

TOTAL FACTOR PRODUCTIVITY - INFLUENCE FACTOR OF THE ECONOMIC GROWTH POTENTIAL. PRACTICAL APPLICATION*

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Abstract

Adequate to the new requirements of economy, the economic research has achieved progresses in addressing the issues regarding the growth and development, the economists drawing a number of theories and models, in order to find resorts that lead to sustainable growth. The paper refers to the means of assessment and forecast of the potential growth of an economy, by using a mathematical model, whose production function takes into consideration the role of three factors, being highlighted the role of the Total Factor Productivity, as an element of influence on growth with the other two factors. The study includes an application of the model use, for the analysis of the growth potential of the economy, at national level.

Keywords

Total Factor Productivity; mathematical model; growth potential

JEL Classification

C53; D24

1. Introduction

The economic literature has given a particular interest to the analysis of growth problems and its determinants, trying to explain the forms of economic phenomena occurrence and provide alternatives concerning the ways to achieve growth. The emphasis was on measures which lead to performance achievement regarding the welfare and sustainable growth: capital investments, stimulate research and development activities and, respectively, technical progress, well-trained workforce etc.

The economic research has achieved progresses in addressing problems regarding the development, economic growth, world trade, the economists initially, formulating theories and models based on perfect competition and, subsequently, moving to models of imperfect competition, according to the new requirements of economy, the aim being to find the springs which lead to sustainable growth.

2. Total Factor Productivity

The estimation and forecast of the growth of an economy potential, basically, takes into account: the available amount of labour, the amount of capital that can be used and the Total Factor Productivity, the latter being considered a "residual", respectively, that part of the output unexplained by the amount of inputs used in production.

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Assimilated to technical progress, the Total Factor Productivity, more broadly, includes the other sources of growth, different from the factors, labour and capital, its level being determined by the extent of efficiency and intensity of the inputs used in production.

The Total Factor Productivity (TFP) is based on the determination of estimated GDP, using the homothetic Cobb-Douglas production function.

$Y = AK^\alpha L^{1-\alpha}$, where:

Y – the output – GDP;

α – the elasticity coefficient;

A – the productivity;

K – the capital stock;

L – the workforce

"Toupticionnaire"¹ defines the concept of "Total Factor Productivity or multifunctional productivity, as a ratio of the production value to the total value of the inputs used (labour and capital)", allowing to measure the effectiveness of productive combination of labour and capital.

The TFP is determined, in general, at a scale of a country or economic zone, its evolution, over time, allowing the evaluation of the relative growth, other than the one in relation to the use of production factors, labour and capital.

The parties of capital and labour are dissociated by the elasticity coefficient, α .

The capital and labour remain the major contributors of production, but the growth vector is considered *the Total Factor Productivity (TFP)*, which can influence the economic growth, its corner stone being the technical progress.

The technical progress determine the increase in the factors productivity, leading to their qualitative and not only quantitative growth, what gives growth an intensive nature.

The production growth is superior to the growth of each factor, as such, the effectiveness of factors, respectively, the productivity increases due to the process of innovation or improvement of work setup.

The difficulty in applying the model results from the assumptions taken into account and the interpretation of results:

- a number of elements may influence the quality of factors productivity (the technical progress), respectively, change of the production structure (the production of more goods and services, with saving of capital and labour) or of its setup, the education, research and development (R&D), the growth of skilled workforce, what makes it difficult to correctly determine the technical progress;
- the information required by the calculation of capital stock and labour development, also, of prices development;
- considering the elasticity rates taken in the series of that two factors.

3. Application for Romania

In the following, it is presented an application regarding the analysis of the potential of economy growth, at national level, using as model, the Cobb-Douglas production function with TFP.

