from TFP, the unemployment gap and the participation rate gap, cf. Chart 7.4. The large, positive output gaps in the years 2006-08 initially took the form of large, positive TFP gaps. Towards the end of the boom, immediately before the outbreak of the financial crisis, the composition of the output gap shifted, however, as the strong boom resulted in considerable pressure on the labour market.

Moreover, it should be noted that the large, negative output gaps in the early 1990s were primarily reflected in large unemployment gaps. In contrast, the large, negative output gaps in 2009 and 2010 primarily appeared as abrupt falls in TFP. One contributing factor can be the suddenness of the crisis' eruption, given that the labour market typically adjusts to cyclical turning points with a certain lag.

Indeed, the composition of the output gap has shifted in the expected direction since the onset of the crisis. The TFP gap has narrowed numer-

DECOMPOSITION OF OUTPUT GAP Chart 7.4



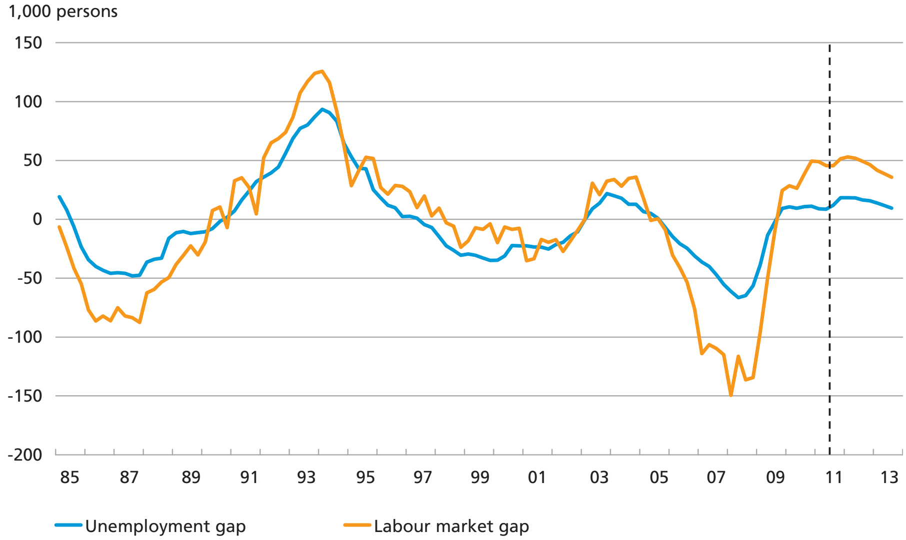
Note: The figures to the right of the dashed line are based on Danmarks Nationalbank's latest forecast of the Danish economy.
Source: Statistics Denmark and own calculations.

ically, constituting a smaller share of the total output gap in the 2nd quarter of 2011 than in 2009. It should be borne in mind, however, that the contribution of the unemployment gap to the output gap is still very modest. This means that the labour market's response to the cyclical turning point has first and foremost taken the form of a marked gap in the participation rate.

This development indicates a new pattern in the labour market's response to cyclical fluctuations. Previously, cyclical fluctuations were primarily reflected in fluctuations in the unemployment gap. In recent years, however, they have increasingly been reflected in cyclical fluctuations in the size of the labour force (and hence the participation rate). This is evident in that the fluctuations in the *labour market gap*, reflecting the unemployment gap and the labour force gap together, have been considerably more pronounced than the corresponding fluctuations in the unemployment gap, cf. Chart 7.5. One contributing factor could be the increased extent of active labour market programmes, since persons in these programmes are counted as being outside the labour force, the latter being calculated as the sum of employed and net unemployed persons, cf. also the next section.

The considerable fluctuations in the labour force gap in recent years should be seen as a reminder that it is not enough to focus solely on the development in the unemployment gap when assessing labour market pressures.

UNEMPLOYMENT AND LABOUR MARKET GAPS Chart 7.5



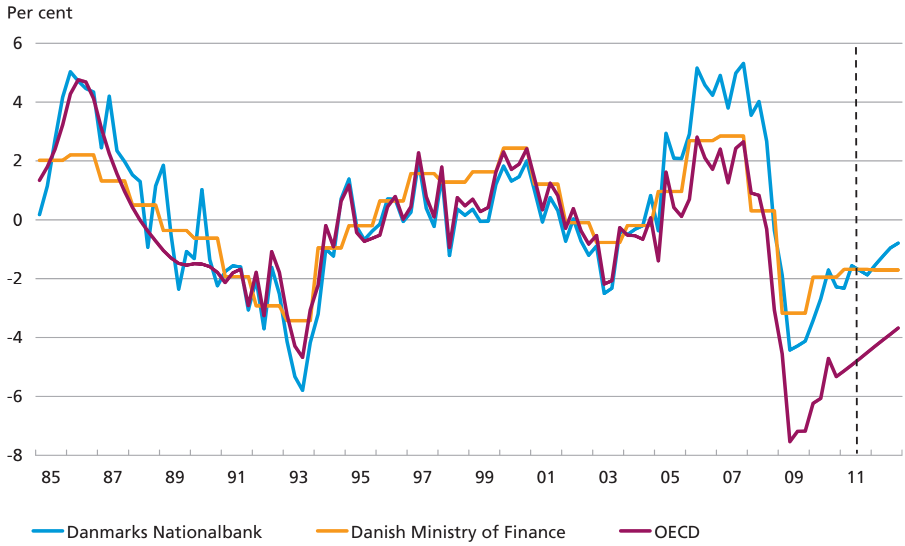
Note: The labour market gap is defined as the unemployment gap less the labour force gap; the latter is calculated as the participation rate gap multiplied by the number of persons in the population in the 16-66 age group. A positive labour market gap indicates that the total input of labour is below the structural level, e.g. because unemployment is higher than the structural unemployment rate or because the labour force is below its structural level. The figures to the right of the dashed line are based on Danmarks Nationalbank's latest forecast of the Danish economy.

Source: Statistics Denmark and own calculations.

Comparison with estimates from other institutions

In most of the estimation period, the described estimates of the output gap mirror corresponding estimates from the Danish Ministry of Finance and the OECD relatively closely, cf. Chart 7.6. In general, the three time series paint the same overall picture of the cyclical patterns in Denmark over the last 25 years. But there are also substantial differences between the three series, not least in recent years, when the estimates of the output gap calculated in this article deviate from the estimates of the other institutions. In particular, the calculations in the preceding sections indicate that the overheating of the Danish economy in the years leading up to the financial crisis was considerably stronger than assessed by the Ministry of Finance and the OECD. This reflects that our estimate of the level of potential output in these years is lower than the estimates of the other institutions. Compared with the OECD's estimate, our estimate of current potential output remains somewhat lower, which means that the OECD's estimate of the output gap is currently considerably more negative than the corresponding estimate in this article. The Ministry of Finance, on the other hand, finds that the level of potential output fell between 2008 and 2009, which brings their estimate of the current output gap to almost the same level as the

OUTPUT GAP ESTIMATED BY VARIOUS INSTITUTIONS Chart 7.6



Source: Danish Ministry of Finance, OECD *Economic Outlook* and own calculations.

estimate in this article. The differences between the three time series illustrate that estimates of the size of the output gap depend on the specific choice of estimation method.

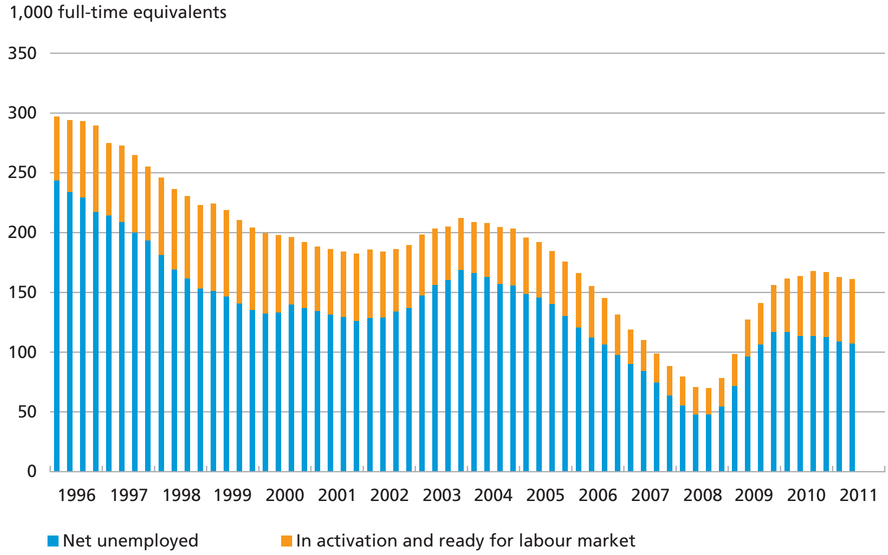
8. ALTERNATIVE UNEMPLOYMENT CONCEPTS

As mentioned, the estimates of potential output and the output gap are calculated using registered net unemployment as a measure of unemployment. Since 2010, Statistics Denmark has also published statistics for another unemployment concept, i.e. *gross unemployment*. The difference between the two unemployment concepts is that persons in active labour market programmes who are ready for the labour market (also called employment-ready persons in activation) are included in gross unemployment but not in net unemployment.

The number of such persons has risen markedly in recent years, cf. Chart 8.1, in 2010 constituting 31 per cent of the total number of gross unemployed. Some of the reasons are earlier activation of unemployed persons and amended refund rules for local governments, encouraging them to increase the extent of active labour market programmes.

Consequently, gross unemployment is considerably higher than net unemployment, and the estimates of structural unemployment and the unemployment gap therefore depend on the choice of unemployment concept. It is important to bear in mind that since gross unemployment is generally higher than net unemployment, the estimate of structural

COMPOSITION OF SEASONALLY ADJUSTED GROSS UNEMPLOYMENT Chart 8.1



Source: Statistics Denmark, Ministry of Employment and own calculations.

gross unemployment will also be higher than the estimate of structural net unemployment, However, it also means that it cannot be concluded in advance that the unemployment gap, i.e. the difference between actual and structural unemployment, will be correspondingly larger when the concept of gross unemployment is used.

