STAFF MEMO

The exchange rate pass-through to consumer prices in Norway

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The exchange rate pass-through to consumer prices in Norway

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The krone depreciated through 2013. It is important for a central bank to understand the potential effects of exchange rate changes on the consumer prices. This Staff Memo presents an empirical analysis of the impact of the exchange rate in Norway, focusing on the extent to which the exchange rate pass-through to prices for imported consumer goods can be regarded as non-linear and symmetric. We find support for the hypothesis of a non-linear exchange rate pass-through. Substantial changes in the krone exchange rate have had a more pronounced relative effect on prices for imported consumer goods than small variations. The results do not, however, provide a basis for asserting that the pass-through is asymmetric.

Changes in the exchange rate are assumed to affect consumer prices through three channels:[2] (i) a *direct effect* on prices for imported consumer goods; (ii) an *indirect effect* via prices for imported intermediate goods, which in turn influence prices for domestically produced goods and services; and (iii) a *profitability effect*, where changes in the exchange rate can influence the profitability of internationally exposed industries and in turn affect consumer prices. This memo focuses on the *direct effect* of exchange rate changes on prices for imported consumer goods.

Prices for imported consumer goods currently account for 29.2 percent of the consumer price index in Norway.[3] Imported consumer goods primarily comprise goods from five main groups: (i) food and non-alcoholic beverages, (ii) clothing and footwear, (iii) furniture, household articles and furnishings, (iv) transport (vehicles), and (v) recreation and culture.[4] The exchange rate pass-through to retail prices can vary across the different industries. Wulfsberg (2009) finds, for example, that the average time between price adjustments varies from around 6 months for food to 11 months for footwear. In addition, the

[1] I thank Kjetil Olsen, Ida Wolden Bache, Snorre Evjen, Nina Larsson Midthjell, Solveig K. Erlandsen, Øystein Sjølie og Pål Bergset Ulvedal for valuable comments.
[2] Norges Bank (2002), *Inflation Report* 2/2002: 32-33.
[3] https://www.ssb.no/en/priser-og-prisindekser/statistikker/kpi/maaned
[4] See Appendix C in https://www.ssb.no/a/publikasjoner/pdf/nos_c680/nos_c680.pdf (Norwegian only)

competitive situation and the degree of currency hedging may vary.[5] In this memo, sector-specific variations in the exchange rate pass-through are disregarded and the analysis focuses on the aggregate pass-through to prices for imported consumer goods.

There is great uncertainty as to how changes in the exchange rate affect prices in the short term. Firms' purchasing agreements may be long-term contracts[6] and some firms' contracts include a hedge against short-term fluctuations in the exchange rate[7]. As a rule, this will limit the impact of the exchange rate in the short term. Long-term changes in the exchange rate, however, can be expected to have a more pronounced effect on prices because firms can then renegotiate contracts.

The exchange rate pass-through may also vary with the magnitude of the change in the exchange rate. Firms may incur costs in connection with price changes. When exchange rate fluctuations are small, the benefit from the change in price can be exceeded by the costs involved. This may induce firms to leave prices unchanged when exchange rate movements are small. Large exchange rate fluctuations, on the other hand, can rapidly affect firms' optimal behaviour and can therefore affect consumer prices more quickly than small movements in the exchange rate.

It is also possible that a depreciation of the exchange rate affects prices more rapidly than an appreciation. When the krone depreciates, the prices on imported goods which the firm imports rise. If selling prices are not adjusted, depreciation will result in weaker margins for importers[8] and lower profits. A comparable appreciation may have less effect on prices as an appreciation in itself results in higher earnings for retail trade firms. Unless there are conditions of perfect competition, firms would have less incentive to change selling prices.

This memo explores whether there is an empirical basis for the hypotheses of asymmetric and non-linear exchange rate pass-through to prices for imported consumer goods in Norway using aggregate data.[9] The empirical literature has traditionally applied two methods to establish asymmetric pass-through in the short term: (i) estimation of individual episodes of long-term monotonic movements in the exchange rate (Mann, 1986) and (ii) estimation of

[5] See for example Børsum og Ødegaard (2005).
[6] See for example Langbraaten, Nordbø og Wulfsberg (2008).
[7] See for example Børsum og Ødegaard (2005).
[8] Importers are assumed to be competing under conditions of monopolistic competition.
[9] Previous literature on the exchange rate pass-through in Norway has analysed two main questions: (i) do movements in the exchange rate fully pass through to prices for imported consumer goods? (see for example Bache (2002) and Naug and Nymoen (1996), and (ii) how rapid is the exchange rate pass-through (Naug og Nymoen (1996) and Benedictow and Boug (2013))?

short-term equations with indicator variables for exchange rate depreciations and appreciations (Knetter, 1994). Method (ii) is applied to Norwegian data in this memo. Our results do not support the hypothesis of asymmetric exchange rate pass-through.

