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Abstract

Although industrialization has long been considered crucial for economic development and growth, the economic landscape of many developed and developing countries has experienced a huge decline in the weight of the industry and manufacturing sectors over the last decades. This paper aims to shed some light on the phenomenon of deindustrialization – defined as a sustained decline in the share of industry, especially manufacturing, gross domestic product, and employment – in Tunisia. We use an autoregressive distributed lag bounds testing approach (ARDL) and data from 1998 to 2017 to investigate the impact of different factors (such as trade openness, economic development, competitiveness, productivity growth, FDI inflows, investment, innovation, and human capital) on the process of industrialization/deindustrialization. The descriptive analysis shows that the Tunisian economy started to deindustrialize recently at a low level of GDP per capita, which is a sign of premature deindustrialization. Furthermore, the empirical results reveal that the main factor behind deindustrialization in Tunisia is a lack of competitiveness; however, trade openness contributes positively to the process of industrialization.

JEL Classification: F1, L1

Keywords: Deindustrialization, premature deindustrialization, openness, manufacturing, industry, employment, value-added shares.

ملخص

على الرغم من أن التصنيع كان يعتبر منذ فترة طويلة أمرًا حاسمًا للتنمية الاقتصادية والنمو ، فقد شهد المشهد الاقتصادي للعديد من البلدان المتقدمة والنامية انخفاضًا كبيرًا في وزن قطاعي الصناعة والتصنيع على مدى العقود الماضية. تهدف هذه الورقة إلى إلقاء بعض الضوء على ظاهرة تراجع التصنيع - التي تُعرَّف على أنها انخفاض مستمر في حصة الصناعة ، لا سيما التصنيع والناتج المحلي الإجمالي والتوظيف - في تونس. نحن نستخدم منهج اختبار الانحدار الذاتي الموزع (ARDL) والبيانات من 1998 إلى 2017 للتحقيق في تأثير العوامل المختلفة (مثل الانفتاح التجاري ، والتنمية الاقتصادية ، والقدرة التنافسية ، ونمو الإنتاجية ، وتدفقات الاستثمار الأجنبي المباشر ، والاستثمار ، والابتكار ، ورأس المال البشري) على عملية التصنيع / إلغاء التصنيع. يُظهر التحليل الوصفي أن الاقتصاد التونسي بدأ مؤخرًا في تراجع التصنيع عند مستوى منخفض من الناتج المحلي الإجمالي للفرد ، وهو علامة على تراجع التصنيع المبكر. علاوة على ذلك ، تكشف النتائج التجريبية أن العامل الرئيسي وراء تراجع التصنيع في تونس هو الافتقار إلى القدرة التنافسية. ومع ذلك ، فإن الانفتاح التجاري يساهم بشكل إيجابي في عملية التصنيع.

I. Introduction

The countries that manage to get richer and pull out of poverty are those capable of diversifying away from traditional goods and services. As labor and resources shift away from the agricultural sector toward modern activities, income expands and overall productivity increases (McMillan and Rodrik, 2011). Industrialization has long been considered the key route by which economies grow and develop. In fact, the manufacturing sector holds high potential for cumulative rises in productivity, increasing returns to scale, and learning by doing due to mechanization and specialization (Pieper, 1998).

According to Kaldor (1966), Cornwall (1977), Tregenna (2009), and McCausland and Theodossiou (2012), the role of the manufacturing sector serves as an engine of economic growth and development in terms of technology diffusion, especially with regard to disembodied and embodied technological progress. Technological progress originating in manufacturing spreads into the economy through intersectoral linkages. Thus, manufacturing is a key sector promoting technological change and it is a crucial driver of growth and competitiveness.

Kaldor (1966) suggests that the manufacturing sector's characteristics and its expansion could be translated into a virtuous cycle of increasing demand, growing productivity, rapid economic growth, and job creation. Furthermore, manufacturing exports often represent a significant percentage of total exports, which helps the economy cover its imports.

Over the last two decades, the global economy has experienced profound transformations. The economic landscape of many developing and developed economies has been marked by declines in the shares of manufacturing in employment and gross domestic product (GDP). With the relocation of many industries to Asian countries, the trend has become globally widespread.

The deindustrialization of developed economies has been considered an inevitable consequence of the process of economic development, since productivity gains allow manufacturing activities to function with fewer employees (Cáceres, 2017). Hence, deindustrialization is a result of economic development and technological progress in developed countries. However, developing countries have begun to witness the deindustrialization process at a low level of GDP per capita and without establishing a high-technology industrial base, which blocked their development (Dasgupta and Singh, 1989; McMillan and Rodrik, 2011). Therefore, this process has been described as premature deindustrialization (Palma, 2014).

Many studies have examined the deindustrialization issue by exploring its determinants and consequences in developed economies. However, few studies have focused on the experiences of the MENA countries. To fill this gap, we provide a wide-ranging review and analysis of deindustrialization, with a special focus on the Tunisian case.

We principally try to answer three main questions. First, has Tunisia been experiencing premature deindustrialization? Second, what are the potential factors impacting the pattern of industrialization/deindustrialization in Tunisia? And finally, is trade openness one of the main causes of deindustrialization in Tunisia?

This paper is structured as follows. The first section presents the concept of deindustrialization, its definitions, and its determinants and consequences, followed by a global overview of this phenomenon. The second section presents a descriptive analysis of the Tunisian experience focusing on the evolution of the manufacturing and industry sectors during a long time span. The third section presents the data, the methodology used to identify the main factors behind deindustrialization, and the results. The last section concludes.

II. Deindustrialization from a global perspective

As income per capita grows over time and development becomes underway, the weight of manufacturing grows and that of agriculture declines via the process of industrialization. At a certain point, the weight of manufacturing declines and that of services rises progressively (Tregenna, 2016). This breakpoint marks the onset of deindustrialization.

1. Definitions and types of deindustrialization

According to Singh (1989), Rowthorn and Ramaswamy (1997), Saeger (1997), Alderson (1999), and Palma (2014), deindustrialization is defined as a continuous decline in the share of manufacturing in total employment. However, Tregenna (2009, 2013) and Uemura and Tahara (2018) define deindustrialization as a sustained decline in the shares of manufacturing in GDP and total employment.

Deindustrialization generally refers to changes in the weight of the manufacturing sector. This can be explained by the fact that manufacturing is the essence of industrial activities in regard to technological development and economies' linkages. Moreover, manufacturing has specific features that make it an "engine of growth" (Tregenna, 2011).

Based on empirical findings, Rowthorn and Wells (1987) formalize two types of deindustrialization: positive deindustrialization and negative deindustrialization (premature deindustrialization).

- Positive deindustrialization

Beyond a certain threshold of income per capita, the employment share of services starts to grow at the expense of manufacturing. This happens as a consequence of the systematic change in the consumption pattern during the course of development and a high rate of productivity growth in manufacturing. Employment freed up by the manufacturing sector due to productivity gains will be absorbed by the service sectors. The growth differentials of labor productivity between manufacturing and services give rise to a shift of employment from manufacturing to services (Uemura and Tahara, 2018). This leads to a structural transformation and a shift in the country's comparative advantage. Countries become more specialized in service activities that have strong linkages with the rest of the economy, continue their specialization in the production of manufactured goods with high technological content, and import manufactured goods with weak linkages. In this case, deindustrialization is a positive phenomenon because it occurs at high levels of GDP per capita, and it is a symptom of economic success (Alderson, 1997).

