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# A new decade for social changes

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# The Predicament of the Tunisian Economy, the Slow-Down in Factors' Productivity

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[3]We are indebted to Monji Ben Chaaben, Economiste principal, Directeur des études sectorielles à l'ITCEQ, for communicating the relevant data, and advising us for their implementation and use

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**Abstract**. Several studies and the mere examination of data provided by National Accounts point to a severe downward change in the economic growth of the Tunisian economy, mainly in the manufacturing sector. The aim of the paper is to perform econometric estimations of the production function, at the aggregate level and for the main sectors and sub-sectors to exhibit a possible change in the global productivity of factors of production, labor and capital.Near-evenly, i.e. with the exception of few sectors or sub-sectors, the breakdown starts from 2013 and various factors, economic and political, may explain it. The topic of the paper is to measure it, not to give explanations. What is at stake is the economic interpretation, either a downturn in the productivity of factors, or a decrease in their utilization. Answering to this question is not easy because there does not exist any survey on the rate of utilization of factors, though indirect methods can be contemplated. This issue, and the related one of the marginal productivity of capital, remain to be assessed.

**Keywords**. Aggregate production function, Total factors productivity, Marginal productivity, and Tunisian economy

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**Introduction: a brief overview of the performances of the Tunisian economy**

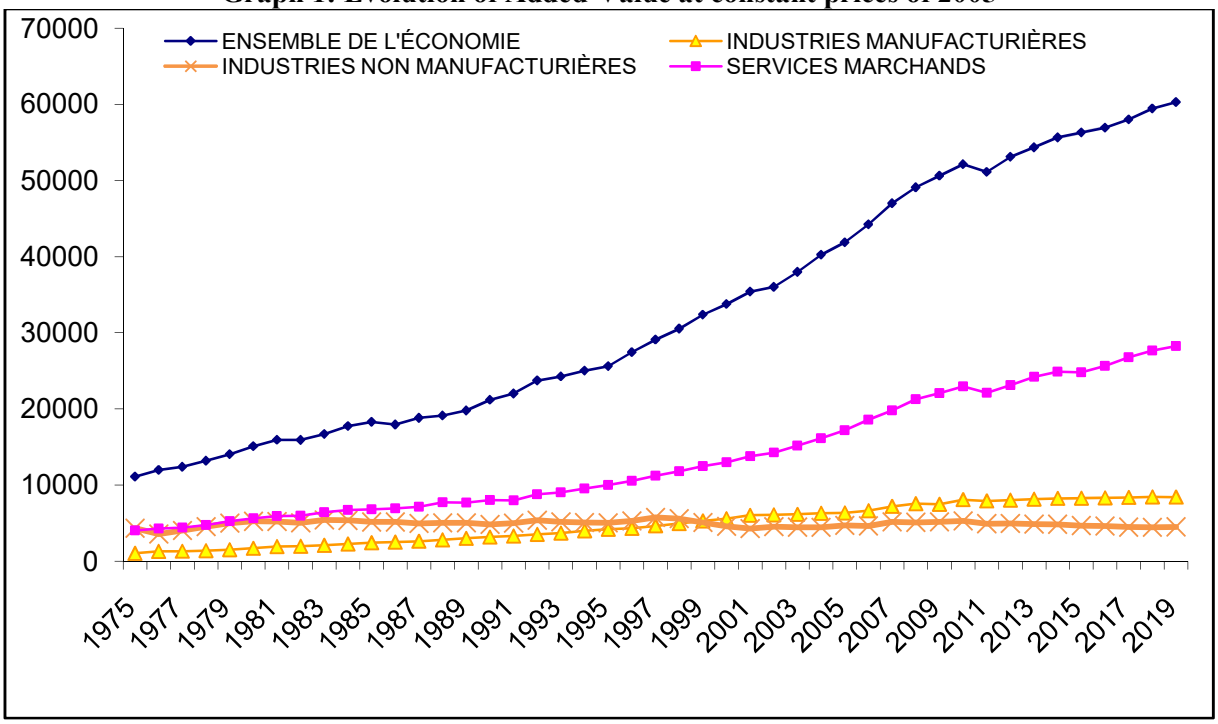
Tunisia has enjoyed during the years 1995 to 2010 a strong growth of its economy coupled with a strong increase in the factors' productivity, capital and labor. Since the Jasmine Revolution of 2011 and a tragic succession of political and economic crises the performances of the country have declined and hamper for the present time the ambitions and the social sustainability of the first and up to now only model of democracy in the Arab world.

The foundations of the economy, a well-educated labor-force and the existence of modern public infrastructures and private productive capital, and an overture to foreign trade are still in place and deserve to be mobilized for the development of the country and the well-being of the population.

Starting from 1975[1], the overview of the Tunisian economy can clearly distinguish three periods: from 1975 to 1995, 1995 to 2010 and from then up to 2019. The Table in the following page reports for the whole economy and the main sectors and sub-sectors.

The three graphs below show the corresponding yearly evolutions of added-value and production factors that materialize the change in the dynamics after 2010.

**Graph 1: Evolution of Added-Value at constant prices of 2005**




[1] Overall statistical information is only available from this year

TECHNIUM SOCIAL SCIENCES JOURNAL

*Technium Social Sciences Journal*
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| | Period 1975 to 1995 | | | Period 1995 to 2010 | | | Period 2010 to 2019 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Average rate of growth of | | | Average rate of growth of | | | Average rate of growth of | | |
| | Added-value | Labor | Capital | Added-value | Labor | Capital | Added-value | Labor | Capital |
| AGRICULTURE & PÊCHE | 1,5% | 0,0% | 3,9% | 5,7% | 2,0% | 4,9% | 3,6% | -2,0% | 1,3% |
| INDUSTRIES MANUFACTURIÈRES | 7,2% | 5,4% | 3,2% | 6,8% | 3,0% | 0,6% | 0,5% | 0,8% | -0,1% |
| Industries Agricoles & Alimentaires | 2,3% | 7,7% | 3,0% | 7,4% | 3,6% | 2,2% | 1,8% | 3,4% | 1,3% |
| Industries Mécaniques & Électriques | 9,1% | 9,5% | 3,6% | 13,7% | 8,5% | 2,1% | 1,6% | 3,0% | 0,6% |
| INDUSTRIES NON MANUFACTURIÈRES | 0,8% | 1,8% | 2,6% | 0,5% | 4,1% | 3,1% | -1,8% | 1,5% | 1,6% |
| SERVICES MARCHANDS | 4,7% | 4,5% | 2,3% | 8,6% | 5,5% | 7,6% | 2,3% | 1,5% | 1,9% |
| ADMINISTRATION | 5,2% | 3,1% | 3,8% | 8,2% | 3,7% | 8,9% | 3,2% | 1,6% | 5,7% |
| ENSEMBLE DE L'ÉCONOMIE | 4,3% | 2,7% | 3,5% | 7,4% | 3,8% | 5,7% | 1,6% | 0,8% | 2,6% |
| ACTIVITÉS MARCHANDES | 4,5% | 2,6% | 2,8% | 7,9% | 3,8% | 5,1% | 1,9% | 0,7% | 1,5% |
| ACTIVITÉS MARCHANDES NON AGRICOLES | 5,2% | 3,9% | 2,6% | 8,3% | 4,4% | 5,1% | 1,6% | 1,3% | 1,6% |

Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
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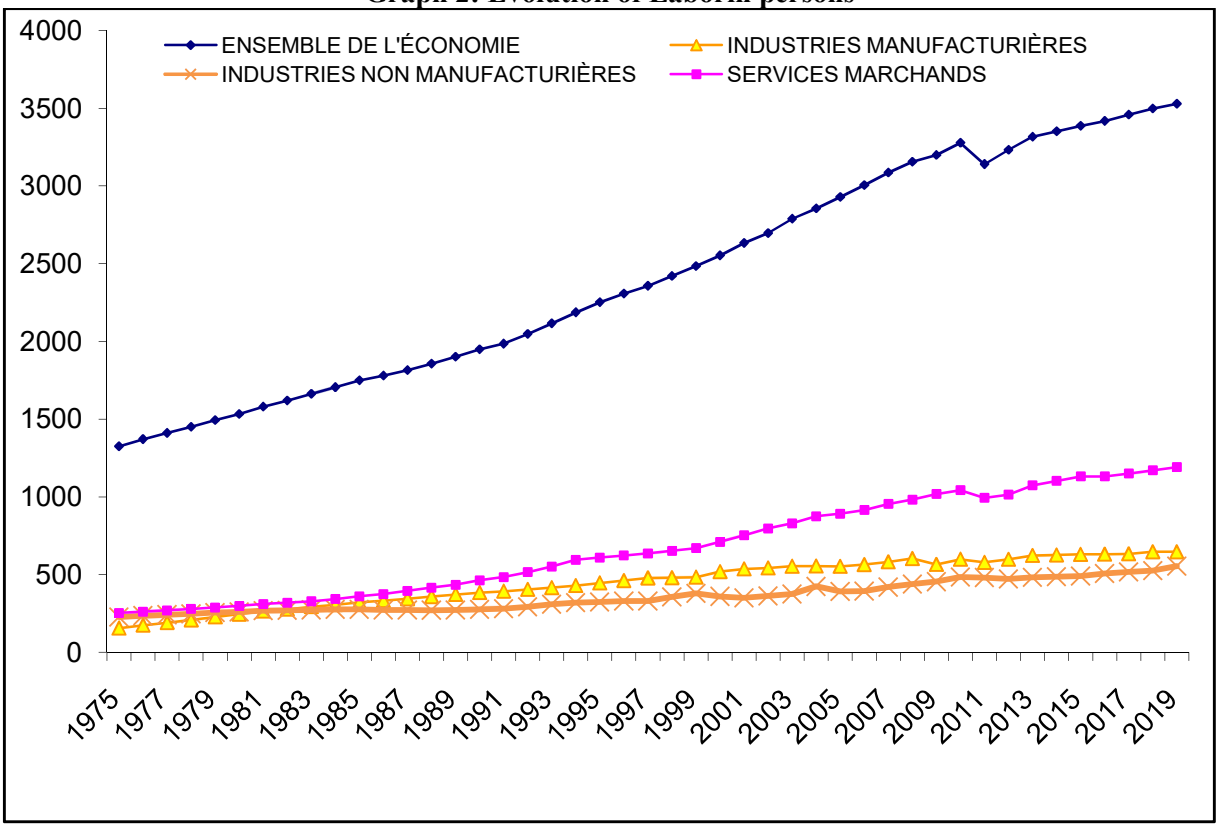
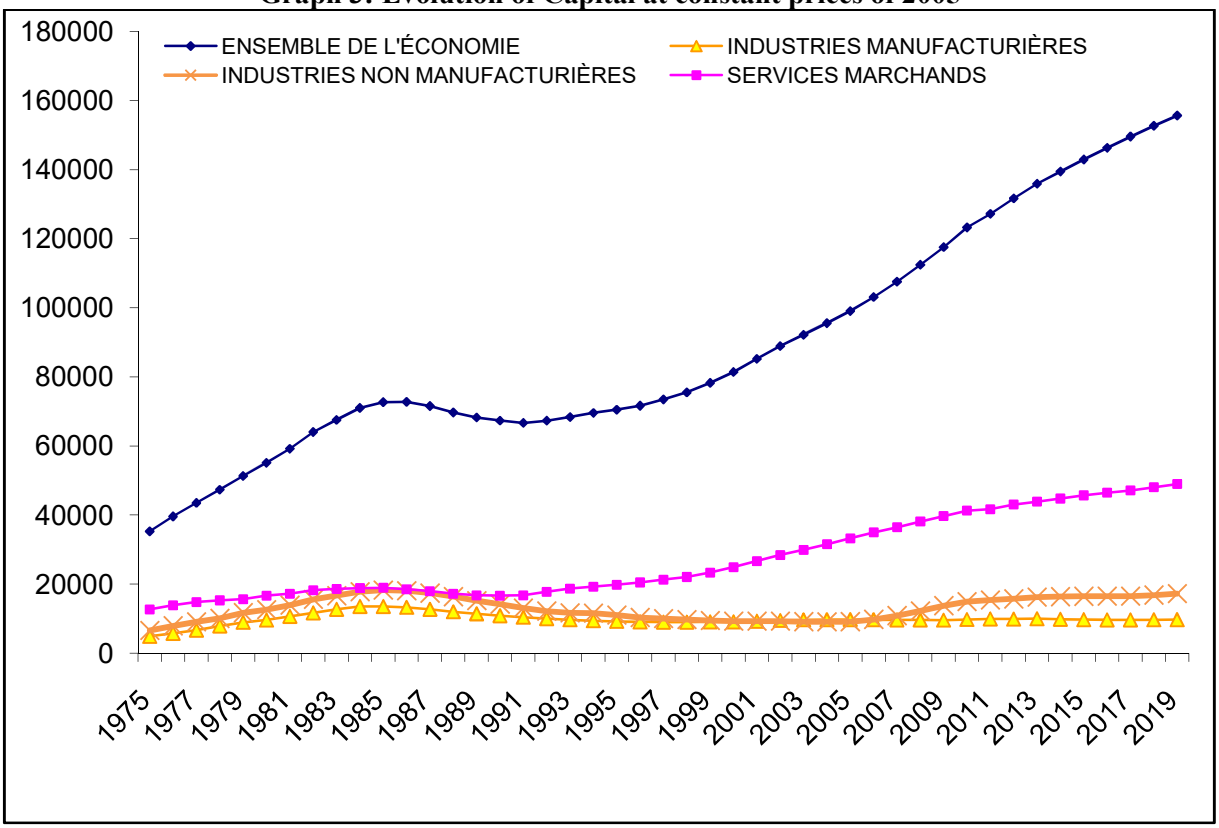
**Graph 2: Evolution of Laborin persons**




**Graph 3: Evolution of Capital at constant prices of 2005**




A first approach to the assessment in the change in factors' productivity is to compare the change in growth in value-added to the corresponding changes in labor and capital. From the

*Technium Social Sciences Journal*
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two 1995-2010 and 2010-2019 periods the average growth in value-added of the total economy lost nearly 5 points while production factors lost approximately 3 points, exhibiting a gap of around 2 points.The same observationcan be made for total market sectors and non-agricultural market sectors.