The hypothesis of non-linear exchange rate pass-through is tested using indicator variables to capture particularly large exchange rate fluctuations. We find support for the existence of non-linear effects in the exchange rate pass-through in Norway; large and long-term changes in the exchange rate have a greater relative effect on prices than small fluctuations

The rest of the memo is structured as follows: Section 1 discusses an economic framework for understanding asymmetry and non-linearity in the exchange rate pass-through. Section 2 presents the data set used. The empirical analysis is presented in Section 3. Section 4 concludes.

1. Importer pricing and exchange rate pass-through

The price setting in many of the goods which are characterised as imported consumer goods can, to a large extent, be described by a framework of *importer pricing*.[10] Assume that prices in Norway are set by firms which import goods from abroad and sell these goods on the domestic market. These firms have three major cost components: (i) the prices on goods abroad, (ii) the krone exchange rate, and (iii) costs related to operations in Norway such as wage costs and distribution costs. In addition, assume that there are costs related to price changes and that the firms can hedge against exchange rate fluctuations either by using financial instruments or by entering into long-term purchasing contracts in NOK.

The framework for importer pricing has two implications for the exchange rate pass-through. The first implication is that exchange rate changes must be prolonged and substantial before changes in the krone exchange rate have an effect on prices. Currency hedging and long-term contracts ensure that firms' purchasing prices remain constant even when the exchange rate fluctuates. The exchange rate has an effect on firms' purchasing prices only when the contracts are renegotiated.

In addition, price changes usually involve costs for firms, and the changes must therefore be large enough for the benefit of adjusting prices to exceed the costs. Expectations regarding

[10] In some groups of goods, the price setting is often described as pricing to market (PTM, for example cars), but most consumer goods can be characterised by importer pricing.

the future krone exchange rate will also play a role (see for example Bache and Naug (2007)). Because of the costs involved in changing prices, firms will take into account the consequences a change in prices today will have for earnings in the future. If exchange rate changes are expected to be temporary, firms will be less inclined to adjust their prices as they will expect to have to change their prices back later, which in turn involves costs.[11] Pronounced exchange rate movements can influence expectations in such a way that firms to a greater extent perceive changes as long-term. A change in the exchange rate will thus only affect prices for imported consumer goods when the change is pronounced and prolonged and firms expect the change to persist.[12]

The other implication is that the exchange rate pass-through can be asymmetric in the short term. Importers in the Norwegian market usually have some degree of market power, and prices for imported consumer goods are set by adding a mark-up over their factor costs. When the krone depreciates, firm purchasing prices will increase when hedge contracts have expired. If the firm does not change its prices, higher purchasing costs will entail lower profits for the firm and a risk of bankruptcy or limited solvency. A comparable appreciation will, on the other hand, entail higher earnings for the firm if selling prices remain unchanged, and the firm will only risk losing market shares. In the short term, this may induce firms to change their prices more rapidly when the krone depreciates than when it appreciates. The following sections explore whether there is empirical support for asymmetric and non-linear pass-through from changes in the krone to prices for imported consumer goods.

