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Analysis of the Decomposition of Energy Intensity in Tunisia

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ABSTRACT: In this article, we are interested in the analysis of energy intensity by the Fisher Ideal Index method, a method belonging to the approach of the Index Decomposition Analysis (IDA), in order to highlight the effects which contribute to its reduction. The use of this method allowed us to decompose the variation of energy intensity in Tunisia for the period 1990-2008 into two effects: one effect due to the structural change of the economy and another arising from energy efficiency. We show that the effect of enhancing energy efficiency is the main contributor to the reduction of energy intensity in Tunisia. Indeed, the setting into action of the policy of energy control has improved energy efficiency by allowing reaching a lower level of energy intensity. On the other hand, the effect of structural change through the orientation of the Tunisian economy toward the tertiary sector has also helped to reduce the energy intensity.

Keywords: energy intensity; energy efficiency; economic structure; Index Decomposition Analysis (IDA)
JEL Classifications: C4; Q4

1. Introduction

During these last years, Tunisia has known a rise in the demand of energy which led to a draining of energetic resources and a rise of Greenhouse gases emissions. Indeed, the demand of energy has increased by 5% per annum since the eve of the 1990s. The government sought to promote the rational use of energy through a set of policies of energy control such as the national policy of energy efficiency. This policy is based on the reinforcement of the institutional framework, with the creation of a National Agency for the Control of Energy (ANME) in 1986, a non-administrative public establishment placed under the protection of the Ministry of Industry having the mission of setting into action the State policy in the field of energy control. It has also been translated by the promulgation of new laws and the adoption of regulatory texts expressing at the same time the support to investments in this field and the growing interest related to energy control as a priority axis of the country's energetic policy. Finally, this policy is concentrated on the creation of a national fund for the control of energy, allocating direct financial aids and by the setting of a line of credits with the purpose of implementing investment in the field of energy efficiency.

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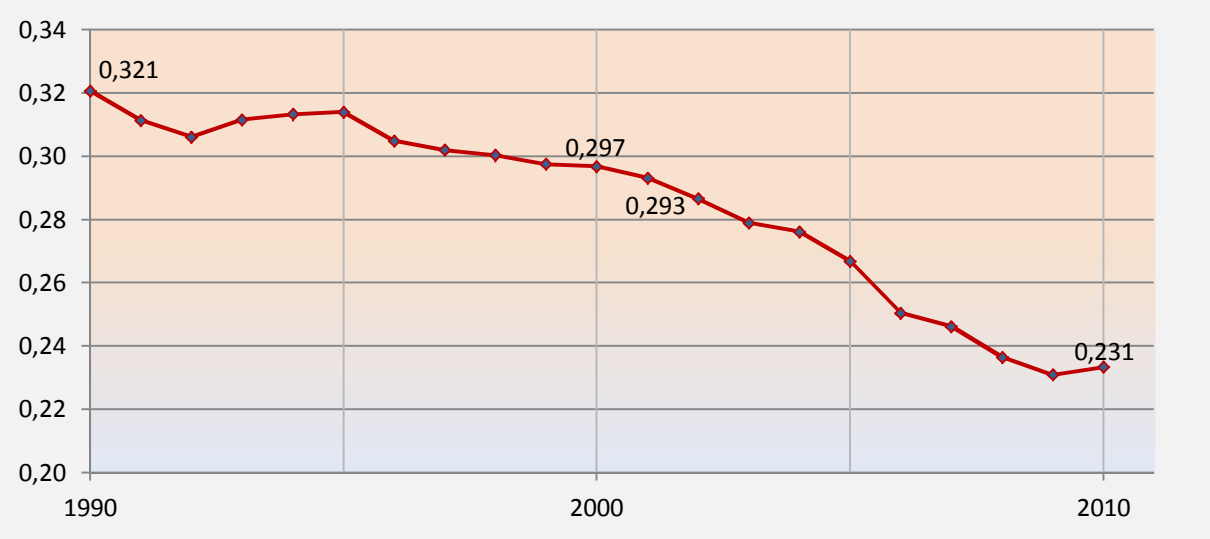
The energetic sector is characterized by a strong dependency on fossil energies. Energy consumption comes mainly from two non-renewable resources which are petrol and natural gas. The pollution of the environment is essentially due to the combustion of these resources. Indeed, the consumption of primary energy has witnessed a continuous progression at a swift speed reaching 7947 Ktoe[2] in 2010[3]. This consumption progression results not only from the growth of the productive sector but also from the improvement of households' level of living, social development consumers' requirements and the country's opening on the foreign market. The improvement of Energy intensity, the ratio of energy consumption to the GDP, indicates the power of the economy to generate wealth by consuming more or less energy. Tunisia has witnessed a decline in primary energy intensity by 27% with regard to 1990 which reflects a gain in energetic productivity. This decline has clearly accelerated from the year 2001, which urges us to wonder on the origin of this reduction.

