

Staff memo

The development and trend of the real exchange rate

Carl-Johan Belfrage, Peter Gustafsson and
Rachatar Nilavongse

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Staff Memo

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Summary

In a small open economy like Sweden, exchange rate developments are important for the inflation outlook. The weakening of the krona over more than a decade has contributed to somewhat higher inflation, partly via higher import prices. To better understand and, if possible, predict the development of the exchange rate, it is important for the Riksbank to form a view on whether the development is persistent or constitutes a temporary, albeit lasting, deviation from the trend.

To the extent that price levels in Sweden and abroad are determined in the longer term by the central banks' inflation targets, this suggests that the krona may change nominally so that the real exchange rate, that is, the relative price level compared to the rest of the world converted into a common currency, moves towards its underlying trend. Estimates of this trend could then provide guidance on the long-term development of the nominal exchange rate.

One challenge in estimating the trend of the real exchange rate is fundamental: it is not obvious how the relevant real exchange rate should be measured. It has proved difficult to ensure comparability of price developments across countries. Moreover, it is not apparent which method best captures a potential trend in the chosen measure of the real exchange rate. In this memo, we therefore adopt a broad approach regarding data and methods and construct a time-varying interval for the deviation of the real exchange rate from its trend.

The analysis suggests that roughly half of the real exchange rate's depreciation since 2013 is persistent due to a deterioration in Sweden's terms of trade and weak growth in GDP per capita compared to the rest of the world. The remaining depreciation can largely be explained by factors with more short-term effects, such as developments in interest rate differentials and measures of uncertainty, but to some extent also by a lack of comparability between Swedish and foreign consumer price indices. The conclusion is robust across different ways of measuring the real exchange rate. Furthermore, the analysis indicates that the real exchange rate was slightly weaker than, but fairly close to, its trend value in the second quarter of 2025.

Authors: Carl-Johan Belfrage, Peter Gustafsson and Rachatar Nilavongse, who work in the Riksbank's Monetary Policy Department¹

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1 Background

A clear depreciation of the krona over more than a decade has raised questions about what is driving the actual and trend development of the krona. For the Riksbank, these issues are of course not new, but they are important. Monetary policy takes account of exchange rate developments because they affect the economic and inflation outlooks. Given that Sweden is an economy with large trade and capital flows to and from the rest of the world, the exchange rate is central.

In the context of policy, the long-term real exchange rate is sometimes discussed. This often refers to the underlying trend of the real exchange rate, assuming that the determinants of the krona converge to their trends and that the real exchange rate therefore correspondingly converges to its trend over a number of years.

However, the trend of the real exchange rate is not observable and may vary over time, but on the basis of the above considerations, attempts to estimate the trend may help to assess future developments in the real exchange rate. For example, if the real exchange rate were to be weaker than its trend at the outset, convergence in the short term would require the nominal exchange rate to strengthen and/or inflation to be higher in Sweden than abroad. The statutory inflation target in Sweden and similar inflation targets in the economies with which Sweden trades the most could then suggest an adjustment that largely occurs via the nominal exchange rate.

In this memo, we take a broad approach and use different data and various estimation methods to identify and try to explain the trend in the real exchange rate. Although the approach to some extent means that important analytical issues more closely linked to nominal exchange rate developments are left out of the analysis, the trend in the real exchange rate is judged to be a relevant reference point for the development of the krona in the slightly longer term, as discussed above.

Attempts to estimate the trend of the real exchange rate are surrounded by several challenges. As a first step, we try to provide an accurate picture of the real exchange rate development based on the challenges that characterise the available measures of relative price levels. Given the estimates of the real exchange rate, we then discuss how to identify its trend in Chapter 3. The chapter begins with a brief review of the theoretical and empirical starting points for the analysis. Next, based on previous studies, we discuss a possible model specification, and which variables might explain the trend development of the real exchange rate. In Chapter 4, we present the empirical results and discuss them in the light of previous studies. Given the uncertainty about the most accurate measure of the real exchange rate and our model estimates, we construct a range for the deviation of the real exchange rate from trend. We further examine what the range says about the development of the real exchange rate in a historical perspective and discuss the plausibility of these statements. We do this partly on the basis of shorter-term determinants of the exchange rate such as interest rate differentials and uncertainty. The fifth chapter contains an application of the model-based range of the trend deviation to the real exchange rate measure traditionally used by the Riksbank which facilitates an interpretation of the more persistent weakening of the real exchange rate.

2 The development of the real exchange rate

Public debate often focuses on the nominal exchange rate, for example how many kronor a euro costs. At the same time, the nominal exchange rate is only one component of the real exchange rate, which relates to international purchasing power and is more closely linked to the allocation of resources in the economy. In a similar example the real exchange rate measures what a consumption basket costs in the euro area compared to what it costs in Sweden.

Here, we define the real exchange rate as:

Real exchange rate =

Relative price level in common currency (rest of the world/Sweden) =

Nominal exchange rate (SEK/foreign currency unit)

× Relative price level in domestic currency (rest of the world/Sweden).

In line with the practice for the krona's nominal exchange rate, the definition means that a higher value corresponds to a weaker real exchange rate from a Swedish perspective. Along with the nominal exchange rate, calculating the real exchange rate generally uses the consumer price index (CPI) for different countries. The real exchange rate can be bilateral, meaning that it is given in relation to another country, or effective, meaning that it is given in relation to a pooled group of countries. In this memo, real exchange rate generally refers to the effective real exchange rate where the rest of the world consists of a pool of the euro area and the United States, hereafter referred to as KIX-2, the largest currency areas in the KIX (the krona index).²

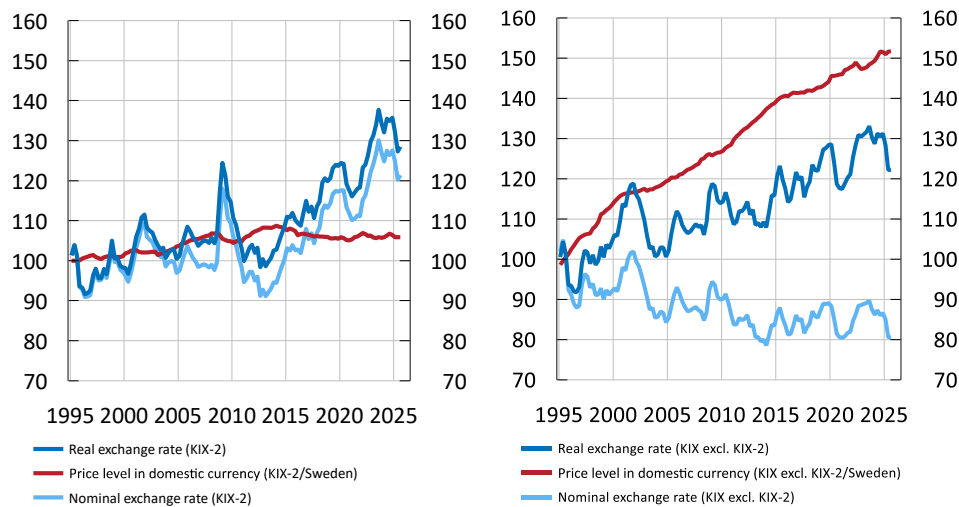
Figure 1 shows the components of the real exchange rate as defined above, in the figure to the left in relation to KIX-2 and to the right in relation to a pool of the other countries included in the KIX. Since 1995, the real exchange rate has depreciated significantly against both KIX-2 and against other KIX countries. As inflation has been relatively similar in Sweden, the euro area and the United States, the real exchange rate has broadly followed its nominal counterpart.³ Compared with the other KIX countries, however, the real exchange rate has diverged from the nominal exchange rate, as inflation in Sweden has been significantly lower than in these countries.

² We have chosen to focus on the real exchange rate against KIX-2 for several reasons. The United States and the euro area account for more than half of the international weight in the broader KIX measure, which also explains why discussions about the krona often precisely revolve around developments against the dollar and the euro. It is also an aggregate of the United States and the euro area that constitutes the rest of the world in the Riksbank's macro models. Moreover, compared with broader aggregates such as the KIX, the KIX-2 offers greater reliability and comparability in the data used to calculate the real exchange rate and identify its trend.

³ Bilaterally, the real exchange rate has weakened significantly against both the US dollar and the euro, but the weakening has been much greater against the dollar, even in nominal terms.

Figure 1. The real exchange rate against different groups of countries

Index 1995=100



Note: The real exchange rate is calculated using the consumer price index.

Sources: National sources, Statistics Sweden, the Riksbank and own calculations.

2.1 The real exchange rate calculated using different measures of relative price levels

The Riksbank often discusses the real exchange rate on the basis of the weighted exchange rate index KIX and the corresponding weighting of the CPI for the countries included in the index, as shown in figure 1.⁴ One challenge inherent in this measure is that different statistical authorities may have slightly different practices for calculating the CPI. This means that, even if prices develop similarly in two countries, the reported development of the CPI can differ. Using relative price levels based on the CPI could therefore give a misleading picture of real exchange rate developments and lead us astray when we try to identify the trend of the real exchange rate.

There are therefore good reasons to compare the CPI as a starting point for measuring relative price level differences, with other alternatives. One of these is the direct price comparisons produced under the guidance of Eurostat and the OECD. Prices of a variety of carefully specified goods and services are collected from national statistical authorities. After conversion into a common currency, the ratios between domestic prices and their equivalents in a reference country (often the United States) are pooled into price levels for GDP and its components. The fact that these comparisons have been made over many years also makes it possible to obtain a picture of how relative price levels in a common currency, i.e. real exchange rates, have evolved over time.⁵ At the same time, this measure comes with its own challenges. For example,

⁴ Throughout this memo, the CPI means the domestic price levels measured using the CPIF for Sweden, the HICP for the euro area and the CPI for the rest of the world. The choice of measures of consumer prices in the rest of the world can be explained by the fact that these are deemed to correspond most closely to the CPIF.

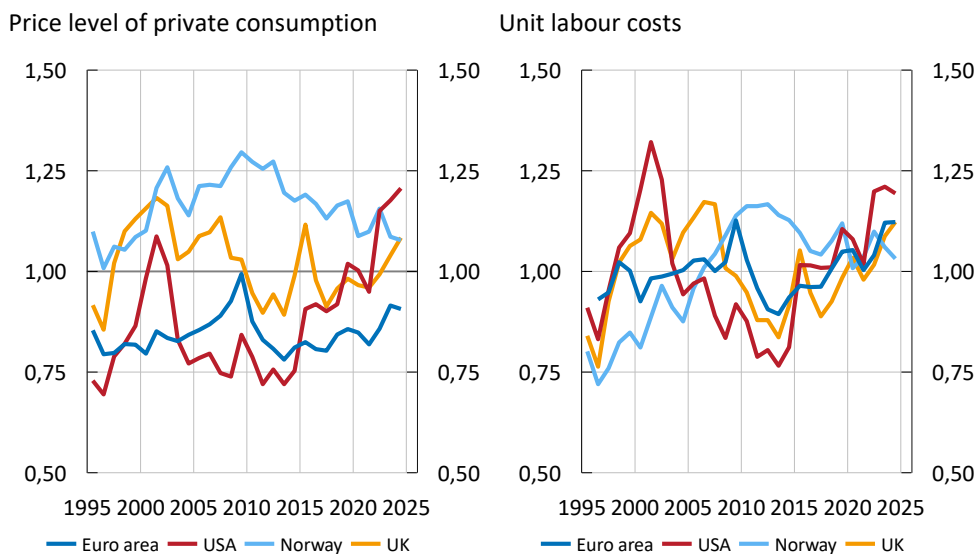
⁵ For details see Eurostat-OECD (2023).

the surveys are conducted much less frequently than those used to calculate the CPI, and the comparisons cover fewer goods and services.

Another, slightly different, approach to measuring relative price levels is to use data on Swedish and foreign unit labour costs. The costs can be used as an approximation for competitiveness, which over time can be expected to have a close relationship with price levels. One problem is that the share of labour costs in total costs may develop differently in Sweden and abroad, which would mean that the development in relative unit labour costs does not provide a true picture of the relative overall cost development.⁶

The left panel of figure 2 shows some of the direct price level comparisons in Swedish kronor. Among other things, the data indicates that Norway has long been among the countries with the highest price levels and that Sweden has long been relatively expensive, but that in recent years, not least the USA has become increasingly expensive from a Swedish perspective. At the same time, the figure shows that the price level in the euro area is still lower than in Sweden, although the difference has narrowed somewhat in recent years. A qualitatively similar development has characterised relative unit labour costs in Swedish kronor, as illustrated in the right-hand panel.

