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Seaport logistics providers' effect on trade

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Background: This study investigates the role of logistics clusters, specifically logistics providers (LP), on international trade, focusing on Rades Port in Tunisia. We aim to assess how the co-location of logistic service providers (LSPs) affects port connectivity and trade flows, and how the competence and productivity of logistics services contribute to export performance.

Objectives: The research analyses the effect of logistics clusters, particularly the co-located seaport logistics providers, on trade dynamics, focusing on exports from Rades port to its eight main importers.

Method: The gravity model incorporates variables such as importer gross domestic product (GDP), distance, and measures of capital productivity of LSPs, both those co-located within LP and those operating outside.

Results: The results confirm a positive correlation between the GDP of importing countries and trade volumes, highlighting the role of economic size in driving exports. Interestingly, the capital productivity of LSPs co-located within the LP is found to negatively impact trade, suggesting potential inefficiencies or overconcentration. In contrast, a 10% increase in the capital productivity of LSPs located outside the platform corresponds to a 14% increase in trade. Additionally, a 10% reduction in geographical distance between countries leads to a 16% increase in exports, reinforcing traditional gravity model expectations.

Conclusion: The findings have important implications for logistics and port policy. Policymakers should reconsider how logistics clusters are managed and supported, as simple co-location may not guarantee improved performance. Enhancing service quality and ensuring competitive dynamics within LPs may be more critical for trade facilitation.

Contribution: The study offers novel insights into how logistics infrastructure and organisational factors influence trade from a major North African port.

Keywords: port; logistics providers; trade; localisation economies; gravity model; cluster.

Introduction

Gani (2017) mentions that trade volume increases more significantly than the ratio of improvements in logistics infrastructure and services:

> The development of logistics and transportation, particularly infrastructure improvements, enables more reliable product distribution and promotes international trade flows, given that international trade depends largely on logistics and transportation services providers. (Hamri & Mraihi 2026:362)

Authorities and authors emphasise the importance of infrastructure investments in the logistics sector, given their contribution to economic growth (Jumah et al. 2024) through their impact on production, consumption, and international trade. Similarly, Carruthers, Bajpai and Hummels (2003) highlighted the role of transportation and logistics infrastructure investments in promoting trade in Hong Kong and Singapore. Chinese exports have increased significantly thanks to changes in its logistics network (Wang, Kim & Kim 2021).

'The work on the relationship between logistics clusters and trade is mainly focused on two main areas, namely LPI, infrastructure (mainly ports), and transport costs' (Hamri & Mraihi 2026). Indeed, port logistics clusters have an important effect on port cities in China (Wang & Ma 2019) and for Asian countries (Gani 2017). Few works in the literature emphasise the impact of logistics service providers' (LSP) concentrations on trade. We work on LSPs' productivity to understand the impact of this concentration on trade. Empirical analysis of manufacturing firms has shown that regional advantages arising from the concentration of firms within the same industrial group, a Marshall–Arrow–Romer (MAR) externality, contribute to productivity gains and strong employment growth at the firm level.

Indeed, Marshallian agglomeration economics theory was important in China, South Korea, Egypt … because technological proximity reduced the cost of moving people, ideas, and goods (Badr, Rizk & Zaki 2019; Choi & Choi 2017; Howell 2017). The production function includes only space and labour as factors of production (Ciccone & Hall 1996). Therefore, we focus our study on capital and labour productivity of two samples: the first one comprised the LSPs collocated on Rades logistics seaport platform, the second comprised LSPs located at different industrial areas. The objective is to understand the impact of this concentration on Tunisian trade. Given that LSPs are clustered at the Rades platform, very close to the port of Rades, can we consider this co-location a determining factor in Tunisian exports? The World Bank considers the competence and quality of services in the private logistics sector to be a weak link in Tunisia's logistics performance; to what extent can this explain these exchanges?