Figure 1. The evolution of Final Energy Intensity in Tunisia (tep/1000DT)



The aim of this article consists in analyzing the variation of energy intensity in Tunisia by the Index Decomposition Analysis (IDA) in order to highlight the effects which contribute to its reduction in the period of 1990-2008 (figure 1). We have shown that the variation of energy intensity at this period can be decomposed into two effects: one effect due to the structural change of the economy and another arising from energy efficiency. Besides, our empirical analysis shows that the improvement of energy efficiency is the main contributor to the reduction of energy efficiency in Tunisia. Indeed, the implementation of a policy of energy control has improved energy efficiency by allowing to reach a lower level of energy intensity. On the other hand, the effect of structural change of the economy has contributed in its turn to the improvement of energy intensity through the orientation of Tunisian economy toward the tertiary sector.

The following part of this article is organized as follows: Section 2 presents the energetic sector in Tunisia. Section 3 presents in a succinct way the principle of decomposition of the variation of energy intensity by IDA method as well as the results of our empirical analysis. Finally, the last section will be dedicated to the conclusion.

2. Description of the Energy Sector in Tunisia

Since the years 2000, Tunisia has become a noticeable importer of internal energy. Renewable energies can no longer replace petrol and resources are getting more and more costly. On the other hand, the consumption of primary energy in Tunisia has witnessed a continuous progression at a swift rhythm which reflects the economic and social development. It increases at a fast speed reaching 7947 Ktoe in 2010. Indeed, the structure of energy consumption was dominated by petroleum products

[2] kilotons of oil equivalent
[3] National Agency for the Control of Energy (ANME), (2012)

during the last decades since petrol has imposed itself as the main energetic source. On average, petroleum products represent 65% of the total consumption of primary energy. However, the government is trying to implement policies that encourage the substitution of petrol by natural gas. Indeed, the utilization of natural gas has been initiated in 1995 and accelerated in mid-2000. That's why since 1995, the proportion of petroleum products in the total consumption of energy is decreasing but on the other hand the proportion of natural gas out of the total consumption of energy is increasing. The aim of petrol substitution shall be to reduce the greenhouse gases emissions.

Nevertheless, the consumption of energy of a sector depends both on the importance of the economic activity of this sector and on the intensity of energy consumption. In Tunisia, the final energy consumption is in continuous progression. During all the period 1990-2000, the industrial sector was the most energy consuming sector. Its ration of energy consumption was 41% of the total consumption in 1990. It decreased so as to reach 36% of the total consumption in 2000. In a parallel way, the ration of tertiary sector consumption in 2000 including transport has increased reaching 42% of the total consumption in 2000 with regard to 38% of the total consumption in 1990. During the period 2000-2008, the tertiary sector including transport has become the most energy consuming sector. Its share of energy consumption has evolved reaching 43% of the total consumption in 2010. In second place we find the industrial sector with 34% of the total consumption in 2008.

The evaluation of the relationship of various sectors of final use of energy in front of the economic growth has allowed us to find these main results: The energy intensity in the industrial sector has decreased by 28% in 2008 with regard to its level in 1990 since its ration of energy consumption has decreased. However, the energy intensity in the sector of transport has increased by 18% in 2008 with regard to its level in 1990 since its portion in energy consumption has increased by 6% and its ration in the formation of GDP has witnessed a slight slump.

Thus, the decline of energy intensity in Tunisia is mainly caused by a decrease of energy intensity in industry (28%). In other words, the reduction of energy intensity is due to the saving of energy in industry. Indeed, since 2004, in order to mobilize the potential of energy saving in industrial sector, the National Agency for the Control of Energy (ANME) has practiced 3 types of activities namely, the Energetic Audit which allows the diagnostic of energy consumption within the establishments, the Task Force IGCE which allows to identify the potential of energy saving in the High Energy Consuming Industries (IGCE, aka HECI) and the project of Energy Efficiency in the industrial sector which aims at the elimination of barriers for the development of the market of energy efficiency in a durable way. On the other hand, the high energy intensity of the transport sector contributes to the rise of total energy intensity since it represents the first energy consuming sector in Tunisia.