¹Toupticionnaire – Le dictionnaire de politique – „Productivité globale des facteurs (PGF)”, La Toupie, <http://www.toupie.org>;

The used model (Ghizdeanu, I.; Tudorescu, V.; Neagu, M.)²: the Cobb-Douglas production function $Y = N^\alpha \cdot K^{1-\alpha} \cdot TFP$, where:

$Y = \text{GDP}$

$N = \text{the employed population}$

$K = \text{the stock of capital}$

$TFP = \text{the Total Factor Productivity}$

For the expression of factors, in a single unit, it is using the linearly-homogeneous function, obtained by logarithm:

$$\ln Y = \alpha \cdot \ln N + (1-\alpha) \cdot \ln K + \ln TFP \rightarrow y = \alpha \cdot n + (1-\alpha) \cdot k + tfp$$

where:

$$y = \ln Y;$$

$$n = \ln N;$$

$$tfp = \ln TFP;$$

α – coefficient of elasticity of the labour factor - N

$1-\alpha$ – coefficient of elasticity of the capital factor – K , $0 < \alpha < 1$

3.1. The work steps of the application

I. The determination of the Total Factor Productivity, as a residual variable in the considered production function, at a given value of the parameter α ; the *tfp* value is determined on each year, based on the values Y , N , K of ASR - INS, for the period 2000-2012; this is the time series of the *observed tfp*.

$$tfp = y - [\alpha \cdot n + (1-\alpha) \cdot k]$$

II. For the time series of *tfp* (from the step 1) it is applied the TREND function and, thus, it is obtained the adjusted series of *tfp*, for the period taken into account (2000-2012), as well as the *ptf* forecast for the years 2013-2015 (noted by *tfp**).

III. For the time series corresponding to n labour factor (the employed population) observed, based on the data from ASR (time series 2000-2012) it is applied the TREND function, achieving thus, the adjusted series of the factor - n - for the period taken into account (2000 -2012), as well as the forecast for the period 2013-2015 (noted by n^*).

IV. The determination of the capital stock for each year of the period (2013-2015), considering the forecast of the indicator *gross fixed capital formation* determined according to the relation:

$$K_t = (1-\delta) \cdot K_{t-1} + I_t$$

where:

K_t - the capital stock for the year t ;

δ - the rate of capital depreciation;

I_t – the investment for the year t .

•The estimation of the size of current investment is accomplished by applying a constant rate - β - to the GDP value of the previous year.

$$I_t = \beta \cdot \text{GDP}_{t-1}$$

•The values determined above shall be entered in the logarithmic production function to obtain the y values for the years for which the forecast it shall be accomplished.

•It shall be determined the Y value, respectively GDP, for the forecast years (by antilogarithm).

²Ghizdeanu, I.; Tudorescu, V.; Neagu M, *Model de determinare a potențialului de creștere a economiei românești în perioada 2005-2025 – sinteză preliminară*, Comisia Națională de Prognoză, www.presidency.ro/include/nssd.

The calculations associated with *the national level* take place alternatively, every year in part, because the current *I* investment, is determined based on the previous year GDP.

3.2. Calculations and analysis associated with work steps

Following the previously announced work steps, the analysis highlights the following issues:

I. The tfp calculation $\alpha = 0.30$: $tfp = y - [\alpha \cdot n + (1 - \alpha) \cdot k]$
 $tfp = y - (0.30 \cdot n + 0.70 \cdot k)$. The evolution of GDP and the main determinant factors (the employed population, capital, tfp) taken into account for the analysis (time series 2000-2012), is mentioned in the Annexes 1 and 2 and shown in the graphics below (Figures 1-3):

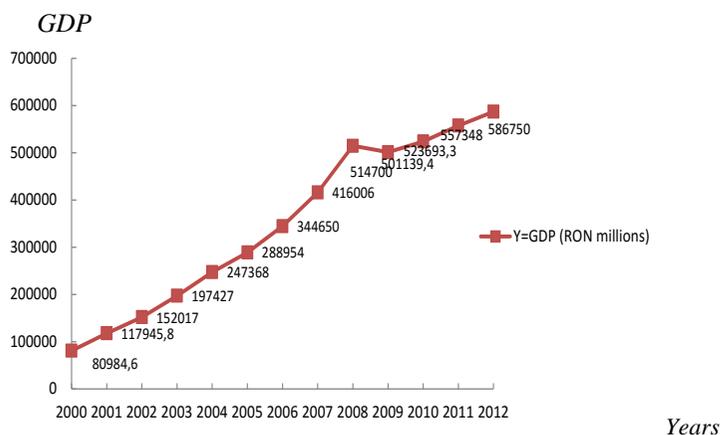


Figure 1 The evolution of the observed GDP in the period 2000-2012

Source: data processing based on the data from ASR 2012, ASR 2013, INS, București, 2013, 2014, www.insse.ro

