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Ratio Working Paper No. 232

# Is China Different? A Meta-Analysis of the Growth-enhancing Effect from R&D Spending in China

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Acknowledgments: Financial support from Torsten Söderbergs Research Foundation is gratefully acknowledged.

# Is China Different? A Meta-Analysis of the Growth-enhancing Effect from R&D Spending in China

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**Abstract:**

In this paper we examine whether China has benefited more from spending on R&D than other countries by conducting a meta-analysis of the relevant literature on a large number of countries at different stages of economic development. The results suggest that the growth-enhancing effect of R&D spending in China has been significantly weaker than that of other countries. It is thus unlikely that R&D spending has been successful as a key contributing factor to economic growth in China.

**Keywords:** meta-analysis; R&D; economic growth; China

**JEL Codes:** F43; O11; O33; O53

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## I. Introduction

Economic theory (Solow, 1957; Romer, 1990) points to technical change as the major source of long run economic growth. New processes allow firms to increase output per worker or per unit of capital, and new products contribute to improving the well-being of consumers. While macroeconomic shocks can affect productivity in the short to medium-term, the extension of technology can make economic growth sustainable, and a key factor behind technological change is R&D.

This concept is captured by China's central government, which is committed to push forward an economic development strategy dependent on R&D, innovation and domestic demand. This model is significantly different from the growth strategy based on low labor costs, exports, and heavy investments. The first real attempt to shift growth model was expressed in the National Medium and Long–term Plan for Science and Technology Development (2006-2020) in early 2006, bringing to the front objectives such as increasing R&D expenditure to 2.5 percent of GDP in 2020; Science and technology contribution to 60% of growth; a key role played by strategic state-owned enterprises; dependence on foreign technology reduced to 30%, and; position China as number 5 for patents and citations of publications worldwide.[2] This strategy was further accentuated by the "Decision of the Third Plenary Session of the 18th Communist Party of China Central Committee" in November 2013 and the resolution of the National People's Congress in March 2014. As a consequence, large public spending programs to fund R&D have been lunched together with improved incentive mechanisms for private firms to allocate more resources to R&D. The objective is to bring China beyond the middle-income country status and establish itself at the frontier of developed nations in terms of technological advancement and standard of living.

A central question of interest for China is whether the spending - public and private - on R&D quickly enough feed back into economic growth. For instance, a central problem with large public funding is that governments' often allocates resources less efficient than the market and is likely to create market distortions. Furthermore, the determinants of efficiency of R&D spending tends to emphasize the role played by framework conditions, e.g., the level of education of the population, the competence of the civil servants, per capita GDP, the strength of the IPR systems, trade openness, transparency in public policy, civil liberty and the existence of political rights, etc., for a growth-enhancing effect to occur (Afonso et al., 2005, Herrera and Pang, 2005 and Jaumotte and Pain, 2005a, 2005b).

[2] In October 2005, the Communist Party of China Central Committee met and elevated indigenous innovation to a strategic level.

In this paper we analyze the relationship between R&D spending and growth by conducting a meta-analysis of the relevant literature on a large number of countries at different stages of economic development.[3] This approach enables us to investigate whether China differs from other countries in terms of how it is affected by R&D. The results suggest that the growth-enhancing effect of spending on R&D in China has been significantly weaker than that of other countries. It is thus unlikely that spending on R&D has been successful as a key contributing to economic growth in the China. These results are likely attributed to both incomplete framework conditions that impede the potentially positive effects from spending on R&D, and the absorptive capacity of firms.

This article is organized as follows. Section II provides a brief overview of the existing literature. Section III explains the model, data and variables. Section IV presents the results and section V concludes.

## II. Literature overview

The literature on the return to R&D presents mixed results and varies across countries, firms, and time. Considering the stochastic nature of R&D this is an expected result, in particular when analyzing firm level R&D. It has been shown that on average, public funded R&D has a positive return, but is lower than the return on privately-funded R&D. This applies both to publicly-funded R&D that is performed by companies and R&D at universities/research institutes. A few studies have directly compared the return on privately-funded and publicly-funded R&D. Mansfield (1980), Griliches (1986) and Lichtenberg and Siegel (1991) all find that publicly-funded R&D has a lower return than privately-funded R&D. Other studies have reached inconclusive results on the capacity of publicly-funded R&D to promote innovative outputs and economic growth (Bilbao-Osorio and Rodriguez-Pose, 2004; Bassanini and Scarpetta, 2000). Griliches (1992) draws the conclusion that there is no major difference in return between privately-funded and publicly-funded R&D at the company level. Cohen and Levinthal (1989) and Geroski (1995) emphasize that R&D can further enhance firms´ absorptive capability of outside knowledge, results which are empirically validated by Branstetter and Sakakibara (1998) while Griffith, Redding and Van Reenen (2004) provide the theoretical foundations underlying the hypothesis of absorptive capability.

