

# EXCHANGE RATE PASS-THROUGH TO DANISH IMPORT AND CONSUMER PRICES

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## INTRODUCTION AND SUMMARY

Price developments play a key role in Denmark's Nationalbank's ongoing assessment of the Danish economy. Increased pressure on production resources will often lead to higher wage and price increases, while a downturn will have a dampening effect. Moreover, in a small, open economy like Denmark, prices are also very much influenced by external factors. This applies not least to developments in the effective krone rate.<sup>1</sup> Due to Denmark's fixed exchange rate policy, the krone is stable against the euro. However, currencies other than the euro have a weight of 54.3 per cent in the calculation of the effective exchange rate of the krone.<sup>2</sup> This means that the effective krone rate mirrors fluctuations in the euro.

This article analyses pass-through of fluctuations in the nominal effective krone rate to import and consumer prices. As regards import prices, pass-through happens already within 1-2 months, although it is not complete. This indicates that some exporters adjust their prices to the Danish market. Pass-through to consumer prices is considerably weaker, reflecting that imports account for only part of private consumption. Furthermore, domestic distributors absorb part of the exchange rate fluctuations in their profit margins. Consequently, since 1998 the estimated pass-through to consumer prices has

been weaker than immediately warranted by the import content of private consumption. There are no indications that changes in the effective krone rate lead to a persistent rise in the rate of price increases.

The analysis indicates that pass-through is lower than previously. The explanation could be that the fixed exchange rate policy is now perceived as more credible than when it was introduced in 1982. A credible monetary policy regime has less scope for a shock to the exchange rate to impact the rate of price increase beyond the very short term. Moreover, the fact that Denmark's current anchor currency, the euro, is, to a higher degree than the D-mark, a major global currency may also play a role. Cross-border trading is often invoiced in major currencies. Pass-through may be reduced if a large share of Denmark's trade with non-euro area countries is invoiced in euro. The declining pass-through may also reflect the increasing prevalence of global value chains or the intensified competition in the product markets.

For a firm exporting to Denmark, fluctuations in the exchange rate between the krone and the currency of the exporter's home country will be passed through to either the firm's price competitiveness in the Danish market or its profit margins. To a certain extent, exchange rate fluctuations can

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1 The effective krone rate is a weighted average of the krone's rate against the currencies of Denmark's largest trading partners.

2 See Denmark's Nationalbank (2014) regarding the current set of weights.

be addressed by hedging via the financial markets. But this implies extra costs for firms.

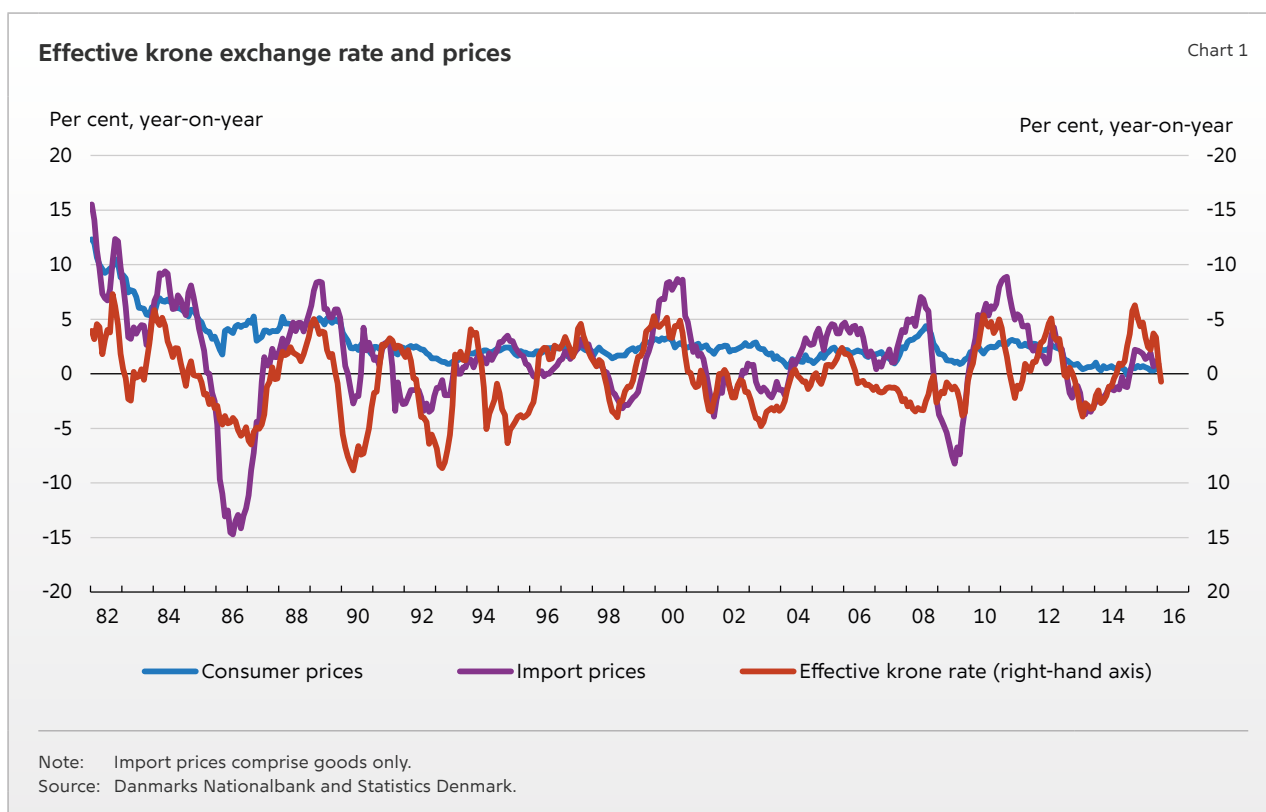
Against this backdrop, the fixed exchange rate of the krone vis-à-vis the euro may contribute to promoting trade between Denmark and abroad. Danish Economic Councils (2009) find that Denmark, like the euro area member states, has reaped considerable trade gains from the introduction of the euro. This is not the case for e.g. Sweden and the UK, given their floating exchange rates.