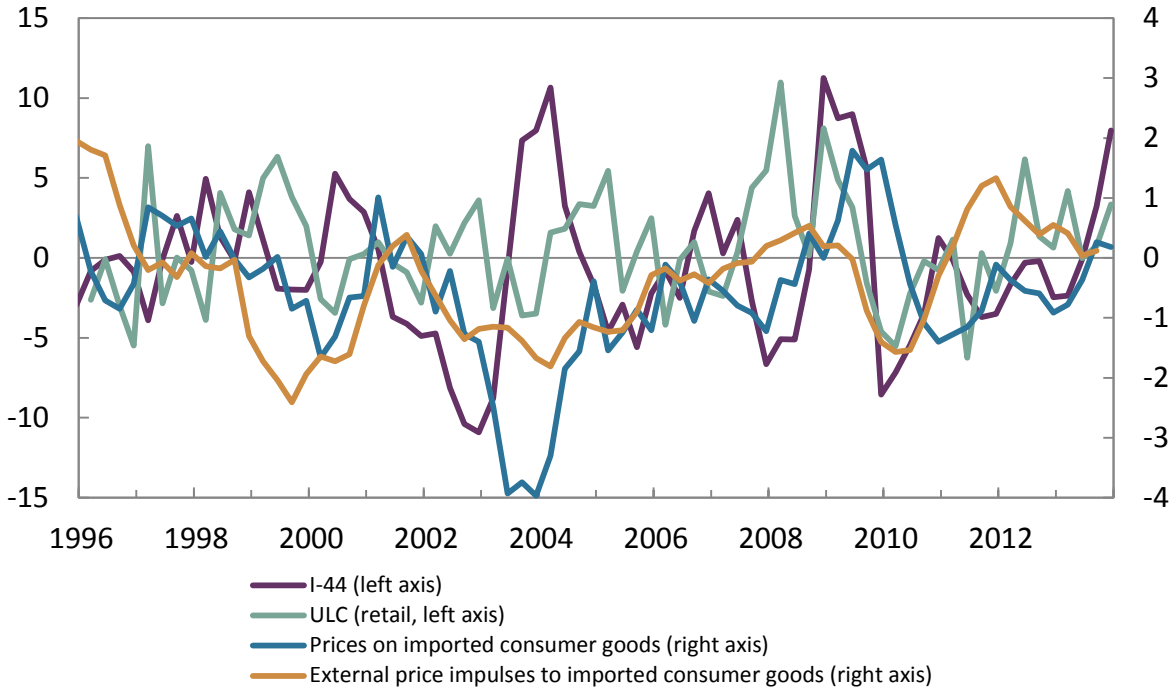
2. Data

We use quarterly data represented by the average of the variable in the respective quarter. The exchange rate is represented by the import-weighted exchange rate index (I-44)[13] in all estimations. Prices for imported consumer goods are represented by prices included in supply sector 4, «Imported consumer goods», in the CPI adjusted for tax changes and

[11] Krone exchange rate expectations, as recorded in the Opinion expectations survey, for example, have indicated that fluctuations in the krone exchange rate are often expected to be partially reversed. See http://www.opinion.no/presse/forventningsunders%C3%B8kelsen-norges-bank.aspx.
[12] Implicit, it is assumed that the firm is forward-looking and chooses its prices by maximising profit with respect to exchange rate expectations.
[13] The I-44 index is a nominal effective exchange rate index based on NOK exchange rates as measured against the currencies of 44 of Norway's main trading partners. See http://www.norges-bank.no/no/prisstabilitet/valutakurser/beregnede-kurser-forklaring/.

excluding energy products (CPI-ATE).[14] The unit labour cost in the retail trade sector is used to represent domestic costs[15] and the index for external price impulses to imported consumer goods (IPK), which is constructed by Norges Bank, is used to represent prices for goods abroad.[16]

Chart 1: Prices for imported consumer goods, the krone exchange rate (I-44)*, unit labour costs in the retail trade sector (ULC) and external price impulses to imported consumer goods(IPK). Four-quarter change. Percent. 1996 Q1 – 2013 Q4



*) A rising curve denotes a depreciating krone. Sources: Statistics Norway and Norges Bank

Chart 1 shows developments in the four-quarter change in prices for imported consumer goods, the krone exchange rate, the unit labour cost in the retail trade sector and external price impulses to consumer prices since 1996. 1996 is chosen as the starting year to avoid problems with regime changes when Norway abandoned the fixed exchange rate. The movements in prices on imported consumer goods have been stable through most of the period, except for two episodes connected with large changes in the exchange rate. In 2002 – 2004, the krone appreciated with more than 10 percent followed by a strong depreciation

[14] See https://www.ssb.no/priser-og-prisindekser/statistikker/kpi.
[15] Unit labour costs in the retail trade sector is calculated from the quarterly national accounts as wage costs in the retail trade sector divided by production in the retail trade sector. See https://www.ssb.no/nasjonalregnskap-og-konjunkturer/statistikker/knr.
[16] The index for external price impulses to imported consumer goods is constructed as a weighted average of the rise in prices for relevant subcomponents among Norway's trading partners. See http://www.norges-bank.no/Upload/import/publikasjoner/penger_og_kreditt/2004-02/rostoen.pdf.

and correlates with a period when the four-quarter change in the prices on imported consumer goods was as low as -4 percent. During the financial crisis in 2008 – 2009, the krone depreciated by more than 10 percent and there was a rise in the four-quarter change in prices on imported consumer goods to about 2 percent. This indicates that the correlation between the krone exchange rate and the prices on imported consumer goods is particularly strong during periods of pronounces movements in the exchange rate.

