International Business and Accounting Research Journal
Volume 1, Issue 1, February 2017, 9-17
http://ibarj.com

Reflections on The Possibility of Using Statistical Analysis Science and Innovation in The Republic of Moldova

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Info Articles

History Articles:
Received 1December 2016
Accepted 15 January 2017
Published 2 February 2017

Keywords:
Statistical evaluation, research and development, profitability of the enterprise, level of the innovation, level of expenses of R&D.

Abstract

The evaluation and comparability of statistics indicators of the science and innovation on international background reflect country competitiveness and it position regarding field of science, innovation and distribution of new technologies. Better comprehensions of the factors that contribute at the success in these fields are helped by using proper indicators like instruments of identification of the best practice. But the system of indicators is developed only for the ”science”. The ”innovation” in Moldova is not covered by statistical work and can only be assessed indirectly.

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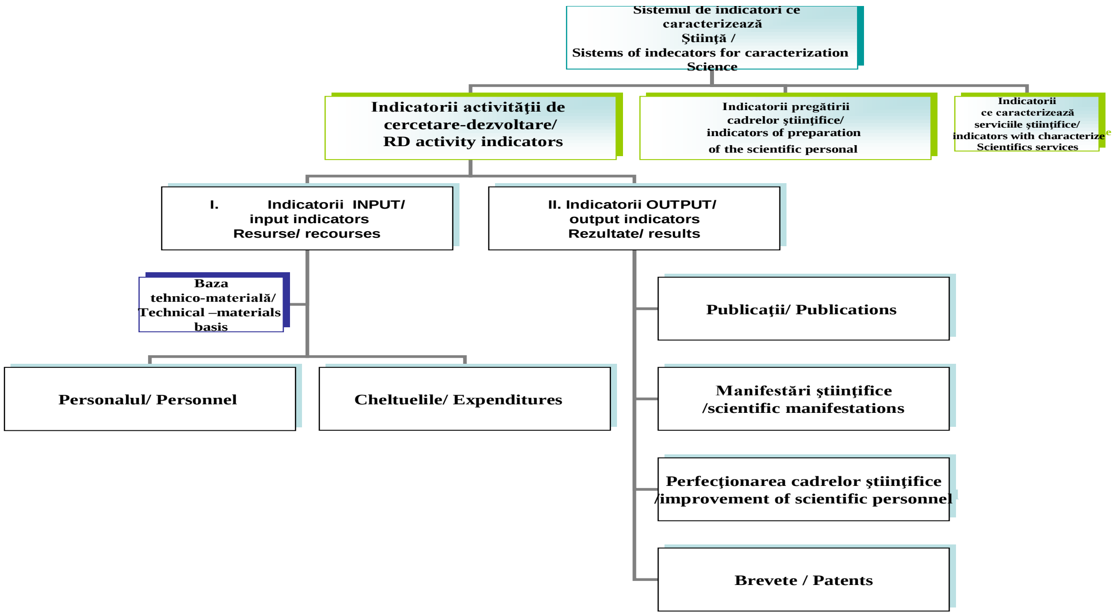
e-ISSN 2549-0303

INTRODUCTION

Statistical evaluation of research and development focuses on two groups of indicators: input and output. Input indicators (input) characterizes research and development resources, and output indicators (output) characterizes the results of research and development. In this study we refer to the characterization of the first group of indicators and specific indicators that characterize the research and development resources.

That is why our analysis will be based on three main parts that characterize the "science": scientific organizations, scientific and expenditure frameworks for this domain.



Schema 1. The system of indicators to characterize the area of "Science" Elaborated by the author in accordance with the Frascati Manual.

The financing of Academy of Sciences of Moldova (from the national budget) is done on the ”science and innovation”.

But the system of indicators is developed only for the”science”. The”innovation” in Moldova is not covered by statistical work and can only be assessed indirectly.