Figure 2. Real bilateral exchange rates calculated using direct price level comparisons and unit labour costs 1995-2024



Note: The left-hand panel illustrates the price level of private consumption in each country/region relative to Sweden after conversion to kronor. A value above (below) 1 means that the price level is higher (lower) than in Sweden. The right-hand panel shows unit labour costs in each country relative to Sweden converted to Swedish kronor divided by the historical average of the series.

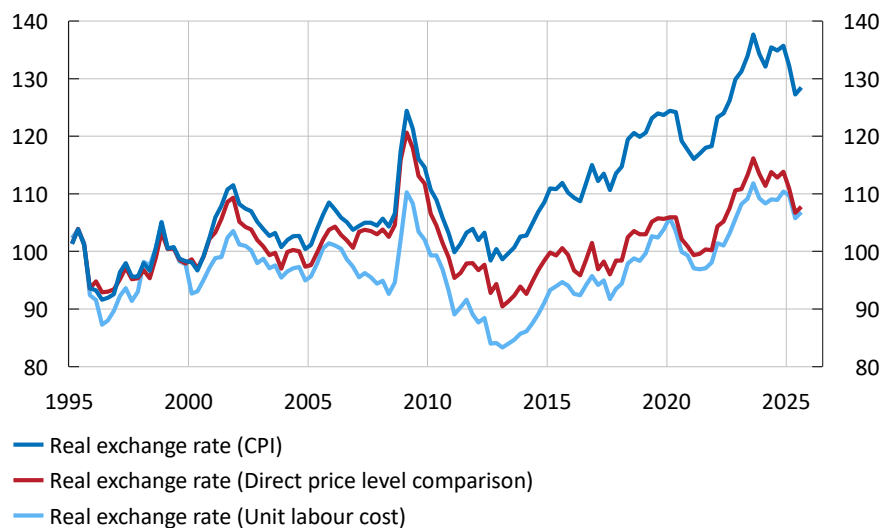
Sources: Eurostat, the OECD, Macrobond and own calculations.

By taking the three different relative price level measures as a starting point, we can use the nominal exchange rate to calculate an equal number of measures of the real

⁶ See Belfrage (2021) for a discussion of how this measure differs from measures based on consumer prices.

exchange rate. Figure 3 shows that the real exchange rates calculated using direct price level comparisons and unit labour costs respectively paint a relatively similar picture of developments. According to these measures, the real exchange rate was at about the same level in 2021 as it had fluctuated around since 1995 before weakening. Based on these measures, the nominal exchange rate depreciation that has taken place in relation to KIX-2 up to 2021 (see figure 1) has been matched by a domestic price or cost increase relative to KIX-2. At the same time, the measure based on the consumer price index paints a slightly different picture. This measure diverges over time from the alternative measures and shows a more pronounced depreciation of the real exchange rate.⁷

Figure 3. The real exchange rate based on different measures of relative price levels
Index 1995=100



Note: The direct price level comparisons are for full years only, but we have converted them into quarterly data by using quarterly averages for the nominal exchange rate together with the annual data for PPP exchange rates that go into the direct price level comparison calculations. We thus implicitly assume that all short-term variations in real exchange rates can be attributed to variation in nominal exchange rates, which applies to the other measures in this case and is in line with what applies to real exchange rates in general according to Itskhoki (2021).

Sources: Eurostat, the OECD, US Bureau of Labor Statistics, the Riksbank and own calculations.

The various price and cost measures therefore do not provide a completely clear picture of how relative price levels have developed over time, and it is not obvious which measure should be given the greatest weight in the continued work of estimating the trend of the real exchange rate. All the measures that have been examined have their merits and drawbacks, as described above.

A documented lack of comparability between Swedish and foreign consumer price indices may, however, help explain the discrepancy between the measures illustrated in figure 3. Tysklind (2020) shows, among other things, that different handling of, for

⁷ The pattern described is most pronounced for the bilateral real exchange rate relationship vis-à-vis the euro area.

example, product substitutions and quality adjustments by statistical authorities in different countries has contributed to a lower rate of price increase in the Swedish consumer price index compared to the corresponding foreign consumer price indices.⁸ This contributes to the fact that, when we next estimate the trend in the different measures of the real exchange rate, we give less weight to the trend estimates derived from the real exchange rate calculated using the consumer price index.

3 Different ways to identify the trend of the real exchange rate

Since the trend of the real exchange rate cannot be observed directly, it needs to be estimated. Like many other studies, we initially approach this question from the strong assumption of absolute purchasing power parity (PPP), i.e. that a basket of goods and services costs the same in different countries when prices are converted to a common currency. The concept dates back to Cassel (1918) and implies that international trade can be expected to equalise prices between countries. The idea is that a country's goods cannot be permanently priced lower than those of other countries if they can be traded freely – should such a situation arise, the possibilities for cross-border trade would drive the adjustment of goods prices and/or the nominal exchange rate to restore purchasing power parity. This does not necessarily apply to the prices of non-internationally traded goods and services, but one argument in favour of PPP in this respect (albeit in the very long term) is that international mobility of factors of production and technology transfer tends to equalise the costs of capital and labour between countries in the long run.

In practice, this strict definition of purchasing power parity has weak support in the data. Simply by looking at the direct price comparisons in figure 2, it is evident that these generally deviate from 1, which corresponds to absolute purchasing power parity. The concept has therefore been qualified to accommodate more reasonable assumptions and thereby better reflect what can actually be observed regarding developments in real exchange rates.

Relative PPP instead stipulates that the relationship between countries' price levels is constant so that a difference in inflation rates between countries will be matched by a change in the nominal exchange rate, entailing that the real exchange rate remains unchanged. From the same diagram, it is evident that the relative price levels are not constant, so this concept does not fully capture developments either.

One possible candidate to explain the development of the real exchange rate could instead be a weaker form of relative PPP, which implies that while relative PPP holds over time, deviations may occur in the shorter term.⁹ According to this reasoning, after periods of appreciation and depreciation, the real exchange rate should tend to

⁸ See Tysklind (2020). Differences in the calculation of the consumer price index naturally give rise to questions related to the interpretation and comparability of other economic statistics based on all or parts of the consumer price index. Possible consequences for the analyses in this memo are discussed further in Chapter 4.

⁹ See Itskhoki (2021) for a more detailed discussion.

revert to its historical average. Ca'Zorzi et al. (2022) find that historical averages fare well in comparisons of the ability of different methods to determine the long-run development of real exchange rates. Burstein and Gopinath (2014) argue that there is broad support in the literature and data for what Rogoff (1996) referred to as the consensus view - that deviations from PPP have a half-life of between 3 and 5 years.

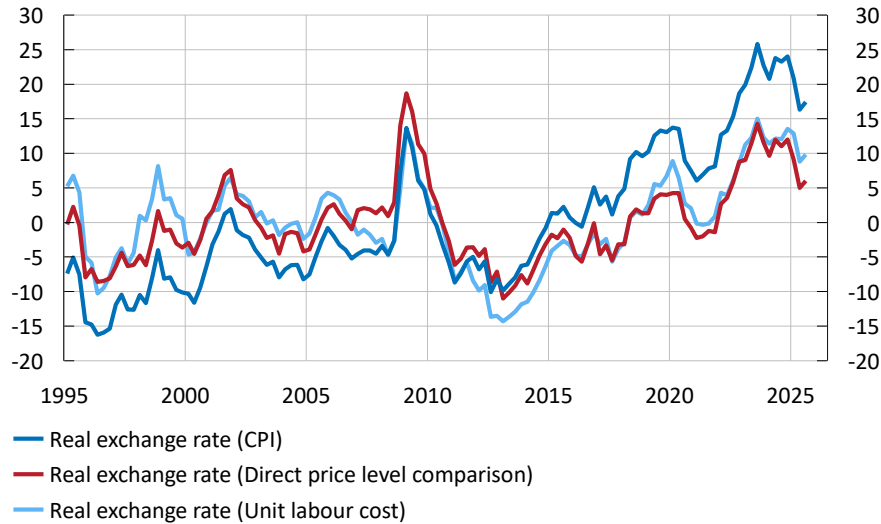
Figure 4 shows deviations from the historical mean for each of our measures of the real exchange rate. At first sight, a pattern of real exchange rate convergence towards its historical mean may be discernible for the real exchange rate calculated using direct price comparisons and unit labour costs respectively, while the deviation calculated using CPI diverges more clearly from its mean. Itskhoki (2021) points out that, in the literature, real exchange rates are often assumed to be stationary but that the empirical support for this assumption is weak. The depreciation is most evident when the real exchange rate is calculated using the CPI, but none of the measures of the real exchange rate in figure 3 is stationary according to more formal tests.¹⁰ However, this does not mean that we can completely reject weak relative PPP. On the other hand, it suggests that we should be cautious about interpreting the average for the period studied as a reliable estimate of what the real exchange rate can be expected to return to over time.¹¹

¹⁰ Using simple Dickey-Fuller tests, without constant or trend terms, the hypothesis of a unit root cannot be rejected for any of the measures. This is also true for a sample period that excludes the quarters after 2021.

¹¹ A longer historical perspective would yield a lower average, as the weakening of the real exchange rate appears to have been ongoing since the mid-1970s. This is at least true for the CPI-based measure of the real exchange rate. Limited data availability makes it difficult to comment on the development of the other measures over the same period. At the same time, fundamental determinants have changed significantly, which could explain this development. Belfrage (2021) provides a longer historical perspective on the real exchange rate and discusses its possible determinants.

Figure 4. The deviation of the real exchange rate from its average based on different measures of relative price levels

KIX-2, percentage deviation from average



Note: The direct price level comparisons are for full years but have been converted into quarterly data by using quarterly averages for the nominal exchange rate together with the annual data for PPP exchange rates that go into the direct price level comparison calculations. We thus implicitly assume that all short-term variations in real exchange rates can be attributed to variation in nominal exchange rates, which applies to the other measures in this case and is in line with what applies to real exchange rates in general according to Itskhoki (2021).

Sources: Eurostat, the OECD, US Bureau of Labor Statistics, the Riksbank and own calculations.

3.1 Theoretical explanations for persistent deviations from PPP

The fact that our measures of the real exchange rate are not stationary thus raises questions about the reliability of a weaker purchasing power parity approach and the historical averages of the series as a guide to understanding trend developments. At the same time, there are several well-known reasons why the real exchange rate may deviate more persistently from PPP. Here, we briefly outline the most common reasons in quantitative analyses of real exchange rates.

1. Changes in productivity or income level relative to the rest of the world. In line with the hypothesis usually attributed to Balassa (1964) and Samuelson (1964), higher productivity in the production of internationally traded goods and services ('tradables') means higher domestic wages. This results in higher costs for, and therefore prices of, production that is only trade on the domestic market ('non-tradables'). Under the assumption that the relationship between domestic and foreign prices for tradables is not affected, this results in a higher price level than in the rest of the world, i.e. a stronger real exchange rate.¹²

¹² There have been both theoretical and empirical arguments against the Balassa-Samuelson hypothesis. For example, Choudri and Schembri (2010) show, in a modified model with product differentiation in all

In this original formulation of the Balassa-Samuelson hypothesis, it is the relationship between total factor productivity in different sectors, in turn related to that of the rest of the world, that is associated with the real exchange rate. An increase in productivity in the economy strengthens the real exchange rate only if the productivity increase primarily occurs in the production of tradables. However, it can be shown that with a higher labour intensity (use of labour per unit of capital) in the production of non-tradables, even a sector-neutral productivity improvement (which in the traditional Balassa-Samuelson approach would have no effect) will strengthen the real exchange rate.¹³

The relative price of non-tradables may also differ across countries in response to differences in the supply of capital per unit of labour. If labour intensity is higher in the production of non-tradables, their relative price will be higher in countries with a greater supply of capital per unit of labour (and hence a smaller supply of labour per unit of capital).¹⁴ It follows that the greater the availability of capital per unit of labour relative to the rest of the world, that is, the richer the country is relative to the rest of the world, the stronger its real exchange rate.

Differences in productivity and income are obvious explanations for the much larger weakening of the real exchange rate against the KIX countries excluding the euro area and the United States than against these two economies (see figure 1). Between 1995 and 2024, GDP per capita rose by 108 per cent in the first group of countries, compared with 52 per cent in KIX-2.

