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Non-technical summary

Research Question

Real exports are commonly specified as depending on an indicator of price competitiveness and on a measure of foreign activity. It is unclear, however, which of the available indicators of price competitiveness is most closely connected to a country's export performance. Since the question of indicator suitability cannot be answered purely on conceptual grounds, we address it empirically.

Contribution

A panel cointegration analysis is conducted to examine which indicator is most closely tied to real exports in the long run for a broad group of up to 20 advanced economies. As a further criterion, the study checks whether models based on any of the indicators lead to superior forecasts of real exports. In the underlying forecast exercise, use is made of repeated sampling- and cross-validation techniques in order to avoid the need for imposing arbitrary sample splits.

Results

According to the estimation results, broad price- and cost-based indicators, such as real exchange rates based on GDP deflators, deflators of total sales or unit labour costs for the total economy, are to be preferred to narrow measures such as CPI- or PPI-deflated exchange rates.

Nichttechnische Zusammenfassung

Fragestellung

Üblicherweise wird unterstellt, dass reale Exporte von einem Indikator der preislichen Wettbewerbsfähigkeit und einem Maß der Auslandsaktivität bestimmt werden. Es besteht allerdings bisher kein Konsens darüber, welcher der verfügbaren Indikatoren in der engsten Beziehung zur Exportentwicklung eines Landes steht. Da die Frage der Eignung der verschiedenen Indikatoren auf Basis rein konzeptioneller Erwägungen nicht abschließend beantwortet werden kann, wird hier ein empirischer Ansatz verfolgt.

Beitrag

Genauer gesagt wird eine Panel-Kointegrationsanalyse für eine breite Gruppe von bis zu 20 fortgeschrittenen Volkswirtschaften durchgeführt, um zu untersuchen, welcher der Indikatoren langfristig am engsten mit den realen Exporten verbunden ist. Als weiteres Kriterium zur Beurteilung der Indikatorqualität wird die Prognosegüte von Modellen auf Basis der verschiedenen Indikatoren analysiert. Dabei werden Verfahren der wiederholten Stichprobenziehung und der Kreuzvalidierung verwendet, um willkürliche Unterteilungen des Untersuchungszeitraums zu vermeiden.

Ergebnisse

Die empirischen Ergebnisse deuten darauf hin, dass breitgefasste preis- und kostenbasierte Indikatoren wie reale Wechselkurse auf Basis von BIP-Deflatoren, von Deflatoren des Gesamtabsatzes oder von Lohnstückkosten in der Gesamtwirtschaft enger gefassten konsumenten- oder produzentenpreis-basierten Indikatoren vorzuziehen sind.

On the suitability of alternative competitiveness indicators for explaining real exports of advanced economies*

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Abstract

Real exports are commonly specified as depending on an indicator of price competitiveness and on a measure of foreign activity. This study empirically investigates the suitability of alternative competitiveness indicators in explaining real exports for a broad group of advanced economies. To this end, a panel cointegration analysis is conducted, augmented by a forecasting exercise. In the latter, repeated sampling techniques are used in order to avoid arbitrary sample splits. We find that broad price- and cost-based indicators are to be preferred to narrow price based measures such as CPI- or PPI-deflated real exchange rates. Furthermore, the evidence points towards using world trade as the external activity variable instead of GDP- or real imports-based measures.

Keywords: international price competitiveness, real export demand, price elasticity of exports.

JEL classification: C23, F14, F31, F47.

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1 Introduction

An economy's international price competitiveness is one of the key determinants of its export performance. As indicators of price competitiveness, various measures of the real exchange rate are available, which largely differ with respect to the price or cost index used for their calculation. There is a broad consensus in the literature, that every indicator of price competitiveness has advantages and disadvantages. In fact, some conceptual considerations 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 and partner economies. However, ultimately, there is no single clear-cut answer as to which specific indicator should be used to measure price competitiveness from a theoretical point of view. Therefore, we address this question empirically. More specifically, we follow a panel cointegration approach to systematically check which of the indicators available is most closely tied to real exports in the long run, and which model specification leads to superior out-of-sample forecasts. While the focus is on the suitability of the alternative competitiveness indicators, we also check the empirical performance of the various foreign activity variables available.

The contributions of this paper are as follows: First, while the focus of the prevailing literature related to this study's topic is on country-specific analyses or analyses with a clear regional focus, we consider a much broader group of up to 20 advanced economies. Second, we make use of modern panel cointegration techniques and estimators which also allow for heterogeneous long-run income and price elasticities. Third, we employ recently introduced repeated sampling and cross-validation techniques in order to avoid the need for arbitrary sample splits when assessing the forecast accuracy of the competing models.

The paper is structured as follows: In section 2 we provide a short summary of the related literature. In section 3, we give an overview of the various indicators available, and address their relative merits from a conceptual point of view. In section 4, we describe the model specification and the data used, and provide the results from a simple preliminary data analysis. In section 5, we describe the panel cointegration approach followed to assess which indicator of price/cost competitiveness is most closely tied to the export performance in the long run, and present the empirical results. In section 6, we compare the out-of-sample forecast accuracy of the associated models. In section 7, we analyse the sensitivity of the estimation results along two dimensions: First, we address the stability over time, and second, we check the degree of heterogeneity of the long-run price elasticity estimates across countries. Section 8 concludes and summarises our main findings.

