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Article

Public support for firms in lagging regions—evaluation of innovation subsidy in Slovakia

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Abstract

This article evaluates effectiveness of EU regional policy-promoting innovation and competitiveness aimed at direct support of private companies in less developed EU regions in Slovakia. By using unique set of firm microdata, we test the effectiveness of this measure with panel data fixed estimator within the framework of Cobb–Douglas production function. We found positive and significant impact on labour productivity that disappears shortly after 1 year following subsidy allocation. By specifying the optimal amount of aid, we find that majority of supported firms could benefit from bigger subsidy size, thus justifying a call for 'more music for more money' policy.

Key words: regional policy; impact study; innovation support; fixed effects panel model.

1. Introduction

Assessment of socio-economic impact of public funds belongs to highly debated issues on political scene as publicly shared resources should be allocated transparently, spent efficiently and used effectively.

Evaluation studies exploring effects of European Union (EU) support in EU lagging regions (Rodríguez-Pose and Fratesi 2004; Stefanik 2014; Radvansky et al. 2016) should stand at the forefront of this literature as their outcomes might strongly differ to those applied on developed ones. Despite the huge financial support allocated to these territories, impact of subsidies materializes only to a limited extent, having many times even zero effects (Rodríguez-Pose and Fratesi 2004). When implementing subsidies in less developed territories, specific problems may occur such as the corruption, 'cathedral in the desert' issue or question of undersized assistance for development (Beugelsdijk, and Eijffinger 2005; Ederveen et al. 2006; Bachtler and Gorzelak 2007; Bahr 2008) that could strongly influence the results of innovation policy interventions. The same is true for the support of research and development activities in private companies where the key drivers of current development are the EU cohesion funds. Innovation support, research, and development assistance along with promotion of entrepreneurship among small and medium enterprises represent a dominant part of the overall support, therefore the assessment of their effects is essential (Czarnitzki and Kraft 2006; Reinkowski et al. 2010; Bondonio and Greenbaum 2014; Cerqua and Pellegrini 2014; Huergo et al. 2015; Radvansky et al. 2016).

Slovakia is one of the countries where cohesion funds from the EU constitute the overwhelming majority of support resources for development. This aid makes up to 80 per cent of total development funds that flow overwhelmingly to three less developed NUTS 2 regions of Western, Central, and Eastern Slovakia. Slovakia may be used as a specific case to conduct impact assessment studies of such a support since major portion of investments in the country are explicitly dependent on EU funds. This is apparent from the fact that planned value of allocated EU funds for the current seven-year cycle 2014–20 (15.3 billion euros) almost coincides with the annual state budget expenditures in Slovakia (15.5 billion euros in 2014).

Slovakia is also interesting for analysis for other few reasons. As a country, it only exists a little more than a quarter of a century, and at first it was a relatively backward and poorly industrialized country. Entry into the EU and FDI inflows then caused the country to grow rapidly especially in industrial production. As a result, the country has achieved strong economic growth but most innovation indicators (e.g. research spending or number of new patents) have improved very slowly, and are well below average in the EU. Stronger presence of international firms located in the domestic market (FDI inflows) as well as exposure towards foreign competition forces domestically owned firms to find new ways how to improve their competitiveness. The EU subsidy aiming at small and medium enterprises with preference towards domestically owned firms may thus represent a helpful tool to fulfil the need to innovate either as a consequence of tougher competition or as a way for domestic firms to satisfy requirements of their foreign-owned business partners in Slovakia.

The main contribution of this article is twofold. First, we assess impact of EU regional policy promoting innovation and competitiveness in small and medium enterprises in conditions of less developed regions in Slovakia. Secondly, by employing unique nonlinear approach to deliver estimates of optimal threshold for public policy financial assistance, we assess effectiveness of public policy in monetary terms, a unique approach among these types of studies.

Our dataset consists of firms that applied, both successfully or not, for innovation and competitiveness support, and technology transfers assistance under the EU regional policy framework during programming period 2007–13. This unique, highly detailed micro dataset enables us to undertake an impact evaluation by fixed effects panel model utilizing the concept of Cobb–Douglas production function. We assess impact of this policy by change in the output elasticity of capital with the labour productivity being the indicator of firm performance.

Our results confirm presence of positive effects of the subsidy on selected indicators of capital utilization, although only in the very short horizon. Additionally, the optimum threshold for financial support per one project supported is estimated around 2 mil. EUR; an amount much bigger than the average size of a subsidy in our sample. Taking into account the distribution of overall subsidy value across companies, while the 'more music for more money' policy might be recommended, at first sight, the quickly dissipating effects of public policy might ask for a caution when setting new standards for current wave of EU regional policy calls in the programming period of 2014–20.

This article is structured as follows. In Section 2, we provide an overview of relevant empirical literature. Section 3 describes methodological approach based on the Cobb–Douglas production function that incorporates nonlinear nature of the public subsidy effectiveness. In the next section, we comment on key results of this study and discuss possible implications for EU regional policy. The last section concludes.

2. Empirical evidence on effectiveness of the EU regional policy

Scientific literature and political practice discuss various impacts of support aimed at improvement of competitiveness of companies (Czarnitzki and Fier 2002; Bartle and Morris 2010; Tokila and Haapanen 2012; Cerqua and Pellegrini 2014; Bondonio and Greenbaum 2014; Huergo et al. 2015) with special attention being paid to innovation and R&D support measures (Czarnitzki and Kraft 2006; Reinkowski et al. 2010; Cappelen et al. 2013; Cin et al. 2014; Bondonio and Greenbaum 2014; Augiar and Gagnepain 2017). However, vast majority of them was oriented on developed countries rather than transition economies.

Among new EU member states, public policy supporting development is most often associated with the auxiliaries of the European Union. This support is complemented with other national, regional and local resources with evidence showing different effects of various types and forms of support (Bondonio and Greenbaum, 2014). The primary objective of this aid is to support convergence processes thus reducing regional disparities with special emphasis on lagging regions that have specific problems and barriers of growth (Rodríguez-Pose and Fratesi 2004). This is particularly true for new member countries (Dzupka and Hudec, 2008; Stefanik, 2014; Radvansky et al. 2016) struggling with the most serious problems of socio-economic development.