2. Changes in the terms of trade. An improvement in the terms of trade, i.e. higher export prices relative to import prices, means that a given export volume gives access to a larger volume of imports. The resulting increase in wealth may have a negative effect on the labour supply, which leads to higher wages and ultimately higher prices for non-tradables and a stronger real exchange rate.¹⁵ In addition, a so-called home bias in the consumption of tradables, i.e. consumers tend to allocate a larger share of their consumption on domestically produced tradables, means that changes in the terms of trade will have a direct effect on the real exchange rate if it is based on the consumer price index.

3. Change in the net international investment position. In the longer run, there are reasons to expect that a stronger net international investment position is consistent

sectors, that productivity improvements in the internationally competitive sector can both strengthen and weaken the real exchange rate, depending entirely on substitution elasticity between domestic and foreign goods. Engel (1999) splits the real exchange rate into prices for goods and services that are traded internationally and those that are not and finds that those that are traded account for almost all the variation in the real exchange rate. This runs counter to the law of one price for internationally traded goods and services, which is the basis of the Balassa-Samuelson hypothesis. However, Crucini and Landry (2017) use microdata that suggest that the assumption that the law of one price holds for internationally traded goods when the content of locally produced services in the retail trade in these is considered.

¹³ See Froot and Rogoff (1995).

¹⁴ This relationship is often attributed to Bhagwati (1984). It is based on the fact that capital is not perfectly mobile between countries.

¹⁵ See, for example, Lane and Milesi-Ferretti (2004).

with a stronger real exchange rate.^{16, 17} By reducing the risk premium on the country's public debt (especially for countries with high initial external indebtedness) and/or by increasing the country's wealth, the labour supply decreases and thus wages and, ultimately, prices rise.

4. Change in public consumption. With higher public consumption, more of the aggregate demand will be directed towards non-tradables, which may push up their prices. As a result, the price level relative to the rest of the world may rise and the real exchange rate may strengthen.¹⁸

In the first three explanations for why the exchange rate can deviate permanently from purchasing power parity, there may, in addition to the described supply components, also be a demand component that temporarily affects the real exchange rate. For example, higher income/wealth that is used to demand non-tradables to a greater extent would drive up their relative price level and strengthen the real exchange rate.¹⁹ Public consumption, in turn, mainly contains a demand component. De Gregorio and Wolf (1994) argue that relative prices are affected relatively little by demand factors when there is high capital mobility, suggesting that demand components, including public consumption, should have a limited long-term impact on the real exchange rate. However, it cannot be ruled out that there are other demand-related mechanisms that give rise to sustained higher price levels in richer countries, for example if consumers in lower-income countries have comparative advantages in seeking low prices for tradables.²⁰

There may also, at least after some economic shocks, be an important link between productivity changes in the internationally competitive sector and the terms of trade. Benigno and Thoenissen (2003) and Bordo et al. (2017) point out that specialisation in production may mean that improvements in productivity in the export sector can be compatible with a deterioration in the terms of trade. The relative improvement in productivity tends to strengthen the real exchange rate, while a deterioration in the terms of trade works in the opposite direction. Estimates of the effects of relative productivity on the real exchange rate may therefore be misleading if the terms of trade are not also taken into account.²¹

Figure 5 shows the development of the variables associated with the above-mentioned reasons for more persistent deviations from PPP and used in the quantitative analysis. They relate values for the rest of the world (KIX-2) to values for Sweden, either in the form of differences (public consumption as a percentage of GDP and the net international investment position as a percentage of GDP) or ratios (real exchange rate measures, terms of trade and GDP per capita). In all cases, the theoretical

¹⁶ Ibid.

¹⁷ In the shorter term, positive net lending would not only strengthen the net international investment position but also, by shifting demand towards foreign currency, would weaken the real exchange rate.

¹⁸ See Froot and Rogoff (1995).

¹⁹ See Bergstrand (1991).

²⁰ See Alessandria and Kaboski (2011).

²¹ In our estimates, the inclusion of the terms of trade is crucial in several cases if the estimated elasticity of the Swedish real exchange rate with respect to GDP per capita is to be significant and have the expected sign.

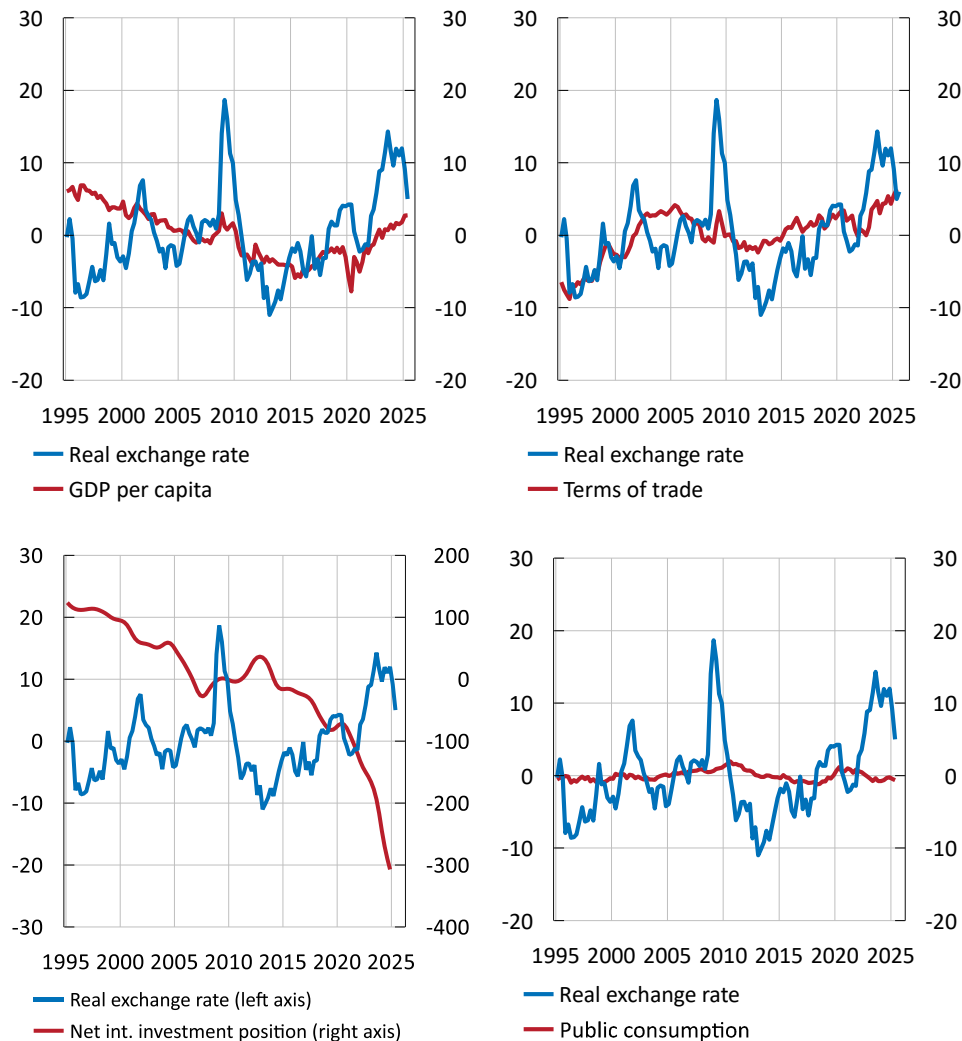
arguments suggest a positive covariation with our definition of the real exchange rate. We thus expect a higher, that is to say weaker, real exchange rate at higher values of these variables.

The terms of trade have clearly co-varied with the real exchange rate in the expected way – a deterioration in Sweden’s terms of trade has gone hand in hand with a weakening of the real exchange rate.²² For the other variables, the expected relationships are not as obvious at first sight. Although GDP per capita has increased slightly faster in the rest of the world than in Sweden since 2015, coinciding with a weakening of the real exchange rate, the correlation was instead negative in the preceding period. The improved net international investment position partly reflects the high level of net lending in Sweden, which has strengthened relative demand for foreign production, which is compatible with a weakening of the real exchange rate in the shorter term. However, in line with the reasoning above, wealth and risk premium effects of a stronger net international investment position should contribute to strengthening the real exchange rate in the long term. The public consumption share has varied relatively little over the analysed years and its explanatory value can therefore be expected to be low.

²² The measure shown is the terms of trade in KIX-2 relative to the terms of trade in Sweden. If KIX-2 had comprised Sweden’s entire foreign trade, the Swedish terms of trade would have been sufficient, but it is entirely possible that both the KIX-2 countries and Sweden experience a deterioration in their terms of trade with third countries, for example in the event of an increase in the oil price. In practice, Sweden’s terms of trade have been more volatile than those of the KIX-2, which have remained close to the current level as well as the 1995 level, while Sweden’s terms of trade deteriorated sharply between 1995 and 2005, for example.

Figure 5. The real exchange rate and possible explanatory variables

Deviations from the historical average in per cent and percentage points



Note: The real exchange rate is calculated using direct price level comparison. GDP per capita refers to GDP per person aged 15–64. The terms of trade refer to the ratio between the export and import deflators in the National Accounts. The net international investment position and public consumption are expressed as a percentage of GDP. In a first step, all measures relate values for the rest of the world (KIX-2) to values for Sweden, either in the form of ratios (the real exchange rate measures, GDP per capita and the terms of trade) or differences (public consumption, as a percentage of GDP). The exception is the net international investment position, where an incomplete series for the euro area means that we have chosen to report only Sweden's net international investment position as a percentage of GDP (with a reversed sign). In a second step, the values obtained have been related to their respective averages for the period 1995–2024, either in terms of percentage deviation (the real exchange rate measures, GDP per capita and the terms of trade) or percentage point deviation (public consumption and net international investment position).

Sources: Eurostat, OECD, Statistics Sweden, US Bureau of Economic Analysis, World Bank, the Riksbank and own calculations.

As several of the other variables have changed relatively much over the period under review, an analysis of the real exchange rate's development needs to take them all

into account. To determine which explanatory variables we initially want to include in our model specifications, we make use of a number of studies that have tried to explain the developments in real exchange rates, some for individual countries and others in multi-country panel estimations.

In these studies, which are reported in more detail in Appendix A, the support for the traditional Balassa-Samuelson effect varies. This is particularly the case for those studies that have explicitly tried to address it by dividing the country's output into tradables and non-tradables and have also used measures of productivity in these different parts of the economy. Explanations for why some studies find weak support for the Balassa-Samuelson effect could be too little variation when the sample of countries is restricted to advanced economies, productivity measures that are unable to capture the intended relationship or measurement problems when highly aggregated sectors are to be categorised, and naturally also that the theory may be based on unrealistic assumptions.

Relative GDP per capita can capture a broader set of effects of productivity changes and relative wealth. Many of the studies report a significant positive relationship between GDP per capita relative to the rest of the world and the strength of the real exchange rate. A significant relationship between a country's real exchange rate and its terms of trade is also consistently found. Public consumption is also important for the real exchange rate in many of the studies that have taken it into account. The empirical support for the idea that the net international position, or the closely related trade balance, would have an impact on the real exchange rate is weaker in advanced economies.²³

After a review of the empirical literature, we conclude overall that our independent variables should include relative GDP per capita and the terms of trade. It is also worth examining whether public consumption, and possibly also the net international investment position, has an impact on the development of the real exchange rate.

4 Estimates of the real exchange rate trend

In this chapter, we first review the results of our attempts to econometrically estimate the trend of the real exchange rate. As the trend estimates are based on different measures of the real exchange rate and we are interested in comparing the estimates, the results are illustrated in terms of the deviation of the real exchange rate from its estimated trend. In addition to the deviations stemming from the econometric estimates, deviations based on comparisons with historical averages in line with weak relative purchasing power parity and deviations based on trend estimates from elasticities found in previous studies are also included.

²³ See, for example, Lane and Milesi-Ferretti (2004), Christopoulos et al. (2012) and Bleany and Tian (2014).

4.1 Trend estimates for different measures of the real exchange rate from two econometric models

In the quantitative analysis, two methods have been used to estimate the trend of the real exchange rate: dynamic OLS (DOLS) and a Bayesian estimated model (TVEVAR). The latter simultaneously captures how the trend in the real exchange rate relates to the trends in the fundamental explanatory variables and how actual real exchange rate's deviations from the estimated trend relate to variables that are often seen as explaining more short-term exchange rate movements.²⁴

Figure 4 and figure 5 and the accompanying notes paint a good picture of the measures of the variables we have used in our estimations. For a more detailed discussion and more details on our choice of variables and measures, see Appendix B.