2 Related literature

In the seminal study by [Goldstein and Khan \(1985\)](#), real exports are modelled as being dependent on their relative price and on a measure of foreign real activity. Several recent studies investigate, however, whether additional explanatory variables should be added in an augmented export equation or whether such variables may affect estimates of the price or income elasticities. [Ahmed, Appendino, and Ruta \(2015\)](#) and [Gangnes, Ma, and Van Assche \(2014\)](#), for instance, explore the effects of global value chain integration on

price and income elasticities of exports, respectively. For a similar reason, [Cheung, Chinn, and Qian \(2016\)](#) take account of imported inputs in their estimation of Chinese exports to the US. For a large sample of 60 economies, however, [International Monetary Fund \(2015\)](#) finds little evidence for the rise of global value chains having led to a disconnect between exchange rates and trade. [Esteves and Rua \(2015\)](#) consider the inclusion of domestic demand pressure as an additional variable in an export equation for Portugal. [Christodouloupoulou and Tkačevs \(2015\)](#), however, report only limited evidence for a domestic demand impact on exports. Moreover, the inclusion of domestic demand does not affect the price elasticities of exports for their sample of countries.¹ [Ratnaike \(2012\)](#) finds trade policy to be largely insignificant in determining export performance. [Berman and Berthou \(2009\)](#) and [Wierst, Van Kerkhoff, and De Haan \(2014\)](#) provide evidence of the price elasticity of exports being affected by financial market imperfections and the share of high technology exports, respectively.

Against the background of the rather mixed evidence on additional explanatory variables, it may not be surprising that recent studies commonly continue to confine the set of exogenous variables in an export equation to the two traditional ones: real exchange rates or some other sort of relative prices and a measure of foreign real activity.² This also applies to the strand of literature most closely related to the present study: empirical analyses of the relative performance of alternative measures of price or cost competitiveness in export equations. An early example of this literature is a study by [Deutsche Bundesbank \(1998\)](#), which reports that German exports are best explained by broadly defined competitiveness indicators, especially by one based on the deflator of total sales. The indicator based on relative unit labour costs in the manufacturing sector performed worst. [Chinn \(2006\)](#) briefly addresses the issue of comparative indicator quality, too. For a US export equation, he finds an indicator based on a unit labour cost index to be superior to a CPI- and a PPI-based one.³ [Ca'Zorzi and Schnatz \(2010\)](#) estimate an export equation for the European Monetary Union (EMU). They are the first to use a forecasting exercise for the assessment of indicator quality. According to their results, no indicator's performance consistently exceeds that of the others.

While the above three studies focus on the exports of a single country or currency area, [Christodouloupoulou and Tkačevs \(2015\)](#) estimate an export equation for each individual EMU country. They conclude that it is difficult to isolate a superior indicator, but note that the estimated elasticities of broadly defined indicators tend to exceed those of indicators that are based on manufacturing sector data only, ie unit labour costs in the manufacturing sector or the PPI. [Giordano and Zollino \(2016\)](#) present a similar investigation for France, Germany, Spain, and, in particular, Italy. In line with [Deutsche Bundesbank \(1998\)](#), they suggest that price-based measures play a more important role

¹[Berman, Berthou, and Héricourt \(2015\)](#) reveal another aspect of the rather complex relationship between exports and domestic demand. They show that exogenous variations in French firm-level exports positively impact on domestic sales.

²See, for instance, [Crane, Crowley, and Quayyum \(2007\)](#) for the Federal Reserve System, [European Commission \(2010, 2014\)](#), and [Hubrich and Karlsson \(2010\)](#) for the ECB and the Eurosystem, or [International Monetary Fund \(2015\)](#).

³It remains unclear, however, whether he considers narrowly defined unit labour costs in the manufacturing sector or a more broadly defined measure. Moreover, the three indicators investigated are provided by different institutions which suggests that the indicators not only differ in terms of the deflator used for their calculation but also in terms of the group of partner countries involved.

in explaining export growth than those based on unit labour costs in the manufacturing sector. Finally, [Bayoumi, Harmsen, and Turunen \(2011\)](#) use panel methods to assess the indicator performance in export equations for 11 EMU economies. According to their findings, CPI-based indicators are inferior to alternative measures.

Methodologically, the present study is most closely related to [Bayoumi et al. \(2011\)](#). It differs, however, from that study and all the others mentioned above in applying modern panel cointegration techniques and estimators, some of which also allow for heterogeneous elasticities across countries. The criteria used for checking indicator quality also go beyond [Bayoumi et al. \(2011\)](#). A particular methodological advancement is the use of repeated sampling and cross-validation techniques, as in [Herwartz and Xu \(2009\)](#), in order to avoid the (ultimately arbitrary, and, most likely, highly debatable) imposition of a sample split when assessing the forecasting accuracy of models based on the different indicators. Apart from these methodological aspects, the present study considers panels of advanced economies that include eight non-EMU countries in order to arrive at conclusions as general and comprehensive as possible. This fills a gap in the literature which has so far focused nearly exclusively on EMU countries' export equations. The present study is also more comprehensive than previous ones in that it compares six alternative indicators of price and cost competitiveness in two panels over time horizons of different lengths.

3 Alternative indicators of price competitiveness: conceptual considerations

Real exchange rates measure movements in the relative price or cost position of a country's economy and are therefore typically used as indicators of price competitiveness. Ideally, these variables should, amongst other things, draw on internationally comparable statistical 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. However, the following considerations suggest that these requirements can hardly be implemented simultaneously and are therefore not fully satisfied by any of the conventional indicators available.⁴ Against this background, we discuss the relative merits of six widely used indicators.

The sales prospects of internationally active enterprises on the world markets are directly affected by export prices, so *real exchange rates based on export prices* seem to be a suitable indicator for determining the price competitiveness of a given economy. However, this is only true if a change in the relative cost position is actually passed on in terms of export prices instead of being absorbed by a corresponding adjustment of profit margins. Moreover, focusing on the prices of goods that are actually traded excludes, *a priori*, sectors of the domestic economy in which tradeable but internationally non-competitive goods are produced. *Real exchange rates based on producer prices* capture the net prices of all goods produced in the domestic industrial sector and thus cover a wide variety of tradeable goods, but they relate solely to industrial products. Significant areas of global trade – such as the entire services sector – are left out. Consequently, an economy's competitiveness might be better captured by focusing on domestic

⁴For an overview of the advantages and disadvantages of the conventional indicators, see [Ca'Zorzi and Schnatz \(2010\)](#) or [Deutsche Bundesbank \(1998\)](#).