[3] Only a few papers collected for the purpose of this analysis divide total spending on R&D into public spending and private spending on R&D, and hence there are too few observations to do such estimations.

In 2003 the Organisation for Economic Cooperation and Development (OECD) conducted a comprehensive survey of the rich countries' economies research funding spanning more than two decades. Their results show that only privately-funded research contributed to economic growth. Not only did publicly-funded research not stimulate economic growth but - by displacing private funding - it might even have inhibited it. Nonetheless, other studies have found a positive impact of publicly-funded R&D (Guellec and van Pottelsberghe de la Potterie, 2001).

Nadiri and Mamuneas (1994) investigated how the stock of public R&D capital and infrastructure affects the cost structure in the manufacturing industry in USA. They showed that the stock of public R&D capital has positive and significant productivity effects and is associated with considerable technology spillovers. Park (1995) find that publicly-funded R&D loses its positive impact on productivity if private R&D estimates are taken into account. The few studies that divide publicly-funded R&D into civil and defense-related R&D show; that defense-related R&D has no or a negative effect on economic growth.

The study from Guellec and van Pottelsberghe de la Potterie (2004) makes a distinction between public/private R&D expenditure and highlights the importance of publicly-funded R&D for economic growth. In particular, this study differentiates three sources of R&D: (1) R&D performed by government and universities, (2) R&D performed by businesses and (3) foreign knowledge spillovers. Notably, the study underlines that for publicly-funded R&D to have positive effects on growth there is need for governments to carry out a broad and coherent innovation policy approach due to the occurrence of strong interactions between the various channels and sources of technology. This conclusion is supported by Afonso et al., (2005), Herrera and Pang, (2005) and Jaumotte and Pain, (2005a, 2005b) in their studies on the determinants of efficiency of public spending. These papers emphasize the role played by well-functioning framework conditions, such as the level of education of the population, the competence of the civil servants, the strength of the IPR systems, trade openness, transparency in public policy, civil liberty and the existence of political rights. Thus, framework conditions are likely to have similar effects regardless the sources of funding.

Another central problems associated with publicly-funded R&D is that it may crowd out privately-funded R&D. Goolsbee (1998), and David and Hall (2000) claim that the most important effect of public-funding is that it increases the salaries of R&D personnel – at least in the short run. The companies then move their resources to other investments. Although the total sum invested in R&D may increase due to public funding, the real quantity of R&D (adjusted for higher costs) may actually be lower. Another argument is that publicly-funded

R&D simply replaces privately-funded R&D. The companies replace their own funding with public funding and continue to conduct R&D at the same level as previously. In such cases, the government funds R&D that would have been carried out in any case. If the government supports an R&D project at a company, this may also discourage other competing companies from investing in R&D. Private R&D is thus crowded out again. Third, the government often allocates resources less effectively than the market, which can create market distortions. Hence, R&D is likely to enhance growth but due to its stochastic nature, results may vary across firms, regions, countries and by source of funding.

## III. Model specification, data and variables

Following Ljungwall and Tingvall (2013), we perform a meta-analysis on a sample of 49 country-specific studies, yielding 538 observations that explore the link between R&D and growth[4]. While meta-analysis has been extensively used to analyze publication bias (Stanley, 2008), we seek to determine whether the relationship between R&D and growth is more significant in China than in other countries.

The dependent variable is the *t*-statistic reported by the country-specific studies which provides us with dimensionless dependent variable. The *t*-statistic is then regressed on a set of study characteristics that are meta-independent and presumed to influence the outcome of the study. Each observation is weighted by the precision (Stdv) of the estimated effect.[5] The standard meta-regression model is therefore specified as follows:

$$B_i / Se_i = t_i = \alpha_0 + \sum_{k=1}^{K} \alpha_k X_{ik} / Se_i + \varepsilon_i; \quad i = 1,\ldots,N \quad \varepsilon \sim iid\ N(0,\sigma), \qquad (1)$$

where *B* is the reported coefficient on the relation between R&D and growth taken from the obtained country-specific studies, *Se* is the associated standard error, *t* is the t-value and *X* contains a set of meta-independent variables capturing the characteristics of the empirical studies in the sample, $\alpha$ are the set of coefficients to estimate, and $\varepsilon$ is the error term.

