DANMARKS NATIONALBANK

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The krone rate has modest impact on the current account

The krone rate affects the current account with a lag

The effect on the current account of a change in the nominal effective exchange rate of the krone is close to zero in the first year. In the slightly longer term, the current account will be weakened by approximately 0.1 per cent of GDP if the krone rate strengthens by 1 per cent.

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The pass-through from the krone rate to the current account is stable over time

Globalisation has increased international trade and has led to production chains been split across countries. This development has not affected the pass-through from the krone rate to the current account.

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In the long term, the current account is driven by other factors than the krone rate

The current account is the difference between national savings and real investment. In the long term, it is driven mainly by other factors than the krone rate. The large surplus at present is primarily attributable to households opting to save, e.g. to reduce their debts.

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Denmark is a small, open economy, so trade with other countries has a cyclical impact. Fluctuations in the effective exchange rate of the krone[1] can affect imports and exports and therefore the current account of the balance of payments. So in relation to Danmarks Nationalbank's continuous monitoring of the Danish economy it is important to understand how and to which extent the exchange rate affects the current account.

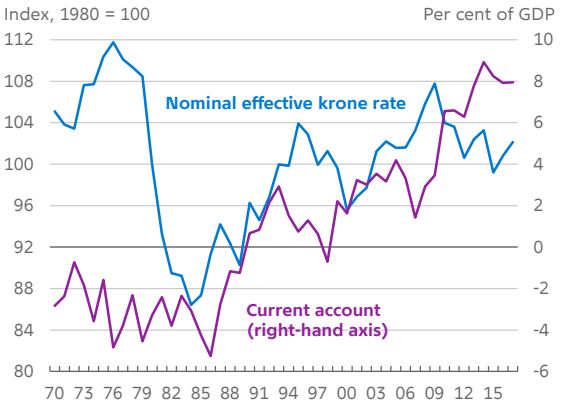
In the long term, the current account is driven by other factors than the exchange rate

The current account can be viewed from various angles. In the long term, it is often expedient to see it as the difference between national savings and real investment, e.g. in buildings and machines. Both savings and real investment – and hence the current account – are ultimately determined mainly by other factors than the effective krone rate, such as demographics. Households save in order to spend later, and pension savings help to ensure that people can maintain more or less the same level of consumption after retirement from the labour market, cf. Autrup et al. (2015).

The fact that the effective krone rate today is close to the 1980 level, while a current account deficit has moved from a deficit to a substantial surplus, cf. Chart 1, illustrates that there is no long-term correlation between the exchange rate and the current account.

Since 2010 the surpluses have been extraordinarily large. This is primarily because households have chosen to save heavily, e.g. to reduce their debts, cf. Jørgensen et al. (2017). So the large surplus is not driven by the exchange rate of the krone.

The current account is driven by other factors than the exchange rate Chart 1



Note: Aggregate current account, including items such as investment income. Nominal effective exchange rate calculated as an annual average.
Source: Statistics Denmark and Danmarks Nationalbank.

The krone rate affects the current account with a lag

The current account can also be seen as the sum of the trade balance and the balances of income and current transfers. The krone rate affects the current account mainly via the trade balance, i.e. the difference between the value of exports and imports.

The pass-through effect moves through import and export prices

When Danish firms trade with firms abroad, they often use another currency than the Danish krone. Denmark has a fixed exchange rate policy against the euro area, meaning that the Danish krone is stable vis-à-vis the euro. But Danish firms trade with the whole world and the prices of goods and services invoiced in other currencies than the krone and

1 The effective exchange rate of the krone has been calculated as a weighted average of bilateral exchange rates against Denmark's most important trading partners' currencies.

the euro are affected by the exchange rate of the krone. If a Danish firm purchases goods in the USA and pays in dollars, a stronger dollar against the krone will, all else equal, increase the price of the goods measured in kroner.

So, viewed in isolation, a weak krone will improve the competitiveness of Danish firms by making foreign goods more expensive and Danish goods cheaper. This can boost the profits of the firms and hence national savings in the short term. In the longer term, large corporate profits will either be paid out to the owners or invested in real capital.[2]

Weakening of the krone also increases net investment income[3], but the effect is assessed to be small compared with the effect on the trade balance.[4] Below, the focus is therefore on the trade balance.

In the short term, the settlement currency determines, in purely mechanical terms, the pass-through from the exchange rate to the price of imports or exports in kroner. If settlement takes place in kroner, there is no pass-through. But if settlement takes place in e.g. dollars, there will be a full pass-through from any change in the dollar against the krone.

In the slightly longer term, exporters and importers will respond to exchange rate fluctuations by changing their behaviour. If, for instance, the krone weakens and import prices rise, the importer may choose to buy the goods elsewhere. To prevent this, the exporter can reduce the price in the foreign currency, so that the price increases less in kroner.