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 price developments in intermediate goods on the one hand and in the domestic services sector on the other.⁵ In addition to these price components, the *indicator based on deflators of total sales* also takes the prices of imported goods and services into account, which, in the case of imported intermediate goods, represent a cost component of domestic output. This indicator thus covers an even broader price and cost base than the indicator based on GDP deflators. 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 due to developments in other cost components, are disregarded. In addition, the substitution of production factors affects unit labour costs, but not necessarily 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 absorbed by way of a corresponding lower profit margin (pricing-to-market behaviour), and they can also be distorted by changes in indirect taxes, such as value added tax. In contrast to the aforementioned indicators, 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 also 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, are included in the underlying baskets of goods.

4 Model specification, data description and preliminary data analysis

This section sets the stage for the empirical analysis. First, we present the export demand equation which emerges from the theoretical model by [Goldstein and Khan \(1985\)](#) in order to provide a framework for the econometric analysis. We then describe the data and present the results of a simple correlation analysis of the various competitiveness indicators to check whether the conceptual differences described above also show up empirically.

[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 , where S denotes the nominal exchange rate in units of the foreign currency for each unit of domestic currency (indirect quotation). Assuming this original function is homogeneous of degree zero, real export demand can also be written as being

⁵The concept of global value chains, which focuses on the increasing vertical specialisation in foreign trade, suggests the use of GDP deflators when calculating indicators of price competitiveness so as to be able to capture price developments in intermediate goods that are in international competition. See, for instance, [Bems and Johnson \(2012\)](#).

determined by function g as

$$X = g\left(\frac{P_X}{P^*/S}; \frac{Y'^*}{P^*}\right). \quad (1)$$

Assuming function g to be log-linear, we obtain the following econometric model to be estimated:

$$x_{it} = \beta_{0i} + \beta_1 r_{it} + \beta_2 y_{it} + \varepsilon_{it}, \quad (2)$$

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

For an estimation of the export equation (2), two alternative panels of quarterly time series have been compiled. The first panel (*Panel I*) comprises data for 20 advanced economies including the USA, Canada, Japan and 17 European countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the UK). The observation period runs from the first quarter of 1996 to the first quarter of 2015. The second panel (*Panel II*) spans a considerably longer period starting as early as in the first quarter of 1975. Because of data restrictions for Greece and Ireland, it covers only the remaining 18 countries.

Real effective exchange rate (REER) series serve as indicators of price (or cost) competitiveness. They are calculated according to a methodology jointly agreed upon within the European System of Central Banks.⁶ Each individual REER series of *Panel I* is computed against 37 partner countries. This comparatively broad group of partner countries includes China and the former transition countries of Central and Eastern Europe, whose importance for international trade has increased significantly over the past two decades. For *Panel II* starting back in 1975, such a procedure is impossible because, at least in the first 15 years of the sample, many of these countries had planned economies in which prices were unrelated to competitiveness. Therefore, REER series of the second panel are computed against a smaller group of 19 advanced partner economies.

Six alternative price and cost indices are used to calculate the REER series: deflators of total sales, GDP deflators, unit labour costs in the total economy, consumer price indices, producer price indices, and export deflators. Below, and in all tables and figures, the indicators will be abbreviated according to the deflator employed as DTS, GDP, ULC, CPI, PPI, or EXD, respectively. Note that the study does not consider indicators based on unit labour costs in the manufacturing sector, which several studies have found to show inferior performance to other indicators for some individual economies. The ULC series used here pertains to a much broader concept of unit labour costs. REERs based on each of the different price indices will be included successively as explanatory variables in a panel estimation of the export equation (2). Due to data restrictions, however, REERs based on unit labour costs and on producer price indices are only available for *Panel I*.

⁶For a description of this methodology, see [Schmitz, De Clercq, Fidora, Lauro, and Pinheiro \(2013\)](#).

Real exports of goods and services (EXP) are used as the endogenous variable of the export equation (2).⁷ Apart from the REER, foreign demand enters the export equation as a second explanatory variable. Previous studies have employed various measures as proxies for foreign demand.⁸ In order to prevent the results from being affected by the selection of a specific foreign demand proxy, the present analysis considers five alternative measures: the volume of world trade (WT), the sum of real GDP across partner countries (GDPS), the sum of real imports across partner countries (IMPS), a weighted average of partner countries' real GDP (GDPW), and a weighted average of partner countries' real imports (IMPW).⁹ While the first of these variables is common to all countries in the sample, the remaining ones are country-specific. The weights used for averaging are identical to those of the corresponding REERs.

To gain a first impression of whether the conceptual differences between the indicators outlined in section 3 really matter empirically, Figure 1 depicts the group mean correlation coefficients for all pairs of indicators for the sample from 1996Q1 to 2015Q1 (*Panel II*). These are calculated in two steps. First, the respective correlation coefficients between each pair of indicators are calculated for each of the 20 advanced countries individually. Second, the average of these correlation coefficients is calculated across countries.

Several observations stand out. First, some of the indicators are highly correlated with each other – both in (log) levels as well as in (log) first differences. In particular, the average correlation coefficient of the DTS and the GPD exceeds 0.9 in levels and differences. However, other frequently used indicators, most notably the EXD, PPI, and ULC, show far less similar behaviour compared to the other indicators.¹⁰ Based on that, it may indeed matter which of the indicators is used to measure competitiveness since they could – at least at times – signal different competitiveness developments.