The data in Figure 1 reflects an upward evolution throughout the period, interrupted in the year 2009 (peak of the crisis), but resumed in 2010.

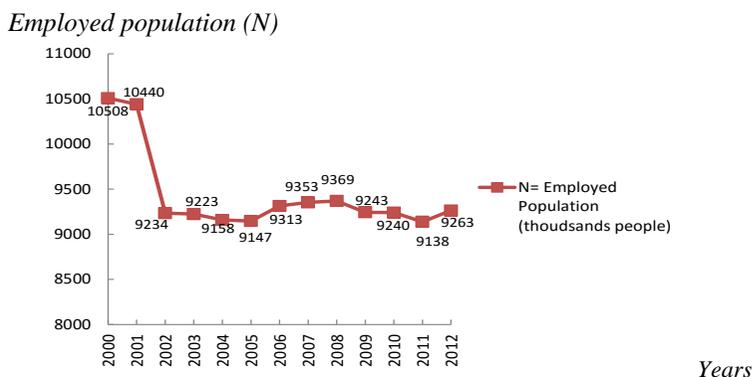


Figure 2 The evolution of the employed population in the period 2000-2012

Source: data processing based on the data from ASR 2012, ASR 2013, INS, București, 2013, 2014, www.insse.ro

The employed population had a sharp decrease in the year 2002 beside the year 2000 (1274 thousands people), respectively, 12%, unrecovered until the year 2012, the increases and decreases in the period, being sensitively contiguous.

Capital (K)

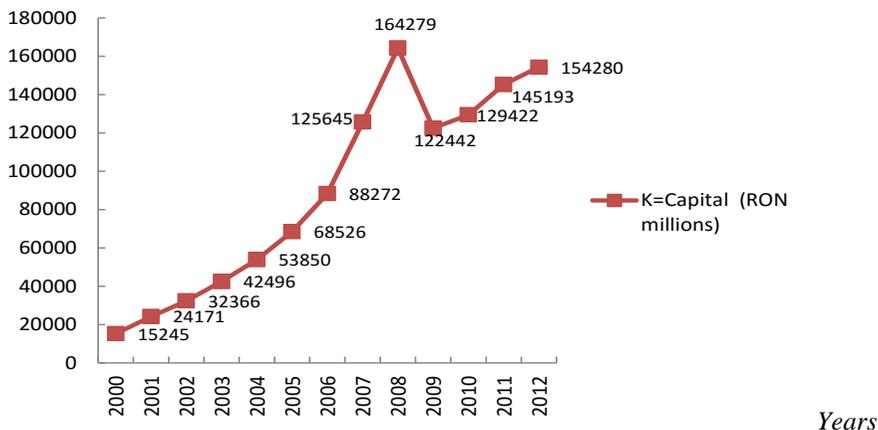


Figure 3 The evolution of the capital in the period 2000-2012

Source: data processing based on the data from ASR 2012, ASR 2013, INS, București, 2013, 2014, www.insse.ro

The capital had an evolution, similarly to GDP, but the decrease in 2009 had not integrally been recovered, by 2012.

II. The determination of the *adjusted tfp* (time series 2000-2012) and the *forecast tfp** (2013-2015) should be found in the Annex 3, represented according to the graphic in the Figure 4.