In other words, the overall effect of exchange rate fluctuations on the value of exports and imports depends on how prices are affected and how volumes are subsequently affected by the price changes.

A number of factors determine the pass-through from the exchange rate to prices and from prices to volumes. For example, fierce competition is characterised by a strong pass-through from prices to volumes, so that even small changes in prices trigger large changes in demand. This means that sellers will be more inclined to keep prices in the local currency unchanged, i.e. the pass-through from the exchange rate to prices will be small.

Splitting up production between firms all over the world may also have an impact on the pass-through. A substantial part of Denmark's imports is used for the production of goods for export. So if the prices of both the imports (subcomponents) and exports (finished goods) are settled in dollars, a weaker dollar reduces the import price in kroner but also the export price in kroner, which points to keeping both the import and export prices in dollars unchanged. This entails a strong pass-through to both import and export prices measured in kroner.[5] At the same time, both import and export volumes remain unchanged, resulting in a very small pass-through from prices to volumes. This example illustrates that to understand the development in import volumes it is important also to consider export volumes and not just import prices.

The exchange rate has little impact on the trade balance

So the aggregate pass-through from the exchange rate to imports and exports depends on how import and export prices change and how volumes are affected by such price changes. This pass-through can be described via elasticities, cf. Appendix 1.[6]

Each elasticity is determined individually by estimating an equation, cf. Appendix 2. The aggregate pass-through can then be calculated.

2 In the longer run higher import prices cause consumer prices to rise. This reduces real income and therefore import. Such second order effects are ignored here.

3 The difference between the return on Danish investments abroad and foreigners' return on investments in Denmark.

4 See Damgaard et al. (2018) for an analysis of the impact of the krone exchange rate on the Danes' net foreign assets.

5 It can also be argued that the pass-through is reduced, cf. e.g. Spange and Kristoffersen (2016). The foundation for this argument is that the weights in the calculations of the effective exchange rate are not based on added value. This reduces the co-variation between exchange rate and import prices. According to Bayoumi et al. (2018), the pass-through is, however, virtually unchanged if the weights are based on added value.

6 Note that this is a partial equilibrium approach. It means that second order effects on e.g. employment are ignored. To take these into account, an economic model is needed, cf. later section.

Pass-through from nominal effective krone rate

Table 1

	Pass-through from exchange rate		Pass-through from prices		Trade balance
	Export prices	Import prices	Export volumes	Import volumes	Semi-elasticity
Pass-through, 1st year	0.45***	-0.58***	0.22	-0.02	0.00
Aggregate pass through	0.45***	-0.58***	-0.56***	-0.10	-0.12

Note: *** indicates a significance level of 1 per cent, ** a significance level of 5 per cent and * a significance level of 10 per cent. Robust standard errors have been applied (Newey-West). A Wald test has been used to calculate the significance of the aggregate pass-through. For import volumes, the estimate for the exchange rate lagged three years is significant at the 1 per cent level, while the Wald test is not significant. The semi-elasticity shows how much the trade balance falls/rises in percentage points of GDP when the nominal effective krone rate strengthens/weakens. It has been calculated as in equation 6 in Appendix 1. The estimations are described in Appendix 1. Cross-elasticity between exports and imports is estimated at 0.60. This means that if exports grow by 1 per cent, imports increase by 0.6 per cent.
Source: Own calculations based on data from Statistics Denmark and Danmarks Nationalbank.

In the short term, the effect on the trade balance of a change in the nominal effective krone rate is close to zero, i.e. the trade balance as a share of the gross domestic product, GDP, remains virtually unchanged (semi-elasticity of 0.00), cf. Table 1. If the effective krone rate strengthens by 1 per cent, export prices, measured in foreign currency, rise by 0.45 per cent. This is equivalent to export prices in kroner declining by 0.55 per cent.[7] Import prices fall by more or less the same, while neither import nor export volumes change materially (the pass-through from prices is not significant in the short term, cf. Table 1).[8] So there are signs of a certain J-curve effect, i.e. only prices respond in the short term and hence the short-term effect of the exchange rate on the trade balance is very small.

In the slightly longer term, the pass-through from the krone rate is not zero, however. If the krone strengthens by 1 per cent, the trade balance deteriorates by 0.12 per cent of GDP, cf. the aggregate pass-through in Table 1. Relative to Denmark's trade balance, which constituted just over 7 per cent of GDP in 2017, this is a modest effect.