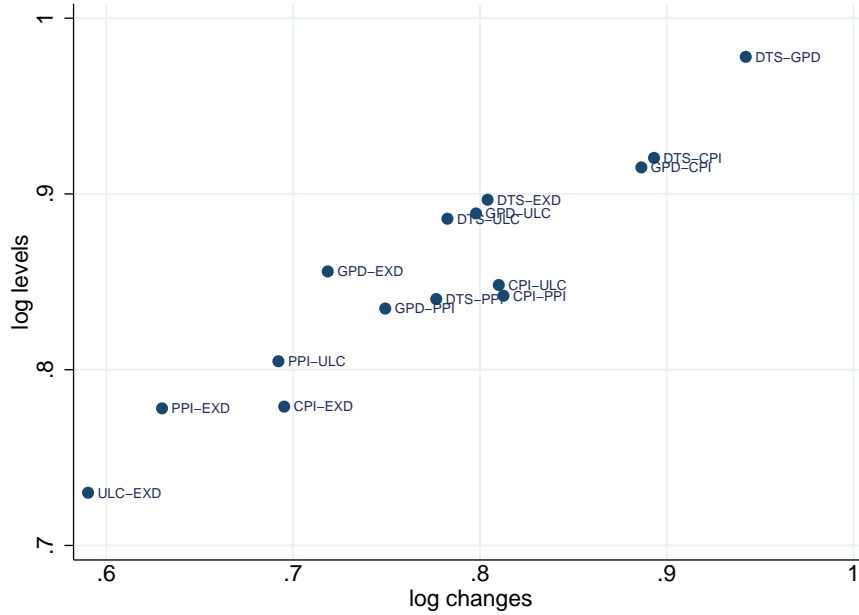
⁷Source: OECD Economic Outlook, series *XGSVD*, exports of goods and services, volume, USD, 2005 prices. For the most recent five quarters, OECD data has been linked to Bundesbank data on real exports of goods and services. In panel estimations of export equations, real exports of goods and services are commonly used; cf for instance [European Commission \(2010, 2014\)](#) and [International Monetary Fund \(2015\)](#).

⁸[Bayoumi et al. \(2011\)](#), and [International Monetary Fund \(2015\)](#), for instance, choose real GDP of partner countries as the proxy, whereas [Christodouloupoulou and Tkačevs \(2015\)](#), [European Commission \(2010, 2014\)](#), and [Grimme and Thürwächter \(2015\)](#) prefer real imports. While [Grimme and Thürwächter \(2015\)](#) compute the sum or real imports of the partner countries, most of the other studies choose a weighted average of partner countries' real imports. [Giordano and Zollino \(2016\)](#), finally, use a world trade series which is common to all countries as a proxy for foreign demand.

⁹The volume of world trade is provided by the CPB world monitor. It is not available for *Panel II*. The primary source of real GDP and real import data is the OECD Economic Outlook. It is supplemented by Bundesbank data.

¹⁰One possible explanation for the weak correlation between ULC and EXD may be that export prices are more closely determined by the international price relationship (law of one price) and do not reflect short-term changes in the relative (labour) cost position.

Figure 1: Correlation matrix of competitiveness indicators



Note: The figure shows the arithmetic average of the Pearson correlation coefficients for the log levels as well as for the log differences of all pairs of indicators across 20 advanced countries for the sample 1996Q1 to 2015Q1 (*Panel I*).

5 Panel cointegration analysis

In some recent studies which present estimates of export elasticities (eg [Christodoulopoulou and Tkačevs \(2015\)](#), or [Giordano and Zollino \(2016\)](#)), an equation like (2) is estimated in first differences on account of the non-stationarity of the variables. However, this approach has two disadvantages if, in particular, long-run export elasticities are to be estimated, as in this paper. 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 considerations, we perform a panel cointegration analysis as set out by [Berman et al. \(2015\)](#) and [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. For this purpose, we make use of a test procedure developed by [Westerlund \(2007\)](#). Put simply, this procedure examines a panel error correction model in which deviations from the long-term equilibrium should be 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. Importantly, by following a bootstrap approach, the Westerlund procedure takes cross-sectional dependencies within the panel into account. It computes marginal significance levels based on various test statistics. The p -values for two such statistics, the pooled and the group mean t -statistic, are presented in Table 1 for all examined specifications. A p -value below 0.05 implies that the null hypothesis of no cointegration

relationship can be rejected at a significance level of 5%.¹¹

Across the long estimation period (*Panel II*), the tests support 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 foreign demand is approximated, CPI is used as the indicator of competitiveness. The results for *Panel II* thus speak against using CPI-based measures as competitiveness indicators in the estimation of long-term export equations. For the shorter *Panel I*, a similar picture emerges, although the results are somewhat less clear.

In order to estimate the long-term elasticities, three different estimation methods are used. First, a classic least squares panel regression with fixed country effects (OLS (FE)) is deployed to estimate equation (2). The fixed effects of this regression account for unconsidered time-invariant, country-specific determinants. Second, panel dynamic OLS (P-DOLS) estimations are performed. In short, this estimator developed by [Kao and Chiang \(2000\)](#) and extended by [Mark and Sul \(2003\)](#) allows for endogenous feedback effects by including (country-specific) leads and lags of the first differences of the explanatory variables. In the context of our analysis, the econometric model to be estimated thus becomes

$$x_{it} = \beta_{0i} + \beta_1 r_{it} + \beta_2 y_{it} + \sum_{k=-K_i}^{K_i} \gamma_{1,ik} \Delta r_{it-k} + \sum_{k=-K_i}^{K_i} \gamma_{2,ik} \Delta y_{it-k} + \kappa_{it}. \quad (3)$$

Third, group mean panel dynamic OLS (GM-DOLS) estimations advocated by [Pedroni \(2001\)](#) are deployed, which, in contrast with the two previous estimators, relax the assumption that long-term elasticities have to be 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, GM-DOLS continues to be a consistent estimator of the *average* long-term elasticity. The estimation procedure is carried out in two steps. First, country-specific dynamic OLS estimations are performed, ie the following model is estimated for each cross-section unit:

$$x_{it} = \beta_{0,i} + \beta_{1,i} r_{it} + \beta_{2,i} y_{it} + \sum_{k=-K_i}^{K_i} \delta_{1,ik} \Delta r_{it-k} + \sum_{k=-K_i}^{K_i} \delta_{2,ik} \Delta y_{it-k} + v_{it} \quad (4)$$

Then, the respective mean values of the estimated country-specific long-term coefficients are calculated, ie $\hat{\beta}_{j,GM} = N^{-1} \sum_{i=1}^N \beta_{j,i}$, where $j = 1, 2$. These can be interpreted as the respective average long-term elasticity.