Average annual change in the prices on imported consumer goods was -0.6 percent and in 2013 Q4, the prices on imported consumer goods were about 10 percent lower than in 2000. One reason for the fall in prices is the liberalisation of trade in textile and clothing products in the WTO and China's entry into world trade (Moe 2002), something which is reflected in low and negative growth in the external price impulses to imported consumer goods for most of the period. By just looking at the chart, it is hard to see a clear pattern in the correlation between unit labour costs and the prices on imported consumer goods.

3. Empirical analysis

In the empirical models, we seek shed light on two implications from the theoretical framework for importer pricing:

(i) Asymmetry: Does exchange rate depreciation have a greater effect on prices than appreciation?

(ii) Non-linearity: Do substantial and prolonged changes in the krone exchange rate have a more pronounced relative effect on prices than small changes?

In the economic literature, the hypothesis of asymmetry in exchange rate pass-through has often been tested by means of a model with indicator variables for depreciation and appreciation (Knetter 1994). Section 3.1 presents such an equation estimated using Norwegian data. In Section 3.2, an equation is estimated with indicator variables for substantial changes in the krone exchange rate.

The four-quarter rise in the variables is used to estimate short-term relationships in all estimations. This is done because exchange rates are very volatile, and using the four-quarter rise removes some of the noise from the variables. Using the four-quarter rise also reduces the effect of seasonal variations in the variables. In addition, the four-quarter rise

captures more long-term changes in the variables and the results will then to a great extent capture the pass-through even with a high degree of short-term price rigidity in price-setting.

3.1. Model with indicator variables for depreciation and appreciation

In this section, a simple model is estimated with indicator variables for depreciation and appreciation to capture any asymmetry in the exchange rate pass-through to prices for imported consumer goods in the short term. This approach follows Knetter (1994), who investigates the hypothesis of an asymmetric response of prices to exchange rates at industry level in trade between Japan and Germany. Knetter finds that the hypothesis of an asymmetric response cannot be rejected for most industry groups. In this memo, the method has been expanded into an error correction model and includes external price impulses to imported consumer goods in Norway. In all empirical specifications, the models have been estimated with a unit labour cost term in the dynamic section which was statistically insignificant in all specifications. Unit labour costs are therefore left out of the models except in the error correction term. In addition, the basic model is estimated without indicator variables for comparison. The empirical specifications are as follows:

$$\boldsymbol{\Delta_4 P_t^{imp} = \beta_0 + \beta_1 \Delta_4 P_{t-1}^{imp} + \beta_2 \Delta_4 IPK_t + \beta_3 \Delta_4 NOK_{t-1} + \beta_5 ECT_{t-1} + \epsilon_t} \quad (3.1.1)$$

$$\boldsymbol{\Delta_4 P_t^{imp} = \beta_0 + \beta_1 \Delta_4 P_{t-1}^{imp} + \beta_2 \Delta_4 IPK_t + \beta_3 d_{t-1}^{appr} \Delta_4 NOK_{t-1} + \beta_4 d_{t-1}^{depr} \Delta_4 NOK_{t-1} + \beta_5 ECT_{t-1} + \epsilon_t} \quad (3.1.2)$$

where equation (3.1.1) is the model without indicator variables, while equation (3.1.2) is the model that can capture asymmetry in the exchange rate pass-through. $\Delta_4 P_t^{imp}$ is the four-quarter rise in prices for imported consumer goods in Norway, $\Delta_4 IPK_t$ is the four-quarter rise in external price impulses to imported consumer goods, $\Delta_4 NOK_{t-1}$ is the four-quarter rise in the exchange rate as measured by the I-44, and d_{t-1}^{appr} (d_{t-1}^{depr}) is an indicator that takes the value 1 when the four-quarter change in the exchange rate shows an appreciation (depreciation) and zero otherwise. The specifications above include only the one-lagged version of the krone exchange rate in the short-run dynamics.[17] It has been tested for various lag specifications, and the main results are robust to these. The equations have an error correction term (ECT) that captures our expectations of a constant relationship

[17] Including more lags of the four-quarter change in the krone exchange rate can be problematic because these will be collinear.

between prices for imported consumer goods, the exchange rate, unit labour costs, and external price impulses over time.[18]

In the estimation, the coefficients β_3 and β_4 are expected to be positive. A depreciation of the krone ($\Delta_4 NOK_{t-1} > 0$) is expected to push up the rise in prices for imported consumer goods. Similarly, an appreciation of the krone ($\Delta_4 NOK_{t-1} < 0$) is expected to dampen the rise in prices. Thus, any movements in the exchange rate will entail that the rise in prices for imported consumer goods will be expected to change in the same direction.

