The impact of alternative indicators of price competitiveness on real exports of goods and services

Traditionally, a country's price competitiveness plays a key role in its export performance. This raises the question – not least in terms of an adequate assessment of the economic situation and cyclical growth – as to which indicators are particularly appropriate in modelling price competitiveness. There does exist a broad consensus that real exchange rates are a comparatively good reflection of the relative price or cost position of a given economy and are therefore suited as indicators of price competitiveness. What is mainly under discussion, however, is which price or cost index should be used to calculate it so that the indicator has a particularly close relationship to real exports.

All of the conventional indicators of price competitiveness have their own specific advantages and drawbacks. However, from a conceptual perspective, there is some evidence to suggest that indicators based on broadly defined price and cost indices may be capable of modelling price competitiveness more appropriately than more narrowly defined indices, since the latter capture price and cost developments only in some subsectors of the domestic economy. For example, indicators based on unit labour costs in manufacturing, which were once in widespread use, cover only one part of relative cost developments. This is not necessarily representative of overall cost developments in the German economy and can therefore easily lead to distortions and misinterpretations. Price and cost indices that focus on macroeconomic variables avoid this disadvantage.

This article presents the latest panel analysis examining the suitability of alternative indicators of price competitiveness as determinants of real exports of goods and services. It was found that a change in price competitiveness generally exerts a statistically and economically significant long-term influence on exports. However, it also came to light that there is often no long-term relationship between indicators based on consumer price indices and real exports. Furthermore, the forecast quality of producer and consumer price-based indicators of long-term export performance proved to be relatively weak. By contrast, more favourable results according to various criteria were obtained for indicators based on deflators of total sales, on GDP deflators or on unit labour costs for the total economy. This supports the above conjecture that indicators based on broadly defined aggregates for modelling price competitiveness are preferable for explaining real exports of goods and services.

Introduction

Position on export markets dependent on price competitiveness, …

An economy's international price competitiveness is one of the key determinants of its success in exports. Not least in order to be better able to assess a country's economic situation and cyclical growth, there arises the question as to the determinants of real exports and thus of suitable indicators of price competitiveness. As a measure of price competitiveness, various concepts of the real exchange rate are available. These chiefly differ with respect to the price or cost index used as a basis for calculating them. This article studies empirically whether one of these concepts is superior to its competing measured variables and should therefore be used as an indicator of price competitiveness in preference to others.[1]

… which can be captured using various concepts of real exchange rates

A systematic analysis of the quality of various indicators of the price competitiveness of the German economy may be found in the November 1998 *Monthly Report* of the Deutsche Bundesbank.[2] This analysis determined what impact the conventional indicators of Germany's price competitiveness and the volume of world trade had on real exports. This relationship was estimated for various competing measurement concepts based on unit labour costs in manufacturing, deflators of total sales, consumer price indices, producer price indices for industrial goods, and the terms of trade. The study came to the conclusion that real exchange rates based on unit labour costs in manufacturing can easily lead to biased results and that competing concepts based on broadly defined macroeconomic price and cost indices – such as deflators of total sales – are more appropriate for modelling the price competitiveness of the German economy. Unit labour costs in Germany's manufacturing sector, in particular – in contrast to other sectors – represent only a relatively small part of overall costs; in terms of their importance, costs of intermediate goods from other sectors as well as costs of energy and raw materials play a greater role. Additionally, Germany's manufacturing sector saw a sharper rise in unit labour costs than the other sectors during the observation period; as a result, there was a disproportionately large deterioration in the relevant indicator of price competitiveness. The debate on the suitability of alternative indicators of price competitiveness for explaining export performance is being revived in this report now that almost two decades have passed – a period characterised not only by marked trends towards globalisation but also by the establishment of European monetary union and the global economic and financial crisis.

Quality of indicators examined from variety of angles

The issue of indicator quality is examined first below in the context of general considerations and then studied with the aid of a panel analysis. In the light of the aforementioned conceptual weaknesses of the relatively narrowly defined indicator based on unit labour costs in manufacturing, this indicator is not included in the analysis; instead, the more broadly defined concept based on unit labour costs for the total economy is used. The study also covers indicators of price competitiveness based on deflators of total sales, GDP deflators, consumer price indices, producer price indices and export deflators.

Alternative indicators of price competitiveness: fundamental considerations and developments in Germany

Requirements for indicators of price competitiveness …

Real exchange rates are measures of developments in the relative price or cost position of a country's economy and are therefore typically used as indicators of price competitiveness. Ideally, these measurement variables should draw on internationally comparable statistical

1 Other particular aspects of competitiveness were analysed in greater detail recently by the ESCB's Competitiveness Research Network (CompNet).
2 See Deutsche Bundesbank, The indicator quality of different definitions of the real external value of the Deutsche Mark, Monthly Report, November 1998, pp 39-52.

data, be calculated for all countries using the same method, capture all internationally tradeable goods as well as the factors required for their production, comprehensively represent the price and cost situation and be available in near time.

… are taken into account in ECB and Bundesbank calculations

The ECB has been calculating and publishing harmonised competitiveness indicators (HCIs) for euro-area countries since 2006. These meet the specified requirements in many ways. The published HCIs are real, effective exchange rates – that is to say, exchange rates calculated against a weighted average of major trading partners' currencies based on consumer price indices, GDP deflators or unit labour costs for the total economy. To calculate them, the ECB uses the methods and data that are also used to calculate the effective exchange rates of the euro. In much the same way, the Bundesbank calculates competitiveness indicators for euro-area and non-euro-area countries based on different less or more broadly defined (and, in some cases, additional) deflators – such as deflators of total sales. The following considerations show that the cited requirements cannot all be implemented simultaneously at present and are therefore not fully satisfied by any of the conventional indicators. The issue of indicator quality will therefore be examined empirically below.[3]

Export deflators capture products that are already successful internationally

The sales prospects of internationally active enterprises on the world markets are directly affected by the export prices of these enterprises in relation to the world market prices of competing enterprises as expressed in the same currency. However, the concept of an indicator calculated using export deflators is suitable for determining the price competitiveness of a given economy only if a change in the relative cost position or exchange rate adjustments are actually passed on in terms of export prices and not absorbed by a corresponding adjustment of profit margins. Focusing on the prices of goods that are actually traded and thus already successful in an internationally competitive environment excludes, *a priori*, sectors of the domestic economy in which tradeable but internationally non-competitive goods are produced that are only partly exposed to international competitive pressure owing, say, to a "home bias" towards domestic goods or to trade restrictions.

Producer price indices take into account net prices of all industrial goods

The use of producer price indices takes into account some of the drawbacks listed above. For instance, producer prices capture not only those export goods that are actually traded internationally but also the net prices of all goods produced in the domestic industrial sector, thus covering a wide variety of tradeable goods. Producer prices relate solely to industrial products, however. Significant areas of global trade – such as the entire services sector, for example – are left out.

GDP deflators focus on overall domestic value added

An economy's competitiveness is likely to be captured better by focusing on domestic total value added rather than solely on industrial goods. The indicator based on GDP deflators models the price component of total value added, thus also capturing the domestic services sector, which has played an increasingly significant role in the price competitiveness of the overall economy in recent years. The concept of global value chains, which focuses on the increasing vertical specialisation in foreign trade, suggests the use of GDP deflators in calculating indicators of price competitiveness so as to be able to capture price developments in intermediate goods that are in international competition.[4]

Deflators of total sales also capture import prices

The indicator based on deflators of total sales takes into account not only domestic value added but also the prices of imported goods and services, which, in the case of imported

3 For information on the advantages and drawbacks of the various concepts for measuring the real exchange rate, see Deutsche Bundesbank (1998), op cit, and M Ca'Zorzi and B Schnatz (2010), Explaining and forecasting euro area exports: which competitiveness indicator performs best?, in P de Grauwe (ed), Dimensions of Competitiveness, MIT Press, pp 121-147.

