MACRO-LEVEL EFFICIENCY OF THE EU NATIONAL QUALITY INFRASTRUCTURE BY DATA ENVELOPMENT ANALYSIS ASSESSMENT

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Abstract

National Quality Infrastructure (NQI) incorporating standardization, accreditation and metrology is vital for each economy as it provides tools which prove that products and services meet specified requirements that can be recognized both on national and international levels. Existing literature confirms that NQI is not only crucial for enterprises enabling them access both to national and international markets and consumers but it has a positive impact on productivity, international trade, innovation and competition as well. This article highlights that this positive impact is achieved through decrease in transaction costs that may be regarded as a transmission mechanism. Relying on existing literature the research provides a much needed examination of NQI relative performance of 25 European Union member states concerning transformation of NQI components (inputs) into macroeconomic variables (outputs) with Data Envelopment Analysis. Differentiation of technical efficiency among the EU member states is the main research implication providing a starting point for further investigation of NQI differences in the EU member states. In terms of practical implications the paper gives hints how performance of NQI in inefficient states could be improved.

Keywords: National Quality Infrastructure, standardization, accreditation, metrology, transaction costs, Data Envelopment Analysis

JEL Classification: C67, M11, O11, O33, O38

1. Introduction

Quality infrastructure (QI) is depicted as "a system of activities which jointly ensure that products and processes meet predefined specifications. It aims at providing technical support to companies so they can improve their production processes and at ensuring compliance with

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regulations or international requirements" (Gonçalves & Peuckert, 2011). A broader definition explains that QI is "the totality of the policy, legal, regulatory, administrative frameworks and the institutional arrangements (public and/or private) required to establish and implement Standardization, Metrology (scientific, industrial and legal), Accreditation and conformity assessment services (inspection, testing and product or system certification) necessary to provide acceptable evidence that products and services meet defined requirements, demanded either by authorities (e.g. in the case of technical regulation) or the marketplace (e.g. contractually or inferred)" (Kellermann & Keller, 2014). There are different approaches to national quality infrastructure (NQI) building blocks (for comparisons see: Frota et al. 2010; Guasch et al. 2007; ISO & UNIDO 2009). In this paper Sanetra's, Marbán's (2007) approach to NQI is employed which covers Standardization, Metrology, Testing and Quality Management which comprising Certification and Accreditation.

In general research on the impact assessment of NQI is carried out on macroeconomic, sector and firm levels. It is dominated by investigation of single components of NQI, especially standardization. Comprehensive studies of the whole NQI system are rare. Concerning methodology, scholars employ pure descriptive methods in form of case studies based on reports and interviews. Statistical and econometric analyses are also performed on the grounds of correlation, regression and growth models. This analysis is based on Data Envelopment Analysis (DEA) evaluating NQIs macroeconomic efficiency of 25 EU member states.

2. Model of NQI influence on economy

There are numerous functions performed by subsequent elements of NQI. All have impact on macroeconomic performance through reduction of transaction costs appearing when goods and services are exchanged (there are still difficulties to define transaction costs, see: Wang, 2003; Coase, 1961; Stavins, 1995; Williamson, 1985). Reduction of transaction costs is claimed to be the main channel transforming functions of NQI into positive macroeconomic outcomes: increase in productivity, volume of international trade, competition and innovation activity. A model of NQI influence on economy is presented in figure 1.