A similar scheme appears for manufacturing industries and commercial services, while the evolution of agriculture and fishing and of non-manufacturing industries are somehow different. Concerning the formerthe decrease in the rate of growth of production is around 2% while rates of growth of factors is substantial (4% for labor and 3.6% for capital).

As for non-manufacturing industries it is a slow-growth and now declining sector, including heterogenous activities which deserve a detailed analytical analysis.

Agriculture and fishing appears as an exception: the period 2010-2019 exhibits a decrease in the average rate of growth of production of 2.1% compared to the period 1995-2010 but which is smaller than the decrease in the growth of factors, 4% for labor and 3.6% for capital.

**An econometric approach through estimation of production functions: methodology**

A detailed and precisely-dated measurement of the decrease in factors' productivity may only result from the estimation of production functions prior to the period of turnaround, which graphs show from 2011 onwards. The methodology is to estimate the production function in the period before 2011 and then calculate from this year what would have been the production with existing factors to be compared to observed production. It raises several problems and in particular the two following ones.

**Issues in the specification of production functions**

The first is the specification of the production function. Several specifications can be contemplated, more or less flexible that is incorporating more or less degrees of liberty. The less flexible one is the COBB-DOUGLAS production function which incorporates a relatively high (unitary) elasticity of substitution between factors. Effectively estimates on the whole economy and on various sectors exhibit poor results, with in particular the coefficients representing factors' shares most often outside the required interval of [0,1]. There is a very abundant literature on this production function which was historically the first to be estimated and it is not necessary to recall it.

At the other extreme is the vintage production function in which the capital is endogenous[2], estimated along the other parameters of the production function. Several attempts gave unequal results, the main reason being the non-availability of long enough series of investment. Note that this specification, in addition to its flexibility, is particularly convenient for taking into account several factors of production, for instance energy coupled with capital and labor.

Intermediate and thoroughly implemented in econometric work is the Constant Elasticity of Substitution (CES for short) production function in which the related parameter, though "constant" i.e. holding everywhere, is endogenous and estimated along the other parameters, in particular technical progress incorporated in the factors labor and capital. CES is the paradigm of second order "Flexible Functional Forms". A major contribution in this field is the article by Arrow, Chenery, Minhas and Solow known by the acronym SMAC[3].

[2] More precisely its law of accumulation from the series of investments. For a detailed presentation see Alain Bernard, « Agrégation temporelle des fonctions de production à générations de capital », Cahiers du Gama Vol VI, N° 1, février 1985.

[3] Arrow, K.J., H.B. Chenery, B.S. Minhas, and R.M. Solow. 1961. Capital–labor substitution and economic efficiency. *Review of Economics and Statistics* 63 (3): 225–247.

For a whole presentation of production functions see Dale W. Jorgenson in The New Palgrave Dictionary of Economics.

Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
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The second issue is the period on which the estimation must be implemented. The various stages of development experienced by the Tunisian economy as described in the introduction plead for a non-too long period. Various attempts show that the best and most reliable results were for the period 1995 to 2010, which has been selected[4]. Variants on longer periods, starting from 1975 or 1990, have been performed, as well as estimates going beyond 2010.

**Specification of the CES production function and estimation**

The structural form writes:

$$Q = \{a [L \exp(gt)]^{(-m)} + b [K \exp(pt)]^{(-m)} \}^{(-1/m)}$$

with:

Q : production (here added-value at constant prices)
L : Labor
K: stock of capital
g : technical progress incorporated in Labor
p : technical progress incorporated in Capital

The elasticity of substitution is represented by the parameter m: more precisely it is defined by the formula:

$$s = 1/(1+m)$$

The estimation can be implemented directly on the structural specification which is nonlinear, but usually and more efficiently taking into account the relation between labor demand and its relative price. Assuming that demand for labor adjusts to its marginal productivity it comes:

$$\text{Log } (Q/L) = [ -\text{Log } a + mgt + \text{Log } (w/p) ] /(1+m)$$

$$\text{Log } (Q/L) = s \text{ Log } (w/p) + (1-s)gt - s\text{Log } a \qquad \text{(equation 1)}$$

with:

p : price of output
w : unit cost of labor

Determination of the remaining parameters b and p is obtained with the relation resulting from the incorporationin the structural specification of the production function of the coefficients estimated with equation 1:

$$(Q/K)^{(-m)}-a [(L/K)\exp(gt) ]^{(-m)} =b \exp(-mpt)$$

$$\text{Log } \{(Q/K)^{(-m)}-a [(L/K)\exp(gt) ]^{(-m)}\}=\text{Log}b-mpt$$

(equation 2)

**Assessment and application to the Tunisian economy, globally and by sector**

A comprehensive assessment requires a two-fold approach, a global one for the whole economy and a detailed analysis by sector.

**Results for the whole economy and interpretation**

Econometric estimation of equation 1 over the period 1995-2010 yields the following results: (Students of coefficients are given between brackets)

| $\sigma$ | $(1-\sigma)\gamma$ | $\sigma \text{Log}(\alpha)$ |
|---|---|---|
| | | |
| 0,306 | 0,014 | -1,909 |
| (1,2) | (2,4) | (4,1) |
| | | |
| R2 | | 0,982 |
| St. Deviation Regression | | 0,015 |

and of equation 2:

[4] In some cases, the estimation on a longer period revealed more satisfying and was selected.

Technium Social Sciences Journal
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| μπ | β | |
|---|---|---|
| | | |
| 0,021 | 1,426 | |
| (4,3) | (32,5) | |
| | | |
| R2 | | 0,570 |
| St. Deviation Regression | | 0,092 |

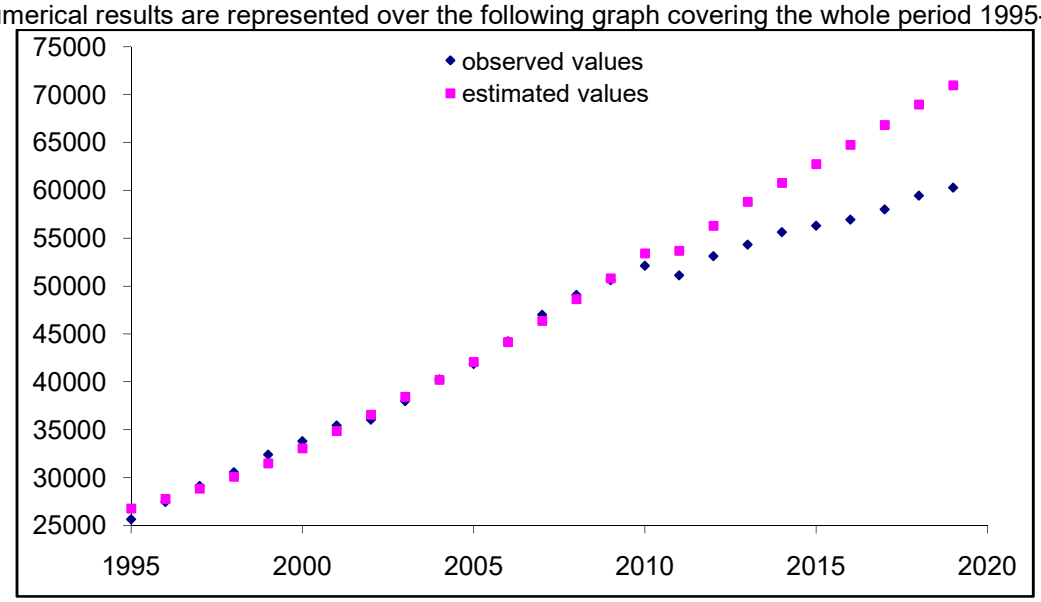
The associated values of technical progress are 2,05% (incorporated in labor) and 0,94% (incorporated in capital).Simulation over the period of estimation gives the following figures, to be compared to observed data:

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 25621 | 27453 | 29109 | 30554 | 32392 | 33785 | 35423 | 36026 | 37996 | 40261 | 41871 | 44238 | 47005 | 49100 | 50633 | 52131 |
| Estimated | 26789 | 27772 | 28858 | 30092 | 31505 | 33066 | 34867 | 36579 | 38457 | 40214 | 42096 | 44154 | 46384 | 48665 | 50815 | 53439 |
| Relative gap | 4,6% | 1,2% | -0,9% | -1,5% | -2,7% | -2,1% | -1,6% | 1,5% | 1,2% | -0,1% | 0,5% | -0,2% | -1,3% | -0,9% | 0,4% | 2,5% |

Extrapolation of the estimated model over the 2010-2019 yields a measure of "potential growth" which can be compared to effective growth:

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 52131 | 51132 | 53126 | 54352 | 55654 | 56315 | 56935 | 58016 | 59467 | 60299 |
| Estimated | 53439 | 53709 | 56296 | 58825 | 60793 | 62786 | 64764 | 66864 | 68976 | 71000 |
| Relative gap | 2,5% | 5,0% | 6,0% | 8,2% | 9,2% | 11,5% | 13,8% | 15,3% | 16,0% | 17,7% |

The numerical results are represented over the following graph covering the whole period 1995-2019:




The numerical results and in particular the graph exhibit a neat and increasing divergence between effective and "potential growth" of the whole Tunisian economy which reaches 17;7% in 2019. They confirm what was already observed on global data.

The interpretation of this evolution must be cautious: it may reflect a drop in the productivity of the factors of production, or alternately a decrease in their degree of utilization, probably both of them. Unfortunately, it does not exist in the Tunisian statistical system a survey on the

Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
ISSN: 2668-7798
www.techniumscience.com

degree of utilization of capital and labor. The fact that the divergence is steadily increasing rather substantiates the first interpretation.

The results obtained here corroborate those of Sawsen Ben Nasr, from the Direction Centrale de la Synthèse et de la Modélisation, "La croissance économique de la Tunisie, Un potentiel décroissant ?" published in the Tribune de l'ITCEQ, N° 23 April 2019.

**Results by main sectors**

**Agriculture and fishing**

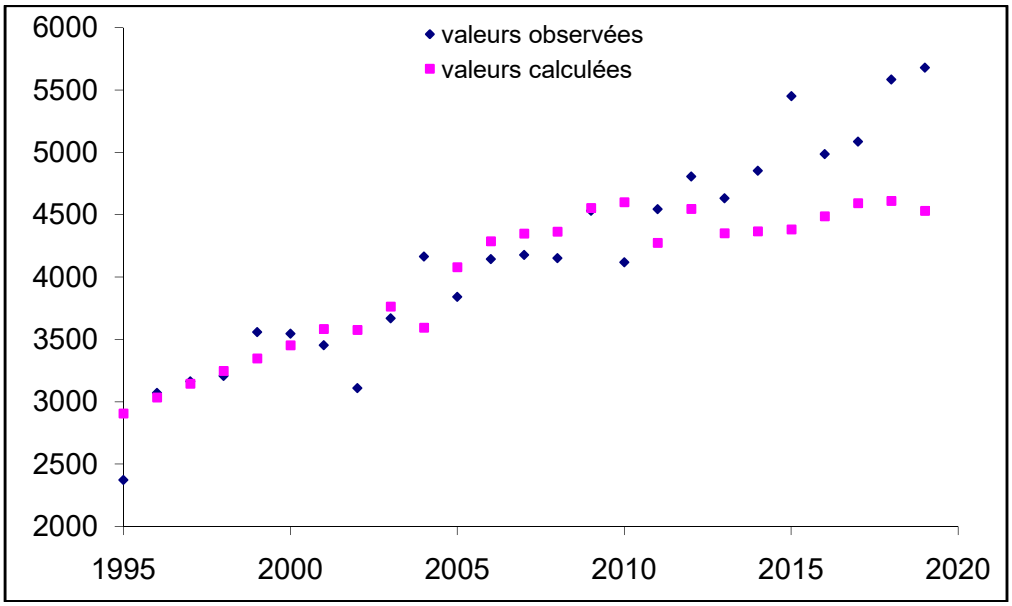
Equations 1 and 2 yields the values of estimated coefficients, from which can be reckoned the estimates of technical progress incorporated in Labor (1,02%) and in Capital (1,04%)

| **Equation 1** | | | | **Equation 2** | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| $\sigma$ | $(1-\sigma)\gamma$ | $\sigma$Log($\alpha$) | | $\mu\pi$ | $\beta$ | |
| | | | | | | |
| 0,327 | 0,007 | -1,404 | | 0,021 | 2,030 | |
| (2,4) | (1,2) | (8,5) | | (0,4) | (4,8) | |
| | | | | | | |
| R2 | | 0,604 | | R2 | | 0,014 |
| St. Deviation Regression | | 0,081 | | St. Deviation Regression | | 0,880 |

| | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 2371 | 3071 | 3162 | 3206 | 3558 | 3544 | 3453 | 3109 | 3669 | 4165 | 3839 | 4144 | 4178 | 4150 | 4532 | 4118 |
| Estimated | 2904 | 3034 | 3144 | 3247 | 3347 | 3452 | 3583 | 3575 | 3764 | 3593 | 4079 | 4288 | 4348 | 4365 | 4555 | 4602 |
| Relative gap | 22,5% | -1,2% | -0,6% | 1,3% | -5,9% | -2,6% | 3,8% | 15,0% | 2,6% | -13,7% | 6,2% | 3,5% | 4,1% | 5,2% | 0,5% | 11,7% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 4118 | 4543 | 4806 | 4632 | 4852 | 5449 | 4986 | 5086 | 5584 | 5679 | | | | | | |
| Estimated | 4602 | 4273 | 4546 | 4350 | 4367 | 4383 | 4487 | 4592 | 4611 | 4530 | | | | | | |
| Relative gap | 11,7% | -5,9% | -5,4% | -6,1% | -10,0% | -19,6% | -10,0% | -9,7% | -17,4% | -20,2% | | | | | | |

