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INTERNATIONAL TRADE AND ENDOGENOUS GROWTH: THE CASE OF CZECH ECONOMY

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Abstract

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The paper is focuses on testing of the presence of increasing returns to scale in the Czech economy production function that is constructed upon Solow growth accounting formula. The growth relation is adapted for imperfect competition in the goods market. In the second step the spillover effect to total factor productivity is tested based on import openness of the economy and share of productive equipment imports to gross domestic product. Using data on Czech economy in years 1993–2009 for OLS estimates, the presence of increasing returns to scale was proved in all tested models, the obtained returns to scale parameter is about 2. Explained variability is relatively poor for the full data sample, limiting the data range to 1999–2009 the model is able explain almost 57 %. Tests for spillover effect modeled through import shares do not bring evidence about appropriate significance, the common test of OLS approach indicated very low contribution for import variables in both versions.

endogenous growth, economic growth, returns to scale, international trade, imperfect competition

In widespread opinion, economic growth is supported by foreign trade effects. Although the economic theory and as well the empirics could demonstrate the opposite case, in majority of situation the foreign trade influences the economic growth in the positive way. A. Smith and D. Ricardo explained this effect by deepening of specialization due to bigger market and possibility to trade the production basket into the structure that is optimal from consumer's viewpoint. Subsequent neo-classical approach also find unambiguous proofs for benefit of free trade to economic growth.

The era of separate and self-contained models of economic growth could be characterized by assumption of autarky from the beginning and for a long time it remained so. The possible role of free trade, free movement of goods, services, factors of production and finally of ideas, knowledge, technology, etc was strengthened during the rising popularity of endogenous growth models. Modern growth models focus on imperfect competition environment that is nowadays common almost in all market served by large multinational firms. The new attitude to technology moreover allows for increasing returns to scale breaking the law of diminishing returns.

The aim of presented paper is to test the presence of increasing returns to scale in the Solow's economic growth accounting relation of the Czech economy. This hypothesis results from the adaptation of original Solow growth model. Secondly the positive correlation of economic growth to import openness for all commodities and production equipment of the Czech Republic is tested. The positive correlation emerges from opinion of technology dissemination through imports.

Neoclassical Solow growth model

Commonly used neoclassical approach to economic growth relies on the Solow growth model (Solow 1956, 1988). According this model the economic growth can occur due to increase in extent of used factors of production or due to progress in production technology. The production technology is held as a exogenous factor, its impact are not usually directly measureable. In the framework of so called "growth accounting" the impact of change in technology is computed as the residuum that cannot be explain by the changes in other variables.

The base formula of Solow model corresponds to typical production function, but equipped with special characteristics. Let us assume that the product is produced using labor L, capital K through the neutral technology A that progress influences both remaining factors of production in the exactly same way. So the production function is:

$$Y = Af(L, K).$$

Dividing the total differential of the above specified production function by the same production function and substituting the dX/X of each variable by its percentage change x we obtain the following expression:

$$y = a + \left(\frac{f_L L}{f(L, K)}\right) l + \left(\frac{f_K K}{f(L, K)}\right) k,$$

where f_L and f_K denote the partial derivatives of production function with respect to labor, respectively capital. The rate of economic growth is the sum of growth in the used factors of production, where the impacts of labor and capital are weighed by the elasticity of output to the appropriate factor of production.

The original Solow approach assumed the perfect competition in the all markets. Than the marginal products of factors, corresponding to partial derivatives of product, are equal to real wages (capital). This enables us to substitute the directly unobservable elasticities of output by the revenues shares of appropriate factor in total product. These revenue shares are denoted θ_L and θ_K respectlively. If we assume the constant returns to scale in addition, the sum of the two revenue shares is always 1, so we can substitute $\theta_K = 1 - \theta_L$ and to obtain the final formula for economic growth in Solow model:

$$y = a + \theta_L l + (1 - \theta_L)k.$$

Adaptation of original Solow growth model

The assumptions used in derivation of the last formula are hardly to meet in the real economy. Weakening assumptions could bring the model to better performance in explaining the reality. In this paper two assumptions will be modified to adapt the model to the different empirics of modern developed economies. Firstly we introduce the increasing returns to scale, than the imperfect competition in the goods markets.