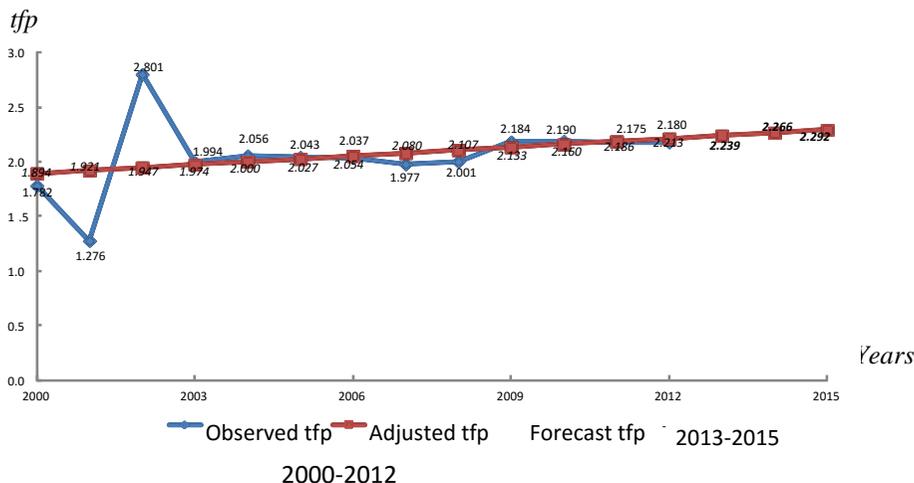


Figure 4 The evolution of the observed, adjusted and forecast tfp

Source: data processing based on the data from ASR 2012, ASR 2013, INS, București, 2013, 2014, www.insse.ro

The evolution of the *observed tfp* shows a higher level of its, at the end of the period - 2012 – beside the start 2000, respectively, 2.18 unto 1.78, the oscillations, increasing or decreasing , in the interval series, being correlated with the changes in other factors and expressing the contribution of *tfp* to GDP achievement, such as:

- The *tfp* level increase in the years 2002, 2004, 2005, beside the previous years, given the conditions of a sensitive decrease of the employed population, expressing the contribution of *tfp* to GDP growth (the capital is also increasing).
- The *tfp* level decrease, in the year 2007, compared to the year 2006, the GDP being sustained by the growth both of the capital and of the employed population, compared to the previous year.
- The *tfp* increase in the year 2009 compared to 2008 (from 2.0 to 2.18) sustaining the GDP achievement that decreased, given the fact that both the employed population and the capital had a substantial decrease, as an effect of the crisis.
- The adjusted *tfp* data, determined based on the trend, follow the same evolution, being sensitively contiguous to the observed *tfp*.

III.The determination of the *adjusted n* factor (the time series 2000-2012) and of the *forecast n** , for the years 2013-2015, should be found in the Annex 4, represented according to the graphic in the Figure 5.

*Adjusted n and forecast n**

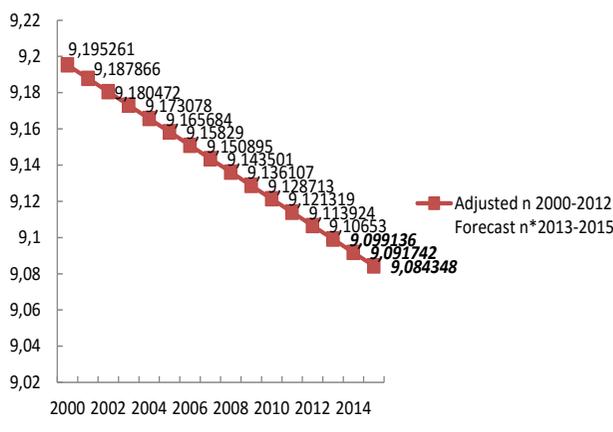


Figure 5 The evolution of the adjusted and forecast n factor

Source: data processing based on the data from ASR 2012, ASR 2013, INS, București, 2013, 2014, www.insse.ro

The evolution of the employed population, highlights, also, in the data determined based on the trend, the continuous decrease of the indicator, both in the period 2000-2012 and in forecast, 2013-2015.

