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Compendium on the diagnostic toolkit for competitiveness

CompNet The Competitiveness Research Network

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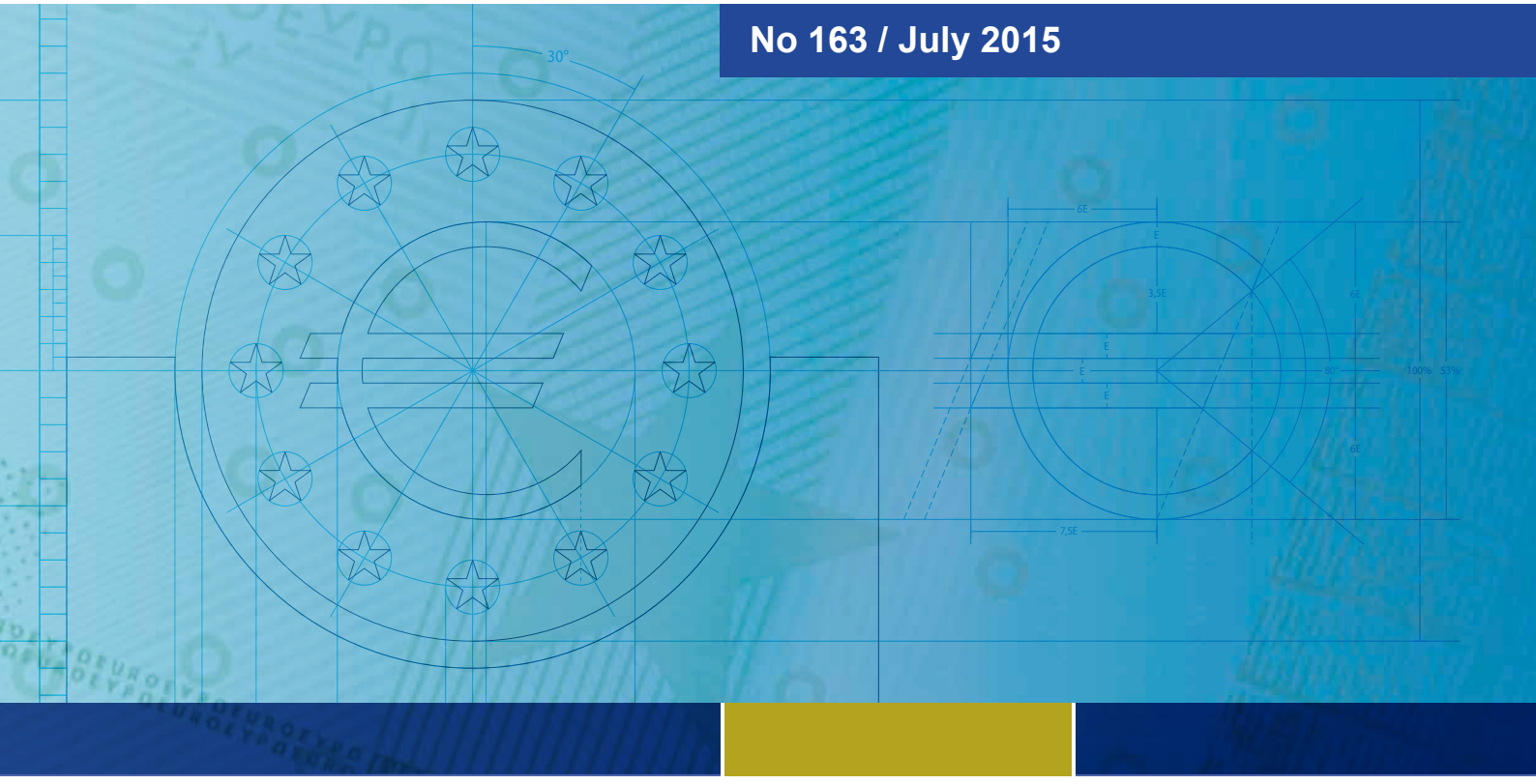

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Abstract

This Compendium describes the contribution of CompNet to the improvement of the analytical framework and indicators of competitiveness. It does this by presenting a comprehensive database of novel competitiveness indicators. These are more than 80 novel indicators designed by CompNet members that capture macro, micro and cross-country dimensions, thus providing a comprehensive view of the competitive position of EU countries and their peers. A short description of each innovative indicator – consisting of the motivation for use, an intuitive explanation of the methodology and a list of advantages and drawbacks – helps the reader to better understand the use of the novel variables. On the analytical side, issues related to the definition of competitiveness are discussed and the empirical evidence on the link between competitiveness indicators and policy objective variables such as real GDP per capita and external trade performance is presented.

JEL-codes: F14, F41, F60, D24, E31

Keywords: Price/non-price competitiveness indicators; measuring competitiveness; determinants of competitiveness

Non-technical summary

The objectives of the Competitiveness Research Network (CompNet) have been to improve the existing analytical framework and indicators of competitiveness and establish a solid connection between competitiveness drivers on both micro and macro levels. At the same time, CompNet considers the globalisation and fragmentation of production at world level to constitute CompNet's third pillar, and as such the purpose of CompNet is to bridge the gap between all relevant levels of analysis: **macro, micro and cross-country** at world level.

Competitiveness is regarded as a comprehensive and multidimensional concept, as it is related to the traditional measures of price/cost advantages and also to other factors such as firm-level characteristics, structural and macroeconomic factors, and international production networks. Competitiveness is considered to be a policy objective, and this Compendium identifies **GDP/capita as** the most appropriate "anchor variable" for competitiveness analysis in an open economy. However **productivity and export market shares** are also considered intermediate "anchors".

One of the main outcomes of CompNet has been the building of innovative indicators that are essential in going beyond traditional price-based measures in understanding short and medium-term trends in competitiveness. This has resulted in the creation of a comprehensive database of innovative and traditional indicators of competitiveness called the "Diagnostic Toolkit for Competitiveness". The Toolkit comprises more than 80 novel indicators based on disaggregated trade, firm-level and input-output data, which facilitates the analysis of various dimensions of competitiveness.

This Compendium provides policy-makers with guidance on the identification of specific weaknesses/strengths in the area of competitiveness, allowing them to adopt the most appropriate measures that would have the maximum effect on the policy objective. The following variables appear to be consistent with the criteria outlined above and should therefore be used for policy-oriented competitiveness analysis: price and cost competitiveness; external performance; quality of institutions and governance; and firm-level indicators.

When considering the role of alternative competitiveness indicators, it is not possible from an empirical standpoint to establish a general ranking of the explanatory power of the different harmonised competitiveness indicators (HCIs) that are traditionally computed. Country-specific analysis is therefore warranted. However, in the current context of the increasing internationalisation of firms' production processes, measuring price competitiveness based solely on unit labour cost (ULC) developments risks conveying misleading signals, as the contribution of other production cost components to a country's export performance is ignored. Structural reforms should better address all production cost items in order to ensure a sound improvement in firms' ability to compete internationally. Moreover, given the rising weight of services in the total economy, the degree of competitiveness of non-tradable sectors is becoming ever more relevant in explaining trade flows. Policy action addressed at loosening restrictive regulation and reducing administrative

burdens in the services sector would also boost trade. Finally, alongside price competitiveness, non-price factors have become crucial determinants of export growth in many euro area countries. Productivity-enhancing structural reforms are therefore warranted to stimulate trade performance, both directly via the non-price channel and indirectly via the price channel.

1 Introduction

The Competitiveness Research Network (CompNet) was established in March 2012 with the objective of improving the existing framework and indicators of competitiveness and subsequently establishing a solid connection between competitiveness drivers and the resulting outcomes. To this end, CompNet has adopted a broad-based approach to competitiveness, which consists not only of looking at macroeconomic developments but also, at microeconomic level, of using firm-level data and aiming to build a bridge between micro and macro analysis. Moreover, in order to take into consideration the globalisation and fragmentation of production at world level, global value chains (GVCs) constitute CompNet's third pillar.

One of the main outcomes of CompNet since its creation has been the building of innovative indicators that are essential in going beyond the traditional price-based measures in understanding short and medium-term developments in competitiveness. This has resulted in the creation of a comprehensive database of innovative and traditional indicators of competitiveness called the "Diagnostic Toolkit for Competitiveness".

The purpose of this document is to give a detailed description of the innovative, and some more traditional, indicators included in the Toolkit database. A set of boxes on particular topics complement this description and illustrate the use of some of these indicators, their practical contribution to the understanding of competitiveness and, last but not least, their possible application in the policy-making process.

This Compendium is addressed to a broad public, spanning public and private institutions, financial institutions, universities and research centres and more generally anyone who wishes to analyse competitiveness from multiple angles, to identify strong and weak points in competitiveness and to make concrete policy proposals. The ultimate aim is to contribute to and support the design of adequate policies to enhance economic performance through the identification of the drivers behind the competitive position.

2 The diagnostic toolkit for competitiveness: a broad-based approach

2.1 Multidimensional nature of competitiveness

Enhancing competitiveness is one of the main goals of economic policy, but the term "competitiveness" remains a rather vague concept, lacking an unequivocal definition. This Compendium regards competitiveness as a comprehensive and multidimensional concept, in line with the definition stated by ECB President Mario Draghi:[1] *"A competitive economy, in essence, is one in which institutional and macroeconomic conditions allow productive firms to thrive. In turn, the development of these firms supports the expansion of employment, investment and trade."*

This definition highlights the fact that competitiveness is related to more than the traditional measures of price/cost advantages. Elements such as relative prices, costs, wages and exchange rates are indeed important in determining the ability of firms to compete in international markets, but there is strong evidence that other factors also contribute significantly: firm-level characteristics, in particular productivity; country-specific structural and macroeconomic factors; and integration into global value chains and international production networks.

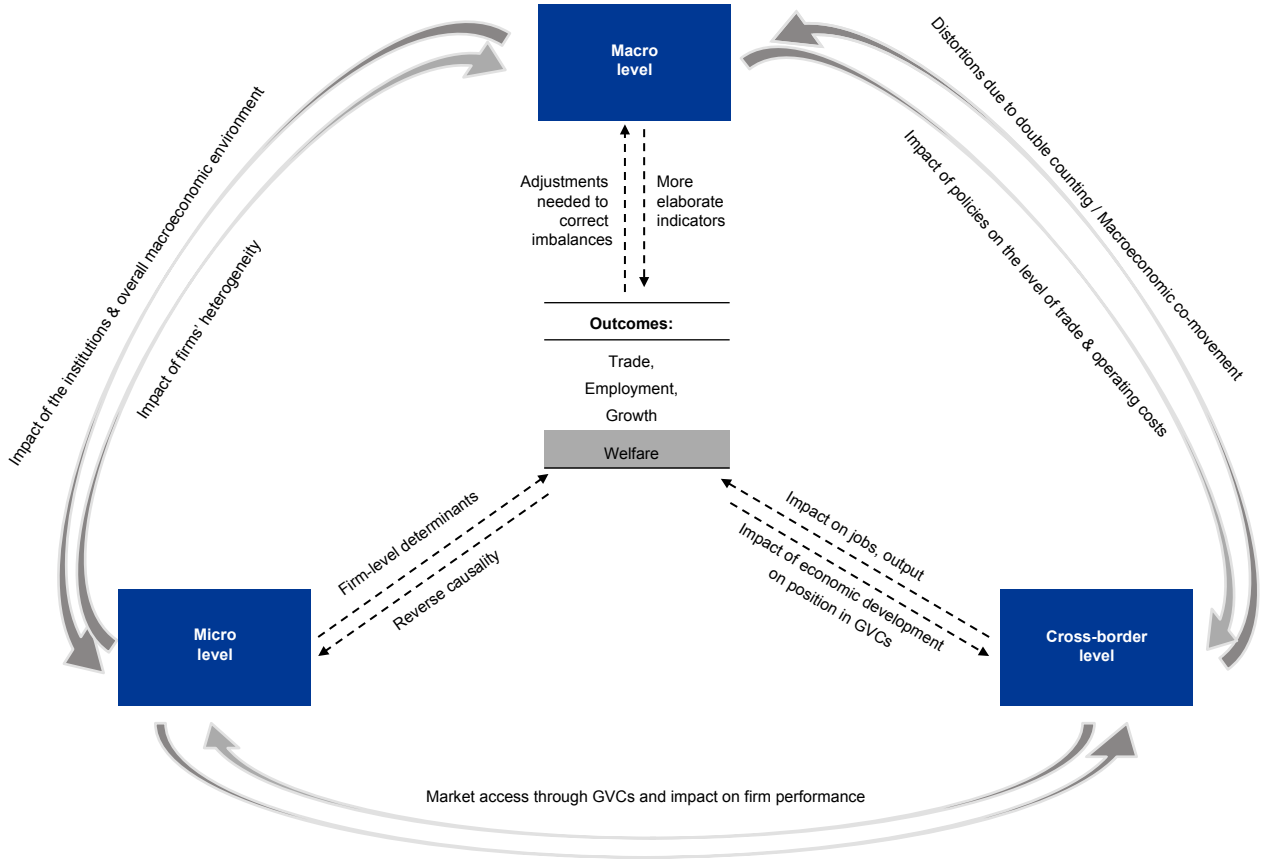
While the analysis of competitiveness has traditionally focused mostly on the macro dimension, the purpose of CompNet is to bridge the gap between all relevant levels of analysis: **macro, micro and cross-country**. Chart 1 illustrates a set of possible links across these dimensions, for instance: (i) the macro level markedly affects the micro one, as it determines the institutional and overall macroeconomic environment in which firms operate; (ii) given the macroeconomic environment, firms take decisions, including with regard to internationalisation, such that the micro level is crucial to understanding the drivers and implications of cross-border activity and (iii) the increased integration into GVCs impacts the macro level, as it causes spillovers among countries and produces vulnerability to shocks and possible co-movements in macro variables across countries.

Following this approach, based on multiple and intertwining levels of economic analysis, this paper suggests that competitiveness analysis, which might also provide policy options to specific questions, should include different analytical levels. Generally, when analysing competitiveness of a specific country, one should first set the stage by looking at **macro indicators** that convey information on the business cycle and show the symptoms of structural problems (e.g. GDP and, unemployment rate) and trade outcomes (current account, growth in exports/imports

[1] Speech of 30 November 2012: "Competitiveness: the key to balanced growth in monetary union", http://www.ecb.europa.eu/press/key/date/2012/html/sp121130.en.html

Chart 1

The CompNet approach to competitiveness assessment



Source: ECB (2013), "Competitiveness Research Network: First Year Results"

and real effective exchange rates, REERs). The next step would be to look at more structural macro factors, including both standard indicators (e.g. related to external trade, the effectiveness of the government, the composition of GDP, potential growth) and also novel indicators, presented in this Compendium, which are derived from highly disaggregated external trade data. Using and studying disaggregated data enables the details and representativeness of the indicators included in this Compendium to be better identified. A typical example is the calculation of non-price competitiveness indicators: here, data from UN Comtrade are used, distinguishing between 5,000 different product categories to derive a unit value measure for the specific product categories and thus arriving at indicators that contain meaningful non-price information. Once the main features of the macro environment have been assessed, one can "zoom in" by looking at **firm-level data**. The advantage of using firm-level data over macro indicators is that they offer information on the distribution of relevant indicators such as productivity, firm size and turnover and as such enables the heterogeneity of the population of firms across and within sectors and countries to be accounted for. An important advantage of the Toolkit is the relatively high cross-country comparability of firm-level data indicators. Usually, cross-country firm-level analysis is hindered, as indicators are often not comparable given that they refer to different periods or methodologies or use different variable definitions.

Moreover, firm-level data is not easily available, and firm-level-based analysis of competitiveness has remained restricted to national level. To overcome these limitations, CompNet has launched a harmonised protocol to process the firm-level data available in the central banks which are members of this research network. The outcome is a set of indicators (such as productivity and unit labour cost) aggregated to industry level to preserve confidentiality but preserving the richness of firm-level information.

The next step in analysing competitiveness of a specific country is to go beyond national borders and analyse firms' internationalisation and trade outcomes through the lens of **GVC data** on the international breakdown of income generated within the global production networks. A broader analysis, such as that performed within CompNet, points to the importance of understanding the implications of integration into global value chains for the overall assessment of competitiveness. First, some recent case studies – of which the one performed by Linden et al. (2009) on iPod is perhaps the most famous – suggest that the share of domestic value added in exports could be very small. Internationalisation of production leads to a diminishing domestic component in exports; therefore data on (gross) export flows are no longer an adequate representative of a country's competitiveness. As noted by Di Mauro et al. (2013), the role of GVCs is also growing for European countries. In an economically integrated world characterised by global production chains, the determinants of inclusion in cross-border value chains and of the income generated through this type of trade might differ from those impacting the "traditional" trade in end-products. One can question how big a country's value added share of the products it sells in international markets is. And how is competitiveness affected by the change in the share of this value added as a result of changes in international fragmentation? In-depth studies using GVC data can thus provide useful information for studying both trade patterns and domestic value added. These novel indicators represent a major asset for analysis, as they indicate the extent to which gross trade generates income for the domestic economy and to the extent to which this is owing to participation in cross-border supply chains and/or the "competitiveness" of the economy.

Finally, as a relative concept, a country's competitiveness can be inferred not only by looking at the dynamics of its trade outcomes, but also by comparing it with a suitable comparison group. In this way, it is possible to pinpoint the areas where there is room for improvement or where action is needed and, in turn, elaborate a more comprehensive policy plan.

2.2 Competitiveness and its potential determinants: an intuitive justification

The Toolkit comprises more than 80 novel indicators based on disaggregated trade, firm-level and input-output data, which facilitates the analysis of various dimensions of competitiveness (a complete list of all novel and traditional indicators and their sources can be found in the appendix). There is to some extent an overlap between indicators covering similar domains. Also, not all indicators are equally suited to a given question. The choice of which indicator to use depends on the goals and

the question considered by the analyst. The availability of multiple, and sometimes alternative, measures enriches the Toolkit and more importantly enables messages and conclusions to be cross-checked. Furthermore, contradicting information from such "potentially overlapping" indicators can in itself point to structural features that warrant deeper investigation. It is acknowledged that each indicator has limitations when taken separately, for instance caused by underlying theoretical assumptions or by the data quality and collection method, as in the case of survey-based data. However, this does not mean that they lose relevance, since they shed light on specific aspects of competitiveness. The combined study of these indicators can add significant value and bring new insights to long-discussed topics.

Most of the innovative indicators described in this Toolkit are not observed data but instead rely on models, assumptions and approximations. Therefore a wide range of potential indicators of trade competitiveness enable us to cross-check the conclusions of any analysis based on the traditional and innovative indicators, reducing the likelihood of reaching erroneous conclusions.

2.2.1 Traditional indicators

The set of traditional indicators captures various aspects related to economic performance, the structure of the economy and the institutional environment. The indicators are classified according to different categories, including variables pertaining to the macroeconomic environment, the labour market, international trade, the financial sector, prices and costs, human capital and innovation, basic infrastructure and the institutional and legal framework. The list of traditional indicators cannot be exhaustive. A large number of traditional macroeconomic indicators (although not exhaustive) are included in this Toolkit. While most of these are publicly available, they are included in this Toolkit (see Appendix A.2.2) to facilitate competitiveness analysis.

2.2.2 Novel CompNet indicators

On the **aggregate or macro side**, the database contains a number of non-traditional indicators that go over and above the traditional price and cost measures. The aim of these indicators is to complement the traditional price/cost measures (e.g. non-price competitiveness; product and geographical specialisation; and competitiveness pressure) and establish a solid theoretical and empirical connection between indicators and policy conclusions. Moreover, the various measures of "non-price" competitiveness factors aim to provide a comprehensive view of the competitive position of EU countries and their peers focusing on the following dimensions: (i) export sophistication; (ii) competitive pressures from other countries; (iii) revealed comparative advantage (by industry, product, etc.); (iv) inter/intra-industry trade; (v) extensive/intensive margins; (vi) relative export prices adjusted for quality; and (vii) market share breakdown into price and non-price factors. A short description of each innovative indicator, as well as boxes describing its use in practice, help the reader to better understand the definition and the use of the innovative variables.

On the **micro side**, it is now widely acknowledged that policy analysis aimed at enhancing competitiveness may greatly benefit from firm-level evidence. In fact, there is a solid theoretical underpinning for using firm-level data in competitiveness analysis. The classical reference is Melitz (2003), with the assumption that a distribution of firms' productivity is not symmetric around the mean. Empirical literature for both the United States (Bernard et al., 2012) and a number of EU countries (Mayer and Ottaviano, 2008) has confirmed that, in general, firm-level productivity is typically distributed following an asymmetric probability distribution.

In turn, this supports (i) an emphasis on removing market distortions in order to favour resource reallocation towards the most productive firms as a means of increasing aggregate productivity, as well as (ii) the need to move away from merely considering average performance – which can be misleading – and to analyse the full underlying productivity distribution instead.

The availability of micro-founded data has until now remained inadequate for meaningful cross-country analysis. The main feature specific to the CompNet database, significantly differentiating it from others and addressing the existing shortcomings, is that the database includes a number of countries with fully compatible and comparable data, creating scope for cross-country comparisons. The database currently comprises firm-level indicators on productivity, labour costs, employment, firms' financial positions, credit constraints and export status determined in fully harmonised fashion based on a large sample of about 150,000 firms per country and year, operating across 58 sectors and 17 EU countries and for a period of 18 years (the number of years differs from country to country)[2].

The set of firm-level indicators is grouped into three clusters: (i) characteristics of firms in different tails of the productivity distribution, including some indicators of their financial position; (ii) full distribution of competitiveness-related indicators such as labour productivity, total factor productivity, labour costs and unit labour costs. The distribution of return on assets, as well as the distribution of collateral and an indicator of the share of credit-constrained firms, are also provided; and (iii) competitiveness-related indicators, including some information on the financial position of the firms, for exporting and non-exporting firms.

The **cross-border dimension** is the third dimension taken into account in CompNet's assessment of competitiveness. The emergence of GVCs has resulted in a reconfiguration of world trade in terms of participants and comparative advantages, which has direct implications for international competitiveness and labour market developments. However, standard trade indicators do not fully reflect the fact that economies are increasingly interconnected at all stages of the production chain. For that reason, CompNet has made efforts to update existing indicators based on a decomposition of value added into its domestic and foreign components, in order to map the impact of GVCs for Europe.

The set of GVC indicators is based on the World Input-Output Database, which combines information from national supply and use tables and bilateral trade in goods and services for 40 countries and 35 industries, over a time span from 1995 to 2011.

[2] For more information on the country samples and coverage, see Lopez-Garcia, Di Mauro et al. (2015).

3 Bridging the gap between research and policy

The Compendium first defines "anchors"…

Competitiveness is considered a policy objective[3], which presupposes a (direct or indirect) causality between the "policy tool(s)" and the all-encompassing competitiveness measure, i.e. the "target variable".

Competitiveness is typically applied to countries as a whole, rather than to individual firms and markets. It may thus be used as a synonym for a very precise concept (e.g. high income level, productivity), which facilitates its operational use both from an analytical point of view (e.g. which factors drive competitiveness, also understood as productivity) and a monitoring point of view (e.g. how is productivity evolving). At times, however, it is also used as a very broad term referring to various "desirable outcomes", or to properties that are thought to be conducive to desirable outcomes. As such, there is no one single approach to competitiveness that could be taken as the starting point for a policy assessment. In fact, one can identify many avenues currently focusing on productivity, trade, cost and price developments, quality of institutions and infrastructure, labour markets and investment, R&D and innovation, infrastructure, etc.

For these reasons, it is important to identify **"anchor(s)" or target variables of economic policy** around which competitiveness indicators can be organised. Such anchors would in turn help determine what constitutes a "competitiveness indicator" and how it should be interpreted. The anchors identified should thus be understood not as a new definition, but rather as forming a practical guideline for the implementation of a policy-oriented competitiveness analysis.