Individual evaluation studies revolve around selected issues, themes, and criteria using various types of methods for assessing the effects of regional development support (Bachtler and Wren 2006). Innovation, research, and development are generally considered as key factors of overall socio-economic development; a fact reflected in the huge amount of aid allocated into this area. At present, support of firm competitiveness and innovation promotion belong to frequently discussed topics especially in conditions of less developed and emerging regions (Czarnitzki and Kraft 2006; Bartle and Morris 2010; Reinkowski et al. 2010; Bondonio and Greenbaum 2014; Cerqua and Pellegrini 2014; Cin et al. 2014; Vaz et al. 2014; Augiar and Gagnepain 2017). Call for a more thorough assessment of effectiveness, efficiency and success of various schemes aiming to support investments in R&D, innovation, and human capital reflects importance of above mentioned factors in determining competitiveness of companies that further channels into wider development of regions (Charlot et al. 2015).

Investments into regional development can bring about various effects depending on the regions' level of development and circumstances surrounding these investments (Rehak et al. 2013). On the negative side, a challenge to avoid the 'cathedral in the desert' issue is often present (Hardy 1998). While aid may help to support individual companies, it does not necessarily mean that it will have a positive effect on the entire regional economy. Additionally, 'one size fits all' approach is often misleading as effects of regional policy might vary strongly by level of socio-economic development. Hence, different and relevant philosophy of promoting innovation needs to be implemented while accepting particularities of each region and depending on specific regional conditions (Todtling and Trippl 2005). Place-based approach recognizes the call for differentiated support of regional development (Barca 2009).

Individual evaluation studies examining effects of support for companies on macro-level (Leonardi 2006), are accompanied by micro-studies (Reinkowski et al. 2010). Support for firms to increase their innovation activities and competitiveness should have in general positive impact in terms of stated objectives of policy measures (Reinkowski et al. 2010), but some studies deliver not significant, zero or even negative effects of public interventions. The impact can yet be reported briefly up to run, but few measures cause mid-term positive response and only rarely have long-term effects on supported entities (Rodríguez-Pose and Fratesi 2004).

The evidence confirms that there exists an optimal threshold limit associated with positive effects of investment into socio-economic development (Duch-Brown et al. 2011). Significance of the amount of support may depend on various factors. Several counterfactual evaluation studies list several determinants of aid effectiveness which distinctly include firm characteristics such as size of the company measured by number of employees (Czarnitzki and Fier, 2002; Reinkowski et al. 2010), ownership, and age of a firm (Duch-Brown et al. 2011).

According to number of empirical studies, amount of aid or support intensity is often critical (Duch-Brown et al. 2011; Bondonio and Greenbaum 2014). Additionally, previous experience with public funding might play an important role in delivering desired positive outcome stemming from a public aid (Huergo et al. 2015). Differences are expected due to type of support measures as well as size effect present assessing national, regional, and other aid schemes (Bondonio and Greenbaum 2014). On top of that, efficiency of public support is highly responsive towards character of the supported projects; large infrastructure projects differ from investments into soft infrastructure, such as improvement in education and human resources projects (Rodríguez-Pose and Fratesi 2004). The actual impact of aid varies from sector to sector with a greater effect achieved in manufacturing industry compared to other sectors, such as services (Huergo et al. 2015). Last but not least, regional and local characteristics ultimately determine success of a project, i.e. the localization matters (Garcia-Mila and McGuire 2001; Czarnitzki and Fier 2002; Pufahl and Weiss 2009).

3. Methodology

Our dataset integrates data on firms applying for a subsidy under the scheme 'Operational Programme Competitiveness and Economic Growth', 1.1. Innovation and Technology Transfers, 1.1.1 Support for Introducing Innovation and Technology Transfer. This measure encapsulates state aid scheme to support introduction of innovative and advanced technologies in industry and services. The key objective of this EU support scheme is to increase competitiveness and spur innovative processes with a particular focus on small and medium businesses.

In general, Slovak firms neither individually report R&D expenditures, nor seem to be highly active in patent applications. Yet, the analysed scheme put an equal emphasis on change in firms' competitiveness as an important outcome of R&D activity. As a matter of fact, firmś innovative practices are expected to be propagated throughout the company and ultimately result in increase in labour productivity and competitiveness, as argued in Peeters and de la Pottserie (2004). On the other hand, firms supported by this scheme may be inclined to use granted money to cover their capital replacement costs related to improvement of stock of physical capital and intangible assets. Again, better utilization of existing or newly accumulated capital is about to improve labour productivity.

Based on this reasoning, we test effectiveness of the analysed EU subsidy using labour productivity as dependent variable (e.g. Brunow and Blien 2015) assuming that the expected outcomes will materialize, ultimately, in improvement of labour productivity leading to higher competitiveness. We use labour productivity as our object of research in accordance with general definition of a firm competitiveness as used by CompNet Task Force and investigated in Brunow and Blien (2015). The CompNet TASK FORCE (2014) defines the competitiveness as the nominal value of sales over number of employees. While acknowledging that positive outcomes of EU subsidy may translate into savings in direct production costs, we hypothesize that the main difference between treated and non-treated firms stems from increase in production activity hence our study focus on competitiveness concept as measured by sales- per-employee rather than of the value-added type.

3.1. Production function and subsidy treatment

As common in this type of literature (Peeters and De La Potterie 2005; Duch et al. 2007; Cin et al. 2014), we use standcard Cobb–Douglas production function to estimate effect of EU subsidy on firm's performance through its effect on total factor productivity and output elasticity of capital. The production function framework might serve as a basis to model growth or productivity of firms (e.g. Hall and Mairesse 1995; Capron and Cincera 1998).

The production function in its general form with elasticity of substitution equalling unity is given by the following:[1]

$$Q_{it} = A_{it} K_{it}^{\beta_1} L_{it}^{\beta_2} \quad [1]$$

where Q_{it} represents the total production, A_{it} the total factor productivity, K_{it} level of capital stock, L_{it} labor input of a firm i at time t, β_1 total output elasticity of capital and β_2 total output elasticity of labor.

The total factor productivity A_{it} can be further decomposed to factors that affect the efficiency of utilization of inputs in productions, such as R&D, technology transfer, and industry and ownership characteristics. The total factor productivity is therefore specified in the following way (Cin et al. 2014):

$$A_{it} = C(R\&D)_{it}^{\beta_3} X_{it}^{\beta_4} \quad [2]$$

where C is a constant term, $R\&D$ are research and development stock, X other factors that can affect utilization of inputs in production and β_3 and β_4 represent respective elasticities.

