STAFF MEMO

Pass-through from exchange rate movements to consumer prices

NO 3 | 2016

PÅL BERGSET
ULVEDAL AND NIKKA
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MONETARY POLICY

NORGES BANK

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ISSN 1504-2596 (online)
ISBN 978-82-7553-905-0 (online)

Pass-through from exchange rate movements to consumer prices

Pål Bergset Ulvedal and Nikka Husom Vonen[1]

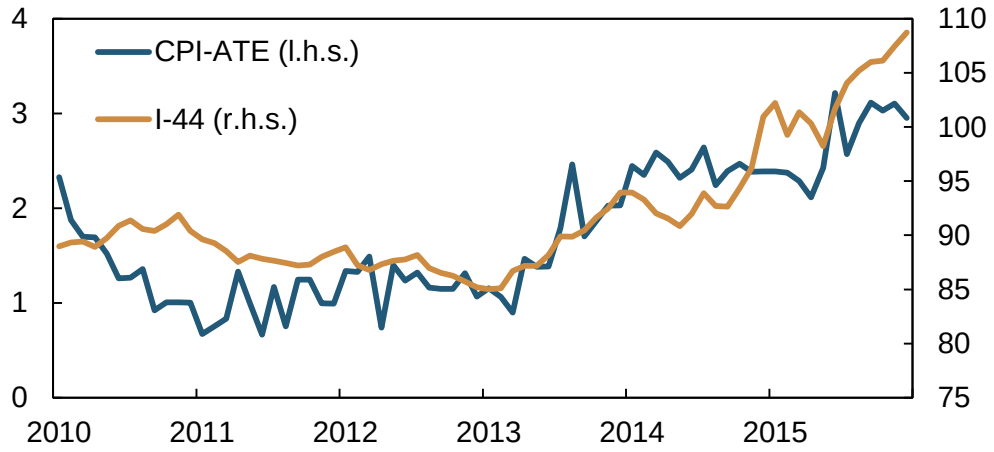
In recent years, the Norwegian krone has depreciated considerably against other currencies, contributing to higher inflation in Norway. The rise in prices for imported consumer goods is currently at its highest level since 1988. In this article, we examine the mechanisms through which the exchange rate affects inflation, and we assess the pass-through from the krone exchange rate to consumer prices with the aid of various models. The pass-through currently appears to be somewhat higher than normal. In periods of substantial and persistent exchange rate movements, it may be reasonable to expect that the exchange rate pass-through to consumer prices is higher or more rapid than usual. Empirical studies do not provide straightforward evidence of whether the exchange rate pass-through to consumer prices is actually nonlinear.

[1] The authors would like to thank Jon Ellingsen, Solveig K. Erlandsen, Kjersti Haugland, Ida Wolden Bache, Per Espen Lilleås, Q. Farooq Akram, Claudia Foroni, Bjørn E. Naug, Martin B. Holm and André K. Anundsen for useful comments and valuable feedback. A special thanks to Norman R. Spencer for translating this Staff Memo to English.

1 Introduction

In a small open economy like Norway, where a considerable share of consumer goods is imported, the exchange rate plays an important role for developments in consumer prices. For a central bank with an inflation target, it is important to understand the size and speed of the exchange rate pass-through to consumer prices. This issue appears to be especially relevant in periods of considerable exchange rate fluctuations.[2]

Chart 1 *Consumer prices adjusted for tax changes and excluding energy products (CPI-ATE) and import-weighted exchange rate index (I-44)[1)]. CPI-ATE: Twelve-month change. Percent. I-44: Index. January 2010 – December 2015*



1) A higher value of the I-44 implies a weaker exchange rate.

Sources: Statistics Norway and Norges Bank

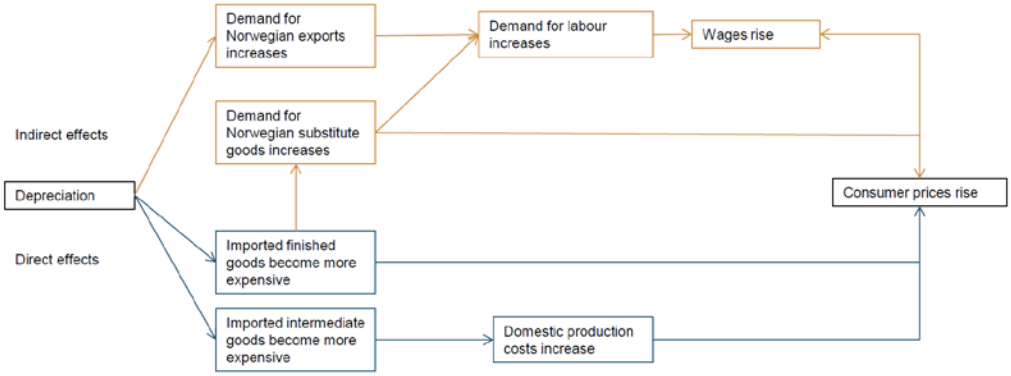
The increase in inflation in recent years must be viewed in the context of developments in the krone exchange rate. Between January 2013 and December 2015, the import-weighted exchange rate index (I-44) weakened by nearly 30 percent.[3] In the same period, consumer price inflation[4] picked up considerably, from 1.6 percent in 2013 to 2.7 percent in 2015 (Chart 1). A depreciation of the krone exchange rate can pass through to consumer prices through a number of channels. Initially, a depreciation may lead to an increase in the prices Norwegian importers pay for the goods they import, hereinafter referred to as import prices or CIF import prices.[5] Higher import prices for finished goods may then result in a rise in prices charged to consumers. Likewise, higher prices for imported intermediate goods may increase costs for some Norwegian producers, which eventually may lead to higher prices for a number of domestically produced consumer goods. These effects, which operate directly through import prices, may be referred to as the *direct exchange rate pass-through*, in keeping with the categorisation in Savoie-Chabot and Khan (2015).

A depreciation of the krone may also have *indirect* effects on consumer prices through effects on the demand for domestically produced goods and services and wage growth

[2] The exchange rate pass-through is a current topic at other central banks as well (see e.g. the box "The effect of imported price pressures on UK consumer prices" in the Bank of England's November 2015 *Inflation Report* and the box "Exchange Rate Pass-Through to Canadian Inflation" in the Bank of Canada's July 2015 *Monetary Policy Report*.
[3] In the analyses in this article, we use the import-weighted exchange rate index, unless otherwise specified.
[4] Consumer prices adjusted for tax changes and excluding energy products (CPI-ATE). References to "consumer prices" in this article are to this price measure, unless otherwise specified.
[5] The price index for Norwegian imported goods from the external trade statistics show developments in the prices that importers pay for imported goods, in NOK terms. This must not be confused with consumer prices for imported goods, which are the prices charged to consumers and which are a component of the consumer price index.

in Norway. A depreciation of the krone will make domestically produced goods cheaper relative to foreign goods. This may lead to a greater preference among Norwegian consumers than previously for domestically produced goods over imports. In addition, foreign demand for Norwegian exports will likely rise. Higher demand for domestically produced consumer goods will, in turn, increase prices charged to consumers, through higher labour costs owing to higher use of labour and because firms make use of the opportunity to raise prices in the face of higher demand. Chart 2 provides an overview of the direct and indirect effects discussed above.

Chart 2 *Effects of a currency depreciation on consumer prices*



Sources: Savoie-Chabot and Khan (2015) and Norges Bank

A number of studies investigate the pass-through from exchange rate movements to CIF import prices (see e.g. Bache (2002) and Naug and Nymoen (1996)). Even though we also review these effects, this article focuses primarily on the pass-through from exchange rate movements to prices charged to consumers. We analyse the exchange rate pass-through using a simple equilibrium-correction model of prices for imported consumer goods in the CPI-ATE[6]. To address the indirect pass-through via the effect on domestically produced goods and services, we use in addition Norges Bank's macroeconomic model NEMO. Furthermore, we use simple empirical models and NEMO, respectively, to investigate whether periods of substantial or persistent exchange rate movements may result in a higher than normal exchange rate pass-through. With the aid of import data, we also look at the importance of invoicing currency. Finally, we discuss how the cyclical situation may affect the exchange rate pass-through. Even though neither earlier studies nor our empirical investigations provide grounds for drawing unequivocal conclusions, several factors suggest that the exchange rate pass-through to consumer prices is currently somewhat higher than normal.