4 See R Bems and R C Johnson, 2012, Value-added exchange rates, NBER Working Paper No 18498.

intermediate goods, represent a cost component of domestic output. This indicator thus focuses on an even broader price and cost base than the indicator based on GDP deflators. Not least in view of the major importance of intermediate goods imports for Germany's value added, the indicator based on deflators of total sales is frequently employed in analyses of the German economy's price competitiveness.

Unit labour costs only ever capture one part of production costs

By contrast, the indicator based on unit labour costs for the total economy captures only one part of the costs incurred in the production process. Changes in price competitiveness not due to domestic labour costs, but rather to developments in other cost components, are disregarded. In addition, substituting production factors has an impact on unit labour costs, but not necessarily on the competitiveness of an economy. Despite these objections, a cost-based indicator also has advantages over price-based measurement concepts. For example, price-based indicators do not show a short-term deterioration in the relative cost position if it is being absorbed by enterprises by way of a correspondingly lower profit margin (pricing-to-market behaviour). Furthermore, price-based indicators can also be distorted by changes in indirect taxes, such as value added tax, if the tax is reimbursed when domestic goods are exported and hence no price effect is felt on the export markets.

Consumer price indices are available in near time, but capital goods are not captured

Most of the aforementioned indicators have the disadvantage that, for many countries, the underlying data required for their calculation become available only with a time lag and are sometimes subject to marked revision. By contrast, the indicator based on consumer price indices is available for many countries in near time. Nevertheless, price developments in capital goods and thus a major part of foreign trade are, by definition, not included in the consumer prices. Aside from this, what is not captured are the prices of intermediate goods, which represent a major cost component of production, whereas non-tradeable consumer goods, which are not in competition with comparable goods from foreign providers and may thus distort the indicator, have a large weight in the underlying baskets of goods. Lastly, the potential bias due to changes in indirect taxes mentioned in the previous paragraph is particularly high in the case of consumer price-based indicators.

From a conceptual perspective, broadly defined indicators tend to be superior

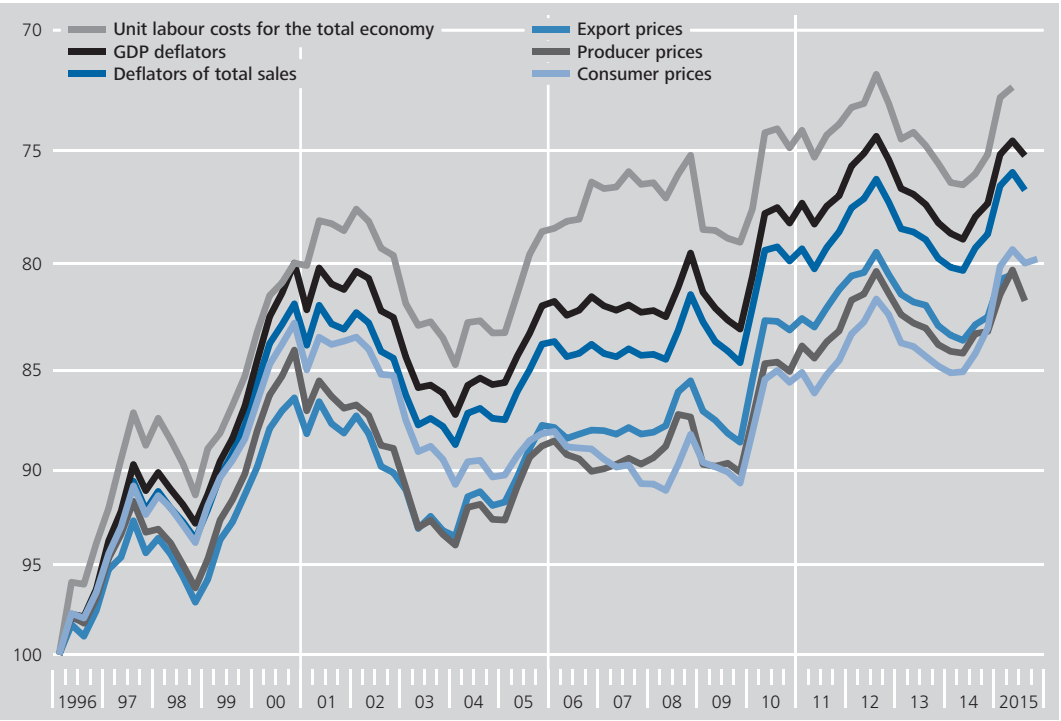
All in all, every indicator of price competitiveness has advantages and drawbacks. However, from a conceptual perspective, there is some evidence to suggest that broadly defined indicators may be capable of modelling price competitiveness more appropriately than narrowly defined indices, which capture price and cost developments only in some subsectors of the domestic economy. Ultimately, there is no single clear-cut answer as to which indicator should be used to assess price competitiveness; instead, this depends on how much importance is attached to the drawbacks cited above under the specific circumstances.

Indicators show a similar pattern for Germany

Looking at the performance of indicators of price competitiveness in Germany compared with 37 trading partners reveals that the cited indicators all display quite a similar pattern. A particularly strong co-movement can be observed in each case between indicators based on export deflators and producer price indices and those based on GDP deflators and deflators of total sales. For example, all of the indicators show that the price competitiveness of the German economy has improved substantially since the mid-1990s as unit labour costs have been relatively favourable in Germany compared with its trading partners. The cumulative improvement in competitiveness when using the unit labour cost-based indicator is therefore particularly pronounced (around 28% from the first quarter of 1996 to the second quarter of 2015); by contrast, it is discernibly weaker according to narrowly defined indicators based on consumer prices indices, export

Price competitiveness of the German economy vis-à-vis 37 trading partners based on various deflators

1996 Q1 = 100, log scale[1]



1 Inverted scale: a rising curve (decline in values) indicates an increase in price competitiveness.
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deflators and producer price indices (at 21% and 20% respectively).[5]

Movements of competitiveness indicators shaped by exchange rates

Overall, the pattern displayed by movements in the indicators since the euro was introduced at the beginning of 1999 has been shaped by exchange rates against the currencies of non-euro-area trading partners, which means that, in most cases, the turning points in trend developments throughout the observation period were reached at the same time. For example, on a weighted average against 19 currencies, the euro lost around 13% of its value in each of the two years following the launch of monetary union and – along with favourable unit labour cost developments – played a part in the marked improvement in the price competitiveness of the German economy during this period. This trend improvement in price competitiveness was interrupted, however, when euro cash was successfully introduced at the start of 2002, with the euro subsequently appreciating by around 25% up to the end of 2004. The euro again came under considerable pressure with the escalation of the sovereign debt crisis in Greece, depreciating by 12% between the end of 2009 and late September 2012. At the same time, the indicators under analysis show an improvement of 10% to 11% in Germany's price competitiveness. Thereafter, the euro was buoyed by the stabilisation in the European financial markets and, by the end of 2013, had appreciated by 7%. Indicators of the price competitiveness of the German economy show competition losses of 4% to 5% over this period. Since spring 2014, euro exchange rate movements have been shaped by diverging monetary policy developments on both sides of the Atlantic. All in all, the euro has depreciated

5 M Schmitz, M de Clercq, M Fidora, B Lauro and C Pinheiro (2013), Revisiting the effective exchange rates of the euro, Journal of Economic and Social Measurement 38, pp 127-158, come to the similar conclusion that, for most euro-area countries in the period from the launch of monetary union to the end of 2011, the HCIs based on unit labour costs have changed more than those based on consumer price indices.

by around 10% since late March 2014, which has been reflected in a marked improvement in the price competitiveness of the German economy.