The estimates confirm what has been observed on global figures in the introduction, i.e. a decrease in the rate of growth of production between the two periods, but which is smaller than the related decreases in the growth of factors. It can be interpreted as a gain in the global productivity of factors or a higher degree of factors' utilization. Results are represented in the graph below:

Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
ISSN: 2668-7798
www.techniumscience.com



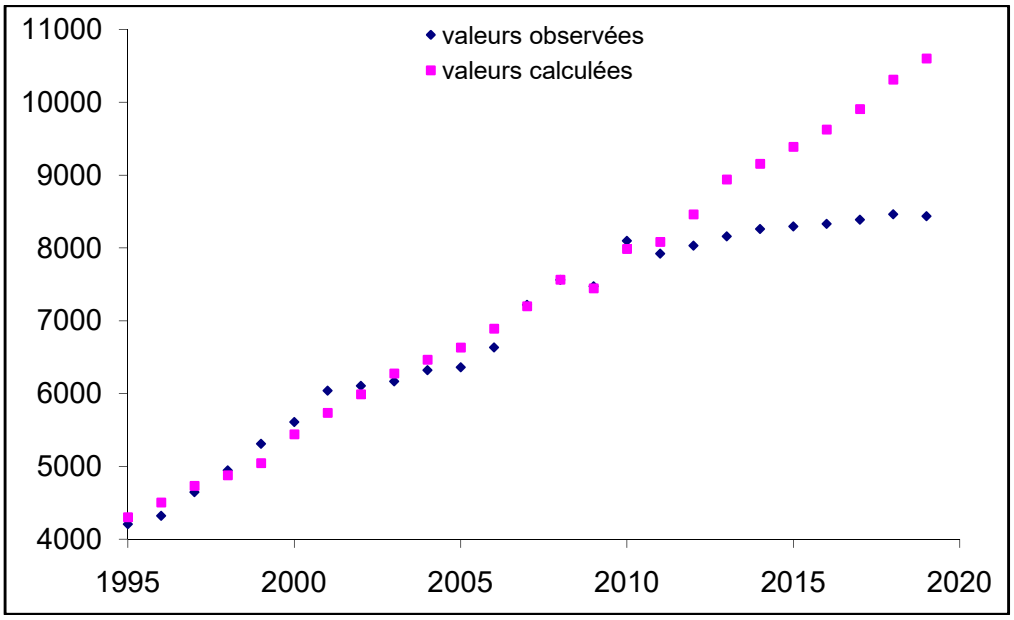

**Manufacturing industries**

Following the same presentation it comes, with associated estimates of technical progress incorporated in Labor of 2,71% and in Capital of 2,65%:

| **Equation 1** | | | | **Equation 2** | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| $\sigma$ | $(1-\sigma)\gamma$ | $\sigma$Log($\alpha$) | | $\mu\pi$ | $\beta$ | |
| | | | | | | |
| 0,315 | 0,019 | -1,657 | | 0,058 | 0,381 | |
| (2,0) | (8,0) | (5,6) | | (5,2) | (3,9) | |
| | | | | | | |
| R2 | | 0,955 | | R2 | | 0,657 |
| St. Deviation Regression | | 0,025 | | St. Deviation Regression | | 0,206 |

| | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 4205 | 4321 | 4645 | 4945 | 5312 | 5609 | 6040 | 6104 | 6168 | 6321 | 6363 | 6634 | 7217 | 7561 | 7474 | 8098 |
| Estimated | 4302 | 4506 | 4734 | 4877 | 5047 | 5442 | 5738 | 5992 | 6279 | 6467 | 6636 | 6894 | 7201 | 7564 | 7449 | 7987 |
| Relative gap | 2,3% | 4,3% | 1,9% | -1,4% | -5,0% | -3,0% | -5,0% | -1,8% | 1,8% | 2,3% | 4,3% | 3,9% | -0,2% | 0,0% | -0,3% | -1,4% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 8098 | 7923 | 8032 | 8161 | 8261 | 8298 | 8330 | 8387 | 8463 | 8437 | | | | | | |
| Estimated | 7987 | 8086 | 8462 | 8941 | 9156 | 9393 | 9631 | 9912 | 10317 | 10607 | | | | | | |
| Relative gap | -1,4% | 2,1% | 5,4% | 9,6% | 10,8% | 13,2% | 15,6% | 18,2% | 21,9% | 25,7% | | | | | | |

Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
ISSN: 2668-7798
www.techniumscience.com




The relative evolutions of effective and potential growth are similar to the ones observed for the whole economy, with a divergence which is significantly higher (25.7% compared to 17.7%). Manufacturing industries, though representing a small share of global activity (15.5% in 2010; 14% in 2019), bear an important responsibility in the decrease of the overall productivity of the Tunisian economy.

**Non-manufacturing industries**

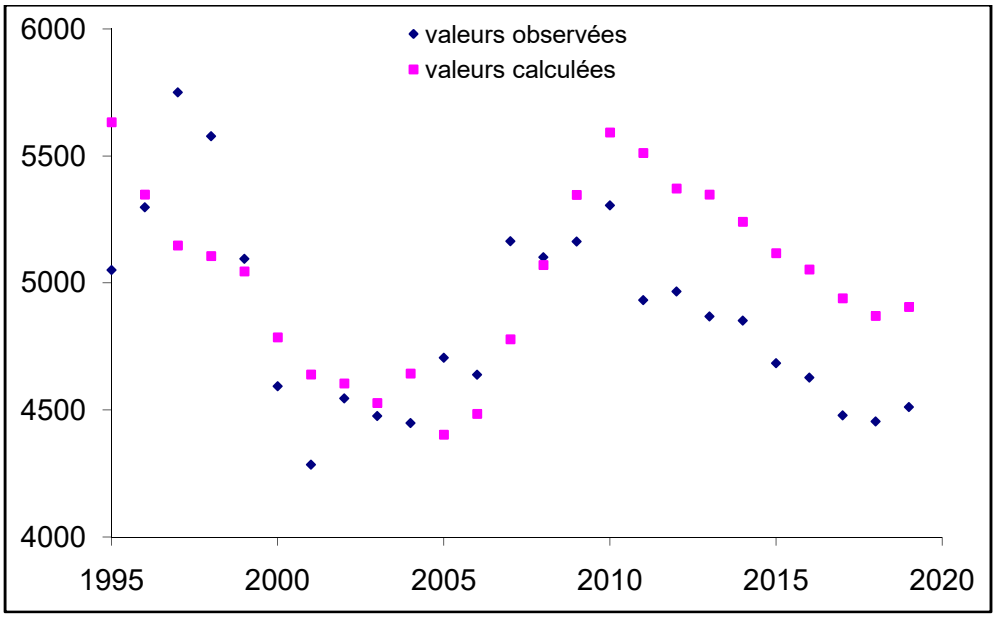
In the global landscape of the Tunisian economy, non-manufacturing industries exhibit a very peculiar case. Growth has been particularly irregular, with a decline in production between 1997 and 2004; then a return to growth from 2004 to 2010 and anew a decline from 2010.

Estimation of the production function yields estimates of the coefficients which are statistically significant. The decrease of production during the estimation period is materialized by a negative technical progress of labor productivity (-8.6%).

| **Equation 1** | | | | **Equation 2** | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| $\sigma$ | $(1-\sigma)\gamma$ | $\sigma$Log($\alpha$) | | $\mu\pi$ | $\beta$ | |
| | | | | | | |
| 0,836 | -0,014 | -1,252 | | 0,005 | -0,365 | |
| (4,6) | (3,6) | (3,8) | | (4,0) | (35,6) | |
| | | | | | | |
| R2 | | 0,893 | | R2 | | 0,537 |
| St. Deviation Regression | | 0,052 | | St. Deviation Regression | | 0,021 |

Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
ISSN: 2668-7798
www.techniumscience.com

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 5051 | 5298 | 5749 | 5578 | 5095 | 4593 | 4284 | 4545 | 4476 | 4448 | 4705 | 4638 | 5164 | 5101 | 5163 | 5305 |
| Estimated | 5633 | 5348 | 5147 | 5106 | 5046 | 4786 | 4639 | 4604 | 4528 | 4643 | 4403 | 4485 | 4779 | 5070 | 5346 | 5592 |
| Relative gap | 11,5% | 1,0% | -10,5% | -8,5% | -1,0% | 4,2% | 8,3% | 1,3% | 1,2% | 4,4% | -6,4% | -3,3% | -7,5% | -0,6% | 3,5% | 5,4% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 5305 | 4932 | 4966 | 4868 | 4851 | 4684 | 4627 | 4479 | 4454 | 4511 | | | | | | |
| Estimated | 5592 | 5512 | 5371 | 5348 | 5241 | 5117 | 5053 | 4940 | 4870 | 4905 | | | | | | |
| Relative gap | 5,4% | 11,7% | 8,2% | 9,9% | 8,0% | 9,2% | 9,2% | 10,3% | 9,3% | 8,7% | | | | | | |




From 2010 effective production remains below potential production of some 10%. Non-manufacturing industries is an aggregate of various and very heterogeneous sub-sectors which deserve to be analyzed separately. This will be implemented in a next section.

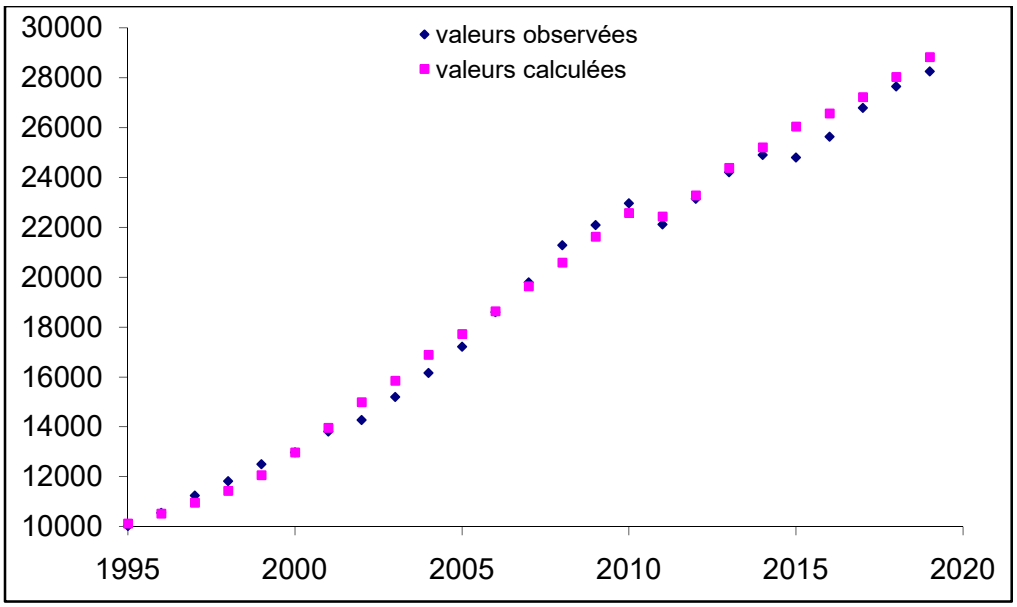
**Commercial services**

Commercial services represent nearly half of the Tunisian economy and an increasing share (44.1% in 2010; 46.9% in 2019). As show the estimates of the production function below, the dynamics of the sector is based on a sustained rate of technical progress incorporated in labor (1,71%) and a growth of labor higher than the average of the economy (1.5% compared to 0.8%).

| **Equation 1** | | | | **Equation 2** | | |
|---|---|---|---|---|---|---|
| $\sigma$ | $(1-\sigma)\gamma$ | $\sigma Log(\alpha)$ | | $\mu\pi$ | $\beta$ | |
| 0,283 | 0,012 | -2,259 | | 0,013 | 1,156 | |
| (1,3) | (2,7) | (5,2) | | (1,8) | (18,8) | |
| R2 | | 0,897 | | R2 | | 0,191 |
| St. Deviation Regression | | 0,031 | | St. Deviation Regression | | 0,129 |

Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
ISSN: 2668-7798
www.techniumscience.com

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 10027 | 10555 | 11236 | 11814 | 12502 | 12981 | 13804 | 14275 | 15190 | 16155 | 17216 | 18602 | 19793 | 21283 | 22091 | 22961 |
| Estimated | 10125 | 10524 | 10959 | 11433 | 12065 | 12969 | 13960 | 14989 | 15856 | 16888 | 17728 | 18638 | 19642 | 20590 | 21632 | 22577 |
| Relative gap | 1,0% | -0,3% | -2,5% | -3,2% | -3,5% | -0,1% | 1,1% | 5,0% | 4,4% | 4,5% | 3,0% | 0,2% | -0,8% | -3,3% | -2,1% | -1,7% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 22961 | 22110 | 23143 | 24214 | 24902 | 24795 | 25638 | 26792 | 27649 | 28257 | | | | | | |
| Estimated | 22577 | 22437 | 23281 | 24391 | 25213 | 26050 | 26573 | 27230 | 28040 | 28830 | | | | | | |
| Relative gap | -1,7% | 1,5% | 0,6% | 0,7% | 1,2% | 5,1% | 3,6% | 1,6% | 1,4% | 2,0% | | | | | | |




The table and the graph above exhibit an evolution of the effective production that is very close to the potential production, which means than there is no apparent decline in the productivity of factors. But as previously, this has to be broken-up according to the various sub-sectors.