To be useful and practical, an anchor should be in the spirit of, and hence **compatible with, most competitiveness definitions.** It should also be a **measurable** and **country-specific** indicator[4]. Finally, it should be of a magnitude that policy-makers can affect using the tools they have at their disposal.

GDP/capita is ideally the most appropriate anchor variable for competitiveness analysis in an open economy for the following reasons:

1. It measures the living standard of a country, which is a central concern to policy-makers and is, hence, compatible with most definitions of competitiveness.

2. It is an absolute country-specific standalone measure that is not affected by the same measure in other countries.

3. It is a variable that policy-makers can potentially influence.

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[3] For instance, in a very recent document, the Ministers of Finance of Germany and France identified the objective of "promoting a competitiveness agenda at the national and EU level".

[4] In some cases it can also be continuous (not a binary yes/no-type indicator) and non-rivalrous (not a share of something).

However, using GDP/capita as a sole anchor variable for a policy-oriented competitiveness analysis and assessment also has some weaknesses. An increase in GDP/capita may occasionally mask either bad policies that should in no way be encouraged – such as unsustainable GDP growth driven by excessive indebtedness to finance consumption – or factors which are barely affected by policies (especially in the short run), such as demographic trends. It should therefore be understood as one objective within a long-term relationship of a large set of economic variables that determine the growth potential of a country/economy.

Based on the above, GDP/capita could be complemented by other intermediate anchors. **Productivity** and **export market shares** – which are not only widely used but may also be considered as having the advantage of better delimiting the concept of competitiveness – should also be used as intermediate anchors, although they may either overlook important aspects of competitiveness or, in the case of export market shares, be considered rivalrous.

Productivity reflects the ability of production factors to generate output, individually and in combination (total factor productivity, TFP). It is consequently a key driver of GDP/capita and can also be considered an additional factor. In fact, the available evidence has shown that the distribution of labour productivity across firms is highly dispersed and asymmetric, and that the most productive countries are those with the highest productivity dispersion[5].

Competitiveness ultimately is more closely related to the "ability to export" and is reflected in **export market shares,** which should be understood as a wider indicator for assessing the external performance of a country. This can be used for comparative analysis, e.g. when applied to a group of relatively homogeneous countries, while further breaking down export market shares (shift-share/constant market share analysis) may provide more useful information. Finally it can be a useful starting point in a comparative analysis (e.g. why did country A's market share change in different proportions than that of country B?)[6].

The proposed anchor, and the two intermediate ones, are in line with the CompNet approach to competitiveness assessment as presented in Chart 1 above, where welfare, trade, employment and growth gains are considered to be the outcomes of an improvement in competitiveness (see Section 2.1). Finally potential output could also be considered a superior anchor to GDP/capita, as it excludes any cyclical phenomena; however problems related to its measurement automatically exclude it from the list of anchors.

Other relative indicators (e.g. institutional/governance rankings) are important, but not sufficiently well suited as an anchor or policy objective. This is because they are not standalone indicators, i.e. the situation of a country depends on the results for other countries and cannot be convincingly related to country-specific policies. Paradoxically, a country with declining competitiveness may come *top* if other countries perform even worse.

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5 If TFP is used, one should take into consideration sensitivity problems related to the estimation techniques.

6 In a longer-term perspective, however, for advanced countries this indicator risks being biased, as new competitors may come on the international markets as barriers to trade at a global level are gradually lifted.

…then identifies the criteria for determining "competitiveness indicators"

Where a policy assessment of a country's competitiveness is to be carried out, consideration of a variable/indicator will depend on whether it has a direct or indirect impact on one or more anchors as defined above. Such a selection strategy would most likely not use all the innovative variables/indicators built into CompNet[7]. The excluded variables/indicators can, however, be extremely useful and informative when further analysis of the competitiveness assessment is carried out, and especially when policy measures related to the improvement of the selected anchors are discussed.

This Compendium provides policy-makers with guidance on identifying specific weaknesses/strengths in competitiveness, enabling them to adopt the most appropriate measures with the maximum impact on the policy objective. The guidance does not assess competitiveness with a view to producing a binary yes/no outcome, but rather as part of a permanent process of "perfectibility". This entails building a classification of different long-established consensuses on policy indicators related to competitiveness and complementing it with other factors pertaining to competitiveness: (i) micro data capturing firm heterogeneity and productivity distribution; (ii) GVC analysis; (iii) non-price competitiveness; and (iv) evidence on credit constraints, without ignoring the need to improve the institutional and macroeconomic environment underlying the business conditions[8].

A pragmatic and realistic grid that provides guidance and assists/supports the country analyst in doing his/her assessment would be useful in prioritising the areas to focus on or the indicators to start looking at. A policy-oriented competitiveness assessment could consist of a two-step procedure:

Step 1 – The application of the evaluation grid would help identify the key weaknesses and define an order of priority for the policy areas to be addressed. The grid would thus serve as a sort of enhanced competitiveness scoreboard, comparable with the one included in the Commission's Alert Mechanism Reports. This analysis would serve as a benchmark to identify the most/least likely drivers of competitiveness.[9]

Step 2 – It would then be up to each analyst to assess the specific weaknesses and resulting measures to be recommended for each economy. In-depth knowledge

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7 The scope of CompNet is multidimensional, and as such the development of new indicators was not necessarily aimed at exclusive use in policy analysis. As a result, some of the novel indicators may not be directly relevant for policy-oriented competitiveness assessment.

8 It is nowadays generally accepted that countries should improve their competitiveness and that the more competitive a country, the better. Against the background of such statements – which capture the connotation of "desirability" inherent in "competitiveness" – one could consider the following issues:
how a diagnosis of the present "state of competitiveness" of a country can be made and competitiveness can be measured;
how the evolution of competitiveness can be monitored over time;
what policy recommendations can be made with a view to improving competitiveness.

9 The results of a Bayesian model averaging (BMA) analysis (see Section 5.2) can also be very useful in such cases.

of each country is therefore an unavoidable requirement for proper policy-oriented analysis of competitiveness. To the extent that policy recommendations need to take account of the country-specific context, structural variables (which are not competitiveness indicators) will become relevant (e.g. country specialisation).

The following variables appear to be consistent with the criteria outlined above and should therefore be used for policy-oriented competitiveness analysis:

Price and cost-competitiveness

ULC-based REERs have to date been the indicator of competitiveness most used by macroeconomists. The interpretation is that a decline in these rates reflects improvements which should ultimately pay out in higher exports and growth, as products become cheap enough to be attractive again, provided that lower costs are passed through to prices. However, one should refrain from overly mechanical interpretations: if factors such as bad institutions and governance lead to a crisis, this would show up as a "competitiveness gain" if labour shedding produces an ULC decrease. Likewise, if deflation/"lowflation" pressures drive down REERs, this would also hardly be in the spirit of a competitiveness gain – although the competitiveness gain could represent a mitigating factor. In the same vein, traditional ULC-based REERs do not account for inter-sector shifts of resources, simply classifying the latter as intra-sector ULC movements (see Table 1, A and B).

External performance

A large number of indicators can be classified under the heading of export performance. A criticism with regard to export performance, however, is that the bulk of exports are carried out by a minority of firms, which are typically more productive, larger and more profitable than the others. This implies neglecting the majority of firms that service the domestic market, unless they indirectly contribute by participating in the production chain of the goods to be exported. As a result, some macroeconomic indicators (e.g. economy-wide deflators) may prove too blunt to capture the situation of exporters. A number of indicators aim to capture specific features of the export structure, such as concentration/specialisation, intrinsic quality, technology content, import content (GVC indicators more generally), import similarity (intra-industry trade, IIT), etc. These indicators cannot be easily and unequivocally linked to the anchors defined above. They are, however, very interesting in their own right and from a research perspective, as well as in analysing the structural features of an economy and facilitating the targeting of structural reform necessary for countries. Moreover the firm-level database that is being developed under CompNet could prove very useful in this respect, especially if available for some of the variables reviewed below (see Table 1, C).

Quality of institutions and governance

The quality of institutions can be also related to GDP/capita, both conceptually and empirically. By setting the framework within which firms operate, it also determines the state of intermediate competitiveness variables, such as productivity. For example, strong competition authorities deter firms from engaging in anti-competitive behaviour, and this fosters productivity and innovation.

The same is ultimately also valid for the quality of the education system and for the quality of infrastructure, which could also be considered as competitiveness indicators, given that their improvement would lead to higher living standards.

For the purposes of operational implementation, however, it is important to identify objectively measurable features of high-quality institutions that can be related to policy tools (as discussed above, rankings can only be useful as complementary indicators). The OECD's product market reform/regulatory reform indicators (which assume the existence of an "optimum" structure) may be useful in that respect (see Table 1, D and I).

Firm-level indicators

CompNet has been developing very important new indicators of firm-level data concerning productivity, cost, labour and credit constraints. All of these data can be used not only to analyse developments but also to improve the understanding of structural issues(see Table 1, A, E, F).

Table 1

A policy-oriented evaluation grid for competitiveness

Competitiveness taxonomy	Specific variables	Key features
A) Cost competitiveness	ULC-deflated harmonised competitiveness indicators	*Traditional indicator*
	Sector ULC-based REERs (EC)	*Controls for changes in the structure of the economy and the evolution of ULCs across sectors*
	Firm-level ULCs (NEW)	*Firm-level data/distribution, skewness, median, average, etc. – available for 17 countries*
	Other cost measures (energy, capital, housing/rental prices, intermediate input prices, etc.)	*Capture specific cost components*
	TWULC	*Weights the sector-specific unit labour costs in accordance with that sector's weight within a country's exports*
B) Price competitiveness	Harmonised competitiveness indicators (deflated by HICP, GDP deflator, PPI)	*Traditional indicators covering the full cost structure and profit margins in tradable and possibly non-tradable sectors (which provide inputs to exporters)*
	Relative export prices adjusted for quality and taste (NEW)	*Measures both price and non-price competitiveness, i.e. it also captures also changes in quality of exports and shifts in consumer tastes/based on "euro per unit of utility" definition*
	Export price assortativity (NEW)	*Relative price indicator showing whether a country competes with countries with higher, similar or lower prices*
C) External performance	Export growth	*Traditional indicator*
	Export market share changes (e.g. MIP)	*Traditional indicator of export market shares included in the EC Alert Mechanism Report*
	Export sophistication	*The sophistication level of a country's exports indicates whether a country specialises in the goods that high-income countries export, with potential implications for growth*
	Revealed comparative advantage (NEW)	*If the index is higher than unity, a country is considered to have a comparative advantage in the trade of a given good/service*
	Dynamic trade link analysis (NEW)	*Monitors the change in trade links of two exporting countries to a common destination market over time*
	Intra-/inter-industry trade (NEW)	*Accounts for the structure/composition of bilateral trade flows*
D) Quality of institutions/governance	Product Market Reform Indicators (OECD)	*Proxy for quality of institutions*
	Ease of doing business indicators (World Bank)	*Proxy for business climate*
	Worldwide Governance Indicators (World Bank)	*Proxy for quality of institutions*
	Global Competitiveness Index (World Economic Forum)	*Proxy for business climate/quality of institutions*
	Corruption perception (Transparency International)	*Proxy for business climate/quality of institutions*
E) Productivity	Labour productivity	*Traditional indicator*
	TFP (AMECO)	*Traditional indicator of factor productivity, proxied by Solow residual*
	Firm-level data (NEW)	*Firm-level data/distribution, skewness, median, average, etc. – available for 17 countries*
F) Financial constraints	Firm-level data on credit-constrained firms and their distribution (NEW)	*Firm-level data/distribution, skewness, median, average, etc. – available for 17 countries*
G) Global value chains	Participation in the global value chain (GVC) (NEW)	*Summarises the importance of the global supply chain for a country*
	Position in the global value chain (GVC) (NEW)	*Captures whether a country is upstream or downstream in the GVC*
H) Innovation capacity	Patent applications	*Summarises number of patent application in different areas*
	R&D expenditure	*Summarises R&D expenditure by sector*
	Quality of education system (e.g. PISA study)	*Evaluates the human capital*
I) Infrastructure (and miscellaneous)	Infrastructure	*Traditional indicators (e.g. WDI)*

4 CompNet novel indicators: motivation, description, added value

Below, the motivation behind individual non-traditional CompNet indicators is described, along with their underlying theoretical concepts and the advantages of using the new indicators.

4.1 Indices of revealed comparative advantages[10]

Indices of revealed comparative advantages (RCAs) have been used extensively in trade-related analysis to describe the nature of trade flows and the relative advantage of each country with respect to relevant classes of goods.

The RCA index was first proposed by Balassa (1965) and is based on a simple formula that uses the information embodied by the trade flows to capture the relative advantage or disadvantage of a certain country in the trade in a certain class of goods or services, as follows:

$$RCA_g = \frac{(x_{jg} / x_j)}{(X_g / X)} \quad (1)$$

where the nominator represents country *j* 's exports of commodity of interest $g(x_{jg})$ as a share of total exports of that country (x_j) and the denominator is world exports of the same commodity (X_g) as a share of total world exports (X).

According to this index, if the RCA is higher than unity, the country is considered to have a comparative advantage in the trade in that relevant commodity.

- The CompNet database includes a set of RCA indices useful for characterising the nature of trade flows of the countries of interest, based on the most detailed product disaggregation available in the Comtrade database. **RCA in exports of goods in high-technology industries**: The indicator uses the OECD classification of high-technology industries based on R&D intensity. These industries are aircraft and spacecraft, pharmaceuticals, office, accounting and computing machinery, radio, TV and communication equipment, and medical, precision and optical instruments (see OECD, 2003).
- **RCA in exports of goods in medium-high-technology industries:** This indicator is also based on the OECD classification and covers exports of electrical machinery and apparatus, motor vehicles, trailers and semi-trailers, chemicals excluding pharmaceuticals, railroad and transport equipment, and other machinery and equipment (see OECD, 2003).
- **RCA in exports and in imports of intermediate goods:** This index uses the classification of intermediate goods in line with that provided by the OECD STAN

[10] Based on Balassa (1965), Hatzichronoglou (1997), OECD (2003).

Bilateral Trade Database by Industry and End-Use (see OECD, 2014). The index may also shed light on the degree of involvement of each country in global value chains by exporting and/or importing goods which are further processed in a later production process.

Advantages of using this indicator

- It provides deeper insights into competitiveness compared with traditional RCA indices, by focusing on different technology levels of exports.
- It sheds light on a country's involvement in GVCs. Can be used together with GVC indicators such as the GVC participation index (see Section 4.10).

Caveats

- The OECD (2003) classification of high and medium-high-technology industries may be outdated for recent years in our sample.

4.2 Intra-/inter-industry trade[11]

Traditional trade indicators do not account for the **structure/composition of bilateral trade flows**, which are affected by ongoing trade liberalisation and regional integration initiatives. An increasing share of trade between countries falls into the category of intra-industry trade (IIT), which occurs when a country simultaneously exports and imports goods and services belonging to the same product category (or which are produced by the same industry). IIT has been **a prominent feature of European integration** and may have substantial macroeconomic significance, for example in terms of symmetry of trade shocks. The Grubel-Lloyd Index of intra-industry trade allows the importance of this phenomenon to be measured.

Description of the Grubel-Lloyd indicator

Intra-industry trade is defined as the **two-way exchange of goods of the same industrial classification**, as opposed to one-way (or inter-industry) trade, whereby countries exchange distinct products. It is most commonly measured by the *Grubel-Lloyd Index* (GLI), proposed in 1975, which captures **the intensity of trade overlap** in bilateral trade in a particular product (for instance, bilateral exchange in cars between Germany and France). The indicator is calculated for bilateral trade at the product level, using the following formula:

$$GLI_{i,j,k,t} = 1 - \frac{|X_{ij,k,t} - M_{ij,k,t}|}{X_{ij,k,t} + M_{ij,k,t}} \quad (2)$$

[11] Based on Brülhart (1994), Dautovic et al. (2014), Fontagné and Freudenberg (1997), Grubel and Lloyd (1975).

in which Xij,k,t (Mij,k,t) represents exports (imports) of a specific traded product *k* from (to) country *i* to (from) partner country *j* in period *t*.

It is then aggregated for the whole economy, weighted by the shares of the respective products and partners in total trade. The resulting index is bound between 0 and 1, where 1 indicates that all trade is of an intra-industry nature and 0 that all trade is of an inter-industry nature.

IIT can be broken down further into **horizontal and vertical IIT**. Horizontal IIT constitutes two-way trade in similar products with some different (minor) attributes (for instance, cars of similar quality and class), whereas vertical IIT represents simultaneous exports and imports of goods of different quality and price (for instance, designer jackets and low-quality, low-price jackets). The distinction is made according to the difference in unit values, which are used as a proxy for quality. IIT is considered to be of a horizontal nature if unit values satisfy the following equation:

$$\frac{1}{1+d} \leq \frac{UV_k^x}{UV_k^m} \leq 1+d \qquad (3)$$

in which UV_{kx} and UV_{km} represent unit values of exports and imports of product *k*, and *d* is a chosen dispersion factor. Following most existing studies, a dispersion factor of 15% is used. If the condition is not fulfilled, IIT is considered to be between vertically differentiated products.

The calculation of IIT is based on disaggregated trade data (HS six-digit) from UN Comtrade, e.g. by reconciling export and import figures, and it thus improves the geographical coverage and comparability of the latter.

Periodicity (annual) and coverage (from 1998 to 2012): three indicators (GLI, horizontal GLI, vertical GLI)

IIT's growing share of world trade indicates that countries are **increasingly producing within the same industries**. This is particularly the case for categories of manufactured goods. Horizontal IIT (trade in different varieties) enables countries with similar factor endowments to exploit economies of scale, thereby generating welfare gains for consumers, notably by providing them with a greater variety of products. On the other hand, vertical IIT (trade in different qualities) has developed among countries with different factor endowments. They specialise along the quality spectrum of a specific product, following the standard concept of comparative advantages.

A higher share of intra-industry trade, especially horizontal IIT, is an **indicator of converging trade patterns** and, in a broader sense, of real convergence across countries. It also appears to be a prominent feature in trade patterns of diversified economies with a higher level of industrial development, given the stronger presence of IIT in the manufactured goods category, and for countries with an advanced level of economic integration, such as within the EU, partly as a result of reduced transaction costs. Furthermore, according to the smooth adjustment hypothesis, IIT is associated with **lower adjustment costs** than one-way trade, for example in terms of human resources reallocation.

The broader macroeconomic implication of these trends can be seen in an **increased correlation between changes in exports and imports** of individual countries. Moreover, high shares of IIT, in particular of horizontal IIT, increase the similarity of countries' production structures and lead to the **synchronisation of business cycles and less asymmetric shocks** between trading partners. As a result, world trade may have become more volatile and sensitive to global economic developments, as confirmed by the 2008 crisis, and the international transmission of certain industry-specific shocks has accelerated.

Advantages of using this indicator

- It reflects the recent changes in trade patterns by accounting for both export and import developments and their interconnectedness.
- It represents an important indicator of economic convergence (in terms of factorial content of the traded goods) as well as of economic integration, leading to greater symmetry of shocks between trading partners.

Caveats

- Sensitive to the level of geographical and product aggregation.
- Double explanation of the majority flow in the GLI: The GLI accounts for the balanced part of the trade exchange only, whereas the remaining imbalanced part of the majority trade flow is registered as inter-industry trade. To avoid the empirical problem in interpretation, an alternative IIT index, e.g. as proposed by Fontagné and Freudenberg (1997), could be used.

The GLI represents a static indicator of IIT: in order to analyse the pattern of changes in trade flows over time, a more dynamic index of marginal IIT, e.g. as proposed by Brülhart (1994), could be employed.

Box 1

Internalisation of the automotive industry: European case

The automotive industry plays an important role in many European economies – both directly and indirectly – in terms of aggregate value added, trade flows and employment. The architecture of the industry has undergone profound changes worldwide in the recent decades, with important consequences, including for example a new European division of labour. These changes, which took place against the background of the expansion of global value chains (GVCs), in turn leading to an increase in intra-industry trade (IIT)[12], are well documented in the literature[13]; however, classical economic indicators (production, gross imports/exports), on which most competitiveness analyses are based on, fail to fully capture their economic implications. This box aims to provide

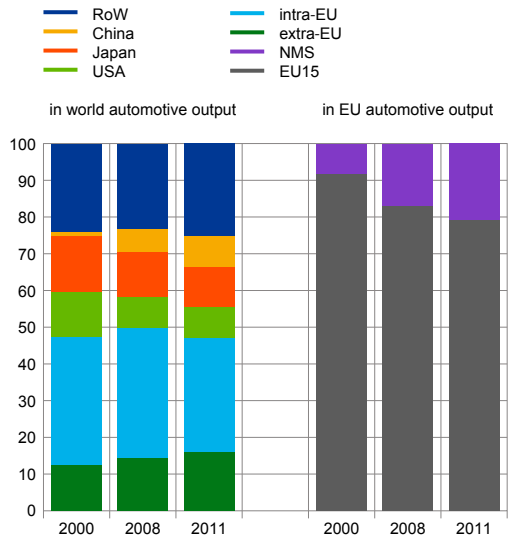
[12] See Section 4.10 for an explanation of global value chains and Section 4.2 for an explanation of intra-industry trade.

[13] See Carrillo et al. (2004), Holweg (2008) or Sturgeon et al. (2008), among others.

an overview of recent developments in the European automotive industry's competitiveness, building on methodologies that take into account the expansion of GVCs and the increase in IIT, in order to assess whether European automotive production is internalised, or, on the contrary, it is creating welfare elsewhere in the world.

Chart A

Share of exports



Sources: BACI and authors' calculations.
Notes: RoW refers to rest of the world; NMS refers to all EU countries that entered the EU after May 2004; EU15 refers to the remaining EU Member States.

Between 2000 and 2008, the European Union (EU) kept its dominant position in the world auto-industry exchange[14]. However, since the onset of the crisis, it appears to have followed the same pattern as its main competitors – the USA and Japan – losing global market share to emerging economies, particularly China (Chart A). A closer look reveals a discrepancy between developments in intra-EU and extra-EU automotive exports which emerged in the recent period: the EU has steadily strengthened its position with the outside world, but intra-EU trade, which represents the bulk of the European exchange, has not recovered to pre-crisis values. At a country level, a number of traditional auto industry exporters in western Europe posted decreasing world export market shares, in marked contrast to industry trends in the new EU Member States (NMSs), where world export shares increased.

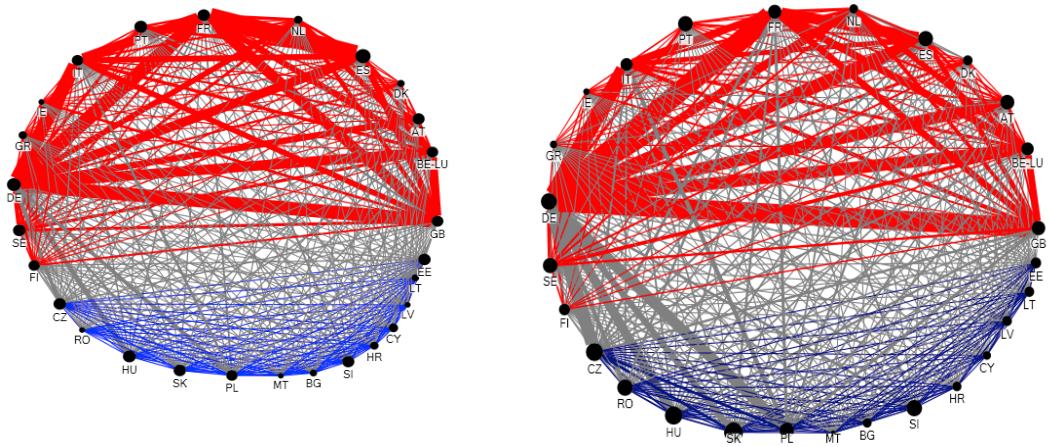
Looking at bilateral trade flows within the EU, the highly interconnected nature of the European auto industry becomes apparent (see Chart B). Germany stands out in this respect, as it appears to have strengthened its role as a hub for most of the trade exchange in Europe. Furthermore, the German auto industry has taken advantage of the EU integration and trade liberalisation processes, reorienting its production towards NMSs, thus balancing the stagnation and overcapacity in the traditional European producers with the potential of a new division of labour and economies of scale. This is in particular true for several countries in central Europe, where the automotive sector has turned into the main driver of economic and export growth.

