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Maritime infrastructure and growth: econometric measurement using panel data from Tunisia

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Abstract

This study applied a Cobb–Douglas production function in an attempt to assess the effect of increased maritime sector investment on economic growth. It did this for the Tunisian economy based on panel data for the 1985–2020 period, thus making it possible to confirm the importance of spillover effects resulting from developing the Tunisian maritime infrastructure. Increases in added value for market services and non-manufacturing industries proves the benefits of investments but also the harm caused by the structuring effects of marine infrastructure. The results reveal, however, that the positive induced effects are not guaranteed, because the development of maritime infrastructure can have the opposite effect, such as by shrinking the size of the manufacturing industries in relation to services, which is a striking example of a negative effect that was suffered by the Tunisian economy.

Keywords: Growth, Spillover effects, Structuring effects, Maritime infrastructure, Shipping

Introduction

Since the end of the 1980s, many economic studies have focused on the effects of transport infrastructure on economic growth (Aschauer 1989; Munnell 1992; Garcia-Mila and McGuire 1992; Nadiri and Mamuneas 1994; Holtz-Eakin 1994; Morrison Paul and Schwarz 1996; Harizi 2008; M'raïhi and Harizi 2014). These studies have differed in several areas, such as model specification (Cobb–Douglas function, translog function, Leontief function); the indicators used for measuring economic growth (Gross domestic product (GDP), household income, gross regional income, etc.); level of disaggregation of economic sectors (national production, sectoral production, regional production); the nature of the data (time series, panel data, instantaneous cross-sections, etc.); and the mode of transport. Nevertheless, they represent important theoretical and empirical progress in revealing several methods for measuring transport's effects on economic growth and the quality of port logistics.

Maritime transport has been studied less in this context, so we became interested in analysing maritime activity, such as shipping, port operations, and logistical activities.

Our evaluation therefore focuses on the effects that investment in maritime infrastructure has had on economic growth in Tunisia between 1985 and 2020. The maritime sector was also chosen due to the important place it occupies in public policy, particularly in a country like Tunisia with its extensive coastal facilities. Furthermore, various economic objectives—such as strengthening economic growth, creating jobs, attracting foreign direct investment, and developing international trade—may depend on the quality of marine infrastructure and port facilities, as well as the performance of logistics operations (Munim and Schramm; Harizi 2020). In addition, Munim and Schramm (2018) used a structural equation model to provide empirical evidence of significant economic impacts of port infrastructure quality and logistics performance of 91 countries. Unlike developed countries, developing countries must continuously improve the quality of port infrastructure as it contributes to better logistics performance, leading to higher seaborne trade, yielding higher economic growth. However, this association weakens as the developing countries become richer.

The remainder of this paper is structured as follows: First, we review the basic effects of transport on growth. Next, we present our research methodology, which starts with modelling a Cobb–Douglas production function to estimate two econometric specifications based on panel data. We then present the econometric results for the estimates based on panel data before discussing the induced and structural effects of shipping on growth. Finally, we conclude the study by discussing its findings and limitations and suggesting avenues for future research.

Background

Since the work of Adam Smith (1776), many studies have dissected the "Transport infrastructure → Exchange → Growth" relationship in an attempt to show that any improvement in transport infrastructure will result in an improved transport service in terms of lower costs, faster speeds, and/or fewer delays (Harizi and M'raïhi 2014). Thus, improving one or more characteristics of a transport system will facilitate the exchange of goods and services by shortening supply routes, lowering costs, improving safety, and enabling new forms of exchange that were previously impossible or uneconomical. Thus, transport has both direct and indirect effects on growth.

Direct effects

The direct effects generally work through improved accessibility to spaces, particularly when they lead to increased traffic and greater mobility for people and goods, as well as reduced transport times (Blayac and Causse 2001; Harizi 2008; M'raïhi et al. 2015; Hasselgren 2018). These effects have been analysed in the literature from several perspectives (e.g., the economic value of building new transport infrastructure, the economic theory of discounted profit, consumer surpluses, and so on. They manifest in the short, medium, and long term, such that investments in transport infrastructure help to link supply with demand, which in turn will lead to improvements in the economic performance of private and public sector activities in the long term (Aschauer 1989; Munnell 1992; Garcia-Mila and McGuire 1992; Nadiri and Mamuneas 1994; Holtz-Eakin 1994). Thus, several previous works linking the kilometric traffic of people and/or goods have shown that improving traffic enhances the circulation of passengers and goods, which in turn facilitates and accelerates economic transactions and leads to efficient economic functioning (The Organization for Economic Cooperation and Development (OECD) 2007; Harizi and M'raïhi 2014).

In economic theory, any economic, social, or landscape modifications, such as developing transport infrastructure, are considered structuring effects. These non-automatic effects affect the territory served by the developed infrastructure and manifest in the medium and long term (Delaplace 2014; Offner 2014). Training effects, meanwhile, are causal (training) relationships between two phenomena, and they can be constructive or destructive (Garrison 1960; Donald 1969; Delaplace 2014). Many researchers have shown that the effects of transport are predominantly structuring ones, with any ripple effects only occurring once the dynamics are already in place (Delaplace 2014; Offner 2014).