The entire price adjustment takes place within the first year, so the pass-through to prices does not change. But volumes adapt more sluggishly, and higher export prices, measured in foreign currency, gradually reduce export volumes (1 per cent higher export prices reduce volumes by 0.56 per cent). Overall, lower export prices, measured in kroner, and lower export volumes entail that if the krone strengthens by 1 per cent, the value of exports declines by approximately 0.4 per cent of GDP.[9] This should be seen in relation to exports in 2017 making up nearly 55 per cent of GDP.

For import prices, the entire price adjustment also takes place within the first year, while the adjustment in volumes is more gradual. They are affected by two opposite effects. A stronger krone means lower import prices, measured in kroner, which increases import volumes by 0.10 per cent. But a stronger krone also increases export prices in foreign currency, which reduces export volumes. Since the import content in exports is high, lower exports will reduce imports. The latter effect is estimated to dominate so that import volumes will decline when the krone strengthens. If the price and volume effects are combined, a 1 per cent strengthening of the krone will cause the value of imports to decline by approximately 0.3 per cent of GDP.[10] By comparison, imports made up approximately 47 per cent of GDP in 2017.

7 The sum of the pass-through to kroner and foreign currency is always 1. If the pass-through to kroner is 0.45 per cent, then the pass-through measured in foreign currency is 1-0.45 = 0.55 per cent.

8 Note that the estimated import price elasticity of 0.58 is very close to the estimate of 0.61 in Spange and Kristoffersen (2016).

9 Calculated on the basis of equation 3 in Appendix 1.

10 Calculated on the basis of equation 5 in Appendix 1.

So a stronger krone reduces both exports and imports. But imports fall by less than exports, and overall the trade balance weakens by approximately 0.1 per cent of GDP if the effective krone rate strengthens by 1 per cent.[11]

In Danmarks Nationalbank's macroeconomic model, the pass-through from the krone rate is also modest

Fluctuations in the effective krone rate not only have a direct impact on exports and imports, they also have derived effects on the current account. For example, a stronger krone dampens exports and hence firms' output. Viewed in isolation, this has a negative impact on the current account. But in the slightly longer term it means that employment and domestic activity decline, reducing demand for imports. Viewed in isolation, this has a positive impact on the current account. To take such derived effects into account, an economic model is required.

According to Danmarks Nationalbank's macroeconomic model, MONA, the current account surplus is reduced by 0.12 per cent of GDP after approximately three years if the nominal effective krone rate strengthens by 1 per cent, cf. Chart 2. This matches the results from the econometric analysis. The effect declines over time as domestic activity adjusts, and after five years the pass-through has halved.

The deterioration of the trade balance primarily reflects a lower surplus on the balance of goods, but the balance of services also has a downward impact.

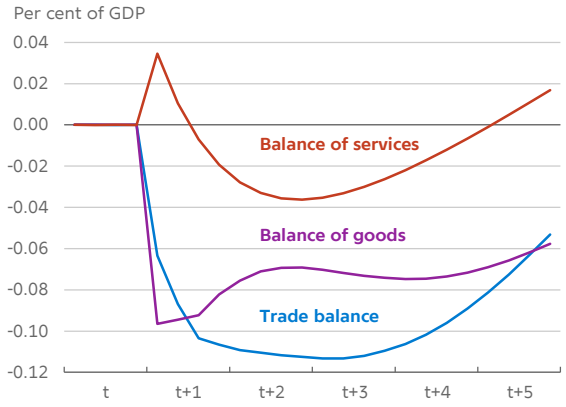
The pass-through from the krone rate to the current account is stable over time

The pass-through from the exchange rate to the current account is not necessarily constant over time. Increased globalisation, i.e. fewer trade barriers and lower transport costs, has affected the volume of Danish foreign trade and how it is conducted.

Denmark's trade with the rest of the world has increased strongly since the mid-1990s, cf. Chart 3.

Current account effect of a strengthening of the effective krone rate

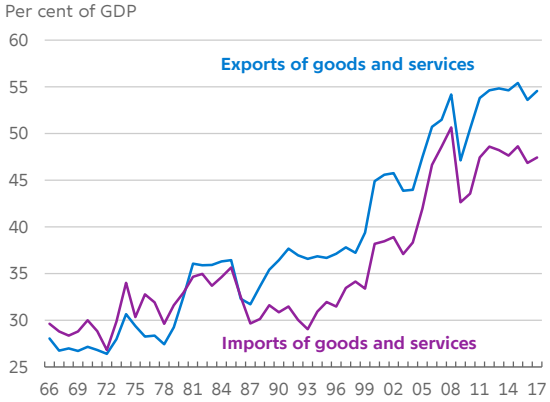
Chart 2



Note: t is year. Change relative to baseline scenario. Effect of a permanent shock of 1 per cent to the nominal effective krone rate.
Source: Own calculations based on MONA.

Extensive trade with the rest of the world

Chart 3



Note: Imports and exports as defined in the national accounts.
Source: Statistics Denmark.