3. The Principle of Energy Intensity Decomposition by IDA Method

Even though an abundant literature has been linked to the analysis of energy consumption and economic growth, little attention has been allocated to the analysis of energy intensity and more precisely at the disaggregated level (by sectors). Many works have proceeded by the decomposition method as a technique for decomposing the variations of energy intensity in order to highlight the different contributors at its variation. According to Hoekstra and Van der Berg (2003), the two decomposition techniques which are currently utilized are the Index Decomposition Analysis (IDA) and the Structural Decomposition Analysis (SDA). The difference between these two techniques lies in the type of the data that are used. The SDA method utilizes the input-output model to decompose the evolution of indicators, whereas the IDA has utilized only sectorial data. In the economics literature, the IDA method has been utilized more often than the SDA method in order to analyze the factors of energy consumption and the emissions linked to energy. The advantage of the SDA method consists in the ability to distinguish indirect effects such as the technical effect and the effects of final demand, which cannot be achieved by the IDA method. But its drawback lies in its need for more disaggregated data. According to Ang (2004), the decomposition methods based on Logarithmic Average of Divisia Index (LMDI) and on Modified Fisher Ideal Method are preferred because they are endowed with desirable properties satisfying the inversion of factors and the change of strong signs.

In order to highlight the explanatory effects of the variation of energy intensity in Tunisia, we have used the method of Index Decomposition Analysis (IDA) which allows to separate the effects of structural changes of the economy from the effects caused by the improvement of energy efficiency.

We have applied the Fisher Ideal Index method belonging to the IDA approach which utilizes only the sectorial data.

The energy intensity (e_t) can be written as a function of the energy efficiency and the components of economic activity[4]:

$$e_t \equiv \frac{E_t}{Y_t} = \sum_i \frac{E_{it}}{Y_{it}} \frac{Y_{it}}{Y_t} = \sum_i e_{it} s_{it} \quad (1)$$

Where E_t and Y_t are respectively the total energy consumption and GDP in year t. We notice by E_{it} and Y_{it} respectively energy consumption and the measurement of economic activity in sector i for the year t. Indeed, we have utilized the measurements of the economic activity linked to the underlying demand of the demand within each sector.

The equation (1) indicates that the total energy intensity is a function of energy efficiency of the specific sector (e_{it}) and the sectorial activity (s_{it}). The effect of efficiency makes reference to the reduced utilization of energy per unit of economic activity whereas the effect of the activity is linked to the changing combination of the economic activity (shift from an economic activity of intensive energetic consumption toward economic activities of less intensive energy consumption). In the study of Metcalf (2008), a Fisher Ideal Index provides a perfect decomposition of a total index of energy intensity into an efficiency index (F_t^{eff}) and an index of activity (F_t^{act}) without any residue. The index of activity indicates that the change of energy intensity is due to the change in the combination of the economic activity, by maintaining the efficiency within a constant sector and the efficiency index signifies that the change of energy intensity is due to the change of efficiency, by maintaining the constant economic structure.

The Fisher Ideal Index is then given by:

$$\frac{e_t}{e_0} \equiv I_t = F_t^{act} F_t^{eff} \quad (2)$$

This decomposition allows to highlight the changes in the consumption of energy resulting from the improvement of energy intensity. We define the savings of energy (Δ_{Et}) due to the changes of energy intensity as follows:

$$\Delta E_t = E_t - \hat{E}_t \quad (3)$$

Where E_t is the consumption of real energy and $\hat{E}_t$ is the consumption of energy which would be produced if the energy intensity remained at its basic level (1990). Thus, the variation of energy intensity due to the efficiency and the activity is presented as follows:

$$\Delta E_t = \Delta E_t \left(\frac{\ln(F_t^{act})}{\ln(I_t)}\right) + \Delta E_t \left(\frac{\ln(F_t^{eff})}{\ln(I_t)}\right) \equiv \Delta F_t^{act} + \Delta F_t^{eff} \quad (4)$$

This last equation allows us to decompose the savings of energy resulting from the improvement of the energy efficiency and the changes in the economic activity.

