

**Charles University in Prague**

Faculty of Social Sciences  
Institute of Economic Studies



MASTER'S THESIS

**The Importance of Non-Price  
Competitiveness: Oil Downstream Sector  
in Europe**

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Academic Year: **2016/2017**

## Declaration of Authorship

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## Abstract

This thesis investigates the role of price and non-price competitiveness factors using a relative export price index, introduced by Benkovskis and Wörz (2016), that is adjusted for changes in quality and taste. First, we replicate their model employing an updated dataset, confirming previous results. Then, the framework is used to study the recent developments in Europe's oil product market. Given the saturation of the market, decreasing demand, and converging prices, importance of non-price competitiveness factors, such as quality, increases. The results suggest that the problems of the underinvested oil downstream industry in Northwestern European producers are caused not only by decreasing aggregate demand, high costs, and low margins, but by non-price competitiveness factors as well. We find profound improvements in product quality in CEE countries, following substantial investments into the sector and market consolidation. Both regions are at risk of rising imports of high-quality products from the Middle East, Russia and USA. This thesis provides a comprehensive picture of price and non-price competitiveness developments of all players in the highly competitive European oil downstream market.

**JEL Classification**

B17, C43, F12, F14, Q02, L15

**Keywords**

International trade, commodity markets, oil market, price and non-price competitiveness, quality, relative export price

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## Abstrakt

Tato práce zkoumá roli cenových a necenových faktorů konkurenceschopnosti za pomoci indexu relativních exportních cen (Benkovskis a Wörz, 2016), který zachycuje změny kvality produktů. Nejprve replikujeme jejich model a testujeme spolehlivost indexu. Model poté využíváme pro analýzu změn konkurenceschopnosti produktů evropského rafinérského trhu. Role necenových faktorů konkurenceschopnosti, např. kvality, roste vzhledem k převisu nabídky ropných produktů nad klesající poptávkou a konvergujícím cenám. Výsledky ukazují, že problémy zastaralých komplexů západoevropských rafinérských a petrochemických firem nejsou způsobeny pouze klesající poptávkou, vysokými fixními náklady a nízkými maržemi, ale i necenovými faktory. Po vlně investic a konsolidaci trhu nalézáme nečekaně vysoké zvýšení kvality ropných produktů ve východoevropských zemích. Oba regiony jsou ale vystaveny tlaku rostoucích dovozů kvalitních produktů ze Středního východu, Ruska a USA. Tato práce poskytuje široký obraz vývoje cenové a necenové konkurenceschopnosti hlavních hráčů evropského rafinérského a petrochemického trhu.

**Klasifikace JEL**

B17, C43, F12, F14, Q02, L15

**Klíčová slova**

Mezinárodní obchod, komoditní trhy, ropný průmysl, cenová a necenová konkurenceschopnost, kvalita, relativní exportní cena

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# Acronyms

<b>BRIC</b>	Brazil, Russia, India, China
<b>CEE</b>	Central and Eastern Europe
<b>CEPII</b>	Centre d'Etudes Prospectives et d'Informations Internationales
<b>CIF</b>	Cost, Insurance and Freight
<b>EFTA</b>	European Free Trade Association
<b>ENI</b>	Ente Nazionale Indrocarburi
<b>EU</b>	European Union
<b>FCC</b>	Fluid catalytic cracking
<b>GCR</b>	Generální ředitelství cel
<b>GDP</b>	Gross domestic product
<b>HS</b>	Harmonized system
<b>IEA</b>	International Energy Agency
<b>Kt</b>	kiloton
<b>LIML</b>	Limited Information Maximum Likelihood
<b>MOL</b>	Hungarian Oil and Gas Public Limited Company
<b>Mbpd</b>	Million barrels per day
<b>Mt/y</b>	Million tons per year
<b>OECD</b>	Organisation for Economic Co-operation and Development
<b>PE</b>	Polyethylene
<b>PKN</b>	Polski Koncern Naftowy
<b>PP</b>	Polypropylene
<b>REER</b>	Real effective exchange rate
<b>RXP</b>	Relative export price
<b>UN</b>	United Nations
<b>US</b>	United States
<b>USA</b>	United States of America
<b>USD</b>	United States Dollar

# Master's Thesis Proposal

**Author:** Bc. Ondřej Sláma  
**Supervisor:** PhDr. Jaromír Baxa Ph.D.  
**Defense Planned:** September 2017

## **Proposed Topic:**

The Importance of Non-Price Competitiveness: Oil Downstream Sector in Europe

## **Motivation:**

The downstream segment of oil & gas sector in Europe has been under pressure for four decades since the second oil price shock. The last golden age of refining in Europe ended with the 2008/2009 crisis and European refiners have been struggling to achieve profits ever since. The European downstream industry suffers from chronic oversupply, low utilization rates, decreasing demand for oil, low margins, high labour costs, expensive feedstock, and costly upgrading investments to comply with EU's environmental regulations.

The sector survives mainly thanks to increasing closures of smaller plants. Many refiners have started to focus on larger scale and closer integration between refining, petrochemical and chemical segments to capture more of the value chain. Recent refining and petrochemical investments in the Gulf and shale gas exploration in USA, however, have changed the market landscape considerably, and the full-scale effect is yet to come. Developing countries such as China or India have built their own plants to satisfy most of their domestic demand. European plants can hardly achieve quality and profitability of larger scale projects overseas or in the Gulf without substantial investments. Moreover, Russia and the whole Caspian region have invested massively into both refining and petrochemical facilities, directly competing with its European peers and putting additional pressure on their profitability.

To capture both price and non-price competitiveness developments of Europe's and its competitors' refining and petrochemical segments, we choose index created by Benkovskis and Wörz (2016). We investigate developments in the quality level, while using the first part of the index as a standard RXP indicator to depict changes in price competitiveness of the downstream sector in past two decades.

## **Hypotheses:**

1. Hypothesis #1: Western European refiners' product quality decreases compared to other competitors, along with fall in refining margins.

2. Hypothesis #2: Russia's and Saudi Arabia's investments in refining and petrochemical segments have had a profound, positive effect on product quality.
3. Hypothesis #3: CEE refiners have significantly increased product quality and benefit from ongoing investments, discounted Urals crude and increasing demand for their products. We would expect the non-price competitiveness to be the main driver of their increased profitability.

**Methodology:**

Along with use of the conventional RXP, this thesis follows work of Benkovskis and Wörz (2016) who relax the assumption of constant elasticity of substitution in Armington's (1969) demand-side oriented theoretical model. Armington examines country's competitiveness from the import demand side, identifying both price and non-price competitiveness. Armington (1969) describes consumer's utility as a CES function, combining demand for domestic and foreign products. Benkovskis and Wörz (2013) rework the model to account for the role of non-price factors such as quality and taste. The index, however, could be used as a more detailed tool, examining changes in non-price (and price) competitiveness within a sector, i.e. oil downstream.

There is no unified database of downstream product types, prices or margins. The companies prefer reporting model operating margins based on quotation prices and the sector numbers within the company (refining, petrochemicals, merchandise etc.) are often reported together, making all assessments of changing quality inaccurate. Therefore, we decide to look at the sectors on the country level, using the UN COMTRADE database. The analysis uses 6-digit HS code from UN COMTRADE database, which is the most detailed, unified level for all countries considered. The use of detailed data allows us to capture differences in elasticities of substitution between varieties and changes in quality of oil products. We choose 1996-2015 period, capturing developments before the crisis, or the golden age of Europe's refining, and several years that followed. Eurostat's COMEXT database, highly disaggregated EU database, might be used for the detailed EU countries comparison in case of lack of data in UN COMTRADE. For the comparisons between countries of four continents, UN COMTRADE database provides information on a sufficiently detailed level.

**Expected Contribution:**

This thesis will provide a detailed analysis of oil downstream sector developments in terms of price and non-price competitiveness factors of selected EU countries, Russia, USA, Saudi Arabia, and China. We will investigate drivers of Europe's falling downstream competitiveness and highlight examples of successful approach to the ever-changing petroleum market. Further, to test reliability of the index, we aim to replicate the index and add four more years for potential future research, computing the index for the entire UN COMTRADE database.

**Outline:**

1. Motivation: We examine regions facing different competitive forces in EU's downstream market and briefly describe their position and current trends.
2. Previous research: We will briefly describe previous and similar competitiveness studies and replicate the original index (Benkovskis and Wörz, 2016).
3. Data: UN COMTRADE database will be used as the only tool capable of unification of such a broad research across countries of the downstream sector.
4. Methods: We will explain the methods used (CES functions, import price index, elasticities of substitution between varieties, LIML method, Herfindahl index).
5. Results: We will discuss the results of the replication, the downstream results and potential drivers behind changes in price and non-price competitiveness.
6. Concluding remarks: We will summarize the findings and their implications for policy and future research.

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# 1 Introduction

The downstream segment of oil & gas sector in Europe has been under pressure for almost four decades since the second oil price shock. The last golden age of refining in Europe ended with the 2008/2009 crisis and European refiners have been struggling to achieve profits ever since. European oil downstream industry suffers from chronic oversupply, low utilization rates, decreasing demand, low margins, high labour costs, expensive feedstock, and costly upgrading investments to comply with EU's environmental regulations. The sector survives mainly thanks to an increasing number of closures of smaller, loss-making plants. Many refiners have started to focus on larger scale and closer integration between refining, petrochemical and chemical segments to capture more profits from the value chain.

Recent refining and petrochemical investments in the Middle East and the shale gas exploration boom in USA, however, have changed the market landscape considerably, and the full-scale effect is yet to come. Developing countries such as China or India have built their own plants to satisfy most of the domestic demand. European plants can hardly achieve quality and profitability of large scale production projects overseas or in the Middle East without undertaking substantial investments. Moreover, Russia and the whole Caspian region have invested massively into both refining and petrochemical facilities, upgrading their obsolete assets and directly competing with their European peers, putting downward pressure on their profitability.

In studies assessing competitiveness, measures of price-competitiveness are usually preferred, e.g. REER or export market shares. To investigate the competitiveness developments of Europe's and its competitors' refining and petrochemical segments, we choose index created by Benkovskis and Wörz (2016) as the best available indicator capable of capturing changes in price and non-price competitiveness. In the first part of the thesis, we introduce the index and discuss relevance of both price and non-price competitiveness. We replicate the index on updated data to test its quality and compare the findings.

In the second part, we investigate developments in quality of oil downstream products, while using the first part of the index as a standard price competitiveness indicator to depict changes in price competitiveness of the products in oil downstream in past two decades. Further, we separate the price and non-price competitiveness drivers of the index. The non-price competitiveness, such as quality, is crucial to

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address due the changing landscape of European downstream sector. The market is highly competitive and oversupplied, its prices converge, and quality of a product plays major role in companies' struggle to survive both local and outside pressure.

The thesis contributes to the literature by the price and non-price competitiveness analysis of an entire sector over nineteen years in EU and other markets. To test reliability of the index, we replicate the index, and add four more years for potential future research, computing the index for the entire UN COMTRADE database. We focus on 1996-2015 interval. We are not aware of such a specific but broad analysis of price and non-price developments of oil downstream sector. We alter the index computation, focus on the drivers of Europe's falling oil downstream competitiveness, and highlight examples of successful markets.

Given Europe's oversupplied and highly competitive oil downstream market, we assess the index, relying on both export and import data, as a thorough and relevant tool to analyse the quality improvements. Oil & gas companies in the downstream sector do not have one unified reporting system that would allow us to work with the company data on a disaggregated level, capturing product quality changes. To our best knowledge, there is no better, unified data source than UN COMTRADE database for our computation of competitiveness developments in the oil & gas downstream segment. Although many producers are not export-driven, as e.g. Russia or Saudi Arabia, and serve domestic needs mainly, e.g. Poland, the Czech Republic, Hungary, the European downstream market is very competitive, and any chance of arbitrage or increased export is immediately realized to increase refinery utilization and thus profitability, stressing importance of export and import data for our research.

The thesis proceeds as follows. In the first part, we introduce the topic. In the second part, we describe different approaches in measuring competitiveness. Methodology follows in the third part. In the fourth part, we describe the database and its limitations. The fifth part summarises our findings of the index replication and discussion. In the sixth part, we introduce Europe's oil downstream segment and its competitors. We discuss the oil downstream results in part seven. Conclusions are given in part eight.



## 2 Literature Review

### 2.1 Price vs. non-price competitiveness

There are many price competitiveness factors affecting the performance of oil downstream companies (foreign exchange rate, inflation, taxes, cost of infrastructure, type of crude and proximity to its source), we focus, however, on non-price competitiveness as well, and investigate changes in quality of oil products in the different regions that face various competitive forces. The index (Benkovskis and Wörz, 2016) we choose to examine competitiveness in the oil downstream industry allows us to observe both price and non-price developments (described in part 3).

Oil downstream is a very competitive market and as product prices converge, the quality factors turn crucial. The first part of the index is the price competitiveness indicator. The second part shows the impact of variety. Benkovskis and Wörz (2016), however, add quality factor to the index. The new indicator allows us to observe changes in quality of oil product from a given country compared to the other oil products from different countries.

### 2.2 Competitiveness methods

Measuring changes in export market shares or REER are one of the most popular ways to measure export performance and therefore competitiveness of a country. Borrowing Eurostat's (2017) definition, 'the export market shares present the shares of each country in total world (or region) exports of goods and services. The indicator measures the degree of importance of a country within the total exports of the region/world. For the calculation at current prices, the market share refers to the world trade (world export market share). A country might lose shares of export market not only if exports decline but most importantly if its exports do not grow at the same rate of world exports and its relative position at the global level deteriorates.

While computation of export market share dynamics is relatively simple, REER computation requires more attention and faces several limitations due to many restrictive assumptions that are introduced due to poor data availability. That said, both indicators are well-known and often used to measure price competitiveness.

Benkovskis and Wörz (2011), who try to overcome limitations of both indicators, by constructing their own indicator, note that there are limitations caused by serious drawbacks when employing each indicator. They picture the market share dynamics outcome only, but tell us little about the fundamentals behind the changes.

In REER computation, we rely solely on price factors, whose availability and quality are often limited. The computed findings might not explain external competitiveness dynamics fully. Other non-price factors of competitiveness must be considered when evaluating the competitiveness dynamics of respective country. While Benkovskis and Wörz (2011, 2012, 2013, 2014, 2016) focus mainly on variety and quality or taste factors, there are also other important factors affecting country's competitiveness in both short and longer term (e.g. institutions).

## 2.3 Benkovskis and Wörz approach

Benkovskis and Wörz (2016) create their own theoretical framework, an adjusted export price index, described below, which explores export market shares developments through both non-price and price drivers, accounting for price, variety and quality or taste. They start from a demand-side model à la Armington (1969), relaxing few restrictive assumptions, and further build on work of Feenstra (1994) and Broda and Weinstein (2006), where product variety is included. Benkovskis and Wörz (2016) further alter the index by adding quality and taste preferences.