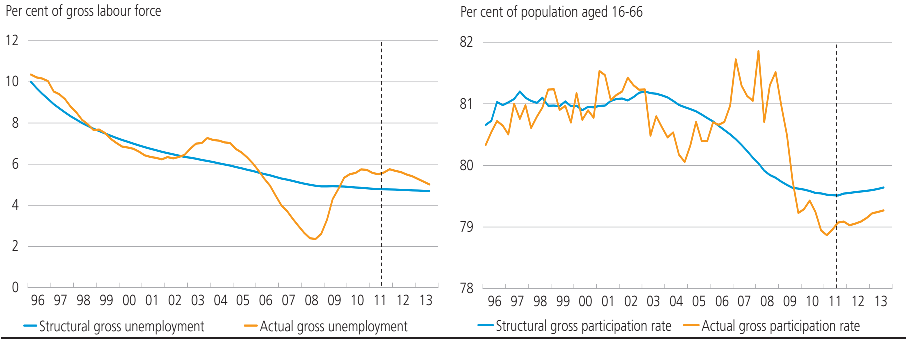
An alternative definition of unemployment also impacts on the calculation of the participation rate. For example, if the unemployment concept used is net unemployment, employment-ready persons in activation are not included in the labour force, while they are included if the concept of gross unemployment is used. The choice of unemployment concept thus influences the estimates of both structural unemployment and the structural participation rate, and the overall effect on the estimate of potential output will depend on the changes in both these estimates.

As an illustration of this point we have estimated time series for the structural levels of unemployment and the participation rate when calculating unemployment as the number of gross unemployed. The estimates are calculated using the same methods as described in sections 4 and 5, with the significant difference that the official statistics for gross unemployment are only available from 2007, while estimates are available back to 1996.[1] Principally, this means that it is not possible to

[1] Statistics Denmark's time series for gross unemployment goes back to 2007. Statistics from 1996 to 2006 are estimates based on statistics from the Ministry of Employment.

STRUCTURAL GROSS UNEMPLOYMENT AND STRUCTURAL GROSS PARTICIPATION RATE

Chart 8.2



Note: Unemployment is calculated as registered gross unemployment. The gross labour force is defined as the number of employed persons plus gross unemployed persons, while the gross participation rate is calculated as the gross labour force divided by the number of persons in the population in the 16-66 age group. The figures to the right of the dashed line are based on Danmarks Nationalbank's latest forecast of the Danish economy.

Source: Statistics Denmark, Ministry of Employment and own calculations.

provide a description of the development in structural unemployment and potential output over a relatively long period using this unemployment concept. In addition, given the shorter time series, the estimates of the structural levels are subject to greater uncertainty, which is one of the reasons why we have chosen to focus on net unemployment as the key unemployment concept in this article.

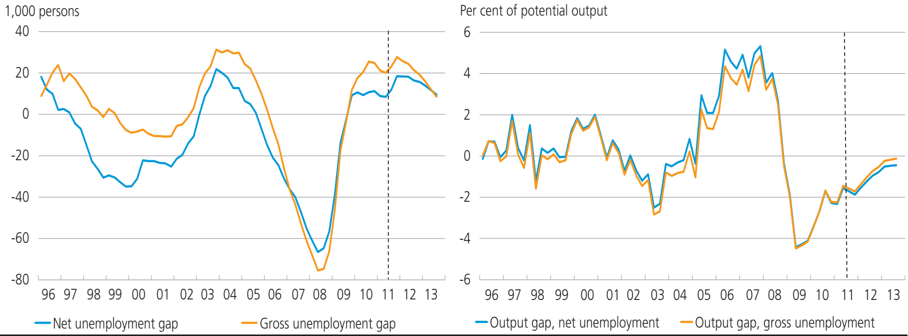
The estimated time series based on the concept of gross unemployment paint the same overall picture as in the preceding sections, cf. Chart 8.2. Structural unemployment has declined over the entire period under review, but the pace of the decline has slowed down in recent years. After a slight increase in the early 2000s, the structural participation rate has fallen considerably since then.

When measured by the number of persons, the size of the unemployment gap varies, as expected, according to whether gross or net unemployment is used, cf. Chart 8.3. For example, the unemployment gap in the 2nd quarter of 2011 is estimated to be just over 20,000 persons, using gross unemployment. For comparison, the net unemployment gap in the same quarter is estimated to be approximately 8,500 persons, cf. section 4.

But the higher gross unemployment gap is offset by a numerically smaller labour force gap. For example, the labour force gap in the 2nd quarter of 2011 is estimated to be only -20,600 persons using the concept of gross unemployment, against -37,000 persons in section 5. Consequently, the total labour market gap, given by the unemployment gap less the labour force gap, shows no great difference when the concept of gross unemployment is used, compared with net unemploy-

UNEMPLOYMENT GAP AND OUTPUT GAP WITH GROSS AND NET UNEMPLOYMENT

Chart 8.3



Note: The figures to the right of the dashed line are based on Danmarks Nationalbank's latest forecast of the Danish economy.

Source: Statistics Denmark, Ministry of Employment and own calculations.

ment. As a result, the estimate of the output gap in the 2nd quarter of 2011 is roughly the same based on gross unemployment as based on net unemployment, cf. Chart 8.3. Again, this emphasises the importance of not limiting the focus to the unemployment gap when assessing capacity pressures in the economy.

A similar point applies to a third unemployment concept, LFS (labour force survey) unemployment, which is based on a continuous, interview-based survey of the population's attachment to the labour market. The calculation of LFS unemployment includes groups of jobseekers who are not included in the register-based unemployment figures. These include e.g. jobseeking students and self-supporting unemployed persons. Increases in the number of LFS unemployed persons in these groups have been a principal factor contributing to the considerably stronger growth in LFS unemployment since 2008, compared with registered net unemployment, cf. Chart 8.4. [1]

The estimation methods applied to net unemployment in section 4 have turned out not to produce satisfactory results for LFS unemployment. This is, among other factors, because statistics for the latter are only available back to 1995. Consequently, a formal estimation of structural unemployment based on the LFS unemployment concept is outside the scope of this article. However, given the stronger increase in LFS unemployment since 2008, a natural conjecture is that our estimate of the current unemployment gap would have been somewhat larger if we had used LFS unemployment as the measure of unemployment.

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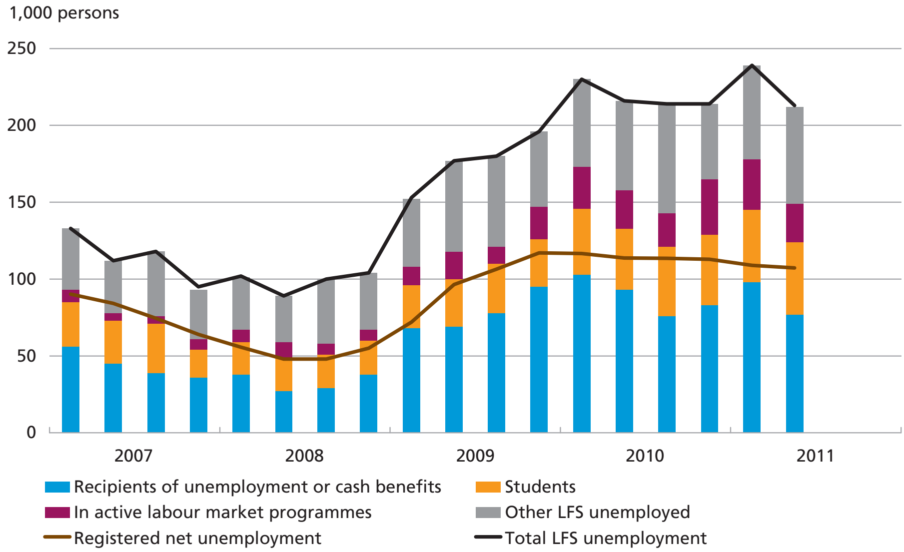
[1] Note that comparisons between LFS unemployment and registered unemployment are complicated by the fact that registered unemployment – as opposed to LFS unemployment – is expressed as the number of *full-time equivalents*. A half-time unemployed person, for example, is included as 0.5 full-time equivalents in registered unemployment statistics, but as an employed person in the LFS statistics.

LFS UNEMPLOYMENT AND REGISTERED NET UNEMPLOYMENT Chart 8.4



Note: Recipients of unemployment benefits and cash benefits should here be taken to mean recipients of unemployment benefits who are not in active labour market programmes and recipients of cash benefits who are not in such programmes and who are ready for the labour market, match categories 1-3. This means that these persons are also included in registered unemployment.

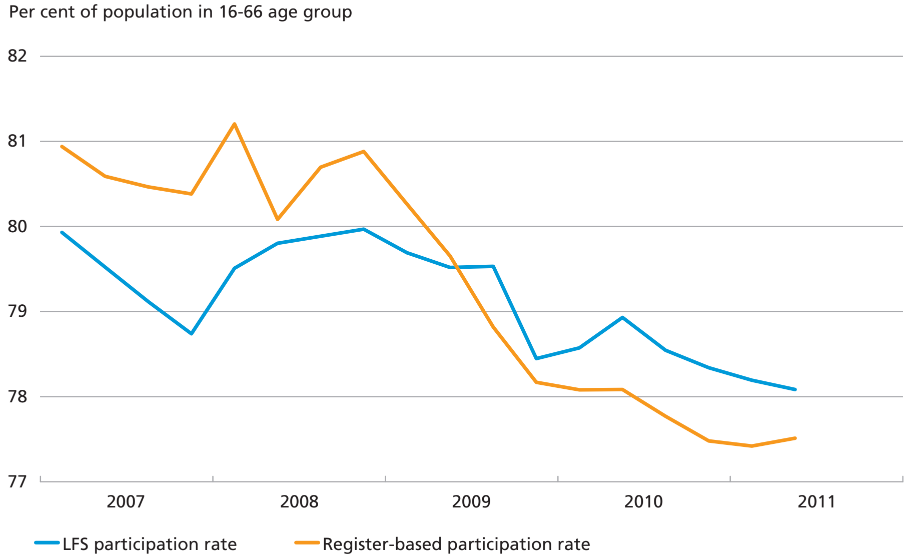
Source: Statistics Denmark.

On the other hand, it is also likely that our estimate of the participation rate gap would have been numerically lower if the estimations had been based on LFS unemployment. This is because the LFS participation rate – calculated as the number of LFS-unemployed persons plus LFS-employees divided by the number of persons in the 16-66 age group – has declined at a more moderate pace since 2008 than the participation rate based on the net unemployment concept, cf. Chart 8.5. A possible reason is that a large number of those who lost their jobs in the wake of the financial crisis were reclassified as self-supporting jobseekers or job-seeking students. In the LFS statistics, they were counted as unemployed, while they were outside the labour force in the statistics for registered unemployment.

In conclusion, we emphasise that, in general, the choice of unemployment concept has only limited impact on the estimates of potential output and the size of the output gap. But the *composition* of the output gap will depend on the choice of unemployment concept: Different unemployment concepts will therefore result in different estimates of structural unemployment and the unemployment gap, while also producing varying estimates of the structural participation rate and the labour force gap – and the differences in the labour force gap will typically tend to neutralise the differences in the unemployment gap.