## EXCHANGE RATES AND PRICES

Exchange rate pass-through is a measure of the effect of a change in the nominal effective krone exchange rate on prices in Denmark. Danish firms trading with abroad invoice in either Danish kroner or foreign currency. If the price of a product or service traded across national borders is fixed in a currency other than kroner, exchange rate fluctuations will have a direct impact on import prices. However, a firm exporting to Denmark may also opt for invoicing in kroner. If so, fluctuations in the krone exchange rate will have

no immediate impact on import prices. Instead, the fluctuations in the exchange rate will initially be passed through to the price which the exporter receives for the product, converted into the exporter's currency. The fixed exchange rate policy means that this also applies if imports are invoiced in euro.

In that situation, exchange rate fluctuations will influence exporter's profit margins. If an imported product is invoiced in foreign currency and the exchange rate of the Danish krone appreciates, the price of the product falls when measured in Danish kroner. The exporter thus gains a competitive advantage over exporters from countries whose exchange rates vis-à-vis the krone have not changed, and over Danish manufacturers. The exporter may exploit this advantage to boost exports. Alternatively, the exporter may raise the price in the exporter's own currency, thus increasing the profit margin. This means that exchange rate fluctuations will not be fully passed through to import prices. The exporter's incentive to change its price in its own currency depends, inter alia, on the competitive environment in the export market, cf. Krugman (1987).



Conversely, an exporter invoicing in kroner or euro will not immediately enjoy higher demand if the krone strengthens. But profit margins are increased. Subsequently, the optimum step could be to reduce the price in kroner in order to utilise part of the competitive advantage to boost sales. The invoicing currency may thus be of less importance in the long term. There is not necessarily a clear relationship between the price adjustment resulting from a change in the krone exchange rate and the observed change in imports. This reflects that firms whose profit margins rise as a result of exchange rate fluctuations may seek to increase their exports e.g. by intensifying their marketing efforts.<sup>3</sup>

A share of imports is made up of production equipment, intermediate goods and internationally traded services bought by firms. The price of those imports influences the production costs of Danish firms and hence the prices which consumers pay for goods manufactured in Denmark. Imports also contain goods directly included in private consumption. Fluctuations in the prices of those imports have a more direct impact on consumer prices.

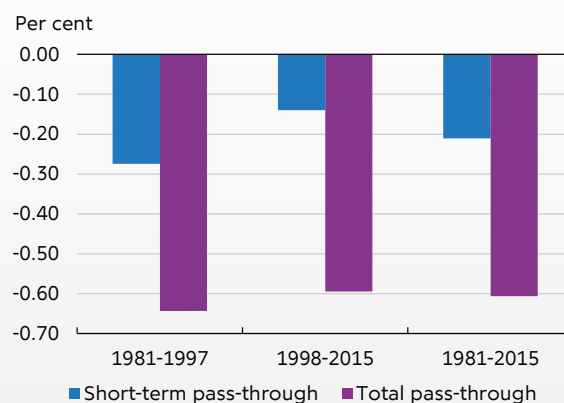
The impact of krone exchange rate fluctuations is far less pronounced in consumer prices than in import prices, cf. Chart 1, reflecting that the import content of private consumption is only around one quarter. But considerable domestic value added is generated even in the consumption of imported goods. For example, the total price of an imported product will contain distribution and marketing expenses, and the final price will also contain indirect taxes. Changes in import prices are to a certain extent absorbed in the profit margins of domestic distributors.

## PASS-THROUGH TO IMPORT PRICES

This section specifies an economic relation estimated on Danish data with a view to providing a more accurate picture of the relationship between the exchange rate and import prices. On the basis

<sup>3</sup> Against this background, the coefficient of an equation stating the response of import and export volumes to exchange rate fluctuations should be interpreted with caution, as there are other transmission channels besides the direct effect of shifts in relative prices.