- **Negative deindustrialization (premature deindustrialization)**

Premature deindustrialization starts at low levels of GDP per capita and/or manufacturing shares (Greenstein and Anderson, 2017). In other words, if an economy starts deindustrializing at a lower level of GDP per capita and the manufacturing sector has not yet reached maturity, then we can speak about premature deindustrialization (Tregenna, 2015).

Furthermore, most Sub-Saharan African (SSA) countries have failed to industrialize; they began to deindustrialize before experiencing industrialization. For this reason, Tregenna (2016) introduces the "pre-industrialization deindustrialization" concept. It refers to a situation where countries begin to deindustrialize when the shares of manufacturing in both employment and GDP are still very low, i.e., at an extremely low level of industrialization (e.g., Mozambique, Liberia, Sierra Leone, Sudan, Kenya, Madagascar, Tanzania, Guinea, and Malawi).

Negative deindustrialization is the consequence of economic failure and structural disequilibrium, which prevent a country from achieving its growth potential. This is manifested in poor performance in the manufacturing sector and is followed by a slowdown in manufacturing productivity and output growth. This reduces competitiveness and has a negative impact on the overall economy. Moreover, the jobs lost in the manufacturing sector cannot be absorbed by the services sector, which is not mature enough.

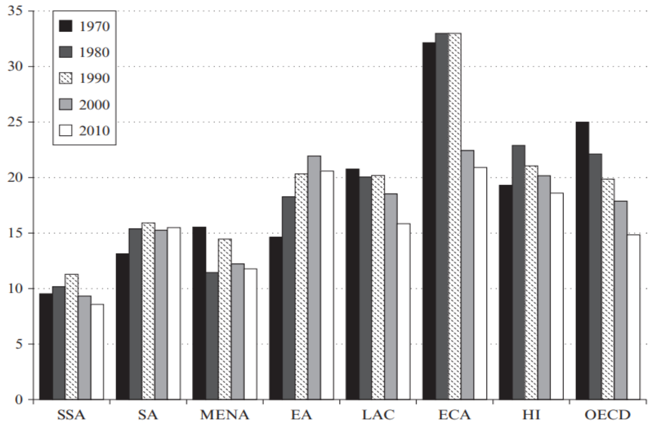
Hence, where positive deindustrialization is linked with productivity improvement and income rising, negative deindustrialization is linked with bad performance and income stagnation (Alderson, 1997).

2. Heterogeneity of deindustrialization paths around the world

The pattern of deindustrialization varies from one country to another depending on its speed and the level of development. Most developed countries have experienced deindustrialization in the past decades, and some developing economies have experienced it more recently.

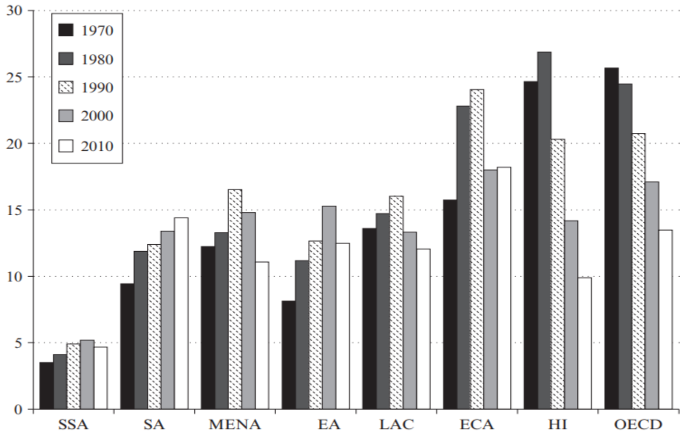
Graphs 1 and 2 present the share of manufacturing in GDP and in total employment between 1970 and 2010 in different regions of the world.

Graph 1. Shares of manufacturing in GDP, in different regions



Source: Tregenna (2016).[3]

Graph 2. Shares of manufacturing in employment, in different regions



Source: Tregenna (2016).

These two graphs show the failure of many African countries to industrialize. The share of manufacturing in employment did not reach more than five percent in SSA, and the share of manufacturing in GDP barely passed 10 percent in 1990 and declined immediately. Therefore, SSA countries have completely failed to industrialize. Furthermore, the peak of manufacturing shares in SSA was lower than the lowest point of other regions. However, deindustrialization began in 2010 before they even industrialized.

On the other hand, South Asian (SA) countries continue their industrialization process, where the share of manufacturing in employment is still growing and the share of GDP is stable. Rodrik (2016) notes: “Asia has not only bucked the international trend in manufacturing employment, but it has also handled to maintain stronger manufacturing performance than would be expected based on its demography and income.”

[3] SSA = Sub- Saharan Africa (excluding South Africa); SA = South Asia; MENA = Middle East and North Africa; EA = East Asia (does not include Pacific); LAC = Latin America and Caribbean; ECA = Europe and Central Asia; HI = High-income non-OECD members; OECD = High-income OECD members.

The most significant drop in the value-added share was experienced by Central Asia (ECA) and Europe between 1990 and 2000. Moreover, the share of manufacturing in total employment has fallen significantly in ECA in response to a productivity increase (Tregenna, 2016).

The deindustrialization pattern in the Latin America (LAC) and Middle East and North Africa (MENA) regions were similar. The shares of manufacturing in GDP reached maximums of 20 percent in LAC and 15 percent in MENA in the mid-90s and later initiated a decline/stagnation. The fall in the share of manufacturing in GDP was more rapid than the fall in the share of employment.

Deindustrialization started at the end of the 1990s in the MENA region; Mouelhi and Ghazali (2018) conduct an empirical study on structural change in three MENA countries (Tunisia, Morocco, and Egypt) between 1960 and 2010. Their results suggest that deindustrialization started at an early phase of development and at low levels of income in the three countries, in contrast to developed countries.

Furthermore, OECD countries have known a continuous decline in manufacturing weight since 1970. However, the fall was more rapid and pronounced in the share of employment than in the share of GDP, indicating a productivity increase.

Even after the decrease, manufacturing shares in high-income countries remain higher than those in low-income countries. In contrast to developing countries, high-income countries have experienced large losses in manufacturing employment; however, they have done well in terms of value-added, with a slight decline. Furthermore, the shares of manufacturing in both GDP and employment have decreased after reaching high levels, in contrast to middle- and low-income countries. In addition, deindustrialization was more rapid in high-income countries.

III. Causes of deindustrialization: A literature review

1. Main causes of deindustrialization

The various factors contributing to or causing deindustrialization have been presented in the literature. We start by discussing internal factors before moving to external ones. According to Rowthorn and Ramaswamy (1997, 1999), Krugman (1996), Rowthorn and Coutts (2004), and Beg et al. (2017), deindustrialization is attributed to internal factors. In addition, Kang and Lee (2011) report that internal factors account for more than 70 percent of deindustrialization.

1.1 Internal factors

- **Income level, consumer demand, and deindustrialization**

The increase in income per capita and the evolution of the elasticity of demand for goods and services are major factors behind deindustrialization. As income rises, consumers shift their spending from manufacturing toward services. Therefore, the demand for services increases, and the share of employment rises in services and decreases in manufacturing. This relationship reflects Rowthorn's inverted-U curve between the share of manufacturing in total employment and income per capita (Rowthorn, 1994).

- **Productivity growth and deindustrialization**

Most developed countries have experienced high labor productivity in the manufacturing sector. Tregenna (2016) reports that rapid productivity growth in manufacturing generates slower employment growth in manufacturing than in services, even if the output is growing at the same pace in both sectors. As a result, rapid productivity growth in manufacturing leads to a decline of employment in manufacturing because production will need fewer employees. Accordingly, high productivity growth is responsible for job losses in manufacturing (Rowthorn and Ramaswamy, 1997). It was responsible for more than 60 percent of the decline in the share of employment in the industry sector in industrialized countries (Beg et al., 2017).