On the back of the trade liberalisation process, the auto industry in Europe has undergone significant changes in its structure, leading to the modularisation and fragmentation of processes as well as the specialisation of production plants. Traditional economic indicators based on trade values fail to fully capture the economic implications of these developments. As a result of the

[14] All HS96 six-digit codes for both final car and car parts exports are covered, following the definitions by the US Department of Commerce's International Trade Administration and Indian Automotive Component Manufactures Association.

Chart B

Bilateral trade flows within the EU



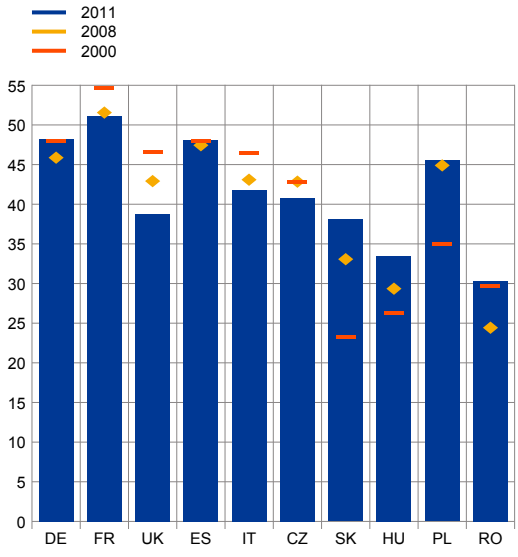
Sources: BACI and authors' calculations

Notes: Red lines represent trade flows between "old" EU Member States (EU countries before 2004), blue all trade flows between "new" EU Member States (EU countries that have joined since 2004) and grey trade flows between an "old" and a "new" EU Member State. The width of the lines depicts the relative intensity of the bilateral trade in all trade flows in the EU (both exports and imports are included), while the size of the dot indicates the relative importance of the auto industry in national trade with the EU.

Chart C

Intra-industry trade with EU28

(IIT measured by GLI = (1;100))



Source: BACI and authors' calculations.

changes, a rise in IIT[15] is observable over the sample. IIT levels have traditionally been high among western European economies, where one would expect a horizontal two-way exchange of products of homogeneous quality. However, IIT levels of NMSs, in particular Slovakia, Poland and Hungary, have also experienced a steep rise (Chart C). A considerable part of this two-way exchange between the EU15 and NMSs remains of a vertical nature, indicating that the NMSs still serve as the preferred location for lower-end production (e.g. smaller petrol-engine vehicles).

Strong internalisation of automotive production within the EU is also evidenced by the structure of value added (VA)[16] incorporated into national final output (Chart D). Important differences concerning the share of domestic VA emerge when comparing the largest exporters in the EU15 and NMS groups. In the case of the EU15 countries, the bulk of VA incorporated into national final production originates at national level, whereas for most members of the NMS group, the ratio between national VA and total VA is much lower. The Czech Republic, Slovakia

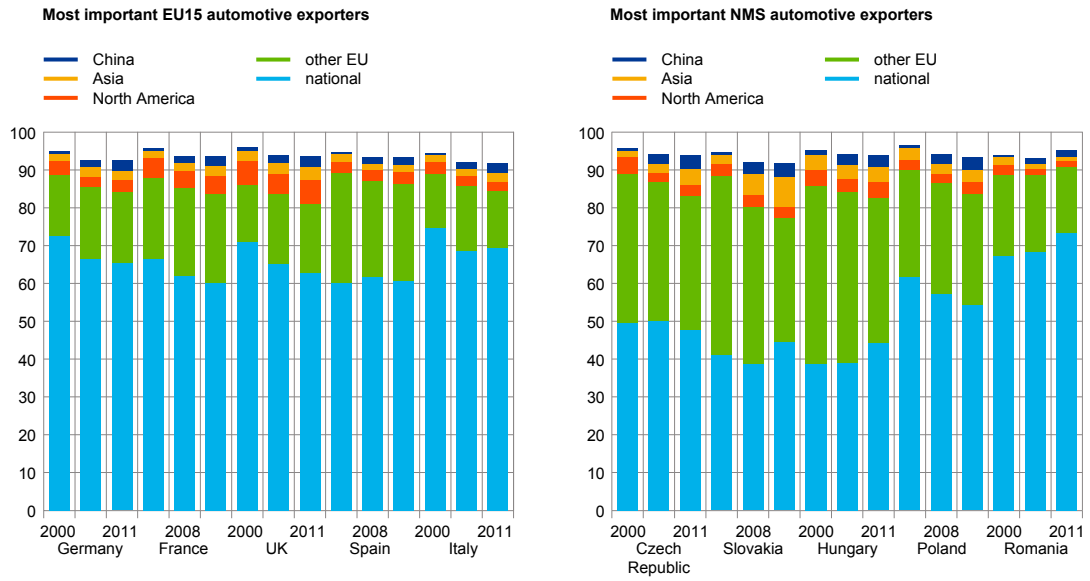
[15] IIT represents simultaneous exports and imports of goods belonging to the same product category. It can be further broken down into horizontal IIT (two-way trade in goods of homogeneous quality) and vertical IIT (two-way trade of heterogeneous quality). See Section 4.2 for further details.

[16] The VA is divided into two components: national VA and foreign VA. See Section 4.10 for further details.

Chart D

VA by origin incorporated into national final production of transport equipment

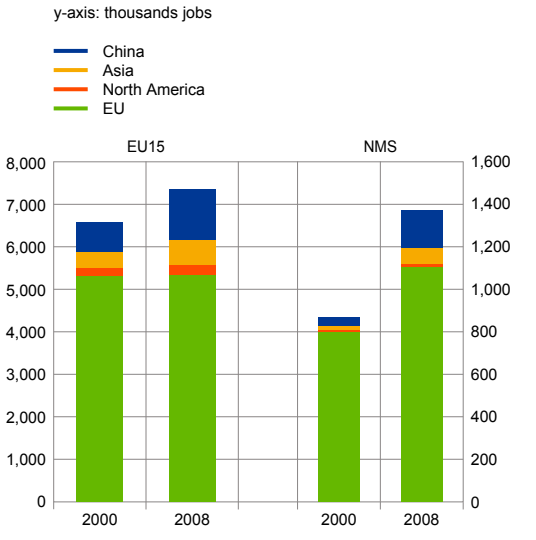
(percentage of total VA)



Source: WIOD and authors' calculations.

Chart E

Number of jobs generated by final production of transport equipment



Sources: Leonte and Orszaghova (2013).
Notes: EU15 refers to an aggregate for DE, FR, ES, UK and IT, and NMS to an aggregate for CZ, SK, PL, HU and RO.

and Hungary stand out in this respect, with national VA representing less than 50% of the total. As such, the benefits from participating in the automotive GVCs finalised on their territory are much less than their production levels would suggest. However, when considering the EU as a whole, an encouraging pattern emerges: between 75% and 90% of total value added is kept within the EU, meaning that automotive industry is strongly integrated Union-wide. For the NMS group, this indicates that a large portion of foreign VA comes from other EU Member States (including the EU15) – the latter countries still benefit even though final production does not take place on their territory.

Changes in jobs directly and indirectly linked to EU automotive production also support the idea that strong integration has been maintained (Chart E). Between 2000 and 2008[17], the number of jobs located within the EU and linked to the five largest EU15 group members' production did not fall, as one might have expected by looking at traditional indicators such as production or world export market share. Although the number of Chinese jobs backing automotive production in these five countries rose considerably,

[17] WIOD data for jobs incorporated into production stop at 2009. Given the impact of the economic crisis, we chose to show results for 2008.

the low weight of Chinese VA in total VA (see Chart D) may suggest that, for the most part, these are low-skilled, low-paid jobs. This is consistent with the findings of Timmer et al. (2013), according to whom advanced EU countries have increased their specialisation in high-skilled activities, on the back of a shift towards service jobs incorporated into manufacturing GVCs. In addition, the lion's share of extra jobs generated by the expansion in production in the NMS group were kept at EU level.

Traditional indicators describing the European automotive industry reveal a bleak situation, but this is only part of the picture, as indicated by the results of the analysis taking into account intra-industry trade and the GVC paradigm. The auto industry is strongly integrated at Union-wide level, creating a new division of labour within the EU. As a result, most of the VA incorporated into Member States' final production is retained within the EU. Furthermore, the results indicate no negative impact of outsourcing on EU jobs on aggregate – the EU took advantage of the rising production in the NMSs and experienced no job losses related to production in developed countries.

4.3 Relative export prices adjusted for quality and taste[18]

Traditional HCIs (or REERs), while providing useful information with respect to competitiveness developments, are limited to cost or price factors, **ignoring any other factors** that can be useful in measuring competitiveness. HCIs also suffer from another drawback: they implicitly assume that the **elasticity of substitution** between any two suppliers **is the same** for each commodity/product. Two indicators based on highly disaggregated trade data enable these limitations to be overcome.

Calculations of novel indicators are based on highly disaggregated trade data (six-digit Harmonised System classification) from UN Comtrade, enabling unit values to be interpreted as prices of trade flows and the elasticity of substitution between varieties for every product to be estimated.

Conventional relative export prices based on unit values:

The conventional REER resulting from relative export prices (RXP) is based on unit values and measures **only price** competitiveness. This indicator is calculated at a very disaggregated level, with product weights adjusted by the elasticity of substitution, which enables the price competitiveness to be evaluated precisely. Conventional RXP takes into account the individual characteristics of each commodity/product market and put more weight on markets with low market power, where price competitiveness matters more. This adjustment is performed by multiplying trade weights by the estimated elasticity of substitution between product varieties. Increases in conventional RXP means losses in price competitiveness.

[18] Based on Benkovskis and Wörz (2013). See technical details in Appendix A3.1.

Relative export prices adjusted for quality and taste:

Conventional RXP, when **adjusted for changes in relative quality**, can be a reliable indicator for measuring **both price and non-price competitiveness**. While conventional RXP is based on unit values, i.e. it uses the "euro per kg" definition of price, RXP adjusted for quality and taste uses the "euro per unit of utility" definition. In addition to prices and costs, this indicator also captures changes in the physical quality of export products and shifts in consumer tastes – factors that are largely missing from traditional price competitiveness indicators such as HCIs.

The unobserved relative quality and taste are proxied by the combination of relative unit values and relative export quantities at commodity/product level. Higher price naturally serves as an indication of better taste or quality. Moreover, increases in export quantity relative to competitors may also reveal favourable shifts in consumer preferences. **Increases** in RXP adjusted for quality and taste **mean losses in price and non-price competitiveness**. By **comparing** conventional RXP and RXP adjusted for quality and taste one can identify changes in non-price competitiveness.

Advantages of using this indicator

- It accounts for non-price factors such as quality and taste.
- It takes into account the degree of market power for each specific product, putting more weight on products with higher substitutability.
- It uses UVs, which are closer to a country's export performance than HICP or PPI.

Caveats

- It cannot distinguish the physical quality of a product from the taste for it.
- A product's relative taste or quality is evaluated indirectly using data on relative UVs and quantities. Moreover, as taste or quality is evaluated as a residual, it may contain other factors. Improvement in relative taste or quality can be e.g. due to increasing participation in the final assembly of high-quality products. Results of relative export prices adjusted for quality and taste should therefore be cross-checked against the GVC position index (see Section 4.10).

4.4 Market share decomposition[19]

Changes in export market shares are often thought to reflect a country's change in competitiveness. However, the market share indicator provides only a limited amount of information for competitiveness analysis: it describes the outcome, while leaving the **driving forces behind changes in market shares unexplained**. The proposed

[19] Based on Armington (1969), Benkovskis and Wörz (2014). See technical details in Appendix A3.2.

decomposition of gains or losses in market share at the very detailed product level makes it possible to assess the main factors behind changes in competitiveness. First, the decomposition **evaluates the role of price and cost competitiveness** more precisely, as the elasticity to changes in relative prices can be estimated for every product on every market. Second, the use of disaggregated data enables the identification of factors that can go **substantially beyond price competitiveness,** taking into account aspects of non-price competitiveness such as unobservable changes in consumer taste and the quality of exports, as well as structural features related to demand and supply-side factors.

The decomposition of changes in export market shares is based on highly disaggregated trade data (six-digit Harmonised System classification) from UN Comtrade, which permits unit values (UVs) to be interpreted as prices of trade flows and makes it possible to estimate the elasticity of substitution between varieties of every product.

The procedure is as follows: changes in export market shares are first decomposed into extensive and intensive margin. This is needed to extract export flows that are non-zero in two consecutive periods and to apply the Armington (1969) theoretical framework for further decomposition of the intensive margin. The main innovation comes at the second stage, when the intensive margin is split into contributions from price factors, non-price factors, changes in the set of competitors and shifts in demand.

Extensive margin:

The contribution of the extensive margin to changes in the export market share is evaluated by comparing the traditional export lines' (i.e. a particular product sold to particular destination country) share of a country's total exports in two consecutive periods. An export line is regarded as traditional in the event of non-zero exports in both periods. If the traditional export lines' share of a country's exports decreases over time, this means that the share of discontinued export lines was smaller than the share of newly established lines, and the contribution of the extensive margin to changes in export market share is positive. The extensive margin captures **the importance of new products and geographical destinations** to a country's export developments. However, the driving forces behind the extensive developments cannot be ascertained without additional information (e.g. firm-level data).

Intensive margin and its further decomposition:

The remaining part of changes in export market shares is explained by the intensive margin, which simply reflects the growth in a country's exports in traditional markets. Unlike the extensive margin, the intensive margin can be further decomposed into four components, providing additional insights into the driving forces behind changes in competitiveness:

1. Price competitiveness. The **contribution of price and costs factors** represents the impact of changes in a country's export prices (UVs) relative to prices of competitors (exporting the same product). The impact of relative prices on

market shares is calculated for each individual export line separately, applying different elasticities of substitution. The total contribution of price and cost factors is then calculated according to the structure of a country's exports.

2. Changes in the **set of competitors** may also influence a country's export performance. The contribution of these changes is evaluated by analysing the market share of suppliers that are present on a market in two consecutive periods. If the share of such stable suppliers decreases over time, it means that the share of competed-out suppliers was smaller than the share of new entrants, and competition has become more intense. As such, it negatively affects the country's export market share.

3. The contribution of **non-price factors** is defined as the residual between changes in export market shares and the contribution of items 1 and 2 for each individual export line. Non-price competitiveness thus captures any change in market shares that is not explained by price and cost factors (taking into account the elasticity of substitution) or by the set of competitors. The total contribution is calculated according to the structure of a country's exports. Despite being a residual, non-price competitiveness can be interpreted as **shifts in consumer tastes and/or changes in quality** of the country's production. **Outsourcing** processes may be another underlying force behind changes in non-price competitiveness.

4. While the previous three items can explain changes in market share in a particular geographical destination (country), this is not suitable for the world market. Import growth rates between individual countries differ due to fundamental factors such as demographics, saving rates, the economic structure and the institutional environment. To account for these different importer characteristics, another term is added to the decomposition: changes in the intensive margin due to **shifts in demand**. This is calculated as the growth in a particular country's imports relative to world imports and is similar in spirit to the geographical structural effect in a shift-share analysis.

The Toolkit database contains the decomposition of log-changes of export market shares. The sum of the abovementioned components differs slightly from the total growth in export market shares, due to log-linearisation and missing data on unit values.

Advantages of using this indicator

- It provides full and theoretically consistent decomposition of changes in market shares.
- It uses a different elasticity of substitution for each specific product, which improves the preciseness of decomposition.
- It extracts the contribution of non-price factors.

Caveats

- The contribution of non-price factors is evaluated as a residual on a very disaggregated level. Consequently, one cannot distinguish product quality from consumer taste for a product. The results for non-price factors can be cross-checked against results obtained from an export sophistication analysis (see Section 4.5).
- Quality and taste are the most obvious, but not the only, possible drivers behind non-price factors. For example, non-price competitiveness changes can be the result of shifts in global production chains due to outsourcing. Results of the decomposition should therefore be cross-checked against the GVC position index (see Section 4.10).

Box 2

What can we learn when using non-price competitiveness indicators?

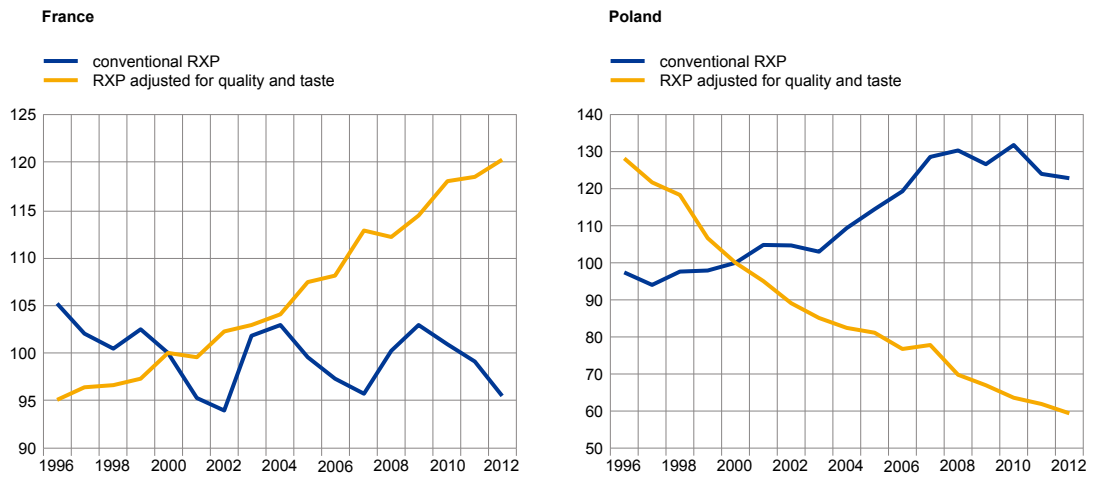
This box presents the contribution of non-price factors to the export performance of the EU countries during the last 15 years. It interprets non-price competitiveness as changes in the quality of export products or shifts in consumer preferences (taste) for a particular country's products. The indicators are based on a methodology developed by Benkovskis and Wörz (2013, 2014) and make use of very detailed UN Comtrade data (six-digit Harmonised System classification).

Relative export prices adjusted for quality and taste

While the conventional relative export price (RXP) index is similar to HCIs based on unit values and measures only price competitiveness, RXP adjusted for quality and taste uses the "euro per unit of utility" definition, thus measuring both price and non-price competitiveness (see also "Relative export prices adjusted for quality and taste", Section 4.3). The traditional and adjusted

Chart A

Conventional RXP and RXP adjusted for quality and taste (2000=100)



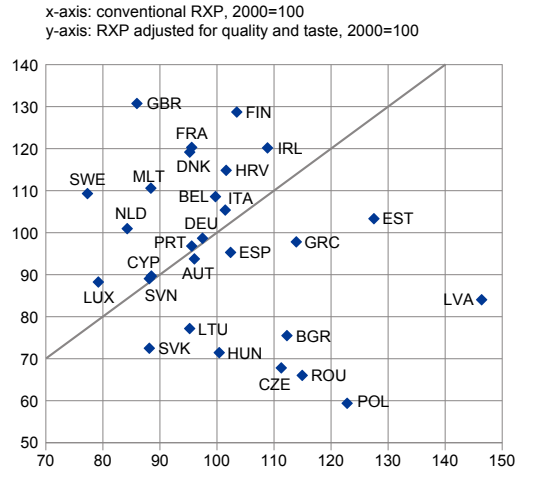
Source: Bank of Latvia and Oesterreichische Nationalbank, UN Comtrade.

RXPs for France and Poland are plotted in Chart A. Similarly to HCIs, an increase in RXP denotes losses in competitiveness, while comparing conventional RXP and RXP adjusted for quality and taste enables the contribution of non-price factors to be assessed.

The conventional RXP shows only modest changes in relative export unit values for France, while indicating significant real appreciation and losses in price competitiveness for Poland (mostly between 2003 and 2007). This is only one part of the story, however, as RXP adjusted for quality and taste signals gradual losses of overall competitiveness for France and remarkable improvements for Poland. Taking non-price factors into account alters the evaluation of the performance of the two countries. RXP indices reveal a decline in the relative quality of French export products and/or lower consumer valuations of French goods. At the same time, relative quality and taste improved for Poland.

Chart B

Conventional RXP and RXP adjusted for quality and taste for the EU28 in 2012



Sources: Bank of Latvia and Oesterreichische Nationalbank calculations, UN Comtrade.

Chart B summarises the dynamics of price and non-price factors for all EU countries since 2000. The horizontal axis denotes changes in price competitiveness (a position to the right of the vertical axis signals a loss of price competitiveness), while the vertical axis denotes the overall changes in competitiveness (a position above horizontal axis signals an overall loss of competitiveness). The 45-degree line helps to uncover the role of non-price factors: countries above this line had a negative contribution from relative quality and taste between 2000 and 2012, while countries below the line enjoyed improvements in non-price competitiveness.

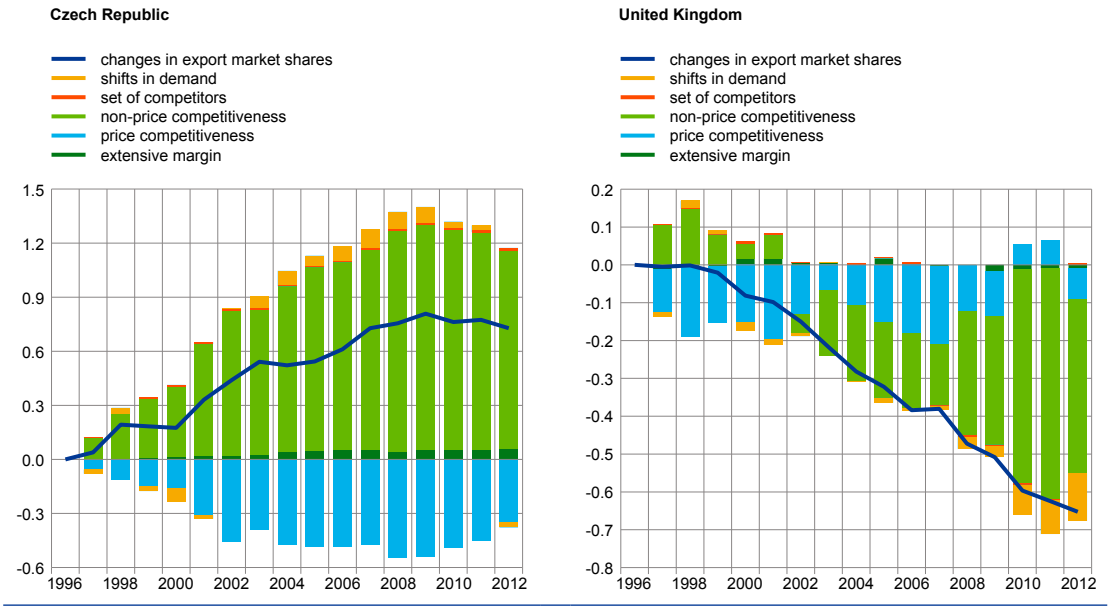
The EU countries can be roughly split into three groups. The first group consists of the new EU Member States (except Cyprus, Malta, Slovenia and Croatia) plus Greece. These countries had an improvement in non-price competitiveness (these improvements were remarkable in some cases, e.g. for Latvia, Poland and Romania) that more than made up for any increases in relative unit values. The second group contains countries with worsening overall competitiveness due to losses in relative quality and taste. This group mainly consists of old EU countries such as the UK, France and Scandinavian countries. Finally, there is a large set of countries (including Germany and Italy) that were able to maintain their non-price competitiveness over the sample period.