The remainder of the article is organised as follows: The pass-through from exchange rate movements to CIF import prices is discussed briefly in Section 2. In Section 3, we examine more closely the pass-through to consumer prices, before assessing factors that may explain possible deviations from an average exchange rate pass-through to consumer prices in Section 4. Section 5 is a summary.

2 Exchange rate pass-through to import prices

Several factors affect the size and speed of the pass-through from a movement in the krone exchange rate to import prices. One factor is whether foreign exporters price

[6] In addition to publishing sub-components of CPI-ATE by consumption group in accordance with COICOP classification, Statistics Norway publishes CPI-ATE by delivery sector. "Imported consumer goods" is one of the delivery sectors. In 2015 this delivery sector accounted for 32 percent of CPI-ATE.

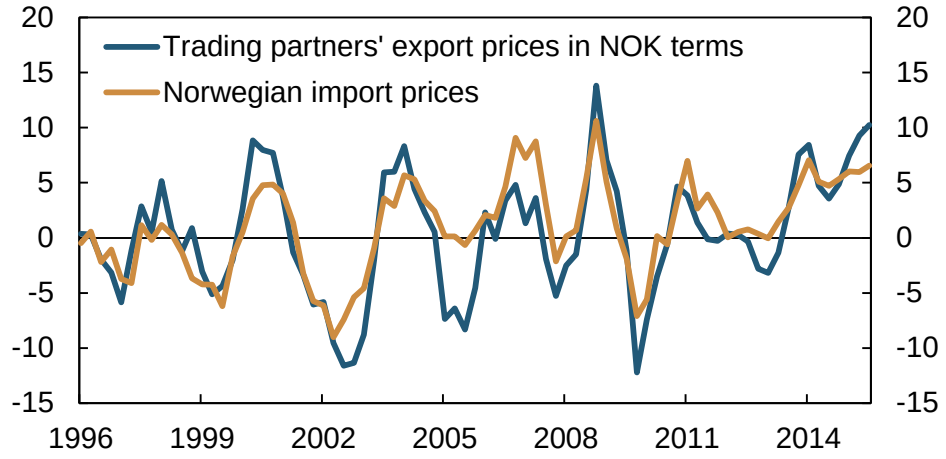
their goods in foreign currency or NOK. An approach where exporters price their goods in foreign currency is usually called "producer currency pricing", while a strategy where goods exported to Norway are priced in NOK is often referred to as "local currency pricing" (Devereux and Engel, 2001). If imported goods are priced in NOK, there is reason to believe that import prices are not adjusted immediately after an exchange rate movement, among other reasons because of costs associated with adjusting prices. This may result in some lag in the pass-through. If the exchange rate movement is of short duration and is reversed before exporters have adjusted their prices, not all exchange rate fluctuations will pass through to import prices. Similarly, some exchange rate movements may be too small for it to be profitable for exporters to adjust their prices. Moreover, some importers use various forms of currency hedging, where, for example, exporters and importers share the foreign exchange risk. Thus, exchange rate movements may not pass through fully to import prices. Various forms of currency hedging may also result in a lag in the exchange rate pass-through.

To the extent that foreign exporters tailor their prices to the Norwegian market, they may opt for a smaller adjustment in the price in NOK than warranted by the exchange rate movement, e.g. in order to avoid the loss of market share following a depreciation. Such a strategy is called "pricing to market" and may entail an incomplete exchange rate pass-through to import prices (Krugman, 1986).

In 2014, just under 30 percent of goods imported into Norway excluding ships and oil platforms was registered as invoiced in NOK (Chart 12 in Section 4.4). The share actually priced in NOK is less than this, however.[7] It is therefore reasonable to assume that local currency pricing is less important in Norway than in larger economies like the US and UK, where 88 and 52 percent, respectively, of imports are invoiced in local currency (Donnenfeld and Haug, 2008). A low percentage of local currency pricing suggests in isolation a high exchange rate pass-through to import prices.

[7] According to Statistics Norway's invoicing data, 29 percent of the value of all imports of goods into Norway excluding ships and oil platforms are registered as invoiced in NOK in 2014. However, there are several reasons for believing that this percentage is overestimated. First, goods included in the simplified customs clearance arrangement are declared in NOK. If a single customs declaration contains several different currencies, all the goods will be classified as imports invoiced in NOK. In the statistics, imports with a total value of less than NOK 10 million are classified as NOK. Finally, imported goods priced in a currency that is not among the 19 currencies Norwegian Customs operates with are also classified as invoiced in NOK.

Chart 3 *Trading partners' export prices in NOK terms[1)] and Norwegian import prices[2)]. Four-quarter change. Percent. 1996 Q1 – 2015 Q3*



1) Weighted export price index for Norway's 19 main trading partners by import weights. The index covers around 80 percent of imports into Norway, but the country composition varies somewhat over time. The index captures effects of the shift of Norwegian imports from countries with higher price levels to countries with lower price levels.
2) Price index for imports of goods excluding ships and oil platforms.

Sources: Statistics Norway, Thomson Reuters and Norges Bank

Chart 3 shows a high correlation between trading partners' export prices in NOK terms and Norwegian CIF import prices. Nevertheless, during much of the period between 1996 Q1 and 2015 Q3, Norwegian import prices appear to vary somewhat less than trading partners' export prices in NOK terms. This may indicate that exchange rate movements do not pass through fully to CIF import prices in the short run. However, the pass-through appears to be fairly rapid, and for the period between 1996 Q4 and 2015 Q3, the simultaneous correlation between the two series is highest.

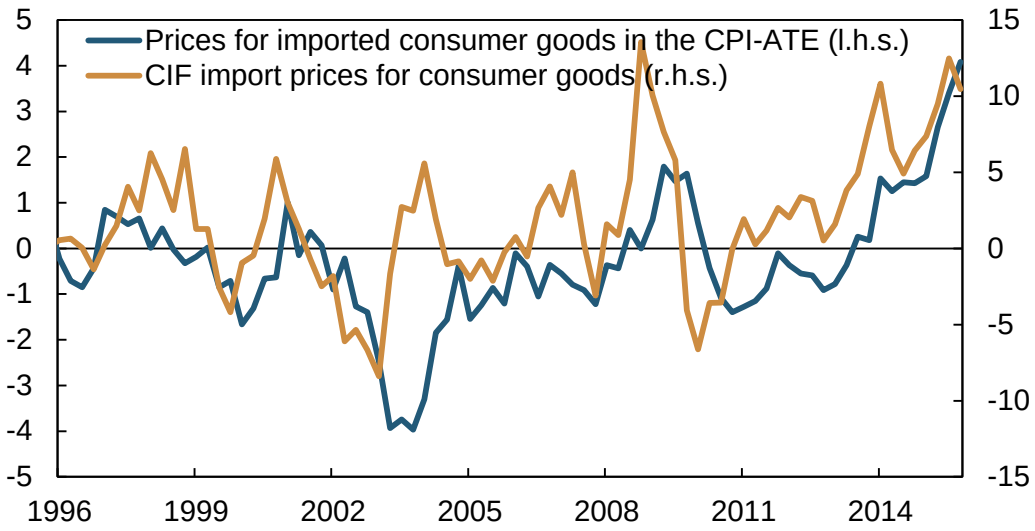
Empirical studies of the exchange rate pass-through to import prices do not provide straightforward results. In a study using Norwegian data, Nymoen and Naug (1996) find that the exchange rate pass-through to import prices is 63 percent in the long run. However, Bache (2002), who performs a similar study for a longer time period, concludes that there is full pass-through (100 percent) in the long run. The Bank of England (2015) finds that the pass-through from foreign export prices to UK import prices varies over time, but finds an average pass-through of around 60 percent. This is in line with the results of a study of 23 OECD countries, where Campa and Goldberg (2005) find an average pass-through of 64 percent.