Moreover, the productivity gains in manufacturing lead to income per capita growth, which impacts the structure of demand leading to the development of the service sectors (Škuflić and Družić, 2016).

- **Competitiveness and deindustrialization**

Poor product and service quality, the inability of companies to respond to new needs and requirements, market conditions, and high labor costs have contributed to the decline of competitiveness in different countries in the last two decades (Alderson, 1997). Many factors are behind the decline of competitiveness, such as bad governance, poor infrastructure, corruption, low skills, high tax rates, and bureaucracy.

Furthermore, in the Mundell-Fleming model (Fleming, 1962; Mundell, 1963), a depreciated currency makes domestic products more competitive, thereby boosting exports and industrial production. One of the major factors influencing the transformation in industry productivity and size is the change in the Real Effective Exchange Rate (REER). REER is considered the relative price of tradable and non-tradable goods, while exchange rate depreciation increases the size and profitability of the industrial sector (Rodrik, 2008). Hausmann et al. (2006) assume that currency depreciation speeds up growth. In addition, Rodrik (2008) mentions that the reallocation of wealth in the economy resulting from the depreciation of the real exchange rate encourages the expansion of industrial exports, thereby impacting competitiveness and long-run economic growth.

- **Investment and deindustrialization**

Investment is regarded as one of the major determinants in regulating the speed of industrialization (Kang and Lee, 2011). Bluestone and Harrison (1982) define deindustrialization as a "systematic disinvestment in a nation's core manufacturing industries."

A rise in the rate of investment can raise the relative demand for manufactured goods and therefore raise the weight of this sector. Furthermore, investment directly oriented toward the manufacturing sector boosts the sector and leads to job creation, thus increasing its weight.

Rowthorn and Ramaswamy (1999) report that a decrease in the ratio of investment to GDP skews demand away from manufactured products in developed economies.

- **Human capital and deindustrialization**

As pointed out by Szirmai and Verspagen (2015) and Hena et al. (2019), human capital plays a major role in the growth of the manufacturing sector. The availability of an educated and skilled labor force is important to achieve the transition to sophisticated and productive activities. Skilled labor is a key factor in achieving competitiveness and economic growth (Tomljanović et al., 2019).

- **Deindustrialization via manufacturing-service linkages**

Deindustrialization via manufacturing-service linkages is induced by the externalization of service activities from manufacturing, thereby inducing a rise in services employment (Uemura and Tahara, 2018).

Rowthorn and Coutts (2004) report that one of the sources of deindustrialization is the reclassification of jobs from manufacturing toward services because of domestic intersectoral outsourcing. This refers to the movement of employees from the manufacturing sector to services, induced by the outsourcing of some services from manufacturing firms to specialized service providers. An industrial development report (UNIDO, 2013) shows that manufacturing-related jobs in services worldwide increased from 73 million to 95 million between 1995 and 2009 due, in part, to outsourcing activities.

- **Dutch disease and deindustrialization**

The theory of Dutch disease (Corden and Neary, 1982) indicates that “the resource dependency of resource-rich countries” may be harmful via, inter alia, deindustrialization in the long term.

Palma (2014) presents the concept of Dutch disease as both an additional source and a specific form of deindustrialization. It is “an economic phenomenon which links the exploitation of natural resources to a decline of the local manufacturing industry.” The author also reports that Dutch disease can change industrial exports into primary goods without seeking to develop the exports of manufactured goods, which causes deindustrialization. It has occurred in industrialized and developing countries that are rich in natural resources, leading to a shift in their comparative advantage and, thus, to their deindustrialization. Furthermore, Dutch disease is not only limited to natural resources; it has also occurred for other reasons, such as the development of financial services exports in Luxembourg, Hong Kong, and Switzerland, and tourism in Malta, Greece, and Cyprus.

1.2 External factors

- **Trade openness and deindustrialization**

According to Beenstock (1984), imports from developing countries are considered a major reason for the deindustrialization of developed countries. Imports from the south are gradually replacing labor-intensive industries in developed economies, and they have changed into more technological and sophisticated exports. Wood (1994) indicates that "North-South trade had accelerated deindustrialization in the North."

North-South integration is linked to deindustrialization via outsourcing because the costs of unskilled employees are much lower in the South, therefore capital accumulation will move there. According to Beenstock (1984), the reason behind deindustrialization is the concentration of manufacturing activities in southern countries. Besides, geographical reallocation is a consequence of trade liberalization.

Moreover, trade openness could be a major factor in deindustrialization in developing countries. Shafaeddin (2006) mentions that trade liberalization in the third world led to deindustrialization, underdevelopment, and specialization in primary commodities. Foreign competition has played a crucial role in the deindustrialization of some developing countries that have not been able to cope with competition from emerging countries and low-cost and very competitive producers.

Rodrik (2016) reports that trade liberalization, China's competition, and technological and automation change have caused, to a large extent, premature deindustrialization. Furthermore, international trade, the reallocation of manufacturing jobs, economic specialization in resource-based manufacturers and primary commodities, shifts in logistics networks and supply chains, and high competition from domestic and foreign markets may produce premature deindustrialization.

On the other hand, the new growth theory suggests that trade openness could enhance efficiency, provide new technology, and encourage innovation (Harrison, 1996). As the economy becomes more open, it will benefit from the spillover effect, develop its manufacturing sector, and grow rapidly.

Many authors such as Edwards (1998) and Henry (2003) report that greater trade openness can accelerate developing economies' adoption of technological innovation that originated in industrial countries. This would stimulate investments and manufacturing growth; however, this remains conditioned by an efficient diffusion and high absorption capacity of technology transfers.

In sum, the overall impact of openness on deindustrialization can be positive or negative. On the one hand, trade liberalization leads to a reallocation of output toward more productive activities and away from less productive ones (Melitz, 2003). On the other hand, trade openness and globalization can drive developing nations to specialize in low value-added goods.

- **Foreign direct investment, delocalization, and deindustrialization**

FDI outflows have been considered one of the major determinants of deindustrialization in developed countries. Beenstock (1984) argues that the FDI of multinational firms was behind the reallocation of manufacturing production from the North to the South.

However, FDI inflows can generate positive effects on industry and the economies of developing countries, often the host countries. Some authors argue that FDI leads to a re-specialization of developing countries away from the traditional specialization in raw materials and food products (Pisano and Shih, 2009). FDI effects can manifest via the transformation of traditional activities into more sophisticated activities via knowledge spillovers (Belloumi, 2014).

- **Technology, innovation, and deindustrialization**

Rodrik (2016) points out that "rapid technological progress in the manufacturing sector leads to an employment deindustrialization, but not output deindustrialization." The enhancement of knowledge and technology has substituted machines for workers and generated labor-saving production. Generally, this scenario only creates employment deindustrialization (Yanikkaya et al., 2019).

Rapid technological progress in the manufacturing sector has decreased the price of manufactured products, thereby discouraging newcomers in developing economies from entry (Rodrik, 2016). However, a large manufacturing sector has contributed to innovation-led growth in developed countries (Coad and Vezzani, 2017).

The availability of technical skills and local suppliers is considered a positive externality that promotes rapid innovative solutions for manufacturing challenges, hence spurring more innovation in manufacturing that might be reflected in strong knowledge accumulation (Dosi, 1988).

It is important to note that premature deindustrialization can have different determinants or immediate triggers than "mature deindustrialization." Premature deindustrialization is not a product of economic maturity and there must be specific factors (from the list of factors presented above) leading an economy to deindustrialize earlier than its peers.