In estimating the DOLS equations, we have, like Ricci et al. (2013) and Bacchetta and Chikani (2021), used a lag and a lead to the variables in first differences, which is within the range given by the most common information criteria.²⁵ In estimating the TVEVAR, we use priors on the elasticities in the long-run relationship in line with what previous studies have found. For GDP per capita, we have chosen 0.2, mainly due to the large concentration of estimated elasticities at that level. For the terms of trade, our choice of 0.6 represents an average of values from previous studies.²⁶

In our preliminary surveys, the coefficient on the net international investment position consistently shows a positive sign – a stronger net international investment position is associated with a weaker real exchange rate. This is true whether we choose to use the official statistics (which form the basis of the series shown in Diagram 5), whether net international investment is measured as cumulative current account balances or whether it is retrieved from the so-called External Wealth of Nations database constructed by Lane and Milesi-Ferretti.²⁷ We interpret this to mean that the estimate captures a more short-term effect on demand and not the long-term wealth effect or risk premium effect that has been shown to be supported for certain countries in some previous studies. Since we are interested in the long-term relation, we

²⁴ TVEVAR is the acronym for Time-Varying Equilibrium Vector AutoRegression. It is the relationship between the trend in the real exchange rate and the trends in the fundamental explanatory variables that is treated as a time-varying equilibrium in the model. The deviations from this 'equilibrium' are simultaneously captured by a VAR. The model is described in greater detail by Belfrage et al. (2020).

²⁵ The equations estimated with DOLS are $RER(t) = a + b1*YREL(t) + b2*TOT(t) + c1*\Delta YREL(t-1) + c2*\Delta YREL(t+1) + c3*\Delta TOT(t-1) + c4*\Delta TOT(t+1)$, where RER is the real exchange rate, YREL is relative GDP per capita, and TOT is the terms of trade, constructed in accordance with the descriptions in the note to figure 5 and expressed in logarithmic form. The DOLS estimates assume that there is a cointegrating relationship between the real exchange rate and the other variables in the long-run relationship. Our ability to find support for the existence of a cointegrating relationship in formal tests is limited by their low power in small samples. The studies cited above that use this estimation method generally report test-based support for cointegration but have had larger samples to work with – in many cases using panels and in other cases, such as Bacchetta and Chikani (2021), using longer time series. In our case, Johansen tests indicate support for a cointegrating relationship only when the short-term variables (current account, interest rate differential and uncertainty) are included as exogenous variables, which could be considered but has not been used in our estimates. The theoretical support for the long-run relationship in question and the fact that previous studies with larger samples have found formal support for cointegration, including with Swedish data, we believe provide sufficient support for our assumption that we are dealing with cointegrating relationships.

²⁶ See Table A1 for the elasticities from a selection of previous studies.

²⁷ See Lane and Milesi-Ferretti (2018).

have chosen to omit the net international investment position from our final estimates.

We have also chosen to exclude government consumption because we do not find it to have any significant impact in the DOLS estimates or any noticeable impact in the TVE-VAR estimates. This is the case irrespective of whether it is included in the long-term or short-term relationship of the latter model. As shown in Diagram 5, variations have been small over the sample period and it is not unlikely that the significant real exchange rate relationships found in some previous studies stem from the decades before 1995 when changes in public consumption were much larger, not least in Sweden.

The main estimation results are reported in Table 1, while a sample of previous studies is summarised in Table A1 in Appendix A.

Table 1. Estimated relationship between the real exchange rate and fundamental variables

Dependent variable	Independent variables	Dynamic OLS	TVEVAR
Real exchange rate calculated using CPI			
	Relative GDP per capita	-0.14	-0.91 (prior: 0.2)
	Terms of trade	2.14***	1.52 (prior: 0.6)
		$R^2=0.52$	
Real exchange rate calculated using direct price level comparison			
	Relative GDP per capita	0.75***	0.22 (prior: 0.2)
	Terms of trade	1.42***	0.75 (prior: 0.6)
		$R^2=0.47$	
Real exchange rate calculated using unit labour costs			
	Relative GDP per capita	1.15***	0.85 (prior: 0.2)
	Terms of trade	1.68***	1.13 (prior: 0.6)
		$R^2=0.56$	

Note: Real exchange rate refers to KIX-2. The estimates are based on quarterly data for the period 1995–2025 Q2. Relative GDP per capita refers to GDP per capita at constant prices relative to KIX-2. Terms of trade refer to the export deflator relative to the import deflator (i.e. terms of trade based on the National Accounts). *** refers to statistical significance at the 1 per cent level. Given the Bayesian approach, it is not possible to report statistical significance in the same way for the TVE-VAR model estimates, but the coefficient on relative GDP per capita takes on an unexpected sign in the estimation of the trend in the real exchange rate calculated using CPI.

When we use DOLS to estimate the real exchange rate calculated using CPI, the point estimate of the elasticity with respect to relative GDP per capita is negative but the relationship is not statistically significant. Even when we estimate the TVEVAR model, a negative coefficient is obtained, despite a prior of opposite sign.

These results thus differ both from previous studies, including those reported in Table A1, and from the estimates where the real exchange rate is calculated using the other measures of relative price levels.²⁸

The fact that the elasticity with respect to relative GDP per capita has the expected sign in the estimates using the real exchange rate measures calculated using direct price level comparisons and unit labour costs is probably explained by the fact that the depreciation of the real exchange rate has not been as dramatic according to these measures. They have therefore not clearly moved in a different direction from relative GDP per capita except in periods when other variables could help to explain the behaviour of the real exchange rate.

In choosing the model specification, we have needed to consider the long-term depreciation trend in the real exchange rate calculated using the CPI. With few exceptions, the real exchange rates examined in other studies are based on the CPI, and the Riksbank's forecasting needs primarily concern this measure. If the previously discussed lack of comparability between Swedish and foreign consumer price indices is constant over time, this could justify a time trend in our model specification when we try to identify the trend for this measure of the real exchange rate. We could then isolate how measurement issues affect our estimates of the trend in the real exchange rate calculated using the CPI. However, there are indications that methodological changes in the calculation of the Swedish consumer price index have reduced the problems associated with the lack of comparability.²⁹ We have therefore chosen to omit a time trend and instead give greater weight to the alternative measures of the real exchange rate and their respective trend estimates.

Although there are relatively small differences between the real exchange rate based on direct price level comparisons and on unit labour costs, apart from the period just before the global financial crisis, the point estimates of elasticities differ markedly depending on the real exchange rate measure used. This applies to both DOLS and TVEVAR. We also note that the two calculation methods provide different pictures of the sensitivity of the real exchange rate to movements in the fundamental explanatory variables. The DOLS estimates, for example, indicate a greater sensitivity to changes in relative GDP per capita than the TVEVAR estimates. It is worth recalling here that the latter refer to the long-run relationship between contemporaneously estimated trends in the fundamental explanatory variables and the trend in the real exchange rate and that they are also affected by our choice of priors. Crucial for our analysis, however, is what the combination of the variables' development and the estimated

²⁸ The deviation from previous studies using relative GDP per capita as the explanatory variable is probably related to some combination of the countries included in the analysis and the investigated time period. When we use Bacchetta and Chikani's data and specifications but limit the sample to the period from 1995 onwards, we also do not find any significant relationship between the real exchange rate and relative GDP per capita. Their and other studies have generally drawn a large part of their observations from periods in which it is not possible to discern the same clear indications of the effects of differences in price measurements between Sweden and the rest of the world as in the first two decades of the 2000s. Our own choice to start the sample in 1995 is partly due to the availability of data for the real exchange rate measures calculated using direct price level comparisons and unit labour costs, and partly because the real exchange rate exhibits dramatically different dynamics under a fixed exchange rate regime.

²⁹ Statistics Sweden (SCB) has taken measures to harmonize certain calculations with Eurostat, which appears to have reduced measurement problems, see Eliasson and Ottosson (2021).

elasticities implies for the trend of the real exchange rate. We discuss this further in the next section.

In this context, it should also be noted that the measured development of GDP per capita relative to the rest of the world used in the analysis may be affected by the previously discussed challenges in measuring developments in the relative price level across countries. This is particularly true of the consumption deflator, which is calculated using consumer price index data. The more moderately the rate of price increase is measured, the higher the measured growth of GDP in constant prices can be expected to be. One way to deal with this is to use nominal GDP per capita converted into the common currency using the price statistics from the direct price level comparisons.³⁰ This gives a partly divergent picture of developments, see figure E1 in the Appendix. Over time, we see the expected tendency for the ratio between international and Swedish GDP per capita to have developed slightly stronger according to the PPP measure. However, we have chosen not to use this measure because it is not based on a single measurement methodology over time and mixes information on other countries' expenditure distribution into the GDP determination.³¹ One indication that the PPP measure may be problematic for our purposes is that it sometimes shows quite dramatic fluctuations in relative GDP per capita. In our estimates, the choice of measure mainly affects the elasticity with respect to relative GDP per capita, while the overall effect on our average model-based trend deviation is small; see figure E2 in the Appendix.

4.2 The real exchange rate's deviation from trend

Given that we use different measures of the real exchange rate to estimate its trend and are interested in comparing these estimates, in this section we summarise what the different measures and estimation methods tell us about the deviation of the real exchange rate from the estimated and calculated trends. We then define a model-based range for the trend deviation based on a sample of the estimated deviations and check the plausibility of the range against variables that are often considered to explain more short-term variations around the trend in the exchange rate. Finally, we contrast the range with IMF estimates of the longer-term real exchange rate and the very simple so-called Big Mac index.

Real exchange rate deviation from trend according to different measures and estimation methods

In figure 6, all estimated deviations are illustrated based on the three different measures of the real exchange rate and four different methods for determining its trend:

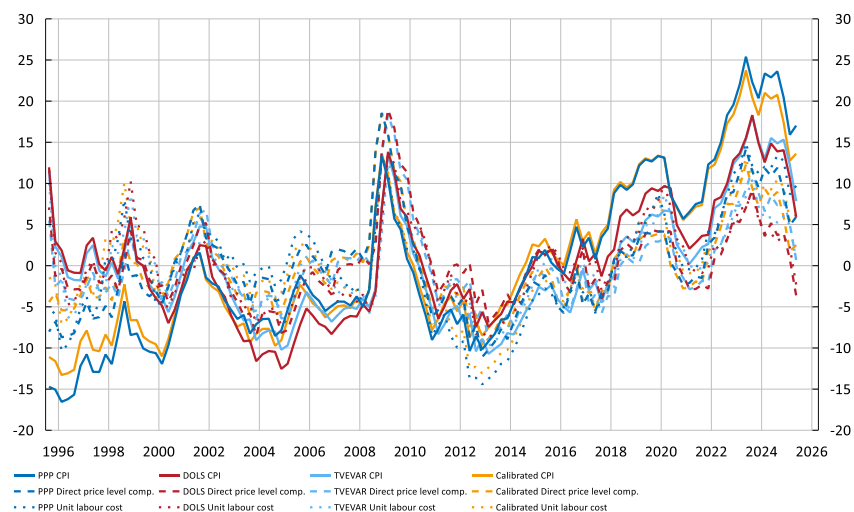
³⁰ Bacchetta and Chikani (2021) as well as Ca'Zorzi et al (2022) state that they have used relative *real* purchasing power adjusted GDP. This should give the same result in terms of evolution over time as using the ratio based on real GDP from national accounts as we have done here.

³¹ For these reasons, Feenstra et al. (2015) recommend using GDP according to the national accounts rather than GDP based on direct price comparisons when the aim is to capture relative volume developments over time.

1. Trend determined by the historical average of the real exchange rate measure, approximately consistent with a weaker purchasing power parity (PPP) approach.
2. Trend estimated in TVEVAR.
3. Trend calculated from elasticities estimated in DOLS and trend values for the independent variables obtained with an H-P filter (see figure 7).³²
4. Trend calculated from elasticities in previous studies and trend values for the independent variables obtained with an H-P filter.

Figure 6. The real exchange rate's deviation from trend using different measures and estimation methods

Percentage deviation from the calculated/estimated trend



Sources: Eurostat, OECD, Statistics Sweden and own calculations.