3 Exchange rate pass-through to consumer prices

3.1 Exchange rate pass-through to prices for imported consumer goods in the CPI-ATE

To assess the pass-through from exchange rate movements to consumer prices, we look at the consumer price index adjusted for tax changes and excluding energy products (CPI-ATE) by delivery sector. We differentiate between domestically produced goods and services and imported consumer goods. In 2015, imported consumer goods accounted for around 32 percent of the CPI-ATE. The prices of these goods appear to track CIF import prices for consumer goods with a lag (Chart 4). In the period 1996 – 2015, the correlation between the four-quarter change in the two indices is highest when import prices precede consumer prices by two quarters. The fluctuations in consumer prices are less pronounced than the variation in import prices.

Chart 4 *Prices for imported consumer goods in the CPI-ATE and import prices for consumer goods. Four-quarter change. Percent. 1996 Q1 – 2015 Q4*



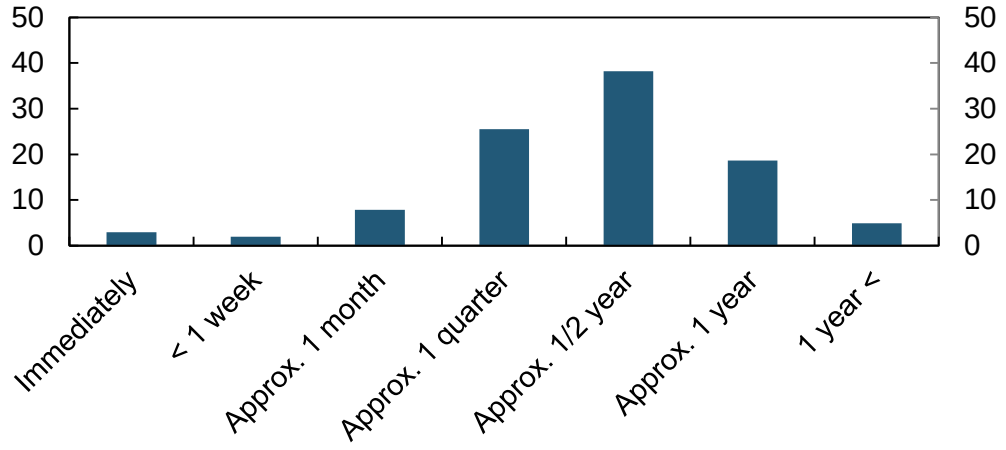
Sources: Statistics Norway and Norges Bank

There may be several reasons why it takes time for consumer prices to change and why they do not vary to the same extent as import prices. From the time a good is imported until it is sold to the consumer it usually passes through both a wholesale stage and a retail stage. Both stages have costs in NOK, including for transport and labour, that are not directly affected by exchange rate movements. It is thus reasonable that the percentage change in the price charged to consumers is less pronounced than the percentage change in the import price of the same good. The lag may partly reflect the time it takes for an imported good to end up on a retailer's shelf. It will also take time for the links in the distribution chain to renegotiate prices and implement price adjustments. Moreover, distribution sector participants may opt to allow their trade margins to vary rather than adjust prices immediately, so that trade margins act as cushions.[8] In a survey of enterprises in Norges Bank's regional network, over 60 percent of enterprises respond that it takes around six months or more for an exchange rate movement to pass through to their selling prices (Chart 5).[9]

[8] See Boug et al. (2013) for a discussion of the importance of trade margins in the distribution (wholesale and retail trade) sector.

[9] The survey was conducted in February 2016 and includes approximately 360 enterprises, of which around 100 responded to this question. The relatively low response rate reflects the fact that the question was only asked of enterprises where imported goods account for more than 20 percent of costs.

Chart 5 *How quickly will an exchange rate movement pass through to your enterprise's selling prices in the Norwegian market? Share of enterprises. Percent*



Source: Norges Bank

3.1.1 Exchange rate pass-through to prices for imported consumer goods in the CPI-ATE – an empirical model

To investigate the effect of exchange rate movements on prices for imported consumer goods in the CPI-ATE, we begin with a simple equilibrium adjustment model. The model contains the following variables: prices for imported consumer goods (P), unit labour costs in the distribution sector (ULC), an indicator of external price impulses to imported consumer goods[10] (EPC), the import-weighted exchange rate index (I-44), seasonal dummy variables (D_i) and a constant term (C). The model is estimated on the basis of the following specification:

$$\Delta p_t = C + \sum_{i=1}^{3} \beta_{1,i} D_i + \sum_{i=1}^{4} \beta_{2,i} \Delta p_{t-i} + \sum_{i=0}^{4} \beta_{3,i} \Delta ulc_{t-i} + \sum_{i=0}^{4} \beta_{4,i} \Delta epc_{t-i} + \sum_{i=0}^{4} \beta_{5,i} \Delta i44_{t-i} + \beta_6 z_{t-1} + \varepsilon_t \quad (3.1)$$

Lower-case letters indicate the logarithm of the variables, and the betas (β) are the coefficients we are seeking to estimate. The equilibrium-correction term z_t is the deviation between the actual prices, p_t, and the long-run solution for the prices, p^*, and is defined by the following equation:

$$\begin{aligned} z_t &= p_t - p^* \\ &= p_t - [\gamma * (i44_t + epc_t) + (1-\gamma) * ulc_t] \end{aligned} \quad (3.2)$$

Homogeneity of degree 1 is assumed, so that a 1 percent increase in both foreign producer prices in NOK terms ($i44_t + epc_t$) and unit labour costs in the distribution sector (ulc_t) will result in a 1 percent increase in prices for imported consumer goods in the long run. The coefficient γ will be an expression of the long-run exchange rate pass-through.

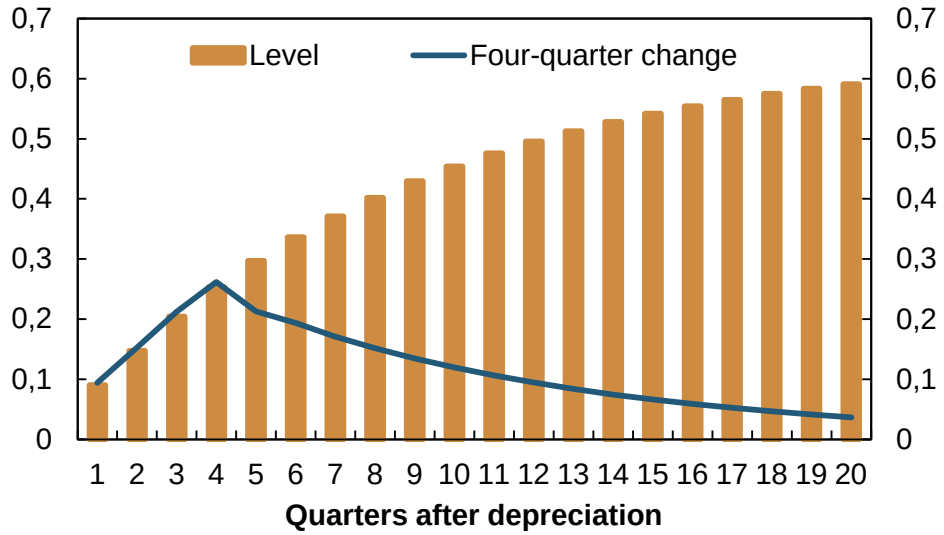
The model is estimated over the period 2001 Q2 – 2015 Q4. It contains significant long-run effects of the exchange rate, external price impulses to imported consumer goods and unit labour costs in the distribution sector. The specification has been

[10] Norges Bank has devised an indicator of external price impulses to imported consumer goods in foreign currency terms (see Røstøen (2004)).

chosen because it appears to be an econometrically well-specified model with good forecasting properties over time compared with other models of the same type.[11] For more details regarding the estimated model, see Appendix B.