Indirect effects

Scholars have studied indirect effects from several theoretical and empirical angles to include induced, structuring, and multiplier effects. More specifically, the multiplier effects manifest in the short term through the effect of an economic multiplier, such as when public investment in regional transport infrastructure induces job creation and income distribution, which then have further positive effects on economic growth (Berndt and Hansson 1992; Leichenko 2001). Furthermore, transport is an integral part of the "production–consumption" cycle, acting as the catalyst for triggering positive interactions between sectors of economic activity (Munnell 1992; Lynde and Richmond 1993; Crain and Oakley 1995).

Bull (2003) proved that when exchanges are more fluid and more intense, they generate greater wealth because access to assets and the speed of point-to-point journeys depends at least partly on the transport infrastructure, so new or improved infrastructure will increase accessibility and productivity and thereby promote growth.

To assess the interactions between road transport and economic and population growth, Harizi and M'raïhi (2014) used vector error correction models that considered the systemic and historical character of transport, with them revealing several interactions between GDP, the transport system, and population over the 1960–2008 period in Burkina Faso. Their results proved that the interactions between growth and population occur over the medium and long term as a "snowball" phenomenon. First, GDP growth stimulates investment in transport, which in turn facilitates the movement of people and goods (i.e., increased trade and added value). Second, an increase in population and employment demands also stimulates transport development through increased demand for it.

Previous work has shown that maritime infrastructure plays a crucial role in economic growth and ensuring the connectivity of regions (Mohamed-Chérifa and Ducruet 2016; Mou et al. 2022) or described the process by which port terminals became cities and how ports do not become cites because of the shadow effect (Lugo and Martinez-Mekler 2022). Indeed, improving maritime transport conditions positively stimulates production and the marketing of products and facilitates greater international trade in goods and services and the internationalization of production units (Panayides and Cullinane 2002; Lasserre and Pelletier 2011; Grushevska and Notteboom 2016).

Previous works have therefore argued that investment in transport leads to improvements in terms of production, time efficiency, accelerated procedures, the decongestion of the traditional networks, and faster average transport speeds.

However, most previous studies that have analysed maritime transport have been limited to assessing the effects of developing maritime navigation equipment on the trade in goods and services and/or the effects of port infrastructure on regional development. Such a partial treatment of the effects of maritime infrastructure cannot possibly reveal the overall effects of maritime infrastructure on economic growth. Indeed, an analysis of the effects of maritime infrastructure on economic growth needs all the relevant infrastructures to be considered within a global framework by taking into account port installations and equipment, maritime navigation equipment, and logistics facilities (Munim and Schramm; Harizi 2020). In other words, a framework should consider the entire maritime sector, not just one of its activities.

There is no economic theory for precisely determining the effects of developing maritime infrastructure on economic growth. It therefore makes sense to study these effects by starting with the theoretical foundations of transport infrastructure's effects on economic growth in terms of how its contribution to economic growth can be measured in different ways. Considering the desire to evaluate the impact of maritime infrastructure on a macro level, as well as the significance and history of our sample, the production function approach seems best suited to this type of evaluation. Nevertheless, several previous studies based on production functions have been strongly criticized due to problems with multicollinearity or non-stationarity in the used time series, because these generally led to biased estimates and very high elasticity values for the factors. Therefore, to obtain reliable results, we estimated a production function using panel data for the Tunisian economy while taking into account these econometric criticisms.

Method

Model and procedure

By means of a Cobb–Douglas production function, our proposed model seeks to assess the effects of maritime infrastructure on GDP. The model considers the seaport capital stock (SPC), the labour factor (LF), and the physical capital (PK) as factors of production. Finally, the production function requires another variable representing the physical capital off seaport capital (PKOSPC) and a coefficient (A) to denote the technological effects on the factors of production. Thus, the proposed model is defined as follows:

$$Y = A.PK^{\alpha}.LF^{\beta}.SPC^{\lambda}.PKOSPC^{\gamma} \tag{1}$$

For Eq. 1 to be estimated with the panel data technique, it is transformed as follows:

$$Y_{it} = A.PK_{it}^{\alpha}.SPC_{it}^{\beta}.LF_{it}^{\lambda}.PKOSPC_{it}^{\gamma};\ \text{where } i = \{1, 2 \ldots 5\} \tag{2}$$

where i denotes the five branches of economic activity, t is the year ithe 1985–2020 period. The parameters (α, β, λ, and γ), meanwhile, represent the scale returns or elasticities of national production with respect to the factors of production. Moreover, the elasticity of national production with respect to maritime infrastructure is the main parameter of interest for this model, because it reflects the effects of maritime infrastructure on growth.

