Dynamic macroeconomic factors in Recycling Industrial Gross domestic product: Empirical Evidence from Tunisia

Lamia Mohamed Ben Amor [*]

*PhD in Economics at faculty of Economics and Management in Sfax, Tunisia.

Adress Email: lamiabenamor.fsegs@gmail.com

Abstract

The objective of this study work is actually to look at the link between the labor force, secondary finished goods and the industrial GDP from recycling manufacturing in 24 Tunisian governorates. As a result, the yearly data collected during the period 2001-2023 were analyzed using the Vector Error Correction Model (VECM). Furthermore, the empirical results showed

that the GDP and capital stock are favorably correlated with the labor component. The findings also demonstrated the existence of a one-way link between the secondary finished goods and the GDP, as well as the macroeconomic factors in the short and long term. Indeed, the personnel and capital stock are critical for the success of recycling plastic industrial production and new-finished goods.

Keywords: Waste Recycling, Industrial Gross Domestic Product, Value added, Macroeconomic factors, Vector Error Correction Model (VECM) ,

1.Introduction

At the beginning of the industrial revolution, no individual thought about the extinction of natural resources. Moreover, these pieces of garbage are subjects of appropriating and technical manipulation. During the last decades of the 20th century, researching for the processes and alternatives had to be inevitably implemented. Therefore, research into the processes and alternatives had to be implemented in the final decades of the 20th century. Therefore, to save the planet, we have to carefully take into account the best course of action. Furthermore, the technological development, including the recycling of materials, is a scrupulous and a crucial solution to protect the natural resources. In fact, it is the signal showing that wasting is becoming unbearable, while recycling is becoming mandatory. In this context, waste represents a convergence of various storage solutions that facilitate material utilization and the frameworks within which we engage in recycling practices. Furthermore, this sector has recently emerged as a viable economic endeavor, contributing to the establishment of markets, including those of a commercial nature. On the other hand, waste can be perceived as a synthesis of various processes that facilitate the utilization of materials, alongside the regulation of these practices, which encompasses recycling. Additionally, the emergence of markets, especially in the commercial realm, has recently demonstrated that this sector can function as a productive economic endeavor.

Therefore, the inhabitants of the various countries have become the wizards of recycling as they know how to benefit from the worst. In fact, they believe that it is possible to repair endof-life objects by integrating them again into the lifecycle as commercial goods. Accordingly, our society can produce some arts with waste, which become objects of

decoration or reused since they become old, useless and off-putting objects find their place in the society. Therefore, new factories and industries got organized around this production by finding a source of profit, according to conversion dialectics. Thus, a new image takes shape for waste when it not treated. For this reason, it is necessary to recycle and reconstruct with this rubbish so that a new material can spring up.

For their part, the residents of various nations have emerged as adept recyclers, skillfully transforming what is often deemed undesirable into valuable resources. They hold the conviction that it is feasible to restore items that have reached the end of their useful life by reintegrating them into the market as commercial products. Consequently, our society has the potential to create artistic works from waste materials, which can be repurposed as decorative items, allowing once discarded and unattractive objects to regain their significance within the community. Hence, this shift has led to the establishment of new factories and industries focusing on this innovative production, identifying profit opportunities through the principles of conversion. As a result, waste is redefined when it is not simply discarded. Therefore, it is imperative to engage in recycling and reconstruction of these materials, enabling the emergence of new resources from what was previously consider.

It is therefore essential to recognize that waste represents a continually expanding resource in the context of lifestyle. This phenomenon possesses some attraction, despite the fact that the employed recycling methods are often artificial rather than organic. We have actually discovered the significance of this process, which paves the way for collective insights and engaging opportunities.

This research seeks to investigate the relationships between the industrial gross domestic product associated with recycling manufacturing and significant variables, including capital stock, labor, and secondary finished products, across 24 governorates in Tunisia. The analysis will utilize data spanning from 2001 to 2022. Therefore, to fulfil our objectives, we will employ contemporary advancements in econometric techniques. In fact, our approach involves a three-phase methodology: executing unit root tests, utilizing Johansen's co-integration tests, and conducting Granger causality tests within the context of the Vector Error Correction Model (VECM).