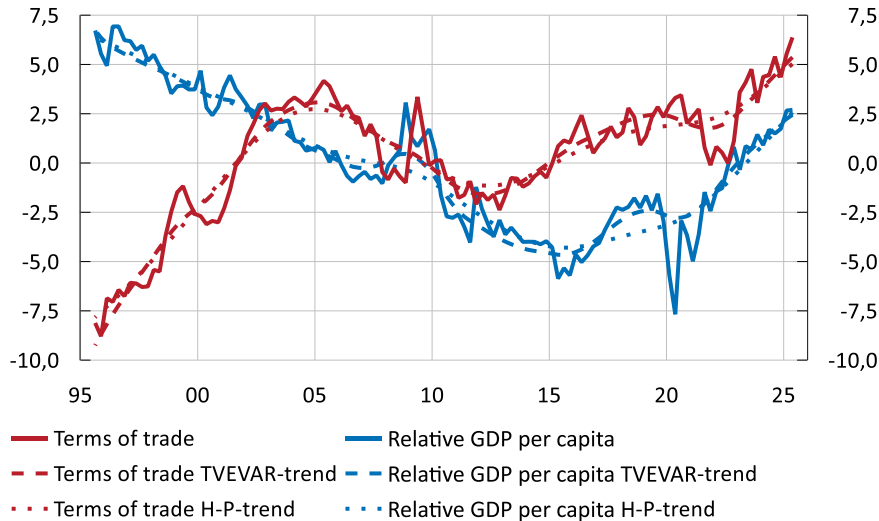
Given the distribution of the different estimated trend deviations, it is clear that the uncertainty surrounding the estimates is significant and that it is relatively large towards the end of the period. The image of the real value of the krona at a given point in time often depends greatly on which measures and methods are used in the analysis. At the same time, the estimates support some qualitative statements, such as that the krona, in real terms and relative to its trend, was weak in early 2009 after the onset of the financial crisis and strong in 2013–2014. The overall picture also suggests that the real exchange rate was relatively close to its trend level at the beginning of 2021, before weakening until the middle of 2023, after which it again approached its trend level.

³² With a DOLS estimation, a candidate to the long-run real exchange rate is the fitted values from the regression, excluding the short-term dynamics captured by the variables in first differences. This is what Bacchetta and Chikani (2021) use in their analyses of the over- and undervaluation of the krona. However, the independent variables are rarely on their trends. We therefore follow Clark and MacDonald (1999) and use trend values calculated with Hodrick-Prescott filters for these variables together with the DOLS-estimated elasticities to determine the real exchange rate.

Figure 7 shows the actual and trend values of the fundamental explanatory variables used to calculate the trend in the real exchange rate using the DOLS and TVEVAR elasticities. The figure illustrates how actual values sometimes deviate sharply, albeit temporarily, from what appear to be trend levels, and that there are small differences between H-P trends and the trends estimated in the TVEVAR model.

Figure 7. The independent variables and their estimated trends

Percentage deviation from average



Note: The terms of trade are given by the ratio of the export deflator to the import deflator in the National Accounts and GDP per capita refers to GDP per person aged 15–64. Solid lines represent the percentage deviation from the average ratio between Sweden and KIX-2 over the period 1995–2025 Q2.

Sources: Eurostat, OECD, Statistics Sweden, US Bureau of Economic Analysis, World Bank, the Riksbank and own calculations.

The fact that we use trend values instead of actual values for the fundamental explanatory variables when calculating the trend of the real exchange rate has limited significance. It is, not surprisingly, mainly during the sharp depreciation of the krona in connection with the financial crisis in 2009 that the difference between the trend calculations is somewhat larger.

Figure 8 shows how the real exchange rate calculated using direct price comparisons has deviated from its average since 1995, together with the real exchange rate trend estimated using TVEVAR and DOLS and the contribution of the independent variables to each trend estimate's deviation from its historical average.³³ We can see, for example, that the real exchange rate at the end of 2005 was a few per cent weaker than the average for the period in real terms, but so was the real exchange rate trend, mainly because the trend level of the terms of trade was relatively weak at that time. In early 2013, the trend real exchange rate was strong relative to its historical average because the trends for relative productivity and the terms of trade were both below

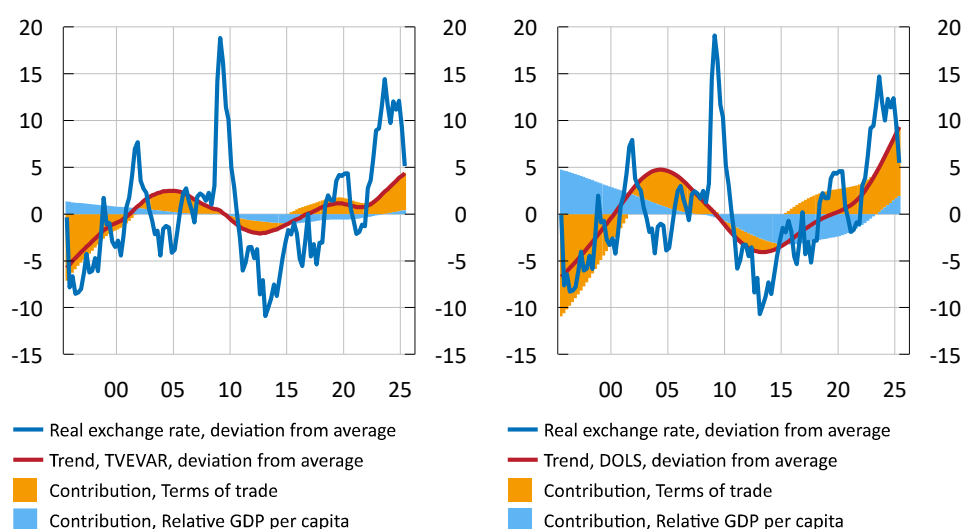
³³ Appendix D shows the corresponding graph when the real exchange rate is calculated using unit labour costs.

the average for the period. At the same time, the real exchange rate was even stronger.

At the end of 2024, the situation was the opposite: the trend was weak while the actual real exchange rate was even weaker. The sharp weakening of the dollar in 2025 has meant that the krona has strengthened significantly in real terms and is now close to its trend according to TVEVAR and somewhat stronger than its trend according to DOLS. The results from the two models highlight the higher estimated elasticities in the DOLS equation, which means that the trend according to this estimation method has varied somewhat more.

Figure 8. The deviation of the real exchange rate from its historical average and decompositions of the deviation of trend estimates from the historical average

Per cent and percentage points



Note: In the left-hand panel, parameter estimates from TVEVAR are used. In the right-hand panel, in addition to the parameter estimates from DOLS, the HP trend of the independent variables is used in the trend and trend contribution calculations.

Sources: Eurostat, OECD, Statistics Sweden, US Bureau of Labor Statistics, the Riksbank and own calculations.

There are strengths and weaknesses in each measure of the real exchange rate and in each method of deriving the unobservable real exchange rate trend. It is therefore reasonable that the overall assessment of the trend rests on several measures and methods.

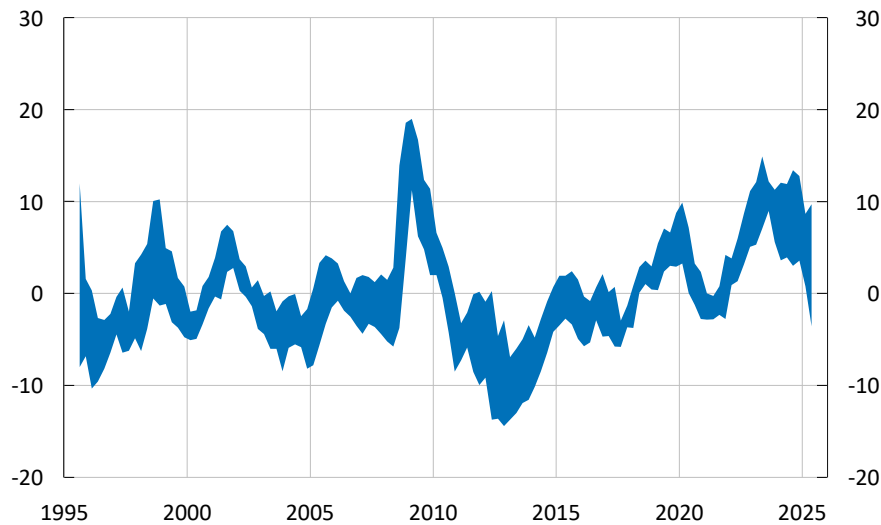
Figure 9 shows a range of the trend deviation based on a selection of the trend estimates with different measures of the real exchange rate and different ways of estimating the trend.³⁴ In the range, we have chosen to exclude trend estimates based on the real exchange rate calculated using the consumer price index. As we have already noted, its persistent weakening contributes to problems regardless of which method we use, and the weakening can in part be attributed to previously discussed

³⁴ See Appendix C for a clearer identification of deviation from trend by different methods

measurement issues. The lasting depreciation also argues against the historical average as a possible reference point for a future adjustment of the real exchange rate. Moreover, in the DOLS and TVEVAR estimates, the elasticity with respect to relative GDP per capita takes on an unexpected sign. The range is thus constructed from the eight remaining estimates of the trend deviation based on the real exchange rates calculated using direct price level comparisons and unit labour costs.

Figure 9. Model-based range for the real exchange rate's deviation from trend

Percentage deviation from the estimated/calculated trend



Note: The blue range is constructed from the highest and lowest estimates of the four different estimates of the deviation from trend of the real exchange rate calculated using direct price level comparisons and unit labour costs respectively.

Sources: Eurostat, OECD, Statistics Sweden and own calculations.

Our selected measures and estimation methods provide somewhat different answers to whether the krona was strong or weak relative to its trend in the years just before the global financial crisis. Otherwise, we get a fairly consistent picture of the real exchange rate's deviation from trend, where it is possible to detect traces of the Asian crisis, the rise and fall in the valuation of the IT sector, the terrorist attacks of 11 September 2001, the global financial crisis, the European debt crisis and the inflationary developments and uncertainties of recent years in the wake of the coronavirus pandemic and geopolitical upheavals. We will return to a brief discussion of how the deviation of the real exchange rate from trend has evolved but note for now that all these deviations support the view that the real exchange rate was close to its long-term trend in 2021. At the last observation, that is, the second quarter of 2025, the real exchange rate was weaker than several of the trend estimates, but the picture of how much weaker it was differed historically quite a lot between different combinations of measures and methods.

Can we understand the real exchange rate's deviation from trend?

We now turn to our model-based range for the trend deviation to discuss how it relates to factors that are often mentioned as possible explanations of short-term fluctuations in the real exchange rate.

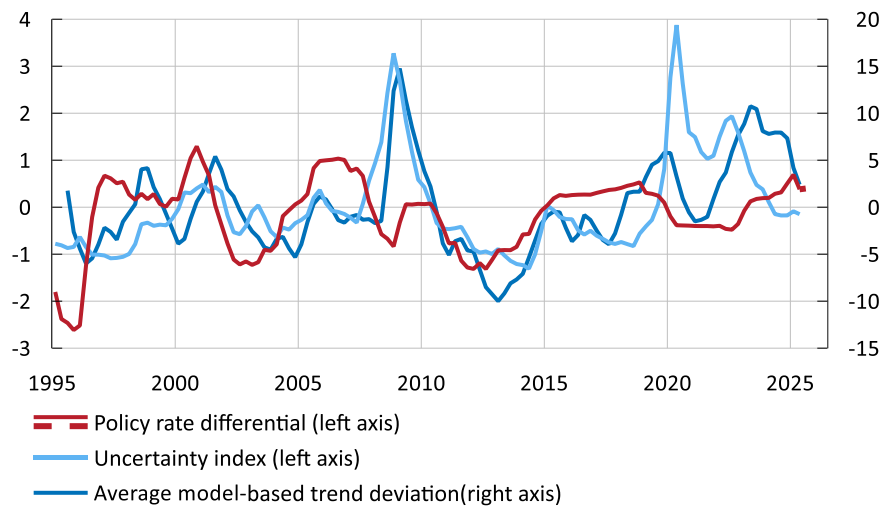
Figure 10 shows the average trend deviation of the estimates included in the range together with the policy rate differential (the difference between KIX-2 and Sweden) and the uncertainty index used to estimate the short-term dynamics of the TVEVAR estimates. It is possible to discern a correlation between the trend deviation and, not least, the uncertainty index. In a simple regression, the policy rate differential and the uncertainty index, together with the deviations of the independent variables from their respective trends, explain a significant part of the variation in the average model-based trend deviation (see Appendix F). The severe weakening of the krona during the global financial crisis coincides well with a sharp rise in the uncertainty index. The strong real exchange rate in 2011–2014 coincides with a period of low uncertainty (the measure used here was not significantly affected by the European debt crisis) and a low policy rate in KIX-2 compared to Sweden. The high level of uncertainty since 2020 is also consistent with a weak krona, but the developments in uncertainty and the policy rate differential (or the deviations of the independent variables from their respective trends) are insufficient to explain the development of the real exchange rate over the period 2022Q3–2024Q4.³⁵ A hypothesis that the Riksbank has previously discussed is that the development of the exchange rate during this period to a significant extent was explained by the investment strategies of financial agents.³⁶ Flam and Persson (2024) also mention that the exchange rate may have been affected by the Riksbank's purchases of foreign currency to adjust the composition of the foreign exchange reserves and changes in the Swedish National Debt Office's currency exposure.