**Administration**

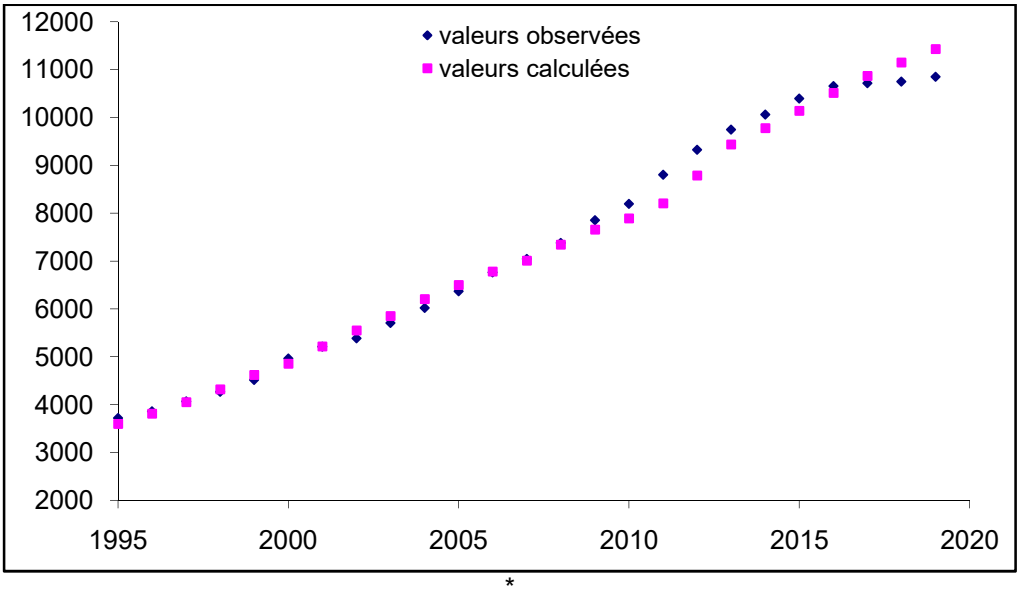
This sector which represents a growing share of the economy (18.0% in 2019 compared to 15.7% in 2010) differs from other sectors in the sense that production is not directly measured on the market but calculated according to the cost of production.

The results presented below are similar to the case of commercial services. Effective growth and potential growth are fairly close, with a gap limited to 5% in 2019.

Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
ISSN: 2668-7798
www.techniumscience.com

| Equation 1 | | | | Equation 2 | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| σ | (1−σ)γ | σLog(α) | | μπ | β | |
| | | | | | | |
| 0,720 | 0,012 | -0,744 | | -0,025 | -1,660 | |
| (12,2) | (8,7) | (6,2) | | (9,9) | (73,1) | |
| | | | | | | |
| R2 | | 0,998 | | R2 | | 0,874 |
| St. Deviation Regression | | 0,007 | | St. Deviation Regression | | 0,048 |

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 3719 | 3860 | 4068 | 4270 | 4518 | 4961 | 5211 | 5385 | 5705 | 6019 | 6370 | 6763 | 7043 | 7378 | 7858 | 8195 |
| Estimated | 3602 | 3812 | 4051 | 4322 | 4623 | 4860 | 5220 | 5551 | 5852 | 6211 | 6500 | 6783 | 7010 | 7348 | 7659 | 7892 |
| Relative gap | -3,1% | -1,2% | -0,4% | 1,2% | 2,3% | -2,0% | 0,2% | 3,1% | 2,6% | 3,2% | 2,1% | 0,3% | -0,5% | -0,4% | -2,5% | -3,7% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 8195 | 8802 | 9329 | 9745 | 10060 | 10396 | 10656 | 10720 | 10752 | 10849 | | | | | | |
| Estimated | 7892 | 8210 | 8791 | 9439 | 9783 | 10141 | 10515 | 10874 | 11155 | 11434 | | | | | | |
| Relative gap | -3,7% | -6,7% | -5,8% | -3,1% | -2,8% | -2,4% | -1,3% | 1,4% | 3,7% | 5,4% | | | | | | |




*

* *

On the whole the decline in factors' productivity observed at the aggregate level occurs mainly in industry, both the manufacturing and the non-manufacturing sectors. The latter exhibits, as noted before, a very irregular evolution with periods of growth and periods of decline. The analysis by sub-sectors is presented below, with numerical results given in three appendices.

Technium Social Sciences Journal
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**Analysis by sub-sectors**

**Manufacturing industries**

Among the main sub-sectors, "**industries agricoles et alimentaires**" and "**industriesmécaniques et électriques**" show a picture similar to the whole sector, with a production still increasing but at a rate slower than potential growth. The gaps in 2019 are 28.3% for the former -with an inflexion starting in 2015- and 45.9% for the latter. The same can be said for "**Matériaux de Construction Céramique& Verres**" with a production that continued to grow till 2014 and started to decline, well under potential growth (gap of 35.3% in 2019)

"**Industries chimiques**" experienced from 2011 a severe collapse in production, from the range 600 – 700 to the range 450 – 550 while factors of production continued to grow. This is reflected in the data and the graph by a stark decrease of the productivity of factors (minus 87% in 2019).

After a sustained growth the production of "**Textiles, Habillement&Cuirs**"started to decline from the year 2002 with a short period of recovery (2006 to 2008) and again downwards till 2019. In the latter period, factors of production decreased faster than production itself then showing an apparent gain in the productivity of factors.

Finally "**Industries manufacturièresdiverses**" exhibit from 2010 a slow growth of both production and factors, without any loss in the aggregate productivity of labor and capital.

**Non-manufacturing industries**

As is the case for manufacturing sectors, non-manufacturing sectors exhibit a large diversity of situations.

On the one hand there are the public utilities, **electricity** and **water**, in which growth of production remains sustained after 2010, close to potential growth for the former, below potential growth for the latter (gap of 22% in 2019).

"**Mines**" experienced from 2010 a severe drop in production while factors, labor and capital, continued to grow and then exhibiting a gap of one to three (potential production approximately three times the effective production). This evolution is particularly disturbing and questions a policy of sustained labor-hiring and investing in a context of declining production.

The sector of **"hydrocarbures"** also experiences a decrease in production which started well before 2010 -with a short recovery during the years 2004 to 2007- but this was associated to a relative stagnation of production factors.

Finally "**Bâtiments&GénieCivil**" exhibits the same picture as the whole economy of a slow growth or stagnant level of production with fast increasing factors of production, with a lag of nearly 50% between effective and potential outputs in 2019.

**Commercial services**

In the sub-sectors of "**Commerce**" and "**Télécommunications**" the growth of production goes on after 2010 but at a slower rate than during the period 1995-2010 while production factors don't exhibit any slow-down. The gap between effective and potential outputs in 2019 is 13.2% for the former and 29.8% for the latter.

Activityin"**Hôtels, Cafés & Restaurants**" fell of some 30% during the years 2011 to 2015 but resumed afterwards, rejoining approximately the level of potential production.

In"**Other services**" the growth of output remained very steady while factors of production stagnated, exhibiting a gain in the efficiency of production, which deserves a more detailed examination.

Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
ISSN: 2668-7798
www.techniumscience.com

**Main teachings and further questions**

The Tunisian economy experienced, after a sustained growth till the end of the years two-hundred ten, a severe slow-down at the aggregate level and in nearly all the sectors, agriculture, industry and services and it is important, in order to implement corrective actions, to determine the main reasons of this evolution. There are of course political and social causes but economic factors are also at stake.

A first explanation is a much slower growth of the main factors of production, labor and capital. At the aggregate level lost more than 3 points of growth, from 3.8% to 0.7% for labor; from 5.1% to 1.5% for capital, but the deceleration of production has been much higher, nearly 6 points in the average rate of growth from 2010 to 2019.

A second likely explanation is a decrease in the rate of utilization of the factors of production, resulting from a weaker demand in the domestic and external markets. There is no statistical data which can substantiate this assumption but the fact that the divergence is progressive and long-standingis rather the sign of a slow-down in the productivity of the factors of production.

In order to highlight this effect, a methodology has been developed based on the detailed estimation of the production function. Resorting to a CES specification allows to determine all the main parameters at work, the elasticity of substitution between factors and the technical progress incorporated in each of them.

The estimations implemented for the whole economy, the main sectors and sub-sectors give significant and sensible values of the coefficients. Extrapolation of the model beyond the period of estimation, namely between 2010 and 2019, and comparison with observed data allows to measure the “gap” of production, which at the aggregate level represents a loss of growth of around 2%.

Beyond this global result it is interesting to extend the analysis to sectors and sub-sectors. There is an important diversity among sectors, and particularly the industrial ones. What appears is that in the case of several there has been after 2010 and sometimes before a real collapse of the activity which raises questions well beyond the factors’ productivity[5].

A further issue is the possible contribution of other factors of production, mainly energy which plays an important role in the industrial sector. This is the topic for a new investigation under consideration.

[5] It will be checked if there are not errors in the series implemented for econometric estimation

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Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
ISSN: 2668-7798
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## Appendix 1: results by sub-sectors of Manufacturing Industries

### Industries agricoles et alimentaires

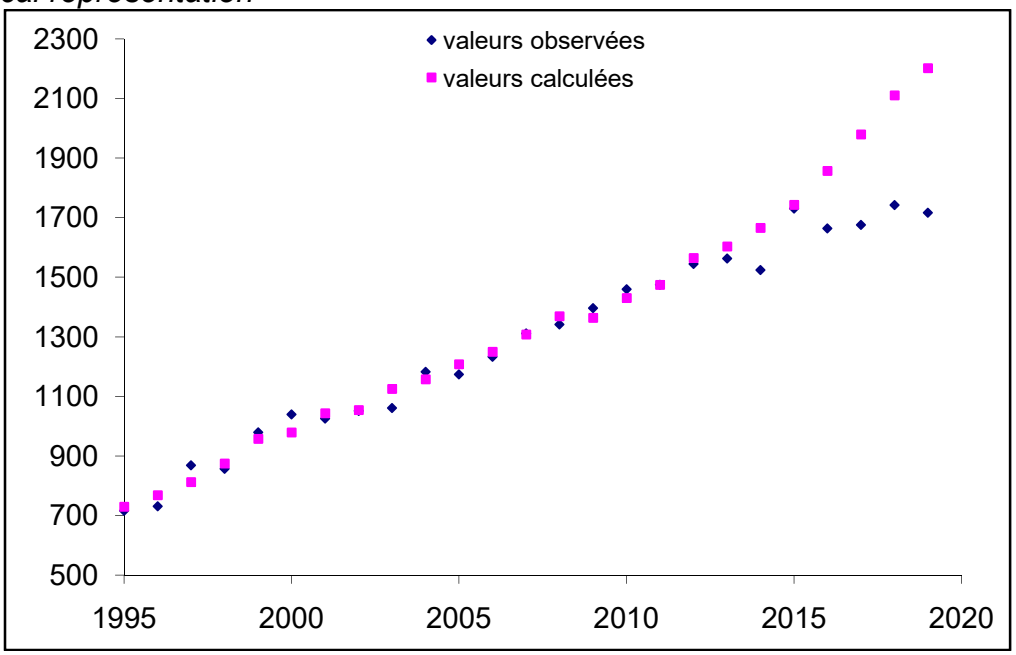
*Estimation of the production function*

| Equation 1 | | | | Equation 2 | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| σ | (1−σ)γ | σLog(α) | | μπ | β | |
| 0,334 | 0,016 | -2,012 | | 0,056 | 0,807 | |
| (2,9) | (4,9) | (8,5) | | (6,6) | (10,7) | |
| | | | | | | |
| R2 | | 0,921 | | R2 | | 0,755 |
| St. Deviation Regression | | 0,035 | | St. Deviation Regression | | 0,158 |

*Comparison of observed and simulated series*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 715 | 730 | 868 | 856 | 979 | 1039 | 1025 | 1051 | 1060 | 1182 | 1173 | 1232 | 1311 | 1341 | 1396 | 1459 |
| Estimated | 729 | 769 | 813 | 874 | 957 | 979 | 1043 | 1055 | 1126 | 1157 | 1207 | 1250 | 1308 | 1369 | 1364 | 1430 |
| Relative gap | 1,9% | 5,3% | -6,4% | 2,1% | -2,2% | -5,8% | 1,8% | 0,3% | 6,2% | -2,1% | 2,9% | 1,4% | -0,2% | 2,1% | -2,3% | -1,9% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 1459 | 1474 | 1544 | 1563 | 1524 | 1731 | 1664 | 1675 | 1742 | 1716 | | | | | | |
| Estimated | 1430 | 1475 | 1564 | 1604 | 1666 | 1743 | 1857 | 1979 | 2110 | 2202 | | | | | | |
| Relative gap | -1,9% | 0,0% | 1,3% | 2,6% | 9,3% | 0,7% | 11,6% | 18,2% | 21,1% | 28,3% | | | | | | |