For the most part all national statistics can only provide information on "Resources"

As a first step in evaluating research and development we will look at indicators of input (Resources). To characterize the **material and technical base** of research and development sector primarily need instutional structural analysis of this sector**: organizations and institutions in the research and development.**

Dynamics of institutions (organizations) working in research and development in Moldova demonstrates a clear tendency to decrease them. If in 1999 85 organizations working in this field, in the year from 2005 to 88 organizations in 2016 when only 68 organizations. This decrease is mainly on account of reduction in the number of specialized research and development, others, including higher education institutions, maintaining the same level.

Research and development in 2016, according to NBS data, was conducted in 68 organizations in the sphere of research and development, including 41 research units specialized in development, design and construction of 10 offices, three organizations design and design-Exploration in construction, 12 higher education institutions, an experimental unit status and an industrial base. The total number of institutions 81% (55 institutions) were public establishments, 12% (8 organizations) private enterprise.

So if we spend very little scientific research, we cannot expect in this case improving the performance and national completeness. Through increased imports policy, we will not achieve the expected goals. And in the situation when either investment is not rushing to run in country what's the path to prosperity? China's miracle economy overwhelms us. But today China attracting 60 billion dollars FDI, a new Republic of Moldova, at this chapter is not among the leaders. Taking into account that foreign investment per capita in Republic of Moldova are not sufficient for a qualitative improvement the question is where will we get and which will be the future of our country?

It is well known that efficient worldwide scientific apparatus costs very expensive. And for Moldova, where prices are higher than in many European countries, decrease spending for research, on the one hand and on the other hand, taking into account, that at this chapter foreign investment per capita Moldova is among the countries with the lowest investments, we can ask how is shown economic development on long term of our country.

The main objective of improvement of the science funding system in terms of reform scientific-technical sphere is to ensure that restructuring and development of this would be made in conditions of limited financial resources. Fiscal policy should include target meeting of state needs and society in this area. Improvement significantly of financial situation in science field can be realized through redistribution and concentration of budget on priority areas, selective support of industry research organizations, and attracting the extra-budgetary sources of private equity funds.

All system of public funding of organization of research and development must be "transparent" to avoid the excess use and for ensure efficient use of budgets funds.

Analyze of the material and technical basis using the available information from the National Bureau of Statistics of Moldova.

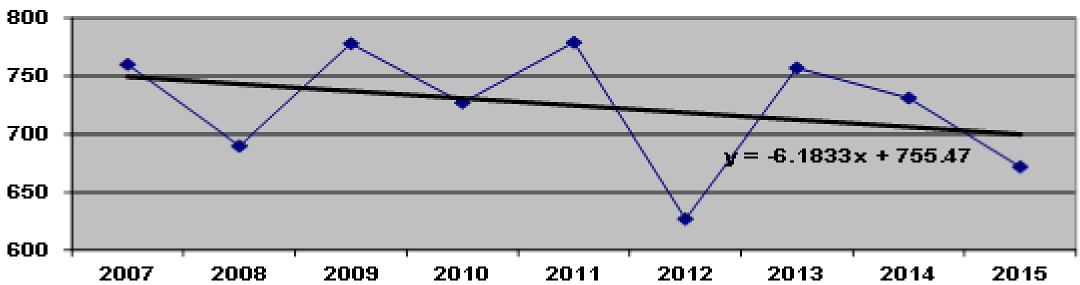


Figure 1. Dynamics of fixed assets in the research and development organizations, million. Source: Elaborated by the author based on information NBS

Changes in this indicator are essential given time segment. It is necessary to note the negative trend in the changes in value of fixed assets in research institutions. Using the analytical method for linear adjustment, it can be concluded that the cost of fixed assets in research institutions in the country show an average annual reduction of more than 3 million. Given the high level of price increases will see a significant reduction of fixed assets.

Statement of assets distribution according to property forms the major share of research confirms the institutions and agencies; private research share is very low and hence the share of assets of private establishments with only a 6.5% share.