Then, the subsequent sections of this paper are structured as follows. Section 2 provides a review of the relevant literature, while section 3 details the data sources, the model estimation, and the empirical findings. Finally, section 4 offers a conclusion to the paper.

2.Litterature Review

In fact, due to urbanization and the intensive population growth, there is an aggressive accumulation of waste, which turns out to be a big problem. Therefore, we have to look for urgent solutions, such as the process of recycling in which several firms are affecting circular economic value chains. Today, the recycling process is developing as the prospective industry occasion to create a more viable and significant value chain for economic, societal and environmental aspects. Therefore, recycling is not only a universal approach but it also assists as an innovative mode of defining business processes, services and products. This subject has actually attracted the attention of several authors, such as Hotelling (1931), who stated that the economic literature has granted more attention to the constraints imposed on economic growth, particularly the exhaustible resources. Nevertheless, the theorists of endogenous growth, like Stiglitz (1974),, who consider this input type, were completely optimistic, and showed the existence of three founding factors of economic growth that would make these exhaustible resources extremely effective. Let us note mainly technical progress, the factors of production, namely capital, labor) and returns to scale In fact, the dynamics of the environmental protection, which was analyzed by Bovenberg and Smulders (1995), Musu and Lines (1995), Olson and Knapp (1997)) in the models of endogenous growth, is related to intergenerational equity Moreover, other theorists, namely Kamien and Schwartz, (1978) as well as Barbier (1996). studied the efficiency of the exhaustible resources, in an empirical investigation, there are three levels relating to the causal relationship between the macroeconomic factors and economic growth, especially the industrial gross domestic product for recycling manufacturing. The first level indicates that waste recycling is a cause of economic growth. Moreover, this vision was maintained by Baumol, (1977), Hoel, (1978); who confirmed that the waste recycling process might improve to maintain the rate of economic growth through the protection of the environment. In the same vein, Di Vita,(2001), proved that waste can be recycled through the production process, equally an input to get secondary products. These new produces can affect the growth rate of the total output. Furthermore, Kinnaman and Fullerton, (2000), showed that the recyclable waste, is sorted out and transformed back into finished products by forming commercial goods, which are reinserted again in the production cycle. As for Stiglitz (1974), he showed the existence of an optimal path of endogenous growth in the models introducing respectively, technological changes, exhaustible resources and flows of secondary materials considering the way reusable products could affect growth rate. On the other hand, the proponents of the endogenous growth theory,

such as Stiglitz (1974), exhibited a strong sense of optimism regarding this type of input. Actually, they identified three fundamental factors contributing to economic growth that would make these finite resources highly efficient. These factors primarily include technological advancement, the inputs of production—specifically capital and labor—and the concept of returns to scale. Furthermore, the dynamics of environmental protection, as examined by Bovenberg and Smulders (1995), Musu and Lines (1995), and Olson and Knapp (1997) within the framework of endogenous growth models, are closely linked to the principle of intergenerational equity. Moreover, this topic has garnered the interest of numerous scholars, including Hotelling (1931), who noted that the economic literature has focused more on the limitations affecting economic growth, especially concerning the exhaustible resources. Therefore, other theorists studied the efficiency of the exhaustible resources, like the example of Kamien and Schwartz, (1978) as well as Barbier (1996). In the empirical investigation, there occur three levels relating to the causal relationship between macro-economic factors and economic growth especially industrial gross domestic product for recycling manufacturing. The first level indicates that waste recycling as a cause of the economic growth. This vision was maintained by Baumol, (1977); Hoel, (1978); who have confirmed that waste recycling process might improve to stand the rate of economic growth with a protection of the environment. In this context, Kaseva et al. (2002) proposed that informal recycling systems could be remarkably efficient, achieving high recycling rates through intensive manual sorting and specialized expertise in extracting valuable waste. Meanwhile, Kamien and Schwartz (1978) directed their focus towards the movement of secondary materials, highlighting the significance of recycling practices in contributing to economic growth over time.

3.Empirical Results and Interpretation

We will follow the recent developments in econometrics to examine the causal relationship between the industrial gross domestic product (IGDP), capital stock (K), labor (L), and secondary finished products (SFP). This approach will be conducted in three steps; the unit root tests, the Johansen co-integration tests, and Granger causality tests as part of an errorcorrection vector model

The econometric results showed that the industrial gross domestic product of recycled plastic is more elastic with both capital and labor than with secondary finished products. This indicates that the recyclers use more capital in cooperation with the workers in the plastic recycling process. We have found that the elasticity of the industrial gross domestic product in relation to the capital is 2.0123, while that of labor is1.024.