Measures

National production and economic activities

National production Y designates the wealth of a country, and it is measured by the economic indicator GDP, which reflects the value of all the goods and services produced in that country over a year. According to Tunisian national accounting, economic activity includes five branches: agriculture and fishing (AG); manufacturing industries (MI), including agricultural and food, materials, construction, glass, mechanical, electrical, chemical, textile, clothing, leather, and other industries; non-manufacturing industries (NMI), such as mining, oil extraction and refining, gas production, production and distribution of electricity, production and distribution of water, building, and civil engineering; market services (MS), such as trade, financial institutions, transport, communications, hospitality, and other merchant services; and non-market activities (NMA), which bring together central public administrations, local authorities, and social security bodies.

Stock of physical capital off transport

The (PK) variable corresponds to the cumulative gross fixed capital formation (GFCF) minus transport depreciation (i.e., road, rail, air, and pipeline). It brings together all the tools and equipment used for national production. The SPC_t variable constitutes a part of this capital that can be estimated separately. They can be deduced as follows:

$$PK_t = SPC_t + K_t \tag{3}$$

$$SPC_t = PK_t - K_t \tag{4}$$

where K_t represents the other tools and equipment used in production processes.

Marine capital stock

This aggregate is measured as investment expenditure in maritime infrastructure, and it aggregates all jobs in the cumulative GFCF net of depreciation related to the maritime sector.

Seaport capital stock

This stock is for ports only. The relative data for SPC_t are not for immediate use, and they are calculated as follows:

$$SPC_t = (1 - \delta_t).SPC_{t-1} + I_{SPC_t} \tag{5}$$

$$I_{SCS_t} = SCS_t - [(1 - \delta_t).SCS_{t-1}] \tag{6}$$

where SPC_t and SPC_{t-1} are the seaport capital stocks at year t and $t-1$, respectively. I_{SPC_t} is the seaport infrastructure investment for year t, while δ_t represents the rate of depreciation of seaport infrastructure, which is 5% according to the Tunisian national accounts (Official Gazette of the Republic of Tunisia [OGRT] 2008; Central Bank of Tunisia [CBT] 2021). Estimating the $SPCS_t$ stock for year t requires calculating the capital of seaports for a base year (SCS_{1985}) and using a capital coefficient ϕ_t to represent the ratio between $SPCS_t$ and the added value of seaports AV_{SPA_t}:

$$\phi_t = SPCS_t / AV_{SPA_t} \tag{7}$$

$$SPC_{1985} = 3.\left(AV_{SPA_{1985}}\right) \tag{8}$$

Labour factor

This factor is measured as the number of people in the population with a job. It includes everyone in one of the following employment situations: practicing a profession (salaried or otherwise), even on a part-time basis; helping a person in his or her work, even without pay; being an apprentice or paid intern; exercising reduced activity; being a student; or being officially retired but still in employment. The statistics are published by the National Institute of Statistics [NIS] (2022).

Procedure

Estimating Eq. 2 requires any autocorrelation problems to be detected and corrected, so we need to make it linear through logarithmic transformation:

$$LogY_{it} = a + \alpha LogPK_{it} + \beta LogSPC_{it} + \lambda LogLF_{it} + \gamma LogPKOSPC_{it}; \quad \text{where} \quad a = LogA. \tag{9}$$

The logarithmic transformation is very useful because the slope of each transformed series corresponds to the discrete growth rate. Thus, the transformation and differentiation of the series address the autocorrelation problem among the variables while making the series more stable.

In order to operationalize the estimation of Eq. 3, the data were broken down by branch of economic activity *i*. Actual *GDP*, meanwhile, was broken down into value added at factor cost by industry. Next, *PK* and *LF* were also broken down by activity branch. In addition, *SPC* and *PKOSPC* could also be broken down by branch of activity, at least in the sense that while they are not specific to a well-defined industry, they could be allocated to branches of activity.

Results

Preliminary analysis

International trade in goods and services

Since the beginning of the 1990s, Tunisia has been gradually liberalizing its foreign trade and establishing free trade agreements with many countries. Indeed, the country's gradual integration into the world economy has resulted in 50 trade agreements with as many countries, giving it access to more than 800 million consumers (Ministry of Trade and Export Development 2022). In addition, the Tunisian customs has two import–export regimes for products and services: the general customs regime (GCR) and the offshore customs regime (OCR).

A customs declaration under the CGR is made directly by the importer or exporter or an approved customs agent, while the OCR is specific to three categories of companies: (i) entirely exporting companies that benefit from a special regime for encouraging off-shore regime into a free zone, (ii) partially exporting companies that benefit from a customs regime that suspends duties and taxes, and (iii) companies making products for the local market and benefiting from the import regime for capital goods, semi-finished products, and raw materials.

Taking advantage of a skilled workforce and a wealth of human resources, the country has diversified its export base by focusing on sectors with high added value and a strong know-how component, such as the mechanical and electrical industries, aerospace, services, and packaged olive oil. To avoid concentrating too much trade with the European Union (EU), the country has diversified its trading partners to Nordic countries, the Arab Free Trade Area, and Africa.