Benkovskis and Wörz (2016) manage to separate price from non-price effects but acknowledge that their analysis does not offer a comprehensive picture of competitiveness, which itself remains a hardly-defined concept, and interpret their results with care (Benkovskis and Wörz, 2014). In defence of the authors, there are no truly universally agreed definitions of competitiveness and reliable measures of the concept—some may stress a country's technological leadership or even its growth rate, others a country's low costs or the level of its exchange rate (Boltho, 1996). OECD defines competitiveness as 'the degree to which a country can, under free and fair market conditions, produce goods and services which meet the test of international markets, while simultaneously maintaining and expanding the real incomes of its people over the longer term' (Boltho, 1996). That said, Benkovskis and Wörz (2011) introduce a simple approach in which impacts of both price and quality levels on export market shares changes are observed.

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The analysis of the non-price competitiveness dynamics impact on export price market shares changes is crucial when looking at the country from macro perspective or employing more detailed analysis. Benkovskis and Wörz (2014) observe differences between their own findings and the real effective exchange rate results in the evaluation of price competitiveness for both developed and developing countries. Looking at country's REER dynamics only may not always be sufficient enough while evaluating and explaining the changes in respective country's changes in export market shares. In that case, non-price factors as taste or quality might be the driving forces behind the dynamics. As an emerging country example, they present case of Argentina, which saw several depreciations in the past two decades but its current REER does not reach levels it had in mid 1990s. On the contrary, China, among other developing countries, has experienced an unprecedented growth of its export market shares in the same period, while its REER increased as well. Benkovskis and Wörz (2014, 2016) do not rule out other factors behind China's success in the global export market share growth like its size and labour force structure, but the outcomes of their analysis suggest that non-price factors are an important the effect of the exchange rate might not be the main driver of China's successes in international trade.

In the analysis of the BRICs countries' competitiveness dynamics, Benkovskis and Wörz (2016) repeatedly show that the non-price factors as taste or quantity contribute to changes in export market shares more than the relative prices, which is the second most important factor in competitiveness development. While the largest and most developed countries experienced losses in non-price competitiveness, the developing BRIC countries saw gains in non-price competitiveness in general with taste or quality contribution being always positive Benkovskis and Wörz (2016). In their analysis of CESEE10 countries based on COMEXT database, Benkovskis and Wörz (2012) study the real appreciation and significant export performance in the transition economies since 1996. The authors' findings suggest that mainly the non-price factors may explain the eye-catching success of the economies, which have been gradually converging to the developed Western Europe in terms of income, wage and price levels, while losing price competitiveness due to the appreciation of their currencies. In this case, non-price factors as quality prove crucial for the economic performance and overcome the negative effects of price competitiveness losses.

## 2.4 Related non-price competitiveness research

Benkovskis and Wörz (2011, 2012, 2013, 2014, 2016) are not the first ones to focus on non-price competitiveness although its role is often omitted from the models: Brech and Stout (1981) investigate links between non-price competitiveness, real exchange rate, and expectations that were later reflected in Mejstrik (1989) who further explores innovation and product quality changes as important drivers of competitiveness. Many studies (e.g. Athanasoglou and Bardaka, 2010), testing the Greek market, find non-price competitiveness drivers as innovation, variety and quality crucial both in the short and longer term with a direct strong positive effect on export performance.

Many other authors focus on non-price competitiveness developments in the emerging countries whose market share in the global economy has risen rapidly since the last two decades and find evidence that non-price competitiveness factors are important drivers of the improved export performance (e.g. Hallak, 2006, Benkovskis and Wörz, 2016). Pula and Santabárbara (2011) consider China, whose export structure is similar to the USA, Japan or the EU economies, but its export unit values are below their levels, as a potential threat to the market position of the USA, Japan or the EU economies. Their findings support a view that emerging countries such as China export both the same kind and quality of products as the technologically most developed economies. However, they lag behind the developed economies due to lower quality varieties. They are, along with Benkovskis and Wörz (2016), one of the pioneers who present an empirical evidence suggesting that the long-awaited revaluation of the Chinese currency might have a limited impact on China's competitiveness.

Undervaluation of currency has been traditionally seen as a type of strategy to achieve higher price competitiveness (and possibly real growth via expansion of export-oriented production). At the same time, anecdotic evidence often suggests that undervaluation may reduce the motivation to increase non-price competitiveness of exported (or import-competing products). Analysis of these linkages requires a concept and measures of competitiveness – which is not an easy task. E.g. Krugman (1994) sees competitiveness as a meaningless word when applied to national economies.

Rodrik (2008) questions optimal setting of an exchange rate to achieve stable economic growth in a longer term. His findings suggest that undervaluation of the currency might stimulate growth in developing countries but finds no such relationship for the developed economies. While Razin and Collin (1997) find that high over-valuation is associated with slower economic growth but moderate under-valuation might lead to faster economic growth. Fischer (1993) provides similar evidence. However, there are other studies suggesting the effects of exchange rate misalignments

are either opposite or ambiguous (e.g. Aguirre and Calderon, 2005 or Magud-Sosa, 2010 among others). Obviously, poorly managed exchange rate policy might lead to a catastrophic scenario for any economy, developed or developing. Rodrik's (2008) findings suggesting the relationship for developing countries only present an important question which should be addressed. He employs his time-varying index of real undervaluation based on price levels in individual countries and highlights that one way relationship between growth and undervaluation the other way around and suggests that undervaluation has a positive impact on the share of tradable goods in the economy, especially industry in developing countries. Rodrik (2008) defines potential causal mechanism for the positive impact of undervaluation on GDP growth – “the institutional channel”. The weak institutions (e.g. corruption) increase transaction costs (e.g. bribes) in domestic tradable sector. The undervaluation of domestic currency increases competitiveness of tradable sector outside home country (higher profits offset the transaction costs) and therefore increase in GDP should be observed.

## 2.5 Czech competitiveness research

The topic of both price and non-price factors impacts on the export market share, and therefore changes in economic growth, developments have been a crucial topic to discuss by the Czech and Slovak economists both during the economic transformation and more recently, during the Central Bank's interventions. From the price competitiveness perspective, the possibility of the negative effects of under-valuations and positive effects of revaluations of the currency have been a subject of historical debates among Czech economists. Discussions led by Czech economists at the beginning of economic transition, in which negative structural effects of the alleged extreme undervaluation of Czechoslovak currency were suggested.

Several Czech economists touched upon both Czech and international non-price factors dynamics of non-price competitiveness (e.g. Mejstrik, 1985, 1988, 1989, 1991 or 2011). The Czech Republic lags behind the most of the developed economies in terms of levels of innovations, over-regulation and institutions (e.g. corruption) (Mejstrik, 2011). However, a detailed empirical non-price factor analysis of the Czech competitiveness developments after the economy transition remains open for further research. In their detailed analysis using the COMEXT database, Benkovskis and Wörz (2012) present findings generated by their export price index adjusted for non-price factors findings and compare them to REER developments. Gains in non-price

competitiveness are found, on back of changes in quality on export competitiveness are present, during the appreciation of the Czech currency. The use of the adjusted export price index (Benkovskis and Wörz, 2011, 2012, 2013, 2014, 2016) or its altered version might serve well in addressing the period affected by the Central Bank's interventions.

## 3 Methodology

In this section, we explain the methodology developed by Benkovskis and Wörz (2016), we test the index on updated dataset, and prepare the ground for our own analysis which modifies their approach by looking at downstream segment competitiveness drivers. Benkovskis and Wörz (2016) construct an adjusted export price index, based on consumer utility maximization in the importing market, which they use as a competitiveness measure. Benkovskis and Wörz (2016) employ exports as an image of imports and aggregate relative price dynamics, considering changes of product quality and in the competitor set at the same time. The adjusted export price index is formed by three parts: a) changes in relative export unit values weighted by importance of both competitors in respective country's exports; b) Feenstra's (1994) part addressing changes in the set of competitors exporting a product, or variety; c) relative quality changes of the exported product compared with the average quality of the same product exported by all rivals. In the oil downstream analysis, we further divide the index and analyse impact of price, variety and quality on the indicator.

### 3.1 Herfindahl index

Before we replicate the method and continue with our own research, we test the sample for data concentration, or quality, employing a simple tool, the Herfindahl index. We employ the test on both commodity and country levels. Although the Herfindahl index is often used as a measure of competitiveness, it has its equivalence, i.e. Simpson diversity index or the inverse participation ratio, and serves as an indicator for which countries and commodities, we might be more cautious when deriving implications in the index developed by Benkovskis and Wörz (2016). As an example, we would expect the Czech Republic to have higher country Herfindahl index due to the foreign market size with Germany or Russia's commodity Herfindahl index to reach higher than average ratio due to the crude oil's extensive export volumes, given the size of other commodity exports. We set the threshold indicating potential bias of the competitiveness index of a country  $i$  at 0.25.

The Herfindahl index is defined as

$$HI = \sum_{i=1}^N s_i^2$$

where  $s_i$  is the share of  $i$  country's or commodity's in the set of all trade partners and in the set all traded commodities, respectively, and  $N$  is the number of countries and commodities, respectively.

### 3.2 Import price index<sup>1</sup>

In the first part of our researchs, we replicate the import price index constructed by Benkovskis and Wörz (2016), who built on work of Feenstra (1994) and Broda and Weinstein (2006), who included product variety development in their research already. Benkovskis and Wörz (2016) add quality changes to the index, which we set as our competitiveness indicator. We start with a three-nested constant elasticity of substitution utility function for a representative household.

Variety and quality are introduced into the bottom-level utility function. Variety is described by different country of origin, quality or taste show how much the consumers are attracted do a particular commodity. Both are important for consumer's choice between goods and therefore affect her utility. We define  $M_{g,t}$  as a non-symmetric CES function, the first nest:

$$M_{g,t} = \left( \sum_{c \in C} d_{gc,t}^{\frac{1}{\sigma_g}} m_{gc,t}^{\frac{\sigma_g-1}{\sigma_g}} \right)^{\frac{\sigma_g}{\sigma_g-1}} ; \sigma_g > 1 \forall g \in G, \quad (1)$$

where  $m_{gc,t}$  stands for import quality  $g$  from country  $c$ ,  $C$  is a set of all partner countries, while the quality or taste is denoted by  $d_{gc,t}$ , and  $\sigma_g$  is elasticity of substitution between varieties of good  $g$ .

The second nest of the utility function is defined by the composite imported good consisting of all imported products:

$$M_t = \left( \sum_{g \in G} M_{g,t}^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}} ; \gamma > 1, \quad (2)$$

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<sup>1</sup> This section closely follows Benkovskis and Wörz (2016)



where  $M_{g,t}$  is the sub-utility from consumption of imported good  $g$ ,  $\gamma$  represents elasticity of substitution among imported goods and  $G$  is the set of imported goods.

The top level of the function, the composite import and domestic goods are consumed:

$$U_t = \left( D_t^{\frac{\kappa-1}{\kappa}} + M_t^{\frac{\kappa-1}{\kappa}} \right)^{\frac{\kappa}{\kappa-1}} ; \kappa > 1, \quad (3)$$

where  $D_t$  represents the domestic good,  $M_t$  stands for composite imports and  $\kappa$  is the elasticity of substitution between domestic and foreign goods.

Given the budget constraint, we solve the utility maximization problem, deriving the minimum unit-cost function of import good  $g$  which is:

$$\Phi_{g,t} = \left( \sum_{c \in C} d_{gc,t} p_{gc,t}^{1-\sigma_g} \right)^{\frac{1}{1-\sigma_g}}, \quad (4)$$

where  $\Phi_{g,t}$  is minimum unit-cost of imported good  $g$  and  $p_{gc,t}$  is the price of good  $g$  coming from country  $c$ . We define the price indices for good  $g$  as minimum unit-cost ratios in the  $t$  period to minimum unit-costs in the  $t-1$  period ( $P_g = \Phi_{g,t}/\Phi_{g,t-1}$ ). The conventional assumption is that quality or taste parameters remain constant over the period for all varieties and products, ( $d_{gc,t} = d_{gc,t-1}$ ), while the set of varieties remains unchanged. The price index is derived from the set of product varieties  $C_{g,t} \cap C_{g,t-1}$  available both in periods  $t$  and  $t-1$ , where  $C_{g,t}$  is the subset of  $C$ , or all varieties of consumed goods in period  $t$ . Sato (1976) and Vartia (1976) present that the price index is derived by the log-change price index for a CES function:

$$P_g^{conv} = \prod_{c \in C_g} \left( \frac{p_{gc,t}}{p_{gc,t-1}} \right)^{w_{gc,t}}, \quad (5)$$

where weights  $w_{gc,t}$  are calculated from cost shares  $s_{gc,t}$  in  $t$  and  $t-1$  as:

$$w_{gc,t} = \frac{(s_{gc,t} - s_{gc,t}) / (\ln s_{gc,t} - \ln s_{gc,t-1})}{\sum_{c \in C_g} (s_{gc,t} - s_{gc,t}) / (\ln s_{gc,t} - \ln s_{gc,t-1})}; s_{gc,t}$$

$$= \frac{p_{gc,t} x_{gc,t}}{\sum_{c \in C_g} p_{gc,t} x_{gc,t}}$$

where  $x_{gc,t}$  denotes the cost-minimizing quantity of good  $g$  that comes from country  $c$ .

Feenstra (1994) adds variety to (5), which does not take into account possible changes in quality or variety. Feenstra (1994) assumes that taste or quality parameters remain unchanged for all varieties of all goods ( $d_{gc,t} = d_{gc,t-1}$ ). If  $d_{gc,t} = d_{gc,t-1}$  for  $c \in C_g = C_{g,t} \cap C_{g,t-1}, C_g = \emptyset$ , then the price index for good  $g$  is:

$$P_g^f = \prod_{c \in C_g} \left( \frac{p_{gc,t}}{p_{gc,t-1}} \right)^{w_{gc,t}} \left( \frac{\lambda_{g,t}}{\lambda_{g,t-1}} \right)^{\frac{1}{\sigma_g - 1}} = P_g^{conv} \left( \frac{\lambda_{g,t}}{\lambda_{g,t-1}} \right)^{\frac{1}{\sigma_g - 1}}, \quad (6)$$

where  $\lambda_{g,t} = \frac{\sum_{c \in C_g} p_{gc,t} x_{gc,t}}{\sum_{c \in C_g} p_{gc,t} x_{gc,t}}$  and  $\lambda_{g,t-1} = \frac{\sum_{c \in C_g} p_{gc,t-1} x_{gc,t-1}}{\sum_{c \in C_g} p_{gc,t-1} x_{gc,t-1}}$

We multiply (5) by an additional term to distinguish the role of appearing and vanishing varieties. Benkovskis and Wörz (2011) further add changes in taste or quality:

$$P_g^q = \left( \frac{\sum_{c \in C_{g,t}} (d_{gc,t} p_{gc,t}^{1-\sigma_g})}{\sum_{c \in C_{g,t-1}} (d_{gc,t-1} p_{gc,t-1}^{1-\sigma_g})} \right)^{\frac{1}{1-\sigma_g}} =$$

$$\prod_{c \in C_g} \left( \frac{p_{gc,t}}{p_{gc,t-1}} \left( \frac{d_{gc,t}}{d_{gc,t-1}} \right)^{\frac{1}{1-\sigma_g}} \right)^{w_{gc,t}} \left( \frac{\lambda_{g,t}}{\lambda_{g,t-1}} \right)^{\frac{1}{\sigma_g - 1}} = \quad (7)$$

$$P_g^{conv} \left( \frac{\lambda_{g,t}}{\lambda_{g,t-1}} \right)^{\frac{1}{\sigma_g - 1}} \prod_{c \in C_g} \left( \frac{d_{gc,t}}{d_{gc,t-1}} \right)^{\frac{w_{gc,t}}{1-\sigma_g}}$$

Equation (7) therefore is a modification of equation (6) with a new term capturing changes in the quality or taste.