Besides, the industrial gross domestic product appears to be slightly elastic compared to the secondary products, obtained from recycling plastic. Then, the estimated values of the individual effects are consistent with the expected results which are positive in cities where the recycling process is developed, such as the cities of Tunis(0833),Sfax (0.57), Nabeul (0.47), Bizerte (0.31). However, these effects arenot significant in the cities where the recycling industry is not too advanced, such as the towns, such as the towns of Tozeur (-1.13) Tataouine (-0.63) Zaghouan (-0.52) Kef (-0.27) etc.

Following the results of the cointegration test, we estimate the VECM panel to test the causality of Engle and Granger (1987). We adopt the two-step procedure, first estimating the long-term model for obtaining the residues.

$$\ln IGDP_{it} = \alpha_{it} + \delta_{it} + \delta_{it}\ln K_{it} + \delta_{it}\ln L_{it} + \delta_{it} + \ln SFP_{it} + it \quad (2)$$

where i keep for each country in the panel and t represents time. The parameters of α_i and δ_i are for the possibility specific of fixed effect of country and the trend. The sit is for the estimated residual.

Table 2 Panel VECM causality test results

Dependent variables	Short-run causality				Long-run causality
	ΔlnIGDP	ΔK	ΔlnL	ΔSFP	ECT
ΔlnGDP	-----------------------		5.603428 (0.0426)**	2.785612 (0.0285)**	- 10.56782 (0.0025)* 25.78532 (0.0004)*
ΔK	11.30522 (0.0025)** (0.0001)*	--------------------------	18.05643 (0.0006)*	0.356741 (0.7563)	9.8 6723
ΔlnL	4.783673 (0.0533)*** (0.6482)	0.617315 (0.5102) 1.75685 (0.5725)	-------------------	0.125326
ΔSFP	1.975632 (0.1126)	0.023456 (0.5223)	0.287946 (0.5332)	--

---------------- 8.37525 (0.1254)
*, **, *** indicates that the parameter estimates are significant at 1%, 5%, and 10%

Therefore, this table shows the existence of a one-way relationship from the small form-factor pluggable (SFP) to the IGDP in the short run. Besides, there is a one-way relationship going from SFP to L. These results were confirmed by Jones and Williams, (1999), while the one employed in waste recycling is 1.5%. The rate denoted to human capital working in secondary material production is very close to the result expected by Di Vita, (2001) in Italy and by Van Beukering and Curlee, (1998) in Colombia.

Additionally, we have indicated that the Granger causality test proposes a one-way relationship from SFP to K. This relationship can be explained by the creation of projects in order to invest in the recycling sector. Moreover, we noted the existence of a two-way relationship between the IGDP and K. This effect is a result identified by Ramsey Rule', (1928), representing the trade-off between investment and production, in which the case to raise the wellbeing over a change of capital, must be completed. The results also demonstrated a twoway relationship between L and K in the short run. In fact, in the developing countries, such as Tunisia, waste management, especially recycling, has headed to even serious problems because there is a lack of consciousness about this sector. Besides, we have found a two-way relationship between L and the IGDP in the short run. These results were also confirmed in the findings of Jones and Williams (2000).

In this situation, the growth rate is countless when these factors, namely physical capiltal, labor and secondary finished products, were taken into account in the recycling process. It therefore, looks interesting to note that even in the developing countries, plastic waste recycling can improve the industrial gross domestic product for manufacturing recycling.

The implication of the error coefficient term (ECT) in. equation (1) proves the presence of a long-term equilibrium of the causal relationship between the IGDP, K, L, L and the SFP., which implies that there is a significant bidirectional causality between the IGDP and K. Additionally; there is a unidirectional causality running from the IGDP to the SFP. Correspondingly, in equation (5), there is a long-term relationship, where the ECT is significant at the 1% level). Indeed, we can note the manifestation of bidirectional causality concerning the IGDP and L.

Hence, there is a long-term unidirectional causality running from the SFP to the GDP, K, and L.