Over the 1985–2020 period, international trade in Tunisian goods and services grew at an average annual rate of 8.97% and 10.64%, respectively. However, since 2011 (the year of the Tunisian revolution), the growth in goods trade has slowed down (8.12%), while the trade in services has experienced much lower average annual growth (4.88%). Therefore, over the long term, developing maritime infrastructure has made the flow of goods and services more fluid and generated ripple effects for Tunisia's international trade (see Fig. 1).

From a theoretical viewpoint, growth in exports implies a corresponding increase in domestic production (GDP). Moreover, although any growth in imports involves the use of foreign currency, it can also positively influence GDP through the tariffs collected on imports. Tunisian service exports, however, greatly exceed their imports, so they generate fairly significant added value (see Figs. 2 and 3).

Promoting international trade in Tunisia has in turn generated additional demand for banking services, since payments for shipping operations go through commercial banks. The insurance sector has also benefited from this situation, because all international shipments require insurance. Finally, the demand for road and rail transport has

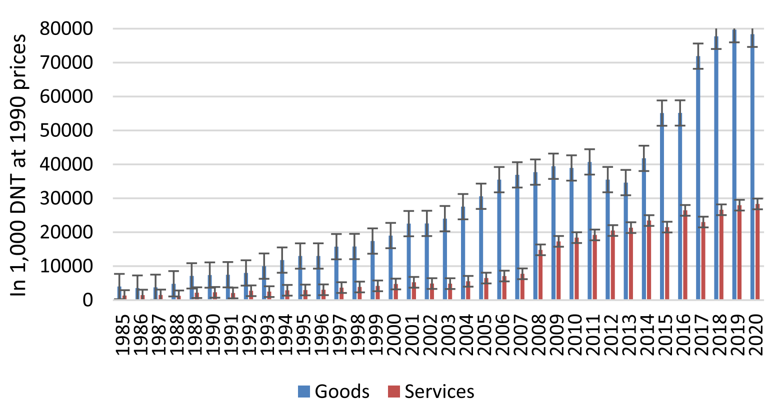

Fig. 1 Evolution of Tunisia's international trade in goods and services (in 1000 DNT at 1990 prices). *Source* Compiled by the author from data collected from several issues of the Statistical Yearbook of Tunisia (NIS 2020)

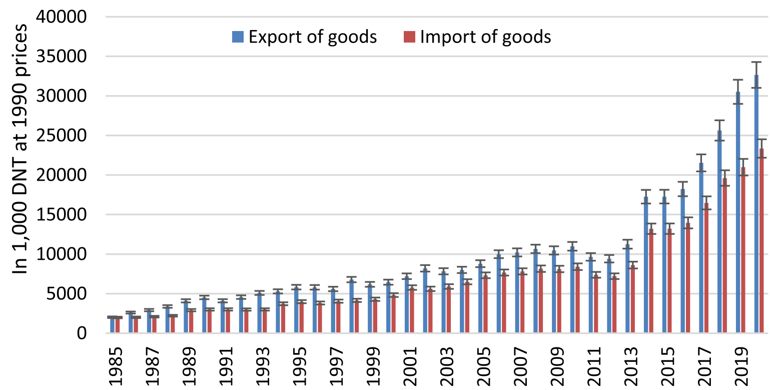

Fig. 2 Evolution of Tunisia's export and import of goods (in 1000 DNT at 1990 prices). *Source* Compiled by the author from data collected from several issues of the Statistical Yearbook of Tunisia (NIS 2020)

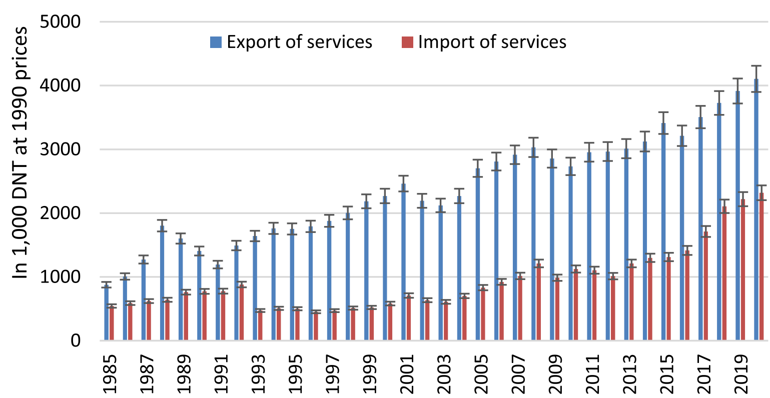

Fig. 3 Evolution of Tunisia's export and import of services at 1990 prices. *Source* Compiled by the author from data collected from several issues of the Statistical Yearbook of Tunisia (NIS 2020)

also grown, because these two modes of transport are most used for the pre-routing and post-routing of goods (Harizi 2008).

Exports and imports by customs regime and branch of economic activity

Through its ripple effects, maritime infrastructure has greatly increased the weight of market services in the economy. Figure 4 shows how the value added for market services grew proportionally more than it did for other economic activities. The ripple effects exerted by developing maritime infrastructure have therefore greatly strengthened the position of market services in the Tunisian economy.