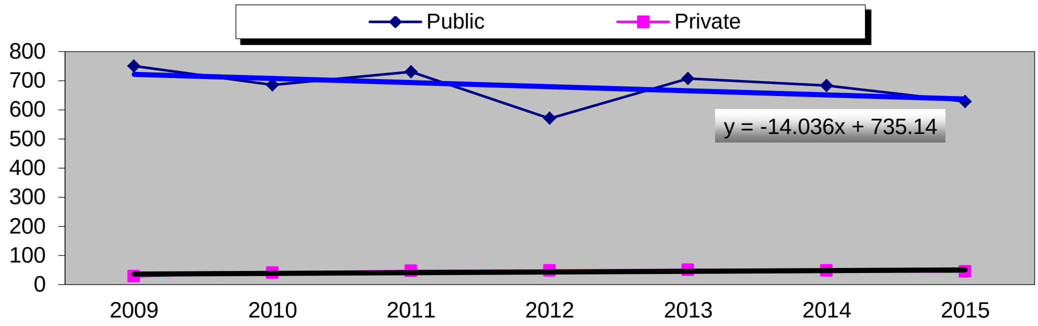


Figure 2. Assets dynamics research and development organizations under the scope of ownership, million lei. Source: Elaborated by the author based on information NBS

Evaluation of the situation with the proposed indicators of this system allows the collection of information needed to conduct correctly this domain statistics scientific and innovation activity.

For a statistical description and an evaluation of the correlation in the domain of science and innovation the research must be based on the use of regression and correlation methods.

The study based on regression and correlation is necessary to be divided into three basic stages.

1. The qualitative analysis of the studied phenomenon.
2. Construction of relationship's model.
3. Interpretation of results.

Statistical relationships are characteristic for the social-economic phenomena, therefore the statistics has developed a set of methods of study of relationships which selection depends on research objectives and on tasks.

One of often used regression's models for economic growth modeling is a Cobb-Douglas function.

Based on the methodology of the International Assessment of innovation can apply the methods of statistical and mathematical modelling.

IUS 2010 methodology broadly follows the methodology of previous editions, namely: there are three types of innovation indicators and eight dimensions, which in total represent 25 different indicators.

POSSIBILITIES found the main engine of innovation performance of firms and distributed within the dimensions of innovation: Human Resources indicators -3; System Research - 3 indicators; Financial Support - 2 indicators.

FIRMS ACTIVITY are innovative efforts at the firms level and are diversified in three dimensions: Investment Company - 2 indicators, links & Entrepreneurship includes three indicators, Intellectual Assets.

OUTPUTS contain effects from innovation activities of the firms and are varied on two innovation dimensions:

Innovators - 3 indicators,

Economic Effects - 5 indicators.

This methodology is predestined to balanced evaluation of innovative activity taking into account the diversity of innovation processes taking place in world economies.

Such methodological approaches that were utilised as criteria of real economic activity economic indicators were used by several authors. For example the number of domestic bidders for patent in Russian Federation (Ivanova, I. Dejina, I, 2008) , the share of high technology exports with high scientific rate and the share of high technology exports in total exports were used as performance indicators.

In the publications of the Ukrainian scientists (Sadcov V., 2002, Liubici F., Harazasvili I., Denisiuc V., 2009, Crotov S. 2004,), based on official statistical data, calculations of the indicators that characterize innovation process were performed. In the publications (Crotov S. 2004) have been proposed innovative modalities to assess the level of society development and the integral criteria for innovation economy evaluating. In the publications (Liubici F etc. 2009) is proposed an aggregate indicator for assessing of the socio-economic innovation level.

This indicator depends on many factors, such as integrated productivity, technological level of production, the shadow economy, the social equity, and the utilization of labour and also the use of not explored potential. Here the supply is modelled using Cobb-Douglas production function, generalized technological factor being characterized by the innovation level. The components of this integrated criterion for socio-economic effectiveness assessing concerns:

1.GDP per one unit of the production capacity or total productivity;
2. Social equity;
3.Shadow economy;
4.Labor force utilization;
5. Technology of the production;
6. Potential GDP.