LFS-BASED PARTICIPATION RATE AND REGISTER-BASED PARTICIPATION RATE

Chart 8.5



Note: The LFS participation rate is calculated here as the number of LFS-employed and LFS-unemployed relative to the number of persons in the population in the 16-66 age group. The register-based participation rate is calculated as the number of persons in the labour force, divided by the number of persons in the population in the 16-66 age group, where the labour force is calculated as the number of employed plus the number of net unemployed.
Source: Statistics Denmark and own calculations.

Consequently, using an alternative concept of unemployment will typically shift the decomposition of the output gap, but not its overall size.

9. UNCERTAINTY AND RELIABILITY IN REAL TIME

As described in the introduction, the output gap is one of the most frequently used indicators of the cyclical position. In macroeconomic policy planning, a natural focus point is the *current* output gap (and any forecasts of the outlook), while assessments of the output gap in previous periods are often of secondary interest.

Ideally, estimates of the output gap should therefore be available with a minimum lag in order to provide policy-makers with the optimum information basis about current capacity pressures in the economy. In practice, however, it is well known that early estimates of potential output and the output gap are associated with considerable uncertainty, and that they are often subject to substantial revisions as new information becomes available, cf. e.g. Orphanides and Van Norden (2002) and Koske and Pain (2008).

Revisions of estimates of potential output and the output gap are attributable to revisions of *previously published* statistics for actual output, unemployment, wage share, etc., as well as the release of *new* statistics for these measures.

Especially GDP in the national accounts is subject to revisions of existing figures, while e.g. the unemployment figures are usually revised to a lower degree. Revisions of the actual GDP figures will result in revisions of the output gap estimate, both directly and via revisions of the estimate of potential output.

The release of figures for later quarters may lead to revisions of the estimated output gap via two channels: Firstly, the new data points will contribute new information on the current cyclical position, which may lead to reassessment of the cyclical position in previous quarters. This is known as the end point problem, since it is particularly the estimates at the end of the sample that are reassessed when new data points are added. To mitigate this problem, the sample is often expanded with forecast-based figures for future quarters.[1]

Secondly, the addition of new figures may lead to changes in the model used in the estimations of the unobservable variables. Such changes will typically be updates of key parameter estimates, which will lead to reassessment of the estimates of the unobservable variables in all preceding periods. This problem is particularly relevant for Unobserved Components Models, which normally involve estimation of a large number of parameters.

The UCM approach described in section 4 provides for calculation of confidence intervals for the unobservable variables, and in principle, they can illustrate the degree of uncertainty. However, in the calculation of the confidence intervals, it is assumed that both the "true" form of the model and the values of the model parameters are known, and possible revisions of the existing data are not taken into account. Hence, the confidence intervals will tend to underestimate the real uncertainty, cf. Orphanides and Van Norden (2002). Finally, the UCM approach provides only confidence intervals for the individual sub-components to which it is applied, and the individual confidence intervals cannot be readily combined into an aggregate confidence interval for potential output or the output gap.

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[1] The end point problem is particularly pronounced for simple, statistical filtering methods, such as the HP filter. The reason is that the HP filter calculates the structural component in a time series as the weighted average of the actual values of the variable in both previous and subsequent periods. At the end of the sample, the values in the subsequent periods are not available, however, so the algorithm behind the HP filter will attach extra weight to the latest observation in the time series. As a result, the estimated structural component will often be close to the actual value in this period, often bringing the estimated gap close to zero. A frequently used solution, which is also used in this article, is to apply forecast-based figures for the future periods to avoid excessive weight on the last observation of the time series.

Real-time estimates of the output gap

In this section, we calculate *real-time estimates* of the output gap as an alternative illustration of the degree of uncertainty. The calculations result in a time series of estimates of the output gap in the period from the 1st quarter of 2000 to the 2nd quarter of 2011. Each element of the time series represents a *contemporaneous* estimate of the output gap in the relevant quarter – or more specifically the estimate that would have been achieved on the basis of the amount of information available immediately after the release of the first preliminary national accounts for the quarter in question. The real-time estimate for the 1st quarter of 2011, for example, reflects the estimate of the output gap in the 1st quarter of 2011 that we would have achieved on the basis of the data available immediately after 31 May 2011, which marked Statistics Denmark's release of the first preliminary national accounts for the 1st quarter. The method behind the calculations of the real-time estimates is described in more detail in Box 9.1.

The *final* estimates of the output gap are the estimates we can obtain with the full amount of information presently available, including revi-

CALCULATION OF REAL-TIME ESTIMATES Box 9.1

The construction of real-time estimates of the output gap is in three steps: The first step consists of constructing a *real-time data set* for each quarter in the period from the 1st quarter of 2000 to the 2nd quarter of 2011. The real-time data set for a given quarter *t* reflects the information available at the time of release of the first preliminary national accounts for quarter *t*. But subsequent revisions of the figures are not reflected in the real-time data sets. In addition to the actual figures available at the time, each real-time data set also includes forecast-based figures for developments in the subsequent quarters. The forecast figures are from Danmarks Nationalbank's own forecasts from the time in question, whereby the full real-time data set is a close reflection of the total amount of information that was available to Danmarks Nationalbank at the time.

In the second step, the real-time data sets are used to estimate time series for the output gap, here called *vintages*. The estimation method is as described in sections 3-6, resulting in one vintage for each real-time data set. The vintage associated with real-time data set *t* describes the development in the output gap from 1985 until quarter *t*, as we would have assessed it to be at the time, if we had applied the same estimation method as in this article. The estimate of the output gap for quarter *t* from vintage *t* is called the *real-time estimate* of the output gap in quarter *t*.

The third and last step consists of production of a *real-time series* based on the vintages, comprising all real-time estimates from the 1st quarter of 2000 to the 2nd quarter of 2011. Hence, the real-time series provides a picture of how the original estimates of the output gap would have been if we had used the estimation method in this article on an ongoing basis for each quarter since 2000.

sions of previously published national accounts statistics. Consequently, the final estimates correspond to the estimates presented in section 7, which are the main findings of this article.

Comparison of the real-time estimates of the output gap and the final estimates gives us an impression of the amount of future revisions that can be expected when a new estimate of the output gap is first published.[1]

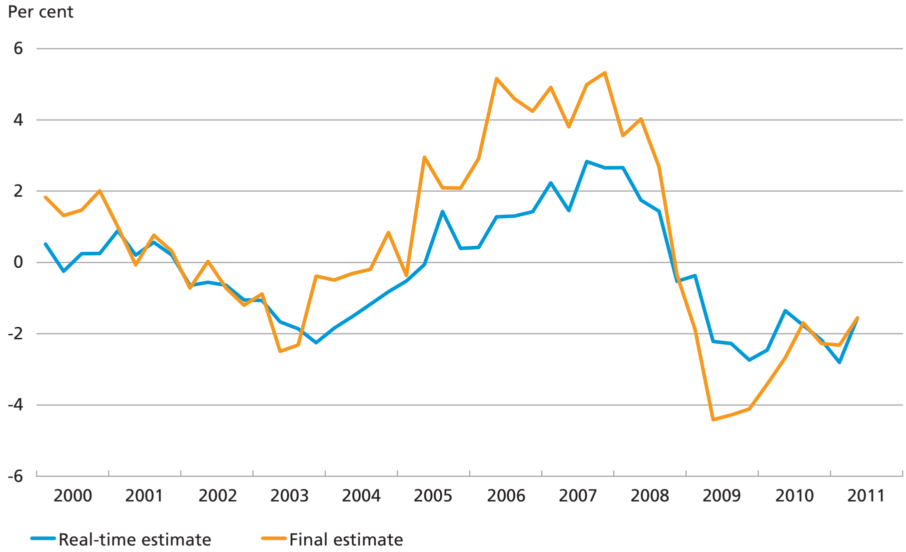
The real-time estimates of the output gap show a strong correlation with the final estimates (a correlation coefficient of 0.91), and in 89 per cent of the cases the two series produce output gaps with the same sign. In addition, the real-time estimates capture cyclical turning points (expressed as a change in the sign of the output gap) with a reasonable timeliness, cf. Chart 9.1.

But when it comes to the *size* of the output gap, the real-time estimates are subject to considerable uncertainty, and pronounced revision is sometimes necessary. The analyses in this article indicate that this occurs particularly when the fluctuations in the output gap are numerically large: For example, the real-time estimates of the output gap in the first half of the previous decade, when cyclical developments were rather stable, are relatively close to the final estimates. But the real-time estimates in the boom years 2006-07 are markedly lower than the final estimates and would thus have led to strong upward revision. In the crisis years 2009 and 2010, the real-time estimates are, on the other hand, considerably higher than the final estimates and would therefore have triggered a substantial downward adjustment of the output gap.

The revisions of the output gap can be decomposed into revisions of the real-time estimates of the TFP gap, unemployment gap and participation rate gap. The revisions of the TFP gap are the primary cause of revisions of the overall output gap, cf. Chart 9.2. Particularly for the boom years 2006-07, the real-time estimates of the TFP gap are notably lower than the final estimates, which may explain almost the entire difference between the corresponding estimates of the output gap in this period. Compared with the TFP gap, revisions of real-time estimates

[1] It can be argued, however, that these results exaggerate the extent of expected future revisions. In the calculation of the real-time estimates, the contents of the forecasts at the time are thus taken as given. In reality, a forecast will always be based on a number of judgements, and – formal or informal – assessments of the output gap are often included as an important element of the basis for these judgements. Consequently, output gap estimates and economic forecasts have a mutual impact, and they are typically the result of an iterative process including many other factors as well. If Danmarks Nationalbank had actually produced formal estimates of the output gap on a current basis, these estimates would most likely have been included in the preparation of the current forecasts, which would then have come out differently. In turn, this would have resulted in other real-time estimates of the output gap, which would probably have been closer to the final estimates.