Over the 1985–2020 period, several policy measures taken by the country and the development of maritime infrastructure have strengthened imports more exports. In other words, they have reinforced the comparative advantages of competing countries. Thus, contrary to what the Tunisian Government expected, developing maritime infrastructure and opening up the country to the rest of the world has actually hindered the development of manufacturing industries. In the CGR, imports far exceeded exports, with the balance of trade being continuously negative with an average growth rate of 9.43%, and this dip is accentuated more over time. In the OCR, in contrast, exports

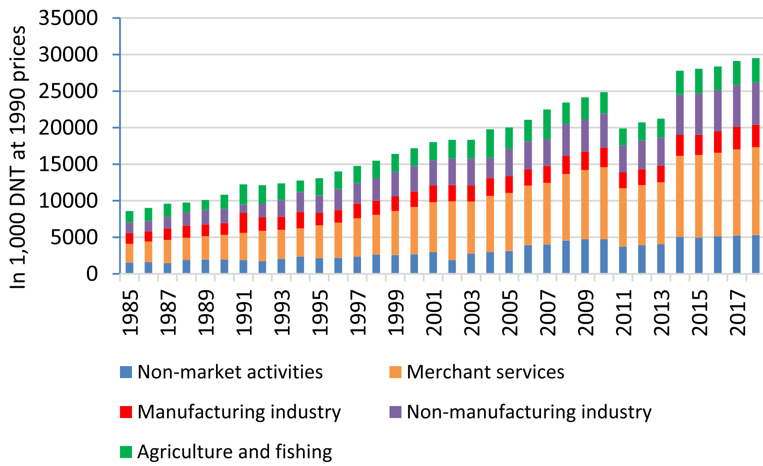

Fig. 4 GDP at factor cost by economic activity branch at 1990 prices. *Source* Compiled by the author from data collected from several issues of the Statistical Yearbook of Tunisia (NIS 2020)

Fig. 5 Balance of manufacturing industry products by customs regime at 1990 prices. *Source* Compiled by the author from data collected from several issues of the Statistical Yearbook of Tunisia (NIS 2020)

greatly exceeded imports, and the balance of trade has grown at an average annual rate of 16.34%. Thus, there is a trade deficit under the general regime and a surplus under the OCR regime (see Fig. 5).

In the GCR, the dominance of imports over exports implies a tendency to consume foreign products. This trend is a result of opening up the Tunisian economy to the rest of the world and improving the conditions for maritime transport and shipping. These two factors have allowed foreign products to be marketed inside Tunisia, where they compete with domestic products. Thus, in combination with other economic policy factors, maritime infrastructure has favoured foreign products by reinforcing their comparative advantages. For the GCR, this implies that maritime infrastructure has not strengthened Tunisian exports in a meaningful way.

Figure 6 shows how the trade in manufactured products fell sharply behind other products, and it gives a clear idea of the balance of trade in the GCR by product and the balance of trade for these products.

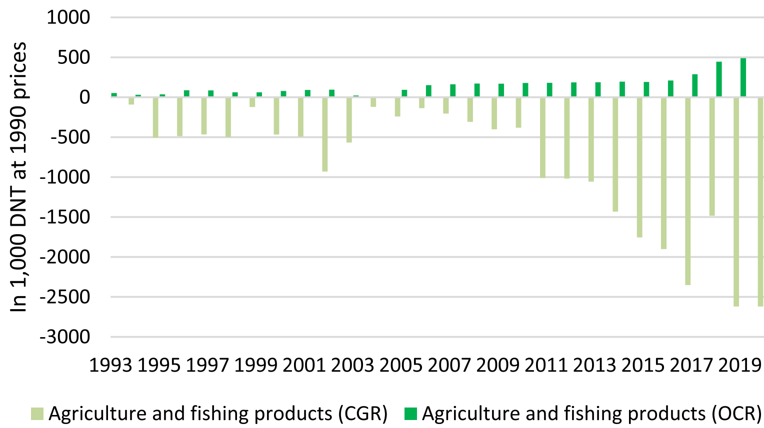

Fig. 6 Balance of trade by product and customs regime. *Source* Compiled by the author from data collected from several issues of the Statistical Yearbook of Tunisia (NIS 2020)

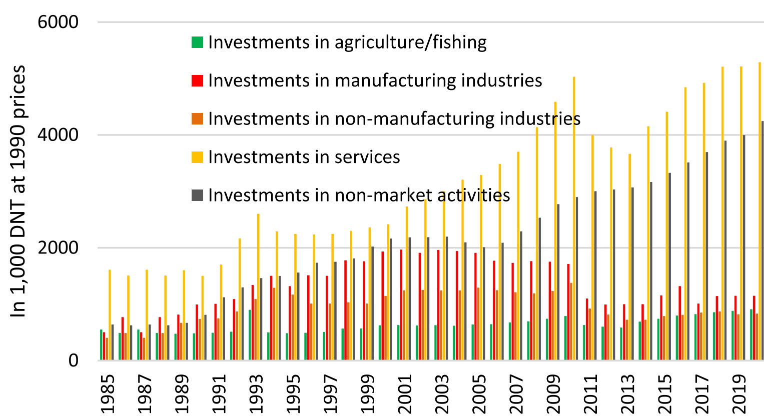

Fig. 7 Evolution of cumulative gross fixed capital formation by economic activity at 1990 prices. *Source* Compiled by the author from data collected from several issues of the Statistical Yearbook of Tunisia (NIS 2020)