Let the production function is homogenous in the degree corresponding to the relative rate of increase in parameter of increasing returns to scale. The returns to scale parameter λ has to be greater 1 to ensure the increasing returns to scale. From the homogeneity condition directly follows $\lambda f(L, K) = f_L L + f_K K$. After substitution into the production function and reformulations we can obtain the final formula for economic growth in Solow model without the assumption of constant return to scale:

$$y = a + \theta_L(l - k) + \lambda k.$$

Breaking the assumption of perfect competition in the goods market is connected with different condition for equilibrium in the market of factors of production. Now the nominal wage equalizes with the product of marginal physical product and declining marginal revenues from final product. The decline is given by the price elasticity of demand curve that firms are facing to; it is equal to $1-(1/e)$, where is the absolute value of price elasticity. The fact of declining marginal revenues has to be introduced into the Solow economic growth formula to adapt the price of final product. We substitute the new expression for marginal revenues valid for imperfect competition into the revenues share calculation and obtain following:

$$\theta_L = \left(\frac{e-1}{e}\right)\left(\frac{f_L L}{f(L, K)}\right).$$

Substituting adapted revenues share into the formula for economic growth in Solow model without the assumption of constant return to scale we reach the growth accounting relation under weaker assumptions allowing for non-constant return to scale and imperfect competition. Both withdrawn assumptions are represented by corresponding parameters in the final relation:

$$y = a + \left(\frac{e}{e-1}\right)\theta_L(l - k) + \lambda k.$$

The economic growth is explained by the growth in the "true" productivity *a*, change in labor to capital ratio multiplied by coefficient depending on price elasticity and change in capital multiplied by return to scale parameter λ.

In the original version of Solow model the productivity of factors is an exogenous variable that value comes from outside of the model. During 1980s appeared theoretical and also empirical works trying to explain the differences in Solow residuals across the countries or/and across the time. The convergence controversy that the original Solow model was unable to explain and stylized facts about the technology like non-rivalry, replicable use, technology as a result of people effort (Romer, 1994) stimulated modeling of formerly exogenous technology with respect to a lot of variables. The special way of creation and dissemination of technological knowledge is often explain by the stock of total capital (Arrow, 1962), investment in human capital (Lucas, 1988), stock of results from former R&D expenditures (Romer, 1986), fiscal policy (Baro, 1990) etc.

Contribution of trade to productivity rise

The international trade could also significantly contribute to the technological progress mainly by fast dissemination of knowledge and technologies among the trading partners. Influence of trade on domestic technology is not always positive as was demonstrated for example in the theory of Immiserizing growth presented by Bhagwati or in centre-periphery models. The negative influence of trade was already discussed by D. Ricardo, who analyzed the different development of real prices in autarky a open economy resulting in different impacts on subject involve in trade.

The modern theories relate economy openness with the free movement of knowledge and technologies incorporated in the traded commodities and these are held as the factors increasing the national growth rates. Usually imports play the decisive role for the knowledge inflow. If there is foreign trade in all commodities, trade is always beneficial, but if trade is limited to only some group of commodities, the result is not so unambiguous.

Feenstra (2004) describes the researches done by Harrison and Levinsohn at the industry level. Harrison used the import penetration to industry as a proxy for changes of the relative price of factors of production and in this way indirectly measured the role of imports in production technology on the example of Ivory Coast. Levinsohn on Turkey data demonstrated the influence of trade liberalization to price mark-ups and so also to appropriate technology.

Grossman and Helpman (1991) endogenized the technology through the variety of differentiated intermediate inputs with argument that in consumption the variety of goods increases the utility so the variety in inputs and semi-products should similarly increase the product. The rise in the number of input varieties is positively correlated to the growth of final-goods industry and so to the economic growth. Trade and knowledge spillovers decrease also the fixed cost of input-producing firms, because exploiting the "common technological knowledge" worldwide relates to lower costs of R&D per new input variety. The existence of spillovers is decisive as demonstrated e.g. by Riviera-Batiz and Oliva (2003), in the absence of spillovers the trade could slower the economic development.

The empirical works in this field are ambiguous. Coe and Heplman (1995) discovered positive correlation between total factor productivity growth and R&D expenditures in home and partner countries supporting the idea, on the other hand Feenstra (2004) offered an overview of contradictory results that paid attention to influence of R&D expenditures, patent data, geographical distance, etc. concluding in zero of very weak influence to total productivity growth in the set of all economies. The only significant result is that foreign trade and membership in the same regional trading agreement supports the convergence as described in original Solow model.

Using meta-analysis of empirical studies and case studies Rivera-Batiz and Oliva (2003) identified four possible causes of international trade and consequently larger market to take-off the economic growth:

1. economies of scale in the presence of increasing returns to scale;
2. inflow of ideas, technology, knowledge, … from abroad;
3. elimination of duplicities in R&D;
4. creative destruction under stronger international competition.