By the nature of an R&D innovation policy, the subsidy provided to the company is expected to affect the firm's production in two ways. First, the innovation subsidies are expected to spur innovation activity within the subsidized companies that may, in turn, lead to better utilization of already existed, or newly created, physical as well as human capital without any further need to increase stock of capital itself. If, however, the pure accumulation of new R&D stock will not lead to introduction of better practices, the marginal returns from R&D are expected to decrease.

Therefore, the effect of the subsidy in the first case can be modelled as follows:

$$A_{it} = C(R\&D)_{it}^{\beta_3 + \gamma_1 D_{it}} X_{it}^{\beta_4} \quad [3]$$

where γ_1 represents the effect of the subsidy on total factor productivity, D is dummy variable for subsidy given to a firm i at time t and X other factors that can affect utilization of inputs in production.

Combining equations [2] and [3], dividing both sides by labor stock L_{it} and taking logarithms, the labour productivity model is specified as follows:

$$\begin{aligned} \ln(Q_{it}/L_{it}) = {} & \ln(C) + (\beta_3 + \gamma_1 D_{it})\ln(R\&D_{it}) + \beta_1 \ln(K_{it}/L_{it}) \\ & + (\beta_1 + \beta_2 - 1)\ln(L_{it}) + \beta_4 \ln(X_{it}) \end{aligned} \quad [4]$$

Secondly, the innovation subsidy might be expected to affect responsiveness of labour productivity to an increase of capital stock of a company due to investing into purchase of new machinery or other intangible assets. As a result, a company's production becomes more capital-intensive, i.e. increasing the capital-to-labour share. While marginal returns are likely to fall when factor of production is subsidized we hypothesize that replacement of old-fashioned capital with newly employed capital stock may lead to improvement in labour productivity rather than simple increase in total stock of capital.

This effect might be modelled in the following way:

$$Q_{it} = A_{it} K_{it}^{\beta_1 + \gamma_2 D_{it}} L_{it}^{\beta_2} \quad [5]$$

Combining [2] and [5], dividing both sides by labour stock LL_{iii} and taking logarithms, we get the following labour productivity model:

$$\begin{aligned} \ln(Q_{it}/L_{it}) = {} & \ln(C) + \beta_3 \ln(R\&D_{it}) + \beta_1 \ln(K_{it}/L_{it}) + \gamma_2 D_{it} \ln(K_{it}) \\ & + (\beta_1 + \beta_2 - 1)\ln(L_{it}) + \beta_4 \ln(X_{it}) \end{aligned} \quad [6]$$

3.2. Empirical model and identification strategy

There are different approaches adopted in evaluation studies field that include difference-in difference method (Adorno et al. 2007), use of fixed effects (Angrist and Pischke 2008; Brunow and Blien 2015) and instrumental variable estimators (Czarnitzki and Fier 2002), or different regression model design and matching techniques (Pufahl and Weiss 2009). While recognising strengths and weaknesses of aforementioned studies, we decide to opt for fixed effect panel data model from the following reasons.

As acknowledged in most of evaluation studies (see Cin et al. 2017), selection bias might be present due to correlation between unobserved characteristics and subsidy dummy variable referring either to the firm's decision to participate in the program or to the selection process by the government based on past performance (e.g. Klette et al. 2000). In order to tackle this issue, matching techniques and two-stage regressions are usually applied.

However, we advocate that the selection bias is likely to be minimized in our sample. First, by project specification the assessment criteria under this scheme heavily relied on quality of project submitted rather than past or present economic performance and characteristics of a firm applying for a subsidy. Additionally, since our dataset includes only those firms that applied for the subsidy, both successfully or not, firms' decision to participate in a program does not need to be specifically modelled by two-step approach estimating participation equation followed by output regression (e.g. Busom 2000). Thirdly, the possible existence of unobserved individual firm characteristics is expected to be captured by the cross-sectional fixed effects entering all specifications. As part of the robustness checks, the fixed effect estimator is accompanied by the two-step robust Arellano–Bond dynamic panel data model as presented in Roodman (2009a, 2009b) that is well-suited for work with short and wide panel data models (Baltagi 2013). By treating the subsidy dummy as potentially endogenous (i.e. dependent on previous firm's performance) in this setup we address the issue of selection bias.

Lastly, since Slovak only very rarely engage in R&D activities and do not standardly report their R&D expenditures, the missing information on potential differences in R&D stocks, as modelled by $\beta_3 \ln(R\&D_{it})$ term in [4] and [6], is expected to be captured by the firm-specific fixed effect. As part of the robustness check, we test for effect of subsidy approximating the R&D stocks with number of patents. Hence, the effect of a subsidy in [4] is translated into general improvement in total factor productivity (TFP thereinafter) in treated firms without any further investigation of channels of transmission.

To summarize, our modelling strategy include estimation of four specifications varying in inclusion of monetary effects and effects of subsidy on total factor productivity and output elasticity.

First, the subsidy is expected to affect total factor productivity as in [4]. This will imply that subsidized firms were successful in improving the utilization of available or newly developed technology via increase in total factor productivity term in comparison to non-treated firms.

The first empirical model is expressed in the following way:

$$\ln(Q_{it}/L_{it}) = \alpha + \gamma_1 D_{it-1} + \beta_1 \ln(K_{it}/L_{it}) + (\beta_1 + \beta_2 - 1)\ln(L_{it}) + \beta_j X^j_{it} + \mu_i + \theta_t \tau_t + \varepsilon_{it} \quad [7]$$

where D_{it-1} denotes dummy variable for a firm i being treated by subsidy in year $t-1$, X^j_{it} is a set of other explanatory variables, μ_i time-invariant firm-specific characteristics, τ_t time dummy for a year τ, and ε_{it} time varying error distributed independently across firms and independently across of all μ_i.

Secondly, the subsidy is likely to introduce a change in elasticity of labour productivity with respect to total capital stock resulting from improvement of stock of physical capital and intangible assets as well as its higher share in production.