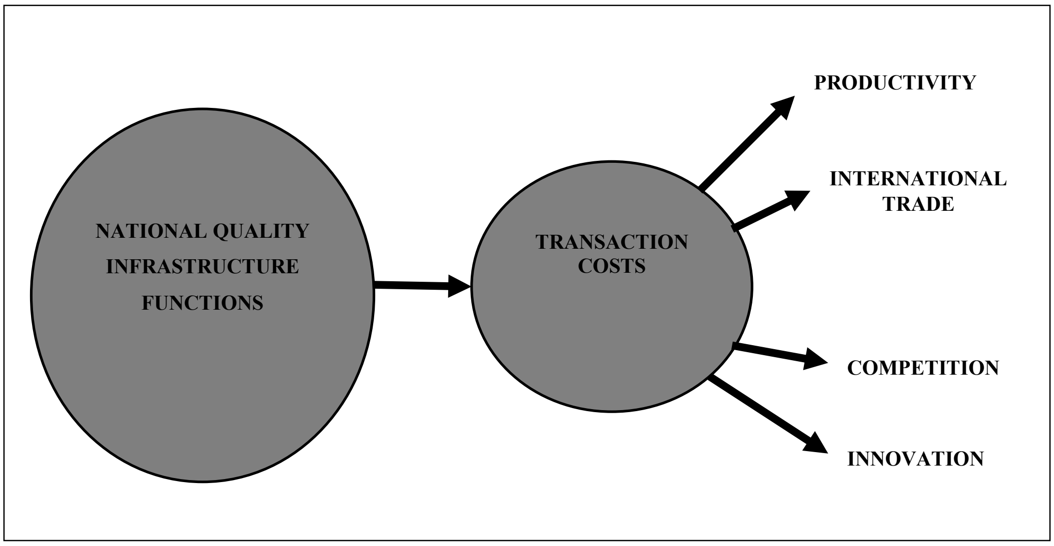

Fig. 1. Impact of National Quality Infrastructure on economy

Source: own work.

Transaction costs are related to the costs of acquiring information. Due to information asymmetries buyers experience difficulties in ascertaining attributes of goods and services. Therefore buyers seek for information which is costly. Moreover in case when buyers are not able to assess the quality "bad-quality" providers can enter the market and drive out the "good quality" providers (Nayyar, 1990). Standards, accreditation related to certification and other parts of NQI can serve as a remedy to information asymmetry problem. They make information less asymmetric and less incomplete, reduce search and information costs as well as bargaining costs thus contributing to curtailing the transaction costs.

All components of NQI, especially standards, accreditation and metrology contribute to trust building what is notably important as far as international trade or innovations are concerned. Trust can be defined as "one party's confidence that the other party in the exchange relationship will not exploit its vulnerabilities" (Dyer & Chu, 2003). Bromiley and Cummings (1995) claim that trust reduces transaction costs. According to them more trust reduces the costs of the control systems. Beccerra and Gupta (1999) acknowledge that trust minimizes agency and transaction costs especially within an organization. First of all transactors will spend less time on ex ante contracting because they are confident that payoffs will be fairly divided. Trust lowers as well monitoring and enforcement costs. Trading partners will spend less time and resources to ensure that agreements are fulfilled. Trust will also reduce the amount of time and resources needed to solve problems that may appear in course of transacting. The supplier who trusts the buyer will be more willing to share confidential information, such as on production costs or on product design and process innovations. Finally, a buyer with a "truth worthy" reputation in exchange relationships should have lower transaction costs, which in turn should translate into better profit performance.

3. Methodology and data description

Choi et al. (2014) note that currently there is no systematic mechanism to measure performance of a national standards system covering testing, certification, accreditation and metrology. Empirical research on the field can be divided into two streams: qualitative (see: Frenz & Lambert, 2012; Guasch et al., 2007) and quantitative (see DIN, 2000; Blind et al., 2011; AFNOR, 2009; DTI, 2005; Haimowitz & Warren, 2007; Frenz & Lambert, 2013; Sampaio et al., 2009; Gerundino & Weissinger, 2011, 2012; Choi et al., 2014). Correlations between QI and economic performance measures (exportation, innovation, competitiveness and income) to evaluate NQI efficiency in 53 countries was carried out by Harmes-Liedtke and Oteiza Di Matteo (2011). This is a background for this study investigating in more details mechanisms beyond revealed correlations.

This study offers measurement of the NQI performance with DEA basing on the model outlined above which assumes that NQI through reduction of transaction costs has a positive impact on productivity, international trade, competition and innovation. DEA is a non-parametric frontier methodology developed by Charnes et al. (1978). A detailed description of DEA and its application can be found in Coelli et al., 2005; da Cruz & Marques, 2014; Golany & Roll, 1989; Cooper et al., 2011; Chien & Hu, 2007; Tong, 1997; Cook et al., 2014.

In this paper technical efficiency will be analyzed. Technical output efficiency reflects the extent to which the output levels of the DMU (decision making unit) concerned can be raised through improved performance and no additional resource while maintaining its output mix. Technical input efficiency illustrates the extent to which the input levels of the DMU concerned can be lowered through improved performance and no output reduction while maintaining its input mix (Thanassoulis, 2001). In this study 25 EU member states will be analysed, the smallest member states: Cyprus, Luxembourg and Malta were excluded as being not homogenous with bigger member states. As there is no justification for constant returns to scale model (CRS), the variable returns to scale model (VRS) will be developed. As proposed input variables illustrate the characteristics of NQI, output oriented VRS model will be applied in the analysis.