Chart 2  
Effect of a 1 per cent strengthening of the effective krone rate on import prices



Note: Estimated pass-through to import prices of a 1 per cent strengthening of the nominal effective krone exchange rate, where the estimates are the result of a regression model, cf. Box 1. Import prices cover only goods.

Source: Statistics Denmark and own calculations.

of the analysis, a short-term pass-through and a total pass-through are determined. The methodology is described in Box 1.

According to the analysis, an increase in the nominal effective exchange rate causes import prices to fall. For the period 1981-2015 taken as one, an appreciation of the effective exchange rate by 1 per cent will in the short term (within the same month) entail a drop in import prices of 0.21 per cent, cf. Chart 2. The total effect is a fall of 0.61 per cent.

Exchange rate fluctuations are thus passed through to import prices gradually. This indicates that prices are, to a certain extent, invoiced in kroner or euro and that exporters subsequently adjust their prices against the background of exchange rate developments. However, the estimated relationships also reflect that the exchange rate is a monthly average, while import prices are calculated on the 15th of each month. Hence, exchange rate fluctuations after the 15th will be included in the results for the next month.

The following equation is estimated in order to determine pass-through from the effective exchange rate of the krone to import and consumer prices<sup>1</sup>

$$\Delta p_t = c + \sum_{i=0}^I \delta_i \Delta e_{t-i} + \sum_{j=1}^J \gamma_j \Delta p_{t-j} + \epsilon_t$$

where  $p$  denotes the price,  $e$  is the effective krone exchange rate,  $c$  is a constant, and  $\epsilon$  is an error term. Moreover, a full set of seasonal dummies is included. Prices are from Statistics Denmark, while data for the effective krone rate is from Danmarks Nationalbank. Both prices and the effective krone rate are included in log differences. Import prices denote prices on the 15th of each month, while the effective krone rate is a monthly average. Consumer prices are typically collected between the 7th and the 15th of each month, but less frequently for certain goods and services, cf. Statistics Denmark (2004).

To achieve the best possible specification of the equation, it includes both the current and last month's value for the exchange rate (i.e.  $I=1$ ). In addition, the values for the last two months for import prices are included as explanatory variables (i.e.  $J=2$ ), while up to and including the 12th lag are included in the specification of consumer prices (i.e.  $J=12$ ). This reflects a higher degree of persistence in consumer prices than in import prices. The equation is estimated using

ordinary least squares. The model is estimated on monthly observations for the period 1981-2015. In order to examine whether pass-through has changed over time, the estimation is divided into the sub-periods 1981-97 and 1998-2015.

$\delta_0$  denotes the immediate price response to a change in the effective krone rate, i.e. the short-term pass-through. However, as a result of pass-through being gradual, the total pass-through will deviate from pass-through occurring within the month. Assuming stationarity, total pass-through to the price level can be calculated as

$$\kappa \equiv \frac{\sum_{i=0}^I \delta_i}{1 - \sum_{j=1}^J \gamma_j}$$

The estimation results are shown in the tables below. A 1 per cent appreciation of the nominal effective krone rate entails a decrease of 0.21 per cent in import prices in the short term for the period 1981-2015 as a whole, while the total decline is 0.61 per cent. Both short-term and total pass-through are statistically significant. The corresponding fall for consumer prices is 0.02 per cent in the short term and 0.32 per cent in total. However, the pass-through figures for consumer prices are not statistically significant, which should be viewed in the light of the general uncertainty in the estimation.

### Estimated pass-through to import prices

	1981-1997	1998-2015	1981-2015
Short-term pass-through	-0.2741***	-0.1398*	-0.2109***
	(0.0710)	(0.0828)	(0.0526)
Total pass-through	-0.6434***	-0.5945***	-0.6065***

Note: \*, \*\* and \*\*\* denote levels of significance of 10, 5 and 1 per cent, respectively. Robust standard errors in parentheses.  
Source: Danmarks Nationalbank, Statistics Denmark and own calculations.

### Estimated pass-through to consumer prices

	1981-1997	1998-2015	1981-2015
Short-term pass-through	-0.0410	-0.0070	-0.0192
	(0.0208)	(0.0280)	(0.0155)
Total pass-through	-0.4589	-0.1151	-0.3239

Note: \*, \*\* and \*\*\* denote levels of significance of 10, 5 and 1 per cent, respectively. Robust standard errors in parentheses.  
Source: Danmarks Nationalbank, Statistics Denmark and own calculations.

1. The equation is a standard specification in the literature on exchange rate pass-through, cf. Goldberg and Knetter (1997).

## INDICATIONS OF DECLINING PASS-THROUGH

A number of international studies have found indications of declining pass-through over time.<sup>4</sup> The increasing prevalence of global value chains is often cited as a major cause.<sup>5</sup> A global value chain is characterised by the processes adding value to goods or services being distributed over several countries.<sup>6</sup> For example, depreciation of the pound sterling vis-à-vis other currencies, including the Danish krone, will make Denmark's imports from the UK cheaper. If a product imported from the UK has been produced via a global value chain, the depreciation will only affect the price in Danish kroner for a part of the total value creation, however. This reduces pass-through.