*Graphical representation*



Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
ISSN: 2668-7798
www.techniumscience.com

## Appendix 1continued

### Matériaux de Construction Céramique & Verres

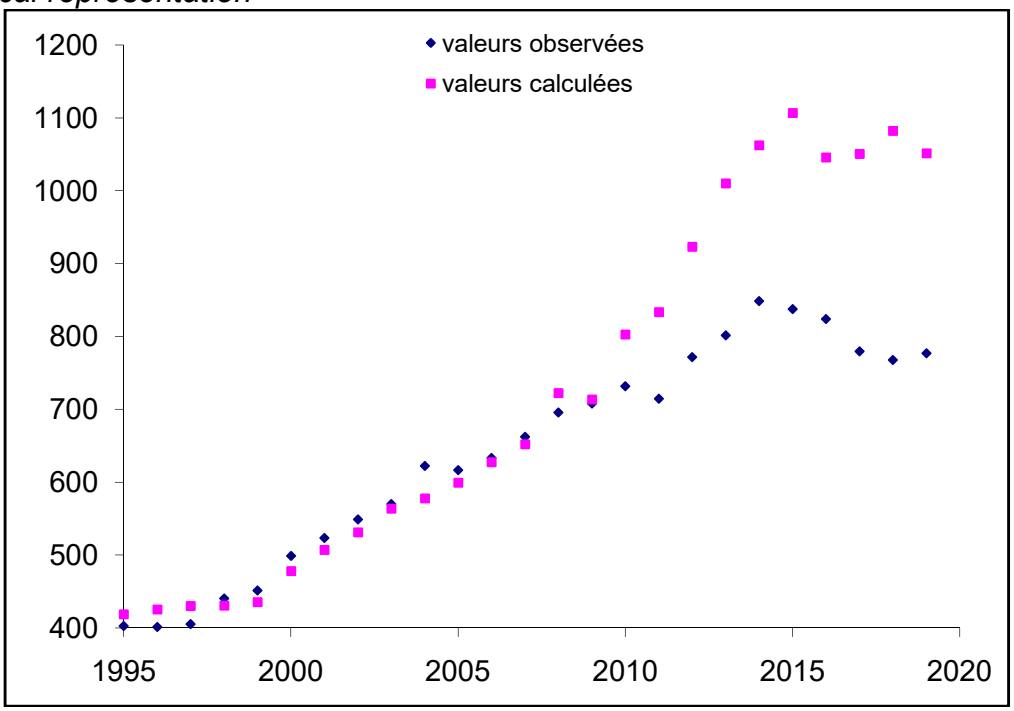
*Estimation of the production function*

| Equation 1 | | | | Equation 2 | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| σ | (1−σ)γ | σLog(α) | | μπ | β | |
| 0,517 | 0,017 | -1,526 | | 0,019 | 0,239 | |
| (2,4) | (2,5) | (3,9) | | (3,9) | (5,5) | |
| | | | | | | |
| R2 | | 0,958 | | R2 | | 0,522 |
| St. Deviation Regression | | 0,036 | | St. Deviation Regression | | 0,091 |

*Comparison of observed and simulated series*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 403 | 401 | 405 | 441 | 452 | 499 | 523 | 549 | 570 | 622 | 617 | 633 | 662 | 695 | 708 | 732 |
| Estimated | 419 | 426 | 430 | 431 | 436 | 478 | 507 | 532 | 564 | 578 | 599 | 628 | 652 | 722 | 713 | 803 |
| Relative gap | 4,0% | 6,0% | 6,2% | -2,2% | -3,5% | -4,2% | -3,0% | -3,2% | -1,0% | -7,1% | -2,8% | -0,8% | -1,5% | 3,9% | 0,8% | 9,7% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 732 | 714 | 771 | 802 | 848 | 837 | 824 | 779 | 768 | 777 | | | | | | |
| Estimated | 803 | 834 | 923 | 1010 | 1062 | 1107 | 1045 | 1051 | 1082 | 1052 | | | | | | |
| Relative gap | 9,7% | 16,7% | 19,7% | 26,0% | 25,2% | 32,2% | 26,9% | 34,8% | 41,0% | 35,3% | | | | | | |

*Graphical representation*



Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
ISSN: 2668-7798
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## Appendix 1continued

### Industries Mécaniques & Électriques

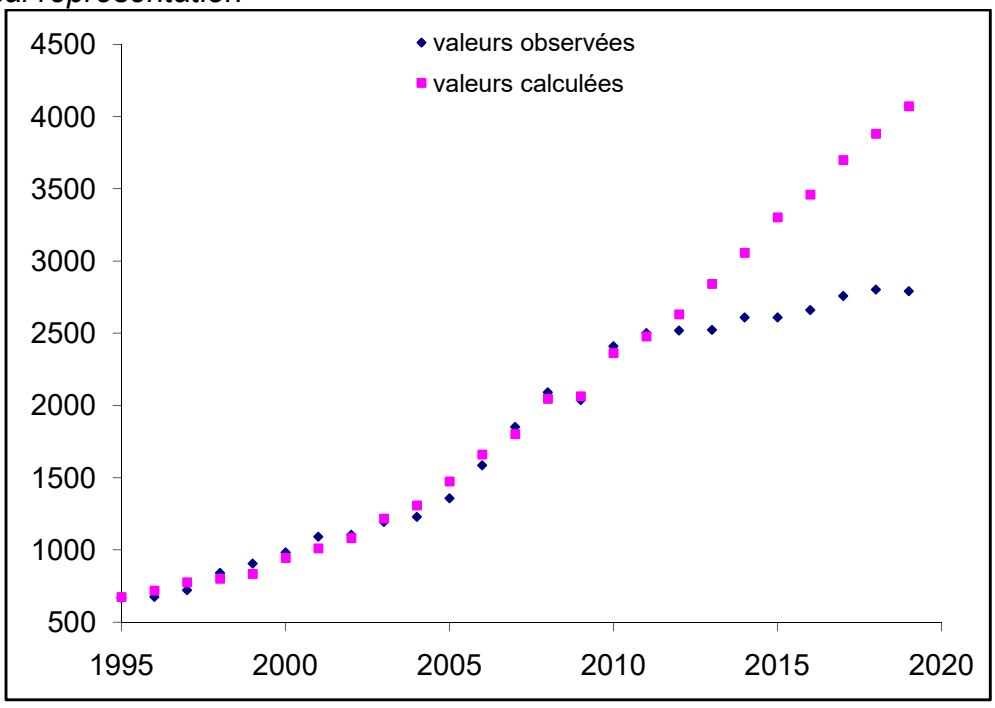
*Estimation of the production function*

| Equation 1 | | | | Equation 2 | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| σ | (1−σ)γ | σLog(α) | | μπ | β | |
| 0,564 | 0,019 | -1,262 | | 0,026 | -0,849 | |
| (2,0) | (3,0) | (2,0) | | (3,2) | (11,8) | |
| | | | | | | |
| R2 | | 0,911 | | R2 | | 0,419 |
| St. Deviation Regression | | 0,049 | | St. Deviation Regression | | 0,150 |

*Comparison of observed and simulated series*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 670 | 676 | 723 | 842 | 907 | 983 | 1092 | 1107 | 1196 | 1229 | 1359 | 1588 | 1854 | 2093 | 2038 | 2411 |
| Estimated | 677 | 720 | 778 | 803 | 835 | 945 | 1013 | 1085 | 1218 | 1310 | 1476 | 1662 | 1804 | 2049 | 2066 | 2364 |
| Relative gap | 1,1% | 6,6% | 7,6% | -4,6% | -7,9% | -3,9% | -7,2% | -2,0% | 1,9% | 6,6% | 8,6% | 4,7% | -2,7% | -2,1% | 1,3% | -1,9% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 2411 | 2502 | 2521 | 2525 | 2610 | 2610 | 2663 | 2759 | 2803 | 2791 | | | | | | |
| Estimated | 2364 | 2479 | 2633 | 2843 | 3059 | 3305 | 3462 | 3701 | 3884 | 4073 | | | | | | |
| Relative gap | -1,9% | -0,9% | 4,4% | 12,6% | 17,2% | 26,6% | 30,0% | 34,2% | 38,6% | 45,9% | | | | | | |

*Graphical representation*



Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
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## Appendix 1 continued

### Industries chimiques

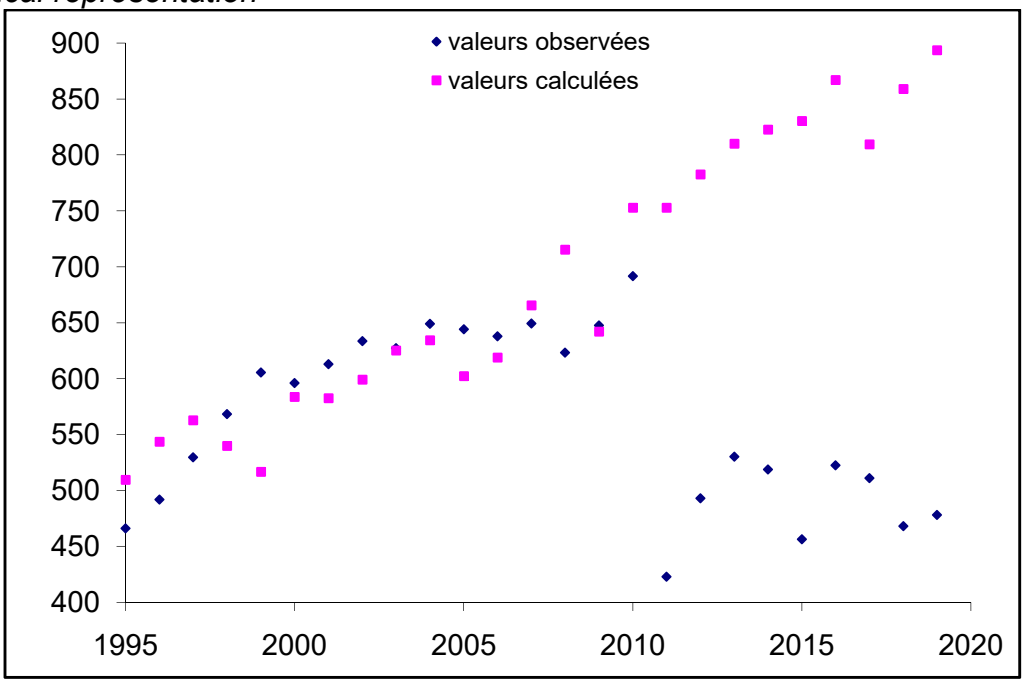
*Estimation of the production function*

| Equation 1 | | | | Equation 2 | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| σ | (1−σ)γ | σLog(α) | | μπ | β | |
| 0,817 | 0,009 | -0,826 | | -0,021 | -1,274 | |
| (6,4) | (2,4) | (2,1) | | (6,0) | (42,2) | |
| | | | | | | |
| R2 | | 0,798 | | R2 | | 0,722 |
| St. Deviation Regression | | 0,049 | | St. Deviation Regression | | 0,063 |

*Comparison of observed and simulated series*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 466 | 492 | 530 | 568 | 605 | 596 | 613 | 634 | 627 | 649 | 644 | 638 | 649 | 623 | 647 | 692 |
| Estimated | 509 | 544 | 563 | 540 | 517 | 584 | 583 | 599 | 625 | 634 | 602 | 619 | 666 | 716 | 642 | 753 |
| Relative gap | 9,3% | 10,6% | 6,3% | -5,0% | -14,6% | -2,0% | -5,0% | -5,4% | -0,3% | -2,3% | -6,5% | -2,9% | 2,5% | 14,8% | -0,8% | 8,9% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 692 | 423 | 493 | 530 | 519 | 456 | 523 | 511 | 468 | 478 | | | | | | |
| Estimated | 753 | 753 | 783 | 810 | 823 | 830 | 867 | 810 | 859 | 894 | | | | | | |
| Relative gap | 8,9% | 78,1% | 58,8% | 52,8% | 58,6% | 82,0% | 65,9% | 58,4% | 83,5% | 87,0% | | | | | | |

*Graphical representation*



Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
ISSN: 2668-7798
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## Appendix 1 continued