IV.The determination of the capital factor – K and, respectively, GDP, alternatively, in forecast each year.

There are considered constant rates, throughout the forecast period, respectively:

- the rate of capital depreciation - 0.15 $\delta = 0.15$
- the investment rate - 0.048 $\beta = 0.048$
- I_t – the investment in the current year

$$gdp_t = \alpha * n_t + (1 - \alpha) * k_t + tfp_t$$

$$K_t = (1 - \delta) * K_{t-1} + I_t$$

$$I_t = \beta * GDP_{t-1}$$

YEAR 2013

$$gdp_{2013} = \alpha \cdot n_{2013} + (1-\alpha) \cdot k_{2013} + tfp_{2013}$$

The factors tfp and n should be found in the data from the Step 2 and, respectively, 3.

$$K_{2013} = 0.85 \cdot K_{2012} + I_{2013};$$

$$K_{2012} = 154288 \text{ (Data base – ASR 2013)}$$

$$I_{2013} = 0.048 \cdot GDP_{2012};$$

$$GDP_{2012} = 586750 \text{ (Data base – ASR 2013)}$$

$$I_{2013} = 0.048 \cdot 586750$$

$$I_{2013} = \mathbf{28164}$$

$$K_{2013} = 0.85 \cdot 154288 + 28164 = 131144.8 + 28164 = 159308.8$$

$$K_{2013} = \mathbf{159308.8}$$

$$k_{2013} = \ln K = \ln 159308.8 = 11.97859$$

$$k_{2013} = \mathbf{11.97859}$$

$$gdp_{2013} = 0.30 \cdot 9.099 + 0.70 \cdot 11.97859 + 2.24$$

$$gdp_{2013} = 2.7297 + 8.385013 + 2.24 = 13.354713$$

$$pib_{2013} = 13.354713$$

$$GDP_{2013} = EXP 13.354713 = 630780.4 \text{ (the natural antilogarithm of the number 13.354713)}$$

$$GDP_{2013} = \mathbf{630780.4}$$

YEAR 2014

$$gdp_{2014} = \alpha \cdot n_{2014} + (1-\alpha) \cdot k_{2014} + tfp_{2014}$$

$$K_{2014} = 0.85 \cdot K_{2013} + I_{2014}$$

$$I_{2014} = 0.048 \cdot GDP_{2013}$$

$$I_{2014} = 0.048 \cdot 630780.4$$

$$I_{2014} = \mathbf{30277.46}$$

$$K_{2014} = 0.85 \cdot 159308.8 + 30277.46 = 135412.5 + 30277.46 = 165689.9$$

$$K_{2014} = \mathbf{165689.9}$$

$$k_{2014} = \ln K_{2014} = \ln 165689.9 = 12.01787$$

$$k_{2014} = \mathbf{12.01787}$$

$$gdp_{2014} = 0.30 \cdot 9.092 + 0.70 \cdot 12.01787 + 2.26$$

$$gdp_{2014} = 2.7276 + 8.412509 + 2.26 = 13.400109$$

$$gdp_{2014} = 13.400109$$

$$GDP_{2014} = EXP 13.4001 = 660009$$

$$GDP_{2014} = \mathbf{660009}$$

YEAR 2015

$$gdp_{2015} = \alpha \cdot n_{2015} + (1-\alpha) \cdot k_{2015} + tfp_{2015}$$

$$K_{2015} = 0.85 \cdot K_{2014} + I_{2015}$$

$$I_{2015} = 0.048 \cdot GDP_{2014}$$

$$I_{2015} = 0.048 \cdot 660009$$

$$I_{2015} = \mathbf{31680.4}$$

$$K_{2015} = 0.85 \cdot 165689.9 + 31680.4 = 140836.4 + 31680.4 = 172516.8$$

$$K_{2015} = \mathbf{172516.8}$$

$$k_{2015} = \ln K = \ln 172516.8 = 12.05825$$

$$k_{2015} = 12.05825$$

$$gdp_{2015} = 0.30 \cdot 9.084 + 0.70 \cdot 12.05825 + 2.29$$

$$gdp_{2015} = 2.7252 + 8.44077 + 2.29$$

$$gdp_{2015} = 13.45597$$

$$GDP_{2015} = EXP 13.45597 = \mathbf{697996.9}; GDP_{2015} = \mathbf{697997}$$

$$GDP_{2015} = \mathbf{697997}$$

According to the calculations above, for the period 2013-2015, the forecast values of the model factors, are presented in the Table. 1.