2. Empirical review

Many studies have empirically discussed the causes of deindustrialization in different countries. In a study that includes both developing and developed countries, Palma (2005) suggests several explanations for this phenomenon. The inverted relationship between income per capita and the percentage of total employment in the manufacturing sector stems from the movement of manufacturing labor to the service sector as economies become more developed. This is also linked with the sector's productivity gains, the diminishing income elasticity of demand for manufactured goods, and outsourcing. Another explanation points to the impact of Dutch disease in economies where there is a boom in commodity exports.

Rowthorn and Ramaswamy (1997) analyze the cases of 18 developed economies using annual data between 1963 and 1994 to determine whether deindustrialization was caused by internal factors or the result of trade expansion with developing countries. Their empirical results show that internal variables, such as a decrease in the price of manufactured goods, a high investment rate, and an increase in the productivity of the manufacturing sector, account for 80 percent of the decline in the employment share of manufacturing, while the remaining 20 percent is explained by external variables, such as imports of manufactured products from developing countries. They also find that the negative impact of this latter variable has a dampening impact on the manufacturing sector's productivity gains. Hence, they conclude that deindustrialization was mainly caused by internal economic factors.

Furthermore, an empirical study conducted by Lawrence (1983) on Sweden, France, and Germany based on data between 1973 and 1985 shows that deindustrialization was caused by internal variables, as did the research conducted by Dollar and Wolff (1993) for the United States. In addition, Lawrence and Edwards (2013) find that the fall in the share of manufacturing in employment was a consequence of an improvement in productivity and a declining demand for manufactured goods relative to services.

Yanikkaya et al. (2019) use the Least Squares Dummy Variables estimation technique to investigate the link between trade/financial openness and deindustrialization in Turkey over the period 1995-2014. They find that openness measures, which are FDI inflows, trade, and GVC backward participation, have negatively impacted the share of manufacturing in employment and GDP.

Mouelhi (2007) finds that trade liberalization may destroy formal employment and decrease industrial output in developing countries because of the local industry's inability to compete, which leads producers to quit instead of expand.

IV. Consequences of deindustrialization

Industry has often been the main source of growth and development in high-income countries. Accounting for a significant share of GDP, the growth of manufacturing has had significant impacts on the overall growth of these countries. Research and development and technological progress have emerged often enough in the industry to spread later to other sectors.

The development of a modern industry induces and generates a growing demand for services, thus contributing to the development of the tertiary sector through a driving effect. Consequently, deindustrialization can lead to a drop in the demand for services.

Since international trade is dominated by manufactured goods, deindustrialization would inevitably lead to a decline in export opportunities.

In addition, the manufacturing sector is a large employer with a strong capacity to absorb both skilled and unskilled labor. The sector offers relatively stable and less precarious jobs than in some sectors of the tertiary. Consequently, deindustrialization would be the cause of job losses and precarity.

However, the negative consequences of deindustrialization are more pronounced in the case of premature deindustrialization. Premature deindustrialization hampers the economic growth and development of countries by limiting their technological development and their productivity increase and, consequently, their insertion into global value chains. Premature deindustrialization occurs at a low level of income per capita without taking advantage of all the manufacturing potential and externalities (Tregenna, 2015). As a result, service activities linked to manufacturing will not improve and economies will be stacked in the traditional tertiary sector (UNIDO, 2013). Some services rely on the growth rate and size of the manufacturing sector.

Conversely, when deindustrialization occurs at a lower level of GDP per capita, there is insufficient demand to support the development of services that can take the lead in the manufacturing sector, as was the case in developed countries (Tregenna, 2015).

In addition, the degradation of the manufacturing share in trade would create some issues, such as a deficit in the balance of payments and currency pressures. Moreover, non-tradable products would be substituted for tradable goods. Deindustrialization can be harmful to development and growth in the short and long run. Rodrik (2016) notes that “premature deindustrialization has potentially significant economic and political ramifications, including lower economic growth and democratic failure.”

V. The pattern of deindustrialization in Tunisia

As shown in Graph 3, the share of agriculture in GDP was higher than that of industry at the beginning of the 1960s. However, it declined near the end of the 1960s, stabilizing at around 10 percent over the last period. The share of agriculture in employment decreased, hitting 14 percent in 2019. Thus, labor moved principally from low-productivity agriculture to modern activities, including, most notably, the manufacturing sector.

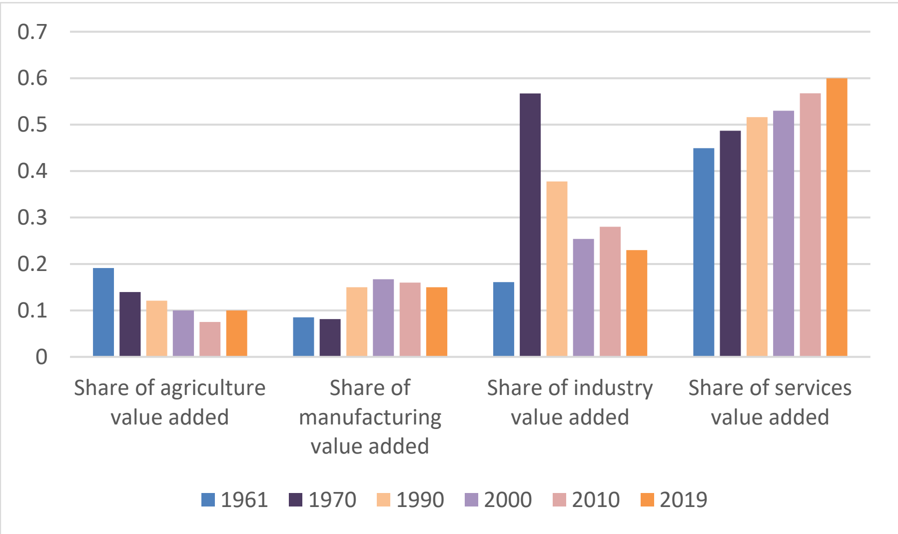
In addition, the weight of the service sector increased progressively and significantly since 1961, reaching 60 percent of GDP in 2019. The share of services in employment increased rapidly over the period, reaching 52 percent in 2019.

At the end of the 1970s, Tunisia started to diversify its economy and industrialize via an export-oriented strategy. Traditionally dominated by the textile sector, the Tunisian manufacturing sector gradually attracted investments in different higher value segments such as electronics, aeronautics, pharmaceuticals, and automotive, encouraged by the presence of a highly educated and skilled workforce (Ndikumana et al., 2009).

As shown in Graphs 3 and 4, the share of industry in GDP started out small (less than 20 percent in 1961) and then increased sharply to peak at 57 percent in the 1970s, the industrialization phase. However, the pattern reversed and fell to 38 percent in 1990. The industry curve stabilized below 30 percent with a decline in recent years, and it hit 23 percent in 2019. Tunisia has been facing a slowdown in its industrial activity and a gradual reduction in its weight. From 1970 to 1997, the share of industry in GDP fell in response to a decrease in the weight of the non-manufacturing sector, while the share of manufacturing in GDP rose. However, from 1998 onwards, both witnessed a slight decline.

As for manufacturing, its contribution to the GDP increased steadily at first, reaching 16.6 percent by 1998 as a peak, and since then it has slightly decreased to stabilize at around 15 percent. The employment share of manufacturing rose from seven percent in 1961 to reach 20 percent in the early 2000s, and then it slightly declined to stabilize at 18 percent during the last period. Gradual until 2011, the manufacturing weight loss accelerated after the 2011 revolution and over the recent period (see Graph 5).