It is assumed that the krone exchange rate is exogenous to the prices on imported consumer goods. It can be argued that the prices on imported consumer goods can have a contemporaneous effect on the exchange rate. For example, a surprisingly rise in the price on imported goods can lead to an exchange rate appreciation because the market expect the central bank to react by increasing the interest rate. This effect, however, is opposite to the expected effect from the exchange rate to the prices on imported consumer goods. Thus, if anything, the results from the equations in this memo will be biased downward.

Equation (3.1.2) can establish asymmetry in the exchange rate pass-through in the short run. If β_3 is significantly different from β_4, this means that the effect of a change in the exchange rate on the rise in prices for imported consumer goods will depend on whether the krone appreciates or depreciates. In other words, if $\beta_3 \neq \beta_4$, we have empirical support for the assertion that the exchange rate pass-through is asymmetric. The results can also give an indication of the direction of the asymmetry in exchange rate pass-through. If for example $\beta_4 > \beta_3$, the effect of the exchange rate on prices for imported consumer goods is stronger when the krone depreciates than when it appreciates.

Table 1 shows the results obtained from the estimation of equation (3.1.1) and (3.1.2). In both specifications, the error correction term is negative. This is as expected and implies that if prices for imported consumer goods are deviating from an equilibrium level, the prices will have a tendency to move toward that equilibrium level. The coefficient determines how rapidly prices for imported consumer goods converge towards such an equilibrium level.

[18] The error correction term is estimated by a co-integration equation under the assumption of homogeneity of degree one and is defined as $\log(P_{t-1}^{imp}) - 0{,}65\log(\mathrm{IPK}_{t-1}) - 0{,}65\log(\mathrm{NOK}_{t-1}) - 0{,}35\log(\mathrm{ULC}_{t-1})$. The error correction term corresponds to the results in Naug and Nymoen (1996).

Table 1: Results from estimation of equation (3.1.1) and (3.1.2)

	A		B	
	1996 Q1-2013 Q4		**1996 Q1–2013 Q4**	
Constant ($\boldsymbol{\beta_0}$)	-0.061*	*(0.036)*	-0.064*	*(0.037)*
$\boldsymbol{\Delta_4 P_{t-1}^{imp}}$ ($\boldsymbol{\beta_1}$)	0.779**	*(0.063)*	0.779**	*(0.064)*
$\boldsymbol{\Delta_4 IPK_t}$ ($\boldsymbol{\beta_2}$)	0.145**	*(0.075)*	0.154**	(0.078)
$\boldsymbol{\Delta_4 NOK_{t-1}}$ ($\boldsymbol{A}$: $\boldsymbol{\beta_3}$)	0.044**	*(0.018)*		
$\boldsymbol{d_{t-1}^{appr} \Delta_4 NOK_{t-1}}$ ($\boldsymbol{B}$: $\boldsymbol{\beta_3}$)			0.035	*(0.029)*
$\boldsymbol{d_{t-1}^{depr} \Delta_4 NOK_{t-1}}$ ($\boldsymbol{B}$: $\boldsymbol{\beta_4}$)			0.054*	*(0.030)*
Error correction term($\boldsymbol{\beta_5}$)	-0.041*	*(0.024)*	-0.042*	*(0.025)*
Adjusted $\boldsymbol{R^2}$	0.745		0.742	
Standard error	0.006		0.006	
Wald Test			0.686	

All equations are estimated using OLS. The figures in brackets are the coefficient's standard deviation.
* indicates significance at 90 %
** indicates significance at 95 %
The Wald Test shows a probability of hypothesis $\beta_3 = \beta_4$ in equation (3.1.2)