A feature of our meta-data is that it often includes more than one study for each country and several observations from a single author. We therefore project two sources of interdependency: country-specific effects and study-specific effects. A common method to improve the precision in the analysis and to handle such group effects is to estimate models

[4] See also Ljungwall and Tingvall (2010); Tingvall and Ljungwall (2012).
[5] See Cipollina and Salvatici (2010).

that allow for either country-specific random intercepts $v_j$ or random study effects $\zeta_l$. To simultaneously control for these effects, we extend (eq. 1) to a two-level model with random intercepts by country and study. First, we assume studies to be nested under the country level, represented by the random intercept $\zeta_{[j]l}$. Subsequently, we relax the assumption of nested data. Thus, the multi-level framework enables us to handle heterogeneity more adequately than would have been possible under a dummy variable framework.

*Description*

The data used are drawn from 49 studies on R&D and growth, which yield a total of 538 observations.[6] This sample is large compared to other economic meta-analyses. In the field of meta-analyses in economics, Görg and Strobl (2001) obtained 25 observations, Meyer and Sinani (2009) obtained 121 observations, and Ljungwall and Tingvall (2013) obtained 437 observations.

**Table 1. Distribution of t-values, China vs. non-China studies**

| | Mean | Share t-val negative and significant | Share t-val positive and significant | Share insignificant t-values |
|---|---|---|---|---|
| **t-val. all obs.** | 3.40 | 4% | 63% | 33% |
| **t-val. China** | 2.45 | 1% | 59% | 40% |
| **t-val. non-China** | 3.62 | 5% | 64% | 31% |
| | | | | |
| **t-val China: growth studies** | 3.31 | 0% | 70% | 30% |
| **t-val non-China: growth studies** | 2.21 | 10% | 61% | 29% |
| | | | | |
| **t-val China: income level studies** | 2.08 | 1% | 54% | 45% |
| **t-val non-China: income level studies** | 5.06 | 0% | 67% | 33% |

In Table 1 we take a closer look at the distribution of *t*-values across China-specific and other country specific studies analyzing the relation between R&D and growth. As shown in Table 1, the distribution of *t*-values for China is distributed around a mean value of 2.45, which is lower than for other countries (2.45 vs. 3.62). One percent of the *t*-values for China are negative and significant, 59 percent are positive and significant and, 40 percent are insignificant. Compared with non-China *t*-values, a typical result suggests that R&D generally play a less significant role in enhancing growth in China than in other countries. A striking

[6] See http://ratio.se/sv/medarbetare/forskare/patrik-tingvall.aspx for a listing of the included studies.

result found in Table 1 is that research design seems to matter for the results. Studies analyzing the change in output (rather than the change in growth rates) record a clearly weaker relation between R&D and output for China than for other countries (2.08 vs. 5.06). The opposite is found for studies analyzing growth rates. When analyzing growth rates, the average *t*-value recorded for China-specific studies is slightly larger than for other countries (3.31 vs. 2.21). One lesson drawn from these observations is that study design seems to matters for the results.

## IV. Results

In Table 2 we continue and analyze whether the observed differences in *t*-values between China and other countries can be explained by data and research design factors and whether the results for China differ significantly from the average results for other countries. The explanatory variables included in the meta-regressions include, degrees of freedom, country type (developing and industrialized country)[7], data type used (aggregated-, industry, and firm level data), period of study, control for human capital, control for population growth, and whether the response in the dependent variable is measured in levels or growth rates, finally we have a China dummy variable indicating whether the study conducted on China or not.

Table 2 reports the results of the meta-regression analysis. In estimations (1) – (5) we sequentially add control for different study characteristics to the analysis. All of these models are standard error weighted with robust standard errors. Results from column (1) suggests that unconditional *t*-values for China are not significantly different from that of other countries. Adding control for country type (column 2) the results for China becomes significantly negative. In estimation (3) additional control for data type used are added, yielding similar results as estimation (2). That is, significant lower t-values for China than for other countries. In estimation (4) we add control for human capital and population growth and decade of study dummies. When these study characteristics are controlled for, the negative significance of the China dummy vanish. That is, results in estimations (1-4) are imponderable for China, e.g., the results are not robust with respect to control for the study characteristics that are accounted for.