Table 1 The forecast of GDP and of its determinant factors in the period 2013-2015

<i>Year</i>	<i>Y=GDP (RON millions)</i>	<i>N (thousands people)</i>	<i>K capital (RON millions)</i>	<i>tfp</i>
2013	630780	8946	159309	2,24
2014	660009	8884	165690	2,26
2015	697997	8813	172517	2,29

Source: data processing based on the data from ASR 2012, ASR 2013, INS, București, 2013, 2014, www.insse.ro

The forecast data show that, for national level, there is the possibility of a GDP growth due to the growth of capital and total factor productivity, the employed labor being in decrease. Taking into consideration the average annual growth rhythm during the 3 years period, the contribution of factors to potential GDP growth, is presented according to data in Table 2.

Table 2 The factors contribution to potential GDP growth

Contributions (%)				
Year	GDP	Employed population	Capital	tfp
2013-2015	5,2	-0,9	4	2,4

Source: data processing based on the data from ASR 2012, ASR 2013, INS, București, 2013, 2014, www.insse.ro

The growth rhythm of GDP of 5.2%, is sustained by the capital, 4% and by the total factor productivity, 2.4%. The negative increase of the labour factor, 0.9%, is the consequence of the significant decrease of population in the series taken into account, respectively, from 10508 thousands people, in the year 2000, to 9263 thousand people, in the year 2012.

The calculations based on testing the parameters, respectively, the coefficients of elasticity, for labour and capital, the rate of investment and the rate of capital depreciation, followed to obtain values for the **forecast GDP in the period 2013-2015, as close as to the values announced, in perspective, by Comisia Națională de Prognoză (CNP). Thus, the data forecast by calculation, for the years 2013, 2014 and 2015 are close to those forecast by Comisia Națională de Prognoză (CNP)³ (March 5, 2014) (Table 3)**

Table 3 The Gross Domestic Product (RON billions)

Year	Forecast in the paper	Forecast by CNP (March 5 2014)
2013	630,8	631,1
2014	660,0	664,4
2015	698,0	698,8

Source: own processing. The results reveal the verity of applying the model

³ Comisia Națională de Prognoză, *Proiecția principalilor indicatori macroeconomici pentru perioada 2014-2017*, 5 martie 2014, www.cnp.ro/prognoza

4. Conclusions

To estimate the forecast GDP and the contribution of factors to its achievement, there were taken into account, in the production function for national level, the following parameters: the coefficients of elasticity for labour and capital factors, $\alpha = 0.30$, and, respectively, $(1-\alpha) = 0.70$, the rate of capital depreciation, $\delta = 15\%$, the investment rate, $\beta = 4.8\%$.

The analysis showed the contribution of the labour and capital factors to the national GDP achievement, but also, the total factor productivity contribution, in the case of this indicator, the participation degree being different, by years, depending on the level of the other two factors, the labour and capital. The data obtained reflect an increase in production, in the forecast period, higher to the growth of each of the labour and capital factors, the level of total factor productivity expressing the efficaciousness of factors use.

The results lead to the conclusion that, the use of the model, although it exposes some difficulties in implementation, as mentioned in the introductory part, may be relevant to such analysis, if should be taken into account a careful testing of the value of the used parameters and a statistical data base, large enough, to be considered methodologically satisfactory.