### Textiles, Habillement & Cuirs

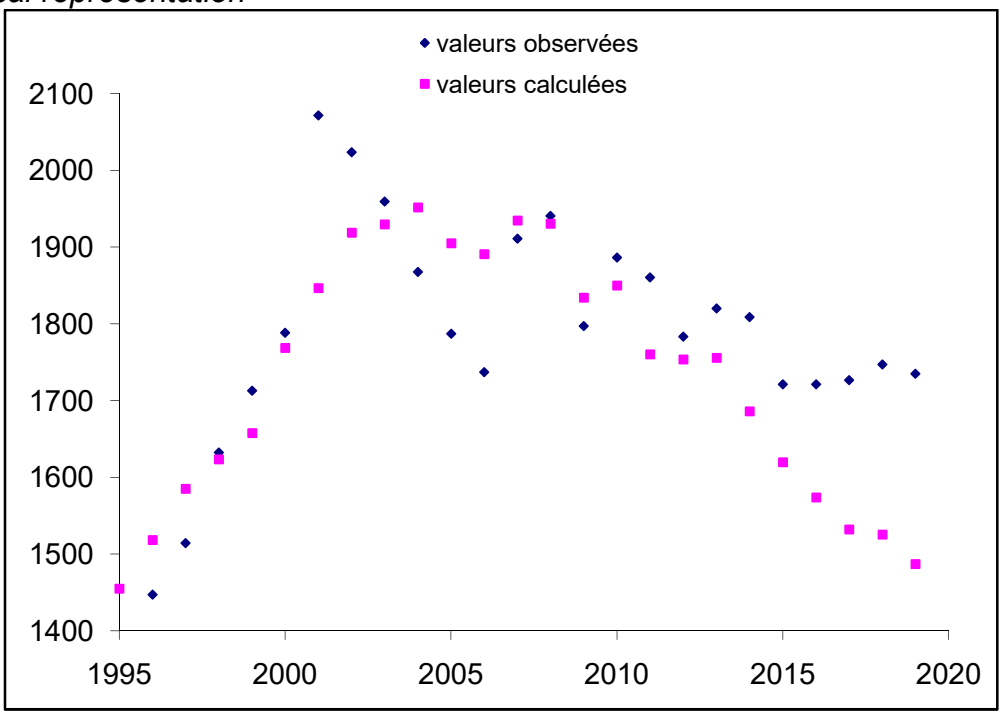
*Estimation of the production function*

| Equation 1 | | | | Equation 2 | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| σ | (1−σ)γ | σLog(α) | | μπ | β | |
| 0,354 | 0,011 | -1,296 | | 0,027 | -0,442 | |
| (2,4) | (4,7) | (5,3) | | (1,2) | (2,3) | |
| | | | | | | |
| R2 | | 0,645 | | R2 | | 0,096 |
| St. Deviation Regression | | 0,042 | | St. Deviation Regression | | 0,403 |

*Comparison of observed and simulated series*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 1399 | 1447 | 1514 | 1633 | 1713 | 1788 | 2072 | 2024 | 1959 | 1868 | 1787 | 1737 | 1911 | 1941 | 1797 | 1887 |
| Estimated | 1455 | 1518 | 1585 | 1624 | 1658 | 1769 | 1847 | 1919 | 1930 | 1952 | 1905 | 1891 | 1935 | 1931 | 1834 | 1850 |
| Relative gap | 4,0% | 4,9% | 4,7% | -0,5% | -3,2% | -1,1% | -10,9% | -5,2% | -1,5% | 4,5% | 6,6% | 8,9% | 1,2% | -0,5% | 2,1% | -1,9% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 1887 | 1861 | 1783 | 1820 | 1809 | 1721 | 1721 | 1727 | 1747 | 1735 | | | | | | |
| Estimated | 1850 | 1760 | 1754 | 1756 | 1686 | 1620 | 1574 | 1532 | 1526 | 1487 | | | | | | |
| Relative gap | -1,9% | -5,4% | -1,7% | -3,5% | -6,8% | -5,9% | -8,6% | -11,3% | -12,7% | -14,3% | | | | | | |

*Graphical representation*



Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
ISSN: 2668-7798
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## Appendix 1 continued

### Industries manufacturières diverses

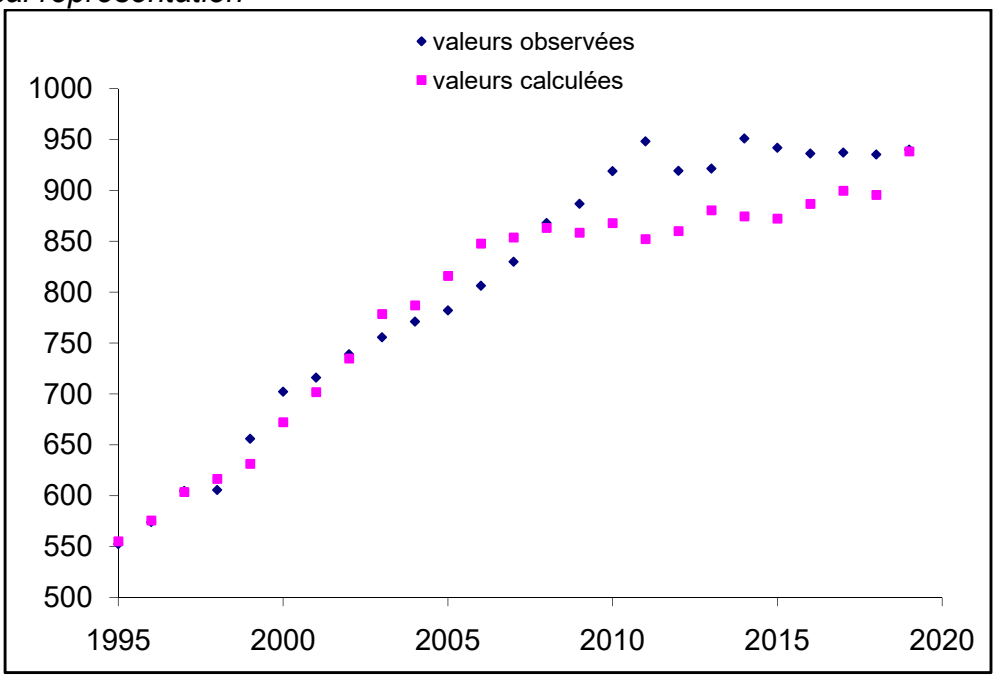
*Estimation of the production function*

| Equation 1 | | | | Equation 2 | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| σ | (1−σ)γ | σLog(α) | | μπ | β | |
| 0,232 | 0,011 | -1,770 | | 0,038 | 1,361 | |
| (3,0) | (9,3) | (16,3) | | (3,3) | (13,4) | |
| | | | | | | |
| R2 | | 0,948 | | R2 | | 0,441 |
| St. Deviation Regression | | 0,016 | | St. Deviation Regression | | 0,212 |

*Comparison of observed and simulated series*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 553 | 574 | 605 | 606 | 656 | 702 | 716 | 739 | 755 | 771 | 782 | 806 | 830 | 868 | 887 | 919 |
| Estimated | 555 | 576 | 604 | 617 | 631 | 672 | 702 | 735 | 779 | 787 | 816 | 848 | 854 | 863 | 858 | 868 |
| Relative gap | 0,5% | 0,3% | -0,2% | 1,8% | -3,8% | -4,3% | -2,0% | -0,6% | 3,1% | 2,1% | 4,3% | 5,1% | 2,9% | -0,6% | -3,2% | -5,5% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 919 | 948 | 919 | 921 | 951 | 942 | 936 | 937 | 935 | 940 | | | | | | |
| Estimated | 868 | 852 | 860 | 880 | 875 | 872 | 887 | 900 | 896 | 938 | | | | | | |
| Relative gap | -5,5% | -10,1% | -6,4% | -4,4% | -8,0% | -7,4% | -5,3% | -4,0% | -4,2% | -0,1% | | | | | | |

*Graphical representation*



Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
ISSN: 2668-7798
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## Appendix 2: results by sub-sectors of Non-manufacturing Industries

### Mines

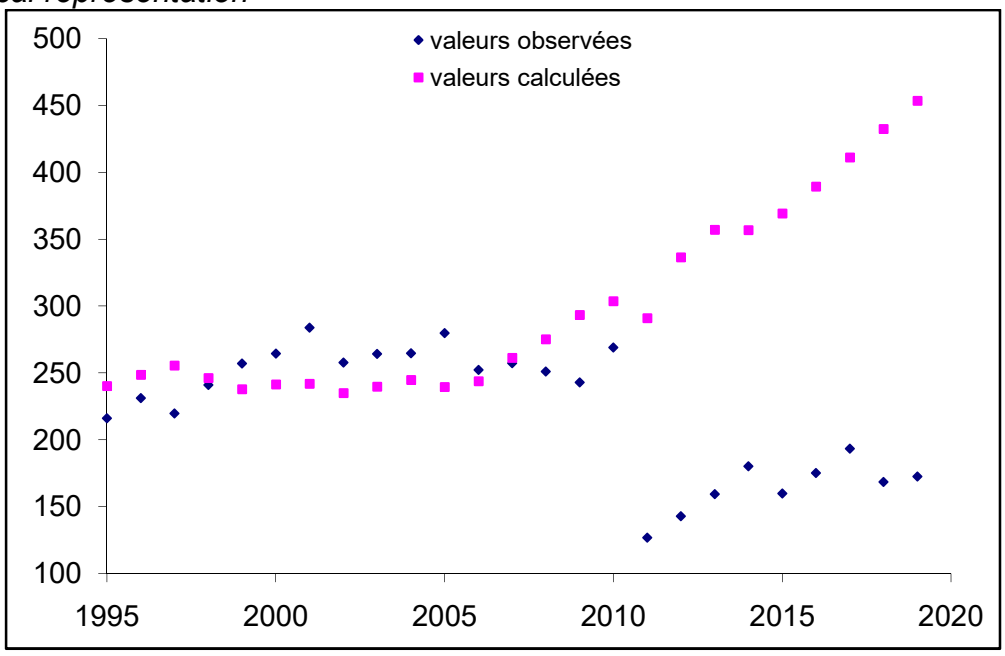
*Estimation of the production function*

| Equation 1 | | | | Equation 2 | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| σ | (1−σ)γ | σLog(α) | | μπ | β | |
| 0,223 | 0,049 | -2,552 | | 0,071 | 3,229 | |
| (2,6) | (12,8) | (12,7) | | (2,1) | (10,9) | |
| | | | | | | |
| R2 | | 0,935 | | R2 | | 0,241 |
| St. Deviation Regression | | 0,070 | | St. Deviation Regression | | 0,621 |

*Comparison of observed and simulated series*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 216 | 231 | 220 | 241 | 257 | 264 | 284 | 258 | 264 | 265 | 280 | 252 | 257 | 251 | 243 | 269 |
| Estimated | 240 | 249 | 256 | 246 | 238 | 241 | 242 | 235 | 240 | 245 | 239 | 244 | 261 | 275 | 293 | 304 |
| Relative gap | 11,2% | 7,6% | 16,4% | 2,2% | -7,4% | -8,6% | -14,8% | -8,9% | -9,2% | -7,5% | -14,4% | -3,3% | 1,5% | 9,6% | 20,8% | 12,9% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 269 | 127 | 143 | 159 | 180 | 160 | 175 | 193 | 168 | 172 | | | | | | |
| Estimated | 304 | 291 | 336 | 357 | 357 | 369 | 389 | 411 | 432 | 454 | | | | | | |
| Relative gap | 12,9% | 129,6% | 135,8% | 123,9% | 98,0% | 131,3% | 122,2% | 112,8% | 157,0% | 162,9% | | | | | | |

*Graphical representation*



Technium Social Sciences Journal
Vol. 24, 362-393, October, 2021
ISSN: 2668-7798
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## Appendix 2 continued

### Hydrocarbures

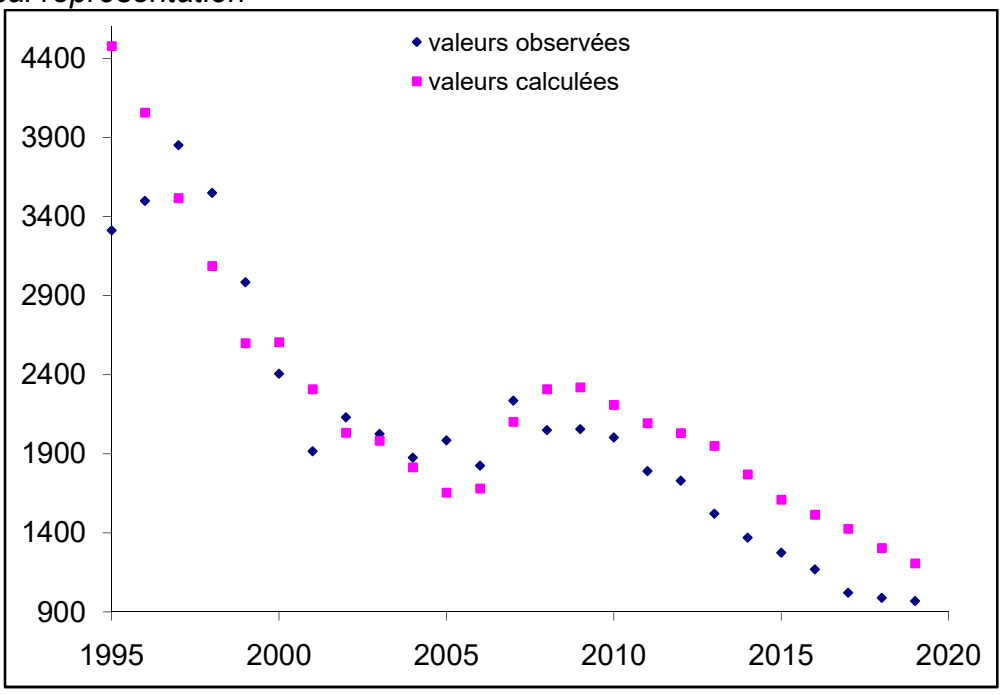
*Estimation of the production function*

| Equation 1 | | | | Equation 2 | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| σ | (1−σ)γ | σLog(α) | | μπ | β | |
| 0,377 | -0,043 | -4,237 | | -0,139 | -0,943 | |
| (2,9) | (3,7) | (5,4) | | (4,4) | (3,4) | |
| | | | | | | |
| R2 | | 0,920 | | R2 | | 0,582 |
| St. Deviation Regression | | 0,110 | | St. Deviation Regression | | 0,579 |