Logistics performance and trade

The logistics performance index

Logistics policies and procedures must consider their impact on trade competitiveness. This topic has recently become easier to study thanks to the introduction of the logistics performance index (LPI) in 2007, which provided valuable information on logistics performance across countries. This index allows comparisons and identification of areas where poor logistics performance can limit economic growth. Most studies used gravity models. Indeed, studies confirm that the effect of logistics on trade in developing countries is greater than in developed countries (Gani 2017; Martí, Puertas & García 2014; Turkson 2011). Also, Çelebi (2017) shows that for low-income and middle-income economies, logistics performance has a greater impact on exports than on imports (a 10% increase in the LPI of an exporting country with a middle to high income increases exports by 41%). Conversely, imports from middle- and high-income countries tend to benefit from better logistics performance than their exports (a 10% increase in LPI increases imports by 59%). Hausmann, Lee and Subramanian (2005) include the effect of transport time on cost. They:

> [*E*]stimate the implicit value of time saved in shipping time. He admits that each additional day in shipping time reduces the probability of trade by 1% (for all goods) and 1.5% (for manufactured goods). (Hausmann et al. 2005:5)

Behar and Manners (2008) found that an improvement in the quality of logistics for the exporter, for example, for Gabon at the level of Guinea, would increase exports by nearly 59%. Exports from landlocked countries depend on the logistics of their neighbours. The authors also found that logistics helps to reduce the effects of distance on trade, but without eliminating them. Zheng, Zhang and Liu (2016) confirm, for a study made on APEC countries for the period between 2004 and 2015, that a 10% increase in the exporter's LPI increases bilateral trade by 14.7% between the countries, while a 10% increase in the importer's LPI increases bilateral trade by 17.4%. However, other studies show the opposite, such as Nguyen and the inability of the Australian transport and logistics sector to stimulate trade growth (with China, the United States, and Japan) (Nguyen & Tongzon 2010). Also, Zaninović, Zaninović and Pavlić Skender (2021) show that differences in LPI sub-index scores between trading partners negatively affect trade; this effect varies across classes of goods.

Cluster and agglomeration

Cluster theory, initiated by Alfred Marshall with his 'industrial districts' (1890) and popularised by Michael Porter (1990), explains how the geographical concentration of companies linked by similar activities creates agglomeration economies (sharing of know-how, specialised labour, suppliers) generating competitiveness and innovation through a network of private and public actors, benefiting both the region and individual companies. Indeed, intra-sectoral externalities (Marshall 1980) are differentiated by a field of similar activities such as concentrations of providers. Arrow (1962) and Romer (1986) highlighted the importance of this type of externality, particularly in specialisation, that is, suppliers in the same field sharing knowledge and engaging in specialised employment. The competition arising from this co-location can also be the origin of these externalities (Porter 1990). Marshall (1920) established hypotheses for the development of industrial complexes. He demonstrated the existence of positive externalities from co-location. These externalities originate from three forces: shared knowledge and spillover between co-located firms, the development of an efficient and specialised supplier base, and the development of local hubs of specialised labour. Then, in 1999, Walter Isard developed models of industrial clusters and proposed methods for analysing them to understand their contribution to regional growth and development. Furthermore, the spatial concentration of logistics activities remains largely ignored in the academic literature, but examples of logistics providers (LPs) (Zaragoza, Guangzhou), port zones (Singapore, Rotterdam), and intermodal hubs (Chicago, Memphis) clearly attract logistics companies to concentrate there. The authors suggest that this spatial concentration is highly relevant.

Logistics infrastructure and trade

Bensassi et al. (2015) estimate bilateral trade between 19 Spanish regions and 64 Spanish regions. The authors highlight the disposition of logistics infrastructure between different Spanish regions and their economic and geographic prospects. Limão and Venables (2001) focus on the impact of a country's infrastructure and transport costs on bilateral trade. They developed an index that estimates the level of infrastructure in each country based on four indicators: the number of km of roads, paved roads and railways, and the number of telephone lines. The authors also obtained primary data on transport costs, including freight costs. Estimates using bilateral trade data confirm the importance of infrastructure. In particular:

> [*A*] 12% increase in transport costs reduces trade by 28%. The estimated elasticity of trade flows with respect to transport is approximately 3. Results from the specific analysis of trade flows in Africa indicate that the low level of trade is due to a lack of appropriate infrastructure. (Bensassi et al. 2015:49)

In summary, most empirical studies use the gravity model to analyse this relationship. Then, the structure of the (panel) data is compatible with the gravity model. Thus, we proceed to a modelling based on this model.