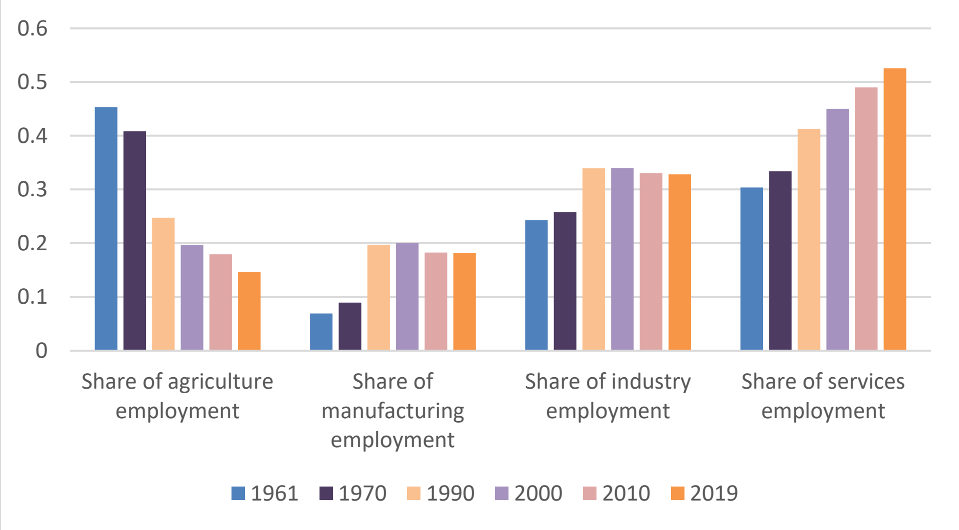
Graph 3. Evolution of sectoral value-added shares between 1961 and 2019



Sources: ITCEQ and INS.[4]

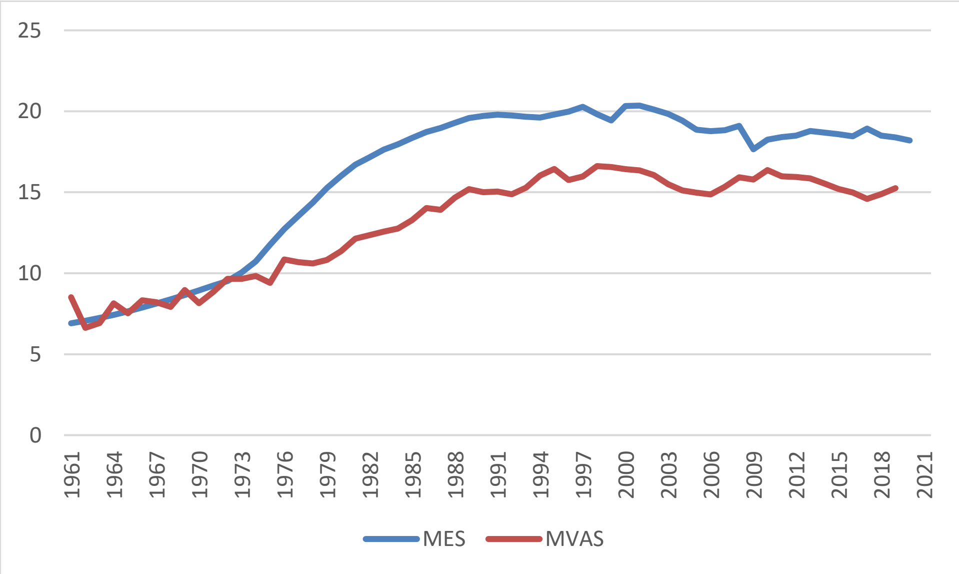
[4] ITCEQ: Tunisian Institute of Competitiveness and Quantitative Studies; INS: National Institute of Statistics.

Graph 4. Evolution of sectoral employment shares between 1961 and 2019



Source: INS.

Graph 5. Evolution of manufacturing value-added (MVAS) and employment shares (MES)



As shown in Graph 5, the manufacturing value-added share peaked at around 16.5 percent in the late 1990s at an income per capita level of around USD 2,300 (low middle-income group), before starting a decline/stagnation. However, manufacturing peaked at around 25 percent of GDP in Western European economies like Britain, Italy, and Sweden, at income levels of around USD 14,000 (high-income group). Therefore, the process of industrialization in Tunisia peaked at a lower level of income per capita than some economies of Western Europe. Deindustrialization began as the manufacturing sector had not exploited its full potential with a low weight, stabilizing at around 16 percent of GDP.

According to Rodrik (2016), developing countries see a decrease in their manufacturing shares at a low income per capita and, for this reason, they experience premature deindustrialization.

Table 1 shows that the Tunisian manufacturing sector has been witnessing a gradual decrease in its growth rate over the considered periods, from 7.8 percent in 1960-75 to 2.1 percent in 2005-18, therefore confirming the sector's slump.

Table 1. Average annual growth rate of manufacturing value added by time period

	1960-1975	1975-1989	1990-2005	2005-2018
Tunisia	7.8%	7.9%	5.2%	2.1%

Source: Authors' calculation from INS data.

VI. Main determinants of deindustrialization in Tunisia: An empirical analysis

In this section, we carry out an econometric analysis to identify the main factors that impacted the process of industrialization/deindustrialization in Tunisia.

Some previous studies have considered the overall industry while others have focused on the manufacturing sector. In our case, we consider both the manufacturing and industry sectors to analyze the phenomenon of deindustrialization in depth.

1. The model specification

Based on previous empirical studies, there is no commonly used model to explain deindustrialization. The selection of the explanatory variables is based on the literature review, previous research, and the specific needs of our research. Our model builds especially on the work of Rodrik (2016) and Rowthorn and Ramaswamy (1997, 1999). We conduct the analysis at the national level, and we start with a basic model:

$$\mathrm{IES_t} = \beta_0 + \beta_1 \ln(\mathrm{Y_t}) + \beta_2 \ln(\mathrm{ILP_t}) + \beta_3 \mathrm{OPENNESS_t} + \beta_4 \mathrm{REER_t} + \sum_{i=1}^{i=n} \beta_i \mathrm{Z_t} + \beta_5 \mathrm{D_t} + \varepsilon_t \quad \text{Equation (1)}$$

$$\mathrm{IVAS_t} = \beta_0 + \beta_1 \ln(\mathrm{Y_t}) + \beta_2 \ln(\mathrm{ILP_t}) + \beta_3 \mathrm{OPENNESS_t} + \beta_4 \mathrm{REER_t} + \sum_{i=1}^{i=n} \beta_i \mathrm{Z_t} + \beta_5 \mathrm{D_t} + \varepsilon_t \quad \text{Equation (2)}$$

The dependent variables measure the employment share (IES) and the value-added share (IVAS) of industry. The same models are estimated for the employment share (MES) and value-added share (MVAS) of the manufacturing sector.

Key explanatory factors

As presented and explained in the second section, many factors could explain the pattern of deindustrialization all over the world under different circumstances. Therefore, we will use the most relevant variables in our empirical study.

- **Economic development**

GDP per capita (Y) has been used as a measure of economic development and standard of living (Bogliaccini, 2013). Furthermore, GDP per capita growth leads to a demand shift from industrial goods to services. In our empirical analysis, we use the GDP at constant prices.

- **Openness**

Trade openness can be defined as “the extent to which an economy allows foreign companies to do business in its domestic market and participates in the global trade” (Gupta et al., 2020).

The literature has presented different measures of trade openness (e.g., the average coverage of quantitative restrictions (QRs), tariff averages, collected tariff ratios (CTR), imposed tariffs…etc.). Due to data availability, we will use ((total exports (X) + total imports (M))/GDP) as a measure of trade openness in our analysis.