*Comparison of observed and simulated series*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 3313 | 3498 | 3851 | 3549 | 2985 | 2405 | 1916 | 2131 | 2025 | 1875 | 1985 | 1824 | 2236 | 2050 | 2055 | 2002 |
| Estimated | 4478 | 4056 | 3517 | 3088 | 2600 | 2607 | 2308 | 2033 | 1983 | 1813 | 1655 | 1681 | 2103 | 2308 | 2321 | 2210 |
| Relative gap | 35,2% | 16,0% | -8,7% | -13,0% | -12,9% | 8,4% | 20,5% | -4,6% | -2,1% | -3,3% | -16,7% | -7,8% | -5,9% | 12,6% | 12,9% | 10,4% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 2002 | 1789 | 1730 | 1521 | 1369 | 1274 | 1169 | 1020 | 988 | 968 | | | | | | |
| Estimated | 2210 | 2094 | 2030 | 1950 | 1771 | 1609 | 1515 | 1425 | 1304 | 1207 | | | | | | |
| Relative gap | 10,4% | 17,0% | 17,4% | 28,2% | 29,3% | 26,3% | 29,6% | 39,7% | 32,0% | 24,7% | | | | | | |

*Graphical representation*



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Vol. 24, 362-393, October, 2021
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**Appendix 2 continued**

**Electricité**

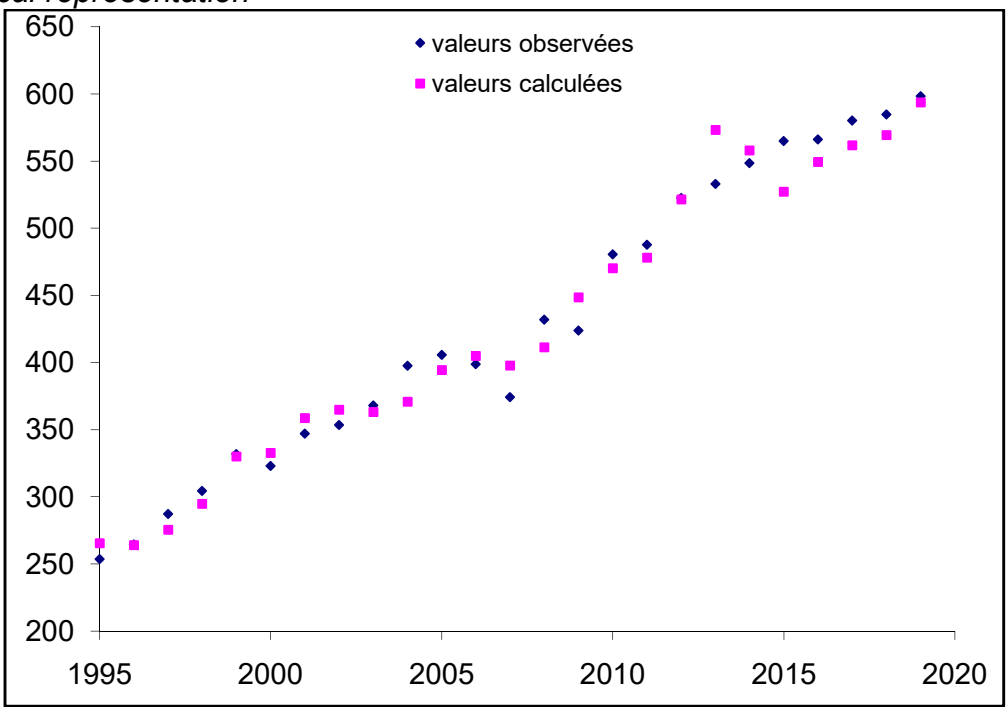
*Estimation of the production function*

| **Equation 1** | | | | **Equation 2** | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| σ | (1−σ)γ | σLog(α) | | μπ | β | |
| 0,389 | 0,009 | -2,436 | | 0,046 | 3,294 | |
| (2,7) | (1,8) | (7,4) | | (8,1) | (66,3) | |
| | | | | | | |
| R2 | | 0,773 | | R2 | | 0,823 |
| St. Deviation Regression | | 0,055 | | St. Deviation Regression | | 0,104 |

*Comparison of observed and simulated series*

| | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 254 | 265 | 287 | 304 | 332 | 323 | 347 | 353 | 368 | 398 | 406 | 399 | 374 | 432 | 424 | 481 |
| Estimated | 265 | 264 | 275 | 295 | 330 | 333 | 359 | 365 | 363 | 371 | 394 | 405 | 398 | 411 | 449 | 470 |
| Relative gap | 4,6% | -0,2% | -4,1% | -3,2% | -0,5% | 3,1% | 3,3% | 3,3% | -1,3% | -6,7% | -2,8% | 1,6% | 6,3% | -4,7% | 5,8% | -2,1% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 481 | 488 | 522 | 533 | 548 | 565 | 566 | 580 | 585 | 598 | | | | | | |
| Estimated | 470 | 478 | 522 | 573 | 558 | 527 | 549 | 562 | 569 | 594 | | | | | | |
| Relative gap | -2,1% | -2,0% | -0,2% | 7,5% | 1,8% | -6,7% | -2,9% | -3,2% | -2,6% | -0,7% | | | | | | |

*Graphical representation*



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## Appendix 2 continued

### Eau

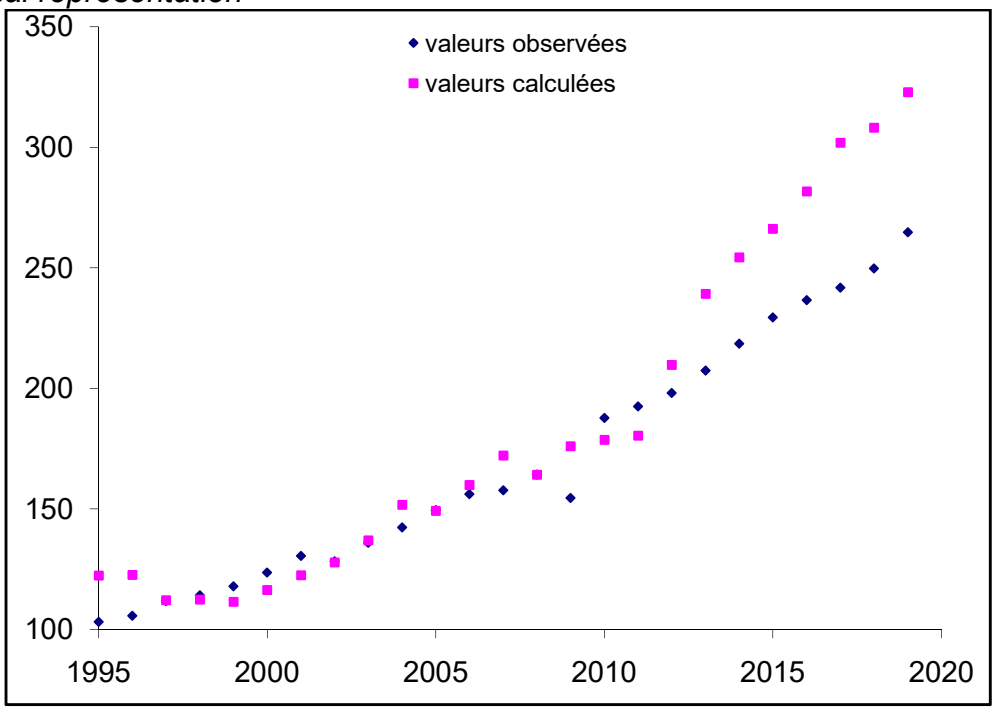
*Estimation of the production function*

| Equation 1 | | | | Equation 2 | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| σ | (1−σ)γ | σLog(α) | | μπ | β | |
| 0,139 | 0,032 | -2,336 | | 0,325 | 14,001 | |
| (0,9) | (1,8) | (11,9) | | (6,1) | (29,6) | |
| | | | | | | |
| R2 | | 0,807 | | R2 | | 0,724 |
| St. Deviation Regression | | 0,117 | | St. Deviation Regression | | 0,990 |

*Comparison of observed and simulated series*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 103 | 106 | 112 | 114 | 118 | 124 | 130 | 128 | 136 | 142 | 150 | 156 | 158 | 164 | 155 | 188 |
| Estimated | 122 | 123 | 112 | 112 | 111 | 116 | 123 | 128 | 137 | 152 | 149 | 160 | 172 | 164 | 176 | 179 |
| Relative gap | 18,7% | 16,1% | 0,3% | -1,5% | -5,4% | -5,8% | -6,1% | -0,3% | 0,8% | 6,6% | -0,2% | 2,5% | 9,2% | 0,1% | 13,9% | -4,8% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 188 | 193 | 198 | 207 | 219 | 229 | 237 | 242 | 250 | 265 | | | | | | |
| Estimated | 179 | 180 | 210 | 239 | 254 | 266 | 282 | 302 | 308 | 323 | | | | | | |
| Relative gap | -4,8% | -6,3% | 5,9% | 15,4% | 16,4% | 16,0% | 19,1% | 24,9% | 23,4% | 22,0% | | | | | | |

*Graphical representation*



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Vol. 24, 362-393, October, 2021
ISSN: 2668-7798
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## Appendix 2 continued

### Bâtiments & Génie Civil

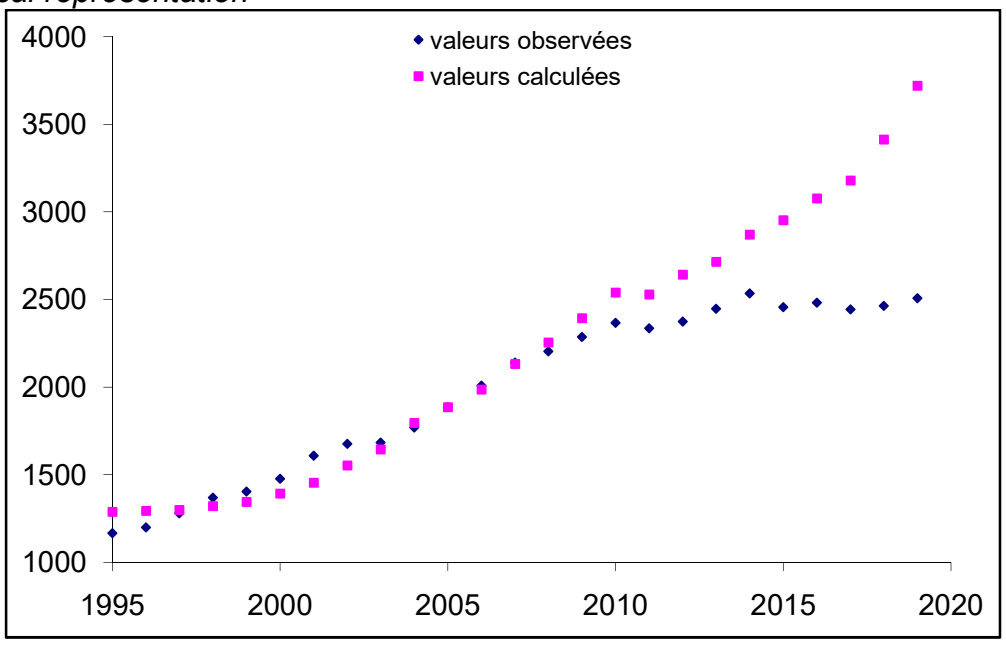
*Estimation of the production function*

| Equation 1 | | | | Equation 2 | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| σ | (1−σ)γ | σLog(α) | | μπ | β | |
| 0,099 | 0,019 | -1,405 | | 0,277 | -1,764 | |
| (0,8) | (3,1) | (49,2) | | (6,5) | (4,7) | |
| | | | | | | |
| R2 | | 0,806 | | R2 | | 0,752 |
| St. Deviation Regression | | 0,057 | | St. Deviation Regression | | 0,783 |

*Comparison of observed and simulated series*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 1166 | 1199 | 1279 | 1369 | 1404 | 1477 | 1607 | 1675 | 1683 | 1768 | 1885 | 2007 | 2139 | 2205 | 2287 | 2366 |
| Estimated | 1289 | 1294 | 1300 | 1321 | 1344 | 1392 | 1454 | 1553 | 1644 | 1797 | 1885 | 1986 | 2132 | 2256 | 2393 | 2541 |
| Relative gap | 10,6% | 7,9% | 1,6% | -3,5% | -4,3% | -5,8% | -9,6% | -7,3% | -2,3% | 1,6% | 0,0% | -1,1% | -0,3% | 2,3% | 4,7% | 7,4% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 2366 | 2336 | 2373 | 2447 | 2535 | 2456 | 2481 | 2444 | 2463 | 2508 | | | | | | |
| Estimated | 2541 | 2530 | 2643 | 2715 | 2871 | 2954 | 3078 | 3180 | 3413 | 3720 | | | | | | |
| Relative gap | 7,4% | 8,3% | 11,4% | 10,9% | 13,2% | 20,3% | 24,1% | 30,1% | 38,6% | 48,4% | | | | | | |

*Graphical representation*



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Vol. 24, 362-393, October, 2021
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## Appendix 3: results by sub-sectors of Commercial Services