As pointed out in the descriptive analysis, the results for China looks different weather the analysis has been performed in levels or by at growth rates. In growth studies, the average t-value for China is above the average for other countries (3.31 vs 2.21) while the opposite is true for income level studies. We therefore proceed by in estimation (5) by adding control for whether the response in the dependent variable analyzed was measured at changes in levels or

[7] Developing country include transition economies.

growth rates. When adding control for growth- vs. level studies the results for China becomes negative and significant, suggesting a less significant role played by R&D in terms of enhancing growth. An obvious observation is that it is of utmost importance to take key study characteristics into account when performing a meta-analysis and that not controlling for relevant study characteristics may yield biased results.

**Table 2. Meta regression models. Dependent variable, *t*-value, R&D and growth studies.**

| | 1. OLS [(a)] | 2. OLS [(a)] | 3. OLS [(a)] | 4. OLS [(a)] | 5. OLS [(a)] | 6. Mixed model [(b)] | 7. Mixed model [(c)] |
|---|---|---|---|---|---|---|---|
| **China** | 7.2e-08<br>(1.7e-07) | -7.6e-07<br>(2.2e-07)*** | -1.2e-06<br>(6.5e-07)* | -9.0e-07<br>(7.6e-07) | -3.6e-06<br>(5.1e-07)*** | -4.0e-06<br>(1.6e-06)** | -4.0e-06<br>(1.6e-06)** |
| $\boldsymbol{ln\sqrt{DGF}}$ | | 2.6e-07<br>(8.6e-08)*** | 3.5e-07<br>(1.1e-07)*** | 4.2e-07<br>(2.0e-07)** | 2.5e-07<br>(1.5e-07) | 2.4e-07<br>(3.0e-07) | 2.4e-07<br>(3.0e-07) |
| **Industralized country** | | -9.1e-07<br>(3.1e-07)*** | -1.24e-06<br>(3.9e-07)*** | -1.50e-06<br>(8.2e-07)* | -2.6e-06<br>(5.8e-07)*** | -2.9e-06<br>(1.4e-06)** | -3.0e-06<br>(1.4e-06)** |
| **Developing country** | | -1.2e-06<br>(3.2e-07)*** | -1.5e-06<br>(4.1e-07)*** | -1.9e-06<br>(7.5e-07)*** | -3.1e-06<br>(5.3e-07)*** | -3.1e-06<br>(1.3e-06)** | -3.1e-06<br>(1.3e-06)** |
| **Aggregated data** | | | 3.5e-07<br>(4.6e-07) | 1.5e-07<br>(4.5e-07) | 7.8e-07<br>(2.0e-07)*** | 9.1e-07<br>(6.9e-07) | 9.1e-07<br>(6.9e-07) |
| **Industry level data** | | | 0.0145<br>(0.0186) | 0.0145<br>(0.0188) | 0.0145<br>(0.0188) | 0.0313<br>(0.0289) | 0.0314<br>(0.02912)*** |
| **Capital** | | | | -3.8e-08<br>(3.1e-07) | 2.2e-06<br>(3.1e-07)*** | 2.5e-06<br>(1.1e-06)** | 2.5e-06<br>(1.1e-06)** |
| **Human capital** | | | | -6.2e-07<br>(4.3e-07) | 1.9e-07<br>(2.2e-07) | 3.1e-07<br>(5.9e-07) | 3.2e-07<br>(5.9e-07) |
| **Population growth** | | | | -3.0e-07<br>(2.2e-07) | -5.0e-09<br>(1.1e-07) | 1.6e-07<br>(3.6e-07) | 1.7e-07<br>(3.6e-07) |
| **Dependent variable in growth (vs. level)** | | | | | 1.8e-06<br>(1.7e-07)*** | 2.1e-06<br>(7.6e-07)*** | 2.1e-06<br>(7.6e-07)*** |
| **Decade dummy 60s, 70s, .., 00s** | no | no | no | yes | yes | yes | yes |
| **Test: Random country effects** | | | | | | 2.7e-06<br>(0.0017) | 2.3e-06<br>(0.0046) |
| **Test: Random study effects** | | | | | | 1.8319<br>(0.2614)*** | 1.875<br>(0.2755)*** |
| **LR test linear model p-value** | | | | | | 0.000 | 0.000 |
| **Obs.** | 538 | 538 | 538 | 538 | 538 | 538 | 538 |

Notes: Standard errors within parentheses (.). ***,**,* indicate significance at the 10, 5, and 1 percent level, respectively. All models weighted by 1/Se.
[(a)] Robust standard errors. [(B)] Random intercept model with studies nested under country.
[(C)] Non-nested (two-way) random country study-effects model.