### 3.3 Relative export price index

The adjusted export price index is derived from the adjusted import price index, interpreting  $x_{gc,t}$  (imports of product  $g$  originating from country  $c$ ) as country's  $c$

exports of a product  $g$  to the importing. Therefore, it follows from equation of (4) that the market share of an emerging country  $k$  is:

$$S_{gc,t} = \frac{p_{gk,t}x_{gk,t}}{\sum_{c \in C} p_{gc,t}x_{gc,t}} = \frac{p_{gk,t}x_{gk,t}}{\Phi_{g,t}M_{g,t}} = \frac{d_{gk,t}p_{gk,t}^{1-\sigma_g}}{\Phi_{g,t}^{1-\sigma_g}} \quad (8)$$

Through (8), we derive changes in adjusted relative export price as inverse growth of country  $k$ 's export market share:

$$RXP_{gk,t} = \frac{S_{gk,t-1}}{S_{gk,t}} = \frac{(p_{gk,t}/p_{gk,t-1})^{\sigma_g-1}}{(d_{gk,t}/d_{gk,t-1})(\Phi_{gk,t}/\Phi_{gk,t-1})^{\sigma_g-1}} \quad (9)$$

where  $RXP_{gk,t}$  captures changes in the adjusted relative export price index for respective country  $k$ , when defined for a single market (exports of good  $g$  to a single destination country). To keep the usual interpretation of the relative price indicator, we employ the inverse growth of the market share. Now, an increasing index captures losses in competitiveness. Combining (7) and (9), we obtain

$$\begin{aligned} RXP_{gk,t} &= \\ &= \prod_{c \in C_g} \left( \frac{p_{gk,t} p_{gc,t-1}}{p_{gc,t} p_{gk,t}} \right)^{(\sigma_g-1)w_{gc,t}} \left( \frac{\lambda_{g,t-1}}{\lambda_{g,t}} \right) \prod_{c \in C_g} \left( \frac{d_{gk,t} d_{gc,t-1}}{d_{gc,t} d_{gk,t}} \right)^{-w_{gc,t}} \end{aligned} \quad (10)$$

The index in (10) describes relative export prices for a specific product exported to a particular market. We construct an aggregate relative export price. We relax the assumption of a single destination for exports to allow for multiple importing countries, where we assume consumers to be maximizing their utility. All parameters and variables entering the three-layered utility function can differ across countries.

The aggregate adjusted relative export price index can be defined as

$$RXP_{gk,t} = \prod_{i \in I} \prod_{g \in G} RXP(i)_{gk,t}^{W_{ig,t}} \quad (11)$$

where  $W_{ig,t} = \frac{S_{ig,t} + S_{ig,t-1}}{2}$ ;  $S_{ig,t} = \frac{p(i)_{gk,t}x(i)_{gk,t}}{\sum_{i \in I} \sum_{g \in G} p(i)_{gk,t}x(i)_{gk,t}}$

and the price of export, volume of export and relative export price index of a product  $g$  exported to country  $i$  from country  $k$  are denoted by  $p(i)_{gk,t}$ ,  $x(i)_{gk,t}$  and  $RXP_{gk,t}$ , accordingly.

### 3.4 Relative quality evaluation

Relative taste or quality being unobservable, the calculation of the relative export price index proves to be difficult. To evaluate unobservable taste and quality, we follow Hummels and Klenow (2005) and Benkovskis and Wörz (2016), employing the utility optimization problem. Before transformation by log-ratios, we take first-order conditions, expressing relative quality or taste in volume, the elasticity of substitution and relative price terms as

$$\ln \frac{d_{gc,t}}{d_{gk,t}} = \sigma_g \ln \frac{p_{gc,t}}{p_{gk,t}} + \ln \frac{x_{gc,t}}{x_{gk,t}} \quad (12)$$

where  $k$  denotes a particular country.

As Benkovskis and Wörz (2016) note, the relative measures like taste or quality are characterised by a high sensitivity to the choice of a benchmark country.

### 3.5 Elasticity of substitution

The main goal of this section is to describe the method of finding elasticity of demand for a commodity of a country employing import prices and volumes throughout period of 19 years.

Again, we follow Benkovskis and Wörz (2016), who define both import and export equations to derive elasticities of substitution between varieties. The export supply equation relative to benchmark is given as:

$$\Delta \ln \frac{s_{gc,t}}{s_{gl,t}} = -(\sigma_g - 1) \Delta \ln \frac{p_{gc,t}}{p_{gl,t}} + \varepsilon_{gc,t} \quad (13)$$

where  $\varepsilon_{gc,t} = \Delta \ln d_{gc,t}$ . Therefore, we presume that the log of quality is a random-walk process.

To derive the demand equation, we take first derivative of the minimum market share unit-cost function and ratios to a reference country:

$$\Delta \ln \frac{p_{gc,t}}{p_{gl,t}} = \frac{\omega_g}{\omega_g + 1} \Delta \ln \frac{s_{gc,t}}{s_{gl,t}} + \delta_{gc,t} \quad (14)$$

where  $\omega_g \geq 0$  is the inverse supply elasticity assumed to be the same across partner countries. As Mohler (2009), the dominant supplier is chosen as a benchmark  $l$  (i.e. the country exporting a product in most time periods). Thus, we increase the stability of estimates.

We do not possess exogenous variables needed to estimate the elasticities of substitution. Therefore, we combine the equations to one by multiplying both sides of the equations, as proposed by (Leamer, 1981) and relying on the independence of errors  $\varepsilon_{gc,t}$  and  $\delta_{gc,t}$ , expressing the following equation:

$$\left( \Delta \ln \frac{p_{gc,t}}{p_{gl,t}} \right)^2 = \theta_1 \left( \Delta \ln \frac{s_{gc,t}}{s_{gl,t}} \right)^2 + \theta_2 \left( \Delta \ln \frac{s_{gc,t}}{s_{gl,t}} \right) \left( \Delta \ln \frac{p_{gc,t}}{p_{gl,t}} \right) + u_{gc,t} \quad (15)$$

where

$$\theta_1 = \frac{\omega_g}{(1+\omega_g)(\sigma_g-1)}; \theta_2 = \frac{1-\omega_g(\sigma_g-2)}{(1+\omega_g)(\sigma_g-1)}; u_{gc,t} = \varepsilon_{gc,t} \delta_{gc,t}$$

To correct inconsistency in estimates of  $\theta_1$  and  $\theta_2$  caused by correlation of relative price and relative market share with the error  $u_{gc,t}$ , we follow Broda and Weinstein (2006) and Benkovskis and Wörz (2016) who highlight the nature of the data (panel) and define moment conditions for each good  $g$ , obtaining consistent estimates.

In the final step of elasticity of substitution among varieties estimation, we employ the Limited Information Maximum Likelihood (LIML) estimator, shown first by Anderson and Rubin (1949), to avoid heteroscedasticity and measurement errors, proposed by Soderby (2012), who points out errors and biases in Broda and Weinstein (2006)'s GMM estimator. Benkovskis and Wörz (2016) tested LIML's ability to

correct for constraint search inefficiencies and small sample biases by Monte Carlo analysis.

As Benkovskis and Wörz (2016), we employ the LIML method on equation (15) and by LIML and non-linear constraint LIML, implemented when elasticity estimates are infeasible. Following Soderby (2012), we compute the elasticities for all commodities where at least three export countries are available. Further, at least two periods are required to estimate the elasticities, consequence of the differentiation of the equations above.

Employing 2SLS estimator might also be an alternative to Broda and Weinstein (2006)'s approach. That said, even though we filter most of the outliers, the estimates might still be biased and we find the LIML method more suitable for our dataset. While employing the LIML method, we have to specify the products and their type and focus on random outliers and errors in the database. Further, if there are too few observations for respective country, the results might be biased. The size and data collection of the oil downstream market in EU, China, USA, Russia or Saudi Arabia, however, are on very good levels, enough to provide estimates on the highest level, looking at other sectors of trade whose disclosure is often limited.

### 3.6 LIML

Both Soderby (2012) and Benkovskis and Wörz (2016) use the LIML method to find elasticities of substitution between varieties. Broda and Weinstein (2006) use a GMM method in the final step of the estimation. Soderby (2012) and later Benkovskis and Wörz (2016) show however, that 2SLS and preferably LIML method provide lower biases of the estimated parameter, compared to the GMM method. We therefore choose to employ LIML method as well.

LIML, suggested first by Anderson and Rubin (1949), is based on minimizing the likelihood of functions used within simultaneous regression equations. The method allows us to find a consistent estimate of an equation with endogenous regressors, employing instrumental variables. Further, it presents a linear combination of estimates using both OLS and 2SLS – two stage least squares regression (applying the methods depending on data type). The weights eliminate bias, which would be otherwise cause by using 2SLS method only. Anderson and Rubin (1949) presented the method to solve

for an estimate of one structural equation in time  $t$ . The correct method use requires one necessary condition: at least an approximate normalization of random errors and, in case of parameter estimation of more equations, it is necessary to use numerical iterative methods. The method is consistent on condition that at least one type of commodity from three different countries, or three markets, is present. Further, two consecutive periods are required (Soderbery, 2012), as a result of differentiation.

More detailed description of the method can be found in Soderbery (2012). To shortly present the method, we assume the most likely estimate of one equation, which is derived from system of simultaneous equations. Without loss of generality, we can assume and equation:

$$\begin{aligned} y_{1i} &= X'_{1,i}\delta_1 + u_{1i} \\ &= Y'_{1,i}\gamma_1 + Z'_{1,i}\beta_1 + u_{1i} \end{aligned} \quad (16)$$

where  $Y_{1,i}$  and  $Z_{1,i}$  are vectors assumed in endogenous and exogenous regressors. For the assumed endogenous regressors, we assume following reduced form of equations:

$$Y_{1,i} = \Pi_1 Z_{1,i} + \Pi_2 Z_{2,i} + V_{1i}$$

Let us assume that we avoid  $Y_{1,i}^*$ , a vector of endogenous variables, which we exclude from the equation (16). Futher, we define the two above mentioned equations in matrix form as:

$$\begin{pmatrix} 1 & -\gamma'_1 \\ 0 & I_{m_1} \end{pmatrix} \begin{pmatrix} y_{1i} \\ Y_{1,i} \end{pmatrix} = \begin{pmatrix} \beta'_1 & 0 \\ \Pi_1 & \Pi_2 \end{pmatrix} + \begin{pmatrix} u_{1i} \\ V_{1,i} \end{pmatrix} \quad (17)$$

or

$$\tilde{A}_1 \tilde{Y}_{1,i} = \tilde{B}_1 \tilde{Z}_i + \tilde{U}_i$$

where

$$\tilde{A}_1 = \begin{pmatrix} 1 & -\gamma'_1 \\ 0 & I_{m_1} \end{pmatrix}$$

$$\tilde{Y}_{1,i} = \begin{pmatrix} y_{1i} \\ Y_{1,i} \end{pmatrix}$$

$$\tilde{B}_1 = \begin{pmatrix} \beta'_1 & 0 \\ \Pi_1 & \Pi_2 \end{pmatrix}$$

$$\tilde{U}_i = \begin{pmatrix} u_{1i} \\ V_{1,i} \end{pmatrix}$$

Further, we assume that the random errors have a normal distribution:

$$\tilde{U}_i | Z_i \dots N(0, \tilde{U}_i)$$

We obtain the estimate for the unknown parameter through deriving equation (18). Therefore, the estimate of parameter  $\delta_1 = (\gamma_1', \beta_1')$  is formed as:

$$\hat{\delta}_1 = (X_1'(I_n - \lambda M)X_1)^{-1} X_1'(I_n - \lambda M)y_1$$

where

$$M = I_n - P$$

$$P = Z'(Z'Z)^{-1}Z'$$

$P$  is a projection matrix and parameter  $\lambda = \min_t \frac{t'W_1t}{t'W_t}$ . Matrices  $W$  and  $W_t$  are defined as

$$W = (y_1 \quad Y_1)'M(y_1 \quad Y_1)$$

$$W_t = (y_1 \quad Y_1)'M_1(y_1 \quad Y_1)$$

and

$$M_1 = I_n - P_1$$

$$P_1 = Z_1'(Z_1'Z_1)^{-1}Z_1'$$

Parameter  $\lambda$  is defined as the smallest eigenvalue of matrix  $W_1 W^{-1}$ .



## 4 Description of the Database

### 4.1 UN COMTRADE database

To replicate the empirical analysis by Benkovskis and Wörz (2016), we use the UN COMTRADE dataset on a six-digit level of the Harmonized system (HS). The data coverage starts in 1996, which we choose as our base year. Firstly, we test the index on 1996-2011 period, compare the findings, and further extend the period to 2015.

COMTRADE is a detailed and truly global trade database. Although several issues with the use of COMTRADE for the analysis of unit values have been pointed out in Berthou and Emlinger (2011), it is still the main source of data for most major projects which use detailed trade data. The database offering 5,132 products ensures a sufficient disaggregation for our research analysis of variety, taste and quality. We decide to enlarge the index generation to 188 of import countries. In recent years, the quality and breath of information obtained by COMTRADE has been increasing, offering more information every single year. The COMTRADE database contains in total 236 countries reporting export figures, providing a highly-detailed information on the world trade.

Oil & gas companies in downstream sector do not have one unified reporting system that would allow us to work with the company data on a disaggregated level. Many companies, private or publicly traded, release model operational margins only and report financials of the segments (refining, petrochemical, chemical, merchandise) together, making any analysis of product prices or achieved margins impossible. To our best knowledge, there is no better, unified data source than COMTRADE database for our computation of competitiveness developments in the oil & gas downstream segment.