The second empirical model is specified in the following way:

$$\ln(Q_{it}/L_{it}) = \alpha + \gamma_1 \ln(K_{it}) D_{it-1} + \beta_1 \ln(K_{it}/L_{it}) + (\beta_1 + \beta_2 - 1)\ln(L_{it}) + \beta_j X^j_{it} + \mu_i + \theta_t \tau_t + \varepsilon_{it} \quad [8]$$

where D_{it-1} denotes dummy variable for a firm i being treated by subsidy in year $t-1$, K_{it} level of capital stock for a firm i at time t, X^j_{it} is a set of other explanatory variables, μ_i time-invariant firm-specific characteristics, τ_t time dummy for a year τ, and ε_{it} time varying error distributed independently across firms and independently across of all μ_i.

Effect of a subsidy granted in year t affects firm productivity with a lag of one year due to the administrative requirements related to the implementation of a project. The sustainability of a supported project and its long- term effects can be investigating through introduction of higher lags, yet we are limited by data availability.

If a firm specific effect μ_i is correlated with ε_{it} due to the existing link between D_{it-1} and μ_i, then the OLS estimator of the policy parameter γ_1 could produce a simultaneity bias. Since our dataset includes only firms that applied for the subsidy, thus manifesting the so far unobserved innate abilities to innovate, we assume that the simultaneity bias common in these studies is to be reduced. As part of robustness check we also address this issue in the dynamic system GMM setup.

In order to analyse impact of EU subsidy on the labour productivity one should also discuss the optimal size of a subsidy expressed in monetary terms. While overall positive (negative) or insignificant impact of EU subsidy might be captured by the models as in [7] and [8], investigation of optimal level of support expressed in monetary terms might provide a beneficial insight for policy makers when discussing future setup of EU regional policy. Based on the models in [7] and [8], we introduce measurement of EU monetary support taking into account absolute nominal value of the EU subsidy. On top of that we assume that the overall effect is of a non-linear nature achieving maximum effectiveness in its optimum. This nonlinearity in relationship between labour productivity and EU financial support is introduced by inclusion of the squared term of subsidy value. As in the [7], the effect of a subsidy is expected to materialize with one year delay. Hence, the model in [7] is adjusted in the following way:

$$\ln(Q_{it}/L_{it}) = \alpha + \gamma_1 D_{it-1} + \gamma_2 D^2_{it-1} + \beta_1 \ln(K_{it}/L_{it}) + (\beta_1 + \beta_2 - 1)\ln(L_{it}) + \beta_j X^j_{it} + \mu_i + \theta_t \tau_t + \varepsilon_{it} \quad [9]$$

where D_{it-1} denotes value of the EU subsidy to a firm i in year $t-1$, K_{it} level of capital stock for a firm i at time t, X^j_{it} is a set of control variables, μ_i time-invariant firm-specific characteristics, τ_t time dummy for a year τ, and ε_{it} time varying error distributed independently across firms and independently across of all μ_i.

In the similar fashion, the model in [8] is adjusted to account for a non-linear relationship between labour productivity and EU subsidy in the following way:

$$\ln(Q_{it}/L_{it}) = \alpha + \gamma_1 \ln(K_{it}) D_{it-1} + \gamma_2 \ln(K_{it}) D^2_{it-1} + \beta_1 \ln(K_{it}/L_{it}) + (\beta_1 + \beta_2 - 1)\ln(L_{it}) + \beta_j X^j_{it} + \mu_i + \theta_t \tau_t + \varepsilon_{it} \quad [10]$$

where D_{it-1} denotes value of the EU subsidy to a firm i in year $t-1$, K_{it} level of capital stock for a firm i at time t, X^j_{it} is a set of control variables, μ_i time-invariant firm-specific characteristics, τ_t time dummy for a year τ, and ε_{it} time varying error distributed independently across firms and independently across of all μ_i.

As discussed in the previous section, the ε_{it} must fulfill all the standard conditions.

3.3. Selection of control variables

In all relevant models ([7]–[10]) we control for set of exogenous variables. This set represented by the X^j vector includes firm, sector and regional characteristics taken from relevant literature (Peeters and De La Potterie, 2005; Czarnitzki and Kraft 2006; Duch et al. 2007; Sissoko, 2011; Cappelen et al. 2013; Cin et al., 2014).

Time-invariant firm and sectoral characteristics that are commonly used in the relevant literature (e.g., Lalinsky 2013), such as level of technological development of an industry or managerial practices, will be captured by the fixed-effect dummy variable. Similarly, we do not control for spatial regional characteristics as those will be partially integrated into firm-specific fixed effects or captured by other regional characteristics. Type of ownership (Lalinsky 2013) is not included as this particular EU subsidy scheme preferred domestically owned firms over foreign-controlled ones. Additionally, presence of individual fixed- effects will make inclusion of time-invariant characteristics irrelevant. Time dummies capture common trend in year-to-year fluctuations in labour productivity caused by potential macroeconomic or other shocks affecting firm competitiveness.

Size of a firm is approximated by number of employees. The size of a firm is expected to be negatively correlated with productivity of labour (Augiar and Gagnepain 2013; Cin et al. 2014), even though some of the studies report unambiguous (Peeters and De La Potterie 2005) or even a positive link (Duch et al. 2007). Highly capital endowed companies with a bigger market share achieve comparably higher productivity, a finding usually confirmed by various empirical studies (Peeters and De La Potterie, 2005; Augiar and Gagnepain, 2013; Cappelen et al., 2013; Cin et al. 2014).

Investments into human capital affecting total factor productivity are approximated by average employee costs. The only study using Slovak firms' level data (Lalinsky 2013) reports negative coefficient for labour costs. As we follow standard procedure of defining the labour costs as relative measure of labour force quality we expect an increase in overhead educational and training expenses to positively stimulate labour productivity (Cin et al. 2014), thus reporting positive signs in final estimates. Expected positive sign associated with average labor costs also reflects standard feature of the Cobb–Douglas production function and price taking behavior, when optimal product maximizing behaviour implies labour productivity to be positively related to real wage costs.

Maturity of a firm is captured by the age variable measured as years of activity since firm's foundation year. The link between firm's age and productivity often remains unclear and depends on model specification (Cin et al. 2014).

The dominant position of a firm within the sector is approximated by ratio of firm sales to total sales of a sector, in line with the Augiar and Gagnepain (2013). The only time-varying sector characteristics is approximated by total sales per sector selected by the first number of the NACE 2 revised specification. Regional differences are captured by the variables measuring level of unemployment, population living in the nearby area, and level of economic development measured by GDP per capita, and are expected to positively contribute to the labour productivity.