In columns (6) and (7), we continue and examine whether the results in estimation (5) could be affected by a lack of control for interdependence. In estimation (6) we extend the analysis to a two-level model with mixed random intercepts at the country and study level, where we assume study effects to be nested under the country level. In estimation (7), we further increase the generality of the interdependence and estimate a two-way model with non-nested crossed random effects by country and study. Tests suggest significant within-study effects while there is less evidence of within-country interdependence. Controlling for possible interdependence driven by study- or country-specific interdependence does not affect the significance of the China dummy variable. These results indicate that the negative estimate for China is robust and not driven by omitted control for within group interdependencies.

*Interpreting the results*

One conclusion is that R&D has less significant and a weaker growth-enhancing effect in China than in other comparable countries. Possible explanations for this result is that incomplete framework conditions e.g., the level of education of the population, the competence of the civil servants, per capita GDP, the strength of the IPR systems, trade openness, transparency in public policy, civil liberty and the existence of political rights, etc., impede the potentially positive effects from R&D on growth. There is also the issue of sub-optimal absorptive capacity by firms. With weak absorptive capacity, the results from successful R&D and new technologies are less easily transferred across firms, hence reducing the impact of R&D investments. Importantly though, the result does not say that Chinese firms are not innovative but suggest that there is a drag on efficiency. Nonetheless, the idea that China's framework conditions hold back on efforts made in R&D may indeed hold some truths to it.

Most notably, the results are evidenced by the overall ranking of China, as measured by the Global Innovation Index 2013, according to which China have experienced an actual drop in innovation ranks in 2013 as compared to 2012, repeating the experience from 2011 to 2012.[8] A more direct example is that among the 2,377,000 patent applications filed with the State Intellectual Property Office of China (SIPO) in 2013 only 355,000 applications were examined and, hence the accumulated backlog for that year amounted to 2,022,000 applications, signifying a drag on R&D efficiency in China. Nonetheless, China's framework conditions – the innovation environment - for allowing R&D to be effectively transformed in to economic growth has experienced fundamental changes since the onset of economic reform and is undergoing rapid changes continuously, particularly after 2006, suggesting that China may be on its way to come at par with other countries.

[8] China is ranked 35th in 2013; a decrease of one spot from 2012 and six from 2011.

## V. Concluding remarks

This multilevel meta-analysis of a sample of 49 studies, which yielded a total of 538 observations of the link between R&D spending and economic growth, suggests that the growth-enhancing effect of R&D in China has been less significant than in other comparable countries. It is thus unlikely that R&D, for the period of observation, has been successful as a key contributing factor to economic growth in the China.

## References


Afonso, A., Schuknecht, L, and Tanzi, V. 2005. Public Sector Efficiency: An International Comparison. *Public Choice*, vol. 123(3), 321–347.

Bassanini, A., Scarpetta, S, and Visco, I. 2000. Knowledge, Technology and Economic Growth: Recent Evidence from OECD Countries. OECD Economics Department Working Paper No. 259.

Bilbao-Osorio, B., and Rodríguez-Pose, A. 2004. From R&D to Innovation and Economic Growth in the EU. *Growth and Change*, vol. 35(4), pp. 434–455.

Branstetter, L. and Sakakibara, M. 1998. Japanese research consortia: a microeconometric analysis of Japanese industrial policy, *Journal of Industrial Economics*, Vol. 46, pp. 207–233.

Cipollina, M. and Salvatici, L. 2010. Reciprocal trade agreements in gravity models: a meta-analysis, *Review of International Economics*, 18, 63–80.

Cohen, W. and Levinthal, D. 1989. Innovation and learning: the two faces of R&D, *Economic Journal*, Vol. 99, pp. 569–596.