Following the methodology of Benkovskis and Wörz (2016), we obtain all the information available in the database: unit value indices serving as a variable for prices and volume of trade as a variable for quantity (dollars per kilogram or other and mainly kg or other, respectively).

Although we focus on changes in export market shares dynamics, both export and import figures are required for the index calculation. As Benkovskis and Wörz (2016) highlight, the index calculation begins with the consumer's maximization

problem where import data are essential, reported in CIF prices, providing the exact cost at the arrival to the country of the importer, and therefore being a better input compared to the export prices, which often prove unreliable due to differences and low disclosure in the developing part of the world.

In our own analysis, we focus solely on the refining and petrochemical segments and decrease the number of countries to EU states and their direct competitors (USA, Saudi Arabia, Russia) and major downstream producers that affect global demand (China).

## 4.2 Drawbacks of the database

The index, or its specific version which we employ in the second part of the thesis, cannot be computed if the values or volumes are missing. Many statistical institutes and state authorities, even in the largest and developed import and export countries, provide only fraction of data collected. Data collection is far better in China, Japan and EU than in USA, or e.g. Canada publishes around half only. That said, data coverage in both refining and petrochemical segments is sufficient enough for our analysis in most cases. Unfortunately, some of the most important Gulf states do not provide any data on the sectors (e.g. United Arab Emirates, Kuwait, Iraq). We take Saudi Arabia, the main oil producers and a country which has increased its refining and petrochemicals capacity the most from the group, as a representative for the whole region. Although the Caspian region plays an increasing role in refining and petrochemical exports to Europe, the data collection in these countries is very poor. Thus, we set Russia as a representative of this group.

In the late 1990s and early 2000s, the data coverage is lower than in the second half of the sample. That said, the results should not be affected significantly as the low coverage seems to be homogenous across different product groups in the sample period (Benkovskis and Wörz, 2016). To follow steps of the original authors, we filter all observations with outlying values from our calculation. As Benkovskis and Wörz (2016) highlight, some import data reported by an importer do not match export data reported by an exporter, especially in emerging countries due to differences in reporting, valuation, timing etc. As many of the countries where export reporting proves weaker than average, these countries face various import taxes and tariffs recorded by the importer, significantly improving the data coverage level.

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Timing and frequent updates and revision of the COMTRADE database are one of the biggest drawbacks that might have some effect on the results. Analysis of Pierce and Schott (2009), focusing on tracking changes in the US Harmonized System database caused by reclassifications and updates, highlights issues which must be dealt with to retain consistency of the research. The coverage ratio does not reach sufficient values in number of countries, therefore, we decided to limit our sample to 1996-2015. Given the worldwide coverage of COMTRADE relevant to our research analysis, we choose it over the COMEXT database which might be favoured due to its higher level of disaggregation and shorter publication lag. Benkovskis and Wörz (2011) use the COMEXT database while analysing the European market, due to its detailed and more suitable form for the analysis.

The empirical problems and possible biases caused by the reliance on COMTRADE database suggests just the need for recalculation which either uses more reliable data or takes the problems of COMTRADE data into account. Empirical evidence has been found by Baldwin and Harrigan (2007) which suggests that there are stable relationships between unit values of exports and imports and distance between countries. The neglect of the possible relationships between distance and unit values may lead to incorrect evaluation of price competitiveness of countries which have experienced a significant change in the structure of their export destinations.

Existence of intermediate inputs and international fragmentation of production chains. The original concept of decomposition of welfare effects starts with utility maximization of a representative household with CES utility function, the logic of which is rather crucial for the whole effect and treats all trade as trade with commodities intended for final use. A modification which considers fragmentation of production (and information from Supply and Use tables from the World Input Output Database) has been proposed in Benkovskis and Wörz (2016). This issue is much more significant. Even the early results from Benkovskis and Wörz (2016) seem to turn many previous results upside down – e.g. the relative quality of production from the USA, Canada, Germany, and the UK did not change or even increased, while many positive qualitative changes of production from e.g. India or Brazil can be attributed due to outsourcing than to real changes the quality of domestically produced output. Consequently, attempts to derive useful empirical measures of changes in competitiveness cannot ignore these effects.

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### 4.3 Alternative databases

**COMEXT** is a detailed database which maps all foreign trade activities of EU (and partially EFTA) member countries at the highest possible level of detail, the eight-digit Combine Nomenclature level offering more than 10,000 commodities, or twice as many as in UN COMTRADE database. Another significant advantage presents the timely data release – authorities report within three months after year-end. Focusing on both EU and non-EU members, we decide to use the UN COMTRADE database instead, retaining consistency of the results. One of the several drawbacks apart from the geographical limitations is frequent category revisions which would have to be addressed with greater cautiousness than in case of UN COMTRADE database. As we are comparing EU markets with Russia, USA, Saudi Arabia, and China, UN COMTRADE is the only available tool. COMEXT database would be, however, preferable in case of comparing inland markets as the Czech Republic, Slovakia or Hungary.

**Trade unit values database** – this less known source derived by CEPII economists from Tariff lines database of the United Nations Statistical Division addresses the possible statistical shortcomings related to calculations of unit values (and related indicators) from the COMTRADE which are aggregated in to 6-digit categories to allow for better cross-country comparability (i.e. Berthou and Emlinger, 2011).

## 5 Results and Discussion

In the first part of our analysis, we focus on replication of Benkovskis and Wörz (2016) method, testing the elasticities of substitution between varieties and the index for its reliability over time. Secondly, we extend the sample by four years from 1996 and 2015 and compare the results, highlighting major changes in the index curves depicted by Benkovskis and Wörz (2014, 2016). Lastly, we employ the index on oil downstream sector in EU, Russia, Saudi Arabia, USA, China and other major oil downstream players affecting EU countries and analyse the drivers (price, variety, quality) of the changing competitiveness in the oil downstream by splitting the index and studying drivers of price and non-price competitiveness developments.

### 5.1 Herfindahl index

Employing the Herfindahl index as a simple tool to test the data concentration, or quality, of UN COMTRADE database, we arrive at sufficiently low levels for most of the countries, especially for the countries of interest. We test the export data at both commodity and trade partner levels. In the partner test, most of the OECD countries fall under the 0.1 threshold. As expected, due to the size of trade with Germany, the Czech Republic's partner Herfindahl index for 1996-2015 stands at 0.15, which still is acceptable as highly concentrated data. From the largest countries considered in our sample, the lowest partner Herfindahl indices are found in cases of Turkey (0.03) or United Kingdom (0.05). The commodity Herfindahl index results also point at good levels of concentration which should not bias findings in the index computation.

Russia's commodity Herfindahl index of 0.14, being one of the highest values in the sample, still falls within the acceptable range. High commodity index values are found for other oil exporting countries but meet the concentration criteria as well. USA, Slovakia or the Czech Republic commodity indices are lower than 0.01, indicating rich diversity of the foreign trade. Values lower than 0.1 are found across most of the tested countries.

Testing the sample on oil downstream only for our own analysis, we observe slightly higher but sufficiently low values in both refining and petrochemical products of commodity and partner indices.

## 5.2 Elasticity of substitution between varieties

We arrive at very close values compared to the original results (i.e. Benkovskis and Wörz, 2016), both in periods 1996-2011 and 1996-2015, despite working with slightly different data due to updates and frequent reclassifications. Testing the elasticity of substitution between varieties over different time periods within the sample, we are surprised by relative stability of the elasticities for the countries. We follow Benkovskis and Wörz (2016) approach and arrive at one single number for a country over the sample period as the reliability increases with higher number of lags. The elasticities of substitution between varieties can be found as sigmas in the attached files.

## 5.3 Index replication: 1996-2011

We compute the index for 1996-2011 and compare the results to the findings in the older papers of Benkovskis and Wörz (2011, 2012, 2013, 2014, 2016) before extending the period for our own research. We test the index on all 188 countries available in UN COMTRADE database to be able to compare our results with all indices for all countries published so far in the past studies.

The first part of the index, which considers price factors only and omits quality or taste and variety, is presented as a grey curve (column) in charts below. The second part of the index, adding variety or set of competitors factor, is shown as a blue curve (column), while the third part, accounting for quality or taste, is plotted as an orange curve (column). The impact of variety is not as pronounced as impacts of price competitiveness or changes in quality or taste. We keep the variety curve (column) but do not discuss its changes in detail. A decrease index over time depicts an increase in competitiveness.

UN COMTRADE database is updated continuously over time and using identical sample as Benkovskis and Wörz (2011, 2012, 2013, 2014, 2016) is not possible, unfortunately. Data for many of the countries are updated even few years back, while some specific data are not released by the countries at all due to various reasons (e.g. security or simply no data coverage and collection). Most of the results, however, indicate reliable and timely and detailed data collection and coverage and our indices are very similar to findings released in past studies.

Our results of the replication, shown in Appendix A, for countries such as the Czech Republic, China or Turkey indicate limited number of updates or reclassifications in UN COMTRADE database, as the very same curves off all three indices (Conventional RXP, RXP adjusted by the set of competitors, and RXP adjusted

by non-price factors) are observed. The elasticities of substitution between varieties differ rarely in the whole sample. However, we observe some differences in the conventional RXP and RXP adjusted by the set of competitors' curves in case of Argentina and Chile. The curves displaying the quality change, or the RXP adjusted by non-price factors, indicate no or little changes.

## 5.4 Index replication: 1996-2015

We extend the period by four years from 1996-2011 to 1996-2015 – essential given the changing patterns that followed in the international trade flows after the 2008/2009 crisis, and particularly in the oil market trade flows in Europe, the United States, China, and the Gulf region.

To briefly address the new index results for some of the countries previously studied by Benkovskis & Wörz (2011, 2012, 2013, 2014, 2016), we observe various developments within the sample. China shows worsening price competitiveness since 2012, which contradicts the general view of its trade partners of artificially undervaluing its currency. We note that the impact of yuan depreciation which followed after 2015 is not considered in our analysis. The improvements in quality, or non-price competitiveness, are slowing down since the crises but remain positive. Japan's non-price competitiveness worsened significantly after the crisis, especially in the last four years of the observation period. Its price competitiveness, however, indicates improvements, as yen depreciated significantly from 2012 until 2015.

Findings for the North American countries, considering recent arguments for higher level of protectionism of the current US Government, show USA's goods quality to halt worsening after the crisis, with little changes in price competitiveness. Canada managed to improve quality moderately after the crises, while becoming more price competitive at the same time, an effect of depreciation of Canadian dollar. Mexico shows substantial quality improvements following the crises, but the overall impact of the price competitiveness hovers at the same levels over the sample period.

We observe strong depreciation of local currencies vs. USD in most of countries trading with USA, making them more price competitive. The only exception is China that has seen its price index increase between 2012-2015, becoming less price competitive. Such development could be attributed to renewed strengthening of yuan. The substantial depreciation which followed in the second half of 2015 might not affect the index values yet.

Turkey and Russia managed to continue increasing quality of their products, although as Benkovskis and Wörz (2016) highlight, oil exports are the main driver behind such improvements in Russia. While Turkey's price competitiveness shows some improvements, Russia managed to stop the price factors decrease entirely and the findings indicate substantial improvements which goes hand in hand with the depreciation of rouble, the war in Ukraine and introduction of sanctions. Again, note that recent depreciation of Turkey's lira, beginning in late 2016, is not considered in our analysis.

The CEE region continues to improve quality of the products while little effect is seen in price competitiveness. In the Czech Republic, the effect of the Central bank's interventions is seen with only a moderate positive price effect. The quality index, however, shows decreasing pace. Similar developments in both price and non-price competitiveness are observed in Romania and Poland, two countries that have seen one of the best quality improvements in the sample. Hungary's depreciation is captured by the price index but little changes are observed in quality changes following the 2008/2009 crisis.

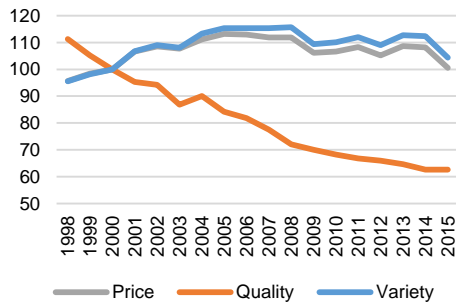
The effect of weakening euro in 2014 is captured in improving price competitiveness of most of the euro zone countries. The most eye-catching non-price competitiveness improvements are seen in Slovakia, Estonia, and Portugal.

France and the United Kingdom show worsening quality, while Spain keeps improving. Germany's non-price competitiveness stalls on the same levels over the entire period. Greece managed to improve its non-price competitiveness right after the crises but the quality index seems to bottom in 2013, followed by substantial increases in 2014 and 2015.

Overall, we find our results to be very close to the previously published findings of Benkovskis and Wörz (2011, 2012, 2013, 2014, 2016), looking at both the older sample and the new 1996-2015, despite employing updated elasticities of substitution derived from the new data. Still, we choose not to employ 2016 or 2017 data due to incompleteness. All three parts of the index show little changes even after accounting for most recent data.



**Index replication: 1996-2015<sup>2</sup>**



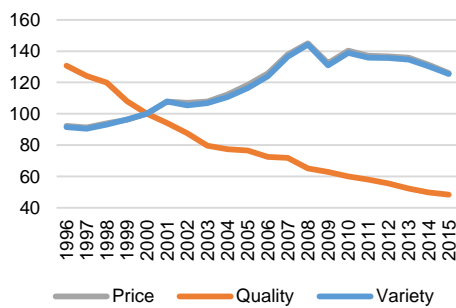
**Figure 5.1: Czech Republic**

Source: author's computations, COMTRADE



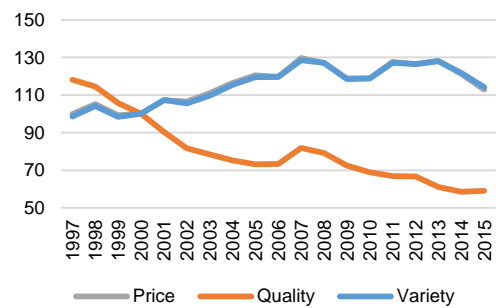
**Figure 5.2: China**

Source: author's computations, COMTRADE



**Figure 5.3: Poland**

Source: author's computations, COMTRADE



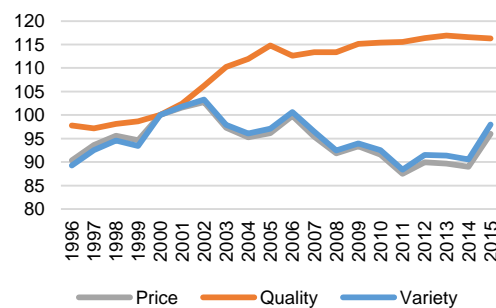
**Figure 5.4: Romania**

Source: author's computations, COMTRADE



**Figure 5.5: Russia**

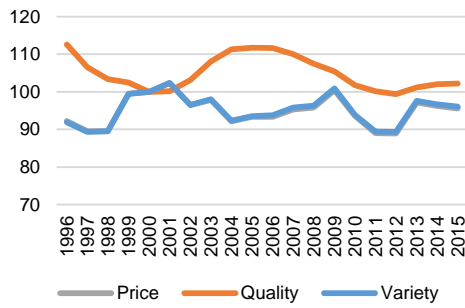
Source: author's computations, COMTRADE



**Figure 5.6: USA**

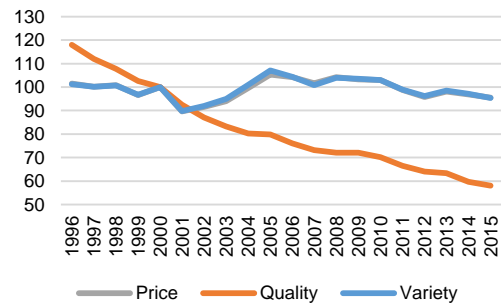
Source: author's computations, COMTRADE

<sup>2</sup> Decrease denotes gain in competitiveness. For all country indices contact the author.