List of other control variables applicable on Slovak conditions, as reported by Lalinsky (2013), include professional managerial practices, foreign management, EU membership, and nature of medium competitive advantage. These features are expected to be captured by time-invariant individual fixed effects in our model.

3.4. Dataset description

The 'Operational Programme Competitiveness and Economic Growth' with its sub-program aiming to increase firms' competitiveness included six calls for grant applications targeted on small and medium enterprises sector in three Slovak regions, except capital city Bratislava. These calls (KaHR-111SP-0801, KaHR-111SP-0902, KaHR-111SP-1001, KaHR-111SP/LSKxP-1101, KaHR-111SP-1101, KaHR-111SP) were announced on yearly basis within the 2008–12 period.

Our dataset gathers information from few sources (Table 1). The primary source for list of submitted applications is provided by the Ministry of Economy of the Slovak Republic. Firm-level data are gathered from the Bureau van Djik Orbis database and missing gaps are filled from the Register of Financial Statements operated by Ministry of Finance of the Slovak Republic active as of 2009 with first data available for year 2008.

Small and medium enterprises from all NUTS 2 regions of Slovakia, except Bratislava region, were eligible to apply under this scheme. The basic characteristics of all firms submitting their applications in all calls are presented in the Tables 2, 3 and 4. As firms were allowed to participate in more than one call, no matter their success in the previous calls, the average monetary treatment is estimated per one firm rather than one project. Few firms in the sample were established during the sample period (16 in 2008, 13 in 2009, and 2 in 2010) and in the very first year of their establishment do not necessary have positive capital stock or initial sales (yet might still get treatment 2 or 3 years after their establishment). We opt to keep them in the sample to capture the life-cycle of a firm that might be potentially affected by a subsidy. As part of the robustness check, we remove zero observation from the sample and results remain very similar.

Per subsidy conditions the small and medium businesses were selected as a priority and the domestically owned firms were preferred over foreign-controlled ones. Out of total firms in the final sample (482), the 81 per cent of all firms in the sample (390) is, by official sources, domestically owned. Altogether, 34 foreign-owned firms and 164 domestically owned received funding.

In total, 304 firms were supported in Central Slovakia region, 302 in the Western NUTS2 region, and in the least developed Eastern Slovakia region 276 companies took part on this scheme. Since only small and medium enterprises were eligible to compete for this state aid, the average company participating in this scheme had little more than 70 employees and was of 11 years age. The average amount of aid per successful project was about 800th EUR.

Regarding the sectoral distribution of aid by the NACE classification, the majority of applicants (585) belonged to the manufacturing sector, 147 companies were from wholesale and retail trade NACE group, followed by the repair of motor vehicles and motorcycles (61) and section of professional, scientific, and technical activities (43).

The original list provided by the Ministry of Finance was adjusted in the following way before used for final estimation in order to increase innate consistency of the sample. All firms located in the Bratislava region were excluded from the sample due to the two reasons: (i) per program conditions only projects with location outside of the Bratislava region are entitled for the EU cohesion support, (ii) as Bratislava, being the capital city of Slovakia, economically strongly outperforms most of the other EU regions, firms located in this regions might face completely different economic conditions than the rest of the sample; a fact that might introduce a bias into our estimations.

Table 1. Data sample characteristics and sources

Specification	Description	Source	Coverage
Treatment	Dummy variable, 1 = treated	Ministry of Economy of the Slovak republic, Slovak Innovation and Energy Agency	2008–13
Monetary effect	Value of subsidy, th. EUR	Ministry of Economy of the Slovak republic, Slovak Innovation and Energy Agency	2008–13
Q	Total sales, th. EUR	Orbis database, Register of Financial Statements Ministry of Finance of the Slovak Republic	2008–13
K	Net book value of fixed assets (tangibles and intangibles), th EUR	Orbis database, Register of Financial Statements Ministry of Finance of the Slovak Republic	2008–13
L	Number of employees by separate groups	Orbis database, Register of Financial Statements Ministry of Finance of the Slovak Republic	2008–13
K*	Amount of fixed tangible and intangible assets, th EUR	Orbis database, Register of Financial Statements Ministry of Finance of the Slovak Republic	2008–13
Cost	Employee costs, th EUR	Orbis database, Register of Financial Statements Ministry of Finance of the Slovak Republic	2008–13
Age	Years of activity since foundation year	Register of Commerce of the Slovak republic	2008–13
Sector dominance	Ratio of firm's sales to total sales in sector of its activity at level 1 by NACE2 rev. classification	Statistical Office of the Slovak republic	2008–13
Total sales in sector	Total sales of the sector at level 1 by NACE2 rev. classification, thEUR	Statistical Office of the Slovak republic	2008–13
Unemployment	Unemployment rate at LAU1 level, %	Statistical Office of the Slovak republic	2008–13
Population	Number of citizens at LAU2 level, %	Statistical Office of the Slovak republic	2008–13
GDP p.c.	GDP p.c. in current prices at NUTS3 level, th EUR	Statistical Office of the Slovak republic	2008–13

Table 2. Dataset characteristics—full sample

Variable	Before cleaning					After cleaning				
	# of obs.	Mean	St. Dev.	Min	Max	# of obs.	Mean	St. Dev.	Min	Max
Sales per employee	4 175	176.68	458.12	−64.04	8 724	3 036	151.96	333.34	0	5 955
# of employees	4 421	71.06	118.66	1	1 500	3 041	88.39	132.98	1	1 500
Cost per employee	4 072	15.07	19.75	0	431.60	3 008	14.97	18.41	0	396.68
Capital intensity	4 177	116.60	484.90	−5.67	10 407	3 039	93.94	449.79	0	10 407
Age (years)	5 372	11.26	5.95	1	41	3 078	11.55	5.82	0	41
Market dominance	4 765	0.0002	0.0009	0	0.0185	3 009	0.0003	0.0010	0	0.0184
Monetary treatment (th. EUR)	5 646	914.39	1 098	0	5 999	3 078	851.32	1 057	0	5 999

Table 3. Statistical properties of treated versus non-treated group of firms (2008)

Variable	Treated					Non-treated				
	# of obs.	Mean	St. Dev.	Min	Max	# of obs.	Mean	St. Dev.	Min	Max
Sales per employee	191	135.89	231.72	0	2 028	266	114.67	209.97	0	2 553
# of employees	192	99.39	138.46	1	750	266	93.67	131.10	1	750
Cost per employee	189	1 120.60	1 748.50	3.56	12 089	261	1 044.80	1 546.40	0.2	14 160
Capital intensity	192	49.96	120.67	0	1 363	266	54.02	257.94	0	3 801
Age (years)	190	9.17	5.12	1	32	262	10.01	5.23	1	36
Market dominance	189	0.026	0.064	0	0.542	264	0.030	0.111	0	1.629

Secondly, our dataset does not include group of sole-proprietors due to high non-reliability of data as this group is not required to make their yearly financial statements public in any form, contrary to the private and public companies. Additionally, regulatory and legislative conditions imposed on sole-proprietors differ from the regulation pertaining to the business conduct of public and private limited companies.