Intensified competition in the product market may also reduce pass-through. In a highly competitive market, even small fluctuations in relative prices will entail considerable shifts in demand. Consequently, firms have only limited scope for passing through exchange rate fluctuations to prices. Another factor which may reduce pass-through is better access for firms to hedge exchange rate risks via financial markets, cf. the European Commission (2015).

### The role of monetary policy

Enhanced credibility of monetary policy may reduce pass-through, cf. e.g. BIS (2015). If a country's currency depreciates and exporters to that country maintain prices in their own currencies, prices in the importing country will rise. A central bank with strong focus on maintaining price stability will seek to address this by raising monetary policy interest rates. This reduces demand and hence price increases. In step with many countries' increasing policy focus on price stability, the scope for exchange rate fluctuations having a permanent impact on inflation has declined.

Denmark's monetary policy stance is not directly aimed at inflation. However, the fixed exchange rate policy is merely an indirect way of obtaining price stability, and a credible fixed

exchange rate policy reduces the potential of pass-through to consumer prices of changes in the exchange rate vis-à-vis currencies outside the anchor country.

Firms' perception of the credibility of the fixed exchange rate policy has strengthened substantially since the introduction of the policy in 1982, so the exchange rate pass-through is calculated for two separate sub-periods. The first sub-period covers 1981-97. During this period, the central rate of the krone against the D-mark was adjusted downwards on several occasions, cf. Chart 3. Although the adjustments of the central rate after the transition to the consistent fixed exchange rate policy in 1982 were not instigated by Denmark, they may have generated a degree of uncertainty in that period.

During this period, Denmark's Nationalbank allowed the krone to fluctuate within a band of +/- 2.25 per cent around the central rate. In connection with the EMS crisis, the fluctuation band was expanded, in August 1993, to +/- 15 per cent, and the krone depreciated markedly. In the subsequent period, the fluctuations of the krone rate were more pronounced than in the preceding years. Since the late 1990s, however, it has been very stable close to the central rate. Against that background, a lower pass-through of fluctuations in the effective exchange rate can be expected.

International trade tends to be invoiced in "major" currencies, not least US dollars. This means that US prices are notably less exposed to exchange rate fluctuations than prices in other countries, cf. Gopinath (2015). The introduction of the euro in 1999 may have entailed that an ever-increasing share of Denmark's non-euro area imports is invoiced in euro rather than in the export country's currency or in dollars. If this is the case, it has contributed to reducing the exchange rate pass-through in Denmark.<sup>7</sup>

The empirical analysis confirms that the short-term pass-through has declined from -0.27 in the period 1981-97 to -0.14 in the subsequent period. The total pass-through has fallen from -0.64 to

4 See e.g. BIS (2015) and Di Mauro et al. (2008).

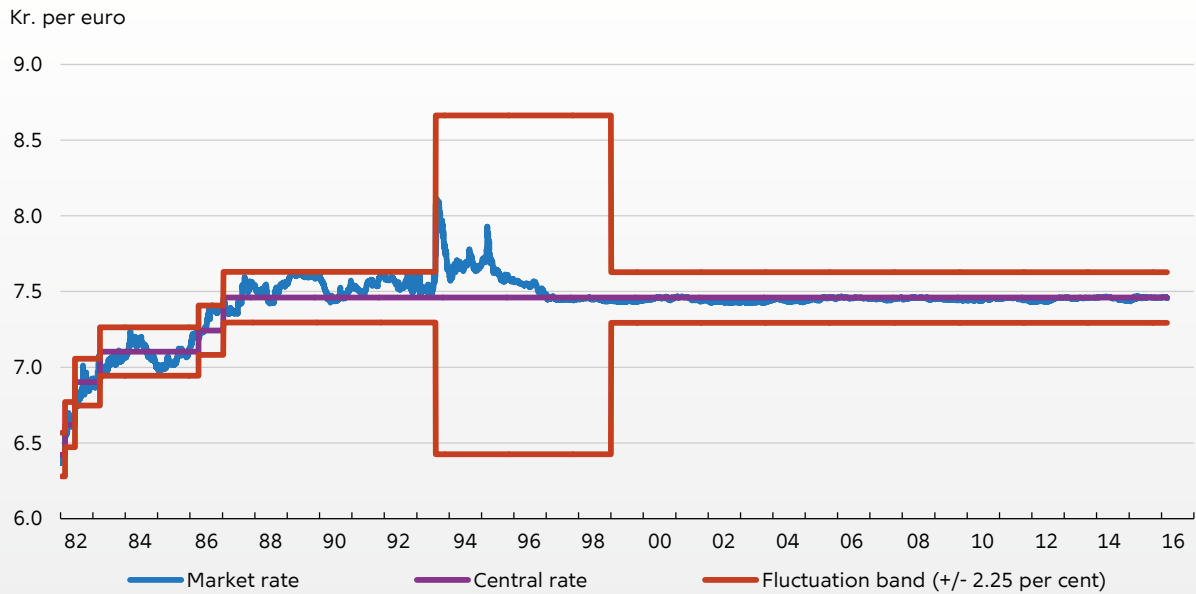
5 See e.g. European Commission (2015).