The estimation results for *Panel I* and *Panel II* are presented in [Tables 2 and 3](#), respectively. First, it may be noted that all significant coefficients are signed as theoretically expected. According to the OLS(FE) results for *Panel I*, the estimated long-term price elasticity of exports is in the range of -0.31 (CPI, PPI) to -0.43 (DTS) when foreign demand is approximated by the world trade volume.¹² This implies that, depending on

¹¹In the case of the pooled t-statistic, the test is 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.

¹²The estimation results for specifications involving the CPI should be interpreted with caution since

Table 1: Westerlund panel cointegration test results for *Panel I* and *Panel II*, robust p -values

			<i>Panel I</i>		<i>Panel II</i>	
			P_t	GM_t	P_t	GM_t
<i>exp</i>	<i>dt</i>	<i>gdps</i>	0.010	0.208	0.028	0.038
<i>exp</i>	<i>gpd</i>	<i>gdps</i>	0.012	0.220	0.054	0.074
<i>exp</i>	<i>cpi</i>	<i>gdps</i>	0.040	0.296	0.080	0.138
<i>exp</i>	<i>ppi</i>	<i>gdps</i>	0.006	0.066		
<i>exp</i>	<i>ulc</i>	<i>gdps</i>	0.004	0.076		
<i>exp</i>	<i>exd</i>	<i>gdps</i>	0.028	0.092	0.016	0.008
<i>exp</i>	<i>dt</i>	<i>gdpw</i>	0.000	0.016	0.092	0.072
<i>exp</i>	<i>gpd</i>	<i>gdpw</i>	0.000	0.034	0.084	0.048
<i>exp</i>	<i>cpi</i>	<i>gdpw</i>	0.002	0.084	0.180	0.148
<i>exp</i>	<i>ppi</i>	<i>gdpw</i>	0.000	0.036		
<i>exp</i>	<i>ulc</i>	<i>gdpw</i>	0.000	0.012		
<i>exp</i>	<i>exd</i>	<i>gdpw</i>	0.000	0.028	0.016	0.008
<i>exp</i>	<i>dt</i>	<i>imps</i>	0.042	0.246	0.006	0.006
<i>exp</i>	<i>gpd</i>	<i>imps</i>	0.062	0.240	0.034	0.024
<i>exp</i>	<i>cpi</i>	<i>imps</i>	0.078	0.254	0.156	0.104
<i>exp</i>	<i>ppi</i>	<i>imps</i>	0.018	0.118		
<i>exp</i>	<i>ulc</i>	<i>imps</i>	0.010	0.044		
<i>exp</i>	<i>exd</i>	<i>imps</i>	0.108	0.226	0.000	0.000
<i>exp</i>	<i>dt</i>	<i>impw</i>	0.080	0.138	0.002	0.004
<i>exp</i>	<i>gpd</i>	<i>impw</i>	0.124	0.146	0.008	0.010
<i>exp</i>	<i>cpi</i>	<i>impw</i>	0.178	0.222	0.106	0.110
<i>exp</i>	<i>ppi</i>	<i>impw</i>	0.108	0.102		
<i>exp</i>	<i>ulc</i>	<i>impw</i>	0.006	0.030		
<i>exp</i>	<i>exd</i>	<i>impw</i>	0.148	0.206	0.000	0.000
<i>exp</i>	<i>dt</i>	<i>wt</i>	0.000	0.072		
<i>exp</i>	<i>gpd</i>	<i>wt</i>	0.002	0.088		
<i>exp</i>	<i>cpi</i>	<i>wt</i>	0.000	0.090		
<i>exp</i>	<i>ppi</i>	<i>wt</i>	0.000	0.040		
<i>exp</i>	<i>ulc</i>	<i>wt</i>	0.000	0.016		
<i>exp</i>	<i>exd</i>	<i>wt</i>	0.010	0.092		

Note: The table shows robust p -values for the pooled t -statistic (P_t) and the group mean t -statistic (GM_t) based on 500 bootstrap replications for all specifications testable in *Panel I* (20 countries, 1996Q1–2015Q1) or *Panel II* (18 countries, 1975Q1–2015Q1), respectively. A p -value below 0.05 (0.10) implies that the null hypothesis of no cointegration relationship can be rejected at a significance level of 5% (10%). In the case of P_t , the test is geared to the alternative hypothesis that the adjustment coefficient is negative for all countries; in the case of GM_t , this is supposed to apply for at least one of the countries.

Table 2: Long-term elasticities in 20 advanced economies estimated over the period from 1996Q1 to 2015Q1 for various specifications (*Panel I*)