Thirdly, as the programming period 2007–13 spans over 7 years and includes six separate calls in total, no regulation prohibited any individual firm to successfully apply for the subsidy in more than one successive round. Yet, as potential effects of the subsidy are likely to influence behaviour of a firm over a medium to long time horizon, inclusion of firms funded by subsidy multiple times might introduce strong

Table 4. Statistical properties of treated versus non-treated group of firms (2013)

Variable	Treated					Non-Treated				
	# of obs.	Mean	St. Dev.	Min	Max	# of obs.	Mean	St. Dev.	Min	Max
Sales per employee	190	131.58	358.67	2.27	4 827	266	120.36	257.65	0	3 290
# of employees	192	91.63	112.58	2	750	266	85.02	128.65	1	750
Cost per employee	187	1 267.60	1 717.30	30.67	14 449	259	1 144.90	1 806.00	1.91	13 028
Capital intensity	190	76.57	321.52	0.39	4 286	266	117.97	719.12	0	10 407
Age (years)	190	14.17	5.12	6	37	262	15.01	5.23	6	41
Market dominance	188	0.033	0.133	0.000	1.565	264	0.026	0.091	0	1.154

Note: Statistical properties are calculated for list of companies existing in 2008.

Table 5. Steps of reduction of the dataset

	Group	# of firms before	Reduction	# of firms after
Step 1 Bratislava region	Treated	340	−14	326
	Non-treated	601	−45	556
Total		941	−59	882
Step 2 Sole proprietors	Treated	326	−20	306
	Non-treated	556	−66	490
Total		882	−86	796
Step 3 Multiple treatment	Treated	306	−37	269
	Non-treated	490	0	490
Total		796	−37	759
Step 4 Age of a firm	Treated	269	−1	268
	Non-treated	490	−2	488
Total		759	−3	756
Step 5 Continuous employment data	Treated	268	−69	199
	Non-treated	488	−205	283
Total		756	−274	482

bias into our estimates. From methodological point of view, since we introduce lags associated with subsidy dummy and monetary effects for more than one year as part of our robustness check the potential overlapping effects of multiple subsidies would simply invalidate our estimates. From this reason, we keep only those firms that successfully applied for a subsidy in exactly one round (treated group) and firms that unsuccessfully applied in at least one call (control group).

Fourthly, as per official program requirements, we require firms to be established no later than one year before a call. Lastly, in order to further increase consistency of the dataset, we exclude firms for which we do not have continuous observations for Number of employees, a variable bearing the crucial information about our competitiveness measure, the labour productivity. We opt for this approach, rather than extrapolating missing information by any purely statistical technique, as the size of the firm might be strongly influenced by the participation of a firm in a public subsidy scheme; a phenomenon that any extrapolation technique might not be able to reflect. Additionally, by excluding firms with missing information on number of employees we make sure that only firms, which were active during the entire programming period and did not leave the market (went bankrupt), are part of our final dataset.

The overview of steps and its impact on the characteristics of the sample is provided in the Table 5.

4. Empirical estimation outcomes—exploring impact of the EU subsidy

As argued previously, the EU subsidy is expected to spur innovation potential of affected firms that is ultimately materialized in an increase of productivity and firm's competitiveness. Following this train of thoughts, this section presents outcomes of models that examine effects of the EU subsidy on firm performance estimated by static labour productivity model with fixed effect estimator. Empirical results presented in the Table 6 can be summarized as follows.

Model I (column 1 and 2) captures possible effect of subsidy on improvement in total factor productivity with and without time-varying sectoral characteristics. In both variations, the coefficient measuring lagged treatment effect is statistically significant on 5 or 1 per cent confidence interval, respectively. This implies that the effect of EU subsidy let to improvement in TFP one year after the subsidy allocation. Since we do not have data that would allow for a more disaggregate analysis we cannot specify the channel through which the change occurs but can only conclude that the funding has been used to improve labour productivity via research and development expenditures, increasing labour expertise or introducing new innovative procedures into the production process. In general, treated firms on average boost their total factor productivity in more than five percent in comparison to the non-treated firms.

Model II (column 3 and 4) deals with possible effects of EU subsidy on capital elasticity of labour production. In a group of treated firms, an increase in capital stock is more efficient that in the non-treated group of firms; a result that might be attributed to more efficient usage of capital in the production process. The response of labour productivity to changes in capital positively increases in about one percent due to the EU subsidy.

The positive influence of the EU subsidy on labour productivity is further confirmed by the Model III (column 5 and 6) and IV