All indicators are normed, the maximum value being equal to one unit, and their product evaluates integrated effectiveness: $EF_t = \prod_1^6 k_i$. As a criterion for effectiveness degree determining is proposed $IE_t = \left(\frac{EF_t}{EF_{t-1}} - 1 \right) 100\%$ .Further, efficiency indicators are calculated based on integrated supply expressed by Cobb-Douglas type production function

$$Y_t = \sigma_t \exp(\gamma t) L_t^{\alpha t} \left(\vartheta_t K_t \right)^{(1-\alpha)t} .$$

Here σ_t is the share of GDP in production volume, γ is the rate of technical progress, L_t are labour costs ($N = \xi NW$), ξ determining share of private sector employees in total employment, N are all employees. K_t is the production capital cost, W is the nominal annual wage, ϑ is the coefficient of production capital use.

At the initial stage is assumed that the pace of technical progress is equal to = 0.5% annually. The authors forward the hypothesis, which argues that the first iteration of this coefficient reflects the innovation. Which enables calculation of the rate of technological progress as endogenous.

Further, this result will be applied to the Republic of Moldova and the calculation of aggregate demand coefficients will use the approach proposed in the publications (Sadcov V., 2002), the production function is Cobb-Douglas type $Y_t = \theta_0 e^{\vartheta_3 t} K^{\theta_1} L^{\theta_2}$.

Here K and L is the aggregate stock of capital and labour, $\theta_i \, (i = 0,1,2)$ are coefficients to be determined. It is well known that estimating aggregate supply as proposed is a very serious problem because only a few countries in development have dynamic data on capital stocks, so it will apply the method proposed in the publications (Gorbanyov, M., 2010), namely, differential equation $K_t = (1-\rho)K_{t-1} + Inv_t$ solution in which ρ is the rate of capital depreciation, maz be written as:

$$\log K_t = \log\left[\sum_{i=0}^{t-1}(1-\rho)^i Inv_{t-i} + (1-\rho)^t K_0\right] \approx$$

$$\log 2 + \frac{1}{2}\left[\log \sum_{i=0}^{t-1}(1-\rho)^i Inv_{t-1} + \log(1-\rho)^t K_0\right] =$$

$$= \log 2 + \frac{1}{2}\log \sum_{i=0}^{t-1}(1-\rho)^i I_{t-1} + \frac{t}{2}\log(1-\rho) + \frac{1}{2}\log K_0$$

Here K_0 is the initial capital stock. So, $\log Y_t = \log\theta_0 + \theta_1 \log K_t + \theta_2 \log L_t = \theta_0^{'} + \theta_1 K_t^{'} + \theta_2 \log L_t$

$$\theta_0^{'} = \log\theta_0 + \frac{\theta_1}{2}\log K_0 \ , K_t^{'} = \log 2 + \frac{1}{2}\log \sum_{i=0}^{t-1}(1-\rho)^i Inv_{t-1} + \frac{t}{2}\log(1-\rho)$$

(Here is used the following decomposition in series $\log(x+y) \approx \log 2 + \frac{1}{2}(\log x + \log y) + \frac{1}{8}(\log x - \log y)^2 + \ldots$,

here $x = \sum_{i=0}^{t-1}(1-\rho)^i I_{t-i}$, $y = (1-\rho)^t K_0$. As in [13] $K_0 = 2.5 * Y$.

Suppose constant return to scale, then ($\theta_1 + \theta_2$ = 1), and dividing expression for the aggregate supply in the logarithm to the $\log(L_t)$ obtaining:

$\log(Y_t / L_t) = \theta_0^{'} + \theta_1(K_t^{'} - \log L_t)$ .Then insert a term into the equation dependent on t, that it becomes

$\log(Y_t / L_t) = \theta_0^{'} + \theta_1(K_t^{'} - \log L_t) + gt$.

The present model has been estimated under complete price-wage flexibility. In these circumstances, the previous equation is the aggregate supply function: the value of TFP is estimated at about 5.9% and the production function coefficients of 0.73 and 0.27 respectively, are higher than those estimated in this parers (Gorbanyov, M. 2010, Papaphilippou, A. 2012),

Gorbanyov, M. 2010 and Papaphilippou, A. 2012, have been modelled and aggregate supply and coefficients were estimated production function, used as a model, taking values 0.54, 0.58 and 0.42 and 046 respectively. In estimating these coefficients was used calibration method based on the ratio of capital to GDP in 1999 equal to 2.5, then using the formula for capital accumulation series data for GDP and employment, annual values was calculated TFP using production function model.