6 See the article "Global value chains" in this Monetary Review for an analysis of Denmark's role in the global value chains.

7 Kamps (2006) finds indications that the role of the euro as an international invoicing currency is increasing. However, at the time of the analysis, its role was still limited compared with the dollar. Lighthart and Werner (2012) find that the introduction of the euro has entailed that a larger share of Norway's euro area imports is now invoiced in the exporter's currency.

Exchange rate of the krone vis-à-vis the euro

Chart 3

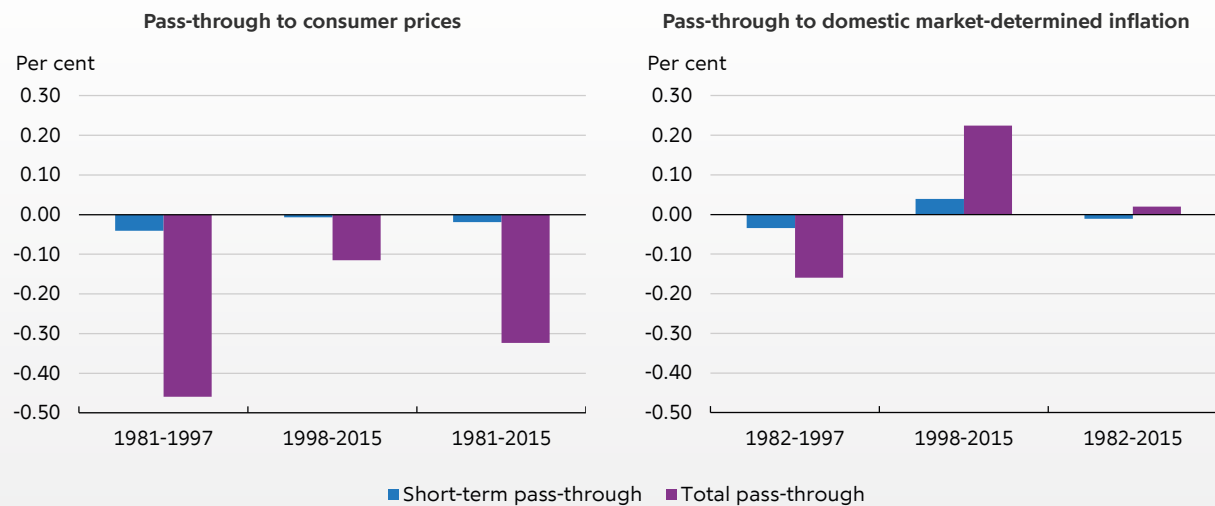


Note: Before 1999 a synthetic exchange rate has been applied for the krone vis-à-vis the euro, calculated on the basis of the krone's exchange rate vis-à-vis the D-mark and the conversion rate between the euro and the D-mark locked on 1 January 1999.

Source: Danmarks Nationalbank.

Effect of a 1 per cent strengthening of the effective krone rate (lower import prices) on consumer prices and domestic market-determined inflation

Chart 4



Note: Estimated pass-through to consumer prices and domestic market-determined inflation, IMI, of a 1 per cent strengthening of the nominal effective krone rate, where the estimates are the result of a regression model, cf. Box 1. Consumer prices are the consumer price index, CPI.

Source: Danmarks Nationalbank, Statistics Denmark and own calculations.

-0.59, although this difference is not statistically significant.<sup>8</sup>

## PASS-THROUGH TO CONSUMER PRICES

The exchange rate of the krone has a direct impact on consumer prices via prices of imported consumer goods and an indirect impact via prices for imported inputs for domestic production. In the short term, a 1 per cent increase in the effective krone rate causes consumer prices to fall by 0.02 per cent for the period 1981-2015 taken as one, cf. Chart 4.<sup>9</sup> The total pass-through is -0.32 per cent.

Pass-through was weaker in the period 1998-2015 than in 1981-97. The lower pass-through to both import and consumer prices in the most recent period may reflect, inter alia, the enhanced credibility of monetary policy, the increasing use of the euro as an invoicing currency and the higher prevalence of global value chains, cf. above. Pass-through to consumer prices has fallen despite a modest increase in the import content, although the estimated pass-through to consumer prices is not statistically significant.

Total pass-through to consumer prices estimated for the period 1981-97 seems disproportionately large, given that the import content of the consumer price index is only around one quarter. This may reflect changes in the inflation rate of a more permanent nature, especially at the begin-

ning of the period, which – given the estimation method applied – may result in overestimation of exchange-rate pass-through.

On the other hand, in the period since 1998, during which the rate of price increases has been more stable, especially short-term pass-through, but also total pass-through, has been lower than immediately warranted by the import content of consumption.<sup>10</sup> Changes in import prices are instead to a certain extent absorbed in the profit margins of domestic manufacturers and wholesalers, which is evidenced by the marginally positive total pass-through to the domestic market-determined inflation, IMI, for the period 1982-2015 taken as one, and by the positive short-term as well as total pass-through in the period 1998-2015.<sup>11</sup> This should be viewed in the light of the considerably enhanced perception among firms of the credibility of the fixed exchange rate policy since the 1980s.