Decomposition of changes in export market shares

Although the RXP indices help to understand whether the price and non-price factors contribute positively or negatively to overall competitiveness, the magnitude of these effects remains unclear. This can be assessed by the decomposition of changes in export market shares into various components, including the contribution of price and non-price factors. Chart C shows an example

Chart C

Decomposition of cumulative log-changes in export market shares



Source: BoL and OeNB calculations, UN Comtrade.

of such a complete decomposition; it presents the cumulative log-changes in export market shares for the Czech Republic and the UK since 1996 and extracts five different factors behind these (see also ”Decomposition of changes in export market shares into price and non-price components”, Section 4.4).

The Czech Republic performed successfully on external markets, as its market shares increased by more than 60% versus 1996 despite the negative contribution of price competitiveness. The major driver behind this success was non-price factors, specifically an increase in relative quality and taste (see also Chart B). Other factors did not play a significant role, except for a tiny positive contribution from shifts in demand due to more rapid demand growth in the eastern European region. The analysis of the UK reveals that declining export market shares (down more than 60% since 1996) came as a combination of increasing relative unit values and declining quality and taste (see also Chart B). Moreover, the contribution of the latter was notably greater, underlining the importance of non-price factors in the analysis of competitiveness.

However, the underlying story may also include outsourcing and fragmentation of production. The Czech Republic is a well-known “final assembly” destination for the German car industry, which may partly explain the positive contribution of non-price factors, thus reducing the positive role of quality and taste. Similarly, the negative contribution of UK non-price competitiveness could reflect an outsourcing process. Therefore, the above-mentioned RXP indices and the decomposition of export market shares should ideally be cross-checked against GVC indicators (e.g. GVC position index or foreign value added in gross exports), which can reveal the fragmentation of production.

Conclusions

Relying solely on price factors in assessing a country's competitiveness may lead to erroneous policy conclusions, as this reduces the policy focus to price competitiveness alone and excludes any change in a country's competitive position from non-price factors such as enhanced quality or better labelling of exported products.

4.5 Export sophistication[20]

Export sophistication can be derived based on the income of exporting countries. The export sophistication index (EXPY) proposed by Hausmann et al. (2007) provides a complementary way of assessing the quality aspects of trade. While other metrics are based on the factor content of exports (e.g. the level of the embedded technology) or on the price at which they are sold internationally, EXPY relies on a hierarchy in goods space according to the level of income of the exporting country. More precisely, it is literally an index of the income level embedded in a country's exports. This indicator is based on the idea that the higher the average income of an exporter, the more sophisticated the exported basket. The rationale for this lies in the factor endowments theory, according to which high-income countries export more skill and capital-intensive goods, whereas low-income countries are more likely to specialise in natural resource or labour-intensive products. High-income countries are also characterised by higher wages, so their ability to compete in international markets does not derive from relatively low prices and costs, but rather from higher productivity.

EXPY is based on a weighted average of the income of all countries exporting a certain good. The first step in calculating EXPY is to build for each traded good (g) a proxy for the productivity embedded in that product ($PRODY_g$). This is done by taking the weighted average of the GDP per capita (Y_j) of all countries (j) that export a certain good.

$$PRODY_g = \sum_j \frac{x_{jg} / X_j}{\sum_j \left(x_{jg} / X_j \right)} \cdot Y_j \qquad (4)$$

where X_{jg} denotes country j's exports of good g and X_j stands for total exports by that country. The weights used to aggregate the income of all countries are given by the revealed comparative advantage of each country in the trade in that good, so that the size of the country does not distort the results. After having obtained the productivity proxy for each product, EXPY aggregates these levels of productivity for each country (c), taking as weights the share of each product in the overall export basket of that country.

$$EXPY_c = \sum_g \left(\frac{x_{cg}}{X_c} \right) \cdot PRODY_g \qquad (5)$$

[20] Based on Di Maio and Tamagni (2008), Hausmann et al. (2007), Lall et al. (2006).

The version of EXPY included in the CompNet data set brings the following modifications to the indicator initially proposed by Hausmann et al. (2007):

- The assessment of the productivity embedded in a country's exports considers only the rest of the world. In this way, a potential endogeneity bias embedded in the indicator initially proposed is eliminated. For example, if a high-income country is the only one exporting a certain good, the original index for that country would be high, reflecting its own income and not the fact that other high-income countries export that good. A related point is that when investigating the link between GDP per capita and EXPY, the former would already be included in the initially proposed indicator.

- Exports of mineral products and other natural resources are excluded when assessing export sophistication, as they are less relevant in that context. This also lowers the impact on EXPY coming from oil-exporting countries.

- This Compendium computes PRODY on an annual basis in order to minimise the impact of arbitrarily choosing reference years[21] (following the approach of Di Maio and Tamagni, 2008).

This version of EXPY is determined using Comtrade data and WDI statistics on GDP per capita in constant prices.

To interpret EXPY, one needs to analyse how it has evolved compared with a benchmark country set. Given that EXPY is basically a weighted average of the GDP per capita of all exporters of a certain set of goods, the evolution of EXPY will also reflect the dynamics of the income of these countries, and not necessarily whether a certain country has specialised in more sophisticated products or not. More precisely, EXPY can change as exporters' GDP per capita does. For this reason, comparative analyses on how the position of a country has evolved relative to a set of countries are more relevant.

EXPY indicates whether a country specialises in the types of goods that high-income countries export, with potential implications for growth. The export sophistication indicator measures whether a country exports products which are sold by high or low-income countries. This differentiation matters; as argued by Hausmann et al. (2007), a country's potential for growth depends on whether it specialises in sophisticated products or not. More sophisticated products are presumed to embody greater skills and more advanced technologies and are more likely to act as a catalyst for growth.

Quality is assessed indirectly, relying on the link between export sophistication and income. Although EXPY offers an important complement to other indicators aiming to capture qualitative aspects of traded goods, it does not account explicitly for the quality embedded in the export basket; rather, this is proxied by the level of income of exporters. However, having a high per capita income does not guarantee a sophisticated export structure (as in the case of some countries rich in certain natural resources).

[21] In the case of the indicator initially proposed, Hausmann et al. (2007) calculate an average PRODY over 1999-2001, which is subsequently used to calculate EXPY.

Advantages of using this indicator

- Evaluates the sophistication of each product and therefore provides a proxy for the sophistication level of a country's exports. Results can be cross-checked against the contribution of non-price factors to changes in export market share (see Section 4.4).

Caveats

- The methodology implicitly assumes the same production functions for a given product across all exporting countries.
- By construction, EXPY index is correlated with GDP per capita growth globally (see equation 4). Thus, comparison with a benchmark country (or a set of countries) will provide better understanding of export sophistication developments for a given country.

4.6 Dynamic Trade Link Analysis[22]

Traditional indicators on the competitive position of a country focus either on the cost side, such as conventional REER measures, or on outcomes, such as measures of export performance or market shares. Most of the time only cross-sector aggregates are analysed.

To better understand the extent of competitive pressure that a country is facing, however, an important element – which is missing from this set of indicators – relates to the information on the product mix that a country is exporting to another specific country and the number of competitors offering the same products. After all, it is not only price that determines the success of an exporter, but also the number (and size) of competitors.

The idea of Dynamic Trade Link Analysis is therefore to investigate in detail single and highly disaggregated product-destination-trade links to gather information on how contested a specific market is. This gives information on patterns of trade diversification over time and delivers deeper insights than aggregate market shares or traditional indicators of market shares, or revealed comparative advantages.

Dynamic Trade Link Analysis monitors the development of trade links of two exporting countries to a common destination market over time. A trade link is a binary variable that takes the value 1 if there is an active export link – i.e. a country exports a product to a given destination country in a given year – and 0 otherwise. Products are classified at the detailed six-digit HS (Harmonised System, 1996) level, which includes more than 5,000 products in every bilateral importer-exporter relationship. The indicators are constructed based on UN Comtrade data, which offer global country coverage.

[22] Based on Benkovskis et al. (2013), Benkovskis et al. (2014), Silgoner et al. (2013).

If country A maintains a trade link with a destination country over a given time span, it receives the code A(1/1), indicating that it was active at both the beginning and the end of the period. If a country stops serving a destination country, it receives the code A(1/0), whereas the code A(0/1) indicates a newly created trade link by this exporter. If country A does not serve a specific market at all and as such is continuously inactive, it receives the code A(0/0).

Dynamic Trade Link Analysis combines this information on trade links for pairs of exporters. Thus, it combines information on the dynamics of trade links of country A (the country of interest) with information on trade links of B (the benchmark country) at detailed product-destination level. Overall, this bilateral comparison yields 4*4=16 possible combinations, which can be grouped into seven meaningful types of competitive pressure (A is inactive; no overlap; existent overlap; new overlap; entry into new markets; potential crowding-out; leaving markets).

Below, we describe three of these combinations in more detail, as they represent particularly interesting cases of competitive pressure. Under certain assumptions they can indicate how exposed individual exporters are towards a specific competitor. They add a disaggregated and dynamic element to the traditional market share analysis, as they are based on highly detailed information on bilateral competition over time.

The "**Existent overlap**" indicator[23] counts the number of product lines in each destination market jointly served by two exporters (the country of interest and the benchmark exporter) over the reference period. More specifically, from the 1/0 patterns for the country pair A and B respectively, the number of product lines in which both countries A and B were active in both years are counted: A(1/1) Ù B(1/1). In other words, both countries overlap in this market in the beginning and at the end of the period.

The **"New overlap"** indicator[24], by contrast, focuses on those cases where country A is continuing to serve an existing market while country B is a new entrant in the same market or vice versa, or where both countries simultaneously enter a new market: A(1/1) Ù B(0/1) or A(0/1) Ù B(1/1) or A(0/1) Ù B(0/1). These cases potentially open a new field of bilateral competition.

In a third case, one of the two exporters may cease to serve a particular market. This is captured by the **"Potential crowding out"** indicator[25], which is the share of product-destination markets where country A stops serving a market at the end of the period of time studied, whereas country B remains active or newly enters the market (or vice versa)

A(1/0) ^ B(1/1)) or A(1/0) ^ B(0/1) or A(1/1) ^ B(1/0) or A(0/1) ^ B(1/0).

[23] Please note that in Benkovskis et al. (2013 and 2014) this indicator is named "Existent competition".

[24] Please note that in Benkovskis et al. (2013 and 2014) this indicator is named "New competition".

[25] Please note that we cannot say anything about causality here, hence the term "crowding out" refers to an outcome rather than to a causal effect.

All three indicators are calculated as a percentage of total non-inactive trade links (in both years) of country A. Thus, the interpretations of the results should always be taken from the viewpoint of the country of interest. Excluding all inactive trade links of country A implicitly controls for country size.

The three indicators provide an assessment of the degree of structural export overlap and changes therein between pairs of exporters. The dynamic pattern, i.e. the development of trade links over time, can give a useful indication about possible competitive pressure.

- If "Existent overlap" is high while not many "Potential crowding out" cases are observed, it can be concluded that the two competitors manage to co-exist in the markets. Product differentiation, non-price competitiveness or very dynamic demand in the destination market may provide enough room for both exporting countries.

- If, however, many cases of "New overlap" on the part of country A and simultaneously many cases of "Potential crowding out" in the same product destination market on the part of country B are found, it can be assumed that competition between countries A and B is fierce and that country B is the outgunned competitor. This hypothesis would, however, need to be verified through further analysis.

A few examples, taken from Silgoner et al. (2013) and Benkovskis et al. (2013), illustrate how *Dynamic Trade Link Analysis* can be interpreted along three different dimensions.

- **Cross-country comparison:** Comparing the "Existent overlap" of country pair A and B with the "Existent overlap" between country C (or D, E, etc.) and B enables analysts to investigate which countries are likely to be in fierce competition with benchmark country B. Benkovskis et al. (2013), for example, compare all EU countries bilaterally with China and show that the greatest overlap in export markets with China is observed for the smaller EU countries.

- **Comparison over time:** Comparing the "Existent overlap" in one period with subsequent periods gives information on whether the extent of direct competition between countries A and B is intensifying over time or not. Benkovskis et al. (2013) show that the extent of existent competition between individual EU Member States and China increased over time for all EU Member States.

- **Sectoral comparison:** Repeating the exercise for broad economic categories (BECs) sheds light on the most contested product segments. Silgoner et al. (2013) show that "Existent overlap" is particularly high in capital goods and transport equipment.

Advantages of using this indicator

- *Dynamic Trade Link Analysis* enables patterns of trade diversification over time to be investigated and the competitive pressure that a country faces to be evaluated. As it is constructed from information at the detailed product

destination market level, it is able to give more insights than aggregate market shares. It thus serves as a supplement to traditional indicators of market shares or revealed comparative advantages.

- The approach is flexible in terms of geographic focus (=choice of benchmark competitor, choice of import market) and degree of sector disaggregation (HS six-digit products can be aggregated according to a wide range of alternative classifications, delivering conclusions for individual activities or end-use categories).
- Calculations are very simple.

Caveats

- *Dynamic Trade Link Analysis* only uses information about the number of trade links, and not about the value of trade flows. This implies, for example, that all trade links are given equal weight when constructing sectoral aggregates, irrespective of their share of country A or B's exports. An appropriate weighting scheme has not yet been developed.
- For the same reason, nothing can be said about partial crowding-out effects in the sense that one competitor expands trade flows at the expense of the other in a specific export market. One can only observe exporters leaving markets altogether.
- Neither can anything be said about causality. There need not be a causal link between the simultaneous observations that country B leaves a market while country A enters it. Our term "Potential crowding out" should thus be understood as a signal that would need to be verified by other methodologies.

Box 3

Can the EU and China co-exist in the global markets?

Summarising the main results of ECB CompNet Working Paper 1617 (Benkovskis et al., 2013), this box shows an application of the *Dynamic Trade Link Analysis* (DTLA), developed by Silgoner et al. (2013). Under certain assumptions, the DTLA methodology can indicate how exposed individual exporters are towards a specific competitor. In Benkovskis et al. (2013) the DTLA is applied to a sample of 25 EU Member States and their competitive position relative to China in the world market.

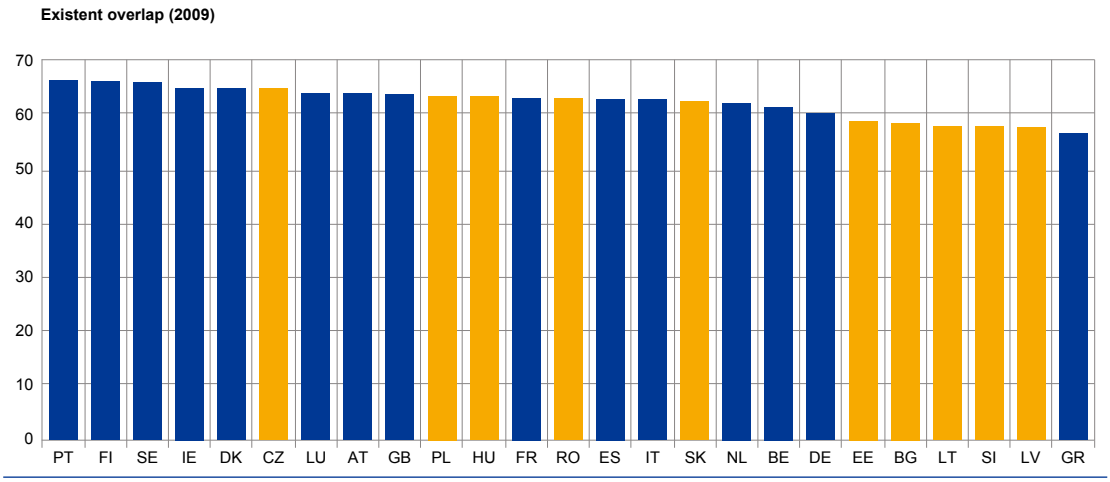
It is shown that in 2009 Chinese and EU producers jointly served a large number of product markets (defined here as the market for one specific good in one specific country), i.e. "overlap" in these markets. On average, EU countries and China are direct competitors in 62% of all active product markets[26], and this share has increased for all EU Member States over time, from less than 50% on average a decade earlier. Chart A shows that the greatest overlap in export markets with China is observed for the smaller western and southern EU countries and not for the largest exporters such as Germany.

[26] "Active" is defined here as those trade links where the country of interest (in this case the EU country) is an active exporter. Excluding all inactive trade links implicitly controls for country size.

Chart A

Product markets served both by EU countries and China

(in percentage of the EU country's active trade links)



Sources: UN COMTRADE, authors' calculations. Yellow bars denote CESEE-10 countries; blue bars denote EU-15 countries.

By contrast, the percentage of product markets where EU countries are not exposed to any competition from China is relatively small (at just 14% of all active trade links), and this figure decreased by as much as 10 percentage points between 2001 and 2009. Among the EU countries, Germany is the country with the highest share of "bilateral monopoly position", serving 26% of global product markets without direct competition from Chinese competitors.

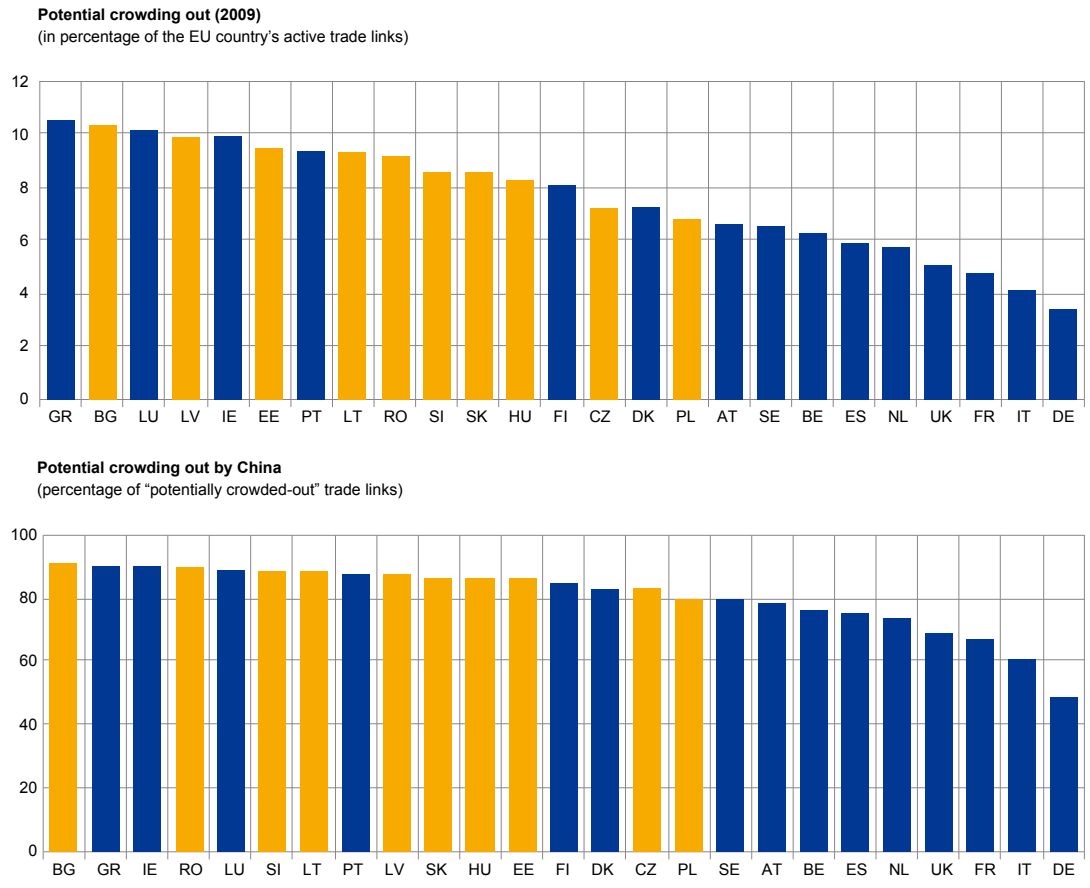
Overall these numbers indicate that most markets are simultaneously served by both the EU exporters and China. But is this development sustainable or might it potentially lead to crowding-out effects for weaker competitors? If a large number of cases where one competitor leaves a market that is at the same time served or newly entered by an important competitor are observed, it can be assumed that potential crowding out effects exist. Since our analysis does not say anything about causality this would then need to be investigated using other methodologies. However, our analysis does not strongly support this crowding-out hypothesis: Chart B shows that on average, around 8% of all active trade links were lost and at the same time served or entered by the competitor. Over time this figure has risen by 2 percentage points, and it is highest in the smaller EU Member States, especially those in CESEE.

However, when distinguishing between cases where China has potentially crowded out European competitors and cases where China itself was the outgunned competitor, it can be concluded that the EU Member States were generally on the losing end. Bulgaria, for instance, has withdrawn from about 90% of markets served by China. The only exception was Germany, where cases of potential crowding out of the world market were generally rare (only around 4.8% of existing trade links). In addition, incidences of China exiting a market that was entered or served by Germany were slightly more frequent than those where Germany left a market that was served or entered by China.

Overall, one can conclude that there is significant potential for EU and Chinese suppliers to co-exist in individual product markets given the low incidence of crowding-out cases. Product

Chart B

Small and peripheral EU Member States frequently leave markets after entry by China



Source: UN COMTRADE and authors' calculations.
Notes: Yellow bars denote CESEE-10 countries; blue bars denote EU-15 countries.

differentiation, non-price competitiveness or very dynamic demand in the destination market may provide enough room for both exporting countries, which in many cases are in fact part of the same production chains. Maintaining this coexistence will, however, require constant fine-tuning of the export portfolio in terms of suppliers, customers, product characteristics and locational advantages. Furthermore, this paper concludes that country size matters, as large exporters are clearly in a better position than smaller countries – even in relative terms – when it comes to withstanding competition from China. In our view, this calls for a further deepening of Europe's single market. It is also important to identify new export niches that remain untapped by large competitors such as China. Economic policies should support such moves into unknown territory through appropriate guarantee schemes and the provision of information on new markets.

4.7 Trade-weighted unit labour cost indicator

Empirical tests often find that price and cost indicators offer only low explanatory power for a country's export performance. To measure the importance of cost for export performance, a novel unit labour cost (ULC) indicator which focuses

sharply on exporting sectors, the TWULC (trade-weighted unit labour cost), has been developed. It takes on board two major findings of the recent trade literature, developed further in the context of CompNet:

First, exporting firms might differ fundamentally from those oriented towards domestic demand, as they are more productive than the domestically oriented sectors (Gaulier and Vicard, 2012, and ECB, 2014). This factor may be especially relevant for countries in a catching-up process. Following the idea expounded in Gächter et al. (2013), the TWULC measures sector-specific unit labour costs according to their relevance for exports.

Second, this indicator accounts for the growing global interconnectedness of production chains by weighting sectors by their value added generated through exports. That can diverge substantially from shares in gross terms. Therefore, the approach is especially informative for countries where the import content of exports is high, since for those countries gross exports are likely to exhibit the strongest bias.