- **Foreign direct investment (FDI)**

To quantify the impact of FDI on the industrialization process, we use FDI net inflows as a share of GDP.

FDI can have a positive impact on the manufacturing sector via technological transfer and knowledge spillover in a developing country.

- **Real effective exchange rate (REER)**

The REER indicates “the evolution of the value of the Tunisian dinar (TND) against the currencies of principal trading partners.”

According to Cizmović et al. (2020), REER appreciation could slow down the industrialization process by discouraging exports and encouraging imports.

- **Labor productivity (ILP)**

One of the best theoretical approximations of competitiveness is productivity. As stated by Krugman (1994), “Competitiveness is a synonym of productivity.” It is estimated by the total volume of output produced per unit of labor during a given period.

Labor productivity is a key measure of economic performance. However, a high growth in labor productivity could lead to a decrease in manufacturing employment (Tregenna, 2011).

- **Investment**

The purpose of this variable is to measure capital accumulation (inter alia investment in infrastructure), which is crucial for shifting from traditional to modern sectors. Moreover, it provides information concerning the extent to which the additional value-added is invested or consumed. We use the gross fixed capital formation (GFCF) variable as a share of GDP to measure investment.

- **Human capital**

The presence of an educated and skilled workforce is required to shift into productive and modern industries, which are principally skill intensive.

Human capital is measured by the mean years of schooling for the adult population, which is the average number of finished years of education of the population aged 25 years and above, excluding years spent repeating individual grades.

- **Innovation and technology**

The adoption of new processes and technologies is necessary for the development of high value-added goods with new market perspectives (Mouelhi and Ghazali, 2018). Additionally, the rise of research and development activities helps produce a large number of high value-added goods, more competitiveness, exports, and long-run economic growth (Smit et al., 2016).

We include the variable of patent applications as a measure of innovation.

Table 2 provides a synthesis of the variables used in our study. All variables are annual and those that are not expressed in shares are logarithmically transformed to reduce the impact of large outliers of variables. Logarithmic transformation reduces or even eliminates the skewness of our dataset and transforms it into a normalized dataset. However, we add the log to labor productivity specifically to avoid the second difference of the unit root test.

Around 19 observations (years) are available for all the variables; therefore, the estimation of our selected variables will be conducted over the period 1998-2017.

Table 2. Description of variables

Variables	Descriptions	Sources	Period
MES_t	The share of manufacturing in total employment	ITCEQ	1961-2019
IES_t	The share of industry in total employment	ITCEQ	1961-2019
$IVAS_t$	The share of industry in GDP	INS	1998-2018
$MVAS_t$	The share of manufacturing in GDP	INS	1998-2018
Ln_Y_t	Natural logarithm of GDP per capita	WDI	1965-2019
Ln_MLP_t	Natural logarithm of manufacturing labor productivity measured by value-added per employee of the manufacturing sector	ITCEQ AND INS	1998-2018

Table 2. Description of variables (contd.)

Ln_ILP_t	Natural logarithm of industry labor productivity measured by value-added per employee of the industry sector	ITCEQ AND INS	1998-2018
FDI_t	FDI net inflows as a percentage of GDP	The World Bank	1970-2018
$Openness_t$	Trade openness measured by the ratio of exports plus imports divide by GDP	The World Bank	1965-2018
Ln_REER_t	Natural logarithm of the real effective exchange rate index	The World Bank	1979-2019
MSC_t	Average total years of schooling for adult population (25+ years old)	United Nations Development Program (UNDP)	1990-2017
$GFCF_t$	Gross fixed capital formation as a percentage of GDP	The World Bank	1965-2018
$Ln\_Patents_t$	Natural logarithm of number of patent applications	World Development Indicators (WDI)	1980-2018

Source: Authors' elaboration.

2. Estimation results

In our study, we investigate the dynamic causal relationship between the dependent variables (weights of industry and manufacturing sectors) and the explanatory variables by applying the Autoregressive Distributed Lag Model (ARDL) and bounds test. The ARDL cointegration method, developed by Pesaran and Shin (1995) and Pesaran et al. (2001), is used to empirically investigate the short-term dynamic interactions and the long-term relationships among the variables of interest. This technique has three advantages compared with other cointegration methods. The first advantage is that the ARDL cointegration test does not require that the entire set of variables be integrated of the same order. The second one is that the ARDL model is relatively more robust in the case of finite and small sample data sizes. The last advantage is that by using the ARDL method, we have unbiased estimates of the long-term model (Belloumi, 2014).

We use the Philipps-Perron (PP) test to test the stationarity of our variables. The PP test deals with heteroscedasticity and serial correlation in the errors. The null hypothesis that "variables are stationary in levels" is rejected for all the variables except FDI. However, the null hypothesis that "variables are stationary in first differences" is not rejected for all the variables. We thus conclude that the variables are integrated of order one except FDI, which is stationary in level (see Annex 1).

After ensuring the stationarity of variables, we check the existence of long-term relationships before estimating the long-term coefficients and error correction models.

Hence, we carry out the cointegration test in order to verify whether the linear combination of our variables is stationary or not. In other words, we check if there is an equilibrium or long-run relationship between the variables. Table 3 presents the results of the Pesaran cointegration test for the manufacturing and industry sectors.

Table 3. Results of the cointegration test of Pesaran et al. (2001) at the five percent threshold

Equation	**MES**		**MVAS**		**IES**		**IVAS**	
	Spec[5]1.1	Spec 1.2	Spec 2.1	Spec 2.2	Spec 1.1	Spec 1.2	Spec 2.1	Spec 2.2
F	801.014	89.243	59.417	29.417	40.683	9.370	5.199	5.449
Borne <	2.22	2.32	2.22	2.32	2.22	2.32	2.22	2.32
Borne >	3.39	3.50	3.39	3.50	3.39	3.50	3.39	3.50

Source: Authors' calculation using STATA Software.

The results of the Pesaran test confirm the existence of a cointegration relationship between the variables (the F value is superior to the upper terminal), which allows for the estimation of long-term relations between the different variables.

Since there is a stable long-term relationship between dependent and independent variables, the ARDL model is used to estimate the coefficients. Hence, our aim is to analyze and quantify the influence of the different factors impacting the weights of both the manufacturing and industry sectors.

We start by estimating the full equation (specification 1.1), then, in order to avoid the problem of multi-collinearity, we eliminate the GDP per capita variable (specification 1.2) because it is highly correlated with the other explanatory variables.

Table 4. Results of the error correction model for the industry sector

	The industry sector			
	Employment share (Equation 1)		**Value-added share (Equation 2)**	
	Specification 1.1	Specification 1.2	Specification 2.1	Specification 2.2
ADJ	-0.922*	-0.355*	1.052	-.302*
Long-run estimates (LR)				
Openness	.0421*	.0292*	.294	.1334
Ln_REER	-1.212	-3.564*	27.038	15.962
Ln_ILP	4.229*	3.274*	20.339	-8.484
Ln_Y	-.001	-	-.0218	-
GFCF	-.213*	-.151*	-.210	1.238*
FDI	-.506**	-.515**	.060	.546
MSC	-1.997*	-1.631*	.464	-2.092
Ln_Patents	.935*	.631*	2.575	-.164

[5] Specification 1.1 is the full equation with all the explanatory variables, while specification 1.2 is the full equation without the variable 'GDP per capita,' which is highly correlated with the other explanatory variables and may lead to a collinearity problem.

Table 4. Results of the error correction model for the industry sector (contd.)