³⁵ The conclusion is based on the fact that the mean gap at the end of the period is much larger than its fitted counterpart in the aforementioned regression of the mean gap on the short-term explanatory variables.

³⁶ See Sveriges Riksbank (2023).

Figure 10. Average model-based trend deviation, Policy rate differential and uncertainty index

Percentage points and standard deviations



Note Policy rate differential refers to the difference in percentage points between the policy rate in KIX-2 and the policy rate in Sweden, here in turn expressed as a deviation from the mean value for the period of -0.18 per cent. The uncertainty index is the 12-month variant of the macro uncertainty index introduced by Jurado et al. (2015), here expressed as the number of standard deviations from its mean for the period.

Sources: ECB, Jurado et al. (2015), the Riksbank and own calculations.

The real exchange rate's deviation from trend compared to the IMF assessment and the Big Mac Index

We find no correlation between the deviation of the real exchange rate from trend and the current account balance, but the current account plays a prominent role in the so-called macroeconomic balance approach to determining the trend of the exchange rate. The approach is partly used by the IMF in their analyses of global imbalances in the annually published External Sector Report focusing on a country's savings and investment, i.e. its current account.³⁷ However, macroeconomic balance does not necessarily mean that the current account is zero, so as a first step a norm for the current account needs to be established, based on demographic factors such as an ageing population (high savings) or high population growth (high investment needs). If the current account balance exceeds the norm (savings are too high in relation to investment), the currency is undervalued in the sense that a stronger currency is needed to achieve macroeconomic balance. The size of the undervaluation is then determined by an assessed or estimated elasticity of the current account with respect to exchange rate changes.

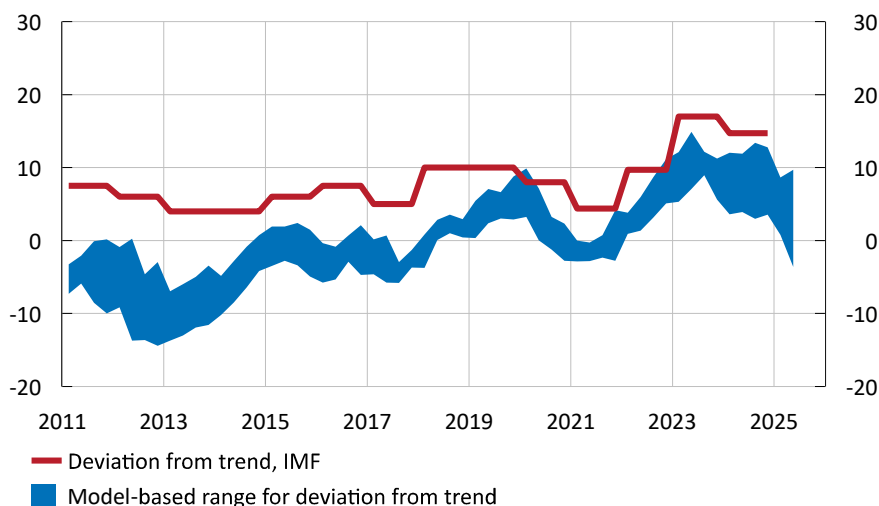
Since the IMF began publishing these assessments in 2011, based on the macro balance approach described above, they have always assessed that the Swedish current account balance has exceeded its norm and therefore concluded that Sweden's real

³⁷ Cline and Williamson (2012) is another example of an attempt to establish so-called fundamental equilibrium exchange rates based on such an approach.

exchange rate is weaker than its trend. Clear differences in the approaches to identifying the trend of the real exchange rate mean that the macro balance approach gives a slightly different picture of the real value of the krona than our model-based range. However, the trend deviations from the two approaches covary to some extent, as shown in figure 11. In recent years' reports, the IMF's justifications have increasingly emphasized the real exchange rate calculated using unit labour costs and its deviation from its historical average as a basis for assessment, and the similarity between our model-based range and the IMF's assessment of the trend deviation has then further increased.

Figure 11. The real exchange rate's deviation from trend according to the model-based range and the IMF assessment

Per cent



Note: The IMF's exchange rate gap refers to the percentage deviation of the real effective exchange rate from the organisation's assessed norm for the real exchange rate, published annually in the *IMF External Sector Report*.

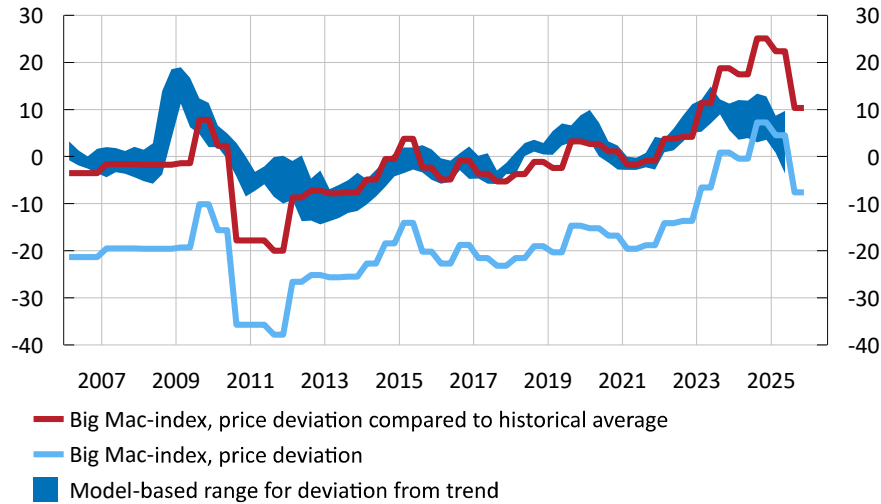
Sources: IMF, the Riksbank and own calculations.

It may also be of interest to relate our model-based range to a well-known and simple measure of the real exchange rate, the so-called Big Mac index compiled by *The Economist*. When converted into a common currency, this index is effectively a real exchange rate based on the price of a Big Mac rather than a consumer basket. As shown in figure 12, a Big Mac has consistently been more expensive in Sweden than in KIX-2 – in line with the broader direct comparisons of price levels that underpin the content of figure 2. The Big Mac index can be said to have absolute purchasing power parity as its norm and, according to the index, the krona has, with the exception of last year, been overvalued in real terms relative to KIX-2. If we instead use relative purchasing power parity as the norm, the Big Mac price ratio needs to be related to its historical average. Apart from occasional deviations, this measure has remained relatively close

to the model-based range for the trend deviation but currently indicates some under-valuation of the krona in real terms.³⁸

Figure 12. The real exchange rate's deviation from trend according to the model-based range and the Big Mac-index

Per cent



Sources: Macrobond, the Riksbank and own calculations.

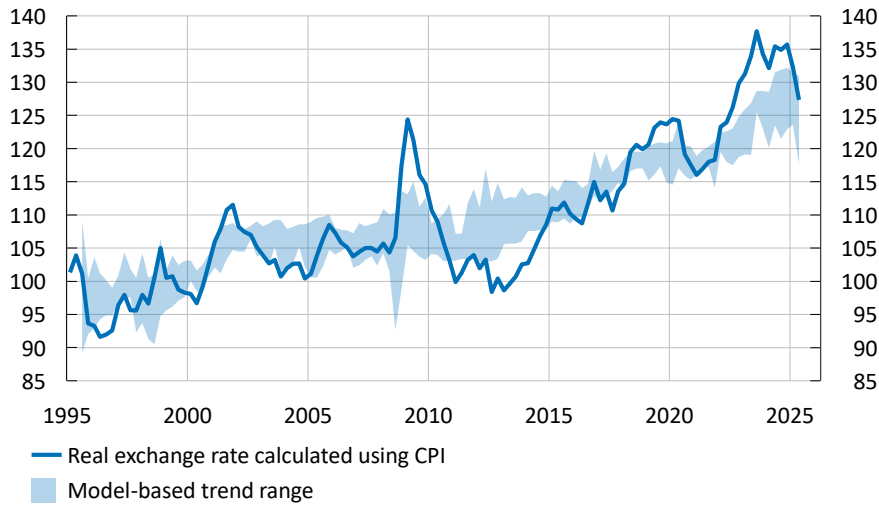
5 Concluding discussion

As already noted, the real exchange rate calculated using the consumer price index is unlikely to provide an entirely accurate picture of how much the krona has depreciated in real terms, and this measure has therefore not been given any weight when producing estimates of real exchange rate's deviation from trend. However, to the extent that we expect the measurement problems in the CPI to be less significant going forward, we can apply our model-based range for the trend deviation by simply subtracting the deviation from trend supported by the analysis from the real exchange rate calculated using the CPI. The real exchange rate calculated using the consumer price index and our estimated range for its trend are shown in figure 13.

³⁸ In 2010–2012, the Swedish Big Mac price was first raised sharply and then lowered again, while the international price level remained more stable.

Figure 13. The development and trend of the real exchange rate

Index 1995=100



Note: The trend range has been calculated by subtracting the model-based range of the trend deviation from the real exchange rate.

Sources: Eurostat, Statistics Sweden, US Bureau of Economic Analysis, the Riksbank and own calculations.

Our analysis suggests that the real exchange rate was significantly stronger than its trend at the beginning of 2013. The sharp depreciation of the real exchange rate, calculated using the consumer price index, that occurred thereafter amounted to just under 30 percent in the second quarter of 2025. According to our model estimates, the trend-based weaker development in both the terms of trade relative to the rest of the world and relative GDP per capita has contributed to roughly half of this depreciation. The remaining depreciation reflects the development of factors that normally have a more short-term impact on the real exchange rate, but to some extent also the lack of comparability between Sweden's and the rest of the world's consumer price indices.

Against the backdrop of the recent general and widespread weakening of the dollar, the real exchange rate has strengthened noticeably during the first half of this year, and our analyses overall suggest that it was relatively close to its trend level in the second quarter of 2025.³⁹ At the same time, it is important to remember that the trend of the real exchange rate varies over time, and the trend in the fundamental drivers may very well change in the future. Not least considering the recent upheavals in the global economy.

³⁹ The krona, measured with KIX-2, strengthened by just over 5 percent in nominal terms between the last quarter of 2024 and the second quarter of 2025

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APPENDIX A – Empirical studies of long-term deviations from purchasing power parity

Many of the studies devoted to explaining deviations from purchasing power parity (PPP) were published in the years up to the mid-1990s and are presented in more detail in Froot and Rogoff's (1995) review. Here, we mainly discuss broader studies published since then. The aim is to provide a synthesised interpretation of the state of knowledge and the background to our own choices of variables and estimation methods.

De Gregorio and Wolf (1994) are one of the first contributions to simultaneously examine relative productivity and the terms of trade in an attempt to explain variations in real exchange rates. They find that both of these variables play an important role and note that when the terms of trade are included in the analysis, the coefficient of relative productivity increases significantly. This suggests a potential bias in previous studies that have focused solely on relative productivity without taking into account the terms of trade.

Berka and Devereux (2010) examine the relationship between real exchange rates and structural factors in 31 European countries over the period 1995–2007 and find that GDP per capita relative to the other countries explains a large part of the variation in real exchange rates, both over time and across countries. Galstyan and Lane (2009) and Bleaney and Tian (2014) are among the studies that do not primarily focus on, but include, relative GDP per capita among their control variables and find a significant relationship with the real exchange rate.