Finally, the negative trade balance for manufactured products in the GCR proves that Tunisian manufacturing industries have been unable to overcome the challenge of foreign competition. The positive trade balance for manufactured products in the OCR indicates a lack of production and an inability by production units to perform all industrial tasks. Agriculture also shows a negative trade balance for exchanges in the GCR.

Investments, capital accumulation, and labour force by branch of economic activity

Investments in activities represent the annual fixed capital of those activities (or GFCF), and public authorities account for them annually as acquisitions less the disposals of fixed assets (tangible or intangible assets) carried out by domestic producers.

In Tunisia, investments in non-market activities, manufacturing industries, and market services increased at an average annual rate of 5.82%, 3.89%, and 3.83%, respectively. Conversely, investments in non-manufacturing industries and agriculture/fishing experienced lower than average annual growth rates of 2.93% and 2.64%, respectively (see Fig. 7). During the 2011–2014 period, investment in all economic activities declined due to the unfavourable environment for investment during the first years of the Tunisian revolution, before there was a gradual revival.

Low investment indicates that limited capital is being allocated to economic activities, while the availability of foreign products at relatively low prices on the Tunisian market has limited opportunities for Tunisian production and international competition.

Compared to other economic activities, a strong focus on investing in market services and manufacturing industries has led to a restructuring of economic activity and employment. Thus, the demand for employment is growing at a very slow pace in all economic branches other than services and manufacturing industries, which recorded an average annual increase of 3.12% and 3.01%, respectively (see Fig. 8). The stagnation in investment in non-manufacturing industries and in agriculture and fisheries has also worked in favour of a restructuring in sectoral employment, with the long-term trend moving toward greater employment in market services and manufacturing industries.

Main analysis

We performed two panel data regressions with cross-section weights. These regressions were represented through the panel EGLS method and executed on EViews 5.0. The first estimate made it possible to identify the overall effect of maritime capital stock on national production, while the second one made it possible to identify the specific effects of maritime capital stock on the production within each branch of economic activity. Tables 1 and 2 give the results of these two estimates, respectively.

The results of the first estimation show that the model is globally significant ($R^2 = .93$) and that its regression coefficients are individually significant at the 1% and 5% levels for everything except for the *SPC*. Indeed, *PK*, *PKOSPC*, and *LF* have a statistically significant influence on GDP, with their coefficients being positive at 0.4.3, 0.262, and 0.191, respectively, and statistically significant at the 5% significance level. This does not necessarily imply the presence of multicollinearity between the factors of production. In addition, the t-statistics obtained were sufficiently high, so these results can be deemed econometrically satisfactory, especially since the model is globally and individually significant at the 5% level.

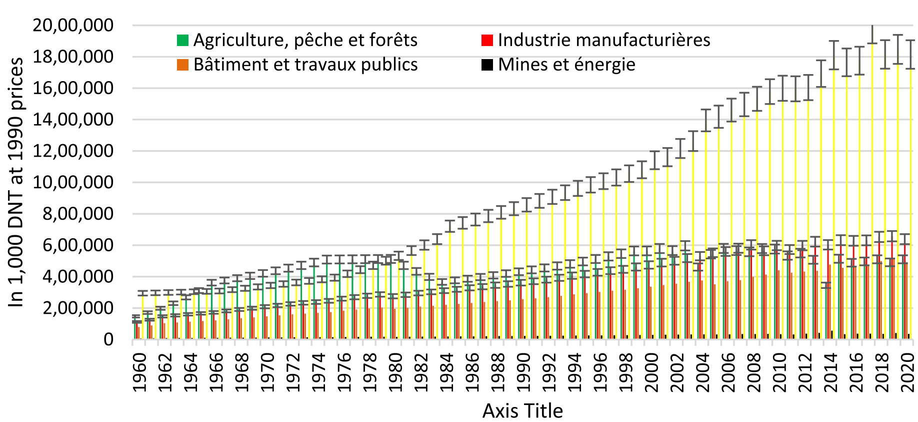

Fig. 8 Evolution of jobs by economic activity. *Source* Compiled by the author from data collected from several issues of the Statistical Yearbook of Tunisia (NIS 2020)

Table 1 Results of the global estimation of Eq. 3 on panel data

Heading level dependent variable: LOG(GDP)
Method: Pooled EGLS (Cross-section weights)
Date: 03/22/21 Time: 10:06
Sample: 1985 2020
Included observations: 36
Cross-sections included: 5
Total pool (balanced) observations: 180
Linear estimation after one-step weighting matrix