More specifically, the TWULC weights the sector-specific unit labour costs in accordance with that sector's weight within a country's exports:

$$TWULC^{k} = \sum_{i=1}^{n} ulc_{i}^{k} * w_{i}^{k} \qquad (6)$$

with the sector-specific weight being $w_i^k = x_i^k / X^k$, with $X^k = \sum_{i=1}^{n} x_i^k$, where *k* denotes the country, *i* is one of n sectors, x_i is the value added generated in sector *i* through exporting, X^k the value added exports of country *k* and *ulc* the nominal unit labour cost, calculated as $ulc_i^k = comp_i^k / va_i^k$, i.e. compensation per employee over the real value added of i = 1 to 30 sectors covering the entire economy. To account for the potentially distorting effect of imported inputs in production within global value chains, the export weights are derived from value added exports. Sector weights are fixed in time as at 2000.

The TWULC accounts for the potential divergence in ULC dynamics in exporting versus more closed sectors, and as such it reflects more accurately the cost-competitiveness of that part of the economy actually exposed to international competition. It is sensitive to potential divergences in ULC developments in domestically oriented sectors such as construction only to the extent that these supply intermediates to exporting firms. As a rule, the TWULC increases by less than total economy ULC, indicating that ULC growth is more moderate in exporting firms. However, when the TWULC based on value added trade weights is compared with an alternative measure using gross trade weights, it turns out that the growth rate of the former is generally higher (Lommatzsch et al., 2015). As a result, intermediates sourced in the respective domestic economy can affect external competitiveness, and trends in sectors considered "sheltered" may matter. The focus on value added exports and their sectoral composition therefore gives a broad picture of domestic cost-competitiveness, including in the domestic sectors that supply the actual exporters. However, heterogeneity is rather high in this respect.

To assess the ability of the TWULC to explain export growth, Lommatzsch et al. (2015) calculate the TWULC for a broad set of OECD countries and use it to construct a TWULC-based real effective exchange rate (REER) measure, the

REER-TWULC. This is then tested econometrically in standard export equations against a set of more conventional REER measures and for different country subgroups. The analysis shows that the REER-TWULC can be regarded as a more reliable competitiveness indicator: its relevance is confirmed in all tested specifications, in contrast to the alternatives such as REERs based on the CPI, total economy ULC, GDP deflators or export deflators.

Even though the TWULC outperforms other price and cost measures within export equations, it shares with these other measures the characteristic of a generally low explanatory power for gross export growth (Lommatzsch et al., 2015). Other factors such as non-price competitiveness or network effects appear to dominate over the cost side. In line with the growing importance of cross-border supply chains, the explanatory power is generally higher for value added exports. An additional problem associated with all relative price and cost measures of competitiveness is that they all focus on dynamics over time rather than on the level of prices or wages. Especially in CEE countries, the high level of competitiveness is the result of the still comparatively low level of prices and wages, while price and cost dynamics are of less relevance. That cannot be reflected in the TWULC or real exchange rates based on it.

The calculation approach introduced in Lommatzsch et al. (2015) has the advantage of providing comparable TWULC measures for 40 OECD countries since 1995. Its drawback, however, is its lack of updatability. The TWULC is based on the Socio-Economic Accounts accompanying the WIOD (World Input-Output Database), the only data sources with comparable sectoral ULC and trade data for a broad set of countries and sectors. However, these data series end in 2009 (as of end-2014). To calculate an indicator suitable for more real-time competitiveness assessments, a database with smaller country coverage is used: Eurostat provides sectoral data on most EU countries, with time coverage up to 2012 (as of end-2014)[27]. The TWULC based on Eurostat data, which is now part of the Diagnostic Toolkit, has the advantage of including longer series, making it a suitable complementary indicator for competitiveness assessments. The drawback, however, is that data for non-European countries are lacking and as such the TWULC cannot be used to regularly update REER-TWULC measurements.

4.8 Export assortativity metrics: network-based measures for relative export prices and specialisation

Motivation and idea

A feature of international trade that has not yet been exploited in great detail within the economic analysis is its network structure, which offers an extra dimension for the evaluation of competitiveness on the macroeconomic level.

The main factor that makes the topology of trade links important is the sparseness of trade relations between countries at single-product level, which can lead to the fragmentation of markets. In such a situation, measures based on global

[27] Even more recent data on a quarterly basis would be available for only a small number of countries and sectors.

comparisons are expected to be less informative than measures taking into account a country's embedding into the international trade network. In this sense, the investigation of the detailed structure of trade links is expected to provide valuable information, not only on global trade, but also on a country's integration into global value chains and globalisation per se.

The idea of export assortativity metrics is to combine the price and product composition of a country's exports and compare them with those of a country's partners and competitors, where the latter are defined as a partner's third-party import and export partners. The final objective is to obtain indicators for a country's relative export prices and product specialisations conditioned on the destinations they trade with.

Methodology

The network structure of international trade can be represented formally by a graph consisting of nodes connected by links. These links can be either binary (on/off) or weighted in some way, and can either be symmetric (mutual) or directed. In their most general form for international trade, countries are nodes and links are given by weighted and directed trade flows between them. A single trade link for a single product is usually evaluated by its unit value (UV), as an indicator for price and price competitiveness, which is also assumed to contain information about quality, and its total value (TV), as an indicator for the importance of the link.

In network science, assortativity is the general property of a node for its similarity or difference compared with its adjacent nodes (neighbours). A country's **export price assortativity** (EPA) and **relative export density** (RED) for a single product is defined as the relative UV and specialisation respectively[28], compared with the average UV and specialisation of its trade partners respectively. For a country and a product , EPA and RED can be written in a uniform manner. Let denote either EPA or RED and be either UV or specialisation:[29]

$$x_b^p = \frac{1}{T_X^b + T_M^b}\left(\sum_{c\in X} f_{bc}^p * x_b^p + \sum_{c\in M} f_{cb}^p * x_c^p\right), \tag{7}$$

$$A_{a,b}^p \equiv \frac{x_a^p - x_b^p}{x_a^p + x_b^p} \in (-1,1], \tag{8}$$

$$X_a^p = \frac{1}{T_X^a}\sum_{b\in X} A_{a,b}^p * f_{ab}^p \in (-1,1], \tag{9}$$

$$\tilde{X}_a^p = \left(\frac{x_a^p + 1}{x_a^p - 1}\right) * 100 \in (0,\infty], \tag{10}$$

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[28] The specialisation is defined as the share of total exports of this product divided by the total amount of exports.

[29] More generally, we can describe the network structure of international trade for a single product p by the real matrix f_{ab}^p, where a and b are country indices. A general assortativity measure for country a and a property x can then be formulated as

$$A_x^a \equiv \left\langle f_{ab}^p * \frac{x_a - x_b}{x_a + x_b} \right\rangle_b \in (-1,1], \tag{1.1}$$

where $\langle\cdot\rangle_b$ is chosen, such that the norm is fulfilled.

First, a trade partner *b*'s average UV and specialisation in equation **(7) is evaluated**, by summing its exports and imports with third-party countries *c* to approximate the price and level of specialisation in that market. Here, f_{ij}^{p} stands for the trade flow from a country *i* to a country *j* of product *p* in terms of TV at a given moment in time, and T_x and T_M are the values of total exports (X) and imports (M) of the left-hand-side country respectively. Note that country size is controlled for in this way, as only trade shares enter the calculation. Equation **(8)** defines the **assortativity factor** of country with respect to property *x* and relative to its export partner *b*. For example, in the case of UV, $A_{a,b}^{p}$ indicates if country is more expensive (positive $A_{a,b}^{p}$) or cheaper (negative $A_{a,b}^{p}$) than country with respect to product . The same reasoning holds for the relative specialisation. Equation **(9)** is the weighted average of single-partner assortativity factors from equation (8). Equations (7) and (9) account for the structure of trade links, as only elements where $f_{ij}^{p} \neq 0$ enter the sums.

The assortativity factor, equation (8), can be interpreted as follows: a value of −1 means that a product is actually *not* exported. This situation is excluded by construction. A value of +1 means that the exporter of interest has a monopoly in market , while a value around indicates equality (similarity) of countries *a* and *b* with respect to the property of interest. Equation **(10)** offers a representation of (8) and (9) in terms of a percentage scale of the average trade partner whose EPA or RED value has been set to 1.

From a policy point of view, consideration of the structure of global trade introduces a *topological component* into the industrial policy plan of a country. Besides addressing export prices or industry composition, which is generally a difficult, long-term process, policy-makers might address the structure of trade links. For instance, using the same methodology, one can estimate one's competitive position (in terms of EPA and RED) for entering or exiting any specific market. One of the main advantages of export assortativity measures is that they carry absolute meaning at any point in time, i.e. no base year indexing is needed for their representation and comparison over time.

Countries concentrate exports in products where they have a price and a comparative advantage.

Using the United Nations Commodity and Trade Statistics (Comtrade) at the six-digit level of the HS-1996 classification, which covers over 5,000 product classes, EPA and RED are calculated according to equations (7)–(10) and the results are aggregated at country level, using single-product export shares.

There are two main findings at aggregated country level[30]:

1. EPA is generally *below 100* for most exporters. This means that countries concentrate their exports in products where they have an *advantage of price conditioned on the markets they serve*.

2. RED is always much greater than 100. This means that countries focus their exports on products where they have clear advantages of specialisation

[30] Numbers refer to equation (10).

(comparative advantage). This finding is crucially coupled to the sparse network structure of trade at the single-product level, in the sense that highly specialised countries tend to export to destinations where a product is prevalent in neither export nor imports. This can be seen from equation (8), where it is impossible for all countries to simultaneously diverge from 1 in the same direction and for all products on a global level.

Both observations are exemplified in Chart 2, A and B, where EPA (A) and RED (B) for 18 euro area (EA) countries between 2000 and 2012 are shown. A possible interpretation of the fact that EPA is located in the 75-100 range for most countries (including the industrialised ones) shows the importance of price competition. It seems basically impossible for countries to sell the bulk of their products at higher prices than their competitors. However, competition in international trade might tip from being price-driven to being driven more by non-price factors, such as quality or branding, as countries develop.

Investigating the evolution over time of both export assortativity measures, two trends can be identified at the global and regional level. One is a general tendency towards rising EPA and falling RED values, which is attributed to the large increase in trade links (globalisation) during this period. Assuming that price and specialisation are the main drivers of competitiveness, it becomes persistently harder to have relatively lower prices and higher levels of specialisation than one's competitors with increasing density of trade relations.

The other trend is that the indicator shows convergence within the EA, as the EPA values of eastern European countries (Estonia, Latvia, Slovenia and Slovakia) rose much faster towards the 100% line than those of the other EA countries.

Advantages

- It introduces an extra dimension to evaluate a country's competitive position with respect to exports, based on its embedding into the topological structure of trade links.
- No base year indexing is needed for representation and comparison over time.
- The general definition of assortativity metrics can be readily extended to situations, where a relational structure between any kind of agents is given with respect to a property of interest.

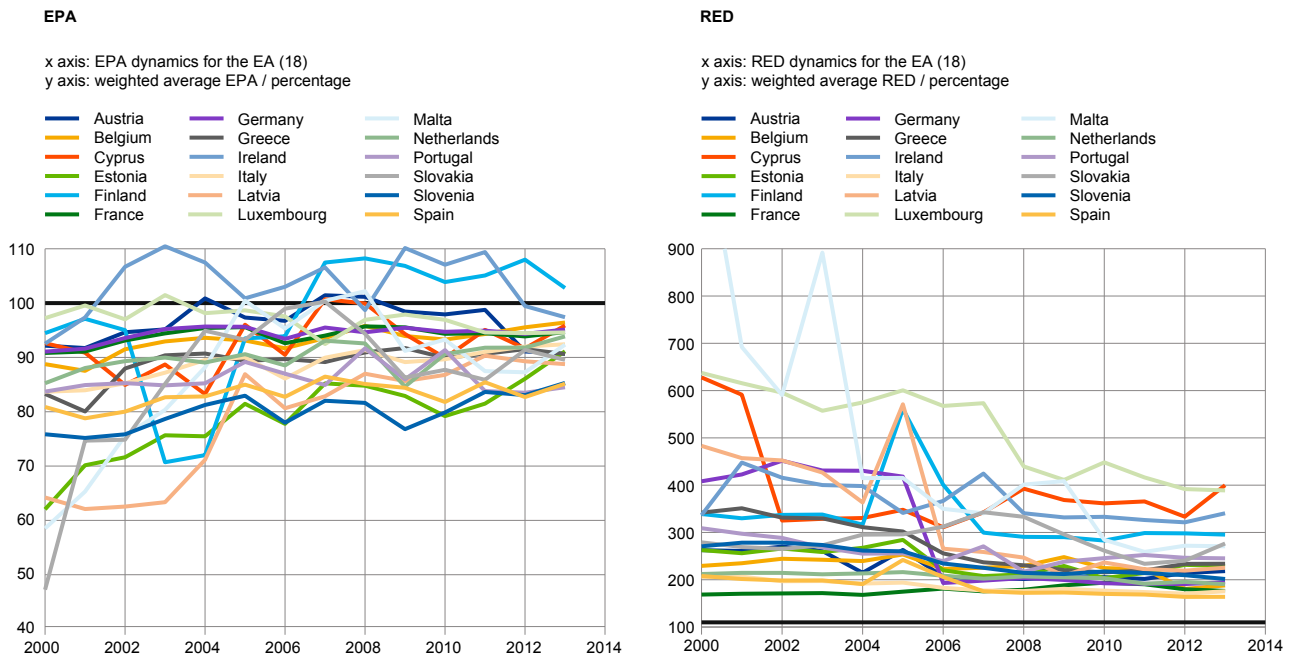
Caveats

- Additional global information is needed for the comprehensive evaluation of a country's exports.
- To investigate the differences in countries' exports, the suggestion is to use EPA and RED on a disaggregated level, as averaged results conceal much

information. For instance, one sees that countries' weighted average prices, in terms of EPA, are comparable with each other, but there are big differences when, for example, differentiating by the technological content of exports.

Chart 2

EPA and RED for 18 euro area Countries



Source:

4.9 Firm-level-based indicators[31]

Why are firm-level indicators needed in the Diagnostic Toolkit for Competitiveness?

An increasing strand of the literature analysing longitudinal firm-level data has documented widespread heterogeneity in terms of firms' performance, even within narrowly defined sectors (see for example Caves, 1998, and Bartelsman and Doms, 2000). Moreover, the distribution of productivity, or any other measure of firm-level performance, is not only very disperse but also very skewed, which means that within a given country or industry there is a large mass of low-productivity firms and very few highly productive firms. These findings have major implications because they highlight the limits of models based on the representative or average agent hypothesis, including those for the analysis of competitiveness.

[31] Based on Caves (1998), Bartelsman and Doms (2000), Bartelsman et al. (2004, 2009), CompNet Task Force (2014), Di Giovanni and Levchenko (2010), Melitz and Redding (2013) and Lopez-Garcia, Di Mauro and the CompNet Task Force (2015).

The large dispersion and skewness of firms' performance distribution also have important implications for policy:

- First, the same policy intervention applied to firms at different tails of the performance distribution may not produce always the same results (see Melitz and Redding, 2013). Alternatively, the same policy intervention in two countries with a different underlying performance distribution might have different results.
- Second, when the distribution of performance is very skewed, Di Giovanni and Levchenko (2010) show that aggregate performance measures, such as the development of aggregate exports, are driven by the largest/most productive firms in the economy, not by the average firm.
- Third, relevant aggregate relations, like the one captured by the elasticity of exports to the exchange rate, might be sensitive to the underlying distribution of productivity or size in the country.
- Fourth, the process of reallocation of resources from low to high-productivity firms, which is vital for restoring growth, can only be tracked using firm-level information.
- Overall, these findings suggest that a better knowledge of the underlying distribution of firm-level performance is extremely useful in attaining a comprehensive assessment of competitiveness as well as enhancing the ability to draw policy conclusions from aggregate patterns.

What is the source of the micro-based data?

The micro-based indicators of the Toolkit are extracted from a new dataset compiled by CompNet. Since individual firm-level data are confidential and cannot be shared outside the respective countries (i.e. they cannot be merged into a common database), a "distributed micro data approach" (see Bartelsman et al. 2004, 2009) was adopted. The approach consists of applying a common protocol on national firm-level data to retrieve comparable indicators and statistical moments aggregated at the detailed industry level to preserve confidentiality. The indicators computed are based on a huge sample of about two million firms with at least one employee per year from 17 EU countries operating across all non-financial business sectors. They provide comparable key stylised facts, concerning but not limited to labour and total factor productivity as well as unit labour cost performance and dynamics of underlying heterogeneous firms, at sector and country level[32].

What micro-based indicators are included in the Toolkit?

To improve cross-country comparability, the indicators included in the Toolkit have been computed considering only the sample of firms with at least 20 employees. This sample is more comparable than that including all firms with employees for two

[32] See Lopez-Garcia, Di Mauro and the CompNet Task Force (2015).

reasons. First, it overcomes the different exclusion rules applied by different countries (for example, the Polish sample includes only firms with ten employees or more). Second, this sample is population-weighted, which implies that it replicates the existing size and sector distribution of the corresponding population of firms. However, due to differences in sampling methods across countries, within-cell (defined in terms of sector and size class) biases persist. For a detailed account of cross-country comparability issues and suggestions on handling the data, see Lopez-Garcia, Di Mauro and the CompNet Task Force (2015) and the references therein. Lastly, the indicators refer to moments of the distribution considering all firms operating in the non-financial private sector (referred to in the remainder of the text as "the economy" or "country level").

To facilitate their description, the indicators have been grouped as follows: 1) characteristics of firms in different segments of the productivity distribution; 2) full distribution of several competitiveness-related indicators; 3) full distribution of several competitiveness-related indicators for the set of exporting and non-exporting firms (this information is only available for firms operating in the manufacturing sector).

Characteristics of firms in different segments of the productivity distribution[33]

The following information on the most and least productive firms, defined as those in the top and bottom 10% of the country-level productivity distribution, is provided.

- Median size of firms in the top and bottom 10% of the productivity distribution. The definition of size is based on the number of employees.
- Median labour cost per employee of firms in the top and bottom 10% of the productivity distribution. Labour costs include nominal wages and salaries including employers' social security contributions.
- Median labour productivity of firms in the top and bottom 10% of the productivity distribution. Labour productivity is measured as the real value added divided by the number of employees, at firm level. Firm-level value added is deflated with the corresponding implicit sector deflator, provided by Eurostat National Accounts by branch (64 industries).[34]
- Median unit labour cost (ULC) of firms in the top and bottom 10% of the productivity distribution. ULC (or cost per unit of product) at firm level is defined as nominal labour cost per employee divided by real labour productivity.

[33] The names of the corresponding variables can be found in Appendix A.2.2

[34] Note that sector deflators are rescaled by a constant to ensure as much cross-country comparability of prices as possible. The scaling factor comes from the sector purchasing power parities (PPPs) computed by the Groningen Growth and Development Centre. The prices in Germany are taken as a benchmark. Note also that the Groningen centre has estimated sector PPPs only for 1997, hence a large assumption has to be made, namely that, at sector level, relative prices between any given country and Germany have not changed over time.

- Median total factor productivity of firms in the top and bottom 10% of the productivity distribution. Total factor productivity is estimated at firm level using a semi-parametric approach. For more information, see Annex 6 to CompNet Task Force (2014) and Box 3 of Lopez-Garcia, Di Mauro and the CompNet Task Force (2015).
- Share of credit-constrained firms in the top and bottom 10% of the productivity distribution. The credit constraint indicator is computed at firm level using similar methodology to the Whited-Wu index.[35] For more information, see Box 4 of Lopez-Garcia, Di Mauro and the CompNet Task Force (2015).
- Median return on assets (ROA) of firms in the top and bottom 10% of the productivity distribution. ROA is defined as operating profits/loss over total assets.
- Median collateral of firms in the top and bottom 10% of the productivity distribution. Collateral is defined as fixed tangible assets over total assets.

Full distributions

The distribution of the firm-level variables in the CompNet database is characterised by the level of the variable in the 10th, 50th (or median) and 90th percentiles. This Compendium also provides information on the average of the distribution[36] and on the inter-quartile range, which is a measure of dispersion, defined as the difference between the variables in the 75th and 25th percentiles of the distribution. The distribution is computed considering all firms in the economy.

- 10th, 50th and 90th percentiles of the firm size distribution. Firm size is defined as the number of employees in the firm.
- Average firm size at country level.
- Inter-quartile range of the firm size distribution.
- 10th, 50th and 90th percentiles of the labour productivity distribution. Labour productivity at firm level is defined as real value added per employee.
- Average labour productivity at country level.
- Inter-quartile range of the labour productivity distribution.
- 10th, 50th and 90th percentiles of the capital intensity distribution. Capital intensity at firm level is defined as real fixed tangible assets per employee. Fixed tangible assets are deflated using the GDP deflator, from Eurostat National Accounts.
- Average capital intensity at country level.

[35] That is, the procedure combines information on credit constraints coming from a survey with information on the financial position of the surveyed firms.

[36] A comparison between the median and the average, in a given country or sector, can give an indication of the skewness of the corresponding distribution.

- Inter-quartile range of the capital intensity distribution.
- 10th, 50th and 90th percentiles of the total factor productivity (TFP) distribution. TFP is calculated as the residual, for each firm in the sample, of a production function estimated at sector level following a semi-parametric approach. For more information, see Annex 6 to CompNet Task Force (2014) and Box 3 of Lopez-Garcia, Di Mauro and the CompNet Task Force (2015).
- Average TFP at country level.
- Inter-quartile range of the TFP distribution.
- 10th, 50th and 90th percentiles of labour costs per employee, defined at firm level as total labour costs (including wages and employers' social security contributions) over number of employees.
- Average labour cost per employee at country level.
- Inter-quartile range of the labour cost per employee distribution.
- 10th, 50th and 90th percentiles of unit labour costs. Unit labour costs at firm level are defined as the nominal cost per employee divided by real labour productivity.
- Average ULC at country level.
- Inter-quartile range of the ULC distribution.
- Share of credit-constrained firms in the economy. The credit constraint indicator is computed at firm level using similar methodology to the Whited-Wu index. For more information, see Box 4 of Lopez-Garcia, Di Mauro and the CompNet Task Force (2015).
- 10th, 50th and 90th percentiles of ROA. ROA at firm level is defined as operating profits divided by total assets.
- Average ROA at country level.
- Inter-quartile range of the ROA distribution.
- 10th, 50th and 90th percentiles of collateral. Collateral at firm level is defined as fixed tangible assets divided by total assets.
- Average collateral at country level.
- Inter-quartile range of the collateral distribution.

Indicators for exporting firms

The full distribution of all indicators listed above is for the set of exporting and non-exporting firms within the manufacturing sector; i.e. the full distributions of firm size, labour productivity, capital intensity, TFP, labour cost per employee, ULC and ROA are

provided. The full distributions of all indicators listed above are computed for the set of exporting and non-exporting firms within the manufacturing sector; i.e. this database contains the full distributions of firm size, labour productivity, capital intensity, TFP, labour cost per employee, ULC, ROA, collateral and the share of credit-constrained firms for the sub-sets of firms with and without export activity.[37] Please note that only manufacturing firms are considered in this part of the firm-level exercise.

Advantages of using the firm-level data

- They provide information on moments of the distribution other than the average, which is not representative if the underlying distribution of firms is asymmetric and disperse.
- They provide information on the characteristics of specific sets of firms within the country, such as exporting firms or firms at the top and bottom of the productivity distribution.
- Indicators are as comparable as possible across countries given the differences in accounting rules and sampling methods. All indicators were computed using a common methodology, variable definitions, deflators and outlier treatment. Additionally, population weights are used in the sample of firms with more than 20 employees to ensure that the samples are representative of the population of firms in each of the countries.