Table 6. Effects of EU subsidy on firm's competitiveness

Model	Model I		Model II		Model III		Model IV	
Constant	7.958	1.030	7.833	0.940	7.856	0.920	7.636	0.731
	(0.462)	(0.923)	(0.470)	(0.930)	(0.469)	(0.932)	(0.482)	(0.946)
L1.Treatment	0.051**	0.062***						
	(0.018)	(0.005)						
L1.Treatment*ln(K)			0.006**	0.007**				
			(0.036)	(0.012)				
L1. Monetary effect					0.111***	0.132***		
					(0.009)	(0.002)		
L1. Monetary effect squared					−0.026**	−0.030**		
					(0.030)	(0.016)		
L1. Monetary effect*ln(K)							0.013***	0.015***
							(0.006)	(0.001)
L1. Monetary effect squared*ln(K)							−0.003**	−0.004**
							(0.000)	(0.000)
Age	0.032*	0.022	0.033*	0.022	0.031*	0.021	0.031*	0.021
	(0.052)	(0.169)	(0.050)	(0.160)	(0.062)	(0.194)	(0.064)	(0.197)
Size = ln(L)	−0.374***	−0.261***	−0.375***	−0.260***	−0.373***	−0.260***	−0.374***	−0.260***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capital intensity = ln(K/L)	0.068**	0.084***	0.068**	0.084***	0.069**	0.085***	0.068**	0.084***
	(0.010)	(0.002)	(0.011)	(0.002)	(0.010)	(0.002)	(0.011)	(0.002)
Employee costs = ln(Cost/L)	0.587***	0.663***	0.587***	0.663***	0.587***	0.663***	0.587***	0.663***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L1.ln(Sector dominance)	0.152***		0.153***		0.152***		0.152***	
	(0.001)		(0.001)		(0.001)		(0.001)	
L1.ln(Total sales in sector)	−0.118		−0.115		−0.117		−0.114	
	(0.400)		(0.414)		(0.406)		(0.419)	
L1.ln(Unemployment)	−0.051	−0.082	−0.051	−0.081	−0.045	−0.075	−0.041	−0.071
	(0.515)	(0.311)	(0.521)	(0.324)	(0.573)	(0.362)	(0.604)	(0.390)
L1.ln(Population)	−0.431	−0.318	−0.425	−0.311	−0.431	−0.317	−0.418	−0.302
	(0.377)	(0.530)	(0.384)	(0.540)	(0.379)	(0.534)	(0.394)	(0.553)
L1.ln(GDP p.c.)	0.210	0.326	0.211	0.327	0.215	0.331	0.217	0.334
	(0.644)	(0.468)	(0.642)	(0.477)	(0.636)	(0.470)	(0.633)	(0.467)
R^2 sq.	0.281	0.297	0.285	0.301	0.282	0.300	0.290	0.308
F stats.	229.66***	225.23***	232.75***	227.45***	214.00***	207.57***	222.91***	219.28***
Number of observations	2 287	2 336	2 287	2 336	2 287	2 336	2 287	2 336
Number of groups (firms)	475	481	475	481	475	481	475	481
Optimal monetary effect I (th EUR)					2 134	2 200		
Optimal monetary effect II (th EUR)							2 167	1 875

Note: *denotes significance at 10 percent level, **denotes significance at 5 % level, ***denotes significance at 1 % level. *P*-values in parenthesis. Treatment represents zero-one dummy variable for EU subsidy. Monetary effect stands for value of EU subsidy in th EUR. *K* denotes stock of fixed assets (tangibles and intangibles), *L* number of employees. Model 1 is estimated using specification [7], Model 2 using specification [8], Model 3 using specification [9], and Model 4 using specification [10]. All models include time and firm-specific dummies.

(column 7 and 8) outcomes where coefficients associated with measure of monetary effects are significant at 1 per cent in all specifications. On top of that, the existence of the optimum level for monetary amount of the EU subsidy is confirmed by negative sign associated with the square of the treatment variable. On average, the function linking the labour productivity and EU subsidy amount reaches its optimum around 2 mil.

EUR. Taking into account the average value of subsidy granted to our sample firms (Tables 2, 3, and 4) is set around 900 ths. EUR (850 ths. for the subset), majority of firms tend to find themselves in a region of increasing total returns to labour productivity given the monetary amount of subsidy.[2]

Age of a company is inclined to positively contribute to the firm's performance, once controlling for the sectoral characteristics. The labour productivity is positively associated with the capital intensity and negatively associated with a size of a firm approximated by the number of employees. In Slovak environment, the relatively bigger firms face disadvantages in increasing their productivity through increase in their size. Contrary, smaller firms are expected to achieve higher productivity due to other unobserved factor, such as more efficient management practices, higher flexibility or more skilled workers, on average. Additionally, positive increase in capital-labour ratio due to the building up of both tangible and intangible assets should lead to higher performance. Both outcomes are in line with prevalent empirical studies (Peeters and De La Potterie 2005; Cin et al. 2014).

Investments into human capital captured by the ratio of average labour costs per employee are expected to bring about positive increase in labour productivity, as captured by statistically significant and highly positive elasticity coefficient associated with employee cost variable. Positive sign associated with average labor costs also implies labour productivity to be positively related to real wage costs, as standard optimizing behaviour implies. This outcome is frequently found in various empirical studies (e.g. Cin et al. 2014).

Regional characteristics are not significant, in all cases. However, the results might be biased do the missing data on lower than NUTS3 or LAU1 level for GDP p.c. or unemployment rate variable, respectively. Due to the relative smallness of domestic market and high interconnectedness of Slovak companies through their upward and downward channels of production, manifested by the degree of trade openness of the Slovak economy,[3] the regional differences do not seem to play a major role in the labour productivity behaviour. Additionally, many regional characteristics are nearly time invariant, hence much of the between variation is included in the fixed effects or in the remaining time error (Brunow and Blien 2015).

On the other hand, one sectoral characteristic might have a positive influence on the labour productivity when sector dominance of a firm is associated with higher productivity in all specifications. One might suspect that inclusion of the sector dominance to models might lead to a bias due to the bi-directional relationship between productivity and sector dominance. In other words, higher productivity is expected to improve sector dominance. Yet, most of the estimation outcomes are robust to inclusion of the sector dominance as the estimated coefficients in regressions remain significant and relatively stable.

Due to the relatively short time dimension of our dataset (6 years in total) the analysis of a delayed effect was restricted to the lag of order 2 and 3 introduced to our treatment variable. The effect of a subsidy seems to evaporate shortly after one year as no significant effect is found for year 2 and 3 in regressions estimated with standard specifications. While estimates for one-year delayed effect presented in the Table 5 are consistently robust, specifications with lag of order two deliver negative and statistically significant sign in some of the robustness check estimates. Estimates for lag 3 deliver statistically insignificant outcomes with beta coefficients having values close to zeros.

This outcome might point out to a possible high speed of adjustment among non-treated firms that react to increase in competitiveness of treated firms in previous years. Another plausible hypothesis suggests that while first year positive effects might be induced by the introduction of new technologies or replacement of written-off capital stock, the consequent year is likely to be adversely affected by rise of operational costs related to newly-utilized capital or newly-hired employees. Taking into account possibly higher substitutability of labour force with capital stock, the positive effect of subsidy in model with one year lag might also be partially driven by an eventual reduction of lower-skilled labour force that formally leads to improvement in the labour productivity. Once a technology is fully operational, need for highly skilled employees operating machines newly put into operation might even result in a year-over-year decrease in labour productivity if not compensated by boost in production and sales. Change in sign from positive to negative value introduced by switch to the 2-year lag model might potentially reflect this kind of cyclical behaviour.