Alternative indicators of price competitiveness in advanced economies

Two sample panels: one with a short observation period, …

Two alternative groups of indicators serve as the basis for a panel analysis of different measures of price competitiveness. One of them takes into account Germany together with all of the other original euro-area countries, as well as Canada, Denmark, Greece, Japan, Norway, Sweden, Switzerland, the United Kingdom and the United States, ie 20 countries in total. The observation period in this case spans the period from the start of 1996 to the first quarter of 2015. For this period, indicators are available for all of the above-mentioned price and cost indices, each of which was calculated vis-à-vis a group of 37 trading partners. Such a comparatively broad group of trading partners has the advantage that it also includes China as well as central and east European countries, whose importance in international trade has increased markedly over the past two decades.

… the other with a longer observation period and a smaller number of alternative indicators

Alternatively, the object of the study is a significantly longer observation period from the start of 1975 to the first quarter of 2015. However, only indicators based on deflators of total sales, GDP deflators, consumer price indices and export deflators are available for such a long period, but indicators based on unit labour costs or producer price indices are not. Furthermore, it is only possible to examine indicators vis-à-vis 19 industrial countries, as many central and east European countries and China still had planned economies prior to the 1990s, which means that recorded prices allow no inferences to be drawn about their price competitiveness for that period. Lastly, the number of countries whose competitiveness is studied is reduced from 20 to 18 in this indicator group as the data required for later analysis do not go as far back as 1975 in the case of Greece and Ireland.

High correlation between indicators based on deflators of total sales and on GDP deflators at the cross-country level, …

For Germany, it was shown above that indicators based on various price and cost indices display a similar pattern of movement. A simple correlation analysis provides initial clues as to whether such an outcome applies generally to the other countries under consideration. In actual fact, it turns out that different indicators correlate relatively strongly with each other at the cross-country level, too. The highest average correlation is shown by the indicators based on the deflator of total sales with those based on the GDP deflator. The lowest correlation is generally between indicators based on export deflators with alternative indicators of competitiveness.

… but indicators generally not interchangeable

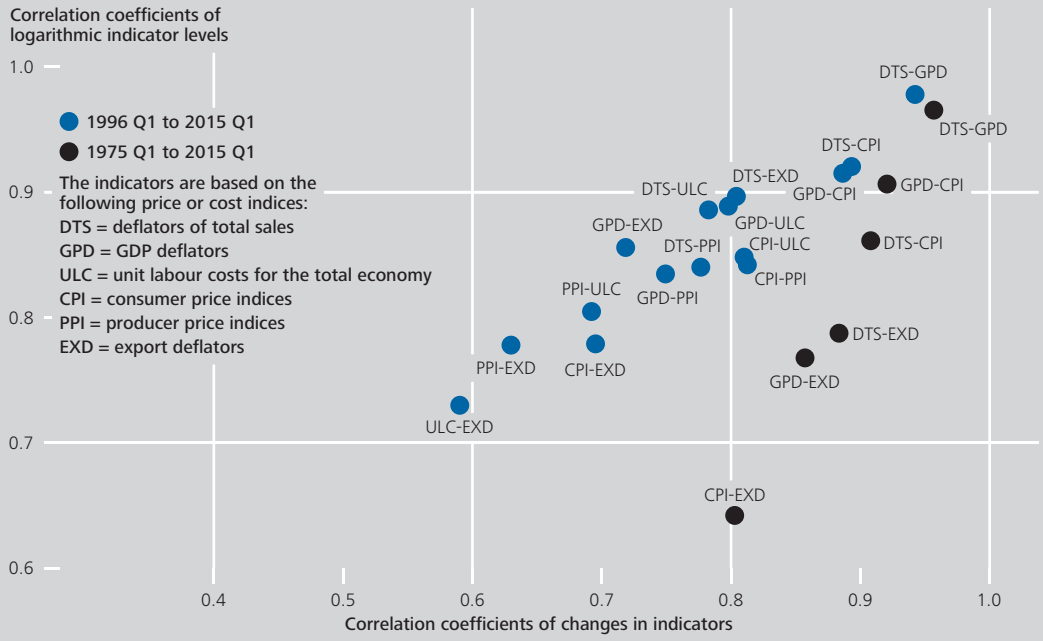
The comparatively high correlation between differently deflated indicators might point to their informative content being relatively similar with respect to price competitiveness. This would be the case, in particular, if indicator series based on differing price and cost indices were cointegrated. A panel cointegration analysis of any two given indicators does, in fact, show that indicators based on the deflator of total sales could be cointegrated at the cross-country level with indicators based on GDP deflators. There are hardly any signs of a pairwise cointegration for the other indicators, however. It may therefore be assumed that indicators are not fundamentally interchangeable in terms of their long-term impact on real exports.

The impact of price competitiveness on advanced economies' real exports of goods and services: a current analysis

Panel analysis of the impact of price competitiveness on real exports …

The question of which indicator of price competitiveness is particularly well suited to explaining the observed developments in real exports is being revived in a current empirical study. In contrast to the aforementioned earlier study in the late 1990s, the current study is not confined to Germany; instead, it includes a

Average correlation coefficients between alternative indicators of price competitiveness*



* The calculations for the observation period from 1996 Q1 to 2015 Q1 are based on indicators of price competitiveness from 20 countries. Each of these indicators was calculated vis-à-vis 37 trading partners. For the observation period from 1975 Q1 to 2015 Q1, indicators from 18 countries are analysed, each of which was calculated vis-à-vis a group of 19 trading partners. First, the correlation coefficient between two indicators was calculated for each country, with these being expressed in one case as logarithmic levels and as quarter-on-quarter rates of change in the other. The cross-country mean shown here was then formed from the correlation coefficients for a given pair of indicators.

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larger group of advanced economies in the study in order to boost the informative content of the database and make it possible to draw more broadly based conclusions. However, this also implies that it is only possible to take account of country-specific conditions to a limited extent.

Empirical studies that estimate the impact of price competitiveness on real exports generally use a measure of real external activity as an additional determinant. For instance, Goldstein and Khan's (1985) partial model of imperfect substitutes provides a theoretical foundation for such a specification.[6] An improvement in domestic price competitiveness, ie a fall in the indicator, should therefore lead to an expansion of real domestic exports – that is to say, the price elasticity of exports is assumed to be negative. Furthermore, an increase in external activity should fuel demand for exports; the income elasticity of exports is therefore assumed to be positive.