Cornell University, INSEAD, and WIPO. 2013. "*The Global Innovation Index 2013: The Local Dynamics of Innovation",* Geneva, Ithaca, and Fontainebleau.

David, P., and Hall, B. 2000. Heart of darkness: modeling public–private funding interactions inside the R&D black box, *Research Policy* 29, 1165–1183.

Geroski, P. A. 1995. "*Do spillovers undermine the incentive to innovate?*", in Dowrick S.(ed.), Economic Approaches to Innovation, Edwar Elgar, Aldershot, pp. 76–97.

Golsbee, A., 1998. Does Government R&D Policy Mainly Benefit Scientists and Engineers? *American Economic Review*, 88(2), 298-302.

Guellec, D., and Van Pottelsberghe De La Potterie, B. 2001. The Effectiveness of Public Policies in R&D. *Revue D'Economie Industrielle*, vol. 94(1), pp. 49–68.

Guellec, D. and van Pottelsberghe de la Potterie, B. 2004. From R&D to Productivity Growth: Do the Institutional Settings and the Source of Funds of R&D Matter? *Oxford Bulletin of Economics and Statistics*, 66, 353-78.

Gustavsson-Tingvall, P. and Ljungwall, C. 2012. Is China different? A meta-analysis of export-led growth, *Economic Letters*, 115, 177–9.

Griffith, R., Redding, S., and van Reenen, J. 2004. Mapping the two Faces of R&D: Productivity Growth in a Panel of OECD Industries, *The Review of Economics and Statistics*, November, 86(4): 883–895.

Griliches, Z., 1986. Productivity, R&D and Basic Research at the Firm Level in the 1970s', *American Economic Review*, 76, 141-54.

Griliches, Z. 1992. The Search for R&D Spillovers, *Scandinavian Journal of Economics*, 94, S29-S48.

Görg, H., and Strobl, E. 2001. Multinational companies and productivity spillovers: a meta-analysis. *Economic Journal* 111, 723-739.

Herrera, S., and Pang, G. 2005. Efficiency of Public Spending in Developing Countries : An Efficiency Frontier Approach. World Bank Policy Research Working Paper No. 3645.

Jaumotte, F., and Pain, N. 2005a. From Ideas to Development: The Determinants of R&D and Patenting. OECD Economics Department Working Paper No. 457.

Jaumotte, F., and Pain, N. 2005b. An Overview of Public Policies to Support Innovation. OECD Economics Department Working Paper No. 456.

Lichtenberg, F.R. and Siegel, D. 1991. The Impact of R&D Investment on Productivity – New Evidence Using Linked R&D–LRD Data, *Economic Inquiry*, 19(2), 535-51.

Ljungwall, C., Tingvall, P. 2010. Is China different? A meta-analysis of the effects of foreign direct investment on domestic firms. *Journal of Chinese Business and Economics Studies* 8(4), 353-371.

Ljungwall, C and Tingvall, Gustavsson, P. 2013. Is China different? A meta-analysis of China's financial sector development, *Applied Economics Letters*, vol. 20(7), pages 715-718, May.

Mansfield, E., 1980, 'Basic Research and Productivity Increase in Manufacturing', *American Economic Review*, 70, 862-73.

Meyer, K., and Sinani, E. 2009. When and where does foreign direct investment generate positive spillovers? A meta-analysis. *Journal of International Business Studies* 40(7), 1075-1094.

Nadiri, M.I., and Mamuneas, T.P. 1994. The Effects of Public Infrastructure and R&D Capital on the Cost Structure and Performance of U.S. Manufacturing Industries, *Review of Economics and Statistics*, 76, 22-37.

Organisation for Economic Co-operation and Development. 2003. *The Sources of Economic Growth in the OECD Countries*. ISBN 92-64-19945-4, OECD.

Park, W. 1995. International R&D Spillovers and OECD Economic Growth, *Economic Inquiry*, 33, 571-91.

Romer, P. 1990. Endogenous Technological Change, *Journal of Political Economy*, 98(5), S71-102.

Solow, R.M. 1957. Technical Change and the Aggregate Production Function. *Review of Economics and Statistics*, Vol. 39(3), pp. 312–320.

Stanley T.D. 2008. Meta-Regression Methods for Detecting and Estimating Empirical Effects in the Presence of Publication Selection. *Oxford Bulletin of Economics and Statistics*, 70**(**1), 103-127.