According to the model, a 1 percent depreciation of the krone leads to a 0.65 percent increase in prices for imported consumer goods in the CPI-ATE in the long run. This is illustrated by the orange bars in Chart 6. Somewhat less than half of the effect comes during the first year. The most pronounced effect on the four-quarter change is reached after four quarters, with an increase in imported inflation of nearly 0.3 percentage point.[12] This is illustrated by the blue line in the chart. In isolation, the estimated model indicates an increase in the CPI-ATE of approximately 0.2 percent in the long run, while the effect on the four-quarter change will be just under 0.1 percentage point after four quarters.

Chart 6 *Effect of a 1 percent depreciation of the Norwegian krone on prices for imported consumer goods in the CPI-ATE. Level: Percent. Four-quarter change: Percentage points*

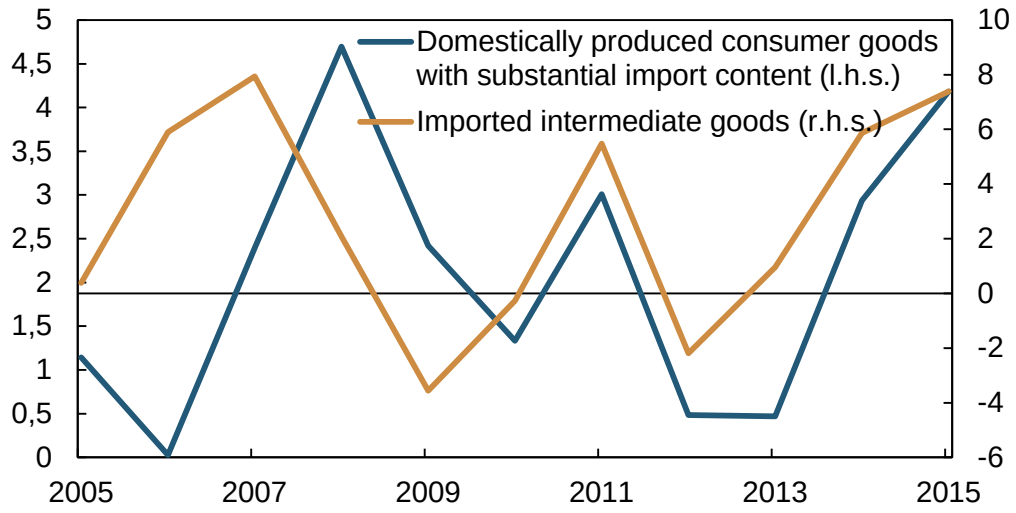


3.2 Exchange rate pass-through to consumer prices for domestically produced goods and services and the CPI-ATE

As mentioned in the introduction, exchange rate movements will also pass through to prices for domestically produced goods and services, which account for most of the CPI-ATE. It is, for example, not unreasonable to view the higher rise in prices in recent years for *other domestically produced goods affected by the world market owing to import content*[13] in the light of the considerable depreciation of the krone. Chart 7 shows the rise in prices for goods in this supplier sector in the CPI-ATE along with the rise in prices for imported intermediate goods from the external trade statistics.

[11] We have evaluated the forecasting properties of various models over the period 2010-2014. Among these models, our preferred model has the lowest forecast errors measured as root mean square errors (RMSEs) in the period 2010-2014.
[12] Like us, Hov et al. (2013) also estimates equilibrium adjustment models to explain developments in consumer price inflation. Their model for imported consumer goods, which includes more short-run dynamics than our simple model, indicates a somewhat larger exchange rate pass-through than we find.
[13] From January 2016, Statistics Norway has made changes in the CPI-ATE by delivery sector. This sub-index is therefore no longer published.

Chart 7 *Prices for domestically produced consumer goods with substantial import content in the CPI-ATE and prices for imported intermediate goods from the external trade statistics. Annual change. Percent. 2005-2015*



Source: Statistics Norway

To quantify the exchange rate pass-through to overall consumer prices (CPI-ATE), we also need an estimate of the exchange rate pass-through to domestically produced goods and services in the CPI-ATE. It is reasonable to expect that the indirect effects described in Section 1 play an important role for this component. Norges Bank's macroeconomic model NEMO is a general equilibrium model for a small open economy that also includes exchange rate effects on inflation through a shift in demand and wage growth.[14] This model will be better suited to quantify the pass-through to overall CPI-ATE than simple one-equation models.

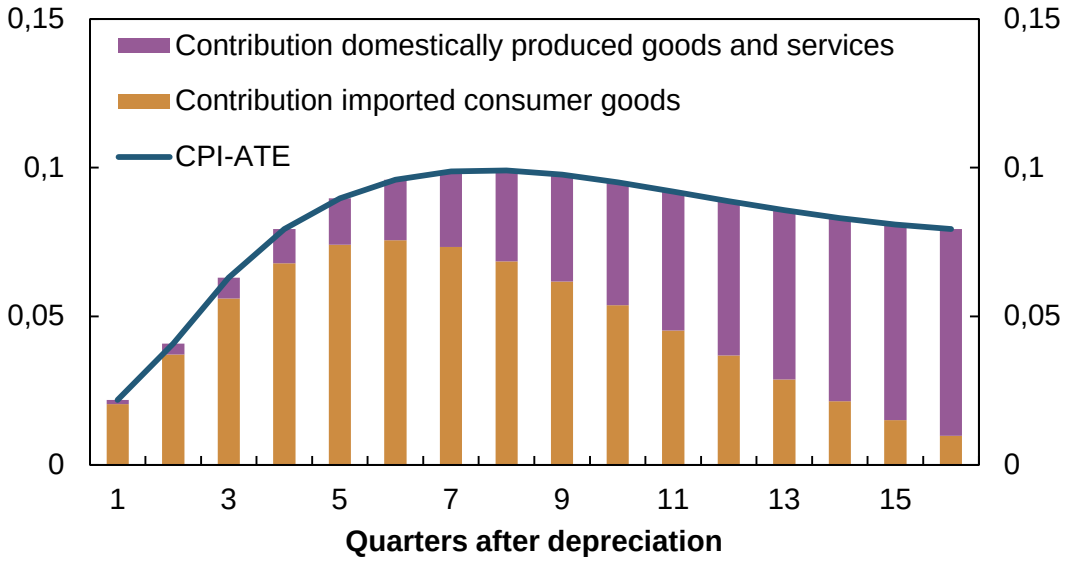
In NEMO, a Norwegian production sector is modelled that produces goods for both the domestic market and the export market. At the same time, goods are imported from abroad that are consumed in Norway. In the model, prices are set in NOK, and there are costs associated with adjusting prices. It therefore takes time for an exchange rate movement to be reflected in an adjustment in imported goods prices. After a depreciation of the krone, imported goods will be more expensive relative to domestically produced goods. This leads to higher demand for Norwegian goods, because Norwegian consumers shift their demand from imported to domestically produced goods and because foreign demand for Norwegian exports rises. With higher marginal costs in the short run, this means firms will seek to raise prices for domestically produced goods. To meet the increased demand, Norwegian firms will demand more labour, resulting in higher wage pressure. This in turn will increase firms' marginal cost and contribute to further inflation. Thus, NEMO captures the key indirect effects of an exchange rate movement on consumer prices as described in Section 1 above.