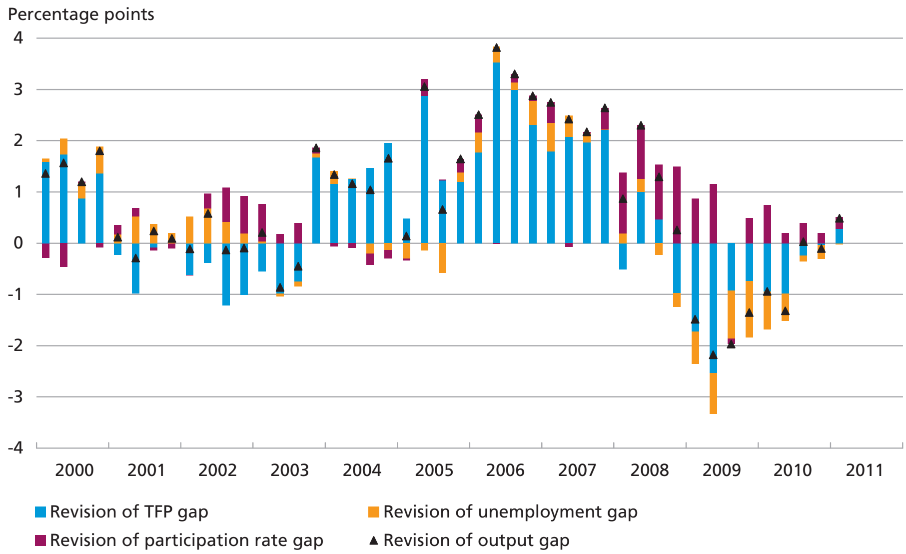
REAL-TIME ESTIMATES AND FINAL ESTIMATES FOR THE OUTPUT GAP Chart 9.1



Source: Statistics Denmark and own calculations.

of the unemployment gap and the participation rate generally play a minor role, although revisions of the unemployment gap contributed substantially to the marked deviations between the real-time estimates and the final estimates of the output gap in 2009 and 2010.

DECOMPOSITION OF REVISIONS OF REAL-TIME ESTIMATES OF THE OUPUT GAP Chart 9.2



Source: Own calculations.

Quasi real-time estimates

One of the reasons for the marked revisions of the real-time estimates of the TFP gap is that revisions of existing GDP data are directly reflected in the TFP series, which is calculated as a residual, cf. section 3. We have performed a so-called quasi real-time analysis in order to throw light on the role of revisions of the existing data. This analysis follows the same method as the real-time analysis mentioned above, but with the difference that we apply only final, revised data for the actual values of GDP, unemployment, wage share, etc.[1] Relative to the final estimates, this difference implies that the quasi real-time estimates use only data up to and including the quarter in question, while the final estimates are based on all information from the current data set. Consequently, the quasi real-time estimate of the output gap in a given quarter is an expression of what our output gap estimate would have been at the time, if we had known the final national accounts data for the quarter in question and the preceding quarters. The difference between the quasi real-time estimates and the real-time estimates can be seen as an indication of the extent of the contribution of revisions of the existing data basis to the uncertainty in real-time estimates of the output gap.

Compared with the real-time estimates, the quasi real-time estimates are generally considerably closer to the final estimates, cf. Chart 9.3. This indicates that the uncertainty of the real-time estimates of the output gap is to a large extent attributable to uncertainty concerning the actual data, and revisions of the existing figures are a considerable source of revision of output gap estimates. As expected, the TFP gap, in particular, is affected by revisions of the actual data. This is seen by the fact that the gap to the final estimates is considerably smaller when the real-time estimates are based on revised data than when they are based on the original, unrevised data. But the TFP gap is still the main cause of revision of the output gap. Even in the absence of revision of the national accounts statistics, the real-time estimates of TFP would be subject to substantially greater uncertainty, compared with the corresponding estimates of the unemployment gap and the structural participation rate, cf. Chart 9.3.

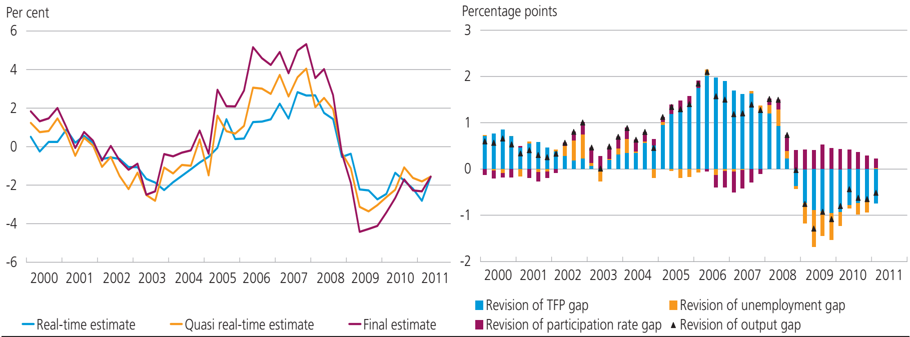
Economic policy implications

The great uncertainty associated with real-time estimates of the output gap raises the question of how policy-makers should address such esti-

[1] However, the data used in the calculation of the quasi real-time estimates do not include forecast-based figures for the following quarters. The reason is that in a given quarter, the forecast would have been different if we, at that time, had known the revised national accounts data. Hence, the quasi real-time estimate of the output gap in quarter *t* is based on the final, revised national accounts data up to and including quarter *t*.

REAL-TIME ESTIMATES, QUASI REAL-TIME ESTIMATES AND FINAL ESTIMATES OF THE OUTPUT GAP

Chart 9.3



Note: The right-hand Chart breaks down the difference between the quasi real-time estimate and the final estimate of the output gap into the corresponding differences for the TFP gap, unemployment gap and participation rate gap.

Source: Own calculations.

mates. In this connection, it should primarily be emphasised that real-time estimates of the output gap are far from uninformative. After all, the correlation between the real-time estimates and the final estimates is strong, as mentioned above.[1] But it should also be underlined that assessments of the cyclical position and capacity pressures in the economy should not rest on real-time estimates of the output gap alone. It is important to include other indicators too.[2] The real-time estimates from the years running up to the financial crisis can be taken as an illustration of this point: Given the amount of information available at that time, the method applied in this article would have resulted in positive estimates of the output gap in these years, which would have been an early indicator of overheating. On the other hand, it is also clear that the subsequent development has led to strong upward adjustment of the output gap in the period in question. This suggests that the method applied in this article would hardly have been sufficient to clarify the serious degree of overheating at the time when political countermeasures could have been implemented.[3]

The consequences of the uncertainty surrounding the output gap to optimum monetary policy have been analysed extensively in the theoretical literature. The studies in this literature typically apply simple macroeconomic models, assuming that a central bank's behaviour can be

1 This point of view is shared by Koske and Pain (2008), among others, while e.g. Orphanides and Williams (2002) are somewhat more critical. The latter authors recommend that economic policy decisions should be based on observable changes in actual output and unemployment rather than on estimates of the unobservable output and unemployment gaps.

2 Other indicators include growth in actual output, questionnaire surveys of capacity pressures and inflation expectations, the development in nominal wages and prices, etc.

3 In May 2006, the Danish Ministry of Finance estimated the output gap for that year to be 1.5 per cent (*Economic Survey*, May 2006), while the most recent estimate for 2006 is 2.7 per cent (*Economic Survey*, August 2011), supporting this interpretation.

described by a simple, monetary-policy rule (often a Taylor rule). A frequently occurring result in the literature is that the greater the uncertainty about the size of the output gap, the less weight should the central bank attach to the output gap in the construction of the monetary-policy rule.[1]

In Denmark, however, monetary policy is committed to maintaining the fixed-exchange-rate policy, so macroeconomic stabilisation is left to fiscal policy. In view of this, it is unfortunate that the implications of uncertainty regarding the output gap to fiscal stabilisation policy have not received very much attention in the literature so far. But one aspect of fiscal policy has attracted attention, namely the consequences for calculations of the structural balance. Since the output gap is included as a decisive component in these calculations, cf. section 11, uncertainty about its size will necessarily spread to the estimate of the structural balance, cf. Koske and Pain (2008). Consequently, it should be endeavoured to take qualified estimates of the extent of the uncertainty into account when calculating the structural balance. Moreover, in order to avoid overly optimistic assessments of the underlying fiscal position, it could also be argued that special weight should be attached to the calculations of the structural balance that are based on "prudent" estimates of the output gap, cf. also D'Auria et al. (2010).

10. POTENTIAL OUTPUT BEFORE AND AFTER THE FINANCIAL CRISIS

The turmoil in the financial markets, which began in 2007 and escalated dramatically in autumn 2008, led to a strong decline in economic activity in Denmark. The real economic consequences of the crisis are analysed in Abildgren et al. (2011). Their macroeconomic analyses focus on the consequences for *actual* output, however, while the underlying trend in GDP is generally taken as given. In this section our point of view is the opposite, since our focus is on the consequences of the crisis for *potential* output. In that sense, this section complements the analyses in Abildgren et al. (2011).

Throughout this article, we have interpreted the concept of potential output as a stable, slowly changing underlying level of actual output, cf. section 2. This interpretation is reasonable, in so far as the development in actual output follows a normal course, where temporary shocks to the economy result in varying, yet dampened, fluctuations in the annual growth rates for GDP. It is more doubtful, however, whether the characterisation of potential output as a relatively stable underlying level

[1] An overview of this literature is contained in Koske and Pain (2008).

also holds water in a situation like the one in 2008 and 2009, when GDP fell by approximately 8 per cent over a few quarters, relative to the peak in 2007. Since there is every probability that shocks of this magnitude will have persistent consequences also on the supply side of the economy, it can be envisaged that the development in the level of potential output will be more abrupt in this period, and that this will not necessarily be captured using the estimation method mentioned previously.[1]

In the following we discuss the likely impacts of the financial crisis on the level of potential output. In line with the overall approach of this article, our point of departure is to decompose potential output, using the production function method, into capital, population, participation rate, unemployment and TFP.

Capital

The most obvious impact channel from the crisis to the productive capacity of the Danish economy is via the negative effects on the level of investment. Investment levels are strongly cyclical and tend to fall in the short term when the economy is hit by strong, negative shocks. This short-term effect is reinforced by the credit squeeze typically resulting from a financial crisis. The crisis is also likely to affect the volume of investment in the longer term due to increased uncertainty about the economic outlook. This greater uncertainty may lead to higher risk premiums, thereby dampening the investment appetite. The level of investment has been particularly hard hit during the current crisis, which has brought the accumulation of capital in the Danish economy to a complete halt, cf. Chart 10.1. Hence, the capital stock is smaller today than before the outbreak of the crisis, which has contributed to lower growth in the level of potential output.

As a rough estimate of the magnitude of this effect, we can compare the actual development in the capital stock with the development in the years 2000-08, which resulted in an average quarterly growth rate of 0.32 per cent. If this development had continued after 2008, the capital stock today would have been 3.3 per cent larger than its actual size. Under the usual assumption that the elasticity of output with respect to capital is 0.35, this missed capital accumulation can be translated into a loss of potential output of just over 1 per cent.