Caveats

- Indicators only become available with a lag, as they are mostly derived from firms' balance sheets.
- The samples of firms with at least 20 employees include a small share of the total population of firms in many countries.
- Despite the application of population weights, within-cell (defined at sector and size level) biases remain in some countries. More information on sample biases and suggestions for the proper use of data can be found in Lopez-Garcia, Di Mauro and the CompNet Task Force (2015) and the references therein.

Box 4

Euro area external adjustment and real exchange rate movements: the role of firm productivity distribution

A corollary of the euro area crisis has been a large current account surplus for the euro area, resulting from better-than-expected export performance driven by cyclical and structural factors and strong external demand.

[37] A minimum of 0.5% of turnover from sales abroad is required to identify a firm as an exporter in a given year.

The macroeconomic costs of external rebalancing can be divided conceptually into two parts: the decrease in domestic spending and welfare, and the real exchange rate depreciation. The extent of the real exchange rate depreciation depends on one important factor that is often ignored due to lack of data: the country-specific distribution of firm productivity (see Di Mauro and Pappadà, 2014).

The ECB CompNet firm-level data suggest that firms' productivity is highly heterogeneous across euro area countries and sectors. In particular, the data show that surplus countries such as Germany are characterised by a productivity distribution with a higher mean and substantially fatter tails than those of deficit countries such as Spain and Italy (see Lopez-Garcia, Di Mauro and the CompNet Task Force 2015).

Conceptual underpinning

Di Mauro and Pappadà (2014) study the macroeconomic implications of the euro area's external rebalancing in a three-country general equilibrium model with a tradable and a non-tradable sector. In both sectors, firms are heterogeneous in terms of their productivity. The adjustment of the external imbalances in a deficit country is associated with a decrease in its demand for imports and an increase in demand for exported goods.

The higher demand for tradable goods produced in the deficit country leads to an increase in aggregate exports. The external adjustment occurs at the extensive and intensive margin, as the sales of new heterogeneous exporting firms (extensive margin) contribute to the external account adjustment along with the sales (old and new) of existing exporting firms (intensive margin). The larger the number and the size of new exporting firms, the greater the extent to which the extensive margin of trade contributes to the increase in aggregate exports driving the trade rebalancing. For a given external adjustment, the larger the contribution of the extensive margin, the lower the required change in relative prices.[38]

External adjustment and real exchange rate movements

We calibrate our model using the first vintage of the CompNet firm-level database (CompNet Task Force, 2014). We consider the larger euro area countries with external imbalances. In our three-country model, Germany is the surplus country, Spain is the deficit country and the rest of the world is the third country. We then replace Spain by Italy as the deficit country. In our simulations, we reproduce the actual external adjustment process of Spain and Italy between 2007 and 2013 (the benchmark case), and we construct a counterfactual in which we keep the cross-country differences in the mean of productivity while switching off the differences in terms of productivity dispersion. This counterfactual is intended to capture the hypothetical consequences of the adjustment in a model in which only the differences in average productivity are considered. For both the benchmark and the counterfactual calibration, we calculate the real exchange rate adjustment predicted by the model given the observed change in the trade balances of the deficit countries (Spain and Italy respectively) in relation to Germany and the rest of the world between 2007 and 2013.

[38] When the sales of new exporting firms play a big role in the overall increase in exports, there is less of a need for a change in relative prices (real exchange rate depreciation) to achieve a given external adjustment.

Table

External account rebalancing, 2007-13

(Percentage changes in real exchange rates. A positive number refers to real exchange rate depreciation)

	Spain		Italy	
	$RER_{ES/DE}$	$RER_{ES/DE}$	$RER_{IT/DE}$	$RER_{IT/ROW}$
Counterfactual	1.26	1.53	0.53	0.44
Counterfactual	3.63	3.79	1.38	0.87
Higher elasticity of substitution deficit countries	5.98	3.28	2.45	0.73

Source: Di Mauro and Pappadà (2014).

There are two main results:

- A model that does not consider the differences in productivity dispersion (counterfactual) between surplus and deficit countries within the euro area may underestimate the required exchange rate depreciation in deficit countries because such a model would overestimate the contribution of the extensive margin to the external adjustment.

- Productivity distribution differences across deficit and surplus countries are informative on the extent to which real depreciation can be expected to be an effective source of readjustment.[39]

The extent of the real exchange rate adjustment required for rebalancing will also be contingent on the substitutability of the products exported. As European deficit countries produce goods with lower high-tech content – and are thus subject to greater competition from developing countries – one might argue that the elasticity of substitution of their products is higher. In an extended version of the model, we allow for higher elasticity of substitution for goods produced by deficit countries. Since Italian and Spanish firms are on average less productive than their German counterparts, higher elasticity of substitution is detrimental to their exports, as the cheaper goods produced by German firms – due to higher productivity – are more attractive for consumers. As a consequence, this further reduces the extent of the extensive margin of trade with Germany and requires larger real exchange rate depreciation.

Conclusions

Cross-country differences in firm-level productivity distributions are fundamental to assessing the extent of real exchange rate movements associated with euro area external rebalancing. CompNet firm-level data point to a rather unfavourable level and distribution of productivity for deficit countries. The hard implication is that – with such strong productivity heterogeneity persisting – the extent of the real exchange rate adjustment needed in deficit countries for rebalancing is far larger than would be indicated by a model neglecting this dimension. This, in turn, points to the need to strike a more precise balance between relative price adjustment and other more structural policies.

[39] See above in the case where productivity distributions are considered the same across countries.

4.10 Global value chain indicators[40]

Nowadays production processes are increasingly internationally fragmented. As a result, intermediate goods and services cross borders multiple times. The multiple crossing of borders inflates gross trade and reduces the reliability of traditional trade statistics as a measure of country's competitiveness. Appropriate measuring of the value that a country actually exports, i.e. corrected for imported value added contained in its gross exports, provides a better understanding of a country's inclusion in the global economy. Global value chain (GVC) indicators shift the focus from the country's performance in gross trade to its value added contribution to the world economy.

Calculations of GVC indicators are based on the **World Input-Output Database** (WIOD), which combines information from national supply and use tables and bilateral trade in goods and services for 40 countries and 35 industries, over a time series from 1995 to 2011. The data in WIOD are in millions of US dollars.

Splitting gross exports into domestic and foreign value added:

Domestic value added in gross exports contains both direct (i.e. by the exporting sectors) and indirect (i.e. by domestic sectors that provide inputs to the exporting sector) value added from domestic producers embodied in gross exports of goods and services. A country's domestic value added can be decomposed into four components by applying the Leontieff inverse transformation matrix (see Koopman et al., 2010, equation (28) for technical details):

$$E_{r*} = DV_r + FV_r = \\ ,= \underbrace{V_r B_{rr} \sum_{s \neq r} Y_{rs}}_{1} + \underbrace{V_r B_{rr} \sum_{s \neq r} A_{rs} X_{ss}}_{2} + \underbrace{V_r B_{rr} \sum_{s \neq r} \sum_{t \neq r,s} A_{rs} X_{st}}_{3} + \underbrace{V_r B_{rr} \sum_{s \neq r} A_{rs} X_{sr}}_{4} + \underbrace{FV_r}_{5} \quad (10)$$

where E_{r*} is total gross exports of country r, DV_r is domestic value added in gross exports, FV_r represents foreign value added in gross exports, V_r gives the share of direct domestic value added in total output, B_{rr} denotes the Leontieff inverse matrix, Yrs is the final demand vector which gives demand in country s for final goods produced in r, A_{rs} is the input-output coefficient matrix, giving intermediate use in s of goods produced in r, and X_{sr} is the output of country s used to produce goods absorbed in country r. The interpretation of the terms in equation (11) is as follows:

1. Domestic value added contained in exports of final products, including all direct and indirect domestic **value added embodied in exports of final goods and services absorbed by the direct importer**. For example, this item includes French value added in wine shipped from France to the US and consumed by US households.

[40] Based on Koopman et al. (2010), Koopman et al. (2014), Timmer et al. (2012).

2. Domestic value added contained in exports of intermediate products remaining in the destination country after a first round of processing, used **by the direct importer to produce its domestically needed products** (both final and intermediate products); for example, Latvian value added in wood products exported from Latvia to Finland that is further used to produce furniture consumed in Finland.

3. Domestic value added contained in exports of intermediary products exported further, covering value added embodied in intermediate exports used **by the direct importer to produce goods and services for third countries** (both final and intermediate products); for example, German value added in exports of computer chips used in China to assemble computers that are further exported outside China.

4. Domestic value added in exports of intermediate **products exported back** (both final and intermediary products). Domestic value added embodied in intermediate exports used by the direct importer to produce goods shipped back to source; for example, German value added in exports of computer chips to China that return to Germany in form of computers "Made in China".

Items 3 and 4 together represent the import content of other countries' exports (IV_r).

Foreign value added in gross exports (FV_r) is calculated as a residual between gross exports and domestic value added in gross exports. It includes all direct and indirect foreign value added.

Value added exports:

Another measure that is closely related to previous measures is value added exports (also called value added trade, *VAX*). It differs in that it reflects how a country's exports are used by importers. VAX is value added produced in particular country and **absorbed in the rest of the world**. As such, VAX does not include domestic value added in exports of intermediary products that are embodied in domestic final use. Value added exports are calculated by pre-multiplying the vector of foreign final use by the total requirements (Leontieff) matrix and the value added coefficient vector of the country of interest:

$$VAX = VBY, \tag{12}$$

where Y is a final demand matrix, V is a diagonal matrix with direct value added coefficients along the diagonal, and B denotes the Leontieff inverse matrix.

Position in the global value chain:

The position in the global value chain is defined as the log ratio of a country's supply of intermediates used in other countries' exports (IV_r) to the use of imported intermediates in its own production (FV_r):

$$GCV\_Position_r = \ln\left(1+\frac{IV_r}{E_{r^*}}\right) - \ln\left(1+\frac{FV_r}{E_{r^*}}\right) \tag{13}$$

This index captures a **country's position (i.e. upstream or downstream) in the production chain** and allows cross-country comparisons to be made. If the country tends to specialise in upstream segments of a production chain (e.g. typical of countries with large-scale natural resources), the numerator tends to be large. On the other hand, if it lies downstream, then the denominator is large. For example, if Germany specialises in providing components to assembly firms in the Czech Republic, the position in the GVC index will take a higher value for Germany than for the Czech Republic.

Participation in global value chains:

Participation in global value chains is defined as the sum of a country's supply of intermediates used in other countries' exports (IV_r) and the use of imported intermediates in its own production (FV_r) relative to total gross exports:

$$GCV\_Participation_r = \frac{IV_r}{E_{r*}} + \frac{FV_r}{E_{r*}} \quad (14)$$

The participation in GVC index summarises the importance of the global supply chain for the country. In other words it shows its **level of integration into GVCs** and is somewhat similar to the trade openness indicator. The participation index has to be used in conjunction with the position index, as two countries can have identical GVC position index values while having very different degrees of participation in GVCs.

Advantages of using this indicator

- Using an inter-country input-output table instead of national input-output tables shows the complete picture of the global value chains, i.e. it enables intermediate inputs to be traced back to their origin and to follow the further path of intermediate exports.
- It shifts the analysis from trade in goods and services to the trade in value added, which measures how much countries actually benefit from trade. It allows for a complementary analysis of competitiveness in a situation of fragmented production processes.

Caveats

- The WIOD database only contains information up to 2011.
- The WIOD database only covers 40 major world countries (others are subsumed into the "rest of the world" bloc) and disaggregates data to just 35 industries. This may lead to underestimation of production process fragmentation.
- The construction of inter-country input-output tables relies on a series of assumption (split between final and intermediate goods and services; attribution of intermediates to different processing sectors). Trade in intermediates between industries is therefore represented by estimates rather than data points.

Box 5

Mapping a country in the global economy (GVC)

The box provides some stylised facts about the position of various countries in global value chains (GVCs) and shows the development of GVCs over the last 20 years. The analysis is based on two recently developed indicators that were introduced by Koopman et al. (2010), namely participation and position in GVCs. Calculations are performed using the World Input-Output Database (WIOD, see Timmer et al. (2012) for a description of the data).

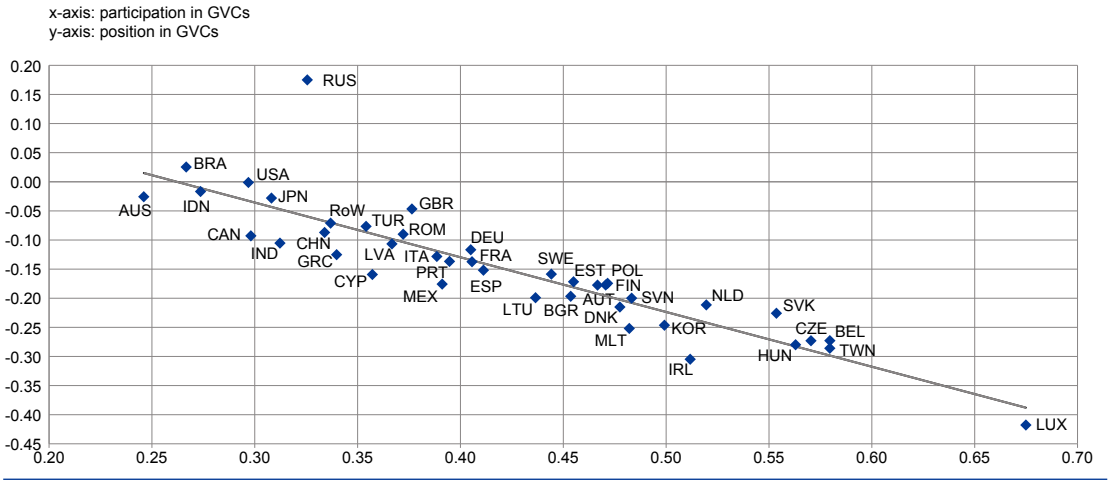
Participation and position in global value chains

Participation in GVCs is somewhat similar to the trade openness indicator, as it measures the level of integration into global production chains: a higher value denotes deeper integration. The second indicator of interest – position in GVCs – captures a country's position in international value chains relative to other countries. A higher value indicates that a country operates mainly upstream in GVCs, i.e. providing inputs, such as raw materials or R&D, to be processed abroad, while a lower value indicates that a country mainly operates downstream, e.g. in final assembly (see also the description of the indicator "Global value chain indicators").

Chart A shows a scatterplot of participation in GVCs versus position in GVCs. It becomes clear that the participation index negatively correlates with position in GVCs: countries with lower participation tend to be situated upstream in the production chain. This correlation is imputed by construction of indices: smaller countries usually have high foreign value added in gross exports (obviously, larger countries are better able to produce inputs domestically, and consequently their exports exhibit a lower import content). Foreign value added, in its turn, enters participation and position indices with different signs: big countries like Japan and USA have a low participation index and consequently a high position index, while Luxembourg, Belgium and Hungary are highly integrated into GVCs and tend to have a lower position in GVCs.

Chart A

Position in GVCs and participation in GVCs in 2011



Source: ECB calculations, WIOD

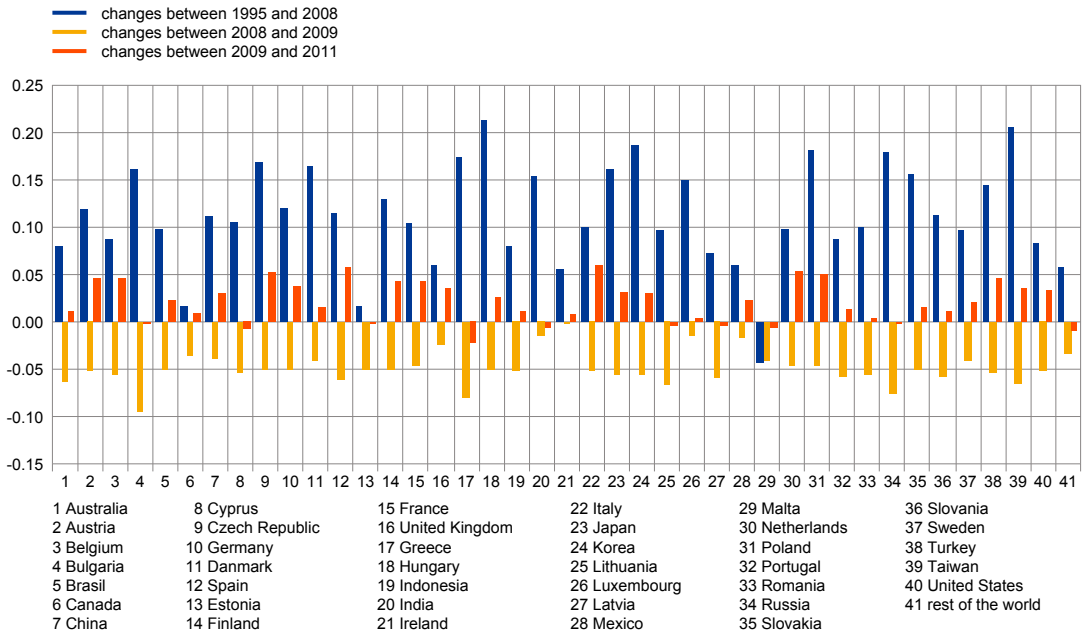
Nevertheless, despite this negative correlation, the joint use of position and participation in GVCs provides some additional information. It is useful to analyse why countries are more upstream or downstream in the production chain than peers that have a similar degree of participation in GVCs. The clear outlier is Russia: its participation index is comparable to India's and China's, while the Russian economy is much more focused on supplying intermediates (i.e. raw materials) to other countries. A position in GVCs above or below the trend is driven by the combination of various factors. A large share of raw materials in exports (Russia, Brazil) or a focus on R&D activities (USA, Japan, UK, Germany) moves the country upstream in the production chain, while countries specialising in final assembly (China, India, Mexico) or tourist services (Greece, Malta, Cyprus) tend to have a lower position in GVCs.

Globalisation of production over time

While cross-country comparisons are somewhat distorted by country size, the dynamics for a particular country are not affected by this. Participation and position in GVCs are structural features of an economy and hence do not fluctuate strongly from year to year (so data for 2011 are still very relevant for 2014). Indeed, the correlation between the participation index in 1995 and 2011 is above 0.8, and the same holds for the position index. However, there are still some important changes over time. Chart B5.2 shows that most countries exhibited an increasing trend in the participation index between 1995 and 2008. This growing participation has been especially pronounced for Hungary, Korea, Poland and Taiwan: these countries participate heavily in electronics and car production chains. As an example, the German car industry became increasingly internationally fragmented during this period, while Hungary and Poland became part of this value chain. For other countries, such as Canada, Estonia and Malta, barely any increase is visible, and indeed Malta even recorded a decrease.

Chart B

Changes in GVC participation index



Sources: ECB calculations and WIOD.

Chart B also reveals that participation in GVCs decreased in virtually all countries during the crisis in 2008-09. The level of integration into the global economy decreased the most for the Baltic states, Bulgaria, Greece and Russia, which can be partially explained by very large output losses during the crisis. The participation index improved gradually afterwards, although the fall during the crisis was not fully recouped and the integration level was still lower in 2011 than in 2008 for most of the countries. A decrease in participation in GVCs could be harmful in the long run, since a country tends to participate in the tasks where it has the largest comparative advantage. As such, a persistent withdrawal from global production chains may signal the inefficient use of a country's resources. However, more in-depth country investigation is necessary to learn why participation in GVCs decreases.

Conclusions

The ongoing process of cross-border fragmentation reduces the reliability of traditional trade statistics as a measure of a country's export performance. Participation and position in GVCs provide complementary measures that give a better understanding of a country's place in the global economy.

Box 6
Assessing export market shares based on domestic value added in exports

Because of the international fragmentation of production, a country's gross exports[41] do not accurately reflect the contribution of exports to the country's GDP. In fact, raw material and intermediate goods imports that are needed as inputs to produce the export product must be subtracted from gross exports to obtain the net contribution of exports to this country's GDP. This box describes a new indicator for calculating export market shares using export data net of imported inputs: domestic value added in exports.[42]

Domestic value added in exports and export market shares

Over the period 2007-11, export market shares based on both gross exports and domestic value added in exports point towards a deterioration of export market shares for most EU countries (see Chart A).[43] For some countries, such as Spain, Sweden, Luxembourg and Cyprus, export market shares using either gross or domestic value added in exports point to similar developments. However, there can be sizeable differences, as in the cases of Bulgaria, the Netherlands, Malta, Slovakia, Ireland and the United Kingdom (GBR in Chart A). When considering gross export market shares, the United Kingdom and Bulgaria show similar losses in

41 The term "gross exports" includes both domestic value added and imported materials included in the countries' exports. The term "domestic value added in exports" excludes the value of imports of raw materials and intermediate goods and services.

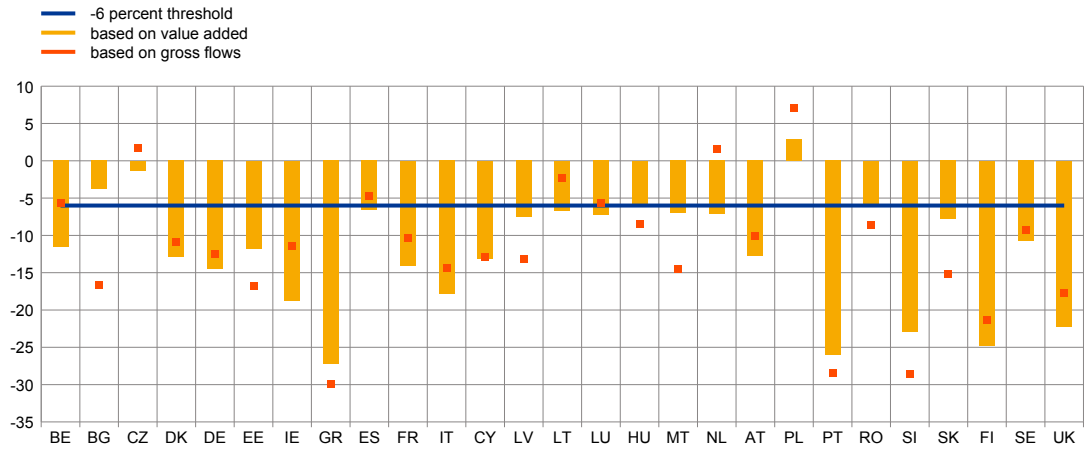
42 Market shares based on gross exports are defined as country's gross exports as a share of world gross exports, whereas the market shares based on domestic value added in exports are defined as a country's domestic value added in exports as a share of world domestic value added in exports.

43 The estimations are based on the World Input-Output Database (WIOD). See Timmer et al. (2012) for details of the WIOD.

Chart A

Export market share changes

(5-year percentage change over 2007-11*)



Source: World Input-Output Database and authors' calculations.
Note: Export market shares are computed as a country's exports (gross or domestic value added) relative to world exports (gross or domestic value added).

market share. However, considering domestic value added in exports, Bulgaria appears to have lost less export market share than the United Kingdom.

To explain part of the discrepancy between the two export market share measures we use the notion of "domestic value content of exports" (VAX), which is calculated as the ratio of the domestic value added in exports to gross exports. In fact, between 2007 and 2011, the VAX ratios show heterogeneous developments across EU countries (Chart B).[44] Most EU15 countries experienced a decline or no change in the VAX ratio, while most of the new Member States experienced an increase in the VAX ratio.[45]

Taking a closer look at individual countries and if we assume that export market shares reflect competitiveness developments, Chart A suggests that Hungary's export competitiveness worsened less when considering domestic value added in exports. This reflects the increase in the Hungarian VAX ratio (Chart B). In addition, it reflects the fact that Hungarian domestic value added in its exports grew more in line with the average for domestic value added traded worldwide, whereas Hungarian gross exports grew markedly more slowly than world gross exports (Chart A). Lower gross export growth is not harmful per se when a country increases its income, i.e. its domestic value added, per unit of export. In the case of the Netherlands, even though the gross export market share increased during 2007-11 (Chart A) its VAX ratio decreased (Chart B), thereby leading to a loss in the Netherlands' value added market share.[46]

[44] The heterogeneity across countries in the share of domestic value added in exports in gross exports has been well documented in the literature. See e.g. Johnson (2014) for an overview.