4. Presentation of the results of the Decomposition

To decompose the economies of energy in Tunisia into two previously cited components, we have collected statistic data on the consumption of energy of the period stretching from 1990 up to 2008 provided by the national energy balance of the National Observatory of Energy (NOE), as well as the observations on the structures of values added by sector of activity at the constant price arising from the nation's accounts of National Institute of Statistic of Tunisia (INST). We have utilized the final consumption of energy to highlight the effect of structural change of the economy and assess the impact of the implementation of energy efficiency in sectorial variations.

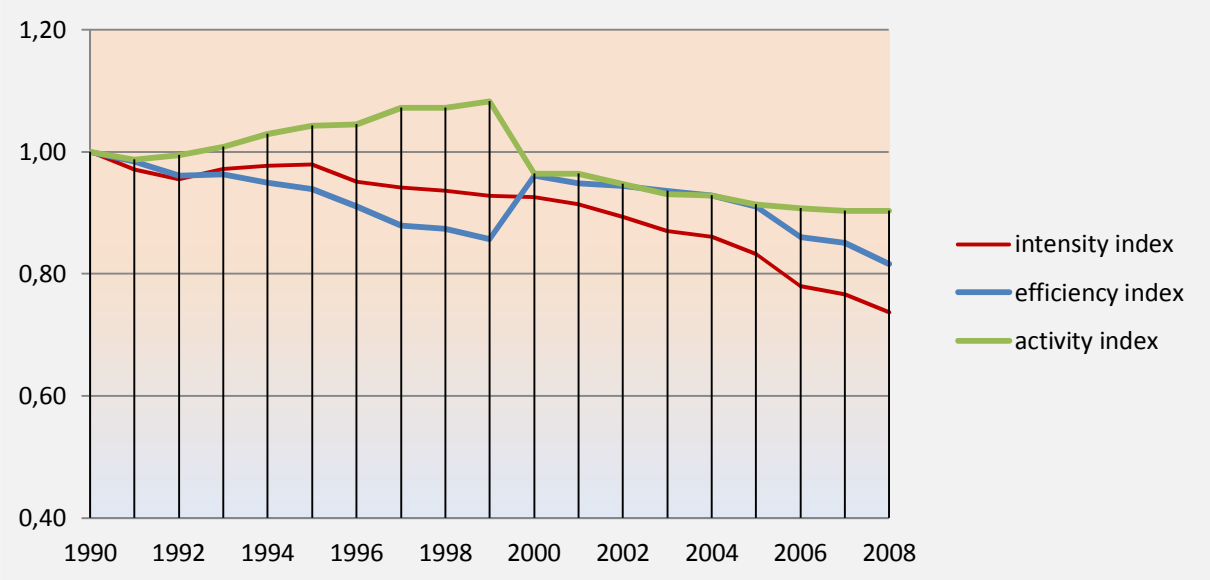
We note by e_0 the global energy intensity for our basic year 1990. Then, we construct an index of energy intensity by $\frac{e_t}{e_0}$. We have presented in figure 2 the indices of decomposition of the energy intensity, of the activity and of the efficiency on the same curve.

[4] In our analysis, we have taken in consideration five sectors : agriculture, industry, tertiary, residential and transport

Table 1. Evolution of Fisher Ideal indexes of Efficiency and Activity

t	I_t	F^{eff}	F^{act}
1990	1	1	1
1991	0,971	0,984	0,987
1992	0,955	0,960	0,994
1993	0,971	0,963	1,008
1994	0,977	0,950	1,029
1995	0,979	0,939	1,042
1996	0,951	0,910	1,044
1997	0,941	0,879	1,071
1998	0,936	0,874	1,072
1999	0,928	0,857	1,083
2000	0,925	0,960	0,963
2001	0,914	0,948	0,964
2002	0,893	0,944	0,947
2003	0,870	0,935	0,930
2004	0,861	0,928	0,928
2005	0,832	0,911	0,914
2006	0,780	0,860	0,908
2007	0,767	0,851	0,903
2008	0,737	0,817	0,903

Figure 2. The decomposition results of the index of energy intensity



We notice that the index of energy intensity has decreased to its initial level so as to reach a rate of 74% in 2008. By maintaining a constant economic activity, the index of energy efficiency in 2008 would have reduced the index of energy intensity by 82% of its level in 1990 and if the energy efficiency had not changed, the structural change has witnessed two phases during the last two decades. Indeed, during the period between 1992 and 1999, the role of reduction of the index of efficiency has contributed to the improvement of the energy intensity. On the other hand, during the period between 2000 and 2008, the combination of both indices, of activity and of efficiency, has allowed to reduce the index of energy intensity. On average, the index of intensity has contributed by 56% to the reduction of energy intensity and the index of activity has contributed by 44% to this

reduction. We can conclude that Tunisia has managed to maintain economic performances with a rate of mean growth around 5% per annum from 1990 to 2008. The consumption of energy is in permanent growth reaching 7949 Ktoe in 2010 but it has increased at a much slower rhythm than the GDP in the last decade.