In in the publications (Casadio, P., Paradiso, A. and R. B. Bhaskara, 2011) have proceeded as follows. From economic growth in the state of the model Sollow stability (Solow, R. M.1956) $y^* = \left(\frac{s}{\delta + g + n}\right)^{\alpha/(1-\alpha)} A$, here $y^* = Y / L$ is the amount of income per capita in the state of stability, s is the ratio of investment to income, δ is the depreciations rate of capital, g is the rate of technical progress, n is the rate of population growth and α is the exponential power of the capital in the Cobb-Douglas production function. This implies that the growth rate in the state of stability is as follows $\Delta \ln y^* = \Delta \ln A = PTF$. Then, the production function $Y_t = A_t K^{\alpha} L^{(1-\alpha)}$ is considered and the stock of knowledge in it evolves the form $A_t = A_0 e^{\left(\gamma_i Z_{it} + \phi_1 S_t + \phi_2 S_t^2 + \varphi_1 W_t\right)}$. After some transformations is obtained $\ln y_t = \ln A_0 + \gamma_i Z_{it} t + \phi_1 S_t + \phi_2 S_t^2 + \varphi W_t + \alpha \ln k_t$ here $y = Y / L$ and $k = K / L$. So, GDP depends on the production factors accumulation and on the variables that do not relate to the production factors: Z,S,W . Because the stability state $\Delta \ln k \to 0$, GDP growth rate is equal to the stock of knowledge, which is shown in the publications (Liubici F., Harazasvili I., Denisiuc V., 2009). Therefore, the authors have proposed two methods for determining the growth of the GDP:

$$g_1 = \gamma_i Z_{it}$$

$$g_2 = \gamma_i \Delta Z_{it} + \gamma_i Z_{it} + \phi_1 \Delta S_t + 2\phi_2 \Delta S + S_t + \varphi \Delta W_t$$

In the case when $Z_1 = TRADE$, $Z_2 = IRAT$, $S = HKI$ as the first variable is the share of Trade Balance in GDP, the second variable is the ratio of investment to GDP and the third variable is nothing than the human capital indices.

So, Ukrainian researchers approach from the publications (Liubici F., Harazasvili I., Denisiuc V., 2009) proposes for the TFP estimation an iterative algorithm that ensures convergence of the effectiveness indicator to the Total Factor Productivity indicator. And the approach offered in the publications (Turcan, A., 2010) provides this indicator estimation through regresional calculus.

We try to apply both approaches to the economic situation of the MR. Based on the statistical information on the main macroeconomic indicators evolution for the years 2000-2011 in current prices, GDP and capital data were recalculated per engaged in work. Then were perfected data for educational level using (Turcan, A., 2010) data for investments, net export offered by NBS were used to calculate these indicators share in GDP. Capital was calculated based on the accumulation relationship, based on the GDP value equal to 2.5 for 2000 (A. Papaphilippou, 2012), applying the formula $K_t = (1-\rho)K_{t-1} + Inv_t$ rate of capital depreciation receiving values 0.023 and 0.04 (A. Papaphilippou, 2012), and then to apply the of Ordinary Least Squares Method for the GDP and TFP estimations respectively. As in the publications Casadio, P, 2011 to estimate GDP were used three variables not related to the of production factors: share of net exports in GDP, share of investment in GDP and the human capital indices in the following formula:

$$\ln y_t = Const + \alpha \ln k_t + \phi_1 \ln HKI_t + \phi_2 (\ln HKI_t)^2 + \gamma_1 \ln HKI_t \cdot t + \\ + \gamma_2 TRADE_t \cdot t + \gamma_3 ERAT_t \cdot t$$

For, $\rho = 0.023$ after several calculations was appealed to a more appropriate from economic point of view functional form, containing variable with increased significance

$$\ln y_t = Const + \alpha \ln k_t + \phi_2 (\ln HKI_t)^2 + \gamma_1 \ln HKI_t \cdot t$$

-0.6279	0.4385	0.009	0.9483
(3.0576)	(0.2018)	(0.0150)	(0.2505)
[-0.2054]	[2.1733]	[6.6389]	[3.7853]

$R^2 = 0.9974$, $F = 1032$

in the round parentheses are standard deviations and in those squares are t-statistics.