… also takes into account different measures of external activity

In line with the model, the two panels of alternative indicators of price competitiveness described above are expanded for the empirical analysis to include export and external activity time series. Real exports of goods and services are used as the variable to be explained in this study. As a measure of external activity, export estimations in the literature use either real foreign GDP or partner countries' real imports. Additionally, differing aggregation methods across partner countries are used, with either the formation of a weighted average or a simple summation of variables expressed in a com-

6 See M Goldstein and M S Khan, 1985, Income and price effects in foreign trade, in R W Jones and P B Kenen (eds), Handbook of International Economics, Vol II, Elsevier, pp 1041-1105. In this model, real export demand depends on foreign real income and a ratio of a domestic export price index to a foreign general price index expressed in a common currency. In empirical applications, this ratio is usually approximated with the aid of indicators of price competitiveness. See p 25.

mon currency.[7] This study uses five alternative measures of external activity. Below, however, this article will primarily address the results obtained in the group formed over the short period, with global trade volume as a uniform measure of external activity for all countries (baseline specification).[8]

In principle, a long-term relationship between competitiveness and real exports of goods and services is confirmed in the baseline specification …

All variables are subjected to panel unit root tests in order to determine their time series characteristics.[9] The tests all suggest that the series are integrated. A long-term relationship can therefore exist between them only if they are also cointegrated. Panel cointegration tests were used to verify this. In the baseline specification, cointegration and thus also the existence of a long-term relationship between the three model variables can actually be assumed with a high degree of probability, irrespective of the choice of price competitiveness indicator. In other specifications, evidence of the existence of a cointegration relationship is in some cases similarly strong as in the baseline specification, but in other cases also less so.

… but usually not in alternative specifications for the indicator based on consumer price indices

The cointegration tests can serve as a first key criterion for identifying which price competitiveness indicator is particularly well-suited to explaining real exports. If, for a given indicator, no cointegration relationship exists between the indicator, real exports and external activity, there is also no long-term relationship between these variables. The relevant indicator would then be unsuitable for determining exports in the long term. Looking across all specifications, what is striking in the present analysis is that the tests for indicators based on consumer price indices suggest a cointegration relationship in only very few cases. In the group formed over the long time period from 1975, irrespective of the external activity variable, we are in fact generally unable to confirm a long-term relationship between the variables for indicators based on consumer price indices.[10] According to this first criterion, all indicators, apart from those based on consumer prices, can therefore reasonably be used as determinants of real exports.

The plausibility of the estimation results is a second criterion for the suitability of an indicator to be incorporated into an estimation equation of real exports. The long-term price elasticity of exports estimated in the baseline specification is -0.37 on an average of the indicators.[11] This implies that a 10% deterioration in price competitiveness reduces real exports by 3.7% in the long term. Such a value appears quite plausible and corresponds broadly to the findings of other studies on this elasticity.[12]

10% deterioration in price competitiveness reduces real exports by 3.7% on average in the long term

7 By way of example, GDP is used by IMF (2015), Exchange rates and trade flows: disconnected?, World Economic Outlook October 2015, pp 105-142, whereas imports are used by S Christodoulopoulou and O Tkačevs (2015), Measuring the effectiveness of cost and price competitiveness in external rebalancing of euro area countries: what do alternative HCIs tell us?, Empirica, DOI 10.1007/s10663-015-9303-5, Deutsche Bundesbank (1998), op cit, or C Grimme and C Thürwächter (2015), Der Einfluss des Wechselkurses auf den deutschen Export – Simulationen mit Fehlerkorrekturmodellen, ifo Schnelldienst 20/2015, pp 35-38. The relevant values are summed up in Deutsche Bundesbank (1998), op cit, and Grimme and Thürwächter (2015), op cit. By contrast, a weighted average is used by Christodoulopoulou and Tkačevs (2015), op cit, and IWF (2015), op cit.

8 The baseline specification was selected on the basis of various criteria. In the empirical analysis, the volume of global trade proved to be particularly well suited in this respect insofar as, with this variable of external activity, the forecast quality was consistently the best and the evidence for a cointegration relationship was especially high. For alternative specifications, see also pp 25-29.

9 Technical details on the chosen procedure and the results of this analysis and the analyses mentioned below are described on pp 25-29.

10 For all other indicators, in contrast, a majority of the tests indicates cointegration if the group of indicators observed over the long time period is considered. This is also consistent with the results of the integration tests, in which, in this group, there was the least evidence for the integration of indicators based on consumer price indices. However, if these indicators are actually stationary, ie not integrated, they cannot be cointegrated with other variables. Even in the baseline specification, there is the least evidence of cointegration when using indicators based on consumer price indices. Indicators based on consumer price indices also perform especially unfavourably in the estimations of T Bayoumi, R Harmsen and J Turunen (2011), Euro area export performance and competitiveness, IMF Working Paper II/140.

11 However, this applies only to a panel least square estimate with fixed country effects. Alternative estimation methods yield somewhat higher price elasticities of up to -0.56 in the baseline specification. See p 27.

12 An estimated value for the price elasticity of exports of -0.37 is more or less identical with the average value calculated by Ca'Zorzi and B Schnatz (2010), op cit, somewhat higher than the value stated by the IMF (2015), op cit, and somewhat lower than the average value of Bayoumi et al (2011), op cit.

All indicators deliver plausible estimates of the price elasticity of exports

The price elasticities of exports estimated in the present analysis range from -0.31, when employing indicators based on consumer or producer prices,[13] to -0.43 if using indicators based on deflators of total sales. The range between these values is relatively small. In no case do these results give cause for concluding that one of the indicators is unsuitable for determining real exports. This applies throughout even given alternative specifications. The second criterion "plausibility of the estimated price elasticity" therefore does not make any contribution to discriminating between the indicators.[14]

Level of income elasticity of exports dependent on the measure of external activity

The income elasticity estimated in the baseline specification is exceptionally stable at around 0.8. The choice of price competitiveness indicator has virtually no influence on this estimated value. It shows that, given a 10% increase in the global trade volume, the real exports of the economies under study increase by 8% on average in the long term. The fact that these results show real exports increasing, even in the long term, by a significantly smaller percentage than the volume of global trade is explained by the selected country composition of the group under study. In the observation period of the baseline specification from 1996 to 2015, the percentage of emerging economies and transition countries in the volume of global trade showed a marked increase. The identified income elasticity reflects the fact that these countries are not included in the group of 20 advanced economies analysed here. Switching instead to the alternative, longer observation period from 1975 to 2015 and using trade-based foreign activity variables which, in this case, do not necessarily take into account the emerging market economies, results in income elasticities which show real foreign imports and the real exports from the analysed countries (approximately) growing in proportion with each other over the long term. If, finally, production-based variables are inserted for external activity, considerably higher income elasticities generally result because real exports have increased disproportionately to output over the past few decades.[15]

Estimated long-term export elasticities in 20 advanced economies (baseline specification)*

Indicator of price competitiveness based on …	Price elasticity	Income elasticity
… deflators of total sales	– 0.43***	0.81***
… GDP deflators	– 0.39***	0.81***
… consumer price indices	– 0.31***	0.80***
… unit labour costs for the total economy	– 0.40***	0.81***
… producer price indices	– 0.31***	0.82***
… export deflators	– 0.38***	0.83***

***** Indicators calculated vis-à-vis 37 trading partners; estimation period: 1996 Q1 to 2015 Q1; estimation method: panel least squares estimation with fixed country effects. ******* Significant at the 1% level; robust standard errors according to J C Driscoll and A C Kraay (1998), Consistent covariance matrix estimation with spatially dependent panel data, Review of Economics 80, pp 549-560.
Deutsche Bundesbank