Lane and Milesi-Ferreti (2004) focus on how the net international investment position affects the real exchange rate through the so-called transfer effect, while controlling for GDP per capita and the terms of trade. In panel data estimates, they find weak support for GDP per capita but strong support for the terms of trade and an appreciating effect of the net international investment position, especially for developing economies but also for industrialised countries. At the same time, they find that the impact of the net international investment position on the real exchange rate varies with the content of the balance sheet. Relatedly, Christopoulos et al. (2012) find that the net international investment position matters most for the real exchange rate of countries with limited access to foreign capital. Bleaney and Tian (2014) find that it is mainly for those countries (predominantly developing economies) with net foreign currency debt that the variable plays a significant role for the real exchange rate.

Ricci, Milesi-Ferreti and Lee (2013) have conducted one of the most comprehensive empirical studies of real exchange rate drivers in terms of the number of countries and variables included. They have a panel of 48 countries, including Sweden, and use dynamic OLS to estimate long-run relationships between, on the one hand, the CPI-based real exchange rate and, on the other hand, relative productivity in the production of internationally traded goods and services, the terms of trade for raw materials,

public consumption and the net international investment position.⁴⁰ For the sample of advanced economies, they find significant relationships with the terms of trade for commodities and public consumption's share of GDP but not with the other variables.

Berka, Devereux and Engel (2018) use a panel data regression to analyse the relationship between real exchange rates and sector-specific total factor productivity (TFP) in nine euro area countries over the period 1995–2009. They find that support for a Balassa-Samuelson relationship between real exchange rates and productivity in different sectors is strengthened when one tries to account for the existence of a 'wedge' between the actual cost of labour and the wage experienced by employees. Berka and Steenkamp (2018) obtain similar results in a study of 17 OECD countries where, in one of their alternative specifications, they also include and find a significant relationship with the terms of trade.

Ca'Zorzi et al. (2022) compare the different methods for finding a long-run real exchange rate used by central banks, focusing on the so-called behavioural equilibrium exchange rate method that the studies described here can be said to apply. In a panel estimation with eleven advanced economies, they find no support for a relationship between the real exchange rate and the net international investment position but do find support for a relationship with relative GDP per capita and the terms of trade.

Previous studies focused on the Swedish real exchange rate

A few previous studies have focussed directly on providing an explanation for the development of the Swedish real exchange rate. Nilsson (2004) finds that the relative price level of tradables as well as the terms of trade and net foreign debt have had significant relationships with the real exchange rate during the period studied (1982–2000). He also uses the long-run relationship in his vector error correction model (VECM) to calculate the long-run real exchange rate and draws conclusions about the over- and undervaluation of the krona at different times.

Lane (2006) uses dynamic OLS to estimate the relationship with the Swedish CPI-based real exchange rate during the period 1970–2005 and finds a significant relationship with the terms of trade but also with the trade balance, which is attributed to demographic factors and the fiscal consolidation that took place after the 1990s crisis.

Larsson (2004) examines the real bilateral exchange rate in relation to Germany during the period 1973–2001 using an error correction model and finds support for a long-run relationship between relative productivity and the real exchange rate in line with the Balassa-Samuelson hypothesis. In addition, she shows that deviations from the long-run relationship are adjusted more quickly after the transition to a floating exchange rate.

Sellin (2007) examines the forecasting properties of a vector error correction model with the Swedish real exchange rate calculated using the consumer price index, GDP

⁴⁰ For the emerging economies in the sample, the authors also include indicators of trade restrictions and price controls.

relative to abroad, the terms of trade and the net international investment position with data for the period 1985–2005. The elasticities of the real exchange rate with respect to the other variables are found to be insignificant in most cases and, for some configurations, the point estimates have the wrong sign. A version with coefficients in the long-run relationship calibrated to what the author believes is implied by some theoretical literature is found to have relatively good forecasting properties if the co-variation of short-term deviations with interest rate differentials is taken into account.

Belfrage, Bonomolo and Stockhammar (2020) describe a VAR model with time-varying equilibrium that has been used for some years to support the Riksbank's assessments of the long-run real exchange rate. Here, the long-run relationship for the real exchange rate (a linear combination of estimated trend values for the fundamental variables) is estimated simultaneously with a VAR model for the short-run relationship between the real exchange rate gap (the difference between the actual real exchange rate and the trend level according to the long-run relationship), the deviations of the fundamental variables from their respective trend levels and the variables that we have chosen here to include in the short-run relationship. The short-run relationship may be of interest in itself, but here it also helps to guide the estimation of the long-run relationship – if the policy rate differential and other variables in the short-run relationship suggest that the real exchange rate should be weaker than its trend level at a particular point in time, this informs the estimation of the long-run relationship that determines the time-varying trend of the real exchange rate.

Bacchetta and Chikani (2021) perform several sets of estimates with dynamic OLS for the period 1970–2018, both with a panel of ten advanced economies and with Sweden alone. They consistently find support for expected relationships between the real exchange rate and GDP per capita relative to abroad and the terms of trade, but not with the relative productivity of the internationally competitive sector, the net international investment position or the trade balance. In the estimates with annual data, where their sample period starts in 1970, they also find a significant relationship with public consumption as a share of GDP. However, estimates of the Swedish real exchange rate tend to be sensitive to the estimation period. When we use the Bacchetta and Chikani data and specifications but restrict the sample to the period from 1995 onwards, we find no significant relationship between the real exchange rate and relative GDP per capita.

Table A1 summarises a selection of the studies mentioned above, namely those that include some form of relative productivity measure as well as the terms of trade. The focus is on the real exchange rate's elasticity with respect to these two variables, although other variables are often included in the estimates. In general, results from several alternative model specifications are reported in each study. As a rule, in the table we only report results from those variants where the estimated coefficients have the correct sign and are significantly different from zero (see further comments in the table).

Table A1. Previous studies estimating the relationship between the real exchange rate and fundamental variables

	Relative productivity or GDP per capita	Terms of trade	Comment
De Gregorio and Wolf (1994) • CPI-based real effective exchange rate • 14 OECD countries • Annual data 1970–1985 • SUR with country constants on logged series in first differences	0.18 – 0.20 Relative TFP in tradables v. non-tradables relative to other countries (TFP calculated as Solow residual)	0.49 – 0.50 Export price index/import price index for goods, i.e. producer prices, IMF data	Also includes in one case GDP per capita (not significant) and in both cases public expenditure as a share of GDP (positive and significant)
Nilsson (2004) • CPI-based real exchange rate for Sweden against 13 OECD countries • Quarterly data 1982–2000 • VAR(2), real interest rate differential included as an exogenous variable to capture short-term variations	0.46 Relative price of tradables v. non-tradables calculated as the ratio of WPI or PPI to CPI, other countries relative to Sweden	0.65 Ratio of unit prices of exports and imports from IMF and for some of the countries OECD	Also includes Sweden's net debt to GDP ratio in the estimates with expected coefficient
Ricci, Milesi-Ferreti and Lee (2013) • CPI-based real effective exchange rate • 48 countries but also separate estimates for 21 advanced economies • Annual data 1980–2004 • DOLS with country fixed effects	Not significant Relative labour productivity in mainly tradables v. non-tradables relative to other countries	0.75 – 0.76 Measure focused on globally traded and priced commodities (Commodity Terms of Trade), aims to avoid the impact of nominal exchange rate movements	Only results for separate estimates with the group of advanced economies are presented here for best comparability with our estimates for Sweden. Also significant relationship to public consumption as a share of GDP.
Berka and Steenkamp (2018) • Bilateral real exchange rate against the US, calculated using direct price level comparisons for private consumption • 17 OECD countries • Annual data 1990–2007 • OLS with country fixed effects	0.22 Relative TFP in tradables v. non-tradables relative to the US	0.39 Export price level in relation to the US relative to import price level in relation to the US, measured using direct price level comparisons	For comparability, only the results with country fixed effects are reported here. The estimates also include variables designed to capture changes in the relationship between wages and labour productivity.

	Relative productivity or GDP per capita	Terms of trade	Comment
Bacchetta and Chikani (2021)	0.79 – 0.80 (panel)	0.31 – 0.44 (panel)	In estimates using annual data, public consumption is also found to have a significant relationship with the real exchange rate.
• CPI-based real effective exchange rate	0.45 (Sweden)	1.28 – 1.31 (Sweden)	
• Panel of 10 advanced economies and Sweden alone	GDP per capita in PPP terms relative to other countries in the sample	Export deflator relative to import deflator (i.e. NA-based terms of trade)	
• Annual data 1970–2018			
• Panel-estimated DOLS with country fixed effects and DOLS with Sweden only	0.26 – 0.28 (panel)	0.45 – 0.48 (panel)	
	0.53 (Sweden)	1.72 – 1.93 (Sweden)	
• As above but with quarterly data 1975–2018			
Ca’Zorzi et al. (2022)	0.22	0.43	A significant relationship is also found with the net international investment position but with the ‘incorrect’ sign.
• CPI-based real effective exchange rate	GDP per capita in PPP terms relative to other countries in the sample	Export deflator relative to import deflator (i.e. NA-based terms of trade)	
• 11 advanced economies			
• Quarterly data 1975–2018			
• Panel estimated FMOLS with country fixed effects			

Note. The table only presents results for regressions that include both some measure of relative productivity (including GDP per capita) and the terms of trade. Unless otherwise stated, only results that are significant at least at the 10 per cent level are shown.

The studies in the table have in common that they use real exchange rates based on the consumer price index, except for Berka and Steenkamp (2018) who use direct price level comparisons for private consumption. Usually, the real exchange rate and the fundamental variables are expressed in log levels and the cointegrating vector is sought. De Gregorio and Wolf (1994) are an exception – they instead use the first difference of the logged levels.

We have combined the estimation results for relative productivity between sectors and GDP per capita on the basis that these are equivalent under certain assumptions. The estimated elasticities with respect to this variable range from not significantly different from 0 (Ricci et al. (2013)) to 0.80 in one of Bacchetta and Chikani’s (2021) panel estimates with annual data. The estimated elasticities with respect to the terms of trade are often larger and, in all cases, significant with the expected sign.

APPENDIX B – Choice and measures of variables

We have used quarterly data throughout – partly to obtain as many observations as possible, and partly to maximise the usefulness of the information in the short-run relationships we use in the TVEVAR model. The disadvantage of using quarterly data is that it precludes the use of the lower-frequency information in the OECD sectoral database that underlies measures of relative productivity in the internationally competitive sector that have appeared in other studies. Given the relatively weak empirical support for this variable in these studies and with the expectation that most of the variation in this variable in Sweden’s case is captured in GDP per capita (which is the case if, as in early designs of the Balassa-Samuelson theorem, productivity changes mainly occur in the internationally competitive sector), we have not tried to find an alternative measure of relative sectoral productivity at quarterly frequency.

In constructing the measure of relative GDP per capita, we have used seasonally adjusted GDP in fixed prices and related it to World Bank data on population aged 15–64, whose annual values have been HP-filtered in order to transform them into quarterly data.

There are several different measures of the terms of trade. We have used the ratio of the export deflator to the import deflator from the national accounts, while some other studies use more commodity-intensive export and import price indices such as the IMF’s Commodity Terms of Trade. Ricci et al. (2013) argue that there are endogeneity problems related to the fact that nominal exchange rate shocks affect the terms of trade, but that this does not apply to the same extent to commodities whose prices are clearly determined in a world market. For an economy as small as Sweden’s, the endogeneity problem in question should be small, while the breadth of Swedish foreign trade makes it important not to limit the measure of the terms of trade to raw materials. We note that the measures give broadly the same picture of developments since 1995, but that the more commodity-intensive measures indicate a greater deterioration in Sweden’s terms of trade up to the global financial crisis and are generally more volatile. If KIX-2 had constituted Sweden’s entire foreign trade, the terms of trade would simply be the ratio between KIX-2’s export prices and Sweden’s export prices. In practice, however, a significant proportion of trade is with other countries – this is particularly true of the KIX-2 countries, for whom trade with Sweden accounts for only a small proportion of total trade. If, for example, the world market prices of exports from third countries rise while Sweden’s and the KIX-2 countries’ export prices remain unchanged, Sweden’s terms of trade will deteriorate, but the KIX-2 countries’ terms of trade will probably deteriorate even more, so that the expected effect on the Swedish real exchange rate relative to KIX-2 is an appreciation. To capture this type of effect, we follow Nilsson (2004) and use the ratio between the terms of trade for the KIX-2 countries and Sweden’s terms of trade.