Input variables selected for the DEA model represent activities of national bodies involved in NQI. Standardization activities are coordinated by national standardization bodies which are involved in works of international bodies like ISO. ISO is an independent, non-governmental organization made up of members from the national standards bodies of 165 countries. ISO standards are developed by groups of experts, within technical committees (TCs). TCs are made up of representatives of industry, NGOs, governments and other stakeholders, who are put forward by ISO’s members. Each TC deals with a different subject. Number of TCs in which particular countries participate may be a proxy of national standardization bodies activities in terms of standards’ development. Activities of national metrology institutions are very difficult to grasp. Poposki et al. (2009) claim that the number of CMCs (calibration and measurement capabilities) could be used as a proxy for the public spending for the provision of the publicly financed national measurement standards. As far as accreditation is concerned most countries have a single national accreditation body issuing accreditation which recognizes that an organization or a person is competent to carry out specific tasks. A greater number of accredited bodies, the more active accreditation body is. All input variables: participation in ISO TCs, number of CMCs and a number of accredited bodies are presented in a form of indices which takes into account the size of economies represented by GDP.

Output variables comprise measures related to these areas of economy that according to the model are affected by the NQI. Productivity of national economies is measured by capital productivity. Exports which is influenced by standards shows importance of international trade for particular EU countries’ economies. Performance regarding innovation is covered by turnover of new or significantly improved products, either new to the firm or new to the market. The indicator captures both the creation of state of-the-art technologies (new to market products) and the diffusion of these technologies (new to firm products). Competition is not included into analysis due to difficulties in finding an appropriate measure and a small number of DMUs that does not permit for larger number of variables.

If it is possible the time lag between input and outputs is respected. Most recent data that are available were selected. A detailed presentation of input and output variables is covered in table 1.

Table 1. Input and output indicators for DEA analysis

Indicator name	Description	Source
INPUT VARIABLES		
TC	Number of ISO Technical Committees in which a National Standardization body participates per1 bln GDP, current situation	ISO
TAB	Number of total accredited bodies per 1 bln GDP, 2010 or current situation	Harmes-Liedtke and Oteiza Di Matteo (2011); own calculations for Estonia, Latvia, Lithuenia, and Slovenia
CMC	Total number of Calibration and Measurement Capabilities per 1 bln GDP, 2010	BIPM and own calculations
OUTPUT VARIABLES		
Productivity	Gross domestic product at 2010 market prices per unit of net capital stock :- Capital productivity (AVGDK), 2012	AMECO database, European Commission, DG Economic and Financial Affaires
Innovations	Sales of new-to-market and new-to-firm innovations as % of turnover	Innovation Union Scoreboard 2014
Exports	Exports of goods and services as a percentage of GDP, 2013 or most recent year available	Global Competitiveness Report 2014-2015

Source: own work.

4. Results and discussion

Table 2 presents output efficiency of 25 EU member states under assumption of variable returns to scale. 16 member states are technically efficient and together they define the best practice or efficient frontier. The remaining countries have the score bigger than 1 which means that they are technically inefficient.

Table 2. Output efficiency scores under VRS

DMU	Score	Benchmark (Lambda)	Times as a benchmark for another DMU
Italy	1	Italy (1.000000)	1
Belgium	1	Belgium (1.000000)	6
Denmark	1	Denmark (1.000000)	6
Estonia	1	Estonia (1.000000)	0
France	1	France (1.000000)	0