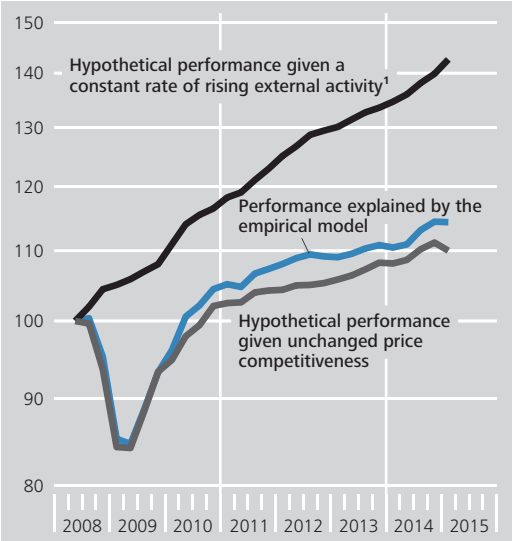
Relevant direction of causality from competitiveness to real exports

A further indication of the suitability of an indicator would be the accuracy of the customary assumption that exports adjust to deviations from the estimated long-term relationship and not, say, competitiveness or external activity, ie that the observed direction of causality is con-

13 Owing to the described weak evidence for cointegration when using an indicator based on consumer price indices, the corresponding coefficients are to be interpreted with particular caution.
14 As a further criterion for assessing the indicators, their respective contribution to explaining real exports is often used. Analyses relating to just one country often initially compare just the relevant adjusted determination coefficients. However, they then usually also employ methods in which at least two indicators are included simultaneously in the export estimation and, consequently, statistically insignificant indicators are eliminated from the equation. See for example, Ca'Zorzi and Schnatz (2010), op cit, Deutsche Bundesbank (1998) op cit, or C Giordano and F Zollino (2015), Exploring price and non-price determinants of trade flows in the largest euro-area countries, ECB Working Paper 1789. With the available data set, however, such a strategy does not lead to a systematic discrimination of individual indicators according to some model calculations.
15 For movements in this ratio over time, see Deutsche Bundesbank, The decline in the elasticity of global trade to global economic activity, Monthly Report, January 2015, pp 27-29.

Hypothetical performance of Germany's real exports of goods and services since 2008 Q2*

2008 Q2 = 100, log scale



* Calculation based on a panel least squares estimation with fixed country effects for real exports of goods and services, with the indicator of price competitiveness based on the deflators of total sales vis-à-vis 37 countries and the volume of global trade as explanatory variables. Growth rates calculated as the differences between logarithmic values. **1** Trend growth in global trade calculated over the period from 1996 Q1 to 2008 Q2.

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sistent with the theoretical considerations.[16] Using the baseline specification to verify this third criterion does, in actual fact, show that it is indeed real exports which undergo an adjustment to the long-term relationship of the variables, irrespective of the indicator of price competitiveness indicators that is used. Specifically, deviations from the estimated long-term relationship, which may occur due to changes in competitiveness for example, are reduced on average by 7% to 15% per quarter. The analysis does also point to adjustment tendencies of other variables, but their statistical and economic significance is far smaller than those determined for the adjustment of exports. In summary, it has to be noted that the third criterion, too, is fulfilled to much the same degree by the various indicators. It therefore does not provide any additional clues as to the relative superiority of one of the indicators.

As a fourth criterion for assessing the various indicators of price competitiveness it is possible to use the precision with which, with the aid of the relevant indicators, real exports can be forecast over the long term.[17] Such a check of forecast quality reveals, first, that the forecasting error, irrespective of the indicator employed, is smallest if the global trade volume approximates external activity, as in the baseline specification.[18] The forecasting errors that occur when using alternative indicators show comparatively minor deviations from each other. It can, at all events, be stated that the forecast errors in models of the baseline specification using indicators based on consumer price indices and, in particular, on producer price indices are, on average, more than 5% higher than in the model with the smallest forecasting errors. Applying the fourth criterion, it can therefore be said that these two indicators are probably somewhat less suitable for using in an export equation than the others.

Indicators based on producer and consumer price indices have somewhat poorer forecast properties

The economic significance of price competitiveness and foreign activity for real export performance

In order to gain an impression of the economic significance of price competitiveness and of external activity for real exports, it may be useful to compare the estimation results for real exports of individual countries with the following two hypothetical scenarios. In the first scenario it is assumed that price competitiveness has remained unchanged at its level before the escalation of the global financial and economic crisis in autumn 2008; in the second scenario it is assumed that external activity has continued to

Estimates suggest that changes in price competitiveness have influenced the volume of German exports noticeably since beginning of crisis

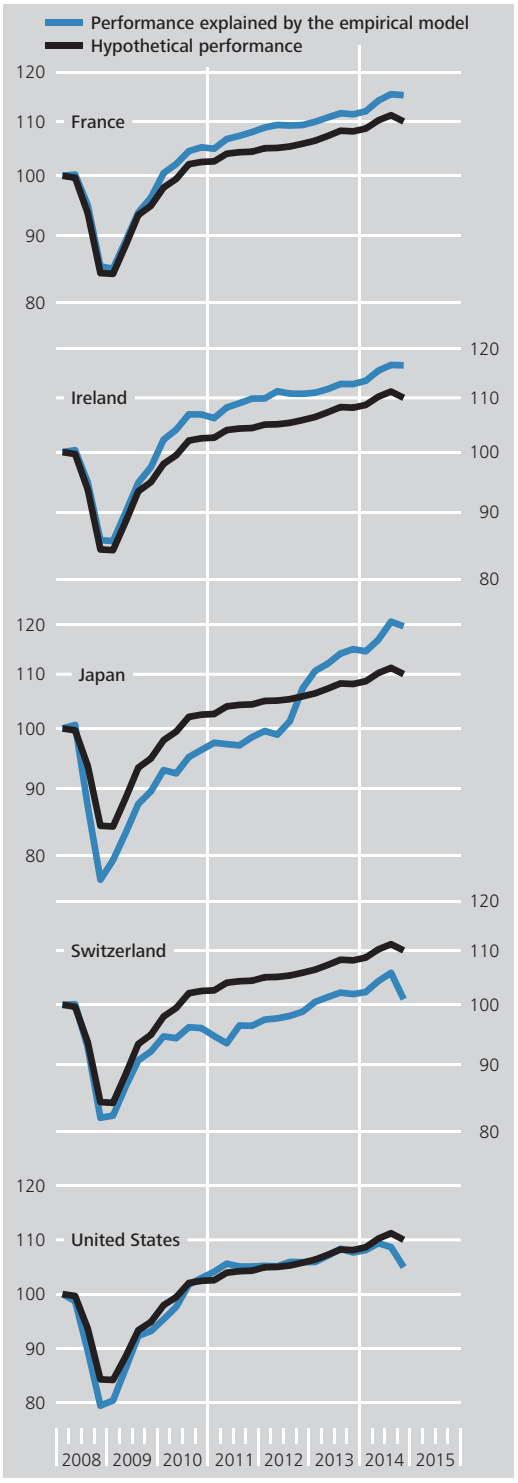
16 If this assumption were not accurate, another estimation method would have had to be used.
17 The strategy of using forecasting quality as a criterion for assessing price competitiveness indicators goes back, first and foremost, to Ca'Zorzi and Schnatz (2010), op cit.
18 The methodology of the analysis is presented on page 29.