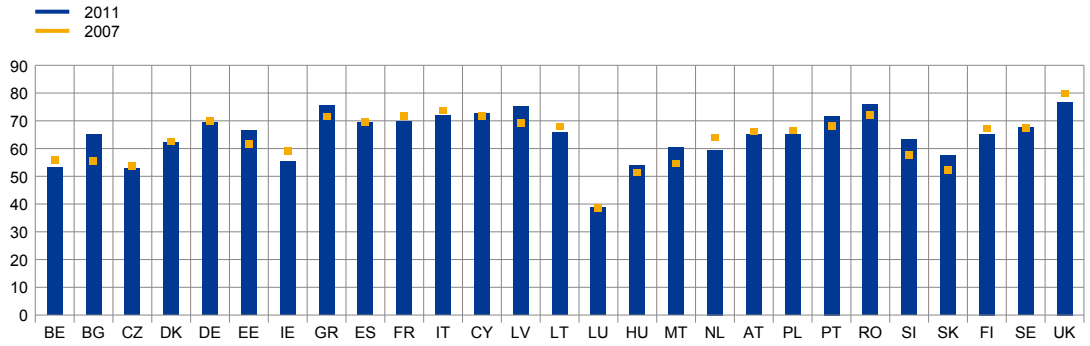
[45] For Bulgaria, Estonia, Greece, Cyprus, Latvia, Lithuania, Luxembourg, Malta, Portugal, Romania, Slovenia and Slovakia, detailed national accounts data were only available up to 2009, which were used to calculate 2010 and 2011 figures for these countries in the WIOD.

[46] It is important to stress that changes in the VAX ratio do not always explain the difference between gross export market shares and value added market shares. For example, the VAX ratios for Spain and Sweden remained constant during 2007-11, but Chart B6.1 clearly shows differences in the domestic value added in exports and gross export market shares. This is because global gross exports and globally traded domestic value added in exports do not grow at the same rate.

Chart B

Share of domestic value added in exports over total gross exports

(percentage)



Source: World Input-Output Database and authors' calculations.

Sectoral drivers of domestic value added in exports

Taking a closer look at the sectoral breakdown of changes in the domestic value added in exports, the table below decomposes the contributions of the primary sector, manufacturing and services to the changes in the total VAX ratio. The colours in the columns represent the change in a country's VAX ratio: dark red for the largest decrease in the VAX ratio (the Netherlands for the "total" column) to dark green for the largest increase in the VAX ratio (Bulgaria for the "total" column).

Table

VAX ratio and sectoral breakdown

(change 2007-11, percentage points)

	2011-2007			
	Total	Primary sector, construction & utilities	Manufactured goods	Services
BEL	-2.6	0.0	-2.3	-0.2
BGR	9.8	2.9	0.3	6.5
CZE	-0.7	0.3	-0.9	-0.1
DNK	-0.3	0.9	-2.6	1.4
DEU	-0.4	0.4	-0.9	0.0
EST	4.9	0.8	-0.2	4.3
IRL	-3.9	-0.2	0.3	-4.0
GRC	4.1	2.9	0.6	0.6
ESP	-0.1	0.3	-2.6	2.1
FRA	-1.7	0.5	-4.4	2.2
ITA	-1.7	0.0	-2.1	0.4
CYP	1.1	-0.8	1.1	0.8
LVA	5.8	1.1	-0.5	5.2
LTU	-1.9	0.3	-2.7	0.6
LUX	0.0	0.0	-1.3	1.3
HUN	2.3	1.1	1.6	-0.4
MLT	5.8	0.3	-1.2	6.7
NLD	-4.4	-0.9	-1.6	-1.9
AUT	-0.9	0.3	-2.2	1.1
POL	-1.5	0.1	-1.6	0.0
PRT	3.5	0.6	-0.2	3.1
ROM	3.7	1.3	0.2	2.2
SVN	5.7	1.1	0.7	3.9
SVK	5.5	1.3	1.1	3.2
FIN	-1.8	0.7	-6.8	4.2
SWE	0.1	1.3	-3.1	1.8
GBR	-3.0	0.0	-0.6	-2.4

Source: World Input-Output Database and authors' calculations.

Based on the results of the table above, we can conclude that the VAX ratio has decreased in the manufacturing sector for most countries, while it has increased in the services sector for the vast majority. These developments reflect to a large extent the deindustrialisation process observed in the EU, where a shift has been observed in the sectoral allocation of value added from the industrial sector to the services sector (see Box 7 of February 2013, ECB Monthly Bulletin).

Conclusions

The analysis undertaken in the current box indicates that the metric used to assess export performance using export market shares based on gross exports versus domestic value added in exports can lead to different interpretations and policy conclusions. For instance, based on the European Commission's MIP critical value of a 6% decline in export market shares over a period of five years, Bulgaria would be in the red when using gross exports, but not when using domestic value added in exports. On the other hand, for Ireland and the Netherlands the domestic value added in export share growth is lower than the growth in the gross export share. This implies that in the context of assessing imbalances, a different picture might emerge depending on whether gross or domestic value added data are used, due to over/underestimation of export market shares. However, for policy analysis the evolution of domestic value added in export market shares will be most important, because this captures the effects of exports on GDP growth.

5 Establishing empirical links between competitiveness indicators and objective variables

The purpose of this Compendium goes beyond a simple description of innovative indicators. To facilitate the policy-making process, empirical evidence on the links between competitiveness indicators and policy objective variables is presented in this final section. While empirical tests cannot unambiguously suggest the best solution, the results of the analysis performed below can provide some guidance in successfully choosing the most appropriate indicators. In the first part, this Compendium investigates the information content of price and cost variables by comparing the significance of alternative harmonised competitiveness indicators (HCIs) on trade performance. In the second part of the section the results of a broader study identifying the empirical links between numerous competitiveness indicators and real GDP per capita, which is our "anchor variable", are provided.

5.1 Addressing the information content of price and cost competitiveness indicators

Trends in price competitiveness are traditionally proxied by the real effective exchange rate (REER, also called the harmonised competitiveness indicator, HCI), i.e. a weighted geometric average of bilateral exchange rates of a country's main trading partners deflated by a variety of measures of relative inflation. According to current computation practices, HCIs can be classified either as price-based (GDP deflator, HICP, PPI, export price) or cost-based (ULC either in total economy or in manufacturing). However, the choice of measure is open to much debate, since no standard indicator is theoretically optimal. Moreover, since the late 1990s the discrepancy between the two classes of HCIs has increased for most European countries, occasionally providing conflicting signals. Building on two recent studies, this section shows that from an empirical standpoint too the best measure of price competitiveness in terms of its explanatory power of trade flows of euro area countries is largely country-specific, depending on the country's pattern of trade, main trading partners and relative structural features.

In particular, Christodoulopoulou and Tkacevs (2014) explore the impact of alternative HCIs on exports and imports of goods and services of all individual euro area countries (with the exception of Belgium[47]) over the sample period 1995 Q1-2013 Q1. The study estimates standard export and import equations with the determinants of exports being foreign demand and HCIs, whereas the determinants of imports are domestic demand, HCIs and exports.[48,49] Giordano and Zollino (2015)

[47] Due to a lack of data on the breakdown of exports into goods and services.

[48] Export growth is included to account for the effect of the import content of exports.

[49] The dynamic equations include all the variables in growth rates, since in most cases they turn out to be non-stationary in level.

provide comparable empirical evidence, but with a focus on the price and non-price determinants of goods trade flows of the four largest countries (France, Germany, Italy and Spain) over the period 1993 Q1-2012 Q4.

5.1.1 Exports of goods and exports of services

In Christodoulopoulou and Tkacevs (2014), exports of goods of around half of euro area countries are found to be unresponsive to changes in relative prices or their reported sensitivity is small (see Table 2). In Giordano and Zollino (2015; see Table 3) price competitiveness proves to play a sound role in explaining merchandise exports in the four largest euro area countries with the exception of Spain, for which evidence is less robust across the time horizon and the estimated model.[50]

Table 2

Long-run elasticity of exports of goods with respect to HCIs

	AT	CY	EE	FI	FR	DE	GR	IE	IT	LU	MT	NL	PT	SK	SI	ES
CPI	-0.77	-2.07	-1.46	-1.42***	-0.73***	-0.54***	-0.86	-0.57	-0.30*	-0.14	-2.31***	-0.45***	-0.65	-0.32	-0.36	-0.80***
PPI	-0.36	-1.37	-0.12	-1.85***	-0.97***	-0.30*	1.00	-0.70	-0.55***	-0.12	-2.15***	-0.31**	0.06	-0.33	-0.40	-0.93**
ULCM	0.25	0.37	-0.98***	-0.75**	-0.76***	-0.38***	-0.46**	-0.03	-0.20*	-0.12	-0.65	-0.26**	-0.23	-0.25**	-0.05	-0.30
ULCT	-0.99**	-0.66	-1.05***	-1.64***	-0.89***	-0.48***	-0.17	-0.67**	-0.44***	-0.21	-0.82*	-0.25**	-0.22	-0.32*	-0.07	-0.69***
GDP	-0.85	-0.03	-0.78*	-2.41***	-0.79***	-0.50***	0.55	-0.45	-0.33*	0.03	-2.66***	-0.39***	-1.12**	-0.43*	0.00	-0.55*

Source: Christodoulopoulou and Tkacevs (2014).
Notes: Coefficients of solved long-run equations and their significance levels are reported. ***, ** and * imply significance levels of 1%, 5% and 10% respectively.

Table 3

Elasticity of exports of goods with respect to HCIs in the four largest euro area countries

	Constant	Potential demand	HCI	HCI (-4)	Relative TFP (-4)	No. of observations	Adjusted R2
A. Italy							
PPI	-0.0046**	1.0326***	-0.5309***	-0.2049*	1.0436	75	0.7322
CPI	-0.0041*	1.0190***	-0.5715***	-0.2208**	1.0114*	76	0.7296
GDP deflator	-0.0036*	0.9985***	-0.5167***	-0.1931*	1.0162*	75	0.7330
UCLM	-0.0022	1.0350***	-0.2264***	-0.1515**	1.2897	68	0.7172
B. Germany							
PPI	0.0022	1.0162***	-0.2419***	-0.0275	1.3535**	75	0.6809
CPI	0.0018	1.0425***	-0.3023***	0.0097	1.4051**	76	0.6842
GDP deflator	0.0017	1.0395***	-0.2396**	0.0275*	1.3806**	75	0.6792
UCLM	0.0032	0.9600***	-0.3401***	0.0071	1.0007*	68	0.7430
C. France							
PPI	-0.0029*	1.0087***	-0.1723	-0.1419	0.7453	75	0.6379
CPI	-0.0036**	1.0026***	-0.2551*	-0.1225	-0.8031	77	0.6340
GDP deflator	-0.0028*	1.0001***	-0.1723	-0.1419	0.7429	75	0.6402
UCLM	-0.0034*	0.9707***	-0.3647***	-0.0799	-0.5665	68	0.6529
D. Spain							
PPI	0.0002	1.4820***	0.1452	0.0325	2.9865*	67	0.3975
CPI	-0.0008	1.5108***	0.0442**	0.2297	2.9680*	69	0.3979
GDP deflator	-0.0001	1.5071***	0.2509	0.0234	3.1645*	71	0.4035
UCLM	-0.0002	1.6373***	0.1697	0.1806	3.8050**	69	0.4456

Source: Giordano and Zollino (2015).
Notes: Dependent variable: exports of goods, 1993 Q2-2012 Q4, log-differences. OLS estimates. ***, ** and * imply significance levels of 1%, 5% and 10% respectively.

[50] Giordano and Zollino (2015) find that in Spain exports of goods do not react to HCIs, however computed, thus confirming the so-called “Spanish paradox” received from the empirical literature.

Exports of services are found to be sensitive to relative price developments in the four largest euro area countries, as well as in the Netherlands and Slovakia; in the rest of the euro area countries, the effect of HCIs is mostly statistically insignificant (see Table 4).

Table 4

Long-run elasticity of exports of services with respect to HCIs

	AT	CY	EE	FI	FR	DE	GR	IE	IT	LU	MT	NL	PT	SK	SI	ES
CPI	-0.36	-0.43	-0.08	0.04	-0.55**	-0.67*	1.68**	-0.65**	-0.72**	0.25	0.72	-0.81***	-0.98**	-0.58**	-0.02	-0.92***
CPIS	1.83*	-0.12	0.05	x	-0.09***	-0.75**	0.68	0.19	-1.06***	1.58***	0.45	-0.47***	-0.43	-0.35	0.70	-0.58**
ULCT	-0.31	-1.29***	-0.18	0.14	-0.53*	-0.54***	1.24	0.00	-0.14	-0.18	-5.83***	-0.88***	-0.39	-0.59***	-0.11	-0.65***
GDP	0.64	-0.28	-0.49*	0.01	-0.55**	-0.58***	2.06***	-0.82	-0.83***	0.10	-1.93	-0.98***	-0.40	-1.12***	-0.04	-0.76***

Source: Christodoulopoulou and Tkacevs (2014).
Notes: Coefficients of solved long-run equations and their significance levels are reported. ***, ** and * imply significance levels of 1%, 5% and 10% respectively. (x) Not able to identify a model with residuals satisfying standard assumptions.

Based on the results of the two studies, the ranking of the explanatory power of the single HCIs is not uniquely established in all euro area countries. In general, more broadly defined indicators, either price or cost-based, support the increasing importance of the role of non-tradable sectors in determining an economy's export performance. For instance, Italy's exports of goods are more strongly related to price-based indicators than cost-based measures, even more so if only indicators based on ULC in manufacturing are considered; the same evidence is not found in Germany and France, where the relationship between output prices and domestic costs has weakened in recent times, plausibly due to more advanced internalisation of production (Giordano and Zollino, 2015).

Non-price competitiveness measures are likely to play an important role in driving exports of individual euro area countries, since standard export equations are normally unable to explain more than 60-70% of export growth. Indeed, by proxying the non-price dimension of competitiveness by relative trends in economy-wide total factor productivity, which capture changes in the efficiency of production processes and the degree of technological progress relative to a country's main trading partners, Giordano and Zollino (2015) found that this variable exerts a significant impact, among the largest euro area countries, on German, Italian and Spanish exports of goods. Moreover, elasticities turn out to be larger than those associated with price competitiveness.

5.1.2 Imports of goods and imports of services

Price competitiveness seems not to matter much, in terms of both statistical significance and size of coefficients, for imports of goods and services, with evidence in some countries pointing to counterintuitive negative effects (see Tables 5 and 6, from Christodoulopoulou and Tkacevs, 2014).

The latter result may be ascribed to an increasing role of those countries in global value chains, implying a growing share of imports of intermediate goods in the production process. Thus real appreciation leads to a decline in both exports and imports as a country becomes disconnected from global value chains.

Table 5

Long-run elasticity of imports of goods with respect to HCIs

	AT	CY	EE	FI	FR	DE	GR	IE	IT	LU	MT	NL	PT	SK	SI	ES
CPI	0.11	-0.83**	0.05	0.08	-0.21	0.01	-0.49	-0.40**	-0.30***	0.55	-0.42	-0.01	0.14	-0.11	0.01	0.15
PPI	0.37**	-0.70***	0.02	-0.10	-0.20*	0.06	-0.01	-0.66***	-0.18	0.20	-0.30	0.11*	-0.10	-0.15	0.01	0.14
ULCM	0.28***	-0.18	0.12	0.07	-0.03	0.10	0.43***	0.02	0.13	-0.07	-0.23	-0.06	0.10	-0.13*	-0.01	0.21**
ULCT	0.15	-0.28	-0.06	0.03	-0.23**	0.14	0.34*	-0.13	0.13	1.49***	0.43	0.02	0.18	-0.02	-0.10	0.27**
GDP	0.13	-0.93**	-0.57***	-0.18	-0.08	0.01	-0.42	0.17	-0.28***	0.08	0.12	0.11	0.52***	-0.34*	0.22**	0.40**

Source: Christodoulopoulou and Tkacevs (2014).
Notes: Coefficients of solved long-run equations and their significance levels are reported. ***, ** and * imply significance levels of 1%, 5% and 10% respectively.

Table 6

Long-run elasticity of imports of services with respect to HCIs

	AT	CY	EE	FI	FR	DE	GR	IE	IT	LU	MT	NL	PT	SK	SI	ES
CPI	0.24	-0.27	1.24**	0.11	-0.24***	-0.23*	0.17	-0.42*	0.49**	0.00	0.69	-0.42**	-0.18	-0.37	0.56**	-0.48***
CPIS	0.48	-0.16	-0.10	-0.96	-0.23	-0.18	-0.26	-0.33**	-1.39**	0.48	0.84**	-0.34*	-0.93**	-0.13	0.25	-0.41***
ULCT	0.10	0.43	-0.16	0.24	-0.49***	-0.25	-0.43	-0.54**	0.44**	0.19	0.28	-0.70***	-0.43	0.04	0.02	-0.36*
GDP	1.06*	-0.59	0.66	-0.26	-0.23	-0.28	-0.29	0.15	0.45**	0.17	0.05	-0.20	-0.07	-0.01	0.27	-0.44***

Source: Christodoulopoulou and Tkacevs (2014).
Notes: Coefficients of solved long-run equations and their significance levels are reported. ***, ** and * imply significance levels of 1%, 5% and 10% respectively.

5.2 Are all indicators equally important in measuring competitiveness?

This section studies the empirical link between numerous traditional and novel indicators of competitiveness described in the Compendium and our "anchor variable" of competitiveness – real GDP per capita.[51] The challenge posed by a broad range of potential drivers of economic growth can be overcome by Bayesian model averaging (BMA), which enables a vast number of models linking GDP per capita to its candidate drivers to be investigated (see e.g. Moral-Benito, 2012).

5.2.1 Addressing model uncertainty using Bayesian Model Averaging

The empirical literature does not allow an unequivocal set of explanatory variables for real GDP per capita to be identified. The numerous variables proposed as growth drivers in previous studies have some ex-ante plausibility but also face uncertainty regarding the significance of variables considered and the appropriate specification of the relevant model. The methodology applied here provides a formal treatment of variables/model uncertainty by considering all possible models and assigning to each model a posterior probability of being "true" based on Bayesian inference.

Under the BMA approach, the importance of each variable can be assessed using the sum of posterior model probabilities for all models that include that variable. The result is a *posterior inclusion probability (PIP)* for each variable, showing how

[51] Similar methodology can be applied to other intermediate anchors of competitiveness mentioned in Section 3. For example, Danquah et al. (2014) use a BMA approach to find the determinants of TFP growth.

relevant that variable is in explaining growth outcomes.[52] The coefficient associated to that variable is a weighted average of the coefficients of all models. The weights are given by the probability of each model of being the "true" one. The results presented here are based on a static panel regression with country fixed effects where all regressors are included with a one-year lag, controlling for possible reverse causality.

The following criteria have been considered during the choice of explanatory variables: (i) economic relevance and comprehensiveness; (ii) data availability; (iii) statistical properties of indicators. In fact, despite the ability of the BMA to deal with very large set of explanatory variables, it cannot include all indicators described in the Compendium. First, data for some novel indicators are available only for a small subset of countries (this excludes all firm-level indicators). Second, the BMA performs poorly in the case of highly correlated regressors (e.g. it is not possible to include GVC participation and GVC position indicators simultaneously, see Section 4.10). Moreover, since panel BMA with fixed effects is employed, we should avoid variables with little variation over time. Finally, the focus is on structural variables, and not on variables related to business cycle fluctuations (such as consumption as a share of GDP or construction investments as a share of total investments).

Thirty-five variables are selected that capture institutions and the business environment, the labour market and demographics, the financial sector, trade specialisation and price/cost measures. The set of variables used in the BMA analysis include both traditional and novel indicators (e.g. dynamic trade link analysis indicators, RCA in high-tech industries, relative export prices adjusted for quality, GVC position). The estimation period goes from 2003 to 2012 and includes 25 EU countries (excluding Croatia, Malta and Luxembourg due to limited data availability). Moreover, in order to address potential cross-country heterogeneity in terms of the robust determinants of growth, the sample of countries is split in two groups: old and new EU Member States.[53]

5.2.2 Empirical results

The main estimation results are provided in Tables 7 and 8, which contain a ranking of the robust explanatory variables according to their posterior inclusion probability (PIP). Variables are labelled as robust if two criteria are simultaneously met, namely (i) PIP exceeds the prior inclusion probability (equals 0.20 given a prior model size of 7) and (ii) the ratio of conditional posterior mean to conditional posterior standard deviation is larger than 1.65 in absolute value, corresponding to a 95% confidence interval. Note that tables do not report results for variables that did not pass the abovementioned robustness criteria.

[52] The methodology follows closely the framework adopted in growth regressions by Fernandez et al. (2001). A natural conjugate prior is adopted in case of the coefficients and the g-prior is elicited based on the "Empirical Bayes – Local" (EBL) approach, as in Liang et al. (2008) and Feldkircher and Zeugner (2009). Moreover, a beta-binomial prior distribution over the model space is assumed. Following Sala-i-Martin et al. (2004), a rather small prior model size of seven is imposed.

[53] Old EU Member States: Belgium, Denmark, Germany, Ireland, Greece, Spain, France, Italy, Netherlands, Austria, Portugal, Finland, Sweden and the UK. New EU Member States: Bulgaria, Czech Republic, Estonia, Cyprus, Hungary, Latvia, Lithuania, Poland, Romania, Slovenia and Slovakia.

For the new EU Member States, this Compendium identifies 11 variables that satisfy both of the above-mentioned criteria and can be labelled as robust (see Table 7). These variables capture a wide range of aspects, such as institutions and the business environment, the structure and quality of the labour force, the role of loans in financing of enterprises, and export structure and comparative advantages.

Four out of 11 variables relate to institutions and the business environment (three of these variables have the expected coefficient sign). Thorough control of corruption, better functioning of legal systems and securing of property rights have had statistically significant and positive effects on GDP per capita of the new EU Member States. These results stress the crucial role of institutions for central and eastern European countries and underline the necessity of structural reforms for long-term economic growth. Freedom to trade is another factor behind the higher growth performance, thus indicating the positive role of accession to the common European market for the new EU Member States. Finally, the BMA analysis suggests a negative empirical link between the regulatory quality variable and economic growth. This counterintuitive outcome may be related either to positive correlation with other institutional variables or to an initially high level of the regulatory quality variable in fast-growing countries (e.g. at the beginning of the sample Estonia already had high regulatory quality, which remained almost unchanged thereafter).

Not only the business environment, but also labour market conditions are notable drivers of competitiveness for the new EU Member States. Labour market flexibility, proxied by part-time employment, is one of them. Another characteristic of their labour market, which has high PIP and low standard deviation, is the quality of the labour force – a high share of labour with secondary education – which affects real GDP positively. The labour force participation rate has a negative and marginally significant link with growth in real GDP per capita.

Table 7

Posterior results for new EU Member States

	PIP	Posterior mean	Posterior SD	Mean/SD
Control of corruption	0.985	0.302	0.082	3.691
Part-time employment (percentage of total employment)	0.944	0.260	0.090	2.905
Loans (percentage of total liabilities)	0.776	-0.325	0.139	-2.467
Public debt (percentage of GDP)	0.751	0.260	0.114	2.272
Freedom to trade	0.699	0.220	0.104	2.123
Regulatory quality	0.691	-0.194	0.087	-2.228
Potential crowding out (versus China)	0.686	0.192	0.088	2.179
Existent overlap with China	0.686	-0.317	0.162	-1.951
Labour force with secondary education (percentage of total labour)	0.637	0.293	0.146	2.000
Legal system and property rights	0.587	0.191	0.098	1.947
Labour force participation rate	0.506	-0.139	0.081	-1.721

Source:

The financing structure of enterprises plays a considerable role in determining GDP per capita. The negative coefficient of the loans' share of total liabilities indicates that the worsening of credit supply conditions in the banking sector over recent years has an adverse impact when firms rely more heavily on bank lending than on other sources of financing.