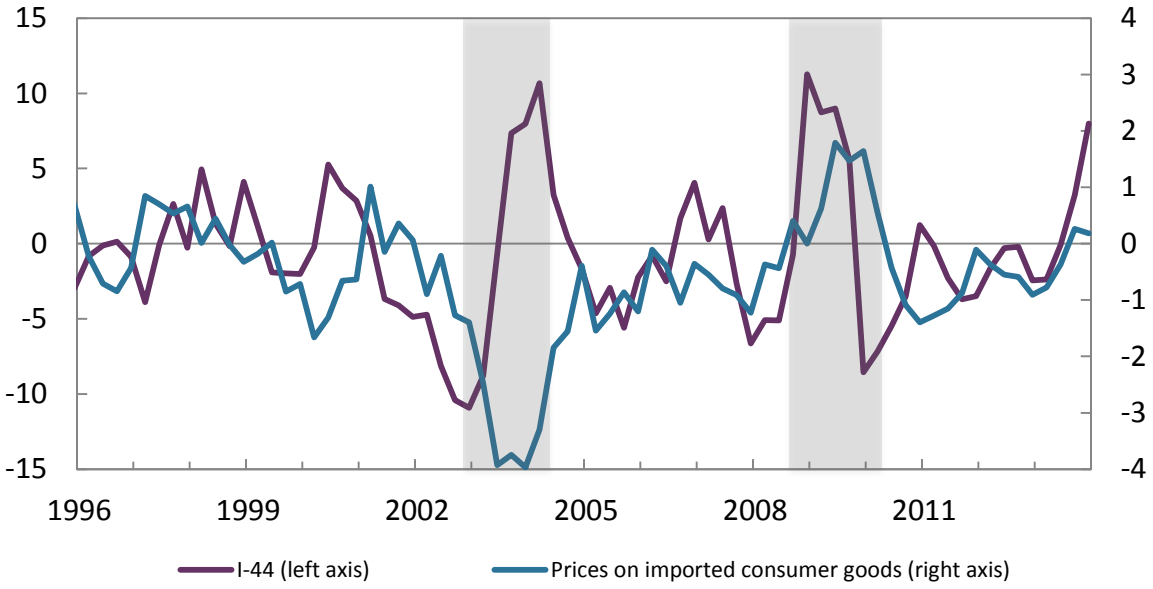
Column A shows the results of the model estimated without indicator variables. The results show that the pass-through from the krone exchange rate to prices for imported consumer goods is positive and statistically significant, although fairly weak. The coefficient has the expected sign and implies that a weaker krone exchange rate lead to higher prices on imported consumer goods.

Equation (3.1.2) seeks to capture asymmetric effects of changes in the exchange rate. The results provide little support for the hypothesis of asymmetric exchange rate pass-through. The coefficients for the exchange rate changes are positive and the coefficient for depreciation is higher than for appreciation. The coefficient for depreciations in the krone exchange rate is statistically significant, but a Wald test shows that there is no support for the assertion that the two coefficients are significantly different. On the other hand, it may be possible that asymmetry can still be found in the pass-through when exchange rate changes are pronounced. The next section explores in more detail the hypothesis of non-linear exchange rate pass-through and asymmetry when changes in the exchange rate are pronounced.

3.2. Model with non-linear effects

The framework for importer pricing suggested that there can be non-linear effects in the exchange rate pass-through, i.e. substantial and long-term changes in the exchange rate have a larger relative effect on imported consumer goods than small, short-term changes. Chart 2 shows the four-quarter rise in prices for imported consumer goods in the CPI-ATE and the exchange rate. The chart indicates that the correlation between the two variables is reasonably high. In two periods, marked by grey bands, where fluctuations in the exchange rate were particularly large, the correlation was particularly strong. In both periods, the four-quarter change in the exchange rate was higher than 7.2 percent. This section investigates the hypothesis of non-linearity in exchange rate pass-through.

Chart 2: Prices for imported consumer goods and krone exchange rate (I-44). Four-quarter change. Percent. 1996 Q1 – 2013 Q4



Sources: Statistics Norway and Norges Bank

Two equations have been estimated to attempt to capture such non-linear effects:

$$\Delta_4 P_t^{imp} = \beta_0 + \beta_1 \Delta_4 P_{t-1}^{imp} + \beta_2 \Delta_4 NOK_t + \beta_3 \Delta_4 IPK_t + \beta_4 d_{t-1}^{big} \Delta_4 NOK_t + \beta_5 d_{t-1}^{big} + \beta_6 ECT_{t-1} + \epsilon_t \quad (3.2.1)$$

$$\Delta_4 P_t^{imp} = \beta_0 + \beta_1 \Delta_4 P_{t-1}^{imp} + \beta_2 \Delta_4 NOK_t + \beta_3 \Delta_4 IPK_t + \beta_4 d_{t-1}^{appr_{big}} \Delta_4 NOK_t + \beta_5 d_{t-1}^{depr_{big}} \Delta_4 NOK_t + \beta_6 ECT_{t-1} + \epsilon_t \quad (3.2.2)$$

where $d_{t-1}^{appr_{big}}$ ($d_{t-1}^{depr_{big}}$) is an indicator that is 1 when the four-quarter rise in the exchange rate is lower (higher) than 7.2 percent in the preceding quarter and d_{t-1}^{big} is an indicator that is 1 when the absolute value of the four-quarter rise in the krone exchange rate is higher than 7.2 percent in period t-1. All other variables are the same as in equation (3.1.1) and (3.1.2).[19] This indicator therefore captures the effect of krone exchange rate changes during a period of considerable exchange rate volatility. Table 2 shows the developments in these indicator variables over time. The level of 7.2 percent was selected in order to capture the two periods marked in grey in Chart 3.[20]