Chart 8 shows the effect on consumer prices of a persistent 1 percent depreciation of the krone, as it appears in NEMO.[15] The orange bars show the contribution made by prices for imported consumer goods. This is consistent with result from the equilibrium-correction model discussed in Section 3.1.1. The effect on prices for

[14] See e.g. Brubakk et al. (2006) for a detailed description of this model.
[15] Technically, this is done by adding a series of risk premium shocks to the Norwegian krone whereby the nominal exchange rate remains 1 percent weaker than in the "baseline scenario". The key policy rate and all other endogenous variables in NEMO are allowed to react normally to these shocks.

domestically produced goods and services is relatively slight in the short run, but persists longer than the effect on imported consumer goods prices and gradually proves to be the largest contributor to sustaining overall consumer price inflation.

Chart 8 *Exchange rate pass-through to the CPI-ATE in NEMO. Effect on the four-quarter change of a 1 percent depreciation of the Norwegian krone. Percentage points*



As shown in Chart 8, the overall effect of a persistent 1 percent depreciation of the krone on the four-quarter change in the CPI-ATE is approximately 0.1 percentage point after five quarters. The effect persists, and after four years, the krone depreciation still continues to underpin consumer price inflation.

With the aid of a large macroeconomic model[16] Boug et al. (2013) find that the four-quarter change in the CPI-ATE rises by 0.16 percent after one year as a consequence of a persistent krone depreciation of 1 percent. They, too, find that a persistent depreciation of the krone contributes to underpinning inflation for several years, but the effect in their model is stronger in the short run and diminishes faster than it does in NEMO.[17]

4. Reasons for possible deviations from the average exchange rate pass-through

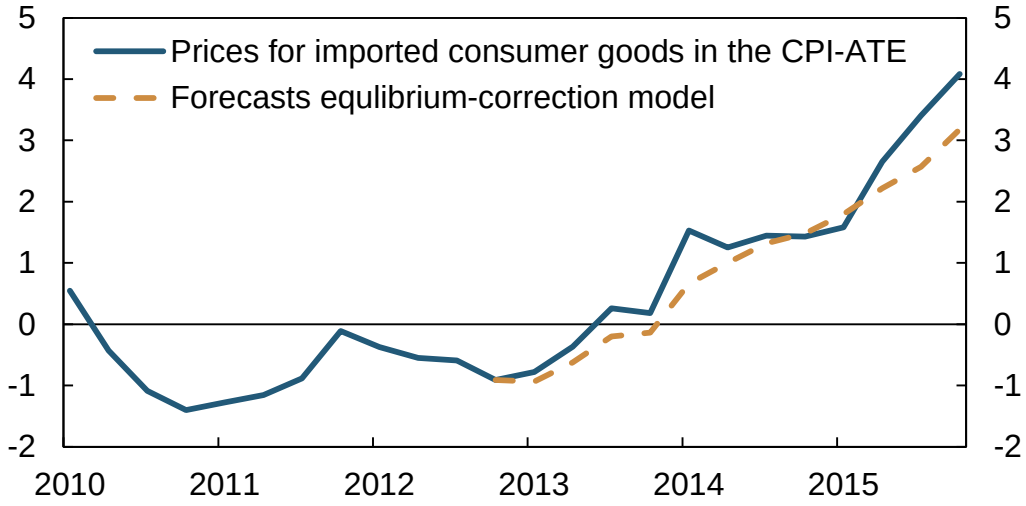
4.1 Deviations from the average exchange rate pass-through?

As mentioned in Section 3.1, our model appears to be well-suited to forecasting developments in prices for imported consumer goods over time. Chart 9 shows actual developments in these prices together with the model forecasts. For this purpose, the model is estimated over the period 2001 Q1 – 2012 Q4, before the model is used to make forecasts conditioned on actual developments in the explanatory variables.

[16]Statistics Norway's KVARTS model (see https://www.ssb.no/forskning/beregningsmodeller/kvarts (Norwegian only)).

[17] An essential difference between these two model calculations is that Boug et al. (2013) keep the interest rate unchanged, while the interest rate in NEMO reacts.

Chart 9 *Prices for imported consumer goods in the CPI-ATE. Forecasts and actual developments. Four-quarter change. Percent. 2010 Q1 – 2015 Q4*



Sources: Statistics Norway and Norges Bank

As the figure illustrates, the model forecasts have matched actual developments reasonably well from 2013. Forecast errors have been both positive and negative. However, in the last quarters, the model underpredicted actual price developments, and the deviation has been increasing since summer 2015. In the model, the estimated exchange rate effect is an average pass-through based on the average developments in the variables in the estimation period. There may be several reasons why at times the pass-through can deviate from this average. Possible explanations are discussed further in Sections 4.2-4.5 below.

4.2 Large exchange rate movements

The krone exchange rate has moved considerably over the past three years, compared with the previous years. The size of exchange rate movements can conceivably affect the degree of the pass-through to consumer prices. In the distribution chain between foreign exporter and Norwegian consumer, there are costs associated with adjusting prices, and it is therefore reasonable to believe that sellers will refrain from adjusting the selling price if the exchange rate movement is small. This may suggest in isolation a higher pass-through to consumer prices from large exchange rate movements than from small movements, so that the pass-through is nonlinear. Greater opportunities for negotiating prices with suppliers are also conceivable in the event of large exchange rate movements, whereas the links in the distribution chain must adjust their trade margins when exchange rate movements are small.

Other factors may conceivably pull in the opposite direction. An importer facing higher costs owing to a weaker krone will at the outset seek to pass on these costs to the next link in the distribution chain. For wholesalers and/or retailers it may be easier to accept minor price increases, while they might oppose bigger increases in resale prices from importers. In isolation, this may suggest a relatively higher exchange rate pass-through from small exchange rate movements than from large ones, so that the nonlinearity goes in the opposite direction.

4.2.1 Empirical investigations

In this section, we first look at findings from previous studies that investigate whether the exchange rate pass-through depends on the size of the exchange rate movement, before reporting our own calculations.

Holm (2014) investigates this topic using equilibrium-correction models with thresholds for exchange rate movements, on the basis of Norwegian data for the period 1996 Q1 – 2013 Q4. He finds support for the idea that large exchange rate movements result in relatively larger changes in consumer prices than small exchange rate movements.

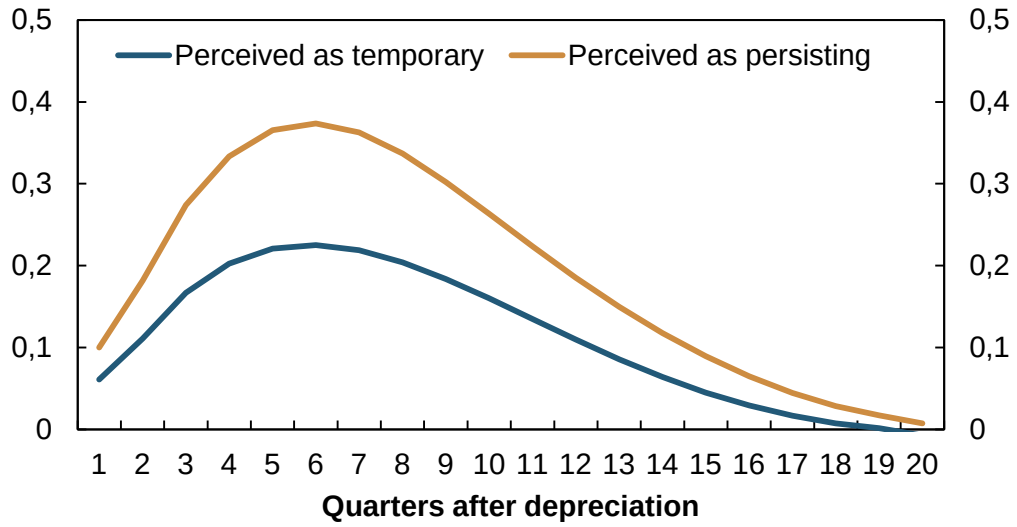
Empirical studies of nonlinearity in the exchange rate pass-through for other countries do not yield any straightforward conclusion. Pollard and Goughlin (2003) find a relatively higher pass-through from large exchange rate movements to US import prices than from small exchange rate movements, while Herzberg et al. (2003) do not find support for dependence of the pass-through to UK import prices on the size of the exchange rate movement. Bussiere (2013) investigates the pass-through to import and export prices in the G7 countries. The results vary across countries, but the study does not find clear support for dependence of the pass-through to import prices on the size of exchange rate movements. The three latter studies investigate the pass-through to CIF import prices, while Holm (2014) examines the pass-through to consumer prices for imported finished goods. If there are price rigidities in the domestic distribution sector, it is conceivable that any nonlinear effects of the exchange rate pass-through will be more evident for consumer prices than for import prices.