Short-run estimates (SR)				
Openness	.1625	.063	-.016	.0403*
Ln_REER	-9.210	-15.227*	-27.901	5.030
Ln_ILP	50.0003	17.210	3.092	9.601**
Ln_Y	-.0119	-	.0119	-
GFCF	-1.167	-.5270	-.699	.375*
FDI	-2.020	-1.0279*	.0516	-.049
MSC	-16.341	-11.343	-31.845	-.633
Ln_Patents	1.887	.0233	-2.710	.577
Dummy2011	-5.352	-2.529	-3.587	1.581*
Constant	339.997	177.946*	-2.862	-3.738
Number of observations	19	19	19	19

Note: * p<.05; ** p<.01; *** p<.001

Source: Authors' calculation using the Software Stata.

Table 5. Results of the error correction model for the manufacturing sector

The manufacturing sector				
	Employment share (Equation 1)		**Value-added share (Equation 2)**	
	Specification 1.1	Specification 1.2	Specification 2.1	Specification 2.2
ADJ	-.719*	-.551***	2.152	-.706**
Long-run estimates (LR)				
Openness	.0272	.054***	-.016	.033*
Ln_REER	-7.566*	-4.729***	-3.742	2.9
Ln_MLP	5.625*	6.506***	1.845	.747
Ln_Y	.001	-	.0004	-
GFCF	-.216*	-.257***	.331*	.382***
FDI	-.070	-.0008	-.148*	-.071*
MSC	-1.109*	-1.688***	.192	-1.713*
Ln_Patents	-1.551*	-.990***	-.283	.560*
Short-run estimates (SR)				
Openness	.019*	.030***	.088	.0236**
Ln_REER	-5.468*	-2.606***	8.201	1.98
Ln_MLP	-11.496*	-9.819***	-1.393	.527
Ln_Y	.0012	-	-.004	-
GFCF	-.052	-.0207	-.080	.270**
FDI	-.011	-.0004	-.018	-.050*
MSC	-2.065	-.930**	-.413	.656
Ln_Patents	-.9119*	-.545***	.779	.3959*
Dummy2011	-.660	-.3757**	-1.476	.661*
Constant	19.843*	14.872***	-20.173	3.097
Number of observations	19	19	19	19

Note: * p<.05; ** p<.01; *** p<.001
Source: Authors' calculation using the Software Stata.

The autocorrelation, heteroscedasticity, and normality of the errors are tested in the different specifications and the results suggest that there was no problem (see Annex 2).

Tables 4 and 5 present the impact of the explanatory variables on the shares of industry/manufacturing in total employment and GDP.

A significant and negative value of the error correction coefficient (ADJ) is consistent with the existence of a long-term relationship.

The adjustment coefficient (ADJ) linked with the restoring force is negative and significant at the one percent level in most of the specifications, which confirms the results of the cointegration bounds test. It determines the rate at which any imbalance between the actual levels of the dependent variables (MES, MVAS, IES, and IVAS) and their desired level is restored after any shock. Thus, there is an error correction mechanism that suggests the convergence of the trajectory of the determinant series into the long-term target. From specification 1.1, the coefficient is estimated at 0.72, which indicates that the speed of adjustment to equilibrium after a shock is generally rapid; approximately 72 percent of disequilibria from the shock of the previous year converge back to the long-term equilibrium in the current year. Furthermore, it would take exactly 1.3 years for the variables to recover their equilibrium value after a shock.

The coefficient of the openness variable is positively related to the share of employment and value-added in both the manufacturing and industry sectors, in the short and long run. A one percent increase in trade openness is likely to raise the employment and value-added shares of manufacturing by 0.054 percent and 0.033 percent, respectively. Openness is statistically significant and positive in most of the specifications, indicating that trade openness contributes to industrialization. Trade has played a key role as a source of technological spillovers via imported intermediate goods and equipment from developed countries and also via more export opportunities.

We include REER and LP as proxies of competitiveness[6] in our models.

The results show a negative effect of the REER on the share of employment in the industry and manufacturing sectors. The REER coefficient remains negative in the short- and long-run estimations. Results are statistically significant and support the strand of literature that suggests that currency depreciation improves competitiveness, leading to a rise in exports (Bose, 2014). Consequently, the strong depreciation of the Tunisian dinar over the last decade moderated Tunisia's deindustrialization process. It is worth noting that the Tunisian dinar lost around 60 percent of its value against the dollar between 2010 and 2022.

[6] Because of the lack of data, we were unable to use some other measures of competitiveness, such as the Global Competitiveness Index (GCI), in our study.

Labor productivity has a positive and significant impact on the share of employment; however, it has no effect on the share of value-added. An increase by one percent in labor productivity generates a rise of 6.5 percent in the employment share of manufacturing. The coefficient of labor productivity is high, positive, and statistically significant with the share of employment in both sectors. In other words, labor productivity is a driver of industrialization in the long term in both the manufacturing and industry sectors. Consequently, the anemic labor productivity growth experienced by Tunisia over the last decade is one of the main factors behind the decline in competitiveness and deindustrialization. Labor productivity has grown at very low rates over the last decade in Tunisia, around 0.7 percent per year between 2016 and 2019, while it was around 5.4 percent between 2006 and 2010 (Amara et al., 2023).

Based on the estimation results, the coefficient of GDP per capita (as a measure of economic development level and standard of living) showed to be statistically insignificant for the shares of both manufacturing and industry in all the specifications. In contrast to the experiences of developed countries, Tunisian deindustrialization is not linked with the level of income per capita. Hence, it is not a result of reaching high levels of development and economic maturity, which can confirm its premature nature.

Furthermore, investment (GFCF) has a positive and significant effect on the shares of manufacturing and industry in GDP. It is used to examine the extension of the profitability supply of an economy and demonstrate the expansion in the efficiency limit (Hena et al., 2019). However, the negative effect of GFCF on employment can be linked to a substitution effect between labor and capital. Thus, investment is one of the major factors boosting industrialization (Kang and Lee, 2011). The precipitous decline in Tunisia's investment rate from 25 percent in 2010 to 14 percent is another factor explaining the phenomena of deindustrialization.

In our analysis, we consider the mean years of schooling (MSC) variable as a measure of human capital. In contrast to previous findings (Raul and Puvanasvaran, 2009; Guisan, 2005), we find that MSC has a negative impact on the share of employment in both sectors, which may be associated with the fact that Tunisia has a traditional industry dominated by unskilled workforce without high qualifications. Thus, the increase in educational attainments experienced by Tunisia did not benefit the industry and manufacturing sectors, which are characterized by low technological content.

Based on our empirical results, the coefficient of FDI inflows is, in most model specifications, not statistically significant. FDI remained at a modest level in Tunisia (less than three percent of GDP/year) between 2010 and 2019 and less than 0.6 percent of GDP is invested in manufacturing (Report 2035). Moreover, FDI is dominated by subcontracting activities that are totally exporting and in almost total disconnection with the onshore sector, thus preventing technology transfer and know-how. As concluded in the report of the industrial strategy

"Tunisia 2035," "Tunisia does not seem to have been able to attract enough FDI and exploited the opportunities that such investments would bring: transfer of technology and know-how, rise and integration into the chain of high added value, skills jobs…etc. The policy pursued to attract FDI seems to have been only partially successful."

We also include the patents variable as a proxy for innovation. The coefficient of patents is related negatively and significantly to the share of manufacturing in total employment, but positively to the share of manufacturing in GDP. Most studies agree that innovation encourages the upgrading of the manufacturing sector (Xie et al., 2019).