	Coefficient	**Std. error**	**t-Statistic**	**t-Statistic**
C	1.906821	0.251234	7.614041	0.0000
LOG (PK)	0.403541	0.031024	13.75223	0.0000
LOG (LF)	0.191332	0.015982	11.51411	0.0000
LOG (SPC)	0.001154	0.024254	0.041323	0.9230
LOG (PKOSPC)	0.262321	0.038231	6.934121	0.0000
Weighted statistics				
R-squared	0.932541	Mean dependent var	10.39214	
Adjusted R-squared	0.929943	S.D. dependent var	4.297927	
Unweighted statistics				
R-squared	0.761123	Mean dependent var	7.777685	
Sum squared resid	4.185413	Durbin–Watson stat	0.177533	

Only the *SPC* was insignificant, (p-value = 0.923) suggesting that it has no overall effect on economic growth, which seems to depend more on the other factors of production. This result is unexpected, because we expected a significant link between the development of maritime infrastructure and the growth in national production.

The second estimate shows that the development of maritime infrastructure has positively stimulated non-manufacturing industries (0.081) and market services (0.073). These results are statistically significant at the 5% level. This situation is logical and expected, since these two activities are highly dependent on maritime infrastructure. In contrast, non-market activities were negatively influenced (-0.044) at the 5% threshold by maritime infrastructure, thus proving the existence of harmful effects that contribute to lowering the added value of non-market activities (Table 2).

Furthermore, the parameters for agriculture (p-value = 0.207) and manufacturing industries (p-value = 0.636) were not significant. The latter result is unexpected, because we expected maritime infrastructure to increase the potential of manufacturing industries by promoting exports. However, there has been increased investment in manufacturing industries due to attracting foreign direct investment. Thus, the added value of these activities has not been directly influenced by the development of maritime infrastructure. Overall, the results of Table 2 are convincing.

Several official reports report the contribution of various Tunisian economic sectors (i.e., branches and sub-branches of activity) to economic growth (World Bank [WB] 2010; African Development Bank [ADB] 2013; BCT 2021). For example, non-manufacturing industries contributed − 12.2% in 1987, 8.2% in 1997, and 6.2% in 2006, while services contributed 12.8%, 43.1%, and 64.1% in the same years, respectively. By calculating the average contributions over the 1985–2020 period and using the results of the second

Table 2 Results of the specific estimation of Eq. 3 on panel data

Dependent variable: LOG(GDP)
Method: Pooled EGLS (Cross-section weights)
Date: 03/22/21 Time: 12:25
Sample: 1985 2020
Included observations: 36
Cross-sections included: 5
Total pool (balanced) observations: 180
Linear estimation after one-step weighting matrix

	Coefficient	**Std. error**	**t-Statistic**	**Prob**
C	2.512251	0.313452	7.653415	0.0000
LOG (PK)	0.182213	0.071872	2.441237	0.0228
LOG (LF)	0.287921	0.059111	4.903352	0.0000
LOG (PKOSPC)	0.304763	0.053514	5.296236	0.0000
_AG—LOG (SPC_AG)	− 0.036771	0.021365	− 1.263456	0.2073
_IM—LOG (SPC_MI)	0.009214	0.023581	0.465534	0.6368
_INM—LOG (SPC_NMI)	0.081213	0.036514	2.132214	0.0326
_S—LOG (SPC_MS)	0.073021	0.029561	2.561237	0.0124
_ANM—LOG (SPC_NMA)	− 0.044523	0.020239	− 2.032518	0.0440
Weighted statistics				
R-squared	0.901345	Mean dependent var		8.061237
Adjusted R-squared	0.892319	S.D. dependent var		1.178823
S.E. of regression	0.106612	Sum squared resid		1.066423
F-statistic	1432.640	Durbin–Watson stat		0.740021
Prob (F-statistic)	0.000000			
Unweighted statistics				
R-squared	0.944172	Mean dependent var	7.776123	
Sum squared resid	1.072447	Durbin–Watson stat	0.669871	

regression, we can draw up the causalities that reflect the effects of developing maritime infrastructure on Tunisian long-term economic growth (see Fig. 1).

Discussion

Key findings

The results of the two estimates complement each other due to the absence of a significant link between maritime infrastructure and overall economic growth. This likely results from a perfect trade-off occurring between the positive and negative effects of maritime infrastructure. In other words, developing maritime infrastructure generated two kinds of effects with different natures, namely direct ripple effects and induced structuring effects. The structuring effects manifest first, and then the ripple effects appear later once the dynamics of the structuring effects become established.

Theoretical implications

The results of this study have several theoretical implications. First, with regard to several previous studies, the results prove that the development of maritime infrastructure is one of the main ways to promote international trade and the trade in services (Panayides and Cullinane 2002; UNCTAD/RMT 2013; Grushevska and Notteboom 2016).