follow the trend of the preceding years.[19] The first thought experiment shows that the slump in Germany's real exports of goods and services, which occurred during the crisis, took place independently of developments in Germany's price competitiveness. In fact, a sustained improvement in price competitiveness in Germany did not set in until the end of 2009 when the euro began to depreciate distinctly on average against major trading partners in the wake of the sovereign debt crisis unfolding in some euro-area countries. The calculations reveal that this resulted in a growth rate for Germany's real exports of goods and services which, during the period from the second quarter of 2008 to the third quarter of 2012, was 4 percentage points higher in the long term than in a scenario with unchanged competitiveness, in which net export growth of 5% was, in any case, already shown in spite of the initial decline in exports. Following the increases in competitiveness associated with the further depreciation of the euro since the second quarter of 2014, export growth for the whole period from the second quarter of 2008 to the first quarter of 2015 is shown as 4 percentage points higher in the long term on balance than in the case of unchanged competitiveness.[20]

The second thought experiment, quite unsurprisingly, makes clear that the decline in Germany's exports during the financial and economic crisis was essentially due to the downturn in external activity. The model suggests that the slump in real foreign demand between the second quarter of 2008 and the second quarter of 2009, on account of the crisis, led to a long-term 17% decline in Germany's real ex-

Hypothetical performance of real exports of goods and services of selected countries assuming unchanged price competitiveness since 2008 Q2*

2008 Q2 = 100, log scale



* Calculation based on a panel least squares estimation with fixed country effects for real exports of goods and services, with the indicator of price competitiveness based on the deflator of total sales vis-à-vis 37 countries and the volume of global trade as explanatory variables. Growth rates calculated as the differences between logarithmic values.

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19 In actual fact, a pronounced weakness in world trade could be observed. See Deutsche Bundesbank, The empirical relationship between world trade and global economic output, Monthly Report, November 2013, pp 13-17 and footnote 15. The hypothetical scenario calculations are based solely on the presented long-term equation. Short-term dynamics, as may be determined, say, in an error correction model are not considered here. Please see page 28 for more details on the methodology.

20 By way of comparison, export growth was actually 16% in the given time period.

ports of goods and services, while exports in the hypothetical scenario of a trend increase in external activity would have risen. Since then, export activity has also not recovered sufficiently to offset the losses which occurred at that time. Given continued trend growth in external activity, the long-term growth in real exports of goods and services estimated since the second quarter of 2008 would still have been 26 percentage points higher in the first quarter of 2015 than the actual growth.

Impact of changes in price competitiveness on exports of euro-area countries since 2008 often smaller than in other countries

The two thought experiments may also be applied to other countries. The second scenario yields results similar to those for Germany. The first hypothetical scenario reveals that the importance of price competitiveness for real exports is smaller in most euro-area countries than it is in countries outside the euro area. This is due to the fact that these countries show a relatively small variation in their competiveness indicators, since they typically conduct a major part of their trade with other euro-area countries, for which nominal exchange rate fluctuations are not possible.

Strong effects in Ireland, Japan and Switzerland

Significantly, the first scenario shows for Ireland, in particular, where the share of trade with other euro-area countries is especially small, that price competitiveness has a relatively large long-term influence on its exports. In some instances, the effects are even more pronounced in countries that do not belong to the euro area. The calculations show, for example, that the deterioration in Japanese competitiveness caused by the appreciation of the yen between 2008 and 2011, taken in isolation, reduced growth in real Japanese exports of goods and services by up to 8 percentage points in the long run vis-à-vis a scenario of unchanged competitiveness. The simulations show that, taken in isolation, the strong depreciation of the yen since 2013, which was mainly related to the Bank of Japan's non-standard measures to provide monetary policy easing, lead in the long term to a strong recovery in exports. As a result, export growth from the second quarter of 2008 up to the first quarter of 2015 is 10 percentage points higher than in the scenario where competitiveness is constant. Calculations performed for Switzerland also suggest that strong changes in price competitiveness can exert a marked influence on real exports of goods and services. According to the model, long-term export growth would have been 9 percentage points higher in the period from the second quarter of 2008 to the first quarter of 2015 if Switzerland's price competitiveness had not deteriorated since the crisis.

Conclusion

Traditionally, a country's price competitiveness is expected to play a key role in its export performance. Our article explores the question as to which of the various indicators of price competitiveness is particularly suited as a determinant of real exports of goods and services. It was found for a panel of countries that a change in price competitiveness generally exerts a statistically and economically significant long-term influence on exports. However, it also came to light that there is often no long-term relationship between indicators based on consumer price indices and real exports. Furthermore, the forecast quality of producer and consumer price-based indicators of long-term export performance proved to be relatively unfavourable. These results suggest that indicators based on broadly defined aggregates, such as the deflator of total sales, the GDP deflator or unit labour costs in the total economy are preferable.

Annex

Estimation of export equations: methodological background and results

This annex provides a more detailed explanation of the methodological approach used to estimate and interpret the export equations referred to in the preceding article. Moreover, it presents additional results arising from the empirical analysis. That said, owing to the wide array of models examined, it is only possible to focus on a limited number of estimation results here, too.

Before turning to the econometric approach applied, let us first take a look at the theoretical framework that was used to estimate the export equations. Here, use was made of the partial model developed by Goldstein and Khan (1985),[21] to which reference is made in the main text.

Theoretical background, estimation equation and database

Goldstein and Khan (1985) specify the function of real export demand X contingent on three nominal variables: the domestic export price index P_x, the foreign price index expressed in domestic currency P^*/S, and nominal foreign income expressed in domestic currency Y'^*/S. Assuming this original function is homogeneous of degree zero,[22] real export demand can also be written as being determined by function g as

$$X = g\left(\frac{P_x}{P^*/S}, \frac{Y'^*}{P^*}\right), \tag{1}$$

where S denotes the nominal exchange rate in units of the foreign currency for each unit of domestic currency (indirect quotation). From the above, it is possible to derive the following export equation to be estimated

$$x_{it} = \beta_{0i} + \beta_1 r_{it} + \beta_2 y_{it} + \epsilon_{it}, \tag{2}$$

where x_{it} is the log of real exports of country i at time t, r_{it} is the log of the real exchange rate and y_{it} is likewise the log of the variable measuring real external activity. Equation (2) is formulated here with a country-specific fixed effect β_{0i} and a country-specific residual ε_{it}. According to the theory, if an increase in r_i corresponds to an appreciation in real terms in country i, the price elasticity of exports should be negative and the income elasticity of exports positive – in other words, $\beta_1 < 0$ and $\beta_2 > 0$.

In the empirical analysis, real exports of goods and services (EXP) are used as the variable to be explained. Real external activity y is approximated using five different variables. These are the aggregate or weighted average real GDP – in terms of relative purchasing power parities – of trading partners (hereinafter AGDP and WGDP respectively), the aggregate or weighted average of real imports of goods and services by trading partners (hereinafter AIMP and WIMP respectively) or volume of global trade (GT).[23] The real exchange rate r is expressed multilaterally using the six different indicators of international price competitiveness described in the main text, these indicators being calculated on the basis of the following price or cost indices: deflators of total sales (DTS), GDP deflators (GPD), unit labour costs for the total economy (ULC), consumer price indices (CPI), producer price indices (PPI) and export deflators (EXD). Generally, the same trading partners serve as the basis for calculating the external activity variable as those used in connection with the various indicators of price competitiveness. In the case of weighted variables, the weights are also consistent. Below, variable names shown in lower case denote the logs of the variables. In the empirical analysis of variables that are computed against the group of 37 trading partners, quarterly data from the first quarter of 1996 up to the first quarter of 2015 are used. If the variables are computed against the group of 19 trading partners, the data used go back as far as the first quarter of 1975.