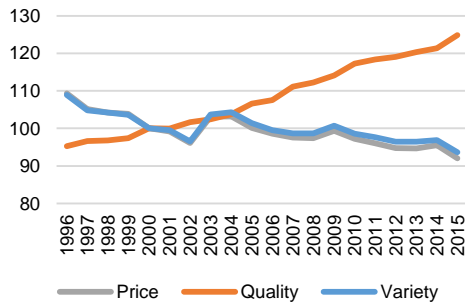
**Figure 5.7: Mexico**

Source: author's computations, COMTRADE



**Figure 5.8: Turkey**

Source: author's computations, COMTRADE



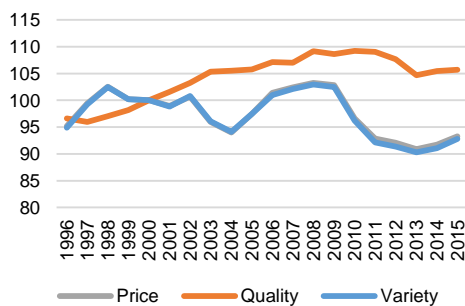
**Figure 5.9: France**

Source: author's computations, COMTRADE



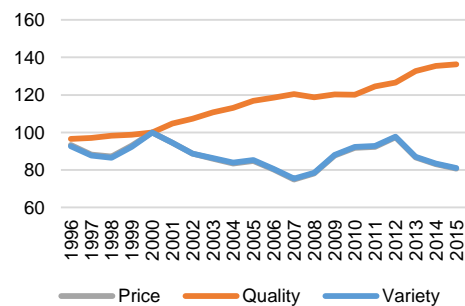
**Figure 5.10: United Kingdom**

Source: author's computations, COMTRADE



**Figure 5.11: Canada**

Source: author's computations, COMTRADE



**Figure 5.12: Japan**

Source: author's computations, COMTRADE

## 6 Oil Downstream in Europe

### 6.1 Oil downstream and competitiveness

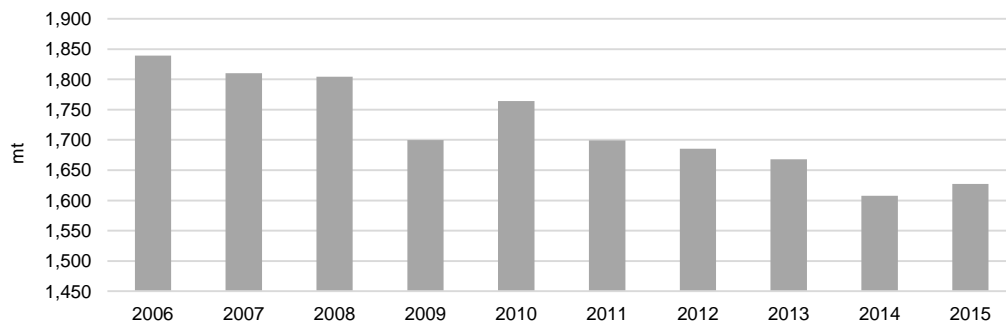
While Benkovskis and Wörz (2016) present the quality index based on all commodity sectors of a country only and do not provide detailed picture of contributions of price, variety and quality to the final index value, we investigate the drivers of the quality index (including price, variety, quality) for a specific sector, the oil downstream. To investigate changing patterns in oil downstream competitiveness, we choose two separate sectors for the analysis, based on UN COMTRADE classification: a) processed mineral products and b) petrochemical products. Both sectors are well covered in most EU countries, Saudi Arabia, USA, China, Russia and most of their foreign trade partners.

European oil downstream market is very competitive and oversupplied with products, although there are some pockets in the East that still enjoy relatively high inland premiums or benefit from lower Urals crude price, thanks to the setup of their refineries that have been historically dependent on the Russian crude supply. The Western refineries, especially coastal ones, and adjacent petrochemical plants, however, face stiff competition from other importers, i.e. the Gulf or USA, whose competitive advantage have grown substantially on the back of latest investments. They benefit from economies of scale and lower feedstock prices. Moreover, we expect the product, especially in petrochemical segment, to increase in quality as well there.

We focus on the main drivers of the index – the quality and the price factors. In a very volatile environment with frequent changes in crude oil prices and in the domestic and USD exchange rates on daily bases, we would expect quality to be the main driver of the changing profitability of the sector in longer term, given its high saturation level of competitiveness and converging taxation and prices. We expect the price factors to be relatively stable in longer term, while changes in quality to have the main impact on competitiveness of the oil products sales and, therefore, the success of the refining and petrochemical segments in the given countries.

## 6.2 European oil downstream history

Europe's oil downstream sector developed mainly after the war and grew further in 1960s on the back of growing oil products demand. Both national and private companies invested heavily in refining and petrochemical capacities to meet the growing demand. The consequences of the second oil shock of 1979-1980 led to growing oil product prices and a substantial fall in consumption, creating long-lasting supply overhang. The imbalance of capacities developed in 1960s and consequential rise in oil inventories still pose one of the main issues in the European and global oil market today. In the following decades, many more factors changed Europe's oil downstream market completely: a) demand for heavy fuel oil was decreased due to nuclear power expansion; b) pipelines to import natural gas from the east were built, causing fall in fuel oil demand; c) the Gulf states invested in their own export-oriented refineries; and more recently; d) imports of petrochemicals and fuels started flowing from USA, where massive shale gas exploration has changed both the refining and petrochemical segments; e) Europe's tax policies have often supported diesel over gasoline as passenger car fuel, creating large overhang of diesel and shortage of gasoline.



**Figure 6.1: Shrinking demand for crude oil in EU: Gross consumption**

*Source: Eurostat*

The capacity overhang has been an issue for four decades now. Europe's refining capacity alone would satisfy its current demand. The refineries run at lower utilization rates due to increasing imports from Russia, the Caspian region, the Middle East, and now also USA. Looking at our sample period of 1996-2015, more than 35 refining plants were closed in Europe, which led to a substantial capacity decrease (Eurostat, 2017). Such a decrease over two decades certainly could not balance the supply overhang. There are many factors that prevent rationalisation of the market by closing the plants or converting them into storage terminals, such as a) strong labour unions; b) national interests and security; or c) costly closures due to high environmental requirements.

Petrochemical production, often integrated into an adjoining refinery, is more profitable due to higher demand for the petrochemical products. Europe's automotive industry, construction, plastics, agriculture etc. offer opportunities for both local producers and importers, opposed to declining refining products market. Although the demand dropped following the crises, it has been growing again since 2010. In Europe, most of petrochemical producers are naphtha-based, opposed to USA, Saudi Arabia, and China, where the most important commodity is natural gas (ethane). Ethane is on average twice cheaper to produce than naphtha (an intermediate hydrocarbon liquid derived from refining of crude oil) and presents a major risk for Europe's naphtha-based producers, as the transport costs decrease by increasing amounts of imports and improving infrastructure. As most of the petrochemical assets rely on naphtha produced in adjoining refineries, increased ethane imports from abroad might cause another wave of refining shutdowns or at least costly changes in configuration.

The current depressed oil prices led to an increase in naphtha-ethane spread, saving many European refining and petrochemical producers from closure or transformation into storage terminals. Sudden rise of crude oil prices, leading to increase in naphtha prices, or an economic slowdown in Europe, will cause another wave of shutdowns of smaller refining and petrochemical naphtha-based players, as the demand for automobiles, construction and packaging decrease on the back of more expensive oil.

### 6.3 European downstream markets

European refineries were built to process specific types of crude oil. Northwestern refineries process mostly the Brent crude type. Mainly the Urals crude is imported to the CEE region, while Southern refineries rely on crude from the Middle East. Each type of crude has its advantages and disadvantages, as the crude type differs and refineries have to undertake substantial investments before switching to a different crude type. The three regions face different pricing mechanisms, competitive forces and inland premiums. CEE refiners now benefit from the slightly cheaper Urals crude but investments in Russia and the Caspian are expected to soon mitigate this advantage. Southern European downstream companies compete directly with the Gulf refineries. Refiners in Northern and Western Europe face competition in the region of the Atlantic Basin, including USA and Canada. All EU refiners and petrochemical producers face much stricter environmental regulations than their global peers. As the Mediterranean

refiners face different pricing than its Northern and CEE peers, we leave this segment for future analysis and focus on CEE and Northern producers only.

### Western Europe downstream

Western European downstream companies rely heavily on high level of integration between refining, petrochemicals and chemical production. The profitability of the sector, especially refining, is being reduced substantially due to high feedstock and labour costs. Decreasing oil products demand and chronic oversupply in the region forced many loss-making, smaller plants out of the market. Some of the facilities were converted into storage terminals as a complete closure requires additional costs, given EU's strict environmental policies. Recently, refineries have been closed in Harburg, Reichstett or Dunkirk (Eurostat, 2017). The coastal refineries are most exposed to the competition coming from the sea.

Rising imports from the Middle East and USA are not the only factors behind decreasing profitability, causing lower utilisation of European refineries. The costs of environmental policies and green gas reductions remain an issue for all producers in the region as most of the plants are more than forty years old and upgrading them requires massive investments. Many investments were postponed due to rising ethane-naphtha spread following the drop in crude oil prices since 2015 to capture the profits before crude oil prices rise again.

Highly integrated petrochemical producers in Germany and the Netherlands run naphtha-based crackers with capacities over 500kt of ethylene and advanced infrastructure to reach both importers and customers. Although there have been several closures of low-capacity plants in the region, the setup of these producers is more advantageous than their French or British peers.

### CEE downstream

Privatization of most of CEE oil downstream companies has brought massive investments to upgrade their obsolete assets. Most of the crude oil is imported from the east, mainly the Urals crude type, which has provided a cost advantage over the Western refiners, due to widening Brent/Ural differential in past years. Few refineries, e.g. Kralupy in the Czech Republic, process sweeter crudes. Although demand for oil products has been rising in CEE markets (IEA, 2017), the sector faces similar competitive disadvantages as their Western European peers. CEE companies invested mainly into higher integration of their assets, technologies and larger scale. The infrastructure is less developed in the CEE region, providing local producers higher competitive advantage in form of inland premiums. These positive price

competitiveness factors could be, however, mitigated by higher cost of crude, delivered mainly by pipelines, as many of them, e.g. Unipetrol, are the last importers at the end of the pipeline and have worse negotiating position. Majority of the crackers are naphtha-based but the high integration between refining and petrochemicals allows local producers to achieve relatively high margins.

Two largest companies, Polish PKN and Hungarian MOL, are the main players in the region. While PKN has the highest market share in Poland and the Czech Republic (via its subsidiary Unipetrol), MOL controls Hungary, Slovakia and Croatia. Both companies have invested in refining and petrochemical upgrades that are already seen in rising quality of the products and increasing profitability. Most of the refining facilities are now equipped by FCCs and hydroskimming units to increase the light yields. More petrochemical upgrades are being developed (PE3 unit in Litvinov) as the industrial base expands. As the companies turn slowly to exports with recent and planned petrochemical capacity increases, both quality and exchange rate changes play a crucial role in successful product sales. Petrochemical semi-finished products exported to Germany are one of the main drivers of petrochemical growth in the Czech Republic, Hungary, and Slovakia.

### Czech downstream

Unipetrol, PKN's subsidiary, has the biggest market share in both petrochemical and refining sectors in the Czech Republic. Large portion of Unipetrol's products is exported, mainly to Western Europe. By acquisition of ENI's 32.4% stake in Ceska rafinerska in June 2015, Unipetrol has become the owner of all refinery assets in the Czech Republic: Litvinov and Kralupy refineries with combined capacity of 8.7mt/y. Unipetrol also owns 1mt/y Paramo refinery with a heavy product slate, closed in 2013 due to underutilization and weak refining margins. Litvinov and Kralupy refineries are operated as a single unit, although being located 72km apart. Litvinov supplies Kralupy with kerosene and reformat while gasoline and light cycle oil and naphtha flow from Kralupy to Litvinov, where the steam cracker is located (Unipetrol, 2017).

The Nelson complexities (a measure of the secondary capacity of refinery) of Litvinov and Kralupy are 7.0 and 8.1, respectively. That is well below both PKN's and MOL's refining assets which are also bigger in size. Kralupy were updated in 2001 by adding FCC unit which increased its light products capacity by 0.7mt to 2.0mt/y. Litvinov is equipped with hydrocrack and visbreaker units. PKN might decide to upgrade Unipetrol's refining assets only if the crude oil price environment changes, hitting petrochemical bottom line. As long as crude oil prices remain at the current

levels or moderately higher, the petrochemical segment performs well enough to offset refining losses (Unipetrol, 2017).

The heart of Unipetrol's petrochemical production is its 544kt steam cracker in Litvinov, the largest in Central Europe, which feeds two polyethylene units and one polypropylene unit, while benzene and C4 fraction are sold on the market. PE and PP production units have approximate share of 5% and 3% of total European output, respectively. By mid-2018, Unipetrol plans to launch production at its new PE3 unit which will increase the annual production capacity to 470kt/y, while closing the 40-year old PE1 unit (Unipetrol, 2017).

In the marketing segment, Unipetrol operations cover both Slovakian and Hungarian markets, where a new subsidiary was established in 2015. In Germany, the Company delivers to Orlen Deutschland, reaching out a major supply of its 572 petrol stations (Unipetrol, 2017).

## 6.4 Russia and the Caspian region

Russia has seen many investments aimed at upgrading both refining and petrochemical assets in the past decade. Russian government, which also owns large stakes in most of the oil companies, continues supporting fuel exports and domestic downstream investments. Many of the of the projects are still ongoing or were put on hold as the crude oil prices dropped. There were 51 refineries in Russia in 2015, of which 15 were small-sized (IEA, 2017). Both refining and petrochemical capacity has risen in the sample period, with exports increasing due to unfavourable GDP growth caused by the Ukraine crisis, low crude oil prices and the sanctions in last three years.