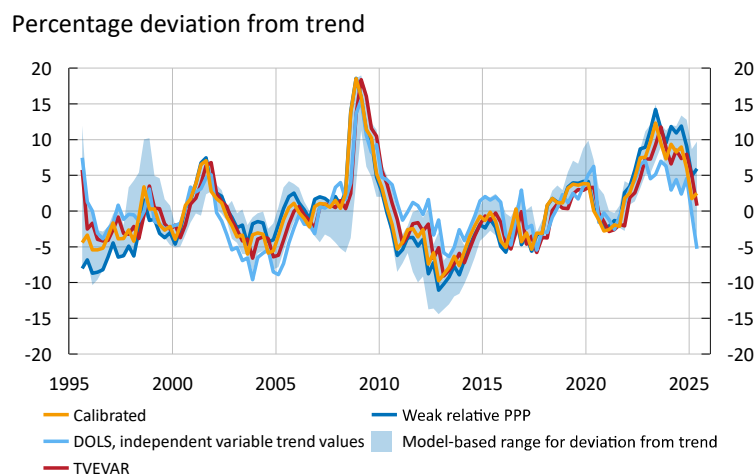
In line with other studies, we have expressed public consumption as a percentage of GDP. For the net international investment position, we have used the IMF’s measure Net International Investment Position, which includes not only financial assets and

liabilities but also foreign direct investment and real estate. This variable is notoriously difficult to measure, and several authors have tried to construct their own measures from available statistics. In addition to the official statistics underlying the series in figure 5, we have examined the impact of a couple of alternative measures, including the cumulation of current account balances. Most of the alternatives produce something similar to what is shown in figure 5, i.e. a large decline in the ratio between other countries' and Sweden's net international investment position throughout the period, mainly driven by a sharp increase in Sweden's net international investment position.

For the TVEVAR model, which also contains a short-run relationship, we have also used the policy rate differential, the difference in the current account balance as a percentage of GDP and an uncertainty index; see Figure 9. We have explored several alternatives to these measures, including differences in risk-free rates at longer maturities. Several uncertainty indices have also been discussed, among them VIX and various variants of the news-based EPU (Economic Policy Uncertainty) index. Our final choice, a macro-uncertainty index created by Jurado et al. (2015), shows more persistent episodes of uncertainty and explains more of the variation in the exchange rate gap than the other uncertainty measures.

APPENDIX C – Estimated trend deviations, using different measures and methods

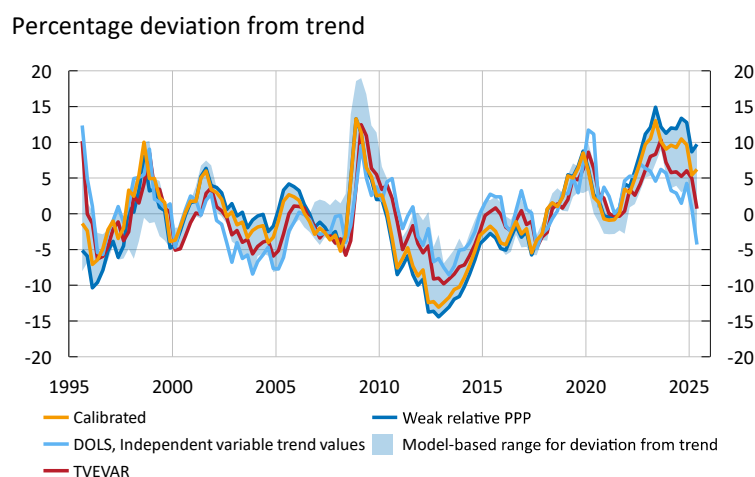
Figure C1. Deviation of the real exchange rate from trend calculated using direct price level comparisons



Note: Deviation from trend is defined as the deviation of the actual real exchange rate, as measured by each measure, from its estimated or calculated trend.

Sources: Eurostat, OECD, Statistics Sweden and own calculations.

Figure C2. Deviation of the real exchange rate from trend calculated using unit labour costs



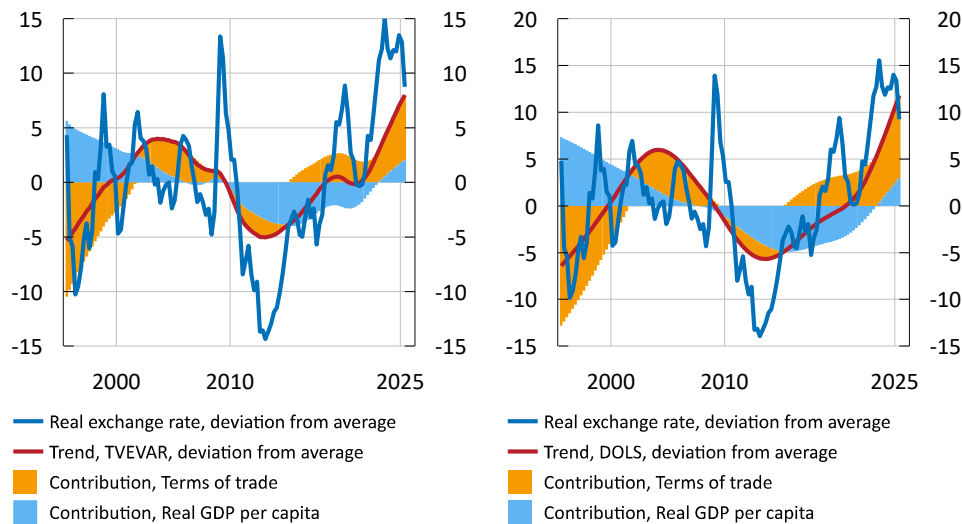
Note: Deviation from trend is defined as the deviation of the actual real exchange rate, as measured by each measure, from its estimated or calculated trend.

Sources: Eurostat, OECD, Statistics Sweden and own calculations.

APPENDIX D – Explanations of the real exchange rate trend

Figure D1. The deviation of the real exchange rate from its historical average and decompositions of the deviation of trend estimates from the historical average

Per cent and percentage points



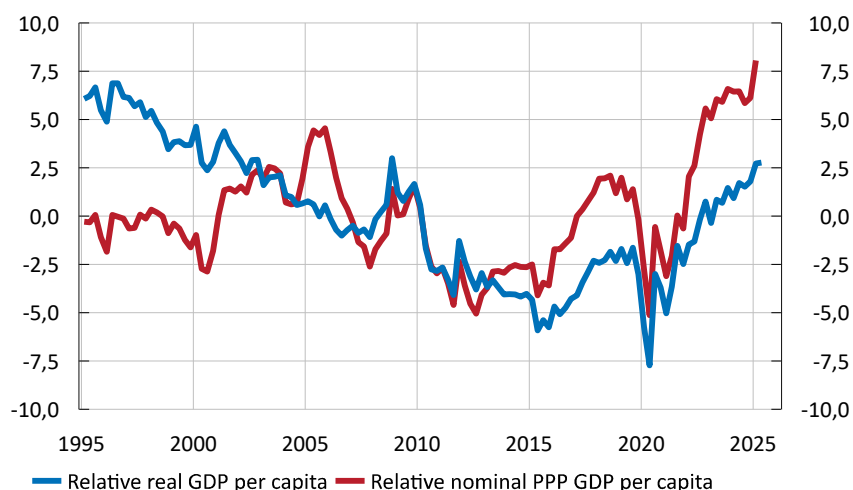
Note: The real exchange rate is calculated using unit labour costs. In the left-hand panel, parameter estimates from TVEVAR are used. In the right-hand panel, in addition to the parameter estimates from DOLS, the HP trend of the independent variables is used in the trend and trend contribution calculations.

Sources: Eurostat, OECD, Statistics Sweden, US Bureau of Labor Statistics, the Riksbank and own calculations.

APPENDIX E – The consequence of using an alternative measure of the development of relative GDP per capita

Figure E1. Relative GDP per capita according to various measures

Percentage deviations from the average for the period

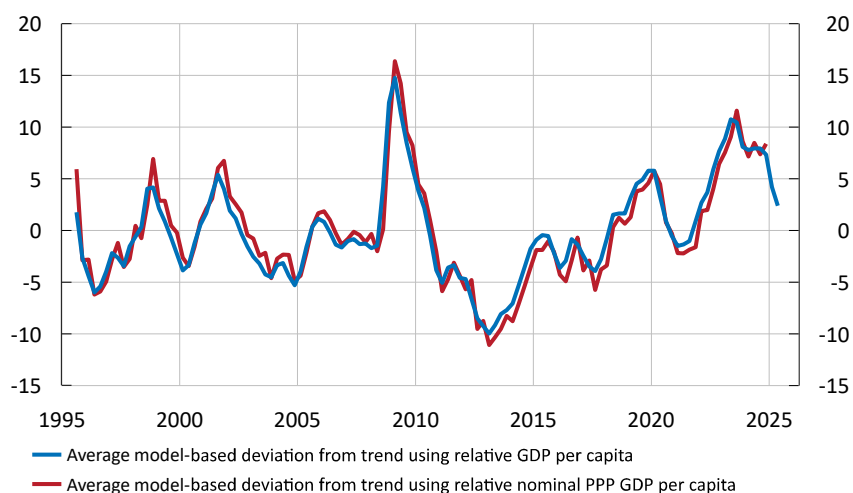


Note: In a first step, the ratio between GDP per capita abroad and GDP per capita in Sweden is calculated. In a second step, the derived ratios have been related to their respective averages for the period 1995–2024, in the form of percentage deviations.

Sources: Eurostat, OECD, Statistics Sweden, US Bureau of Economic Analysis, World Bank, the Riks-bank and own calculations.

Figure E2. Average model-based trend deviation according to different measures of relative GDP per capita

Percentage deviation from the trend



APPENDIX F – The correlation between the average model-based trend deviation and short-term explanatory factors

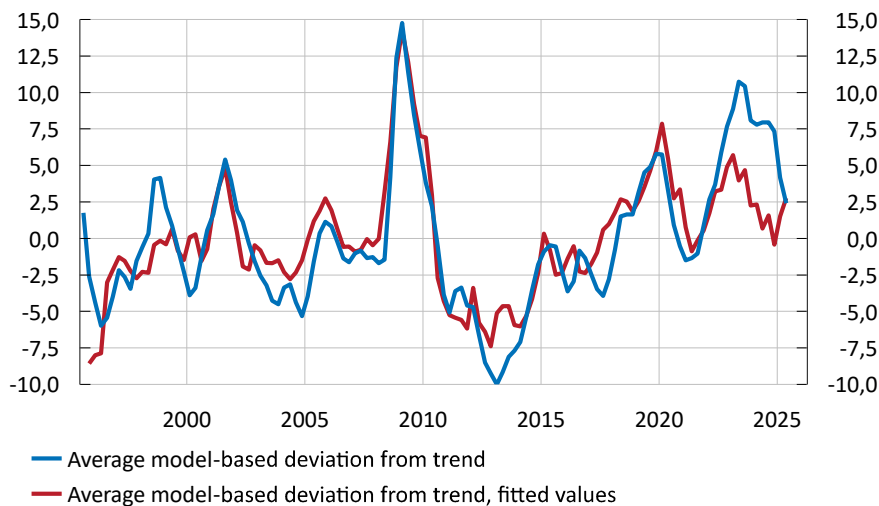
Table F1. The estimated relationship between the average model-based trend deviation and short-term explanatory factors

Dependent variable	Independent variables	Coefficient	P-value
Real exchange rate, average model-based trend deviation	Relative GDP per capita, deviation from trend	0,886	0,002
	Relative GDP per capita, deviation from trend (-1)	1,305	0,000
	Terms of trade, deviation from trend	1,047	0,000
	Uncertainty index	3,146	0,000
	Policy rate differential (-1)	1,791	0,000

Anm. $R^2 = 0,71$. The independent variables consist of the short-term explanatory factors we identified in the memo, which are also used in the estimations with the TVEVAR model. The parameters are estimated for the period Q4 1995–Q2 2025. The balance of payments was not found to be significant and has therefore not been included.

Figure F1. Actual and explained model-based trend deviation

Percentage deviation from the trend





SVERIGES RIKSBANK

Tel +46 8 - 787 00 00

registratorn@riksbank.se

www.riksbank.se

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