The phase of decrease of energy intensity of the first decade of the year 2000 illustrates the 'uncoupling' between the economic growth and the energy during this period. The improvement of energy efficiency represents the driving force that played a major and leading part in the reduction of the energy intensity. During the decade 1990-2000, the index of energy intensity has slightly evolved. We notice a decrease in the index of energy efficiency. Since the year 2001, the government has taken a set of decisions aiming at significantly strengthening the measures of energy control in Tunisia. More precisely in 2004, with the rise of petrol prices, the Tunisian Agency for the Control of Energy (TACE) has focused on the acceleration of the policy of energy efficiency. Indeed, between 2005-2008, a triennial program of energy control has been implemented by TACE. The high scale spreading diffusion of low-consumption lamps, the rational utilization of energy in public lighting , the diagnostic of automobile engines, the energetic substitution, the energetic audit, etc.. are among the actions of this program. Accompanied by the creation of a national fund for the control of energy, this program has allowed to accelerate the policy of energy efficiency, which explains the rapid decline of the index of efficiency during that period and, consequently, the major contribution of the effect of efficiency in the improvement of energy intensity.

Moreover, we notice that the change of the economic structure has contributed, in its turn, to the improvement of the energy intensity albeit in lower proportions than those of energy efficiency. Indeed, the economic structure of Tunisia has not changed that much before the year 2000, which explains the fact that the activity affect has not contributed to the variation of energy intensity during that period. On the other hand, the weight of the tertiary sector has started to move up since the year 2003. Indeed, the tertiary sector and mainly the trade sector have recorded a progress during the period 2001-2005 with regard to the period 1990-2001. Its portion of GDP is evolving as time goes by reaching up to 58% in 2008. This progress is explained mainly by the fact that Tunisia has considered the human factor as a primary wealth. This progress is also explained by the imposition of communications and transports as sectors of the new economy of knowledge. These sectorial mutations and this orientation of the Tunisian economy toward a sector with high added value and weak energy intensity, particularly the tertiary sector, have played an important part in the lowering of energy intensity.

5. Conclusion

In Tunisia, the awareness of lowering the energetic balance expressed in mid-1980s has launched programs of energy control. In order to control the demand of energy, the energy efficiency has become an absolute priority for reaching energetic and climatic objectives. Indeed, the improvement of energy efficiency was one of the solutions contemplated by Tunisia in order to guarantee to the country a better mode of energy supply at the lowest cost, an improvement of energetic independency and a less polluting management of energy by the attenuation of greenhouse gases emissions.

The implantation of energy control policies has allowed to achieve a better level of energy intensity. These later affect the level of energy intensity through the improvement of energy efficiency. However, despite the efforts applied for controlling energy, the energetic balance was showing a deficit in 2011 which might worsen during the next decades. The evolution of energy demand diminishes of about 1% per annum. This remains high with regard to the advanced performances of the country concerning energy efficiency. Tunisia has managed to maintain a viable energetic development in its strategy allowing the lowering of the level of energy intensity but the applied means are insufficient for the exploration of the potential energy efficiency. Tunisia should further reinforce its efficiency policy so as to act on the energetic demand. In order to promote energy efficiency, Tunisia must rely more and more on technological progress.

The structural change of the economy has played at its turn an important role. The economic structure in Tunisia has become dominated all the more by the tertiary sector, less intensive in energy with regard to the industrial sector. On the other hand, the portion in the GDP of the industrial sector, very intensive in energy, is relatively constant or rather tending to diminish from the year 2003, reaching up to 30.2% in 2008. More fundamental changes in the Tunisian economic structure are

necessary in order to achieve progress in the reduction of energy intensity and this by directing the Tunisian economy towards toward the Direct Foreign Investments in the tertiary sector, with high added value and low energetic consumption.

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