But they also summarize that there is a great controversy in result, mainly due to different contribution of exporting industries to economic growth in individual countries. Zhang (2008) in his overview of empirical tests stresses the role of education proxies and mainly the relation of total factor productivity to trade in equipment, trade in capital goods, etc. He argues that the economic productivity depends on the access to technologies of leaders that are usually spread by trade in equipment.

Data and empirical results

The estimated relation corresponds to Solow growth equation modified for non-constant returns to scale and existence of imperfect competition as derived above. The change in total factor productivity is firstly assumed to be fixed factor of the economy. In the second step the trade openness is included into the estimated equation to test for contribution of this factor to the explaining efficiency. The estimated equation has following form:

$$y = \alpha + \delta T + \beta\, \theta_L(l - k) + \gamma k + \varepsilon,$$

where

α .... is estimated parameter for fixed effect describing the technology changes,

δ..... parameter for trade coefficient,

β .... coefficient describing the imperfectly competitive firms price mark-up (i. e. level of imperfection competition in the market),

γ..... is parameter for returns to scale ratio and finally

ε..... is random component.

The data for equation estimation are taken from SourceOECD statistics that are accessible at internet address <stats.oecd.ord>. The data for the Czech economy range from 1993 to 2009. The annual changes in consumption of fixed capital are used as the proxy for changes in capital inputs, the changes in labor inputs comply with the product of change in employment and annual average working hour. The labor revenue income is directly available in OECD statistics.

The trade data are from OECD International Trade and Balance of Payments Statistics. To test the relation of change in total factor productivity to the access to knowledge spillovers, the total import openness indicator expressed as the share of total imports to GDP was chosen. The second trade indicator openness to machinery imports is narrower. It is calculated as the share of import of Harmonised System 1988 group 84 – Nuclear reactors, boilers, machinery & mechanical appliances, computers and group 85 – Electric machinery & equipment and parts, telecommunication equipment, sound recorders and television recorders, the basis for the second indicator is also country GDP.

I: *Regression result, equation without trade indicators, 1993–2009*

OLS estimates using the 17 observations 1993–2009					
Dependent variable: y					
	coefficient	**std. error**	**t-ratio**	**p-value**	
const	1.20537	1.03167	1.168	0.2622	
mark-ups	2.46509	0.837825	2.942	0.0107	**
returns ratio	1.95488	0.609847	3.206	0.0064	***

Mean dependent var	2.691765	S.D. dependent var	2.951392
Sum squared resid	79.93862	S.E. of regression	2.389540
R-squared	0.426435	Adjusted R-squared	0.344497
F(2, 14)	5.204365	P-value(F)	0.020421
Log-likelihood	–37.28034	Akaike criterion	80.56069
Schwarz criterion	83.06033	Hannan-Quinn	80.80916

II: *Regression result, equation without trade indicators, 1999–2009*

OLS estimates using the 11 observations 1999–2009					
Dependent variable: y					
	coefficient std.	**error**	**t-ratio**	**p-value**	
const	0.988800	0.924692	1.069	0.3161	
mark-ups	2.20687	0.783734	2.816	0.0226	**
returns ratio	2.15967	0.567820	3.803	0.0052	***

Mean dependent var	3.181818	S.D. dependent var	3.059673
Sum squared resid	32.23043	S.E. of regression	2.007188
R-squared	0.655717	Adjusted R-squared	0.569646
F(2, 8)	7.618334	P-value(F)	0.014050
Log-likelihood	–21.52091	Akaike criterion	49.04182
Schwarz criterion	50.23551	Hannan-Quinn	48.28937

The regression estimates using ordinary least square method for the first relation without trade indicator are presented in table I:

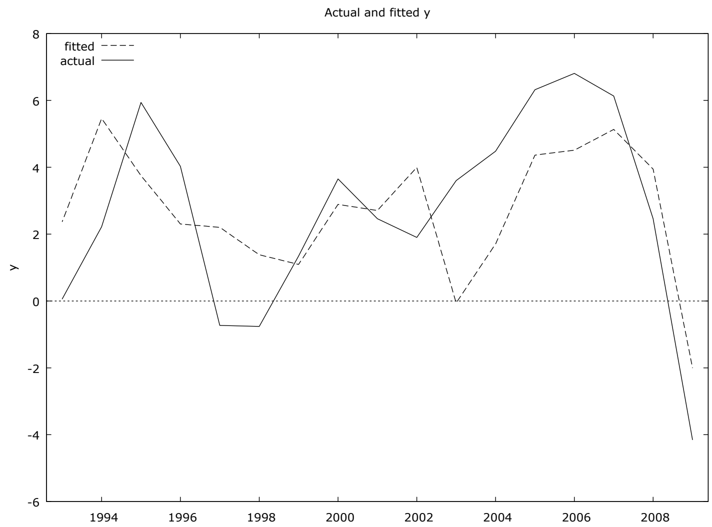
The obtain results indicate that the model is not able to explain at least the majority of variability in growth rates of the Czech economy although the individual variables are highly significant. The signs of estimated coefficients comply with the model assumptions and correspond to the anticipated values. Using the total F-test, the model is significant at reasonable level. The plotted actual versus fitted values in Figure 1: Actual and fitted values of economic growth rate of Czech Republic in 1993–2009 demonstrates similarity in trends in the second two thirds of analyzed period, while the development in the first third is a bit dissimilar. This development could be explained by still unfinished economic transition and system changes that were declared in 1997 to be almost done. Ranging the data sample to years 1999–2009 the explained variability is for two thirds higher (see Table II), but the values of variable coefficients are almost unchanged.