11 Calculated on the basis of equation 6 in Appendix 1.

When e.g. exports constitute a large share of GDP, even small percentage changes in exports will affect the current account as a share of GDP. Viewed in isolation, this points to a stronger pass-through from the exchange rate to the current account as a share of GDP.

However, globalisation also means that firms increasingly buy or produce subcomponents in practically all parts of the world.[12] Today, goods sold by Danish firms in Denmark or abroad to a large extent include components produced in many different countries by many different firms. This split-up of production between firms all over the world is known as global value chains.

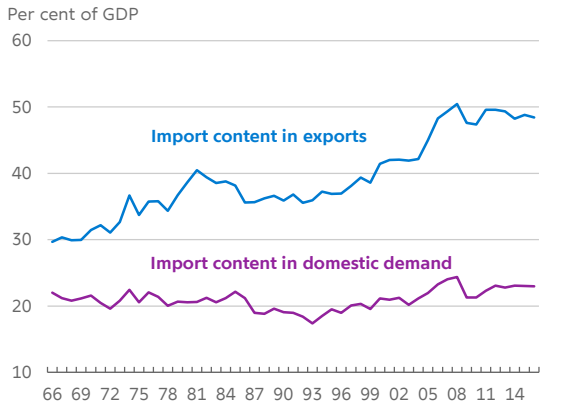
In Denmark, the import content in exports has risen from around 30 per cent in 1966 to around 50 per cent today, cf. Chart 4. In other words, approximately half of the value of Danish exports of goods comes from goods produced abroad.

In contrast, the import content in the Danes' consumption and investment in e.g. machines – i.e. domestic use – has virtually not increased. This illustrates that growth in imports as a share of GDP is almost entirely a result of higher exports.

There is some uncertainty as to how firms' use of global value chains affects the pass-through from the exchange rate. One the one hand, the pass-through is reduced because shocks that increase exports/export prices in kroner also increase imports/import prices in kroner. If the rise in exports is equal to the rise in imports, the trade balance is not affected. On the other hand, Danish exports increasingly consist of profits from goods owned by Danish firms but produced abroad.[13] The exchange rate pass-through to such profits is presumably much higher.

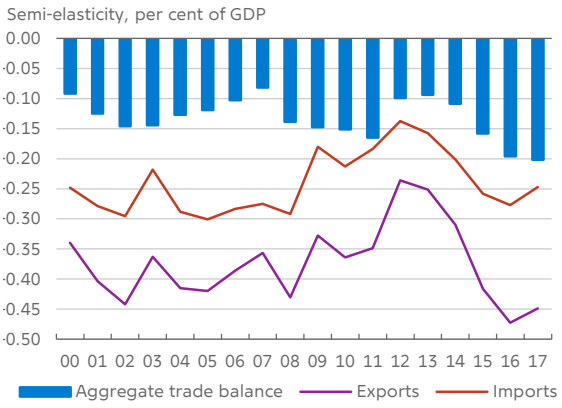
To assess whether the pass-through has changed over time, it is estimated using a rolling 25-year window from 1975 to 2017. The rolling estimations show that in most of the sub-periods the pass-through from the exchange rate to the trade balance is stable in the interval from 0.10 to 0.15 although slightly higher in recent years, cf. Chart 5. For imports and

Increased trade is mainly attributable to global value chains Chart 4



Note: Import content (direct and indirect) calculated using input-output tables. For a more detailed description of the calculation method, see Statistics Denmark (2014).
Source: Statistics Denmark and own calculations.

A stable exchange rate pass-through over time Chart 5



Note: Rolling estimations are 25 year windows. The first estimation period is 1975-2000 (shown as 2000), the next one is 1976-2001 and so forth until 1992-2017.
Source: Own calculations based on data from Statistics Denmark and Danmarks Nationalbank.

12 See Nellemann and Nissen (2016) for a detailed analysis of how global value chains affect Denmark.

13 E.g. in the form of merchanting. See e.g. Jørgensen et al. (2018).

exports, respectively, fluctuations have been a little stronger, especially during the financial crisis, but overall they are also relatively stable.