A mechanical calculation of pass-through to consumer prices on the basis of pass-through to import prices and the import content of consumption is, however, subject to considerable uncertainty, since the estimated pass-through to import prices covers only goods, just as pass-through to consumer prices will depend on the impact of higher prices on indirect taxes.

The applied method is relatively simple. A more advanced method shows a relatively modest pass-through to consumer prices, cf. Box 2. According to this method, pass-through in the period 1998-2015 is not markedly different

8 There may be concerns that the strong fluctuations in the prices of selected goods, e.g. energy, lead to strong fluctuations in import prices which are not related to the exchange rate. To examine this, a specification is also considered as from 2005, whereby only prices of imported manufactures are considered, to the exclusion of e.g. commodities. However, this does not entail any substantial shifts in the estimated relationships.

9 Pass-through has been calculated using the same method as for import prices, cf. Box 1.

10 The mechanical pass-through to consumer prices is calculated as the product of the estimated pass-through to import prices and the import content of the consumer price index. The import content, which constitutes the sum of the direct and indirect import contents, has been calculated on the basis of input-output tables showing the share of final consumption (excluding indirect taxes, etc.) made up of imported products (excluding indirect taxes, etc.), by 74 components of consumption, cf. Statistics Denmark (2011). The import content of the consumption components is then weighted using the weights of the consumer price index (distributed on the 74 consumption components of the input-output tables). An input-output table from 1990 has been used for the period 1981-97 and an input-output table from 2006 for the period 1998-2015. Price weights for the respective years are applied. The calculated import content was 24 per cent in 1990 and 27 per cent in 2006.

11 With a view to examining domestic price pressures, Danmarks Nationalbank calculates a price index for domestic market-determined inflation, IMI. On the basis of the headline consumer price index, HICP, the price effect of exogenous factors is gradually excluded, cf. e.g. Hansen and Knudsen (2005) and Mortensen and Staghøj (2015). The exogenous factors which are excluded are energy, unprocessed food, administered prices (e.g. rent, day care institutions and public transport), duties and indirect taxes and the (direct and indirect) import content.

This box presents an alternative estimation of the exchange rate pass-through to consumer prices on the basis of a Bayesian vector autoregressive, BVAR, model, cf. e.g. Litterman (1986). The point of departure is a vector autoregression

$$Y_t = B_1 Y_{t-1} + B_2 Y_{t-2} + \dots + B_p Y_{t-p} + D Z_t + \varepsilon_t$$

where  $Y_t$  is an  $n \times 1$  vector of endogenous variables,  $Z_t$  is a  $d \times 1$  vector of exogenous variables,  $\varepsilon_t$  is an  $n \times 1$  vector of error terms with an expected value of zero and the variance-covariance matrix  $\Sigma$ . The  $B$ s are  $n \times n$  matrices with the parameters for the endogenous variables, while  $D$  is an  $n \times d$  matrix with the parameters for the exogenous variables.

The endogenous variables of the model are the oil price, a short-term interest rate, real GDP, the nominal effective krone exchange rate, import prices, producer prices and consumer prices. All variables except the short-term interest rate are included in logarithms. Two exogenous indicator variables, for the 4th quarter of 2008 and the 1st quarter of 2009, are included in order to take special conditions during the financial crisis into account. The model is estimated on quarterly data, whereas monthly data is applied in the analysis in the main text, and four lags are included ( $p=4$ ). This analysis considers a temporary shock to the krone rate, while the analysis in the main text concerns a permanent shock.

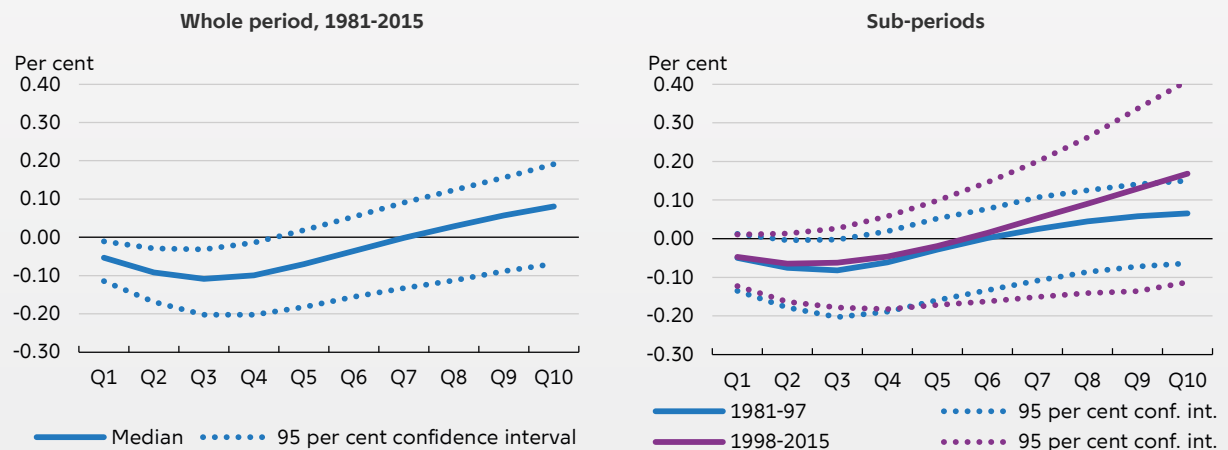
The model is estimated using a Bayesian approach. In Bayesian econometrics, the parameters are regarded as sto-