Both Russia and the Caspian countries are expected to increase exports of high-quality products into Europe and, with the declining European demand, to Asia, already building the infrastructure. Investments in Kazakhstan or Azerbaijan aimed at increasing capacity and higher yields are expected to significantly improve the export portfolio. The region is the largest threat to CEE oil downstream but the effect of the investments remains ambiguous. Russia has a sizable cost advantage and is expected to slowly improve the product quality.



## 6.5 USA

While refineries kept being shut down in USA after the crisis, the refining capacity increased. This is due to growing shale gas exploration industry boom that offers cheap production of ethane and fuel. Although many projects are in first stages of development, USA is expected to become a net exporter of petrochemicals in the upcoming years. Local producers are slowly abandoning naphtha-based production, which might cause a shortage of naphtha related petrochemical products such as propylene as only ethylene and fuel are cracked from ethane.

Several countries, such as China or South Korea, already started building ethane-based crackers. Similar trend might be introduced in Europe, although current strong USD and high transportation costs of ethane protect Europe's naphtha-based producers. The effect is not seen yet but gas imports from USA, where gas is twice cheaper, to Europe will radically change European gas markets (OPEC, 2017). The well-developed gas infrastructure offers a significant competitive advantage by lowering the production cost. The refining and petrochemical quality improvements are expected to play a major role as well, competing directly with the Middle Eastern and Russia's exports.

## 6.6 Middle East

The Middle East region has emerged as an important player in petrochemical on the back of large investments into both refining and petrochemical assets. The Gulf region turned into a net exporter that benefits from lower operational costs, proximity to high demand markets and high-technology plants. More projects are being build, although some of them have been stalled due to the drop in crude oil prices. The Gulf investments substantially contribute to troubling overcapacity and oversupply on global scale, as the local demand for oil products remains limited. Local producers are currently looking at increasing petrochemical capacities, putting pressure on Europe's producers. Further, Iran, now free from the sanctions, is ready to flood the market with both refining and petrochemical products. Iran invested massively into petrochemical capacity increase in last decade (OPEC, 2017). The Gulf petrochemical producers are ethane based and have a considerable advantage over their Europe peers.

## 6.7 Rising developing countries: India and China

Although we analyse the impact of recent investments in China, we highlight that building refineries and petrochemical plants in developing countries has been aimed

mainly at satisfying the growing local demand. Both China and India remain net importers of oil products. The importance of the capacity increases is captured by changing trade flows of oil products, hitting oversupplied markets, such as Europe, where oil consumption decreases.

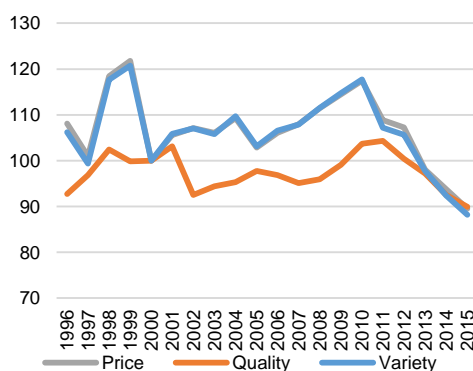
## 7 Oil Downstream Results

We divide this section into the Western Europe and CEE oil downstream, their foreign competitors from the Middle East and Russia, and important markets such as USA and China that affect demand for refining and petrochemical products on a global level.

### 7.1 Western Europe

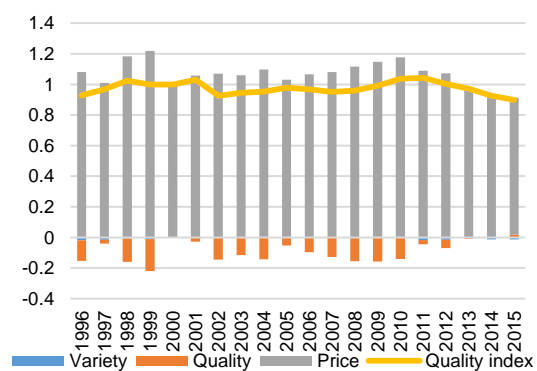
Overall, the index shows significant losses in non-price competitiveness of petrochemicals in the Western Europe, confirming our original hypotheses. Recently, there are some improvements seen in EU petrochemical price competitiveness, which we attribute to the weakening euro vs. dollar. The refining segment performs better but mainly on the back of the ongoing refining closures or decreasing capacities, due to the oversupply on the market. The price competitiveness in refining generally hovers around the same levels. Germany's persistence in refining product quality (Figure 7.1, Figure 7.2) comes unexpected. We observe sustained index levels for petrochemicals which are supported mainly by price factors (Figure 7.3), as the positive impact on quality is clearly worsening (Figure 7.4), despite Germany's proximity to less oversupplied and growing oil markets in CEE and high integration between the downstream assets. We would expect it to decline in past two years but also in future, given the rising imports of high-quality and price-competitive products from USA, the Gulf and CEE.

#### Germany: Refining sector



**Figure 7.1: Competitiveness indices**

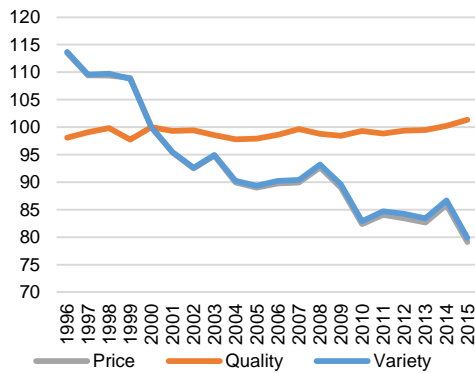
Source: author's computations, COMTRADE



**Figure 7.2: Quality index decomposition**

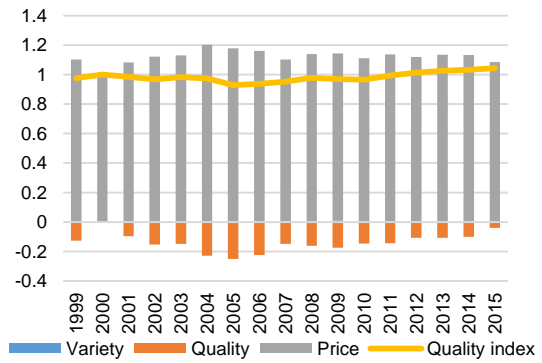
Source: author's computations, COMTRADE

**Germany: Petrochemical sector**



**Figure 7.3: Competitiveness indices**

Source: author's computations, COMTRADE

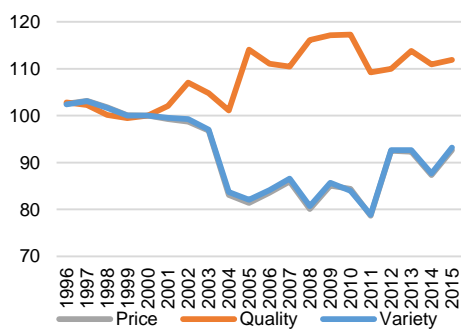


**Figure 7.4: Quality index decomposition**

Source: author's computations, COMTRADE

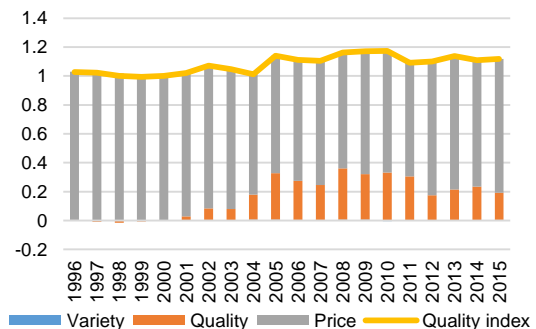
As we expected, most of the Northwestern European markets show deterioration of non-price competitiveness. While the refining sector performs better in price competitiveness than we would have originally expected, most of the countries show substantial fall in petrochemical non-price competitiveness. This finding is crucial as petrochemical segment is very often the profitability generator of integrated refineries with petrochemical plants. Losing market share in petrochemical segment translates into lower utilization of refineries and even lower profits. We attribute the relatively stable price competitiveness to the refinery closures, but we see the issues in the petrochemical market mainly as result of delayed investments, that had a negative impact on the product quality.

**France: Refining sector**



**Figure 7.5: Competitiveness indices**

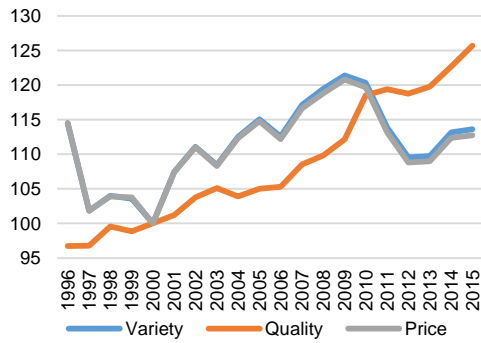
Source: author's computations, COMTRADE



**Figure 7.6: Quality index decomposition**

Source: author's computations, COMTRADE

**France: Petrochemical sector**



**Figure 7.7: Competitiveness indices**

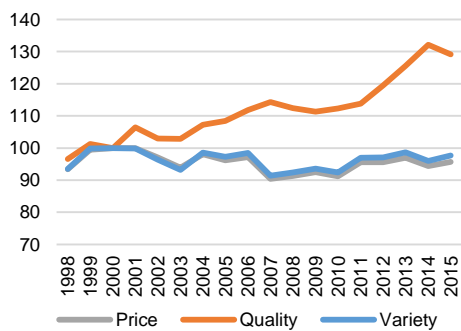
Source: author's computations, COMTRADE



**Figure 7.8: Quality index decomposition**

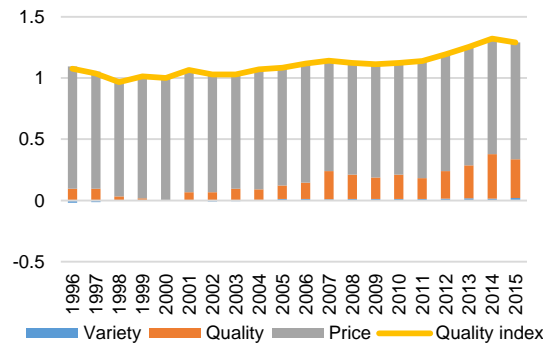
Source: author's computations, COMTRADE

**United Kingdom: Refining sector**



**Figure 7.9: Competitiveness indices**

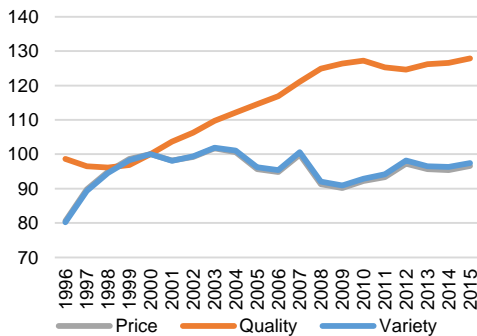
Source: author's computations, COMTRADE



**Figure 7.10: Quality index decomposition**

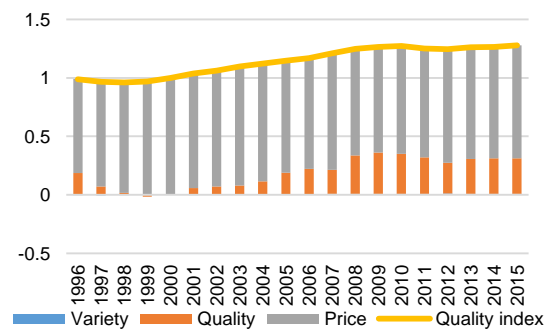
Source: author's computations, COMTRADE

**United Kingdom: Petrochemical sector**



**Figure 7.11: Competitiveness indices**

Source: author's computations, COMTRADE



**Figure 7.12: Quality index decomposition**

Source: author's computations, COMTRADE

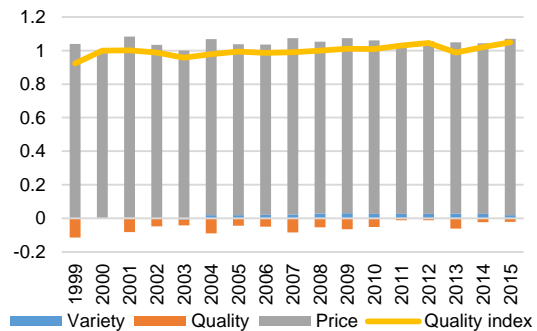
While decreases in non-price competitiveness in France or the United Kingdom were expected (Figures 7.5-7.12), we are surprised that the Dutch petrochemical market has been becoming less competitive in quality terms, given the scale of recent investments and high integration of local producers (Figure 7.20). We explain this trend by direct exposure to imported products. The quality decreases in both refining and petrochemical products in the United Kingdom are alarming (Figure 7.9-7.12). The Belgian petrochemicals quality shows resistance but the quality factor gradually diminishes (Figure 4.4), pointing to decreasing non-price competitiveness in future. We observe some improvements in France’s refining sector quality after the 2008/2009 crisis. The quality effect has been, however, negative since 2000 (Figure 7.6). Petrochemical quality started worsening in years that followed the crisis.

**Belgium: Refining sector**



**Figure 7.13: Competitiveness indices**

Source: author’s computations, COMTRADE



**Figure 7.14: Quality index decomposition**

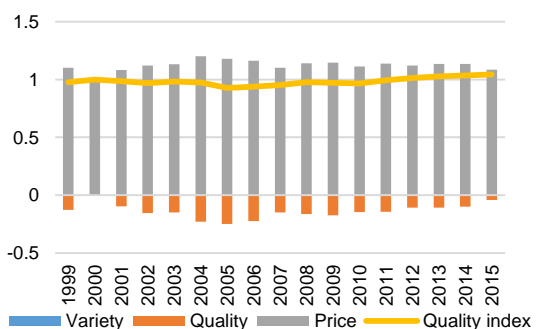
Source: author’s computations, COMTRADE

**Belgium: Petrochemical sector**



**Figure 7.15: Competitiveness indices**

Source: author’s computations, COMTRADE



**Figure 7.16: Quality index decomposition**

Source: author’s computations, COMTRADE

**Netherlands: Refining sector**



**Figure 7.17: Competitiveness indices**

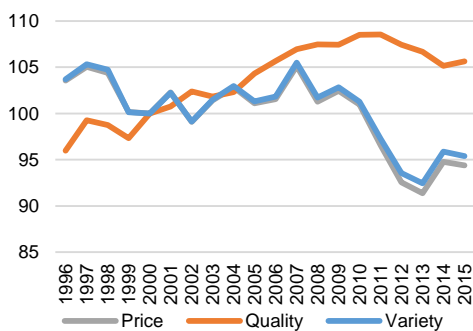
Source: author’s computations, COMTRADE



**Figure 7.18: Quality index decomposition**

Source: author’s computations, COMTRADE

**Netherlands: Petrochemical sector**



**Figure 7.19: Competitiveness indices**

Source: author’s computations, COMTRADE



**Figure 7.20: Quality index decomposition**

Source: author’s computations, COMTRADE

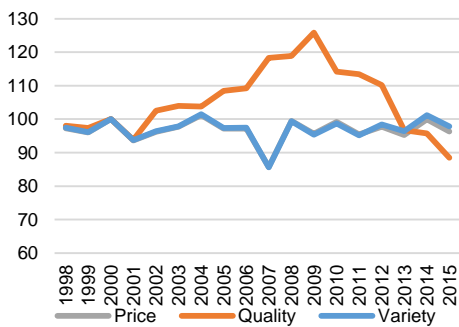
**7.2 CEE**

We observe a profound impact of consolidating the market, increasing integration and substantial investments in the CEE region. The non-price competitiveness improvements, especially in petrochemicals, are incomparable with any of their Western European peers. However, some of the quality improvements might stem from closures of low quality plants as in Western Europe. (e.g. seizure of urea production in the Czech Republic etc.).