The fixed exchange rate policy reduces exchange rate fluctuations

Denmark has a fixed exchange rate policy against the euro area, which is Denmark's largest export market by far. So a very large share of Denmark's foreign trade is settled in a currency that is fixed vis-à-vis the krone. Consequently, the effective krone rate is far more stable than the currencies of economies without fixed exchange rate policies, cf. Chart 6.[14]

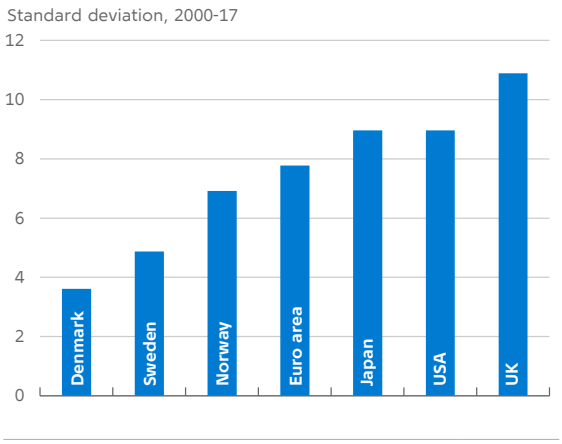
However, the pass-through from the exchange rate to the current account is not affected by the fixed exchange rate policy. Across 60 countries, the IMF (2015) finds that if the exchange rate weakens by 1 per cent, the trade balance improves by approximately 0.15 per cent of GDP, which is close to the estimate for Denmark, cf. Table 1.

So the fixed exchange rate policy primarily implies that exchange rate fluctuations are dampened, while the pass-through from exchange rate fluctuations is in line with those seen in other countries.

The krone rate has little impact on relative import and export prices

Viewed in isolation, weakening of the exchange rate boosts a country's competitiveness by making domestically produced exports cheaper and imports more expensive.[15] But a weaker krone will also make imports of raw materials and intermediate goods more expensive. So overall Danish firms experience only a modest improvement in competitiveness. Consequently, the impact of the exchange rate on the trade balance is small.

The effective krone rate is stable Chart 6



Note: Nominal effective exchange rates, monthly observations. All indices have been standardised so that the average for the period 2000-17 is 100.
Source: Macrobond.

Not only the exchange rate but also firms' costs and productivity, i.e. how cheaply goods can be produced, have an impact on competitiveness. Strong competitiveness can, for example, be reflected in the prices of Danish firms being lower than those of foreign firms for the same goods converted into the same currency.

The real effective exchange rate is one such measure since the price level in Denmark is compared with the price level abroad and converted into the same currency using the nominal effective krone rate. The real effective exchange rate is often based on consumer prices.[16]

If the real effective krone rate increases, this indicates that prices of goods produced in Denmark are rising more than those of goods produced abroad, measured in the same currency. This points to weaker competitiveness, which, all else equal, causes the current account to deteriorate. The real effective krone rate is used by e.g. the IMF in its External Bal-

14 In large economies, such as the USA and Japan, exports and imports make up a smaller share of GDP than in e.g. Denmark. Consequently, exchange rate fluctuations have a relatively smaller impact on large economies, and the pass-through from the exchange rate to domestic consumer prices is smaller.

15 Competitiveness is a complex concept that covers many factors. Good or bad competitiveness is temporary, and in the long term market conditions, including wages, will adjust.

16 A very simple measure of the real effective exchange rate is the "Big Mac index", which compares the price (in dollars) of a Big Mac across countries.

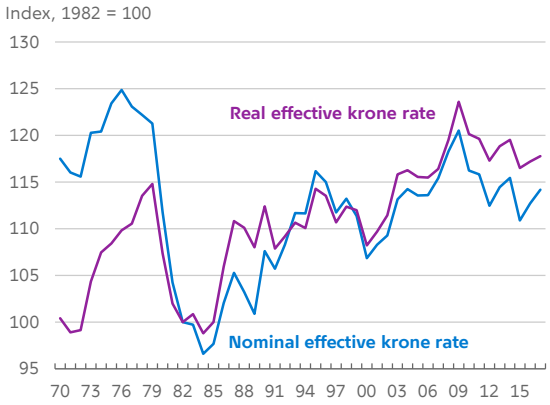
ance Assessment, which tries to identify unsustainable current account surpluses or deficits, cf. Box 1.

Since 1982, when Denmark began to pursue a fixed exchange rate policy, the nominal and real krone rates have mirrored each other closely, although the real rate has strengthened a little more than the nominal rate since the turn of the millennium, cf. Chart 7.

The high degree of correlation between the two means that the pass-through from the real effective krone rate to the current account is almost identical to the pass-through from the nominal krone rate.

The strengthening of the real effective krone rate since the early 1980s could indicate that Denmark's competitiveness has gradually deteriorated and that the Danish krone is therefore above its equilibrium level. However, this cannot be said with certainty. Private consumption to a large extent comprises goods and especially services not traded across national borders, such as hairdresser services. Price developments for these services are of no significance to competitiveness.[17] So it is not clear which prices should be compared across countries, and hence neither which price indices should be included in the calculation of the real effective exchange rate. This makes it difficult to assess competitiveness by means of the real effective exchange rate, and a rising or falling real effective exchange rate does not necessarily mean that the exchange rate is moving away from its equilibrium level.