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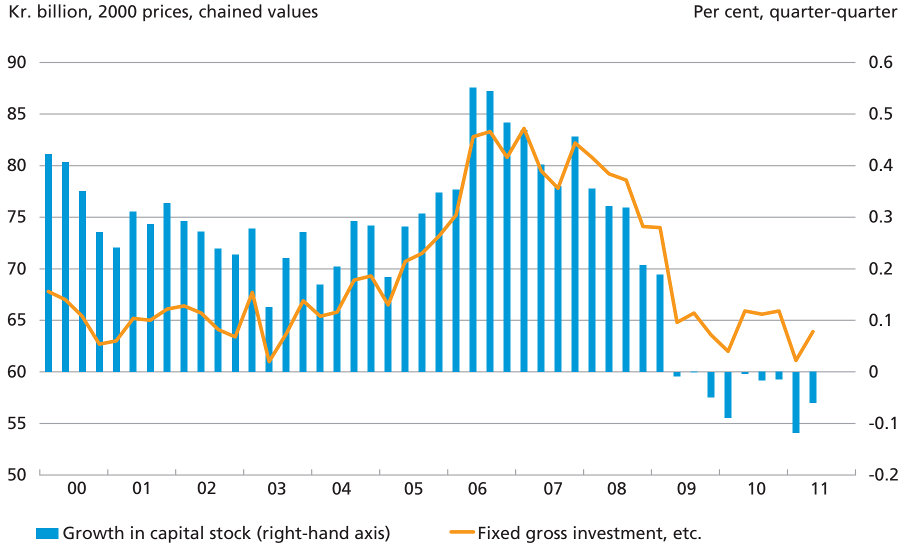
[1] This interpretation is supported by the empirical literature on the consequences of financial crises to *actual* output: The historical experience of a large number of countries shows that financial crises often entail permanent, or at least prolonged, output losses, cf. *inter alia* Cerra and Saxena (2008), IMF (2009), Cecchetti et al. (2009) and Reinhart and Rogoff (2009). See also the analyses of the real economic consequences of Danish banking crises in Abildgren et al. (2011) in this Monetary Review.

GROSS FIXED INVESTMENT AND GROWTH IN CAPITAL STOCK Chart 10.1



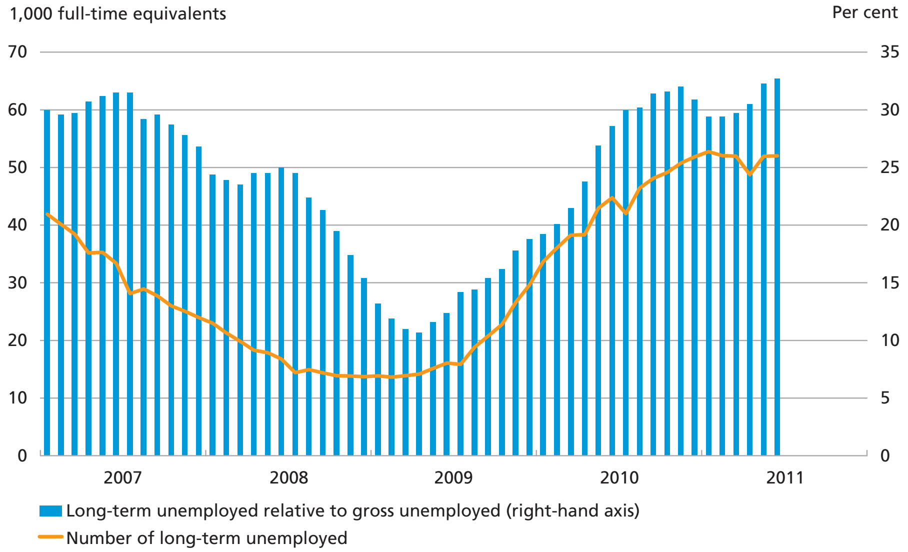
Note: Quarterly figures for the capital stock are calculated by combining annual national accounts figures with quarterly national accounts figures for gross fixed investment, given the assumption of a constant depreciation rate within the same year.
Source: Statistics Denmark and own calculations.

Besides the investment channel, the crisis may also have had a negative impact on the size of the capital stock via extraordinary depreciation of existing capital equipment. Many firms have failed, and, moreover, the remaining firms are likely to have a large need of restructuring. The possible implication is that part of the existing capital stock has become redundant, or at least that the value has deteriorated strongly. However, the extent of such extraordinary deterioration of value is difficult to measure, and it is doubtful whether the effect of the deterioration is captured in the official figures for the size of the capital stock. Consequently, there is a real risk of measurement error in the size of the capital stock, and such errors will be registered in the TFP residual. A non-measurable fall in the capital stock will thus result in a lower TFP measure, cf. below.

Structural unemployment and structural participation rate

The financial crisis triggered a sharp increase in actual unemployment in 2009 following the historically low levels in 2007 and 2008. Such increase in actual unemployment may possibly impact the development in structural unemployment via *hysteresis* effects: Persons who are jobless for a relatively long time and unable to keep their qualifications updated will be harder to re-employ, which entails an increase in structural unemployment, cf. Blanchard and Summers (1986) and Blanchard (1991).

LONG-TERM UNEMPLOYMENT SINCE 2007 Chart 10.2



Note: The number of long-term unemployed persons is calculated as the number of gross unemployed recipients of unemployment benefits or cash or start-up benefits in match group 1, converted to full-time equivalents who have been unemployed/in activation for at least 80 per cent of the time within the last 52 weeks.
Source: Jobindsats.dk

The risk of hysteresis is particularly great if the increase in actual unemployment results in a higher number of long-term unemployed, cf. Ball (2009). Long-term unemployment rose by almost 40,000 in the period from March 2009 to January 2011, cf. Chart 10.2. Viewed in isolation, this causes some concern about the consequences for structural unemployment in the longer term. It should be noted, however, that the rise in long-term unemployment can to a reasonable extent be characterised as a return to normal, and the share of long-term unemployment out of total gross unemployment is now roughly the same as at the beginning of 2007.

Indeed, the results in section 4 do not indicate any increase in structural employment since the outbreak of the crisis. Unemployment has risen, but has so far stabilised at a level close to the level which – also before the crisis – is generally considered to be consistent with stable wage and price developments. Despite the higher unemployment, the wage share is still somewhat higher than its historical average, cf. Chart 4.2, although it has declined substantially from the peak in 2009.

All in all, developments so far seem to indicate that the increase in unemployment in the wake of the financial crisis can be characterised as closing a large, negative unemployment gap, while there are no indications of higher structural unemployment. One contributing factor may be the reduction of the maximum unemployment benefit entitlement period from four to two years, which was adopted as part of the unemployment benefit reform in May 2010 and should be expected to lead to lower structural unemployment.

Theoretically, the effect of the financial crisis on the structural participation rate may go either way: In the short term, poorer employment opportunities may induce more people to withdraw from the labour market as a result of a "discouraged worker effect", cf. section 5. Conversely, the falls in equity and house prices that characterised the early stages of the financial crisis may have made it more difficult to withdraw from the labour market, which may have contributed to a higher participation rate, especially for the elderly part of the population. Both of these short-term effects may influence the structural participation rate in the medium term, as it may be difficult to return to the labour market after withdrawal.

The actual development in the participation rate since autumn 2008 indicates that the first of the above effects has dominated. In this connection it is worth noting that the decline in the participation rate is, to a higher degree than in previous recessions, attributable to an increase in the number of students, cf. also section 8. It is likely that part of this group will be willing to return to the labour market when cyclical conditions normalise, pointing to a limited negative impact on the structural participation rate.

It should be emphasised, however, that this does not mean that the participation rate will return to its 2007 level: As a result of the overheating of the Danish economy, the participation rate in that year was considerably *higher* than its structural level, cf. section 5, so a return to this situation would not be sustainable.

Structural TFP

Theoretically, the effect of the financial crisis on TFP is the most inconclusive. This reflects general uncertainty as to what exactly the TFP residual measures and which factors determine its size. On the negative side, it can be argued that the cyclical downturn, the tighter credit terms and reduced risk appetite will reduce the volume of investment in research and development in the private sector, which will result in lower TFP growth in the long term. Moreover, credit squeezes may delay necessary, but costly restructuring measures in the economy, locking resources in less productive sectors. On the other hand, a severe recession may have a "purging effect", weeding out the least productive firms in the economy and freeing resources to more productive firms.[1]

[1] This effect is often called "creative destruction", cf. Schumpeter (1942).

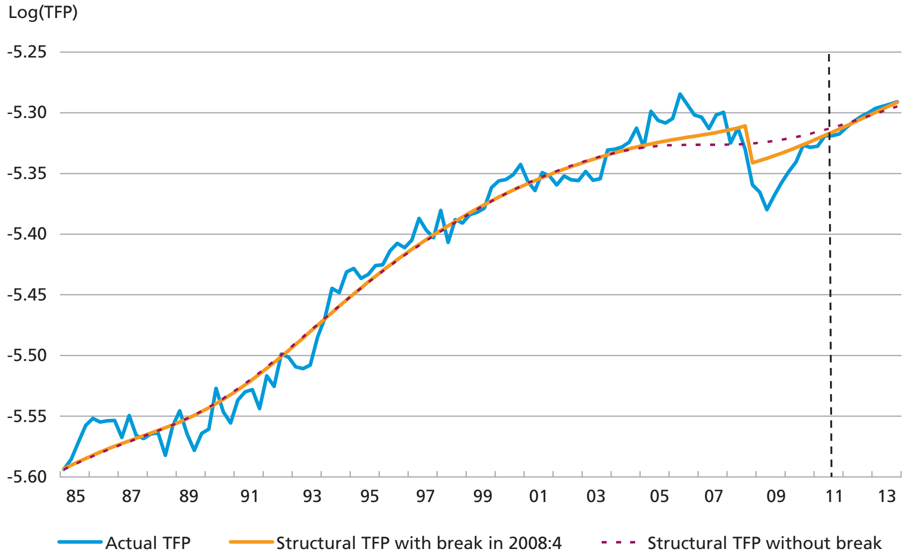
The results in sections 6 and 7 indicate that the growth in structural TFP has been unusually low after the financial crisis, but according to the estimates here, this effect began already *before* the outbreak of the crisis. The lowest growth rates for structural TFP are thus observed in 2006 and 2007. Compared with the development in actual TFP, this results in large, positive TFP gaps immediately before the crisis and correspondingly large, negative gaps in 2009 and 2010. This is interpreted as significant overheating of the Danish economy in the years leading up to the financial crisis, and, as a result, the eruption of the financial crisis triggered a "boom-bust" pattern around an otherwise stable potential level. The unusually high capacity utilisation in manufacturing industry before the crisis also supports this interpretation to a certain extent, cf. also section 6.