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**Annex 1 Database for the calculation of logarithm values to:
 GDP, employed population, capital**

t	YEAR	Y=GDP RON millions	y=Ln GDP	N= Employed Population thousands persons	n=LnN	K=Capital RON millions	k= Ln K
1	2000	80984,6	11,30201	10508	9,259892151	15245	9,632007
2	2001	117945,8	11,67798	10440	9,253399861	24171	10,89396
3	2002	152017	11,93175	9234	9,130647603	32366	11,13497
4	2003	197427	12,19312	9223	9,129455643	42496	10,65717
5	2004	247368	12,41863	9158	9,122383093	53850	10,89396
6	2005	288954	12,57402	9147	9,121181236	68526	11,13497
7	2006	344650	12,75028	9313	9,1391665	88272	11,38818
8	2007	416006	12,93845	9353	9,143452426	125645	11,74122
9	2008	514700	13,15134	9369	9,145161646	164279	12,00932
10	2009	501139,4	13,12464	9243	9,131621787	122442	11,71539
11	2010	523693,3	13,16866	9240	9,131297165	129422	11,77083
12	2011	557348	13,23095	9138	9,120196822	145193	11,88582
13	2012	586750	13,28235	9263	9,133783249	154280	11,94652

Source: data processing based on the data from ASR 2012, ASR 2013, INS, București, 2013, 2014,
www.insse.ro

Annex 2 Database for the calculation of observed tfp

t	YEAR	0.30*n	0.70*k	0.30*n+ 0.70*k	Observed tfp 2000-2012
1	2000	2,777968	6,742405	9,52037	1,7816
2	2001	2,77602	7,62577	10,4018	1,2761
3	2002	2,739194	6,391453	9,13065	2,8011
4	2003	2,738837	7,460016	10,1989	1,9942
5	2004	2,736715	7,62577	10,3625	2,0561
6	2005	2,736354	7,794478	10,5308	2,0431
7	2006	2,74175	7,971725	10,7135	2,0368
8	2007	2,743036	8,218851	10,9619	1,9765
9	2008	2,743548	8,406525	11,1501	2,0012
10	2009	2,739487	8,200775	10,9403	2,1843
11	2010	2,739389	8,239584	10,979	2,1896
12	2011	2,736059	8,320073	11,0561	2,1748
13	2012	2,740135	8,362567	11,1027	2,1796

Source: data processing based on the data from ASR 2012, ASR 2013, INS, București, 2013, 2014,
www.insse.ro

Annex 3 The calculation of adjusted tfp and of forecast tfp*

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t	YEAR	Observed tfp	Adjusted tfp 2000-2012 and forecast tfp* 2013-2015
1	2000	1,781642	1,894303
2	2001	1,27619	1,920838
3	2002	2,8011	1,947374
4	2003	1,994272	1,97391
5	2004	2,056147	2,000446
6	2005	2,04319	2,026982
7	2006	2,03681	2,053517
8	2007	1,976568	2,080053
9	2008	2,001266	2,106589
10	2009	2,184378	2,133125
11	2010	2,189689	2,15966
12	2011	2,174813	2,186196
13	2012	2,179652	2,212732
14	2013		2,239268
15	2014		2,265803
16	2015		2,292339

Source: data processing based on the data from ASR 2012, ASR 2013, INS, București, 2013, 2014, www.insse.ro

Annex 4 The calculation of *adjusted n* and *forecast n**

t	YEAR	Observed n	Adjusted n 2000-2012 Forecast n*2013-2015
1	2000	9,259892	9,195261
2	2001	9,2534	9,187866
3	2002	9,130648	9,180472
4	2003	9,129456	9,173078
5	2004	9,122383	9,165684
6	2005	9,121181	9,15829
7	2006	9,139167	9,150895
8	2007	9,143452	9,143501
9	2008	9,145162	9,136107
10	2009	9,131622	9,128713
11	2010	9,131297	9,121319
12	2011	9,120197	9,113924
13	2012	9,133783	9,10653
14	2013		9,099136
15	2014		9,091742
16	2015		9,084348

Source: data processing based on the data from ASR 2012, ASR 2013, INS, București, 2013, 2014, www.insse.ro