Several novel indicators based on detailed trade data and described in the Compendium are significant to explaining growth performance. Two indicators suggest that the structure of a country's exports matters for competitiveness. On the one hand, countries that compete directly with China on third markets face lower GDP per capita growth. It may be that the competitive pressure from Chinese producers negatively affects export prices and thus diminishes profit margins. On the other hand, growth performance is positively correlated with the potential crowding out variable, which indicates cases where either exporters from China or new Member States leave the market. This positive correlation seems counterintuitive but may be related to the fact that escaping the direct competition with China and searching for alternative markets is a successful strategy.

Finally, the positive impact of public debt (as a % of GDP) may be explained by the fact that country fixed effects eliminate the expectedly negative effect of a high debt level on GDP growth. A positive coefficient reflects short-term effects (due to changes in debt), rather than the long-run impact of debt level.

For the old Member States, the paper identifies nine robust indicators (seven of them with the expected sign), which reveal different drivers of real GDP per capita (see Table 8). The relevance of institutions and the business environment is less important for the old Member States than for the new ones. This may be related to the fact that institutions have a longer history and higher quality in the old Member States, therefore further improvements have a smaller effect on real GDP per capita growth. Only freedom to trade appears to have a significant (and positive) impact on GDP growth, providing a strong argument against barriers to international trade.

Table 8

Posterior results for old EU Member States

	PIP	Posterior mean	Posterior SD	Mean/SD
Loans (percentage of total liabilities)	0.936	-0.473	0.097	-4.901
Loans growth	0.881	-0.229	0.073	-3.147
Freedom to trade	0.823	0.302	0.095	3.193
HCI based on CPI	0.520	-0.178	0.073	-2.435
Relative export prices adjusted for quality	0.520	0.155	0.064	2.420
Change in GVC position	0.290	0.145	0.079	1.837
Share of temporary employees (percentage of total employment)	0.272	-0.133	0.076	-1.744
New overlap with China	0.256	0.157	0.093	1.690
RCA in high-tech industries	0.245	0.120	0.068	1.763

Source:

Much as for the new EU countries, there is an empirical link between financial factors and real GDP per capita. As in Table 7 for the new Member States, greater reliance on bank lending compared with other sources of funding is harmful for real GDP per capita growth. This also fits with the negative coefficient with loan growth.

Another similarity with the results described above is the importance of the export structure for a country's competitiveness. Having a comparative advantage in high-tech products (according to the OECD classification) is associated with better competitiveness and real GDP growth for the old EU Member States. The positive coefficient with "new overlap with China" seems counterintuitive but may be related to

the outsourcing process. While Chinese exporters entering traditional markets of EU countries put pressure on competitiveness, participation in the production chain of "Made in China" products delivers a positive contribution to real GDP growth. The last statement is in line with a positive and statistically significant coefficient with changes in GVC position – the BMA results suggest that moving upstream in the production change is improving the growth performance of the old EU Member States.

The indicator "relative export prices adjusted for quality" – another novel indicator based on disaggregated trade data – has a significant but counterintuitive positive sign in the BMA equation. In other words, an increase in relative prices corrected for quality factors improves competitiveness. Again, this may signal that changes in quality are due not to domestic factors, but rather to participation in GVCs. Higher relative quality (and thus lower relative prices adjusted for quality) boosts export market share, but also increases imports of higher-quality intermediates, leaving net exports and real GDP unchanged. The research wants to stress the negative and statistically significant sign before the HCI based on CPI, which indicates that price and cost competitiveness cannot be disregarded when analysing GDP growth in old Member States.

Finally, the analysis observes a negative effect from the share of temporary employees on real GDP per capita. This could be related to the negative impact of uncertainty (associated with temporary positions) on productivity and thus on economic growth.

5.3 Conclusions and policy implications

When considering the role of alternative competitiveness indicators, it is not possible from an empirical standpoint to establish a general ranking of the explanatory power of the different HCIs that are traditionally computed. Country-specific analysis is therefore warranted. However, in the current context of the increasing internationalisation of firms' production processes, measuring price competitiveness based solely on ULC developments risks conveying misleading signals, as the contribution of other production cost components to a country's export performance is ignored. Structural reforms should better address all production cost items in order to ensure a sound improvement in firms' ability to compete internationally. Moreover, given the rising weight of services in the total economy, the degree of competitiveness of non-tradable sectors is becoming ever more relevant in explaining trade flows. Policy action addressed at loosening restrictive regulation and reducing administrative burdens in the services sector would also boost trade. Finally, alongside price competitiveness, non-price factors have become crucial determinants of export growth in many euro area countries. Productivity-enhancing structural reforms are thereby warranted to stimulate trade performance, both directly via the non-price channel and indirectly via the price channel.

The BMA-based evidence supports the usefulness of augmenting HCIs and other traditional determinants of competitiveness with newly developed CompNet indicators that can serve as explanatory variables for the developments of real GDP per capita. The BMA analysis suggests several common drivers of real GDP per

capita for all EU countries. For instance, freedom to trade remains one of the most important prerequisites for stable economic growth. Competitiveness pressures from China are an important factor for growth outcomes for both new and old Member States. Furthermore, a heavy reliance on bank lending compared with other sources of funding shows a negative impact on real GDP growth in our analysis.

The results show that there is some heterogeneity in the drivers of economic growth for the new and old EU countries, suggesting important difference in the structure of the two sets of economies and the relevance of adopting country-specific measures in order to boost growth performance. For the new EU Member States, variables capturing the quality of institutions and labour force conditions appear to be robust drivers of real GDP dynamics. The production internalisation process, reflected directly by the GVC position indicator and indirectly by other trade indicators, also acts as an important determinant of real GDP per capita.

Finally, one should note the fact that some indicators were not found to be robust according to the BMA analysis does not necessarily mean that they are not relevant from a policy point of view, but just that their explanatory power within the given sample of countries, years and explanatory variables is not particularly high. Also, indicators that did not appear to be significant regressors for real GDP may well explain other potential “anchors” of competitiveness indicated above: productivity and export market shares.

6 Conclusions

This document describes a comprehensive database of innovative and traditional indicators of competitiveness called the “Diagnostic Toolkit for Competitiveness”. The database contains a large set of traditional indicators that capture various aspects related to economic performance, the structure of the economy and the institutional environment. However, the most important contribution of the Compendium is the **systematic description of numerous (more than 80) novel indicators** designed by CompNet members. Most of the innovative indicators of competitiveness included in the Compendium are not hard data, but rely on models, assumptions and approximations. Moreover, novel indicators are based on various statistical data sources that ensure the understanding of strong and weak points in competitiveness from multiple angles. A short description of each innovative indicator – consisting of the motivation for use, an intuitive explanation of the methodology and a list of advantages and drawbacks – helps the reader to better understand the use of the innovative variables.

In general, all novel indicators can be attributed to three broad categories. First, **aggregate or macro indicators** based on very detailed bilateral external trade data go over and above the traditional price and cost variables, providing a comprehensive view of the competitive position of European Union countries and their peers. Second, the Compendium contains a large set of indicators based on **micro or firm-level** data. The unique feature of the Toolkit database is the comparability of indicators across countries. Firm-level data provide information on moments of the distribution other than the average, thus enabling underlying processes such as resource reallocation to be tracked and leading to important policy conclusions. Third, several novel indicators make use of the recently constructed World Input-Output Database. This enables the role of GVCs to be assessed and the value added to be decomposed into its domestic and foreign components.

The Compendium is more than a simple collection of descriptions. In order to bridge the gap between research and policy implications, this Compendium identifies **“anchor(s)”** or target variables of economic policy around which competitiveness indicators can be organised. The identification of “anchors” thus serves as a practical guideline for the implementation of a policy-oriented competitiveness analysis. The Compendium identifies **GDP/capita** as the most appropriate anchor variable for competitiveness analysis in an open economy. However, **productivity** and **export market shares** are also considered intermediate anchors.

Finally, the Compendium presents the **empirical evidence on the link between competitiveness indicators and policy objective** (“anchor”) variables. Several important findings should be highlighted. First, the focus is on the ability of alternative price competitiveness indicators to explain the trade performance of EU countries. Empirical evidence suggests that it is not possible to establish a general ranking of the explanatory power of the different harmonised competitiveness indicators that are traditionally computed. Country-specific analysis is therefore warranted.

Second, a broader study identifying the empirical links between numerous competitiveness indicators and real GDP per capita is performed. The BMA-based evidence supports the usefulness of augmenting harmonised competitiveness indicators and other traditional determinants of competitiveness with newly developed CompNet indicators. Empirical findings suggest several common drivers of real GDP per capita for all European Union countries: freedom to trade, competitiveness pressure from China, share of loans in total liabilities. The results show that there is also a degree of heterogeneity in the drivers of economic growth for the new and old European Union countries, suggesting important differences in the structure of the two sets of economies and the relevance of adopting country-specific measures in order to boost growth performance.

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Appendix

A.1 Data sources

The Diagnostic Toolkit mainly uses time series data for the current 28 EU Member States. Where possible, it extends the coverage to EU enlargement and EFTA countries in order to cover a broader European perspective. OECD and G20 members are also considered. Most of the macroeconomic variables are taken from international institutions in order to ensure comparability between countries, while firm-level data derives from confidential national datasets. The complete database can be found at: http://www.ecb.europa.eu/home/pdf/research/compnet/compendium_diagnostic_toolkit.zip. For the majority of the variables the time series data start from 2000. An overview of the main data sources used can be found at http://www.ecb.europa.eu/home/pdf/research/compnet/compendium_appendix.pdf?63a66170ff3d7244f2bf36b4dd2de4be

A.2 Firm-level data

A.2.1 Technical Notes

All variables are defined at country level. All variables have been computed using the sample of firms with more than 20 employees. The latter is population-weighted, which ensures that it is fully representative (in terms of sector and size) of the underlying population of firms with more than 20 employees. However, as it is clearly stated in Lopez-Garcia, Di Mauro and the CompNet Task Force (2015), for some countries there is still within-cell bias. This means, for example, that the average value added of firms in a given cell defined at sector and size level is larger than that provided by Eurostat considering the full population of firms. This is due to the sampling methodology in some countries or certain exclusion rules. The user of the data should refer to the above paper for information on these problems and suggestions on how best to handle the data.

Country coverage is provided in Table A2.3. The table in the annex summarises country coverage in terms of firms and employment as well as time and sector. The two first columns of the table report the coverage of firms (average number per year) and employment relative to the population of firms with at least 1 employee (20 or more employees in France, Poland and Slovakia) operating in the sectors covered by CompNet. Columns 3 and 4 show the coverage of CompNet with respect to the overall economy, i.e. total value added and employment reported in the national accounts (from Eurostat). The fifth column provides the time span available for each country. Note that the indicators computed for the sample of larger firms (20 employees or more) are provided only from 2001 onwards. The last column of the table shows the specific sectors excluded in each country. The default is that countries cover all non-financial business industries, with the exception – for

technical reasons – of mining and agriculture, manufacture of petroleum and coke, and utilities. The label="exp" identifies the firm as an exporter.

Note that we consider only exporting firms in the manufacturing sector.

Germany and Austria have no data on exporting firms. Croatia, Austria and Malta provide partial coverage of financial variables.

A.2.2 Sector coverage

Table 1

Sector coverage: definition of macro sectors

macro sectors numbver	Name of sector	2-digit industry correspondence
1	Manufacturing	2-digit industries between 10 and 34
2	Construction	2-digit industries >=41 & <44
3	Wholesale and retail trade	2-digit industries >=45 & <48
4	Transportation and storage	2-digit industries >=49 & <54
5	Accommodation and food service	2-digit industries >=55 & <=56
6	Information and communication activities	2-digit industries >=58 & <64
7	Real estate activities	2-digit industry=68
8	Professional, scientific and technical activities	2-digit industries >=69 & <76
9	Administrative and support service activities	2-digit industries >=77 & <=82

Source:

A.2.3 Country samples

Table 2

Country samples

(percentages)

	Coverage vs. similar population of firms (OECD)[1]		Coverage vs. national accounts (Eurostat)[3]		Time and sector coverage of CompNet samples	
Country	Average no. of firms per year (%)	Total employment (%)	Value added (%)	Total employment (%)	Time coverage	Sectors excluded (deviations from default)
Austria	1	29	20	NA	2000-2012	12, 50, 53, 60, 75, 80
Belgium	31	76	49	39	1996-2010	-
Croatia	32	36	NA	46	2002-2012	12
Estonia	73	95	25	56	1995-2012	12
Finland	48	96	NA	45	1999-2012	12, 68
France[2]	73	88	43	36	2001-2012	12
Germany	3	41	32	20	1997-2012	12, 55, 56, 68, 75, 77, 78, 79, 80, 81, 82
Hungary	44	88	20	50	2003-2012	12
Italy	10	53	27	30	2001-2012	-
Lithuania	27	43	20	46	2000-2011	12
Malta	NA	NA	7	24	2003-2011	12, 13, 15, 24, 29, 30, 45, 46, 47, 49, 50, 51, 52, 53, 63, 68, 75
Poland[2]	77	80	15	24	2005-2012	75
Portugal	30	80	40	45	2006-2012	-
Romania	70	47	29	37	2003-2012	53
Slovakia[2]	91	95	NA	29	2001-2011	12, 50, 51, 53, 59, 60, 65
Slovenia	31	85	NA	46	1995-2012	12
Spain	19	47	25	32	1995-2012	-

1) Coverage is computed over the period 2004-07, with the exception of Portugal (2006-07). Data on the population of firms with at least 1 employee come from the OECD Structural Business Statistics repository.
2) France, Poland and Slovakia only provide information on firms with 20 employees or more. The coverage is computed over the population of firms with 20 employees or more.
3) Coverage of the whole economy (not only the private sector) is computed for 2005, with the exception of Portugal for which 2006 is used instead. Eurostat data come from national accounts: series nama_gdp_c and nama_aux_pem respectively.

A.3 Technical details on selected novel indicators

A.3.1 Relative export prices adjusted for quality and taste

While the conventional RXP for country *k*'s exports of a product *g* to country *i* is calculated using only the **first term** of equation (A1), the RXP adjusted for quality and tastes uses **all three terms**. Equation (A2) aggregates to the total RXP of a country *k* (either conventional or adjusted for quality and taste).

$$RXP(i)_{gk,t} = \underbrace{\prod_{c \in C(i)_g} \left(\frac{p(i)_{gk,t}}{p(i)_{gc,t}} \frac{p(i)_{gct-1}}{p(i)_{gk,t-1}} \right)^{\left(\sigma(i)_g - 1\right) w(i)_{gc,t}}}_{1} \underbrace{\left(\frac{\lambda(i)_{g,t-1}}{\lambda(i)_{g,t}} \right)}_{2} \underbrace{\prod_{c \in C(i)_g} \left(\frac{d(i)_{gk,t}}{d(i)_{gc,t}} \frac{d(i)_{gc,t-1}}{d(i)_{gk,t-1}} \right)^{-w(i)_{gc,t}}}_{3} \quad \text{(A1)}$$

$$RXP_{k,t} = \prod_{i \in I} \prod_{g \in G} RXP\,(i)_{gk,t}^{w(i)_{g,t}} \quad \text{(A2)}$$

where *k* denotes a particular exporting country, $p(i)_{gc,t}$ is the unit value of good *g* exported from country *c* to country *i*, $d(i)_{gc,t}$ is the unobservable quality or taste parameter of a product, $C(i)_g$ is the set of countries exporting the particular product to country *i* in both periods, $w(i)_{gc,t}$ represents the shares of exporting countries serving a particular market, $w(i)_{g,t}$ shows the share of a particular market in country *k*'s exports, $\lambda(i)_{g,t}$ describes the share of new or disappearing exporters, while $\sigma(i)_g$ is the elasticity of substitution among varieties of good *g* in country *i*.

A.3.2 Decomposition of changes in export market shares

Changes in export market shares of country *k* ($ms_{k,t}$) are decomposed into extensive ($em_{k,t}$) and intensive margin ($im_{k,t}$), which is further split into the contributions of price factors ($pp_{k,t}$), non-price factors ($qq_{k,t}$), changes in the set of competitors ($cc_{k,t}$) and shifts in demand ($ds_{k,t}$):

$$ms_{k,t} = em_{k,t} + im_{k,t} = \underbrace{em_{k,t}}_{1} + \underbrace{pp_{k,t} + cc_{k,t} + qq_{k,t} + ds_{k,t}}_{2} \quad \text{(A3)}$$

Extensive margin

$$em_{k,t} = \ln\left(\sum_{i \in I} \sum_{g \in G} \mathrm{P}(i)_{gk,t}\, M(i)_{gk,t} \right) - \ln\left(\sum_{i \in I} \sum_{g \in G} \mathrm{P}(i)_{gk,t-1}\, M(i)_{gk,t-1} \right)$$
$$- \ln\left(\sum_{i \in I} \sum_{g \in G(i)i,t,t-1} \mathrm{P}(i)_{gk,t}\, M(i)_{gk,t} \right) + \ln\left(\sum_{i \in I} \sum_{g \in G(i)i,t,t-1} \mathrm{P}(i)_{gk,t-1}\, M(i)_{gk,t-1} \right) \quad \text{(A4)}$$

where i is a running index for importing countries, g for products and c for exporting countries, while k indicates the exporting country under consideration. $M(i)_{gc,t}$ represents the quantity of country i's imports of product g from exporting country c, while $P(i)_{gc,t}$ is the price of the respective import flow. I, G and C are the respective sets of importing countries, products, and exporting countries, $G(i)_{i,t,t-1}$ is the set of products shipped by exporter k to country i in both periods.

Price competitiveness

$$pp_{k,t} = \sum_{i \in I} \sum_{g \in G} s(i)^{X}_{k,t}\, s(i)^{X}_{gk,t}\, pp(i)_{gk,t} \qquad \text{(A5)}$$

$$\text{where } pp(i)_{jk,t} = \left(1-\sigma(i)_{j}\right) \ln \pi(i)_{jk,t} - \left(\gamma(i)-\sigma(i)_{j}\right) \sum_{c \in C(i)_{j}} w(i)_{jc,t} \ln \pi(i)_{jc,t} -$$

$$- \left(1-\gamma(i)\right) \sum_{g \in G} \sum_{c \in C(i)_{g}} w(i)_{gc,t}\, w(i)_{g,t} \ln \pi(i)_{gc,t} \; ; \pi(i)_{gc,t} = P(i)_{gc,t} \,/\, P(i)_{gc,t-1} \; ;$$

$s(i)^{X}_{k,t}$ and $s(i)^{X}_{gk,t}$ are weights representing the structure of country k's export, $\gamma(i)$ is elasticity of substitution among import goods, $\sigma(i)_{g}$ is elasticity of substitution among varieties of good g and $w(i)_{gc,t}$ and $w(i)_{g,t}$ are the share of a country c in a particular market.

Changes in the set of competitors

$$cc_{k,t} = \sum_{i \in I} \sum_{g \in G} s(i)^{X}_{k,t}\, s(i)^{X}_{gk,t}\, \frac{\gamma(i) - \sigma(i)_{g}}{1 - \sigma(i)_{g}} \left(\ln \lambda(i)_{g,t} - \ln \lambda(i)_{g,t-1}\right) + \qquad \text{(A6)}$$

$$+ \sum_{i \in I} s(i)^{X}_{k,t}\, \frac{(1 - \gamma(i))\; w(i)_{g,t}}{1 - \sigma(i)_{g}} \sum_{g \in G} \left(\ln \lambda(i)_{g,t} - \ln \lambda(i)_{g,t-1}\right) \; ;$$

where $\lambda(i)_{g,t}$ and $\lambda(i)_{g,t-1}$ are indices introduced by Feenstra (1994) that measure changes in variety (set of suppliers is perceived as variety by consumers).

The contribution of non-price factors

$$qq_{k,t} = \sum_{i\in I}\sum_{g\in G} s(i)^{X}_{k,t}\ s(i)^{X}_{gk,t}\ qq(i)_{gk,t} + \tag{A7}$$

$$+ \sum_{i\in I}\sum_{g\in G} s(i)^{X}_{k,t} s(i)^{X}_{gk,t}\ \frac{\sigma(i)_g - \gamma(i)}{1-\sigma(i)_g}\left(\ln\lambda(i)_{g,t} - \ln\lambda(i)_{g,t-1}\right) +$$

$$+ \sum_{i\in I} s(i)^{X}_{k,t}\ \frac{(\gamma(i) - \sigma(i)_g)\ w(i)_{g,t}}{1-\sigma(i)_g} \sum_{g\in G}\left(\lambda\ln\lambda(i)_{g,t} - \lambda\ln\lambda(i)_{g,t-1}\right),$$

where

$$qq(\mathrm{i})_{gk,t} = \ln\mu(i)_{gk,t} - \sum_{g\in G}\sum_{c\in C(i)_g} w(i)_{gc,t}\, w(i)_{g,t} \ln\mu(i)_{gc,t} + \sigma(i)_j \ln\pi(i)_{jk,t} +$$

$$+ \left(\gamma(i) - \sigma(i)_j\right) \sum_{c\in C(i)_j} w(i)_{jc,t} \ln\pi(i)_{jc,t} - \gamma(i) \sum_{g\in G}\sum_{c\in C(i)_g} w(i)_{gc,t}\, \mathrm{w}(i)_{g,t}\, \pi(i)_{gc,t};$$

$$\mu(i)_{gc,t} = M(i)_{gc,t} \Big/ \mathrm{M}(i)_{gc,t-1}.$$

Shifts in demand

$$ds_{k,t} = \sum_{i\in I} \tilde{\mathrm{s}}(i)^{X}_{k,t}\, ds(i)_t, \qquad \text{(A8)}$$

where

$$ds(m)_t = \ln\left(\sum_{c\in C}\sum_{g\in G} P(m)_{gc,t}\ M(m)_{gc,t}\right) - \ln\left(\sum_{i\in I}\sum_{c\in C}\sum_{g\in G} P(i)_{gc,t}\ M(i)_{gc,t}\right) -$$

$$- \ln\left(\sum_{c\in C}\sum_{g\in G} P(m)_{gc,t-1}\ M(m)_{gc,t-1}\right) + \ln\left(\sum_{i\in I}\sum_{c\in C}\sum_{g\in G} P(i)_{gc,t-1}\, M(i)_{gc,t-1}\right)$$

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The Competitiveness Network

The network is composed of economists from the European System of Central Banks (ESCB) – i.e. the 28 national central banks of the European Union (EU) and the European Central Bank – a number of international organisations (World Bank, OECD, European Commission), universities and think-tanks, as well as a number of non-European central banks (Argentina and Peru), organisations (US International Trade Commission) and national statistics institutes.

The objective of CompNet is to develop a consistent analytical framework for assessing competitiveness, delivering a better correspondence between determinants and outcomes.

CompNet is chaired by Filippo di Mauro (ECB). The research is carried out in three workstreams: 1) Aggregate Measures of Competitiveness (chaired by Pavlos Karadeloglou (ECB) and Konstantins Benkovskis ((Latvijas Banka)); 2) Firm Level (chaired by Antoine Berthou (Banque de France) and Paloma López-Garcia (ECB)); 3) Global Value Chains (chaired by João Amador (Banco de Portugal) and Frauke Skudelny (ECB)). Monika Herb is responsible for the CompNet Secretariat.

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