4. Conclusion and findings

In conclusion, we can say that this study is to examine the link between the industrial gross domestic product, capital stock spending, labor , and secondary finished products for 24 Tunisian governorates, which include Ariana, Tunis, Ben Arous, Manouba, Nabeul, Bizerte, Sfax, Sousse, Monastir, Mahdia, Kairouan,Sidi-Bouzid, Gabes, Gafsa, Kasserine, Kebeli , Medinine, Kef, Beja, Jendouba, Seliana, Zaghouan,Tozeur, Tataouine.

By means of the Johansen cointegration test, we have proved the presence of a long-term relationship between the different variables in our model. Empirical results by the FMOLS method revealed that determinants factors such as capital, labor and secondary finished products have a significant impact on industrial gross domestic product from manufacturing recycling in in Tunisia's various government departments. In this sense, the recycling technique modifies the image of waste because garbage is reused again. In other words, we sort out and recycle to enable the technology to continue its way, the production to remain and the consumption to always offer us more and better, while paying more attention to the environment. The recycling technique introduces the end of antagonisms between production and waste, to make consumption pursue its lifecycle.

Moreover, this study demonstrates that manufacturing recycling stimulates economic growth in Tunisia. Subsequently, policy makers would ruminate on the significance of the recycling sector and contribute to the prevalence of the diverse platforms, principally the features and the measurements of its services as it has a substantial effect on the added value of the firm's and can lead to more sustainable development for both the government and Tunisia as a whole. Consequently, we have to think of the adequate alternatives to ensure a fair balance between the economic and environmental sphere. From this perspective, the incorporation of the recycling plastic in the production cycle requires an alliance between the R&D and technology, which involves a new vision of the manufacturing recycling in the future research activity. Further issues will be the estimation of our model with the new data base that will contain the "Technology Stock" as a new variable. In the statement, as we have previously indicated, the available technology of plastic recycling will decrease the usage of exhaustible resources.

References

Barbier, E. B. and T. Homer-Dixon (1996), 'Resource Scarcity, Institutional Adaptation, and Technical Innovation: Can Poor Countries Attain Endogenous Growth?', Occasional Paper, The Project on Environment, Population and Scarcity, University of Toronto and the American Association for the Advancement of Science, Washington DC.

Baumol, W.J., 1977. On recycling as a moot environmental issue. J. Environ. Econ. Manage. 4, 83_87.

Bovenberg, A. and S. Smulders (1995), 'Environmental Quality and Pollution-Augmenting Technological Change in a Two-Sector Endogenous Growth Model', Journal of Public Economics (57), 369–391

Di Vita, G., (2001),"Technological change, growth and waste recycling", Journal of Energy and Economics, Vol 23, pp 549-567.

Gerdes, P., and Gunsilius, E., (2010), "The Waste Experts: Enabling Conditions for Informal Sector Integration in Solid Waste Management"; Lessons learned from Brazil, Egypt and India. Eschborn, Germany:GTZ.

Hadri, K. (2000), "Testing for Unit Roots in Heterogeneous Panel Data", Econometrics Journal, 3, 148- 161.

Hoel, M., 1978. Resource extraction and recycling with environmental costs. J. Environ. Econ. Manage. 5, 220_235.

Hotelling, H., 1931. The economics of exhaustible resources. J. Polit. Econ. 39, 137_175. Martina Novotná , Ivana Faltová Leitmanová , Jiˇrí Alina and Tomáš Volek,(2020), "Capital Intensity and Labour Productivity in Waste Companies".Sutainability Journal, 12,10300,1-15. Jones, C.I., Williams, J.C, (2000). Too Much of a Good Thing? The Economics of Investment in R&D. Journal of Economic Growth 5, 65–85.

Jones, C.I, (2016), The facts of economic growth, Handbook of Macroeconomics, Elsevier Journal, Vol.2, pp.3- 69.

Kamien, M.I, Schwartz, N.L, (1978),"Optimal exhaustible resource depletion and endogenous technical change",Review of Economy Studies, Vol 139, pp 179-196.

Lupton., S., (2001), ", Environmental and health safety, the controversial goods " RuralEconomyVol 262, pp3-18.

Medina, M., (2000),"Scavenger cooperatives in Asia and Latin America",Resource, Conservation and Recycling, Vol 31, n°1, pp 51–69.