It should be borne in mind, however, that the results for the TFP gap depend to a high degree on our assumptions and especially on our view of potential output as a level that may change over time, but does not fluctuate sharply from quarter to quarter. Using the extended HP filter, the abrupt fall in actual TFP in the 4th quarter of 2008 will not only lead to reduction of the estimates of structural TFP in the subsequent quarters, but will also pull down the estimates for the *preceding* quarters.
As mentioned in the introduction to this section, it is not evident that the level of potential output and its components, including structural TFP, followed a stable, smooth course at the end of 2008 and the beginning of 2009. Extraordinary depreciation of capital equipment that was suddenly made redundant may, for example, have led to an abrupt one-time drop in the level of potential output. As explained above, this will most likely appear as a drop in the *measured* TFP level.

Consequently, as an alternative to the estimates in section 6, we have performed an estimation of structural TFP allowing a one-time structural break in the 4th quarter of 2008. The size of the break has been estimated by including a simple dummy variable in the extended HP filter. This approach causes the estimated series for structural TFP to dive by 3 per cent in the 4th quarter of 2008, cf. Chart 10.3. Compared with the estimates without a structural break, and in accordance with expectations, this means that the estimates of structural TFP are higher during the boom leading up to the break, but lower in the crisis years after the break.

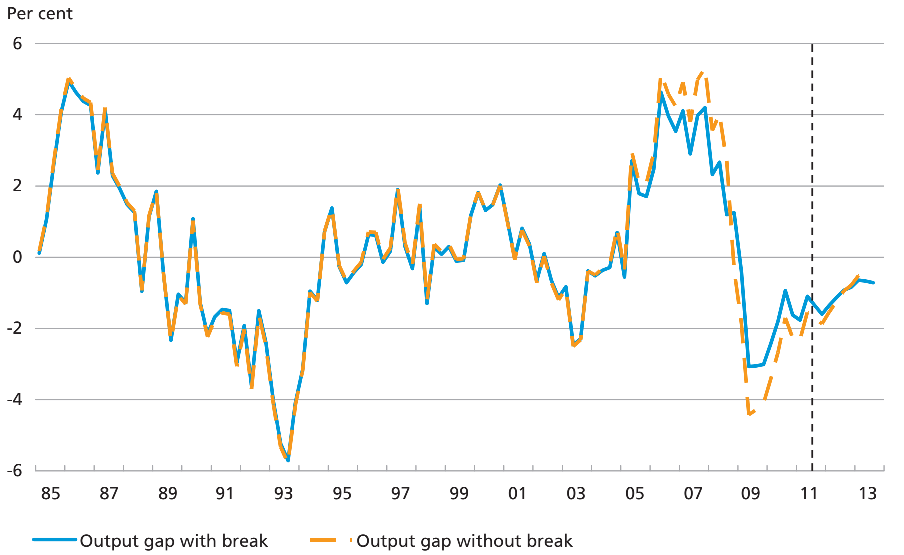
In combination with the development in capital, population, structural unemployment and structural participation rate, the sudden drop in structural TFP causes the level of potential output to fall by 2.7 per cent in the 4th quarter of 2008. Relative to the estimations without a structural break, this implies somewhat more dampened fluctuations in the output gap around of the turn of the year 2008/09, cf. Chart 10.4. This

STRUCTURAL TFP WITH BREAK IN Q4 2008 Chart 10.3



Note: The figures to the right of the dashed line are based on Danmarks Nationalbank's latest forecast of the Danish economy.
Source: Statistics Denmark and own calculations.

OUTPUT GAP WITH AND WITHOUT STRUCTURAL BREAK IN Q4 2008 Chart 10.4



Note: In the estimation with a break in structural TFP, the potential output level drops 2.7 per cent in Q4 2008. In the estimation without a break, it rises 0.4 per cent in the same quarter. The figures to the right of the dashed line are based on Danmarks Nationalbank's latest forecast of the Danish economy.
Source: Statistics Denmark and own calculations.

reflects that the estimated level of potential output tends to mirror the development in actual GDP to a higher degree. But it is notable that the output gaps in 2005-07 remain unusually large.

The estimation with the structural break provides for a slightly different interpretation of recent years' events: According to this interpretation, the growth in potential output in the boom years 2005-07 was indeed dampened, but not unusually low, until a sudden collapse in the world economy in the autumn of 2008 led to a unique drop in the productive capacity of the Danish economy. However, even with this interpretation, it remains beyond doubt that the Danish economy was exposed to severe capacity pressures in the years leading up to the financial crisis.

11. FROM OUTPUT GAP TO STRUCTURAL BALANCE

Public finances in Denmark are subject to a high degree of cyclicality. In a boom, the public finances automatically improve since higher output, incomes, consumption and employment generate higher revenue from direct and indirect taxes and lower expenditure for transfer incomes. Conversely, revenue tends to fall and expenditure tends to increase in an economic slowdown. As a result of this cyclicality, the actual balance is not an accurate measure of the underlying fiscal position.

In this section, we illustrate how estimates of the output gap can be used to calculate a *structural* budget balance. The structural balance is the actual balance adjusted for cyclical and temporary fluctuations, thus providing a more accurate picture of the fiscal position in the medium term. Several economic institutions calculate estimates of the structural budget balance in Denmark, and the calculations are included in their assessments of the public finances and current fiscal policy. The structural balance plays a particularly large role in an EU context, since it is included as a key element in the European Commission's assessment of a member state's compliance with the Stability and Growth Pact.

The structural balance is calculated on the basis of the actual balance in the following way:

Structural balance = Actual balance – Cyclical component – Special items

The *cyclical component* reflects the effect of the cyclical position on the actual balance. Estimates of the size of the output gap are a key element of the calculation of this component. Consequently, the first step in identifying the cyclical component is to find out how the cyclical position deviates from normal, and the output gap is indeed a measure of the sign and size of this deviation.

Another necessary element of the calculation of the cyclical component is to determine the sensitivity of the balance to fluctuations in the output gap. The sensitivity can be expressed by a budget factor indicating the change in the government balance as a percentage of GDP on a 1 percentage point increase in the output gap. In this article, the budget factor is calculated by means of simulations using Danmarks Nationalbank's macroeconometric model of the Danish economy, MONA. The simulations describe the change in a number of government revenue and expenditure items on an increase in GDP as a result of higher aggregate demand, summarising the results as a total budget factor, cf. Box 11.1. The cyclical contribution to the actual budget balance in a given year is then found by multiplying the budget factor by the output gap for the year in question.

The last step in the calculation of the structural balance is to adjust for a number of *special* items. They are budget items that may fluctuate substantially from year to year due to temporary factors, so they may exert strong influence on the actual budget balance in a particular year, but their fluctuations do not systematically follow the business cycle.
These items consist firstly of revenue from pension yield tax, which is strongly influenced by the development in equity and bond prices. Furthermore, we adjust for corporate tax proceeds, excluding revenue from North Sea production, since the fluctuations of the corporate tax of the financial sector do not necessarily match the business cycle. North Sea revenue is subject to separate adjustment, since it is strongly affected by oil price fluctuations. Car sales follow the business cycle only to a limited extent, so separate adjustment is made for revenue from registration fees. In addition, we make adjustment for the possible variation in government interest costs from year to year due to temporary interest-rate fluctuations. Similarly other special budget items, e.g. transfers to the EU, Greenland and the Faroe Islands, early retirement benefits and state pensions to Danes abroad, etc. are subject to separate adjustment as they do not follow the business cycle either. In this article, we apply the adjustments of these special items performed by the Danish Ministry of Finance.[1]

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[1] The adjustment of the respective items is described in more detail in Skaarup (2005) and Economic Survey, August 2011.

CALCULATION OF BUDGET FACTOR IN MONA Box 11.1

The cyclical component in a given year is calculated on the basis of the formula:

$$Cyclical\ component_t = \varepsilon_t \cdot output\ gap_t \,.$$

The output gap has been converted to annual levels, based on the quarterly figures from the preceding sections. The parameter ε is the budget factor defined as:

$$\varepsilon_t \equiv \frac{d(B_t / (P_t \cdot Y_t))}{dY_t / Y_t^*} \,,$$

where *B* is the government budget balance, *P* is the GDP deflator, and *Y* is real GDP. The budget factor indicates how much the government balance, in per cent of nominal GDP, changes when real GDP changes by 1 per cent of potential GDP. The expression of the budget factor can be rewritten as:

$$\varepsilon_t = \left[\sum_i \left(e_{B^i,Y} \cdot \frac{B_t^i}{P_t \cdot Y_t} \right) - \frac{B_t}{P_t \cdot Y_t} \right] \frac{Y_t^*}{Y_t} \,, \qquad (11.1)$$

where $e_{B^i,Y}$ denotes the elasticity of budget item *i* with respect to real GDP.[1] The expression in square brackets in equation (11.1) captures the effect on the balance, as a percentage of GDP, of a 1 per cent increase in GDP. It consists firstly of the sum of changes in the individual budget items.[2] For a given budget item, this can be found by multiplying the elasticity of the budget item with respect to real GDP by the item's share of nominal GDP in the year in question. The elasticities are here assumed to be constant, while the budget items' shares of nominal GDP may vary year-on-year. This can result in variation in the budget factor over time, cf. Chart 11.1. The second term in the square brackets represents the effect of a numerical decline, all other things being equal, of the balance as a percentage of nominal GDP when GDP increases. Finally, the expression in the square brackets is multiplied by the ratio of potential GDP to actual GDP in the year in question, thus taking into account that the output gap is expressed as a percentage of *potential* GDP.

The elasticities of the individual budget items are estimated using simulations in MONA. The simulations investigate the fiscal effects of a shock to the model's private demand components, increasing real GDP by 1 per cent relative to a similar scenario without shocks.

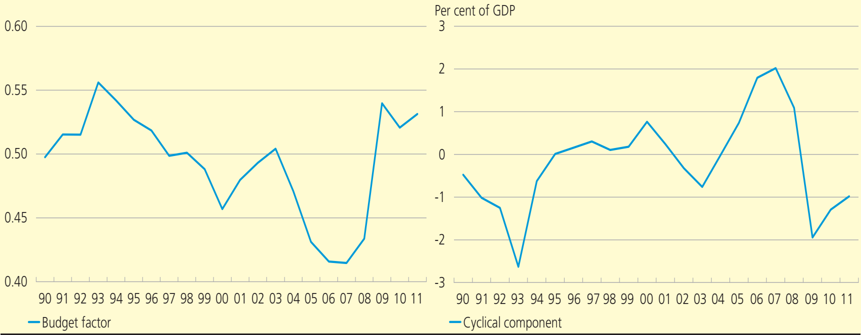
When modelling the demand shock, it is necessary to determine the demand component driving the increase in GDP. This choice is of great significance to the effect on the individual budget items and hence to the size of the total budget elasticity. This reflects varying taxation of different demand components, among other factors. For example, private consumption has a high content of indirect taxes and duties, whereas this content is very low in export goods. Ideally, this should lead to varying budget factors depending on the type of shock that should be regarded as the cause of the size of the output gap in the year in question. The estimates of the output gap as calculated in this article contain no information about the factors determining the size of the output gap, however.[3]

CONTINUED Box 11.1

Consequently, the increase in GDP is modelled by means of a proportional shock to private consumption, private investment and net exports. The calculated budget factor can thus be taken as an expression of the sensitivity of public finances to "average", demand-driven cyclical fluctuations.