We have based our analysis on the simple equilibrium-correction model discussed in Section 3.1.1, and investigated whether the exchange rate pass-through to prices for imported consumer goods in the CPI-ATE depends on the size of the exchange rate movement. The estimates do not provide grounds for drawing a clear conclusion. We find some support for the hypothesis that large exchange rate movements result in a relatively higher pass-through to consumer prices than small exchange rate movements, but the result is sensitive to the choices of threshold values and estimation period. A detailed description of the procedure and results of the estimations are found in Appendix C.

4.3 Persistent or temporary exchange rate movements

The degree of pass-through from an exchange rate movement to consumer prices may also be affected by how persistent the exchange rate movement is expected to be. To the extent costs are associated with adjusting prices, it may be profitable to keep prices unchanged if the exchange rate movement is believed to be temporary. If the exchange rate movement is perceived as persisting, however, it may be profitable to adjust prices. It is not obvious how to capture or define whether an exchange rate movement is temporary or persistent, or how to test the importance of this empirically. We have chosen to use NEMO for this purpose. Chart 10 shows the effect of a 1 percent depreciation of the krone on the rise in consumer prices for imported goods. To distinguish between temporary and persistent exchange rate movements, we have modelled agents' exchange rate expectations in two different ways. In both cases, the exchange rate is depreciated by 1 percent permanently. The blue line shows the pass-through to inflation when agents believe that the exchange rate will be temporary and in each period are surprised that the exchange rate movement is not reversed. The orange line is based on the assumption that agents expect the exchange rate movement to persist. In NEMO, agents have costs associated with adjusting prices, and the depreciation of the exchange rate has a more pronounced effect when it is expected to persist than when agents expect a reversal of the exchange rate movement.

Chart 10 *The effect in NEMO of a 1 percent permanent depreciation of the krone exchange rate on the four-quarter change in prices for imported consumer goods. Under different assumptions among agents. Percentage points*



Forbes et al. (2015) are among those who emphasise the importance of examining the cause of an exchange rate movement for drawing any conclusion about the effect of such a movement on prices. Exchange rate fluctuations owing to persistent changes in fundamentals will likely be considered to be permanent. The depreciation of the krone since summer 2014 may reflect the substantial oil price fall in the same period. Since lower oil prices have weakened the outlook for the Norwegian economy, it is conceivable that agents expect that the krone will remain at weaker levels for a long time. If this is the case, it may help to explain why prices for imported consumer goods have risen more than our model, which assumes an average exchange rate pass-through, would indicate.

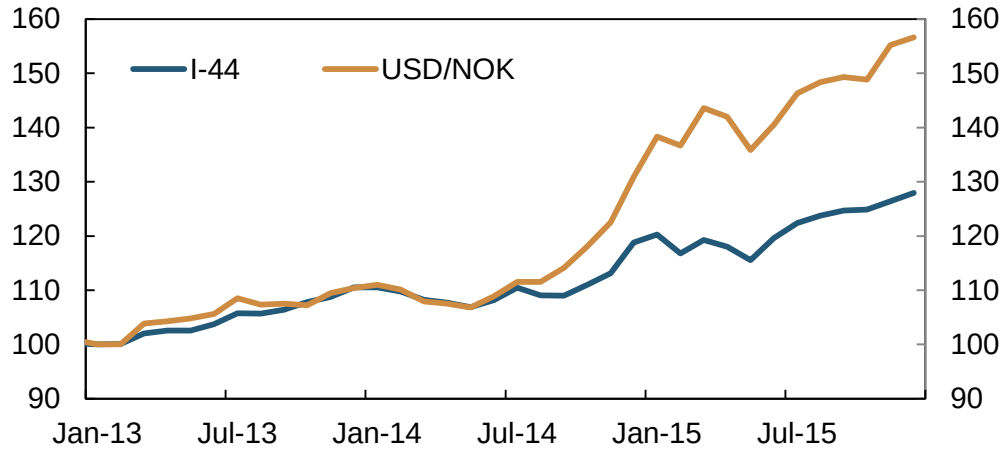
4.4 Importance of invoicing currency

The currency in which imports are invoiced may also be important for assessing the exchange rate pass-through to consumer prices. Gopinath (2015) is among those who emphasise the importance of invoicing currency for the exchange rate pass-through to prices. We have pointed out above that the percentage of imports invoiced in local currency has a bearing on the exchange rate pass-through to import prices. In the same way, owing to nominal price rigidities in the invoicing currency, an import-weighted exchange rate aggregate such as the I-44 may underestimate effect on prices of movements in some important bilateral exchange rates. Since the krone depreciation of the past year and a half has been particularly pronounced against the US dollar (USD) (Chart 11), it may be relevant to examine more closely imports invoiced in this currency. Even though only 6 percent of goods imports[18] into Norway came from the US in 2014, over 23 percent of imports were invoiced in USD (Chart 12). The share of imports invoiced in USD is therefore considerably greater than the USD's weight in the I-44 of around 6 percent. To the extent that it takes time before prices in the invoicing currency are adjusted, import prices may rise more than the changes in the I-44 would indicate. The fact that a larger share of imports is invoiced in USD than

[18] Calculated as a share of goods imports excluding ships and oil platforms in 2014.

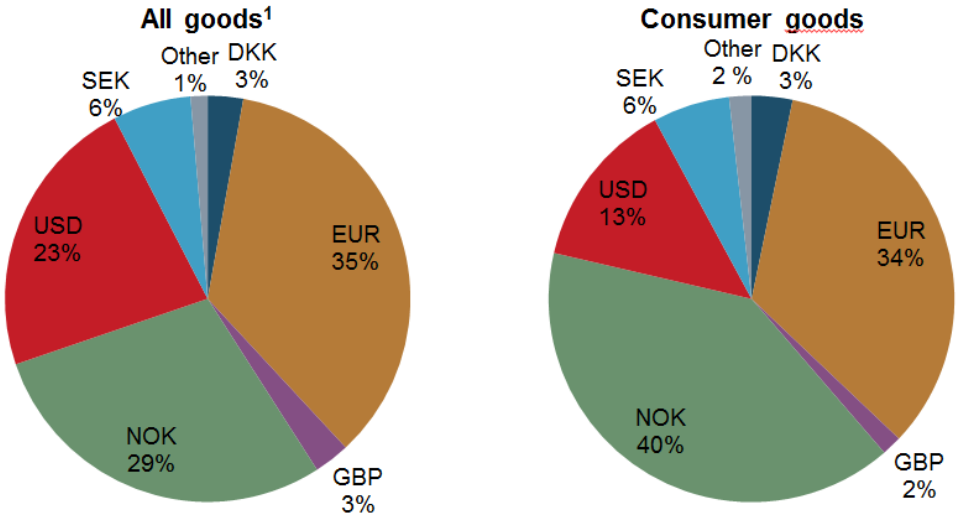
what is reflected in the I-44 may thus also be a possible explanation for why inflation has recently been higher than the projections from our models.[19]

Chart 11 *Developments in the krone exchange rate measured by the I-44 and USD/NOK. Index. January 2013 = 100. January 2013 – December 2015*



Source: Norges Bank

Chart 12 *Goods imports by invoicing currency in 2014. Percent*



1) Excluding ships and oil platforms.