### Commerce

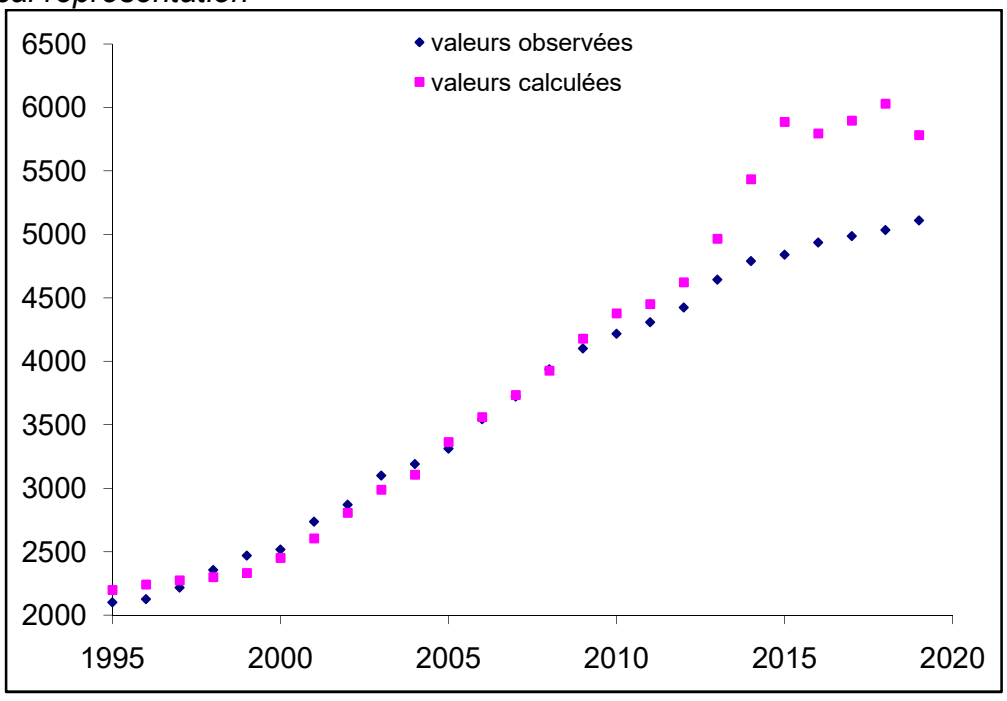
*Estimation of the production function*

| Equation 1 | | | | Equation 2 | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| σ | (1−σ)γ | σLog(α) | | μπ | β | |
| 0,259 | 0,003 | -1,843 | | 0,124 | -1,843 | |
| (2,3) | (2,2) | (9,2) | | (9,0) | (15,1) | |
| | | | | | | |
| R2 | | 0,468 | | R2 | | 0,852 |
| St. Deviation Regression | | 0,029 | | St. Deviation Regression | | 0,256 |

*Comparison of observed and simulated series*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 2103 | 2126 | 2219 | 2356 | 2470 | 2518 | 2738 | 2870 | 3100 | 3192 | 3313 | 3545 | 3725 | 3938 | 4101 | 4218 |
| Estimated | 2199 | 2243 | 2274 | 2300 | 2333 | 2453 | 2607 | 2808 | 2989 | 3108 | 3366 | 3563 | 3735 | 3929 | 4180 | 4380 |
| Relative gap | 4,6% | 5,5% | 2,5% | -2,4% | -5,5% | -2,6% | -4,8% | -2,1% | -3,6% | -2,6% | 1,6% | 0,5% | 0,3% | -0,2% | 1,9% | 3,9% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 4218 | 4309 | 4426 | 4643 | 4790 | 4840 | 4937 | 4986 | 5036 | 5111 | | | | | | |
| Estimated | 4380 | 4452 | 4623 | 4966 | 5435 | 5889 | 5798 | 5897 | 6032 | 5785 | | | | | | |
| Relative gap | 3,9% | 3,3% | 4,5% | 6,9% | 13,5% | 21,7% | 17,4% | 18,3% | 19,8% | 13,2% | | | | | | |

*Graphical representation*



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**Appendix 3 continued**

**Télécommunications**

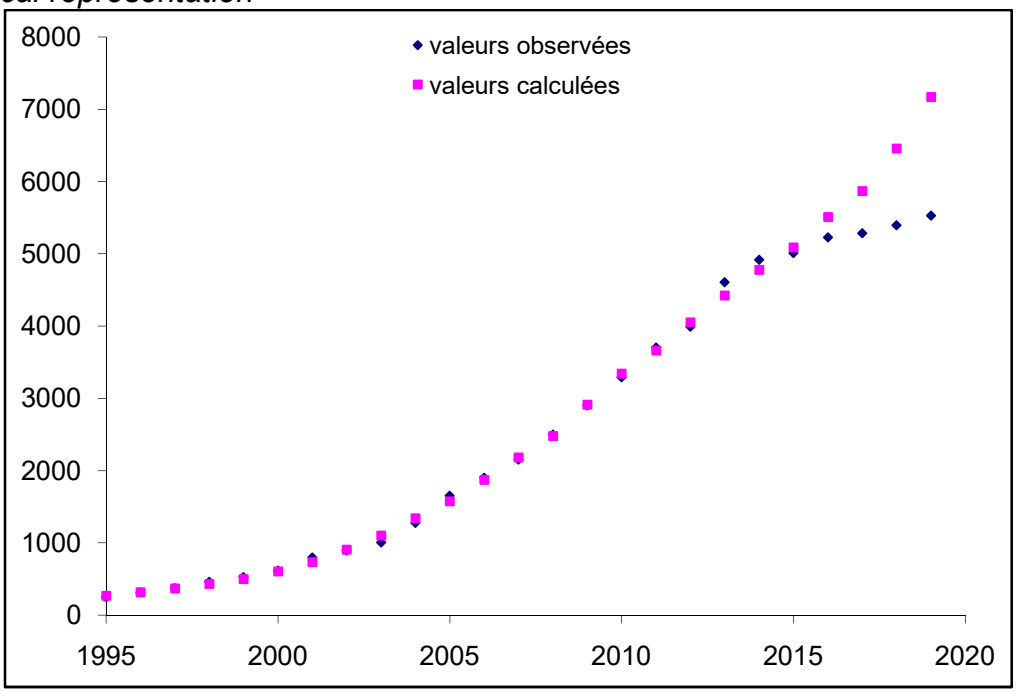
*Estimation of the production function*

| **Equation 1** | | | | **Equation 2** | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| σ | (1−σ)γ | σLog(α) | | μπ | β | |
| 0,356 | 0,068 | -2,253 | | 0,185 | 2,994 | |
| (3,2) | (5,1) | (11,4) | | (25,5) | (46,9) | |
| | | | | | | |
| R2 | | 0,995 | | R2 | | 0,979 |
| St. Deviation Regression | | 0,041 | | St. Deviation Regression | | 0,134 |

*Comparison of observed and simulated series*

| | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 249 | 316 | 374 | 461 | 526 | 617 | 796 | 897 | 1007 | 1277 | 1651 | 1899 | 2154 | 2498 | 2901 | 3290 |
| Estimated | 271 | 319 | 373 | 434 | 500 | 605 | 736 | 906 | 1103 | 1340 | 1578 | 1872 | 2183 | 2479 | 2913 | 3345 |
| Relative gap | 9,2% | 1,0% | -0,2% | -5,8% | -5,0% | -1,9% | -7,5% | 1,1% | 9,5% | 4,9% | -4,4% | -1,4% | 1,3% | -0,8% | 0,4% | 1,7% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 3290 | 3701 | 3991 | 4604 | 4915 | 5009 | 5224 | 5281 | 5392 | 5527 | | | | | | |
| Estimated | 3345 | 3663 | 4054 | 4424 | 4779 | 5090 | 5507 | 5868 | 6457 | 7172 | | | | | | |
| Relative gap | 1,7% | -1,0% | 1,6% | -3,9% | -2,8% | 1,6% | 5,4% | 11,1% | 19,7% | 29,8% | | | | | | |

*Graphical representation*



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Vol. 24, 362-393, October, 2021
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## Appendix 3 continued

### Hôtels, Cafés & Restaurants

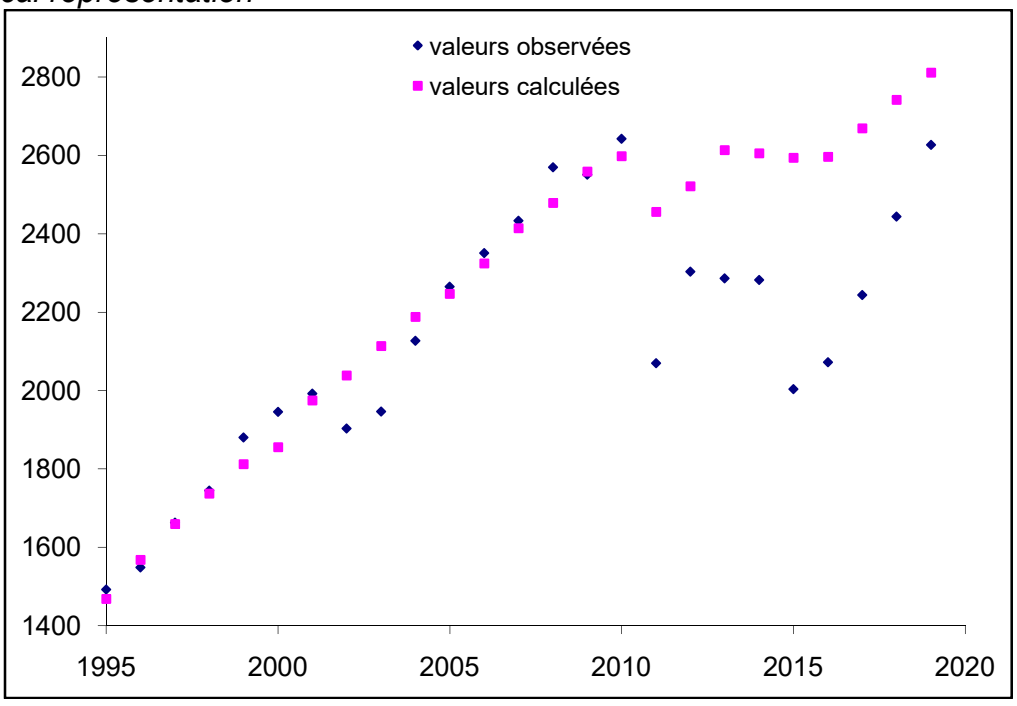
*Estimation of the production function*

| Equation 1 | | | | Equation 2 | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| σ | (1−σ)γ | σLog(α) | | μπ | β | |
| 0,740 | 0,006 | -1,438 | | 0,001 | -0,229 | |
| (5,5) | (3,7) | (5,1) | | (1,2) | (23,0) | |
| | | | | | | |
| R2 | | 0,724 | | R2 | | 0,094 |
| St. Deviation Regression | | 0,026 | | St. Deviation Regression | | 0,021 |

*Comparison of observed and simulated series*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 1492 | 1548 | 1663 | 1744 | 1880 | 1945 | 1992 | 1903 | 1947 | 2126 | 2265 | 2351 | 2433 | 2569 | 2551 | 2643 |
| Estimated | 1468 | 1568 | 1659 | 1737 | 1813 | 1856 | 1975 | 2039 | 2114 | 2188 | 2247 | 2325 | 2414 | 2479 | 2559 | 2598 |
| Relative gap | -1,6% | 1,3% | -0,2% | -0,4% | -3,6% | -4,6% | -0,9% | 7,1% | 8,6% | 2,9% | -0,8% | -1,1% | -0,8% | -3,5% | 0,3% | -1,7% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 2643 | 2070 | 2303 | 2286 | 2282 | 2004 | 2072 | 2244 | 2444 | 2627 | | | | | | |
| Estimated | 2598 | 2456 | 2521 | 2613 | 2605 | 2594 | 2597 | 2669 | 2742 | 2811 | | | | | | |
| Relative gap | -1,7% | 18,7% | 9,5% | 14,3% | 14,2% | 29,5% | 25,3% | 19,0% | 12,2% | 7,0% | | | | | | |

*Graphical representation*



Technium Social Sciences Journal
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**Appendix 3 continued**

**AutresServices**

*Estimation of the production function*

| **Equation 1** | | | | **Equation 2** | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| σ | (1−σ)γ | σLog(α) | | μπ | β | |
| 0,095 | 0,015 | -2,744 | | -0,203 | 1,536 | |
| (0,8) | (6,1) | (16,0) | | (5,3) | (4,6) | |
| | | | | | | |
| R2 | | 0,824 | | R2 | | 0,668 |
| St. Deviation Regression | | 0,038 | | St. Deviation Regression | | 0,705 |

*Comparison of observed and simulated series*

| | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed | 3140 | 3302 | 3478 | 3604 | 3767 | 3803 | 4046 | 4567 | 5037 | 5120 | 5269 | 5768 | 6016 | 6351 | 6560 | 6813 |
| Estimated | 3129 | 3205 | 3283 | 3448 | 3573 | 3912 | 4332 | 4743 | 5075 | 5557 | 5763 | 5951 | 6119 | 6173 | 6136 | 6096 |
| Relative gap | -0,4% | -2,9% | -5,6% | -4,3% | -5,2% | 2,9% | 7,1% | 3,8% | 0,8% | 8,5% | 9,4% | 3,2% | 1,7% | -2,8% | -6,5% | -10,5% |
| | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | | | | | | |
| Observed | 6813 | 6882 | 6983 | 7272 | 7495 | 7597 | 7813 | 8028 | 8243 | 8458 | | | | | | |
| Estimated | 6096 | 5896 | 5913 | 5997 | 6060 | 6041 | 6047 | 5990 | 5894 | 5715 | | | | | | |
| Relative gap | -10,5% | -14,3% | -15,3% | -17,5% | -19,1% | -20,5% | -22,6% | -25,4% | -28,5% | -32,4% | | | | | | |

*Graphical representation*