The budget sensitivity to changes in GDP also depends on the choice of time horizon. The reason is a certain lag in the adjustment of employment, prices and wages. For example, the rise in employment in MONA will not occur until a few quarters after the increase in demand, resulting in a certain lag in the effect on the public finances. In order to take this into account, the final elasticity of each budget item is calculated as an average of elasticities in the first three years after the demand shock.

BUDGET FACTOR CALCULATED IN MONA AND THE CYCLICAL COMPONENT Chart 11.1



Note: The cyclical component is calculated by multiplying the budget factor for the year in question by the output gap in the same year.
Source: MONA data bank and own calculations.

The calculated budget factor fluctuates between 0.42 and 0.56, averaging 0.49. This budget sensitivity is somewhat lower than the findings of other institutions for Denmark. The Danish Ministry of Finance finds that the government budget changes by 0.79 per cent of GDP on a change by 1 percentage point in the output gap (Skaarup, 2005), while the OECD's corresponding figure is 0.59 per cent of GDP (André and Girouard, 2005). The differences can be attributed to different estimation approaches, among other factors. The OECD calculates the budget factor on the basis of econometric estimations of elasticities for a limited number of budget items, cf. André and Girouard (2005), while the Ministry of Finance applies a different macroeconometric model, ADAM, than we do. Despite strong similarities, the two models are not identical, so the calculations produce different budget factors. For example, ADAM takes into account the progressivity of income taxation, while MONA applies an average income tax rate to all income levels. This can contribute to a lower budget factor calculated in MONA.

[1] In the derivation of the expression in equation (11.1) it is assumed that the GDP deflator *P* is exogenous, disregarding that a demand-driven change in GDP will also lead to a change in the price level. In the short term, the change is limited, however, so we exclude this effect from our calculation of the budget factor.

[2] In this connection, expenditure items are counted as negative budget items, while revenue items are counted as positive budget items.

[3] Note that the output gap can, of course, be decomposed into the TFP gap, unemployment gap and participation rate gap, cf. previous sections. Such decomposition shows *how* the output gap is reflected on the supply side of the economy, but not *why* it has that particular size.

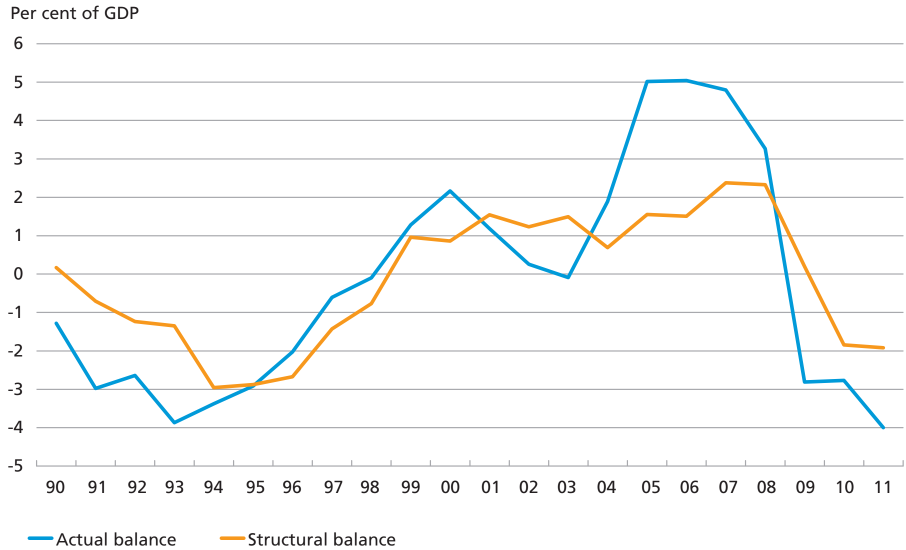
Denmark's structural budget balance 1990-2011

The structural balance has fluctuated strongly since 1990, cf. Chart 11.2, mainly due to the effects of structural policy, but also to fiscal policy activism. The structural balance deteriorated in the early 1990s. The weakening was particularly pronounced in 1994, which can be attributed to the easing of fiscal policy in connection with the "kick-start". From 1996 until the millennium rollover, the structural balance improved from a significant deficit to a surplus. This should be viewed in the light of an increase in structural employment in the same period due to the marked fall in structural unemployment, which was partly offset by a lower participation rate, however. Moreover, the expansionary measures in connection with the kick-start were gradually rolled back as the economy recovered, which also contributed to strengthening the structural balance.

From 2000 until the outbreak of the financial crisis in late 2008, the structural balance showed a stable surplus. The expansionary measures, such as the tax cuts in 2004 and increased public consumption, were offset by lower structural unemployment, lower interest costs and, especially in 2005-08, an extraordinarily high level of investment, which boosted potential output.

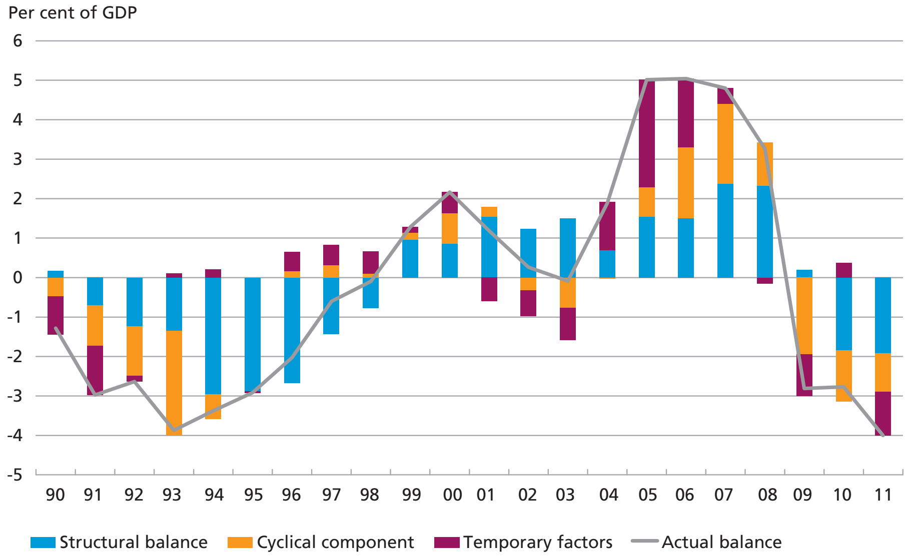
2009-10 saw a considerable deterioration of the structural balance due to the pronounced easing of fiscal policy as a reaction to the severe economic slowdown in the wake of the financial crisis. This deterioration

STRUCTURAL BALANCE IN DENMARK 1990-2011 Chart 11.2



Note: Figures for 2011 are based on Danmarks Nationalbank's latest forecast for the Danish economy.
Source: Statistics Denmark, Ministry of Finance and own calculations.

DECOMPOSITION OF ACTUAL BUDGET BALANCE 1990-2011 Chart 11.3



Note: Figures for 2011 are based on Danmarks Nationalbank's latest forecast for the Danish economy.
Source: Statistics Denmark, Ministry of Finance and own calculations.

has now ceased as a result of, *inter alia*, the subsequent consolidation effort in the form of e.g. the Fiscal Consolidation Agreement from May 2010. The structural deficit for 2011 has been estimated to be 1.9 per cent of GDP.

The substantial discretionary easing in 2009 and 2010 was supplemented by the effect of the automatic stabilisers that play a key role for the government budget in Denmark. The cyclical component is a decisive factor for the development in the actual balance, cf. Chart 11.3. For example, in the period 2005-08, the cyclical component contributed significantly to the surplus on the actual balance, whereas it strongly reduced the actual balance in 2009-11.

TECHNICAL APPENDIX

Theoretical basis for equation (4.1)

The theoretical background for the specification in equation (4.1) is based on the following simple model of wage and price developments in a small, open economy:

$$\Delta w_t = \Delta p_t + \eta \cdot \Delta y_t - \theta(w-p-y)_{t-1} - \gamma \cdot u_{t-1} + a_{t-1} + \varepsilon_t^w \qquad \text{(A.1)}$$

$$\Delta p_t = \lambda(\Delta w_t - \Delta y_t - \omega(1-(w-p-y)_{t-1} - q^*)) + (1-\lambda)\pi_t^* + \varepsilon_t^\pi . \qquad \text{(A.2)}$$

Equation (A.1) states that the relative change in nominal wages depends on price inflation (Δp), productivity growth (Δy), unemployment in the preceding quarter (*u*) and a temporary noise term (ε^w). The variable *a* captures time-varying structural factors influencing wage formation. One example is the degree of compensation of the unemployment benefit system, but *a* may also include other factors that may be difficult to observe or measure. If the parameter θ is positive, wage inflation is furthermore influenced by an error correction mechanism via the ratio of real wages (*w-p)* to productivity (*y*) in the last quarter. If productivity is approximated by average labour productivity, this ratio corresponds to the wage share. There is empirical evidence that this error correction mechanism is a widespread phenomenon in wage formation in European labour markets, cf. Blanchard and Katz (1999).

Equation (A.2) states that domestic inflation depends on domestic factors, inflation abroad (π^*) and temporary price shocks (ε^π). The domestic factors firstly depend on unit labour costs, expressed as growth in real wages less productivity growth. In addition, a positive relation is assumed between inflation and the wage share in the last period. The reason is that firms will aim at a certain profit ratio, q^*. Consequently, if the wage share becomes too high and the profit ratio too low, they will try to counter this by raising prices more than warranted by inflation abroad and the development in unit labour costs.