	Price elasticity			Income elasticity		
<i>Foreign demand measured by aggregate real GDP (GDPS)</i>						
	OLS (FE)	P-DOLS	GM-DOLS	OLS (FE)	P-DOLS	GM-DOLS
DTS	-0.32***	-0.38*	-0.19**	1.10***	1.06***	1.03***
GDP	-0.30***	-0.34**	-0.29**	1.10***	1.06***	1.05***
CPI	-0.21**	-0.24	-0.28***	1.09***	1.05***	1.07***
ULC	-0.33***	-0.36**	-0.48***	1.10***	1.07***	1.09***
PPI	-0.22***	-0.24	-0.47***	1.11***	1.06***	1.09***
EXD	-0.32***	-0.35**	-0.15*	1.12***	1.08***	1.00***
<i>Foreign demand measured by weighted average of real GDP (GDPW)</i>						
	OLS (FE)	P-DOLS	GM-DOLS	OLS (FE)	P-DOLS	GM-DOLS
DTS	-0.09	-0.10	-0.37***	1.45***	1.38***	1.61***
GDP	-0.11**	-0.12	-0.37***	1.45***	1.38***	1.61***
CPI	0.02	0.03	-0.36***	1.45***	1.40***	1.61***
ULC	-0.14***	-0.13	-0.44***	1.45***	1.39***	1.64***
PPI	-0.03	-0.01	-0.52***	1.46***	1.38***	1.65***
EXD	-0.16***	-0.16	-0.48***	1.47***	1.39***	1.63***
<i>Foreign demand measured by aggregate real imports of goods and services (IMPS)</i>						
	OLS (FE)	P-DOLS	GM-DOLS	OLS (FE)	P-DOLS	GM-DOLS
DTS	-0.39***	-0.47***	-0.35***	0.75***	0.73***	0.74***
GDP	-0.36***	-0.42***	-0.33***	0.74***	0.73***	0.74***
CPI	-0.27***	-0.33**	-0.38***	0.74***	0.72***	0.74***
ULC	-0.37***	-0.41***	-0.41***	0.75***	0.74***	0.75***
PPI	-0.27***	-0.33**	-0.50***	0.75***	0.73***	0.77***
EXD	-0.36***	-0.41***	-0.40***	0.76***	0.74***	0.76***
<i>Foreign demand measured by weighted average of real imports of goods and services (IMPW)</i>						
	OLS (FE)	P-DOLS	GM-DOLS	OLS (FE)	P-DOLS	GM-DOLS
DTS	-0.25***	-0.31*	-0.38***	0.77***	0.75***	0.79***
GDP	-0.24***	-0.28*	-0.35***	0.77***	0.75***	0.80***
CPI	-0.11	-0.16	-0.36***	0.77***	0.75***	0.79***
ULC	-0.25***	-0.28**	-0.39***	0.77***	0.75***	0.80***
PPI	-0.14**	-0.19	-0.49***	0.78***	0.75***	0.81***
EXD	-0.27***	-0.30**	-0.49***	0.78***	0.76***	0.82***
<i>Foreign demand measured by volume of global trade (WT)</i>						
	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***
GDP	-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***

Note: For the OLS(FE) estimates, robust variances according to [Driscoll and Kraay \(1998\)](#) are used to evaluate the statistical significance. ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. P-DOLS and GM-DOLS estimations include two leads and lags of the first differences of the explanatory variables.

Table 3: Long-term elasticities in 18 advanced economies estimated over the period from 1975Q1 to 2015Q1 for various specifications (*Panel II*)

	Price elasticity			Income elasticity		
<i>Foreign demand measured by aggregate real GDP (GDPS)</i>						
	OLS (FE)	P-DOLS	GM-DOLS	OLS (FE)	P-DOLS	GM-DOLS
DTS	-0.23***	-0.28**	-0.37***	1.88***	1.88***	1.90***
GPD	-0.30***	-0.32***	-0.34***	1.89***	1.88***	1.91***
CPI	-0.22***	-0.28**	-0.41***	1.88***	1.88***	1.91***
EXD	-0.21***	-0.24*	-0.58***	1.89***	1.88***	1.87***
<i>Foreign demand measured by weighted average of real GDP (GDPW)</i>						
	OLS (FE)	P-DOLS	GM-DOLS	OLS (FE)	P-DOLS	GM-DOLS
DTS	-0.20***	-0.24	-0.40***	2.17***	2.16***	2.22***
GPD	-0.27***	-0.29**	-0.36***	2.17***	2.17***	2.22***
CPI	-0.19***	-0.24	-0.44***	2.16***	2.16***	2.22***
EXD	-0.17***	-0.19	-0.61***	2.18***	2.16***	2.18***
<i>Foreign demand measured by aggregate real imports of goods and services (IMPS)</i>						
	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***
<i>Foreign demand measured by weighted average of real imports of goods and services (IMPW)</i>						
	OLS (FE)	P-DOLS	GM-DOLS	OLS (FE)	P-DOLS	GM-DOLS
DTS	-0.32***	-0.36**	-0.51***	0.99***	0.98***	1.00***
GPD	-0.37***	-0.39**	-0.44***	0.99***	0.98***	1.00***
CPI	-0.26***	-0.30	-0.52***	0.98***	0.98***	1.00***
EXD	-0.26***	-0.27*	-0.69***	0.99***	0.98***	1.00***

Note: See note for Table 2.

the particular indicator used, a 10% deterioration in price competitiveness reduces real exports by 3.1% to 4.3% in the long term. These values do not appear grossly implausible. Thus, the estimates do not give cause to discard any of the indicators.¹³ We furthermore observe that the estimation results for the long-run price elasticities are fairly robust across the different estimators used. However, the choice of foreign activity proxy exerts some influence on the estimated price elasticity coefficient. In most cases, however, these coefficients remain in a highly plausible range.¹⁴ The estimated price elasticities for *Panel II* (Table 3) are qualitatively similar to the ones obtained for *Panel I*, but somewhat more dispersed across the different estimators.

6 Relative forecast accuracy based on repeated sampling approach

The previous section provided some evidence that the CPI does not share a long-run relationship with real exports. However, the results were less informative with regard to whether any of the other competitiveness indicators are superior to the remaining ones. To shed more light on this issue, we compare the forecast accuracy of models based on the different indicators. This part of the analysis is based on *Panel I*, since *Panel II* lacks data for two of the competitiveness indicators.

In typical *ex post* forecasting exercises, a sample is split into two parts in an *ad hoc* fashion or at the time of a specific economic event. The model is estimated over the first part of the sample. The second part of the sample is reserved to check how well the forecasts obtained from the estimated model compare with the realised values of the dependent variable. One fundamental problem presented by this kind of analysis is the often arbitrary choice of the estimation and the forecast window upon which the relative forecast quality of the models might ultimately hinge.