Table 2: Indicator variable values for substantial changes in the exchange rate. At all other times, the indicators are at zero.

	d_t^{big}	$d_t^{appr_{big}}$	$d_t^{depr_{big}}$
2002 Q2	1	1	0
2002 Q3	1	1	0
2002 Q4	1	1	0
2003 Q1	1	1	0
2003 Q4	1	0	1
2004 Q1	1	0	1
2008 Q4	1	0	1
2009 Q1	1	0	1
2009 Q2	1	0	1
2009 Q4	1	1	0
2013 Q4	1	0	1

The equations have been constructed to investigate the hypothesis of non-linear exchange rate pass-through. In equation (3.2.1), β_2 captures the exchange rate pass-through during a period of low exchange rate volatility, while β_4 captures the extra effect from the exchange rate on prices for imported consumer goods in a period of high volatility. The hypothesis of non-linear exchange rate pass-through in equation (3.2.1) can then be formulated as follows: $H_0: \beta_4 \neq 0$. In equation (3.2.2), the indicator term for substantial changes in the exchange rate is divided between periods of appreciation and depreciation of the krone. The hypothesis of non-linear exchange rate pass-through can again be formulated as follows:

[19] In equation (3.2.1) and (3.2.2), the contemporary version of the krone exchange rate is applied instead of the lagged variable as in equation (3.1.1) and (3.1.2). The main result holds under both assumptions.

[20] The results for non-linearity prove to be significant at a 90 percent confidence level in both equation (3.2.1) and (3.2.2) when the indicator variable is defined as 1 when the change in the krone exchange rate is between 7.1 and 8.4 percent.

$H_0: \beta_4 \neq 0$ or $\beta_5 \neq 0$. In addition, whether exchange rate pass-through is asymmetric when changes in the exchange rate are pronounced can be examined in equation (3.2.2). This hypothesis can be formulated as follows: $H_0: \beta_4 \neq \beta_5$.

Table 3 shows the results from equation (3.2.1) and (3.2.2) for the period from 1994 Q1 to 2013 Q4. Both equations support the hypothesis of non-linear exchange rate pass-through. In equation (3.2.1) (column C), β_4 is significantly positive, which implies that the exchange rate has a greater relative effect on prices for imported consumer goods when exchange rate volatility is high. In equation (3.2.2) (column D), β_5 is significantly positive, which further implies that this non-linear effect is mainly driven by periods of depreciation in the krone exchange rate. The coefficient intended to capture exchange rate pass-through in a normal period, β_2, is not significantly different from zero in either equation and the coefficient for large exchange rate changes in equation (3.2.1) is considerably larger than the coefficient for exchange rate changes in section 3.1.[21] This indicates that the exchange rate pass-through to prices on imported consumer goods is strongest when the krone exchange rate fluctuations are pronounced.

[21] A possible interpretation could be that the results are driven by long periods where there is little movements in the krone exchange rate and few episodes with large changes. For short samples, average estimations, such as in section (3.1), can possibly underestimate the actual exchange rate pass-through, while an model with dummies for large changes in the krone exchange rate to a larger extent will estimate the actual exchange rate pass-through.

Table 3: Results from estimation of equations (3.2.1) and (3.2.2)

	C		D	
	1994 Q1–2013 Q4		1994 Q4–2013 Q4	
Constant	-0.086**	*(0.035)*	-0.091**	*(0.035)*
$\Delta_4 P_{t-1}^{imp}$ (β_1)	0.770**	*(0.067)*	0.766**	*(0.067)*
$\Delta_4 NOK_t$ (β_2)	-0.021	*(0.020)*	-0.022	*(0.020)*
$\Delta_4 IPK_t$ (β_3)	0.093	*(0.081)*	0.111	*(0.080)*
$d_{t-1}^{appr_{big}} \Delta_4 NOK_t$ (D: β_4)			0.056	*(0.038)*
$d_{t-1}^{depr_{big}} \Delta_4 NOK_t$ (D: β_5)			0.083**	*(0.041)*
$d_{t-1}^{big}\ \Delta_4 NOK_t$ (C: β_4)	0.068**	*(0.031)*		
d_{t-1}^{big} (C: β_5)	-0.001	*(0.002)*		
Error correction term (β_6)	-0.057**	*(0.024)*	-0.060**	*(0.024)*
Adjusted R^2	0.733		0.734	
Standard error	0.006		0.006	
Wald Test			0.585	