Long-term equilibrium is defined as a situation without temporary shocks where productivity growth equals its long-term trend value, Δy^*, and where the growth rate for real wages equals that for productivity. Furthermore, in a small, open economy pursuing a fixed-exchange-rate policy, inflation in the long-term equilibrium must equal inflation abroad. By combining equations (A.1) and (A.2) and inserting $\varepsilon^w = \varepsilon^\pi = 0$, $\Delta y = \Delta y^*$, $\Delta w - \Delta p = \Delta y$ and $\Delta p = \pi^*$, structural unemployment in period t-1 is given as:

$$u_{t-1}^* = \frac{1}{\gamma}\left(a_{t-1} - \theta(1-q^*) - (1-\eta)\Delta y^*\right).$$

Hence, equation (A.1) can be rewritten as

$$\Delta ws_t = -\theta\left(ws_{t-1} - ws^*\right) - \gamma \cdot (u_{t-1} - u_{t-1}^*) - (1-\eta)(\Delta y - \Delta y^*) + \varepsilon_t^w , \qquad \text{(A.3)}$$

where $ws \equiv w - p - y$ can be approximated by the wage share, and $ws^* \equiv 1 - q^*$ is the equilibrium wage share. It should be noted that equations (4.1) and A.3) are almost identical. The only difference is that (4.1) includes more lags of the wage share and productivity growth on the right-hand side, and that equation (4.1) includes more control variables that are likely to exert temporary influence on the change in the wage share.

Technical description of the model for structural unemployment

The model consists of the following equations:

$$u_t = u_t^* + u_t^c \tag{A.4}$$

$$\Delta u_t^* = \rho \cdot \Delta u_{t-1}^* + \zeta_t \ , \ \zeta \sim N(0, \sigma_\zeta^2) \tag{A.5}$$

$$u_t^c = \alpha_1 u_{t-1}^c + \alpha_2 u_{t-2}^c + \kappa_t \ , \ \kappa \sim N(0, \sigma_\kappa^2) \tag{A.6}$$

$$\Delta ws_t = \sum_{i=1}^{4} \left(\alpha_i (ws_{t-i} - ws^*) \right) - \gamma \cdot u_{t-1}^c + \mathbf{x}_t{}'\beta + \varepsilon_t \ , \ \varepsilon \sim N(0, \sigma_\varepsilon^2), \tag{A.7}$$

where u denotes registered net unemployment as a percentage of the labour force. In equation (A.4), this is decomposed into a structural component, u^*, and a cyclical component, u^c.

Equation (A.5) models the change in structural unemployment as an autoregressive process without specifying the drivers of the change. The parameter ρ indicates the persistence of the process. In the special case $\rho = 1$, the change in u^* will follow a random walk, whereby u^* is I(2). In the special case $\rho = 0$, u^* will itself follow a random walk and thus be I(1).

In equation (A.6), it is assumed that the cyclical component can be described by an AR(2) process. The autoregressive parameters α_1 and α_2 should meet the conditions for stationarity $|\alpha_2| < 1$, $\alpha_1 + \alpha_2 < 1$ and $\alpha_2 - \alpha_1 < 1$. This formulation takes into account that cyclical fluctuations in unemployment may be persistent, but they are still temporary. Hence, the equation implies that actual unemployment, viewed over longer periods, tends to fluctuate around structural unemployment.

Equation (A.7) describes a relation between the cyclical component of unemployment and the change in the wage share, Δws, conditioned on the latter's previous deviations from its equilibrium value, ws^*, and a number of control variables. The composition of the control variables is given by:

$$\begin{aligned}\mathbf{x}_t{}'\beta = {} & \beta_1(\Delta raa_t - \overline{\Delta raa}) + \beta_2(\Delta raa_{t-1} - \overline{\Delta raa}) + \beta_3(\Delta raa_{t-2} - \overline{\Delta raa}) \\ & + \beta_4(\Delta efkrks_t - \overline{\Delta efkrks}) + \beta_5(\Delta efkrks_{t-1} - \overline{\Delta efkrks}) + \beta_6(\Delta efkrks_{t-2} - \overline{\Delta efkrks}) \\ & + \beta_7(\Delta prod_t - \overline{\Delta prod}) + \beta_8(\Delta prod_{t-1} - \overline{\Delta prod}) + \beta_9(\Delta prod_{t-2} - \overline{\Delta prod})\end{aligned}$$

where raa is the commodity price index, $efkrks$ is the effective krone rate, and $prod$ is hourly productivity in the private non-agricultural sector, all in logarithms. A bar above a variable denotes the variable's sample average. Equation (A.7) corresponds to equation (4.1) and is described in more detail in section 4.

The noise terms ζ, κ and ε are assumed to be normally distributed, independently and identically distributed over time and mutually uncorrelated.

PARAMETER ESTIMATES IN THE ESTIMATION OF STRUCTURAL UNEMPLOYMENT — Table A.1

Parameter	Estimate	Standard error
Coefficients on variables in equation (A.7):		
Unemployment gap (t-1)	-0.40	(0.16)
Wage share (t-1)	-0.67	(0.09)
Wage share (t-2)	0.30	(0.09)
Wage share (t-3)	0.01	(0.09)
Wage share (t-4)	0.26	(0.07)
Commodity price inflation (t)	-0.03	(0.03)
Commodity price inflation (t-1)	0.08	(0.03)
Commodity price inflation (t-2)	-0.10	(0.03)
ΔEffective krone rate (t)	0.02	(0.12)
ΔEffective krone rate (t-1)	0.47	(0.12)
ΔEffective krone rate (t-2)	-0.14	(0.12)
Productivity growth (t)	-0.62	(0.08)
Productivity growth (t-1)	-0.33	(0.10)
Productivity growth (t-2)	-0.05	(0.10)
Long-run equilibrium wage share, ws^*	0.65	
Other parameters:		
α_1	1.719	(0.073)
α_2	-0.752	(0.071)
ρ	0.898	(0.051)
σ_ε	0.052	(0.185)
σ_κ	0.007	(0.024)
σ_ζ	0.002	

Source: Own calculations.

The unobservable variables and model parameters are estimated by maximum likelihood and the double-sided "smoothing" Kalman filter. For an elaboration on the estimation method, reference is made to e.g. Hamilton (1994, Chapter 13). It is well-known that the maximum likelihood method suffers from a potential stability problem that may lead to the variances of the unobservable variables being estimated to be zero. In order to circumvent this problem, the model is estimated subject to the restriction that the variances σ_ζ^2 and σ_κ^2 are locked in the ratio 1/15. The ratio has been chosen so that the smoothness of the resulting series for structural unemployment corresponds to our priors, as suggested by Gordon (1997). All other parameters, including the equilibrium value of the wage share, are estimated without restrictions. The full number of parameter estimates is reported in Table A.1.

Technical description of the model for structural participation rate

The model consists of the following equations:

$$E_t = E_t^* + E_t^c \qquad (A.8)$$

$$E_t^* = E_{t-1}^* - \Delta ogy_t + \mu_1 \cdot \Delta leave_t + \mu_2 \cdot \Delta sh6066_t + \zeta_t\,,\quad \zeta \sim N(0,\sigma_\zeta^2) \qquad (A.9)$$

$$E_t^c = \phi_1 \cdot E_{t-1}^c + \phi_2 \cdot E_{t-2}^c + \chi \cdot u_{t-1}^c + \kappa_t\,,\quad \kappa \sim N(0,\sigma_\kappa^2) \qquad (A.10)$$

$$shortage_t = \eta_0 + \eta_1 \cdot E_t^c + \varepsilon_t\,,\quad \varepsilon \sim N(0,\sigma_\varepsilon^2) \qquad (A.11)$$

PARAMETER ESTIMATES IN THE MODEL FOR STRUCTURAL PARTICIPATION RATE Table A.2

Parameter	Estimate	Standard error
Coefficient parameters:		
μ	-0.76	(0.36)
φ_1	0.84	(0.11)
φ_2	0.04	(0.11)
χ	-0.04	(0.05)
η_0	0.02	(0.00)
η_1	1.32	(0.55)
Variance parameters:		
σ_κ	0.002	(0.003)
σ_ε	0.015	(0.020)
σ_ζ	0.001	

Source: Own calculations.

Equation (A.8) denotes that the participation rate, E, can be decomposed into a structural component, E^*, and a cyclical component, E^c. The remaining equations are described in detail in section 5. As in the model for structural unemployment, it is assumed that all noise terms are normally distributed, independently and identically distributed over time and mutually uncorrelated.

The model is estimated using the Kalman filter and maximum likelihood under a restriction locking the variances σ_ζ^2 and σ_κ^2 in the ratio 1/15. All other parameters are estimated freely. All parameter estimates are reported in Table A.2.

The extended HP filter and structural TFP

In the extended HP filtering of TFP, the logarithm of actual TFP is specified as the sum of a structural component, a cyclical component and a noise term representing non-cyclical stochastic shocks. At the same time, an unknown, linear relationship is postulated between the cyclical component and an external indicator, here the indicator of spare capacity. The estimated series for structural TFP and the TFP gap are then found by solving the following minimisation problem:

$$\min_{\{tfp_t^*, tfp_t^c\}_{t=1}^T, \beta_0, \beta_1} \left(\begin{array}{l} \lambda \sum_{t=3}^{T} \left(\Delta tfp_t^* - \Delta tfp_{t-1}^* \right)^2 + \sum_{t=1}^{T} \left(tfp_t - tfp_t^* - tfp_t^c \right)^2 \\ + \sum_{t=1}^{T} \left(tfp_t^c - \beta_0 - \beta_1 \cdot sparecap_t \right)^2 \end{array} \right), \qquad \text{(A.12)}$$

where tfp_t denotes the logarithm of observed TFP in quarter t, tfp_t^* is the estimated level of the logarithm of structural TFP, tfp_t^c is the estimate of the logarithm of the cyclical component and $sparecap_t$ is the indicator of spare capacity. The latter is scaled so that the value zero corresponds to the average value in the sample. The parameter λ is the well-known weighting parameter from the HP filter, which is set here at the standard value 1600 for quarterly data.

OLS REGRESSION OF CYCLICAL TFP COMPONENT ON INDICATOR OF SPARE CAPACITY Table A.3

Variable	Coefficient	Standard error
Spare capacity	-0.10	(0.00)
Constant	-0.00	(0.00)
R^2	0.83	
Observations	119	

Source: Own calculations.

The parameters β_0 and β_1 describe the relationship between the indicator of spare capacity and the estimated cyclical component of TFP. They are both estimated simultaneously with the series for structural and cyclical TFP, and the estimates correspond to the parameter estimates obtained by OLS regression of the estimated series for the cyclical component on the indicator. In relation to the well-known HP filter, the extended HP filter includes an extra criterion in the objective function in (A.12), i.e. the sum of the squared residuals from such regression.

Table A.3 shows the regression output from the estimated relationship between the cyclical TFP component and the indicator of spare capacity. The coefficient on the indicator of spare capacity is negative and clearly significant. This means that higher capacity utilisation is associated with a larger cyclical TFP component, so minimisation of the sum in (A.12) will result in a larger estimate of the cyclical component of TFP in the quarters with high capacity utilisation.

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