The real and nominal effective krone rates mirror each other closely Chart 7



Note: Real effective krone rate based on consumer prices.
Source: Danmarks Nationalbank.

17 Many advanced economies have seen rising real effective exchange rates for longer periods, e.g. Japan. A possible explanation is the "Balassa-Samuelson effect". It says that productivity growth is low in industries producing goods and services that are not traded across borders. This creates inflation as wage developments are identical across sectors, i.e. wage increases are also seen in sectors with low productivity growth. Advanced economies have high productivity and high wages in sectors trading internationally, but wages are also high in industries with lower productivity. Hence the price level typically rises with the prosperity of a country. See e.g. Taylor and Taylor (2004).

The IMF's External Balance Assessment

Box 1

An important element of the IMF's mandate is to monitor balances of payments and identify external imbalances. A strongly over- or undervalued exchange rate increases the risk that external imbalances will build up, including substantial current account surpluses or deficits, which can ultimately lead to economic crises. The External Balance Assessment, EBA, is a uniform methodology for assessing current accounts and exchange rates across countries, cf. IMF (2018).[1]

Current account surpluses or deficits do not necessarily reflect imbalances. Countries with a young population and high growth typically need to invest more than they save. They can do so by borrowing abroad, i.e. by having current account deficits. Conversely, prosperous countries with an ageing population, such as Denmark, need to save up to prepare for a situation with a larger share of pensioners, i.e. they need to have current account surpluses. In the short term, the current account is also affected by cyclical factors and economic policies. During a boom the current account typically deteriorates because the private sector invests more and saves less. As regards the public sector, accommodative fiscal policy has a negative impact on the current account.

The IMF applies a statistical model that tries to account for all these factors. In this way the IMF can estimate the expected surplus or deficit of a country. The gap to the actual level of the current account is known as the current account gap, and a large gap may indicate an imbalance or ill-suited economic policy.

This methodology is subject to considerable uncertainty, partly because it is difficult to take into account whether public finances and the pension system are sustainable. So the IMF's recommendations to e.g. Denmark are not based exclusively on the estimated current account gap, but also on an expert assessment. In this connection, the IMF holds consultations with the economic ministries, employer organisations, the financial sector and Danmarks Nationalbank, among others. For Denmark, the IMF estimates the current account gap at approximately 3.9 per cent of GDP in 2018, cf. the table below. Like the IMF, Danmarks Nationalbank assesses that the large surplus seen at present is not an equilibrium level, but rather indicates that households are saving heavily in order to reduce their debts. It is difficult for the IMF's model to take this into account.

On the basis of the current account gap, the IMF also calculates the change in the real effective exchange rate required in order to close the current account gap (the REER gap). The IMF's point of departure is standardised import and export elasticities that form the basis for calculation of the aggregate pass-through from the exchange rate to the trade balance, i.e. by how many percentage points of GDP the trade balance will change if the exchange rate strengthens by 1 per cent (a semi-elasticity). However, this semi-elasticity is often adjusted on the basis of a country-specific expert assessment. An implicit assumption behind the REER gap is that the full adjustment of the current account takes place via strengthening or weakening of the exchange rate. So when calculating the REER gap the IMF disregards its own recommendations for measures to close the current account gap. But as described above, the current account is only to a modest extent determined by the exchange rate. Consequently, the REER gap cannot directly be used to assess whether an exchange rate is in equilibrium.

For Denmark, the IMF applies a semi-elasticity which is fairly large and considerably larger than the estimates in Table 1 above and also larger than those typically found in international studies.[2] This may reflect an attempt by the IMF to factor in the many other elements besides the exchange rate that affect the current account.

	Current account gap (per cent of GDP)	REER gap (per cent of real effective exchange rate)	Implied semi-elasticity
EBA (2018)	3.9	7.5	0.52

1. The European Commission also has focus on large current account surpluses or deficits, cf. the Macroeconomic imbalance procedure.
2. IMF (2015).

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Appendix 1

Deriving how exchange rate fluctuations affect the trade balance

Box 2

The trade balance is the difference between the value of exports and imports, i.e. it can be written as:

(1) $TB = x_{val} - m_{val}$

where x_{val} is the value of exports measured in kroner and m_{val} is the value of imports measured in kroner. Exports as a share of GDP can be written as:

(2) $x_{val}/GDP = \frac{1}{e} * p_x^*(e) * x_{vol}(p_x^*(e))/GDP$

The price of exports in foreign currency, p_x^*, is a function of the exchange rate, while the volume, x_{vol}, is a function of the price. The elasticity from currency to price is defined as $\varepsilon_e^{p_x^*} = \frac{dp_x^*}{de}\frac{e}{p_x^*}$ and the elasticity from price to volume as $\varepsilon_{p_x^*}^{x_{vol}} = \frac{dx_{vol}}{dp_x^*}\frac{p_x^*}{x_{vol}}$. If equation 2 is differentiated with respect to the exchange rate, we get the following:

(3) $\frac{dx_{val}/GDP}{de/e} = \left(-1 + \varepsilon_e^{p_x^*}\left(1 + \varepsilon_{p_x^*}^{x_{vol}}\right)\right) * \frac{x_{val}}{GDP}$

Imports are partly driven by global value chains, i.e. by exports. So imports can be written as:

(4) $m_{val}/GDP = p_m(e) * \left(m_{vol}^d(p_m(e)) + m_{vol}^e\left(x_{vol}(p_x^*(e))\right)\right)/GDP$

The elasticity from currency to price is defined as $\varepsilon_e^{p_m} = \frac{dp_m}{de}\frac{e}{p_m}$, the elasticity from price to volume as $\varepsilon_{p_m}^{m_{vol}} = \frac{dm_{vol}}{dp_m}\frac{p_m}{m_{vol}}$ and from exports to imports as $\varepsilon_{x_{vol}}^{m_{vol}} = \frac{dm_{vol}}{dx_{vol}}\frac{x_{vol}}{m_{vol}}$. If equation 4 is differentiated with respect to the exchange rate, we get the following:

(5) $\frac{dm_{val}/GDP}{de/e} = \left(\varepsilon_e^{p_m} * \left(1 + \varepsilon_{p_m}^{m_{vol}}\right) + \varepsilon_{x_{vol}}^{m_{vol}} * \varepsilon_{p_x^*}^{x_{vol}} * \varepsilon_e^{p_x^*}\right) * \frac{m_{val}}{GDP}$

So the aggregate semi-elasticity is:

(6) $\frac{dHB/GDP}{de/e} = \left(-1 + \varepsilon_e^{p_x^*}\left(1 + \varepsilon_{p_x^*}^{x_{vol}}\right)\right) * \frac{x_{val}}{GDP} - \left(\varepsilon_e^{p_m} * \left(1 + \varepsilon_{p_m}^{m_{vol}}\right) + \varepsilon_{x_{vol}}^{m_{vol}} * \varepsilon_{p_x^*}^{x_{vol}} * \varepsilon_e^{p_x^*}\right) * \frac{m_{val}}{GDP}$

If weakening of the exchange rate is to improve the trade balance, the following must apply:

(7) $\frac{dx_{val}/GDP}{de/e} - \frac{dm_{val}/GDP}{de/e} < 0 \Leftrightarrow \left(-1 + \varepsilon_e^{p_x^*}\left(1 + \varepsilon_{p_x^*}^{x_{vol}}\right)\right) * \frac{x_{val}}{GDP} - \left(\varepsilon_e^{p_m} * \left(1 + \varepsilon_{p_m}^{m_{vol}}\right) + \varepsilon_{x_{vol}}^{m_{vol}} * \varepsilon_{p_x^*}^{x_{vol}} * \varepsilon_e^{p_x^*}\right) * \frac{m_{val}}{GDP} < 0$

This condition is called the Marshall-Lerner condition. If global value chains are ignored, i.e. $\varepsilon_{x_{vol}}^{m_{vol}} = 0$, the price pass-through is assumed to be full, i.e. $\varepsilon_e^{p_x^*} = 1$, and $\varepsilon_e^{p_m} = -1$, and if the trade balance is in equilibrium, i.e. $x_{val} = m_{val}$, then the Marshall-Lerner condition can be written as:

(8) $\varepsilon_{p_x^*}^{x_{vol}} + \varepsilon_{p_m}^{m_{vol}} < -1$

Appendix 2

To estimate how the exchange rate of the krone affects the trade balance, it is necessary to estimate various elasticities, cf. Appendix 1. For this purpose, four equations are estimated. Annual data for the period 1975-2017 is used.[18] It is sought to explain changes in import and export prices by means of the nominal effective krone rate and lags of it as well as control variables. This makes it possible to estimate both short- and long-term effects, even with a relatively short estimation period.[19]

The estimation involves several econometric challenges. The main challenge is to take endogeneity, especially between prices and volumes, into account to a sufficient degree. Increased demand pushes up prices, but viewed in isolation higher prices will dampen demand.

Export and import prices

Export prices are stated in foreign currency, while import prices are in Danish kroner. Controls are performed for demand and the price level in the import country as a measure of the competitive situation and the price level in the export country as a measure of the level of costs. Furthermore, fluctuations in freight rates and oil prices are taken into account. The lagged values of the nominal effective exchange rate are not significant (controls have been performed for up to three lags) so the entire pass-through is seen in the first year. If the nominal effective krone rate rises by 1 per cent, the export price, measured in foreign currency, increases by 0.45 per cent, cf. Table 2. This effect has the expected sign.