Germany	1	Germany (1.000000)	0
Greece	1	Greece (1.000000)	0
Ireland	1	Ireland (1.000000)	0
United Kingdom	1	United Kingdom (1.000000)	0
Latvia	1	Latvia (1.000000)	3
Lithuania	1	Lithuania (1.000000)	3
Netherlands	1	Netherlands (1.000000)	0
Poland	1	Poland (1.000000)	1
Romania	1	Romania (1.000000)	1
Slovakia	1	Slovakia (1.000000)	8
Spain	1	Spain (1.000000)	5
Hungary	1.035066	Belgium (0.460088); Denmark (0.037720); Lithuania (0.137506); Slovakia (0.364686)	0
Czech Republic	1.071919	Belgium (0.409666); Slovakia (0.520834); Spain (0.069499)	0
Finland	1.07981	Denmark (0.622147); Slovakia (0.048431); Spain (0.329423)	0
Slovenia	1.114148	Belgium (0.609163); Latvia (0.225381); Slovakia (0.154209); Spain (0.011248)	0
Croatia	1.159201	Denmark (0.218218); Lithuania (0.003698); Poland (0.390018); Romania (0.346341); Slovakia (0.041725)	0
Austria	1.206082	Belgium (0.394558); Denmark (0.260734); Italy (0.244051); Spain (0.100657)	0
Portugal	1.237001	Denmark (0.019138); Latvia (0.090355); Slovakia (0.243552); Spain (0.646955)	0
Bulgaria	1.427625	Belgium (0.118926); Slovakia (0.881074)	0
Sweden	1.604433	Belgium (0.212144); Denmark (0.662371); Latvia (0.043224); Lithuania (0.069507); Slovakia (0.012754)	0

Source: own work.

To discriminate 16 efficient EU member states methodology applied by Kumar and Gulati (2008) was employed. For discrimination purpose the frequency in the “benchmark set” is used. The frequency which an efficient country shows up in the benchmark set of inefficient countries represents the extent of robustness of that country relative to other efficient country. It is an indication of exemplary operating practices. Efficient countries that appear seldom as a benchmark are likely to possess very uncommon input/output mix. Efficient country with zero frequency in the benchmark set is termed as "efficient by default" because it does not have characteristics which must be followed by other inefficient countries (Kumar & Gulati, 2008). Table 3 illustrates discrimination of efficient EU member states.

Table 3. Discrimination of efficient EU member states

Highly robust countries	Marginally robust countries
Slovakia (8) Spain (5) Belgium (6) Denmark (6)	Latvia (3) Lithuania (3) Italy (1) Poland (1) Romania (1) Estonia (0) France (0) Germany (0) Greece (0) Ireland (0) United Kingdom (0)

Source: own work.

Slovakia, Spain, Belgium and Denmark may be regarded as global leaders of the EU. There are 6 countries (Estonia, France, Germany, Greece, Ireland and the United Kingdom) which may be regarded as "efficient by default".

5. Conclusion

Existing literature proves that there is a link between NQI and macroeconomic performance. Through a reduction in transaction costs which are the main transmission channel, development and smooth functioning of NQIs contribute to an increase in macroeconomic performance grasped by productivity, international trade, innovation and competition that ultimately enhance economic growth. Based on this finding, relative efficiency of NQIs 25 EU member states was evaluated with DEA.

DEA analysis reveals that on average EU NQIs are efficient, more precisely 16 out of the 25 countries are technically efficient under the VRS output oriented model. 9 countries are inefficient with the scores ranging from 1.04 to 1.6. There are areas for improvement in these countries: adjustment of their overall output levels and adjustment of levels of particular inputs and outputs that enable them to achieve efficiency.

Although the number of efficient countries seems to be high, discrimination analysis shows that only four: Slovakia, Spain, Belgium and Denmark are highly robust while 6 (Estonia, France, Germany, Greece, Ireland and the United Kingdom) are “efficient by default” which means that they are not benchmarks for another EU member states.

The following lessons may be learned from the study:

- deeper investigation of Slovak, Spanish, Belgian and Danish NQIs should be carried out in order to identify best practices allowing these countries to serve as benchmarks for a relatively large number of inefficient countries,
- incorporation of best practices by member states with worse performing NQIs would contribute to supporting their economies in terms of increase in productivity, international trade, innovation and competition,
- as QI may be regarded as a public good, a strategic national policy on NQI is essential for a faster adoption of new standards, new technologies as well as a better protection of intellectual property rights.

One should however remember that the results obtained in this analysis should be treated with caution. First, the proposed DEA model should be possibly verified and checked against alternative variable measures. Second, it would be very difficult to formulate policy detailed recommendations for particular countries.

This research supports findings identified in the literature on importance of NQI not only for the business sector but also for the whole economy. Its added value lies in efficiency differentiation among the 25 EU member states and identification of countries whose NQIs should be investigated in a more detailed manner.

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