In the Czech Republic, refining product price competitiveness has been the major driver behind the sectors worsening competitiveness before the crisis (Figure 7.21). The refining quality decreased despite Unipetrol’s FCC unit investment in 2001

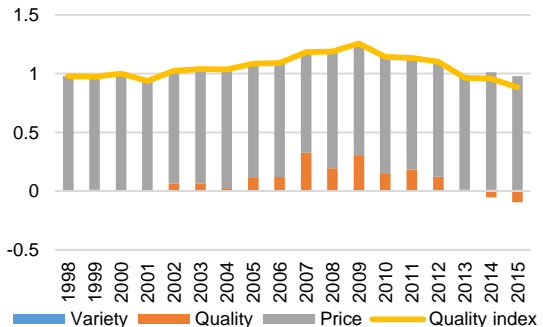
but continues to improve after the crisis (Figure 7.22). This finding is intuitive, given the increased cooperation within the PKN group and PKN’s gradual takeover of Ceska Rafinerska to increase integration of refining and petrochemical sector with positive impact on margins and quality. The decreases in quality before the crisis could be explained by increasing demand for high-quality products domestically while exporting low-quality products abroad.

**Czech Republic: Refining sector**



**Figure 7.21: Competitiveness indices**

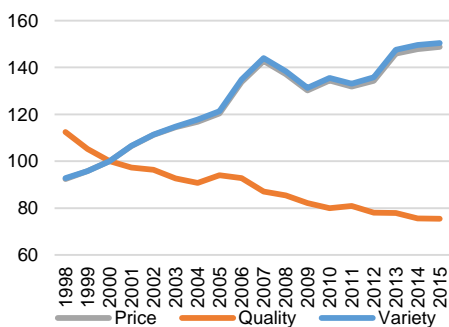
Source: author’s computations, COMTRADE



**Figure 7.22: Quality index decomposition**

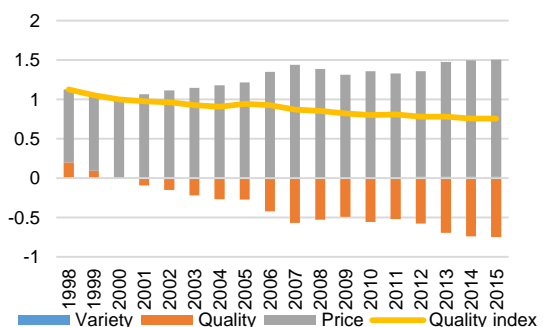
Source: author’s computations, COMTRADE

**Czech Republic: Petrochemical sector**



**Figure 7.23: Competitiveness indices**

Source: author’s computations, COMTRADE



**Figure 7.24: Quality index decomposition**

Source: author’s computations, COMTRADE

As expected, the Czech petrochemical segment shows clear improvements in quality but the price competitiveness worsens almost over the entire period (Figure 7.24). We attribute the decline to the appreciating Czech crown but PKN’s pricing policy might be an important factor as well. The Central Bank’s recent interventions to weaken the currency had a positive impact on both refining and petrochemicals segments, looking at the quality index curves. We expect the quality to improve further with Unipetrol’s new PE3 unit being operational in 2019. The petrochemical segment’s



non-price competitiveness decreases much more than refining's. The size of petrochemical exports to Germany and higher liquidity of the petrochemical market, compared to much lower refining export, explains such development.

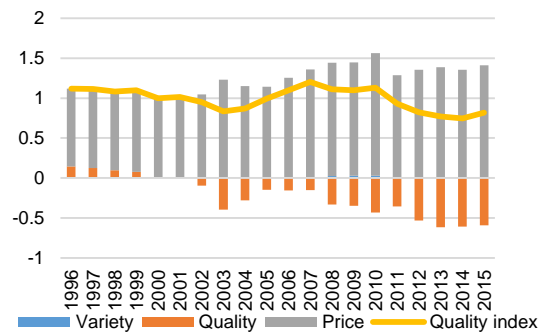
We see similar patterns in refining and petrochemicals markets in cases of Poland, Slovakia and Hungary. While refining quality increases in Poland and Slovakia over the entire period, Hungary has shown a moderate decrease in quality since 2012. We observe a pronounced effect of strengthening local currencies on price-competitiveness, except for Hungary. Petrochemical quality shows substantial improvements over the entire period in all three countries. The size of investments Lotos, Grupa Azovy, PKN (Poland) or MOL (Hungary, Slovakia) spent on petrochemical segments and refining satisfying mainly the domestic markets, explain such developments, confirming our original hypothesis.

**Poland: Refining sector**



**Figure 7.25: Competitiveness indices**

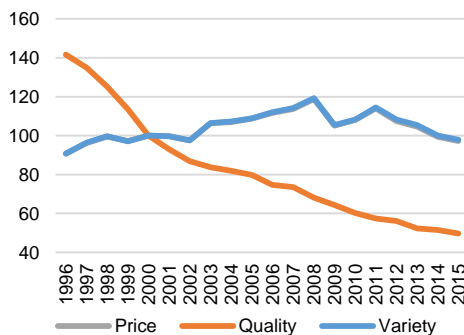
Source: author's computations, COMTRADE



**Figure 7.26: Quality index decomposition**

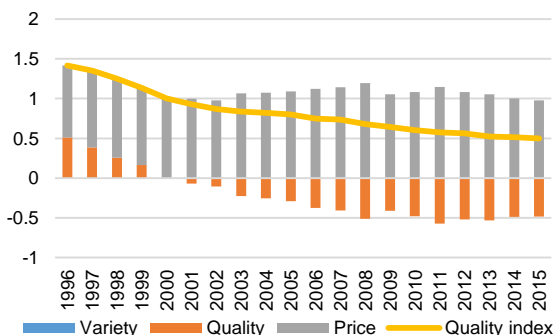
Source: author's computations, COMTRADE

**Poland: Petrochemical sector**



**Figure 7.27: Competitiveness indices**

Source: author's computations, COMTRADE

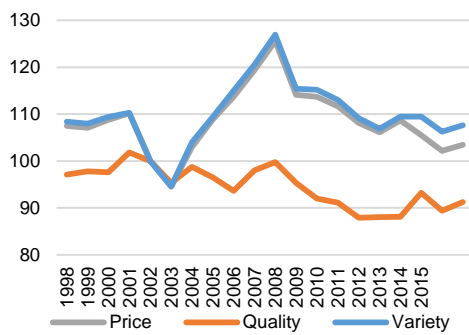


**Figure 7.28: Quality index decomposition**

Source: author's computations, COMTRADE

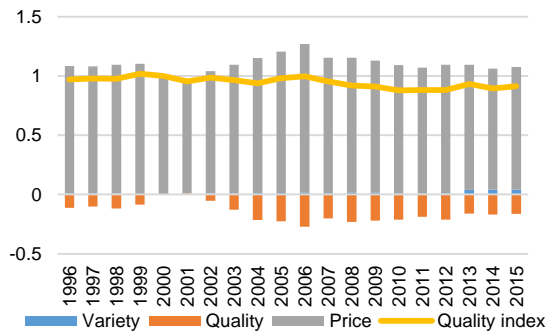
These vast quality improvements could be also attributed to relative improvements to its Western European peers due to the wave of investments after partial or full privatization of the state-controlled and lower quality base. Refining quality improvements in Poland and the Czech Republic indicate producers' ability to export to Western markets, while enjoying lower operational costs.

**Hungary: Refining sector**



**Figure 7.29: Competitiveness indices**

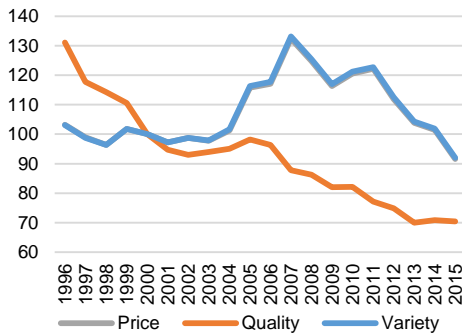
Source: author's computations, COMTRADE



**Figure 7.30: Quality index decomposition**

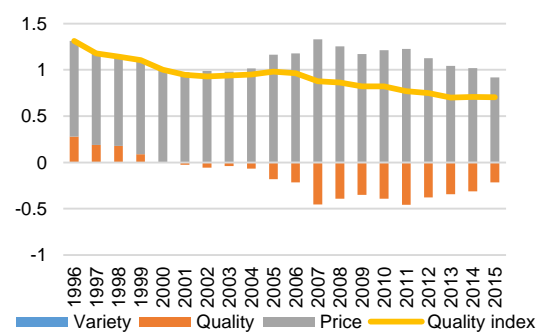
Source: author's computations, COMTRADE

**Hungary: Petrochemical sector**



**Figure 7.31: Competitiveness indices**

Source: author's computations, COMTRADE



**Figure 7.32: Quality index decomposition**

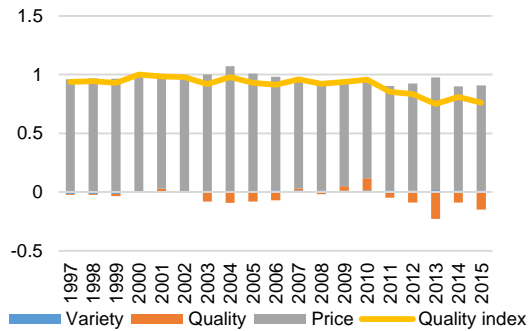
Source: author's computations, COMTRADE

**Slovakia: Refining sector**



**Figure 7.33: Competitiveness indices**

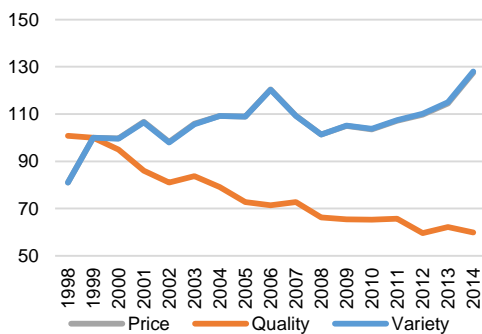
Source: author’s computations, COMTRADE



**Figure 7.34: Quality index decomposition**

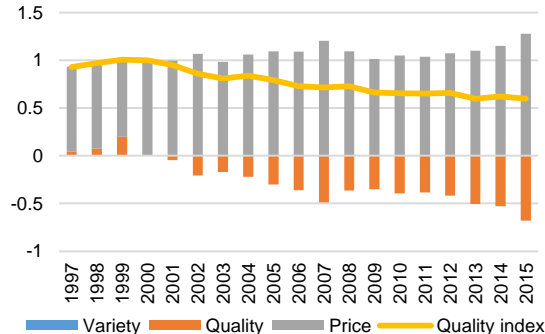
Source: author’s computations, COMTRADE

**Slovakia: Petrochemical sector**



**Figure 7.35: Competitiveness indices**

Source: author’s computations, COMTRADE



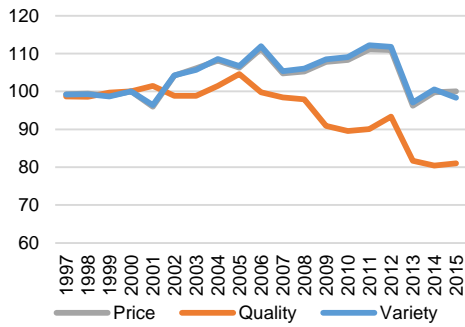
**Figure 7.36: Quality index decomposition**

Source: author’s computations, COMTRADE

### 7.3 Russia

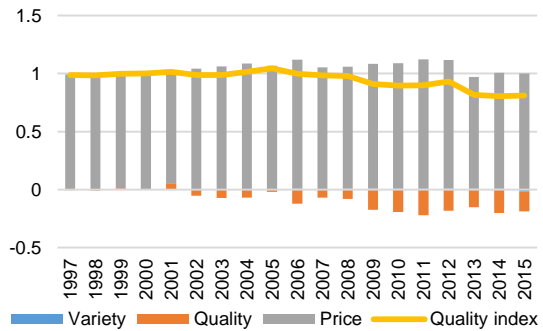
Russia’s quality of refining products has increased significantly over the sample period (Figure 7.37), while petrochemical segment shows only moderate quality improvements (Figure 7.40). Although the quality improvements in refining were expected, we would have expected much higher improvements in petrochemicals as well. We assume that Russian petrochemical producers have not started to export sufficient quantities of high-quality products to Europe by 2015 and the impact is yet to come.