21 See Goldstein and Khan (1985), op cit.
22 Typically, real export demand is modelled and estimated as a function of real variables. In order to arrive at a real specification from Goldstein and Khan's (1985) nominal specification, the three specified nominal arguments of $X = g'(P_x, P^*/S, Y'^*/S)$ can be divided by the foreign price index expressed in domestic currency, P^*/S, which results in the function g in Equation (1). However, real export demand only remains unaffected by this operation if g' is homogeneous of degree zero, ie if a proportional change in all nominal variables sees no change in the real variables (neutrality of money assumption).
23 In the case of the weighted variables, the same weights are applied as those used to calculate the indicators of international price competitiveness.

Westerlund panel cointegration tests*

Variables			Robust (bootstrapped) *p*-values	
			Group mean t-statistic	Pooled t-statistic
exp	*dts*	*agdp*	0.02	0.04
exp	*gpd*	*agdp*	0.07	0.06
exp	*cpi*	*agdp*	0.09	0.10
exp	*exd*	*agdp*	0.02	0.03
exp	*dts*	*wgdp*	0.07	0.05
exp	*gpd*	*wgdp*	0.06	0.03
exp	*cpi*	*wgdp*	0.21	0.16
exp	*exd*	*wgdp*	0.01	0.02
exp	*dts*	*aimp*	0.02	0.03
exp	*gpd*	*aimp*	0.04	0.01
exp	*cpi*	*aimp*	0.21	0.14
exp	*exd*	*aimp*	0.00	0.00
exp	*dts*	*wimp*	0.02	0.01
exp	*gpd*	*wimp*	0.01	0.00
exp	*cpi*	*wimp*	0.09	0.08
exp	*exd*	*wimp*	0.00	0.00

* 18 advanced economies; indicators computed against 19 trading partners; 1975 Q1 to 2015 Q1.
Deutsche Bundesbank

Empirical requirements for estimating export equations

In the vast majority of studies estimating export elasticities, Equation (2) is estimated in first differences on account of the non-stationarity of the variables. However, this approach has two disadvantages. First, it primarily focuses on analysing short-term dependencies between the variables. Second, such models may be misspecified and the estimators for the other coefficients can be biased if a long-term relationship actually exists between the variables. In view of these facts, we perform a panel cointegration analysis as set out by Bayoumi et al (2011), by means of which it is first of all possible to check whether a long-term relationship exists between the relevant variables.[24] For this purpose, we make use of a test procedure developed by Westerlund (2007).[25] Put simply, this procedure examines whether deviations from the long-term equilibrium are corrected by changes in the dependent variable. The approach is thus closely related to the logic expressed in the Granger representation theorem, according to which a long-term equilibrium implies a correction mechanism in the event of deviations.[26]

The Westerlund test computes marginal significance levels (*p*-values) based on four different test statistics, each calculated in a different way. The *p*-values based on two of these variants, namely the pooled and the group mean t-statistic, are shown for all of the examined specifications over the long observation period (see adjacent table) as well as for a selection of the specifications over the short observation period (see table on page 27).

A *p*-value below 0.05 signifies that the null hypothesis of non-existence of a cointegration relationship can be rejected at a significance level of 5%. In the case of the pooled t-statistic, the test was geared to the alternative hypothesis that the adjustment coefficient is negative for all countries; in the case of the group mean t-statistic, this is supposed to apply for at least one of the countries.[27]

Over the long estimation period, the tests suggest the existence of a long-term relationship between the variables at this significance level for the vast majority of the specifications, the sole exception being specifications where, irrespective of how external activity is approximated, the CPI is used in the computation of the indicator of competitiveness.[28] The results for the long estimation period and the corresponding panel composition thus speak against

24 See Bayoumi et al (2011), op cit. The results of several different panel unit root tests suggest that the variables included in the analysis really are non-stationary. It is only with respect to the CPI that the findings are ambiguous.
25 See J Westerlund (2007), Testing for Error Correction in Panel Data, Oxford Bulletin of Economics and Statistics 69, pp 709-748. This approach is also used for the pairwise cointegration analysis of the various indicators of price competitiveness, the results of which are referred to in the main text.
26 Compared with "first generation" procedures, the Westerlund test method employed here has the advantage of taking cross-dependencies between countries into account using a bootstrap method. Non-inclusion of these could lead to the test results being biased.
27 A homogeneous adjustment coefficient is assumed across all countries for the pooled tests, while the adjustment coefficients may be heterogeneous in the group mean tests. The tests were designed to have a particularly high degree of power with regard to the respective alternative hypothesis, making it highly likely that false zero hypotheses actually get rejected. In practice, however, it is often difficult to unambiguously interpret rejections of a null hypothesis as both tests exhibit power with regard to both alternative hypotheses.
28 This is consistent with the results of the panel root unit tests, which, in some instances, suggest stationarity of the indicators on the basis of the CPI. In this event, the indicator in question would be unviable as a long-term determinant of real exports, which are themselves unambiguously non-stationary.

using CPI-based measures as a competitiveness indicator in the estimation of long-term export equations.[29]

Comparison of the results of different estimators

The next step of the analysis consists of using three different estimation methods for the computation of the long-term elasticities. First, a classic least squares panel regression with fixed country effects (OLS (FE)) is deployed. The fixed effects of this regression account for time-invariant, country-specific determinants that are not considered.[30] Second, panel dynamic OLS (P-DOLS) estimations are performed. This estimator developed by Mark and Sul (2003)[31] is an expanded version of the original dynamic OLS estimator created for use with individual cross-sectional units. In this method, the model to be estimated is supplemented with lead and lagged values of the first differences in the explanatory variables in order to take account of any endogenous feedback effects. In Mark and Sul's (2003) extension of the method to include a cross-sectional dimension, the estimation process occurs in two steps. In the first of these, the time series are adjusted for individual short-term dynamics and country-specific fixed effects.[32] In the second step, an estimation is made of a cross-country least squares regression of the "adjusted" time series.

Third, group mean panel dynamic OLS (GM-DOLS) estimations are deployed,[33] which, in contrast with P-DOLS estimations, cast aside the assumption that long-term elasticities have to be uniformly homogeneous across countries. Should they in fact prove heterogeneous, this would indicate that – strictly speaking – the two other estimators are biased with respect to the long-term elasticities to be estimated. By contrast, even in this case, the GM-DOLS estimator continues to deliver a consistent estimation of the average long-term elasticity. The estimation procedure is likewise carried out in two steps. First, country-specific dynamic OLS estimations are made. Second, the respective mean values of the estimated country-specific long-term coefficients are calculated and interpreted as the average long-term elasticity.

The tables on pages 28 and 29 display the estimated results of the two panel compositions. However, in each case, they only show estimated results for specifications with a specific external activity variable; for the longer time frame, this is the sum total of real imports by a given country's trading partners, whereas this refers to the volume of global trade in the case of the shorter estimation period.