Source: Statistics Norway

[19] We have also attempted to estimate simple equilibrium adjustment models in which we include the USD/NOK exchange rate, instead of and in addition to the import-weighted exchange rate index. However, we have not found models using USD/NOK as an explanatory variable that explain the recent inflation better than our simple model based on the I-44.

4.5 A downturn may dampen the pass-through

So far, we have pointed to factors that may explain why the exchange rate pass-through is currently higher or more rapid than the average pass-through over time. It is also conceivable that there are factors that in isolation dampen the exchange rate pass-through in a downturn such as the Norwegian economy is currently experiencing. To avoid a sharp decline in demand, foreign exporters who set their prices specifically for the Norwegian market may seek to limit their price increases in Norway in periods when demand is low. For the same reason, it may be more difficult for importers, wholesalers and retailers to raise prices much in the face of a fall in demand. This may lower the exchange rate pass-through following a depreciation in periods of economic weakness.

The empirical results of analyses of this issue also vary. By analysing data for Brazil, Correa and Minella (2006) find support for a lower exchange rate pass-through when the output gap is below a certain threshold. In a study of 12 euro area countries, Cheikh (2012) finds that the pass-through depends on the cyclical situation in six of these countries, but that the direction of this nonlinearity varies across countries. In some countries, the pass-through is higher in upturns than in downturns, while in other countries, the opposite is the case.

5 Summary

The Norwegian krone has depreciated markedly over the past three years. This has contributed to a substantial rise in prices for imported consumer goods in the CPI-ATE.

In this article, we have examined the channels through which exchange rate movements pass through to consumer prices and the magnitude of the price change a given exchange rate movement will result in. Movements in the krone exchange rate affect consumer prices with a lag, and the pass-through to consumer prices is lower than the effect on import prices. We have presented a simple equilibrium-correction model that over time has proved to be well-suited to forecasting developments in prices for imported consumer goods in the CPI-ATE. However, the model will not capture indirect effects and effects via prices for domestically produced goods and services. When we use our macroeconomic model NEMO, we find that a 1 percent depreciation of the krone results in an increase in the four-quarter change in the CPI-ATE of around 0.1 percentage point after approximately five quarters.

The model estimates are expressions of an average pass-through to consumer prices over time. There may be reason to believe that the exchange rate pass-through may currently be higher than our model calculations indicate. Large exchange rate movements can conceivably have a relatively greater effect on prices than small movements. Likewise, exchange rate movements perceived as persisting may result in larger price changes than if the exchange rate movements are perceived as temporary. In recent years, the depreciation of the krone against USD has been more pronounced than the depreciation measured by the import-weighted exchange rate index. To the extent there are price rigidities in the invoicing currency, an underrepresentation of USD in the import-weighted exchange rate index will mean that calculations based on the latter underestimate the exchange rate pass-through to inflation. On the other hand, price-setters may seek to limit consumer price increases in a downturn such as Norway is now experiencing. All these effects may result in a deviation in the exchange rate pass-through from the average pass-through estimated in our models.

Empirical findings in studies of possible deviations from the average exchange rate pass-through vary. It is particularly difficult to determine whether large exchange rate movements have a higher pass-through to inflation than small ones. Also the evidence relating to the importance of the cyclical situation is ambiguous. Effects that are plausible in theory and that may occur on the micro scale may be difficult to capture for the economy as a whole. Various effects across sectors and over time may impede capturing effects in estimated models of aggregated data. Even though the formal empirical investigations do not provide grounds for straightforward conclusions, we nevertheless believe there is evidence for the argument that inflation is currently somewhat higher than the average relationship between consumer prices and the import-weighted exchange rate would suggest. This may reflect the fact that the recent depreciation of the krone exchange rate is largely regarded as being persistent and that a clearly larger share than what Norway imports from the US is invoiced in USD. This suggests that the exchange rate pass-through is currently somewhat higher than normal.

Appendix A: References

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Appendix B: Estimated model of prices for imported consumer goods in the CPI-ATE

Our starting-point is the following equilibrium-correction model for prices for imported consumer goods in the CPI-ATE (P):

$$\Delta p_t = C + \sum_{i=1}^{3} \beta_{1,i} D_i + \sum_{i=1}^{4} \beta_{2,i} \Delta p_{t-i} + \sum_{i=0}^{4} \beta_{3,i} \Delta ulc_{t-i} + \sum_{i=0}^{4} \beta_{4,i} \Delta epc_{t-i} + \sum_{i=0}^{4} \beta_{5,i} \Delta i44_{t-i} + \beta_6 z_{t-1} + \varepsilon_t \quad \text{(A.1)}$$

where the variables are defined as in Section 3.1.1. The equilibrium-correction term is given by the following equation:

$$z_t = p_t - [(\gamma * (i44_t + epc_t) + (1 - \gamma) * ulc_t)] \quad \text{(A.2)}$$

The results of estimating the model over the period 2001 Q2 – 2015 Q4 appear in Table A.1. γ, which is an expression of the long-run exchange rate pass-through, is estimated at 0.65. This indicates that an increase in external producer prices in NOK terms will result in the long run in a 0.65 increase in prices for imported consumer goods in the CPI-ATE. A 1 percent increase in the ULC in the distribution sector will result in a 0.35 percent increase in prices for imported consumer goods (cf. the coefficient $(1 - \gamma)$ in equation (A.2).

Table A.1: Results of estimating equation 3.1 (A.1) for the period 2001 Q2 – 2015 Q4

Variable	Coefficient	Standard error	*t*-value
Constant (C)	-0.168***	(0.022)	-7.81
D1 ($\beta_{1,1}$)	-0.017***	(0.003)	-6.07
D3 ($\beta_{1,3}$)	-0.015***	(0.003)	-5.07
Δp_{t-1} ($\beta_{2,1}$)	-0.234**	(0.103)	-2.28
z_{t-1} (β_6)	-0.139***	(0.016)	-8.49
Adjusted R^2	0.919		
Standard deviation	0.004		
White test[1] (*p*-value)	0.801		
LM test[2] (*p*-value)	0.705		
Jarque-Bera[3] (*p*-value)	0.834		

1) Heteroscedasticity test. The null hypothesis is that the error terms are homoscedastic. The high *p*-value does not provide grounds for rejecting the null hypothesis.
2) Autocorrelation test of the remaining terms with five lags. The null hypothesis is that the error terms are not autocorrelated. The high *p*-value does not provide grounds for rejecting the null hypothesis.
3) Normality test of the remaining terms with five lags. The null hypothesis is that the error terms are normally distributed. The high *p*-value does not provide grounds for rejecting the null hypothesis.
****** Indicates significance at the 5 percent significance level.
******* Indicates significance at the 1 percent significance level.

The model contains a term including inflation in the preceding period in addition to the constant term, dummy variables for seasonal effects and the equilibrium-correction term. We have estimated different variants of such a model in which several terms with short-run dynamics are included. The reason that we have chosen precisely this model is that it has good forecasting properties, and that it appears to be econometrically well-specified.