If the nominal effective krone rate strengthens by 1 per cent, import prices are reduced by 0.58 per cent, cf. Table 3.

Regression model for export price Table 2

Explanatory variable	Coefficient	t-value
Constant	-0.00	-0.21
Dlog(EFKRKS)	0.45	4.33
Dlog(FY_EU)	-0.13	-0.63
Dlog(PCP_EU)	-0.28	-1.05
Dlog(PCP)	1.03	3.41
Dlog(PSHIP)	0.06	1.95
Dlog(PRAOLI)	0.04	2.59
R^2	0.73	

Note: The model has been estimated on annual data for 1975-2017. Robust standard errors have been applied (Newey-West). The export price, PE*EFKRKS, is measured in foreign currency, EFKRKS is the nominal effective krone rate, FY_EU is an index for GDP in the euro area, PCP_EU is the euro area consumer price index, PCP is the Danish consumer price index, PSHIP is freight rates in dollars, PRAOLI is the oil price in dollars.
Source: Own calculations.

Regression model for import price Table 3

Explanatory variable	Coefficient	t-value
Constant	-0.01	-2.90
Dlog(EFKRKS)	-0.58	-3.86
Dlog(FYTR)	0.17	2.26
Dlog(PCP_EU)	0.49	1.71
Dlog(PCP_{-1})	0.24	1.19
Dlog(PSHIP*EUSD)	0.03	2.06
Dlog(PRAOLI*EUSD)	0.08	3.75
R^2	0.89	

Note: The model has been estimated on annual data for 1975-2017. The import price, PM, is in kroner, FYTR is domestic demand, EUSD is kroner per dollar. For other variables, see the note to Table 2.
Source: Own calculations.

18 Quarterly data is not used as it is noisy, which results in very unstable parameter estimates.

19 Econometric tests do not find clear signs of co-integration, so error correction models have been disregarded. In theory, a VAR model is more suitable for handling endogeneity challenges. We tried to set up a VAR. Due to the relatively short time period, the results were highly sensitive to even small changes in the specification and the time period.

Export and import volumes

Demand for exports and imports in volumes has been explained on the basis of export and import prices with up to three lags, i.e. it may take up to three years before volumes respond to price changes. In addition, controls have been performed for demand and local prices (competitive situation). In the imports equation, the export volume has been included in order to take global value chains into account.

The estimation shows that a 1 per cent higher export price measured in foreign currency reduces exports by 0.56 per cent in the long term, cf. Table 4. This effect has the expected negative sign. In the short term, the parameter estimate is positive but not significant.

The import volume decreases by 0.10 per cent in the long term if import prices rise by 1 per cent, cf. Table 5. In the short term there is no effect.

Regression model for export volume Table 4

Explanatory variable	Coefficient	t-value
Constant	0.01	2.29
Dlog(FY_EU)	1.18	3.99
Dlog(FYTR)	0.21	1.23
Dlog(PCP_EU)	0.61	3.77
Dlog(PE_FX)	0.22	0.99
Dlog(PE_FX$_{-1}$)	-0.03	-0.35
Dlog(PE_FX$_{-2}$)	-0.50	-5.25
Dlog(PE_FX$_{-3}$)	-0.24	-3.10
R^2	0.59	

Note: The model has been estimated on annual data for 1975-2017. FE is exports in volumes, PE_FX is the export price measured in foreign currency. The short-term effect is 0.25 (not significant) and the long-term effect is -0.56 (0.22-0.03-0.50-0.24, significant). For other variables, see the note to Table 2.
Source: Own calculations.

Regression model for import volume Table 5

Explanatory variable	Coefficient	t-value
Constant	-0.00	-0.09
Dlog(FYTR)	1.33	11.34
Dlog(PCP)	-0.09	-0.54
Dlog(FE)	0.60	6.46
Dlog(PM)	-0.02	-0.15
Dlog(PM$_{-1}$)	0.05	0.85
Dlog(PM$_{-2}$)	-0.02	-0.20
Dlog(PM$_{-3}$)	-0.11	-3.94
R^2	0.92	

Note: The model has been estimated on annual data for 1982-2017. PM is import prices in kroner. For other variables, see the note to Table 2.
Source: Own calculations.

ABOUT ANALYSIS

As a consequence of Danmarks Nationalbank's role in society we conduct analyses of economic and financial conditions.

Analyses are published continuously and include e.g. assessments of the current cyclical position and the financial stability.

The analysis consists of a Danish and an English version. In case of doubt regarding the correctness of the translation the Danish version is considered to be binding.

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