Because there are not significant differences between full range and 1999–2009 limited data samples estimates excluding the share of explain variability in economic growth we can return to full range data. Also the aim is to test the contribution of trade indictor and not to explain the changes is economic growth variability. Adding the trade indicators in two separate forms into the model we obtain result presented in Table III and Table IV.

The contribution of additional explaining variables in both forms is almost similar and very poor, without any significant effect. Also the t-statistics recommend omitting these variables with relatively high p-values. Moreover, embodiment of trade variable changes the sign of constant in regression indicate a contradiction with underlying theory. We can conclude that there is no evidence of significant contribution of trade indictors to the model estimations.

The estimated coefficient for return to scale are stable regardless the trade variable. It indicates, that the returns to scale parameter is about value 2. It corresponds with increasing return to scale, the proportional rise in both inputs – labor and capital – has more than squared impact on the rate of economic growth.

The estimate of markups is also almost stable; it drops from about 2.5 to 2.1 when the trade variable was introduced in the model. From the estimated values we can derive the "representative" price elas-



1: *Actual and fitted values of economic growth rate of Czech Republic in 1993–2009*

III: *Regression result, equation with share of total import to GDP*

OLS estimates using the 17 observations 1993–2009					
Dependent variable: y					
	coefficient	**std. error**	**t-ratio**	**p-value**	
const	−1.48996	2.36142	−0.6310	0.5390	
mark-ups	2.05853	0.881469	2.335	0.0362	**
returns ratio	1.95156	0.597297	3.267	0.0061	***
share_total	7.65442	6.06125	1.263	0.2288	

Mean dependent var	2.691765	S.D. dependent var	2.951392
Sum squared resid	71.20371	S.E. of regression	2.340344
R-squared	0.489108	Adjusted R-squared	0.371210
F(3, 13)	4.148569	P-value(F)	0.028795
Log-likelihood	−36.29677	Akaike criterion	80.59355
Schwarz criterion	83.92640	Hannan-Quinn	80.92484

IV: *Regression result, equation with share of group 84 and 85 HS 1988 to GDP*

OLS estimates using the 17 observations 1993–2009					
Dependent variable: y					
	coefficient	**std. error**	**t-ratio**	**p-value**	
const	−1.31318	2.29120	−0.5731	0.5763	
mark-ups	2.08393	0.879966	2.368	0.0341	**
returns ratio	1.97050	0.599328	3.288	0.0059	***
share_84_85	21.7316	17.7299	1.226	0.2421	

Mean dependent var	2.691765	S.D. dependent var	2.951392
Sum squared resid	71.65754	S.E. of regression	2.347790
R-squared	0.485852	Adjusted R-squared	0.367203
F(3, 13)	4.094850	P-value(F)	0.029932
Log-likelihood	−36.35078	Akaike criterion	80.70156
Schwarz criterion	84.03441	Hannan-Quinn	81.03285

ticity of demand in the economy describing the level of imperfect competition and so mark-ups of imperfectly competitive firms. The price elasticity of demand then ranges from about −1.6 to −2.0.

SUMMARY

The paper is focuses on testing of the presence of increasing returns to scale in the Czech economy production function that is constructed upon Solow growth accounting formula. The growth relation is adapted for imperfect competition in the goods market. In the second step the spillover effect to total factor productivity is tested based on import openness of the economy and share of productive equipment imports to gross domestic product. Using data on Czech economy in years 1993–2009 for OLS estimates, the presence of increasing returns to scale was proved in all tested models, the obtained returns to scale parameter is about 2. Explained variability is relatively poor for the full data sample, limiting the data range to 1999–2009 the model is able explain almost 57 %. Tests for spillover effect modeled through import shares do not bring evidence about appropriate significance, the common test of OLS approach indicated very low contribution for import variables in both versions.

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