The results highlight a striking similarity between the estimated long-term elasticities across the various estimators for most of the indicators over the short observation period. This applies both to the estimated price elasticities and estimated income elasticities.[34]

Westerlund panel cointegration tests*

Variables			Robust (bootstrapped) *p*-values	
			Group mean t-statistic	Pooled t-statistic
exp	*dts*	*gt*	0.00	0.07
exp	*gpd*	*gt*	0.00	0.05
exp	*cpi*	*gt*	0.00	0.11
exp	*ulc*	*gt*	0.00	0.02
exp	*ppi*	*gt*	0.00	0.06
exp	*exd*	*gt*	0.00	0.04

* 20 advanced economies; indicators computed against 37 trading partners; 1996 Q1 to 2015 Q1.
Deutsche Bundesbank

29 Incidentally, the results of the cointegration tests suggest that any modelling of Equation (2) in differences actually generates biased estimators for the remaining coefficients if the relevant explanatory variable is correlated with the ignored adjustment term.
30 To avoid biased standard errors as a consequence of autocorrelation, heteroscedasticity or dependencies between the cross-sectional units (countries), use is made of robust standard errors according to J C Driscoll and A C Kraay (1998), Consistent covariance matrix estimation with spatially dependent panel data, Review of Economics and Statistics 80, pp 549-560. Nevertheless, these should also be interpreted with caution as they were conceived for cases where the variables are stationary.
31 See N C Mark and D Sul (2003), Cointegration vector estimation by panel DOLS and long-run money demand, Oxford Bulletin of Economics and Statistics 65, pp 655-680.
32 In the present estimations, no additional adjustments are made to take account of individual trends.
33 For more information, see P Pedroni, 2001, Purchasing power parity tests in cointegrated panels, Review of Economics and Statistics 83, pp 727-731.
34 In the case of the longer observation period, if the sum total of imports by a given country's trading partners serves as the activity variable, this results in more pronounced deviations in some of the estimated long-term price elasticities.

Long-term elasticities in 20 advanced economies estimated over the period from 1996 Q1 to 2015 Q1, based on different estimators*

Indicator of price competitiveness	Price elasticity			Income elasticity		
	OLS (FE)	P-DOLS	GM-DOLS	OLS (FE)	P-DOLS	GM-DOLS
dts	– 0.43***	– 0.50***	– 0.42***	0.81***	0.78***	0.80***
gpd	– 0.39***	– 0.44***	– 0.39***	0.81***	0.78***	0.80***
cpi	– 0.31***	– 0.36**	– 0.46***	0.80***	0.78***	0.80***
ulc	– 0.40***	– 0.43***	– 0.44***	0.81***	0.79***	0.81***
ppi	– 0.31***	– 0.36**	– 0.56***	0.82***	0.79***	0.83***
exd	– 0.38***	– 0.42***	– 0.47***	0.83***	0.80***	0.82***

* Indicators computed against 37 trading partners; global trade volume approximates external activity; ***/** significant at the 1%/5% level.
Deutsche Bundesbank

Method for analysing hypothetical scenarios

In order to gain an impression of the actual economic impact of the two explanatory variables on real exports in recent times, the main text makes reference to the results of an analysis of hypothetical scenarios. The method applied is described in brief below. The starting point of the analysis is the third quarter of 2008, that is to say, the quarter in which the US investment bank Lehman Brothers filed for insolvency and the financial crisis escalated on a global scale. An analysis of hypothetical scenarios consists of two steps. First, the baseline model is estimated.[35] Second, based on the estimated coefficients, the dependent variable – in this case, log real exports – are forecast for a variety of values of the explanatory variables. In this analysis, the actual values observed from the third quarter of 2008 to the first quarter of 2015 for the explanatory variables are first inserted into the estimated model, which gives the forecast values of the dependent variable in the reference scenario. These are then compared with the real export values that would be generated by the model estimated in the first step if it were assumed that the international price competitiveness of the country under review had not changed since the second quarter of 2008. The resulting differences between the two scenarios in terms of the forecast log real exports are thus attributable to the movements of the (log) indicators of international price competitiveness since the escalation in the financial crisis. The same method is applied in a second thought experiment where, however, global trade is not fixed at its level recorded in the second quarter of 2008; instead, global trade is assumed to rise continuously throughout the forecast period in line with its trend growth rate in the preceding period.

Comparison of forecast quality based on iterative estimations

An additional criterion for comparing the suitability of the various indicators is provided by the forecast quality of the models based on these different indicators. To judge the forecast quality of a given model, a certain number of the available observations are allocated to an estimation period, while the remaining observations are attributed to a forecast period. Since the actual realised values of the dependent variable are also known for the forecast period, it is easily possible to calculate the forecast errors by deducting the values projected on the basis of the different models estimated for the predefined estimation period from the actually observed values of the dependent variable. The forecast errors for the various observations are subsequently aggregated to produce an indicator of forecast quality. One indicator established in the econometric litera-

35 The estimation is carried out using the least squares panel regression with fixed effects over the period from the first quarter of 1996 to the first quarter of 2015, based on the observed values of the variables. If, alternatively, the estimation is performed merely on the basis of the data gathered up to the second quarter of 2008, this delivers qualitatively similar results with regard to the thought experiment.

Long-term elasticities in 18 advanced economies estimated over the period from 1975 Q1 to 2015 Q1, based on different estimators*

Indicator of price competitiveness	Price elasticity			Income elasticity		
	OLS (FE)	P-DOLS	GM-DOLS	OLS (FE)	P-DOLS	GM-DOLS
dts	– 0.30***	– 0.33**	– 0.49***	0.94***	0.93***	0.94***
gpd	– 0.35***	– 0.37***	– 0.42***	0.94***	0.94***	0.94***
cpi	– 0.25***	– 0.29*	– 0.51***	0.94***	0.93***	0.94***
exd	– 0.28***	– 0.29**	– 0.69***	0.95***	0.94***	0.94***

***** Indicators computed against 19 trading partners; aggregate imports of trading partners approximate external activity; *****/**/*** significant at the 1%/5%/10% level.
Deutsche Bundesbank

ture is the mean absolute forecast error. This is obtained by calculating the arithmetic mean of the absolute forecast error for observations made over the forecast period.

One fundamental problem presented by this kind of analysis is the often arbitrary choice of the estimation and the forecast period upon which the relative forecast quality of the models ultimately also hinges. To avoid such arbitrariness, we apply a repeated sampling approach. To this end, one observation per country is omitted from the estimation period and this observation that is left out when estimating Equation (2) is forecast based on the actual values of the explanatory variables.[36] This procedure is repeated until all the available observations have been omitted from the estimation period once and predictions have been generated for each of them. In the literature, the method in question is referred to as the "leave one out" classification analysis.[37] Next, the mean absolute forecast error of the respective model over the entire observation period is calculated. This procedure is repeated for all of the specifications in order to pave the way for a comparison of the mean absolute forecast error for the various models. In this context, the model with the lowest mean absolute forecast error serves as the reference model, with the forecast quality of the remaining models being assessed in relation to this reference model. For the broad group of countries and the case where the volume of global trade approximates real external activity, the forecasts produced in this manner are most accurate when use is made of the indicator based on unit labour costs for the total economy. However, the mean absolute forecast error is just 1½% to 3% higher if use is made of the indicator based on EXD, GPD or DTS instead. Opting for either the CPI or PPI-based indicator leads to increased quality losses, with the forecast error going up by around 6% to 6½% compared with the reference model.

The choice of the external activity variable, however, has an even greater impact on forecast quality. If Germany's external activity is approximated (either in aggregate or weighted terms) by the real income of its trading partners, the mean absolute forecast errors are consistently higher than in a situation where external activity is captured using real imports (either in aggregate or weighted terms) or the volume of global trade, irrespective of the choice of competitiveness indicator.

36 For each of the countries, the same quarter is left out of the estimation so as to enable the estimation of a balanced panel in each iteration.
37 The "leave one out" analysis belongs to the cross-validation family of methods. An empirical application based on panel data can be found in H Herwartz and F Xu (2009), Panel data model comparison for empirical saving-investment relations, Applied Economics Letters 16, pp 803-807.