All equations are estimated using OLS. The figures in brackets are the coefficient's standard deviation.
* indicates significance at 90 %
** indicates significance at 95 %
The Wald Test shows a probability of hypothesis $\beta_4 = \beta_5$ in equation (3.2.2)

In addition, the results from equation (3.2.2) (column D) can be used to investigate the hypothesis of asymmetric exchange rate pass-through in the case of substantial changes in the krone exchange rate. A significant difference between β_4 and β_5 may indicate that the pass-through is asymmetric. The results show that the coefficient for periods of substantial depreciation is higher than the coefficient for periods of substantial appreciation, indicating asymmetry in the pass-through. In particular, the coefficient for periods of substantial depreciation is high and statistically significant. A Wald test, however, does not provide support for the hypothesis that the exchange rate pass-through is asymmetric. We therefore conclude that the results indicate that the exchange rate pass-through might be asymmetric when exchange rate changes are substantial, but this result is not statistically significant.

4. Conclusion

This memo has presented a framework based on importer pricing to understand the exchange rate pass-through in Norway. We have investigated two possible implications for

the exchange rate pass-through. The first possible implication is that the exchange rate pass-through can be non-linear. Long-term contracts and currency hedging contribute to keeping firms' purchasing prices constant even when the exchange rate fluctuates. Because of the costs associated with price changes, price changes must be substantial for the benefit of adjusting prices to exceed the costs. In addition, expectations regarding the krone exchange rate ahead play a role because the costs involved in changing prices will deter firms from changing prices in the future. Thus, a change in the exchange rate will have a substantial effect on prices for imported consumer goods only when the change is large and prolonged and firms expect the change to persist.

The other possible implication is that the exchange rate pass-through can be asymmetric in the short term. Importers in the Norwegian market usually have some degree of market power, and prices for imported consumer goods are set by adding a mark-up to the import price. When the krone depreciates, purchasing prices will increase when hedge contracts have expired. If a firm does not change its prices, higher purchasing costs will entail lower profits for the firm. A comparable appreciation will, on the other hand, entail higher earnings for the firm if selling prices remain unchanged. In the short term, firms may therefore be more inclined to change their prices more rapidly when the krone depreciates than when it appreciates.

The two hypotheses on the exchange rate pass-through have been investigated empirically using Norwegian data. We find support for the hypothesis that the exchange rate pass-through is non-linear. Large changes in the krone exchange rate have historically had a larger relative effect on prices for imported consumer goods than small fluctuations. The results do not, however, provide a basis for asserting that the exchange rate pass-through is asymmetric.

REFERENCES

Benedictow, A. and P. Boug (2013). "Trade liberalisation and exchange rate pass-through: the case of textiles and wearing apparels." Empirical Economics **45**(2): 757-788.

Bache, I.W. (2002). "Empirical Modelling of Norwegian Import Prices." Norges Bank WP **1**:2002.

Bache, I.W. and B.E. Naug (2007), "Estimating New Keynesian import price models." Norges Bank WP **15**:2007.

Boug, P., Å. Cappelen and T. Eika (2005). "Exchange rate pass-through in a Small Open Economy." Statistics Norway Discussion Paper No. 429.

Børsum, Ø. G. and B. A. Ødegaard (2005). "Valutasikring i norske selskaper." Penger og Kreditt **33**(1): 29-40.

Knetter, M. M. (1994). "Is export price adjustment asymmetric?: evaluating the market share and marketing bottlenecks hypotheses." Journal of International Money and Finance **13**(1): 55-70.

Langbraaten, N., E. W. Nordbø and F. Wulfsberg (2008). "Prissetting i norske bedrifter. Resultater fra en spørreundersøkelse." Penger og Kreditt **36**(2): 22.

Mann, C. L. (1986). "Prices, profit margins, and exchange rates." Fed. Res. Bull. **72**: 366.

Moe, M. V. (2002). "Faktorer bak prisutviklingen på importerte klær." Økonomiske analyser **2**(2002): 48-55.

Naug, B. E. and R. Nymoen (1996). "Pricing to Market in a Small Open Economy." Scandinavian Journal of Economics **98**(3): 329-50.

Norges Bank (2002). "Inflasjonsrapport 2/2002." 32-33.

Webber, A. G. (2000). "Newton's gravity law and import prices in the Asia Pacific." Japan and the World Economy **12**(1): 71-87.

Wulfsberg, F. (2009). "Price Adjustments and Inflation: Evidence from Consumer Price Data in Norway 1975-2004." Norges Bank WP **11**: 2009.