Appendix C: Nonlinear effects of exchange rate movements on consumer prices

To investigate whether there are nonlinear effects of exchange rate movements on consumer prices, we begin with our simple equilibrium-correction model (as described in Section 3.1.1 and Appendix B). As the equilibrium-correction term is defined in our model, a depreciation of the krone exchange rate will raise the long-run equilibrium level of prices for imported consumer goods, p^*. A depreciation (appreciation) of the exchange rate will increase (decrease) the value of z_t in equation (A.2). Since the appurtenant coefficient is negative, this will lead to higher (lower) imported consumer goods inflation, Δp_t. We may call this an equilibrium correction, since the actual price moves towards its long-run equilibrium level. One way to test whether the exchange rate pass-through is stronger from large exchange rate movements is to investigate whether the equilibrium correction happens more quickly after periods of large exchange rate movements. We can test this by changing our model in the following way:

$$\Delta p_t = C + \sum_{i=1}^{3} \beta_{1,i} D_i + \sum_{i=1}^{4} \beta_{2,i} \Delta p_{t-i} + \sum_{i=0}^{4} \beta_{3,i} \Delta ulc_{t-i} + \sum_{i=0}^{4} \beta_{4,i} \Delta epc_{t-i} + \sum_{i=0}^{4} \beta_{5,i} \Delta i44_{t-i} + \beta_6 D_t^{big} z_{t-1} + \beta_7 (1 - D_t^{big}) z_{t-1} + \varepsilon_t \qquad \text{(A.3)}$$

where D_t^{big} is a dummy variable with value 1 when the krone exchange rate has moved more than X percent over the past year and 0 otherwise.[20] All other variables are defined in the same way as in our main model. In the model in equation (A.3), β_6 will express how quickly the equilibrium correction takes place when the exchange rate movement is large (given by X), while β_7 will express how quickly the equilibrium correction takes place in all other periods. If the equilibrium correction is larger when the krone exchange rate has changed substantially, $|\beta_6|$ will be $> |\beta_7|$. In the following regression, we have set X = 5.5.[21]

[20] We also performed estimations where the dummy variable is defined independently of whether or not the equilibrium price is far from the actual price. This produced the same result as when the dummy variable is defined on the basis of the four-quarter change in the exchange rate.
[21] The dummy variable is equal to 1 when the four-quarter log difference is above 0.055.

Table A.2: Results of estimating equation (A.3) for the period 2001 Q2 – 2015 Q4

Variable	Coefficient	Standard error	*t*-value
Constant (C)	-0.168***	(0.022)	-7.75
D1 ($\beta_{1,1}$)	-0.017***	(0.003)	-6.04
D3 ($\beta_{1,3}$)	-0.015***	(0.003)	-5.03
Δp_{t-1} ($\beta_{2,1}$)	-0.227**	(0.105)	-2.15
$D_t^{big} z_{t-1}$ (β_6)	-0.139***	(0.017)	-8.41
$(1 - D_t^{big}) z_{t-1}$ (β_7)	-0.139***	(0.017)	-8.44
Adjusted R^2	0.910		
Standard deviation	0.004		
White test[1] (*p*-value)	0.906		
LM test[2] (*p*-value)	0.637		
Jarque-Bera[3] (*p*-value)	0.866		

1) Heteroscedasticity test. The null hypothesis is that the error terms are homoscedastic. The high *p*-value does not provide grounds for rejecting the null hypothesis.
2) Autocorrelation test of the remaining terms with five lags. The null hypothesis is that the error terms are not autocorrelated. The high *p*-value does not provide grounds for rejecting the null hypothesis.
3) Normality test of the remaining terms with five lags. The null hypothesis is that the error terms are normally distributed. The high *p*-value does not provide grounds for rejecting the null hypothesis.
****** Indicates significance at the 5 percent significance level.
******* Indicates significance at the 1 percent significance level.

The results show that $\beta_6 \approx \beta_7$, which indicates that there is no difference in how quickly the equilibrium correction takes place in the two regimes. Thus, this model does not provide grounds for concluding that large exchange rate movements result in a relatively faster exchange rate pass-through. We have tested various thresholds for how large the exchange rate movement must be before the dummy variable D_t^{big} is equal to 1, but the results are hardly dependent on the choice of threshold value. Nor are the results especially sensitive to the choice of estimation period. We have also estimated a variant of the model in equation (A.3) that permits the long-run exchange rate pass-through (γ in equation (A.2)) to vary between the two regimes. However, we do not find support for the hypothesis that the long-run exchange rate pass-through depends on the size of the exchange rate movement.

Inspired by Herzberg et al. (2003), we have also attempted to specify variants of the model with an indicator variable that produces a smooth transition between the two regimes rather than an abrupt transition at a given threshold. Again, we do not find support for the hypothesis that large exchange rate movements have relatively more pronounced effects on prices with such a specification of the model.

An alternative way to test for nonlinearity in the exchange rate pass-through is to include terms with short-run effects of the exchange rate movement, as in Holm (2014). We have investigated this further by estimating the following model:

$$\Delta p_t = C + \sum_{i=1}^{3} \beta_{1,i} D_i + \sum_{i=1}^{4} \beta_{2,i} \Delta p_{t-i} + \sum_{i=0}^{4} \beta_{3,i} \Delta ulc_{t-i} + \sum_{i=0}^{4} \beta_{4,i} \Delta epc_{t-i} + \sum_{i=0}^{2} \beta_{5,i} \Delta_4 i44_{t-i} + \sum_{i=0}^{2} \beta_{6,i} D_{t-i}^{big} \Delta_4 i44_{t-i} + \beta_7 z_{t-1} + \varepsilon_t \quad \text{(A.4)}$$

where Δ_4 indicates four-quarter change and D_{t-i}^{big} is a dummy variable with the value 1 when the exchange rate has moved by over X percent over the past year and 0 otherwise. In this model, any extra effects on inflation from large exchange rate

movements are captured by the fact that the $\beta_{6,i}$s are significantly different from zero. In the following regression, we have set X = 5.5.

Table A.3: Results[22] of estimating equation (A.4) for the period 2001 Q2 – 2015 Q4

Variable	Coefficient	Standard error	*t*-value
Constant (C)	-0.362***	(0.045)	-8.04
D1 ($\beta_{1,1}$)	-0.015***	(0.003)	-5.82
D3 ($\beta_{1,3}$)	-0.013***	(0.003)	-4.97
Δp_{t-1} ($\beta_{2,1}$)	-0.269***	(0.095)	-2.82
$\Delta_4 i44_t$ ($\beta_{5,0}$)	0.033	(0.024)	1.36
$\Delta_4 i44_{t-1}$ ($\beta_{5,1}$)	-0.07**	(0.029)	-2.44
$\Delta_4 i44_{t-2}$ ($\beta_{5,2}$)	-0.031	(0.023)	-1.34
$D_t^{big} * \Delta_4 i44_t$ ($\beta_{6,0}$)	-0.024	(0.023)	-1.01
$D_{t-1}^{big} * \Delta_4 i44_{t-1}$ ($\beta_{6,1}$)	-0.005	(0.024)	-0.19
$D_{t-2}^{big} * \Delta_4 i44_{t-2}$ ($\beta_{6,2}$)	0.048**	(0.023)	2.04
z_{t-1} (β_7)	-0.218***	(0.026)	-8.3
Adjusted R^2	0.924903		
Standard deviation	0.004		
White test[1] (*p*-value)	-		
LM test[2] (*p*-value)	0.347		
Jarque-Bera[3] (*p*-value)	0.993		

1) We do not have a sufficient number of observations to perform a White test on this model.
2) Autocorrelation test of the remaining terms with five lags. The null hypothesis is that the error terms are not autocorrelated. The high *p*-value does not provide grounds for rejecting the null hypothesis.
3) Normality test of the remaining terms with five lags. The null hypothesis is that the error terms are normally distributed. The high *p*-value does not provide grounds for rejecting the null hypothesis.
****** Indicates significance at the 5 percent significance level.
******* Indicates significance at the 1 percent significance level.

The results show that $\beta_{6,2}$ is significantly different from zero at a 5 percent significance level. This provides some support for the hypothesis that large exchange rate movements result in a relatively higher pass-through to prices for imported consumer goods than small exchange rate movements. However, the result is dependent on the choice of threshold value and estimation period.

Overall, the various estimations we have presented in Appendix C provide some support for the hypothesis that the exchange rate pass-through varies with the size of the exchange rate movement. However, the results are dependent on the choice of model, threshold value and estimation period.

[22] In this model, γ (from equation (A.2)) has been re-estimated to 0.70. The change is due to our inclusion of short-run effects of the exchange rate.