In all specifications, we introduce a dummy variable to capture the specific impacts of the revolution experienced by Tunisia in 2011. The coefficient of Dummy2011 is negative and statistically significant for the share of employment in manufacturing. Since 2011, the business environment deteriorated due to political instability, social claims, and bad governance, which led to the exodus of multinational firms and business bankruptcy, generating a high unemployment rate. The revolution accelerated the process of deindustrialization in Tunisia.

In sum, our empirical results strongly suggest that deindustrialization in Tunisia is a consequence of a lack of competitiveness, mainly illustrated by a very low growth of labor productivity. Many factors have contributed to the deterioration of the country's competitiveness, such as political instability, corruption, inefficient government bureaucracy, lack of adequate competition policies, the inequitable taxation system, skills gaps, the rigidity of the labor market…etc. Furthermore, openness remains a driver of industrialization.

VII. Conclusions

Despite the key role of the industrial sector in economic development, many countries have exhibited a fall in the share of industry and manufacturing in GDP and employment (Timmer et al., 2015; Rodrik, 2016). This trend has been exhibited by both developed and developing countries in the past few decades (Rowthorn and Ramaswamy, 1997; Rodrik, 2016; Felipe et al., 2019). The worrisome aspect of this deindustrialization in developing countries is that it began before realizing its full potential and reaching a mature stage as is the case in developed countries (McMillan and Rodrik, 2011; Cizmović et al., 2021). Moreover, the manufacturing sector has special features that assign it a unique role as the driver of economic growth (Tregenna, 2014).

A strategic geographic location and a competitive and highly skilled workforce enabled Tunisia to build a robust and diverse industrial sector in the 1970s and 1980s. However, recent years of social unrest, political instability, and low competitiveness have impinged on the previous success.

Our study examines two main questions. First, whether Tunisia has been experiencing premature deindustrialization, and second, the role that trade openness and other factors have played in this process of industrialization/deindustrialization.

In order to analyze this phenomenon in a comprehensive way and beyond some descriptive statistics, we apply the ARDL cointegration technique to investigate the existence of a long-term relationship between the measures of industrialization/deindustrialization and the main explanatory variables during the period 1998-2017.

The results suggest that Tunisia faced premature deindustrialization, as the decrease in the weights of manufacturing and industry starts at the end of 1990s/early 2000s at an early stage of development compared to the developed countries. This would have contributed to the decline in growth experienced by Tunisia over the last decades.

Furthermore, the manufacturing sector has been deeply affected by the COVID-19 crisis. In 2020, manufactured output contracted by 10 percent compared to 2019 (World Bank, 2020).

Our key finding is that deindustrialization has mainly been caused by internal factors in Tunisia, primarily a lack of competitiveness. In addition, trade openness has positively impacted the weight of both the manufacturing and industry sectors, therefore contributing to industrialization. Because of a lack of data, we were unable to investigate the impact of different measures of trade openness on industrialization/deindustrialization.

The consequences of premature deindustrialization are not only the delay of economic growth and its impact on job creation, but also other chronic problems such as persistent trade imbalances and informal employment (Cruz, 2015). Moreover, Tunisia is lagging in terms of technology and innovation, which prevents the economy from becoming competitive in the production of technological goods and gaining from opportunities related to Industry 4.0 (Andreoni and Tregenna, 2018).

The findings are very insightful, especially for economic policymakers; it is necessary to recognize innovation and technology as the key factors for growth and job creation in the manufacturing sector (Baffour et al., 2020). A typical example is the experience of East Asian countries, and lessons from the “East Asian Tigers 22” affirm that good technological policies may help encourage businesses and develop their competitiveness. Hence, East Asian countries still provide a useful role model (Dasgupta and Singh, 2007).

In light of our empirical findings and in the context of establishing an alternative economic policy strategy, the Tunisian economy may need to implement a reindustrialization plan as a road to prosperity and wealth. This requires improving competitiveness via effective and active policies and an efficient industrial policy promoting and supporting the manufacturing sector.

Improving competitiveness and attractiveness should be a priority. The revival of industry requires national visions, the mobilization of all actors, plans for the recovery of industry, financial and fiscal incentives, and resource mobilization. This also requires improving the business climate quality, removing the barriers to investment, strengthening the financial sector and facilitating access to finance, simplifying the regulatory framework on paper and in the field, enforcing the role of law, and labor training, among others.

State intervention is more important than ever for the support of the sector in its modernization and digital transformation process.

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Annex 1: Phillips-Peron (PP) stationarity tests

PP stationarity test results in levels

	With a constant		With a constant and a trend		Conclusion
	Value	CV[7] (5%)	Value	CV (5%)	
MVAS	-1.60	-3.00	-1.80	-3.60	Non-stationary
IES	-2.034	-2.924	-1.135	-3.492	Non-stationary
MES	-2.373	-2.924	-0.268	-3.492	Non-stationary
IVAS	-1.236	-3.000	-0.919	-3.600	Non-stationary
Ln_Y	-1.704	-2.927	-1.629	-3.496	Non-stationary
Ln_ILP	-0.558	-3.000	-1.865	-3.600	Non-stationary
Ln_MLP	-0.172	-3.000	-1.801	-3.600	Non-stationary
Openness	-1.739	-2.927	-2.616	-3.496	Non-stationary
FDI	-4.782	-2.936	-5.057	-3.508	Stationary
GFCF	-2.097	-2.928	-2.258	-3.497	Non-stationary
Ln_REER	-1.515	-2.958	-0.990	-3.540	Non-stationary
MSC	-1.317	-2.994	-0.942	-3.592	Non-stationary
Ln_Patents	-0.561	-2.969	-3.632	-3.556	Non-stationary

Source: Authors' elaboration using Stata.

PP stationarity test results in first difference

	With intercept		With intercept and trend		Conclusion
	Value	CV (5%)	Value	CV (5%)	
MVAS	-7.330	-3.00	-7.005	-3.600	Stationary
IES	-7.259	-2.924	-7.607	-3.493	Stationary
MES	-5.120	-2.924	-6.179	-3.493	Stationary
IVAS	-3.316	-3.000	-3.641	-3.600	Stationary
Ln_Y	-6.816	-2.928	-6.798	-3.497	Stationary
Openness	-6.957	-2.928	-6.955	-3.497	Stationary
GFCF	-5.221	-2.928	-5.205	-3.498	Stationary
Ln_REER	-5.066	-2.961	-5.106	-3.544	Stationary
MSC	-4.352	-2.997	-4.457	-3.596	Stationary
Ln_MLP	-3.696	-3.000	-3.633	-3.600	Stationary
Ln_ILP	-4.496	-3.000	-4.432	-3.600	Stationary
Ln_Patents	-9.930	-2.975	-9.678	-3.564	Stationary

Source: Established by the authors, the calculations are carried out using the Software Stata.

[7] The critical value.

Annex 2: Diagnostic tests

Results of autocorrelation, homoscedasticity, and normality tests

Decision rule	Tests	Probabilities								Conclusions
		MES		MVAS		IES		IVAS		
		S1.1	S1.2	S2.1	S2.2	S1.1	S1.2	S2.1	S2.2	
If the probability is greater than 5%, we accept Ho	Breusch-Godfrey	0.306	0.4951	0.7430	0.6481	0.3071	0.3946	0.3106	0.1004	Absence of autocorrelation of errors
	White	0.3946	0.3946	0.3946	0.3946	0.3946	0.3946	0.3918	0.3946	Homoscedasticity of errors
	Jarque-Bera	.8871	.6924	.4265	.2147	.3447	.7268	.2897	.5253	Normality of errors

Source: Author's calculation using the Software Stata.