While for $\rho = 0.04$ in the same formula $R^2 = 0.9987$, $F = 1020$

$$\ln y_t = Const + \alpha \ln k_t + \phi_2 (\ln HKI_t)^2 + \gamma_1 \ln HKI_t \cdot t$$

-1.9102	0.4876	0. 009	0.9483
(3.5731)	(0.2218)	(0.0131)	(0.2862)
[-0.5346]	[2.1987]	[8.1598]	[3.725]

In parentheses are standard deviations indicated in those squares and t-statistics, R2 = 0.9974, F = 1041.289.

The TFP coefficient calculating in accordance with approach offered in [1] will be based on the indicators values: GDP in relation to production volume, education level, labour utilization, the poverty rate of the shadow economy, trade balance, so $EF_t = \prod_1^6 k_i$. Using historical data for these indicators, the effectiveness index values for all years in review were calculated.

Note, that applying three approaches outlined above, averages result were obtained: 1. PTF ese examined as exponential term in production function estimated using statistical data on investment, which is equal to 0.059, 2. TFP is calculated based on indicators that are educational level, with an estimated value of 0.056, 3. PTF is assessed against the product of six socio-economic indicators, refer to the power exponential increase in the production function and equals 0.041. Reveals that the first two values are very close, while the third value is much lower. Explanation could be that values of the indicators used in this calculation are of the lower credibility.

Table 1. Lstimated value of the TFP and lny lognormal logarithm from GDP/L

Yars/ ρ	2000	2001	2002	2003	2004	2005	2005	2007	2008	2009	2010	2011
0.023	5.43	5.58	5.72	5.86	5.99	6.12	6.21	6.28	6.34	6.39	6.43	6.52
0.04	5.02	5.16	5.30	5.43	5.56	5.67	5.75	5.81	5.87	5.91	5.94	6.03
lny .023	9.26	9.46	9.64	9.88	10.09	10.29	10.47	10.65	10.80	10.92	11.02	11.15
lny 0.04	9.26	9.46	9.64	9.88	10.09	10.29	10.47	10.65	10.80	10.92	11.02	11.15

Calculation (Total Factor Productivity) PTF under the approach will be made based on the values of the six indicators above, the supplement to the rate of remittances in GDP, the rate of investment in GDP

Table 2. Total Factor Productivity

Yars	2001	2002	2003	2004	2005	2005	2007	2008	2009	2010	2011
GDP/X	0.473	0.459	0.459	0.452	0.455	0.460	0.447	0.440	0.4473	0.480	0.482
Education	0.107	0.105	0.102	0.1	0.098	0.095	0.092	0.089	0.086	0.083	0.081
Labour	0.199	0.198	0.221	0.184	0.154	0.167	0.163	0.186	0.212	0.246	0.283
Poverty	0.678	0.546	0.404	0.29	0.265	0.302	0.258	0.264	0.263	0.219	0.204
Informal economy	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Trade	-0.24	-0.25	-0.34	-0.30	-0.41	-0.47	-0.52	-0.53	-0.37	-0.39	-0.41
PTF	6.6	5.2	5.6	2.9	3.0	4.1	3.6	4.1	3.3	3.4	3.7

Source: Created by author based on information from http://www. statistica.md

CONCLUSION

We can live certainly, and without science, using result of research from other countries. But in this case, without scientific and technological capabilities in our country will be impossible to build a economy of XX century. It is well known that the countries with a strong scientific basis determine that will be the quality of life and of technology in future.

Therefore, to obtain a qualitatively new situation in statistical science and innovation is necessary to solve two problems simultaneously:

1. developing a correctly system of indicators for the pemanent monitorings
2. The use of factor analysis to improve the situation in the field.

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