chastic variables to be characterised by a distribution. This contrasts with classical econometrics, where the parameters are regarded as having a "true" value to be estimated in the best possible way. Combining data for the endogenous and exogenous variables with an a priori distribution of the underlying parameters and the variance-covariance matrix allows estimation of an ex post distribution of the model parameters.

The chosen a priori distribution is a normal Wishart distribution, which is a combination of a multivariate normal distribution for the parameters and an inverse Wishart distribution for  $\Sigma$ . The choice of a priori distribution follows Comunale and Kunovac (2016), who estimate a similar model. The parameters of the model are identified by means of a Choleski factorisation, including the endogenous variables in the order stated above.

Once the model has been estimated, impulse response functions can be derived, showing the effect on the endogenous variables of a shock to one of the other endogenous variables. In this case, the relevant impulse response function is the effect on consumer prices of a shock of 1 per cent to the nominal effective krone rate. For the total period 1981-2015, it is found that pass-through from the effective krone rate to consumer prices is significant for up to four quarters and then the effect becomes insignificant, cf. the chart. In the period 1981-97, the effect is significant in the 2nd and 3rd quarters, while the estimated pass-through is not significant in any of the quarters for the data period 1998-2015. However, the difference in the estimated median pass-through between the two periods is very modest.

Pass-through to consumer prices of a temporary 1 per cent strengthening of the nominal effective krone rate



Note: The impulse response of consumer prices resulting from a shock to the nominal effective krone rate on estimation of the Bayesian vector autoregressive model described above. The shock has been normalised to 1 per cent in the 1st quarter. The BEAR toolbox has been used in the estimation, cf. Dieppe et al. (2015).

Source: Danmarks Nationalbank, Statistics Denmark and own calculations.



from pass-through in the preceding period. This illustrates that the results are subject to some uncertainty.

The gradual pass-through to consumer prices is illustrated in Chart 5 on the basis of the estimation for the period 1998-2015. The effect on the price level in a given month is the result of accumulating the effects on the rate of price increases up to and including that month. Although the effect on the rate of price increases is temporary, changes in the effective krone rate will have a permanent effect on the price level.

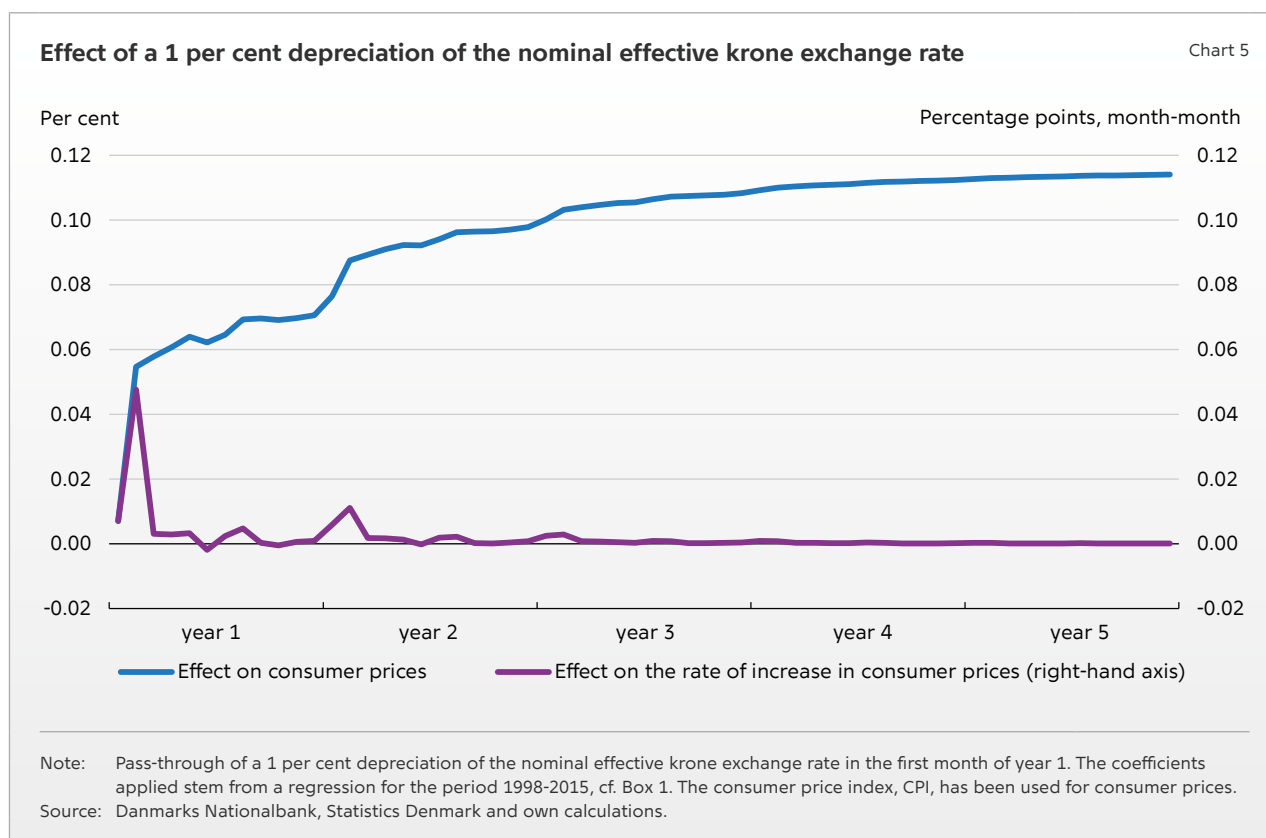
Unless employees have a clear picture of whether inflation will be kept stable in the longer term, they will attach a certain probability to the higher rate of price increases being a permanent phenomenon. This may prompt them to demand higher wages in the collective bargaining process. Higher wage increases which are not justified by higher productivity growth will lead to higher consumer prices.