To avoid such an arbitrary sample split, we make use of leave-one-out cross-validation and repeated sampling techniques.¹⁵ In the leave-one-out cross-validation analysis conducted below, the full sample is split into t different training (or estimation) samples, each containing $t - 1$ observations per cross-section unit, and a testing (or, in our case, forecast) sample, which contains just the remaining observation (for each individual cross-section unit). This approach can be properly applied in a cointegration framework in which all variables are observed at the same point in time, and no leads or lags of variables enter the long-run relationship. A model containing leads and lags would complicate the analysis considerably since we could not simply leave out individual observations.

the variables do not seem to be cointegrated.

¹³The differences among the estimated income elasticities are, as anticipated, quite large for the different real activity measures. Based on the simple panel fixed effects OLS regressions, the only scenario in which unit income elasticity could not be rejected is if the weighted imports of the partner countries served as the proxy for real external activity and if *Panel II* was considered.

¹⁴An exception to these results is constituted by some specifications in which foreign activity is measured by the weighted average of the GDP of the partner countries. In that case, we observe somewhat larger differences in the estimated long-term price elasticities for the different estimators. Moreover, OLS(FE) and P-DOLS estimates of the price elasticity all turn out to be rather small in absolute value.

¹⁵A recent application of this kind of technique with regard to panel data is provided in [Herwartz and Xu \(2009\)](#).

The model is estimated over the t different samples and forecasts are conducted for the respective omitted observation. The procedure is repeated until each observation has been omitted from the estimation period once and real export predictions \hat{x}_{it} for this omitted observation have been obtained. The mean absolute forecast error of the respective model across the entire observation period and across all countries is calculated as $MAE = \frac{1}{NT} \sum_{i=1}^N \sum_{t=1}^T |\hat{x}_{it} - x_{it}|$. Given that $N = 20$ and $T = 76$, we thus calculate the arithmetic average of $N \cdot T = 20 \cdot 76 = 1520$ absolute forecast errors. This procedure is repeated for all of the models based on the different competitiveness indicators in order to pave the way for a comparison of the mean absolute forecast error of the various models.

The results of this analysis are shown in Table 4. For ease of exposition, 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 case in which the volume of global trade approximates foreign demand, 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 1.5% to 3% higher if use is made of the EXD, GPD or DTS instead. Opting for either the CPI or PPI-based indicator leads to increased forecast accuracy losses, with the forecast error going up by around 6% to 6.5% compared with the reference model.¹⁶

¹⁶The choice of the foreign demand variable, however, has an even greater impact on forecast quality. Generally, the forecast accuracy based on models in which foreign demand is approximated by the world trade volume is higher than for models using one of the other proxy variables for foreign activity.

Table 4: Comparison of forecast accuracy (*Panel I*)

	MAE	Relative to Benchmark
<i>Foreign demand measured by aggregate real GDP (GDPS)</i>		
DTS	0.07992882	2.30%
GPD	0.07949495	1.74%
CPI	0.08043896	2.95%
ULC	0.07813338	0.00%
PPI	0.08030186	2.78%
EXD	0.07856027	0.55%
<i>Foreign demand measured by weighted average of real GDP (GDPW)</i>		
DTS	0.08041020	0.67%
GPD	0.08039886	0.65%
CPI	0.08000258	0.16%
ULC	0.07987842	0.00%
PPI	0.0802391	0.45%
EXD	0.07992898	0.06%
<i>Foreign demand measured by aggregate real imports of goods and services (IMPS)</i>		
DTS	0.06419866	2.79%
GPD	0.06377969	2.12%
CPI	0.06560101	5.03%
ULC	0.06245683	0.00%
PPI	0.06590707	5.52%
EXD	0.06288548	0.69%
<i>Foreign demand measured by weighted average of real imports of goods and services (IMPW)</i>		
DTS	0.06635740	2.08%
GPD	0.06610722	1.70%
CPI	0.06671018	2.62%
ULC	0.06500435	0.00%
PPI	0.06684141	2.83%
EXD	0.06529868	0.45%
<i>Foreign demand measured by volume of global trade (WT)</i>		
DTS	0.06326273	3.12%
GPD	0.06275927	2.30%
CPI	0.06492946	5.83%
ULC	0.06135079	0.00%
PPI	0.06525002	6.36%
EXD	0.06227969	1.51%

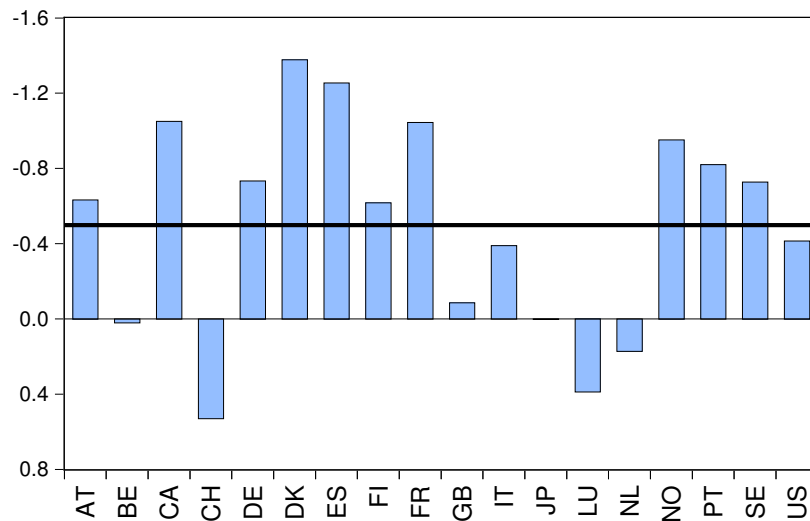
Note: The table shows the mean absolute forecast error of each of the models in the second column, calculated as the arithmetic average of $N \cdot T = 20 \cdot 76 = 1520$ absolute forecast errors. These are obtained by repeatedly dropping one observation per country, re-estimating the model with OLS(FE), and forecasting the excluded observation. In the third column, the relative deterioration (in per cent) of the respective model compared to the reference model (which thus has the value 0.00%) is presented separately for each of the five foreign activity variables. *Panel I* is used since data on PPI and ULC is missing for *Panel II*.