However, the subsidy does not tend to lead to significant change in labour stock in treated to control group. According to the Tables 3 and 4, there was a decrease in the average size of a firm (both treated and non-treated) during the 2008–13 period. Both, treated and non-treated firms decreased labour stock in approximately same amount of employees. Yet, the standard deviations are rather high thus formal *t*-test cannot rule out the mean being equal in both groups, hence not leading to higher labour substitution by capital in treated than control group.

4.1. Robustness checks

As part of our robustness check, we estimate all four model specifications on a dataset with unbalanced panel data without excluding firms with missing data during the 2008–13 period (step 5 in Table 5). Almost all models deliver results that are fully in line with estimates presented in the Table 5 magnifying the effect of subsidy with even more pronounced size of coefficients and lower standard errors, with one exception. Squared term in the Model 3 is not statistically significant implying that the marginal monetary effects of the EU subsidy on total factor productivity remain positive over the entire sample.

Even if per official subsidy requirements, the past economic performance of a firm was not scrutinized in the application process, except 1 year before application deadline, there can exist concerns regarding the selection bias, as discussed in the methodological part of this article. Comparing statistical properties of treated and control group (Tables 2, 3, and 4) the productivity of an average firm in the former one is comparable to the latter one, given the size of standard deviation. The same observation can be applied on all other firm-related characteristics, such as the size of a firm, age or capital intensity. In other words, an average firm of a treated and control group tends to show similar properties suggesting no presence of systemic selection bias.

In order to address this issue, econometrically we estimate models [7]–[10] by dynamic system GMM (SGMM) estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998) which allows for dynamic panel data models with large N and short T (see application in Lalinsky 2013; Cin et al. 2014). The SGMM has been found to be more precise and to reduce finite-sample bias (Baltagi 2013). Since the subsidy dummy may potentially suffer from endogeneity bias we treat it thus while all other determinants are taken as fully exogenous and time dummy are included (see Roodman 2009a, 2009b). The number of instruments is limited by the option collapsed (as in Fidrmuc et al. 2015) and their validity confirmed by Hansen test accompanied by the Arellano–Bond test for AR(2).

In all estimated specifications [7]–[10], we exclude variables for sector dominance and total sector sales as the models do not satisfy requirements imposed by Hansen test. The one year lagged effect of subsidy dummy in the model [7] and monetary treatment variables in [9] and [10] are statistically significant at ten percent confidence level, while specification in the model [8] does not confirm positive and statistically significant effect of the subsidy. Coefficients associated with the subsidy dummies (monetary treatment) also point to a potentially smaller final effect of a subsidy on labour competitiveness than in our baseline regressions. The optimal amount of subsidy according to the model [9] and [10] is set at 1.74 mil. EUR, approximately. In models with 2-year lagged subsidy all specifications deliver statistically insignificant effect of the EU subsidy on firms' competitiveness.

The theoretical specifications in [4] introduces role of R&D stocks being part of the total factor productivity, yet it is omitted from the final estimates in [7]–[10] due to missing data on R&D expenditures in Slovak firms. As a proxy variable for the R&D activity, we collect data on successful patent applications in Slovak firms from the Orbis database and Industrial Property Office of the Slovak Republic. According to the data, only around 400 Slovak firms have been successful in patent application over the last decade confirming the fact that patent activity in Slovakia is negligible and highly concentrated. We use this data to estimate equation [4] to investigate potential effect of subsidy on labour productivity via innovation activity and introduce number of patents as control variable in equation [7] and [8]. While the number of patents is positively highly statistically significant in all cases, there is no effect of subsidy on labour productivity via this innovation channel present and the results from the equation [7] and [8] remain unaltered.

Our results are also robust to inclusion of businesses with historical communist and transition period legacy. There are only eight companies in the sample that were established before fall of the iron curtain and 50 established during the 1990–92 period, but only 4 of them received treatment. Results from regressions with sample excluding companies established before 1993 deliver qualitatively as well as quantitatively very similar results, with small decrease in statistical significance of dummies capturing treatment effect (one exception being the model [8] with sector- specific covariates where the interaction term *P*-value drops to 0.13).

As part of further robustness checks we combine models [7] and [8] into one regression, hence introducing effect of a subsidy on both changes in TFP and elasticity, while acknowledging potential multicollinearity issue. The results, available upon request, report statistically significant effect of subsidy on TFP, while all other effects of subsidy (elasticity, monetary treatment) lose their significance. Removing size or employee costs from model specifications does have less pronounced effect on TFP than on measure of elasticity, underlining the importance of subsidy on TFP improvement for treated firms.

5. Conclusions

The aim of the article is to evaluate the effects of EU regional policy in less developed regions of Slovakia, specifically the 'Operational Programme Competitiveness and Economic Growth' scheme aiming to increase innovation potential and firms' competitiveness. Using the panel dataset including supported and not supported companies applying for the subsidy, we evaluate the effects of this policy by fixed effect model in the framework of the Cobb–Douglas production function. Our results confirm presence of positive effects of the subsidy on firms' competitiveness, however, only in the very short term.

This finding may support the argument that in less developed regions without proper ability to 'embed' the innovation within regional innovation system, the impact is of a very short-term nature, practically without any multiplication effect. This could happen specifically in the case if the criteria for support are set up nationally and not tailored to regional specific conditions.

As an addition, we identify the optimal monetary amount of this subsidy by linking firms' labour productivity to subsidy in a non-linear fashion. The optimum level is set around 2 mil. EUR which is comparably higher amount that the average size of a subsidy. Taking into account, distribution of subsidy across companies, the empirical evidence seems to suggest that the treated firms were located in the area of increasing total returns to capital. In other words, looking only at the optimal threshold for monetary support 'more music for more money' policy might be justified in this specific case.

Notes

1. We do not impose any restriction on returns to scale specification.
2. By eliminating the top percentile of firms receiving the funding the optimal level of the subsidy further increases to 2.5 mil. EUR.
3. The Slovakia ranked 7th in the world in 2014 measuring the trade openness as the sum of exports and imports of goods and services on gross domestic product, according to the World Bank data.

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