This means that higher wage demands in the wake of consumer price increases may trigger a price-wage spiral. A situation where an increase in prices leads to higher wages which result in a prolonged rise in inflation is called second round

effects. However, there are no indications of fluctuations in the effective krone rate entailing marked second round effects, since the rate of price increase quickly falls back, cf. Chart 5.

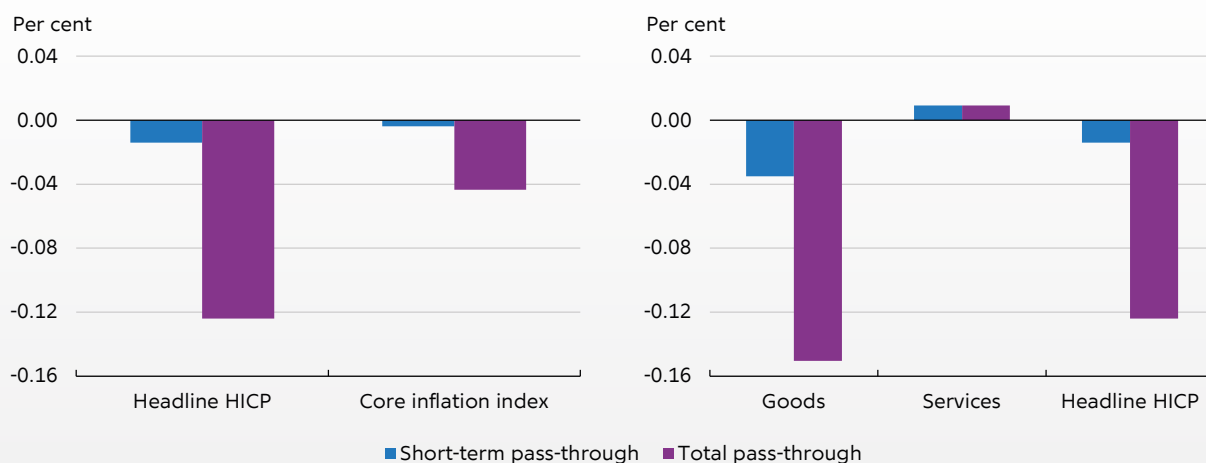
Pass-through from fluctuations in the nominal effective exchange rate of the krone to the total consumer price index is stronger than pass-through to the core inflation index calculated excluding energy and unprocessed food, cf. Chart 6. BIS (2015) also finds that the relationship between exchange rates and core inflation is weaker than that between exchange rates and the headline consumer price index.

The exchange rate pass-through to goods prices is more pronounced than that to service prices, cf. Chart 6. This should be viewed in the light of the much larger import content in goods than in services. For the period 1998-2015, an increase in the effective krone rate of 1 per cent led to a decline in goods prices of 0.04 per cent in the short term and a total fall of 0.15 per cent, of which only the total pass-through is statistically significant, however. In contrast, a corresponding fall in the effective krone rate led to a marginal increase in service prices of 0.01 per cent, which is not significantly different from zero.



### Effect of a 1 per cent strengthening of the effective krone rate on consumer prices, HICP and the core inflation index, 1998-2015

Chart 6



Note: Estimated pass-through to consumer prices of a 1 per cent strengthening of the nominal effective krone rate, where the estimates are the result of a regression model, cf. Box 1. For the sake of comparison, the EU Harmonised Index of Consumer Prices, HICP, has been applied to consumer prices. The core inflation index has been calculated as HICP excluding energy and unprocessed food, cf. Hansen et al. (2013).

Source: Statistics Denmark, Eurostat and own calculations.

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