Second, in Tunisia, the development of maritime infrastructure over the 1985–2020 period had training effects on international trade, and these manifested by rapidly increasing international trade in Tunisian goods and services, with Tunisian imports and exports having evolved proportionally. While a growth in exports implies an increase in GDP, the growth in imports can also influence it through tariffs on imports. Historically speaking, service exports have largely exceeded their imports, and any development of these exports generates significant added value for the sector.

Third, the growth in international trade has in turn boosted the banking sector through payments for shipping operations, the auxiliaries of port operations, and the need for insurance for freight transport. Demand for other modes of transport has also grown, especially road and rail, which remain the main options for the pre-routing and post-routing of goods (Harizi 2008). Through these ripple effects, maritime infrastructure has therefore increase the weights of the market services and non-manufacturing industries branches of the economy. This builds upon the contributions of Delaplace (2014) and Offner (2014).

Fourth, maritime infrastructure has had structuring effects on the Tunisian economy. Indeed, the development of maritime infrastructure and opening the country's economy to the rest of the world have greatly limited the development of manufacturing industries. The development of maritime infrastructure was expected to strengthen exports, but in contrast, it strengthened imports instead by amplifying the comparative advantages of competing countries.

Fifth, the significant contribution of maritime infrastructure to the development of market services—to the detriment of other activities, especially manufacturing industries—provides insight into the nature of the role played by maritime infrastructure. Indeed, it plays a traditional role that does not meet the aspirations of economic policies (e.g., greater exports, job creation, more foreign direct investment). The weakness in the export of manufactured products demonstrates the inability of this sector to compete internationally. Moreover, the large share of offshore exports and the marginal share of offshore imports prove that developing maritime infrastructure has been ineffective in attracting foreign direct investment to manufacturing industries. The shrinking weight of these industries and agriculture is reflected in a drop in the number of jobs associated with these economic activities.

Practical implications

For maritime infrastructure to contribute to growing national production, it must contribute to promoting activities that have previously been weakened by it, especially the manufacturing industries. Maritime infrastructure must therefore generate positive effects for investment in industry, agriculture, and fishing to promote exports in these sectors. Economic governance measures are therefore needed to set suitable targets and find ways to achieve them.

The role of the maritime supply chain should not be limited to simply ensuring the transit of goods—it should also extend to attracting foreign direct investment and enabling efficient logistics platforms. Therefore, public authorities must act to improve the productivity of the maritime chain and its participation in the international freight transport chain. Any upgrades to port infrastructure must try to fit with a hub-and-spoke model. Given that the opportunities for expanding Tunisia's current commercial maritime ports are limited, it has become necessary to establish a new commercial maritime hub port capable of handling massive volumes of products that meet the needs of international users. Moreover, over 15 years ago, researchers discovered an ancient Roman deep-water port in the Enfidha area, and restoring this port would allow the country to receive larger cargo ships.

The country must also develop a national fleet of vessels to transport goods, thus reducing the dependence on foreign fleets. It must also implement modern logistics equipment to manage the ships serving Tunisian ports, such as by accelerating container management, streamlining customs control, coordinating with land transport vehicles, and optimizing the multimodal transport networks serving Tunisian ports. The country must also invest in human capital for transport and logistics to make the maritime sector run efficiently, such as by developing forwarding agents, customs brokers, freight forwarders, ship agents, cargo agents, and so on.

Conclusion

Our econometric analysis of the effects of maritime infrastructure on growth in Tunisia shows that it has thus far had no overall effect on enhancing economic growth. However, it has had significant training effects on economic activities that are very sensitive to maritime transport, particularly market services and non-manufacturing industries. The development of marine infrastructure has, however, contributed to a decline in the weight of manufacturing industries and agriculture through negative induced effects, thus cancelling out the benefits of developing maritime infrastructure over the 1985–2020 period.

The current Tunisian maritime sector is still traditional in nature, with its role not extending beyond the mere provision of maritime transport services. It has not evolved significantly enough to become a factor in attracting foreign direct investment or transformed into an efficient platform that will appeal to major shipping companies and multinational firms. It will be also useful to develop maritime infrastructure in a way that will strengthen the country's manufacturing industries, because this is essential for ensuring there will be a positive overall effect on Tunisian economic growth.

Abbreviations

A	Technological coefficient
ADB	African Development Bank
AG	Agriculture and fishing
AV_{SPA_t}	Added value of seaports activities
CBT	Central Bank of Tunisia
EU	European Union
GDP	Gross domestic product
GCR	General customs regime
G	Gross fixed capital formation
i	Branche of economic activity
I_{SPC_t}	Seaport infrastructure investment for year t
K_t	Kapital or Other tools and equipment used in production processes
LF	Labour factor
MI	Manufacturing industries
MS	Market services
NMA	Non-market activities
NMI	Non-manufacturing industries
NIS	National Institute of Statistics
OCR	Offshore customs regime

OECD	The Organization for Economic Cooperation and Development
OGRT	Official Gazette of the Republic of Tunisia
PK	Physical capital
PKOSPC	Physical capital off seaport capital
SPC	Seaport capital stock
WB	World Bank
Y	National production
δ_t	The rate of depreciation of seaport infrastructure

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