7 Cross-country dispersion and temporal stability

In this section, we analyse the sensitivity of the estimation results along two dimensions. First, we check the heterogeneity of the long-run price elasticity across countries. Second, we analyse the stability of the results over time. We only present results for *Panel II* because the (country-specific) number of degrees of freedom is considerably lower in *Panel I* than in *Panel II*. This should be particularly pertinent when performing country-specific cointegration analyses.

Figure 2 exemplarily shows country-specific DOLS (2,2) estimation results for a specification involving the DTS as indicator variable and the sum of real imports of the partner countries as foreign activity proxy.¹⁷ While we observe a substantial degree of heterogeneity regarding the point estimates, we find that the estimated long-run price elasticity carries the expected negative sign in 14 out of 18 countries. Incidentally, the graph reinforces the importance of having checked the robustness of the the estimated long-run price elasticities with regard to relaxing the homogeneity restriction by comparing the OLS(FE) and the P-DOLS results, respectively, with the GM-DOLS results.

Figure 2: DOLS price elasticity estimates for 18 countries from 1975Q1 to 2015Q1 (*Panel II*): country-specific vs. group mean

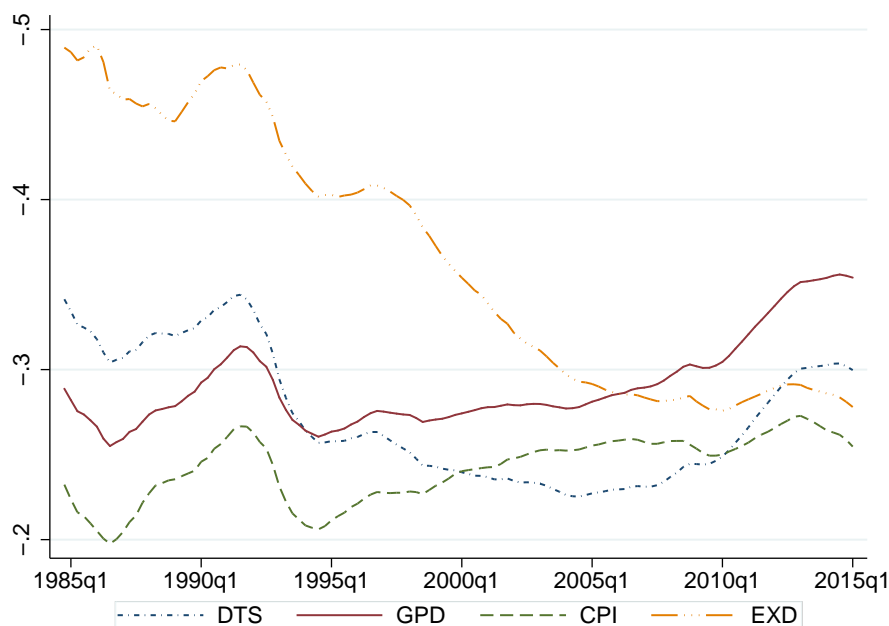


Note: The figure shows country-specific DOLS estimation results of the long-run price elasticity and the respective group mean estimate (bold horizontal line). The DOLS and the GM-DOLS regressions include two leads and lags of the first differences of the regressors. The estimation sample spans 1975Q1 to 2015Q1, the indicator based on total sales measures price competitiveness, the sum of real imports of the partner countries serves as proxy for external activity. For half of the 18 countries (DE, FI, GR, IE, IT, DK, SE, GB, and NO) the estimated coefficients are insignificant at the 5% level. For CH, the coefficient is significant, albeit with an implausible positive sign.

¹⁷The choice of this specification is motivated by two previous results in this study. Regarding the choice of the competitiveness indicator this study suggests using broad cost- or price-based indicator such as DTS (ULC, for instance, is not available in *Panel II*); regarding the choice of the foreign activity proxy, the results suggest using the world trade volume, which is not available for *Panel II*, however. We regard the sum of real imports of the partner countries as the closest substitute for this (actually preferable) variable, and therefore employ it in this part of the analysis.

Figure 3 depicts recursively estimated long-term price elasticities based on four different indicators (DTS, GPD, CPI, EXD) starting from the estimation window 1975Q1 to 1984Q1 (ie 40 observations per country). It can be observed that the estimated price elasticities are reasonably stable over time, the only exception being those based on EXD. Furthermore, and despite the widespread notion that price elasticities have decreased with the rise of global value chains, they seem to have increased lately, particularly since the onset of the financial crisis.

Figure 3: Recursively estimated long-run price elasticities of real exports (*Panel II*)



Note: The figure shows recursively estimated long-run price elasticities for four different indicators of price competitiveness based on panel fixed effects regressions. The start estimation window of the recursive analysis is 1975Q1 to 1985Q1. The estimated price elasticity is plotted for the last quarter of the estimation window. Data on ULC and PPI is not available for *Panel II*.

8 Conclusions

Based on a panel cointegration and repeated forecasting analysis encompassing up to 20 advanced economies, we find broad price- and cost-based indicators of price competitiveness, such as real exchange rates based on GDP deflators, deflators of total sales, or ULC for the total economy, to be better suited to predict real exports of advanced economies in the long run than narrow indicators, such as PPI- or CPI-based real exchange rates. Thereby, the results reinforce the conceptual advantages of broad indicators, which are also addressed in this paper. Furthermore, the evidence suggests that long-run price elasticities have increased since the onset of the financial crisis, which is somewhat in contrast to the widespread perception that they have decreased due to the rise of global value chains. It will require further studies to identify the reasons behind this observation.

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