**Russia: Refining sector**



**Figure 7.37: Competitiveness indices**

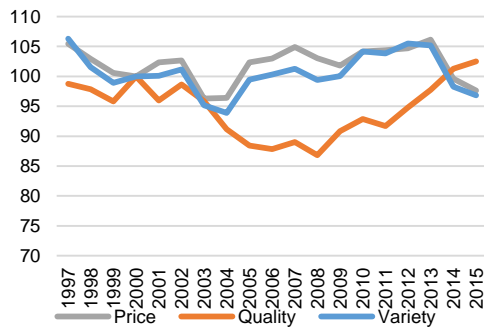
Source: author’s computations, COMTRADE



**Figure 7.38: Quality index decomposition**

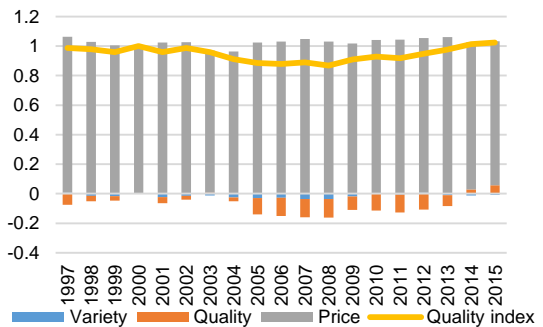
Source: author’s computations, COMTRADE

**Russia: Petrochemical sector**



**Figure 7.39: Competitiveness indices**

Source: author’s computations, COMTRADE



**Figure 7.40: Quality index decomposition**

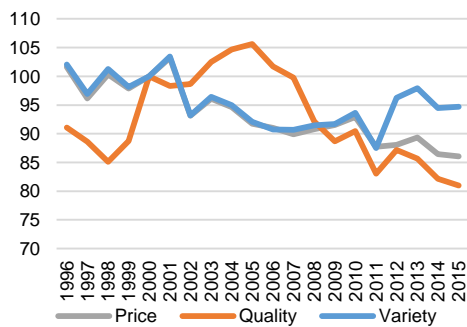
Source: author’s computations, COMTRADE

We expect similar developments in the Caspian region. With the domestic demand decreasing due to unfavourable GDP growth, we would expect Russian exports to Europe to increase much more in past three years. The price-competitiveness gains since 2014 might be attributed to both weakening rouble and export prices reflection due to the oversupply of Russian products in the export markets. Thus, we assume that the effect of ongoing refining and petrochemical investments to capture more of the value chain are therefore yet to come and will have a considerable, negative impact on its CEE competitors’ profitability.

## 7.4 USA

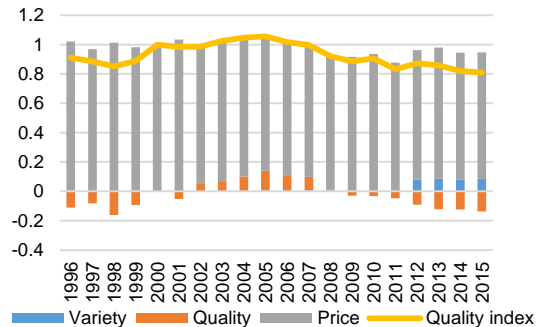
While USA’s refining quality shows substantial improvements following the crises (Figure 7.42), the effect of new wave of investments into ethane plants is not yet seen in the petrochemical segment exports (Figure 7.44), as the quality factor remains negative throughout the entire sample period. A small increase in petrochemical quality is observed in 2015. Refining price competitiveness improves moderately over the period, but a massive price competitiveness worsening, on the back of strengthening dollar, is seen in petrochemicals following the crises. This could be attributed to USA increasing reliance on imported naphtha-based petrochemical semi-products due to increase in ethane production, while leaving the naphtha cracking, gradually. Although the petrochemical quality effects slowly turn into positive territory in the last years of the sample, the effect on price competitiveness worsening, on the back of increasing dollar, has much larger effect on the final quality index curve. We expect the petrochemical quality trend to improve much faster in past two and then in future years and overcome potentially even stronger appreciation of USD. That would have a sizable effect on both the Western European and CEE markets.

**USA: Refining sector**



**Figure 7.41: Competitiveness indices**

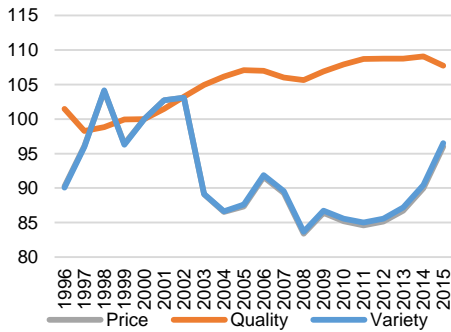
Source: author’s computations, COMTRADE



**Figure 7.42: Quality index decomposition**

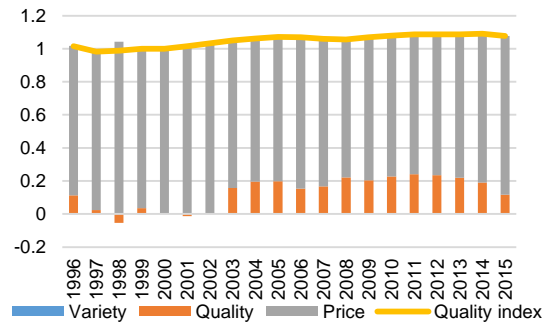
Source: author’s computations, COMTRADE

**USA: Petrochemical sector**



**Figure 7.43: Competitiveness indices**

Source: author’s computations, COMTRADE



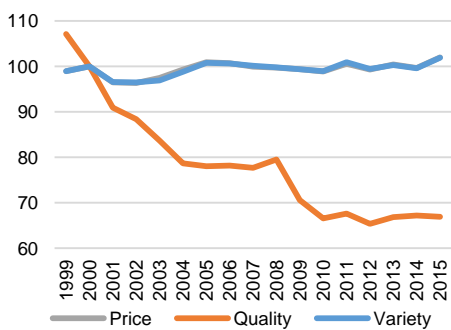
**Figure 7.44: Quality index decomposition**

Source: author’s computations, COMTRADE

## 7.5 Saudi Arabia

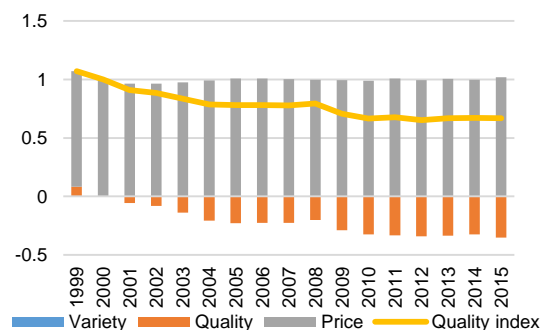
Saudi Arabia shows substantial improvements in petrochemical quality while price competitiveness stays at the same level with little decrease in price competitiveness on the back of strengthening dollar (riyal fixed to USD for the entire sample period).

**Saudi Arabia: Petrochemical sector**



**Figure 7.45: Competitiveness indices**

Source: author’s computations, COMTRADE



**Figure 7.46: Quality index decomposition**

Source: author’s computations, COMTRADE

In Figure 7.46, the quality improvements since the start of large petrochemical investments in 2000s are the main factor behind the decrease in the quality index. Given that most of the petrochemical plants are export-oriented, we shall only expect increase in high-quality exports of relatively cheap Saudi products, creating sizable downward pressure on petrochemical margins in Europe. Some of the largest investments were halted or rescheduled due to the crude oil prices decrease since 2014, still, petrochemicals only benefit from low crude oil prices and increased pressure on European producers is inevitable. Both price and non-price refining competitiveness

do not change significantly over the forecasted period. the quality effect is moderately positive.

## 7.6 China

China has managed to slowly increase its refining competitiveness, mainly on the back of improving price-competitiveness (Figure 7.48), but the index should be taken with some degree of caution, as the exported volumes are very low compared to China’s consumption size and most of the refining and petrochemical products are imported or consumed domestically. That said, China’s improving product portfolio is a main game changer on global scale. Similar developments are observed in India.

### China: Refining sector

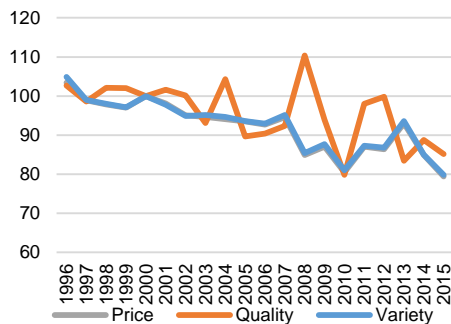


Figure 7.47: Competitiveness indices

Source: author’s computations, COMTRADE

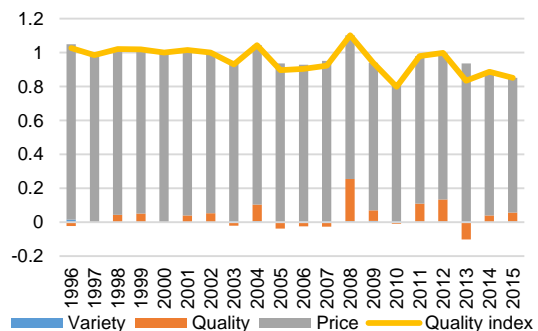


Figure 7.48: Quality index decomposition

Source: author’s computations, COMTRADE

### China: Petrochemical sector



Figure 7.49: Competitiveness indices

Source: author’s computations, COMTRADE

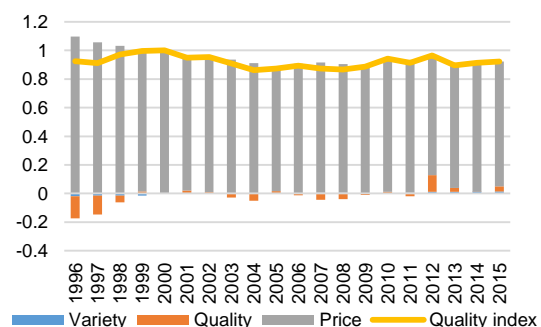


Figure 7.50: Quality index decomposition

Source: author’s computations, COMTRADE

## 8 Conclusion

Price competitiveness and its measures, such as REER or relative market shares, are often favoured over non-price competitiveness factors, such as quality, which can lead to incorrect evaluation of a country's competitiveness and economic performance as a whole. We choose the index developed by Benkovskis and Wörz (2016) to capture changes in both price and non-price competitiveness of the oil downstream market. Firstly, we replicate their work to test the reliability of the index on updated UN COMTRADE data. Secondly, we add four more years and compute the index for all countries available in the database for future research. Our results are very close to the published findings by the authors in past decade. Findings of additional four years capture several crucial changes in both price and non-price competitiveness. We use the UN COMTRADE dataset on a six-digit level of the Harmonized system, starting in 1996. In our own analysis of oil downstream sector, we further decompose the index and show importance of both price and non-price factors.

This thesis highlights importance of product quality developments in changing European oil downstream sector. The highly competitive European oil product market suffers from chronic oversupply, product prices converge, and quality plays a crucial role as a competitiveness factor. While price competitiveness remains an important factor in successful sale of a product, the improving product quality in countries that have undertaken massive investments and achieved higher integration between low-margin refining and more profitable petrochemical and chemical segments, already transcends into financial performance.

Following investments into export-oriented refining and petrochemical plants to capture more of the value chain in oil producing countries, quality improvements in the export portfolio are observed, putting downward pressure on Europe's producers in a form of a high-quality product supply. Moreover, developing countries such as China or India have built their own plants to satisfy most of the domestic demand, changing the trade flows of oil products on global scale.

We observe profound improvements in product quality in CEE petrochemical sector. We attribute these improvements to market consolidation that followed after privatization of state assets, increasing integration of oil downstream segments, and sizable investments in the region. Although the price competitiveness has not improved in most of the countries, on the back of strengthening of the local currencies, we believe



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the quality improvements will play a crucial role in the upcoming years, given the oversupply of oil products in the region, high competition, and expected decrease of ethane-naphtha spread, which inversely follows growth of crude oil prices. In price competitiveness terms, the local producers will to some extent continue benefitting from discounted Urals crude and higher inland premiums, opposed to their Western European peers which are directly exposed to increasing imports from the Middle East and USA.

Overall, the index shows significant losses in non-price competitiveness of petrochemicals in Western Europe, confirming our original hypotheses. These findings indicate uncertain future of oil downstream in Western Europe as the petrochemical segment is frequently the profitability generator, being integrated with loss-making or low margin refineries. There are some improvements observed in petrochemical price competitiveness in the euro zone countries, which we attribute to the weakening euro vs. dollar.

The refining segment in Western Europe performs slightly better in terms of quality changes, which we explain by the ongoing refining closures of obsolete plants and decreasing capacities. Petrochemical producers in Belgium perform better in terms of quality. The quality effect, however, has diminished over the past decade. Germany shows persistence in both refining and petrochemical segments, but mainly due to increased price competitiveness. The product quality is decreasing as well. Although the petrochemicals quality does not show significant worsening in the Netherlands, we would expect local petrochemical market to perform as in case of Belgium, which has shown quality improvements over the entire period, given the recent investments, high integration, and advanced infrastructure in both countries. We expect the relative quality to decline in future, given the lack of investments of Western Europe producers and their direct exposure to the rising imports of high-quality and price-competitive products from USA, the Gulf and CEE.

To our surprise, we observe only limited improvements in quality of Russia's petrochemical product exports. The refining segment shows increases in quality, as expected. We assume that Russian petrochemical producers have not started exporting sufficient quantities of high-quality products to Europe by 2015 and the impact is yet to come. We expect similar developments in the Caspian region. The ongoing refining and petrochemical investments to capture more of the value chain in the area will considerably impact profitability of CEE competitors in the upcoming years.

Saudi Arabia shows substantial improvements in petrochemical quality, while price competitiveness stays at the same level. Thus, we assume that the quality

improvements since the start of large petrochemical investments are the main driver of the decrease of the index. Given that most of the petrochemical plants are export-oriented, we shall only observe increases in high-quality exports of relatively cheap Saudi products, increasing pressure on petrochemical margins in Europe. The effect is still limited due to suspension of a number of projects following the crude oil prices drop since 2015.

While USA's refining quality shows substantial improvements following the crises, the quality impact of new shale gas exploration is not seen yet in the petrochemical segment and remains negative. Refining price competitiveness improves moderately over the period, but a massive price competitiveness worsening is seen in petrochemicals following the crises. This could be attributed to USA increasing reliance on naphtha-based petrochemical semi-products due to increase in ethane production while gradually abandoning the naphtha cracking. Although the quality effects slowly turn into positive territory, the impact of price competitiveness worsening, on the back of strengthening dollar, has had a decisive effect on the final index curve. We expect the petrochemical quality trend to improve much faster in the upcoming years with potential to overcome effects of even stronger appreciation of dollar. That would have a sizable, negative effect on the entire European oil downstream.

Although recent drop in oil price has had a profound impact on increasing ethane-naphtha spread, which supported profitability of many European naphtha-based petrochemical producers that in an attempt to capture the short-lived profits postponed long-awaited investments, we see clearly that with the gradually increasing crude oil prices, the European oil downstream companies will have to undertake massive investments and configuration changes to become competitive again on global scale if the industry is to survive, both in the West and the East. More closures of smaller plants are expected due to oversupply, the slowdown in the oil demand in Europe, and increasing imports from the Middle East, USA, and Russia.

We find the changing quality patterns in Europe and in other markets as crucial factors of survival in the oversupplied European downstream market. While the CEE market benefits from recent investments, improved product quality and higher demand, the Western European market faces darker future, given the gradual fall in product quality and limited options in price competitiveness. CEE downstream will, however, face increased imports of high-quality products from Russia and the Caspian region in future, as the effect of recent investments there is yet to come.

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# Appendix A

Please contact the author for the empirical data and the source codes.