Research methods and design

Empirical analysis

Gravity model

Head and Mayer (2014) outlined the various theoretical foundations of the gravity model. The authors defined gravity equations as a model of bilateral interactions in which size and distance effects enter multiplicatively. In the last decade, trade theorists have focused on the fact that gravity equations emerge from the main modelling frameworks in economics and should no longer be considered to derive from an analogy with Newtonian physics. Meanwhile, empirical studies established a series of stylised facts about the determinants of bilateral trade. Thanks to recent modelling, we now know that gravity estimates can be combined with trade policy experiments to calculate implied welfare changes.

Data and variables

Head and Mayer (2014) noted that the gravity equation and trade are closely related in terms of specification, and that there are different definitions (equations) of this model. We have opted for this definition (Equation 1). Firstly, because it fits the research objective, and secondly, because it has two main points: the most evident is that every element is multiplicative, and this equation involves that the country effects be mediated through elements *i* and *j* (Equation 1):

$$X_{ij} = GS_i M_j B_{ij} \quad \text{[Eqn 1]}$$

Where:

- S_i: refers to the attitude of exporter *i* as a supplier to all destinations.
- M_j: refers to features of the importer market that favour imports from all sources (*i*). The bilateral accessibility of *j* to exporter *i* is taken into account in B_{ij};
- *G*: gravitational constant.

Equation 1 is not linear. Indeed, most gravity model estimates are based on a linear transformation of Equation 1. The linear version is given by the following expression (Equation 2):

$$\ln X_{ij} = \ln G + \beta \ln S_i + \gamma \ln M_j + \sum \delta_k B_{ij} + \varepsilon_{ij} \quad \text{[Eqn 2]}$$

Where:

- *X: variable to explain*
- *G, S, M et B: explanatory variable*
- *β: coeficient of elasticity*
- *ε : error term*

Ln is the natural logarithm, $\sum \delta_k B_{ij}$ represents the variables that facilitate bilateral trade between countries (typically binary).

The study includes variables that affect logistics; we focus on their impact on exports. These variables are the LPI of the exporter and importers, particularly the skills and quality of logistics services; the capital and labour productivity of LSPs collocated on the platform; the capital and labour productivity of LSPs outside the platform; and the road density. The relationship between the location on an LP and the productivity level of logistics facilities requires comparing productivity levels between the two previously mentioned subsamples. We propose, on the one hand, to measure the productive efficiency of labour by dividing the annual turnover by the number of employees, and, on the other hand, the productive efficiency of capital by the ratio of the annual turnover to the area of logistics facilities. We can also note that the LSPs are informed in different years; 2024 is the most informed. Firms communicated their precise turnover while others preferred to keep it as a professional secret, therefore, we worked on a direct survey to bring the turnover to reality indicating the interval at which the turnover is located and using the traffic handled in tones by the firm to determine the turnover, also the number of employees and the areas of logistics facilities (m²) Eventually, we have gathered data for 56 LSPs spread over two subsamples:

- The first subsample includes LSPs co-located in the logistics centre of Rades (LC). It represents 75% of the LSPs in our sample (42 LSPs). We also note that the majority of LSPs are type 1 PL (40%).
- While the second subsample includes LSPs which are far from the LC of Rades. It represents only 25% of the LSPs in our sample (14 LSPs) spread over the state of Ben Arous, mainly in industrial zones (Sidi Rzig, Borj Cedria, Meghira, Bir Kasaa …).

As shown in Equation 3:

$$\begin{aligned} ln\, X_{ijt} = {} & \alpha_0 + \beta_1\, ln\, Y_{ijt} + \beta_2\, ln\, D_{ij} + \beta_3\, ln\, LPI_{it} + \beta_4\, ln\, LPI_{jt} \\ & + \beta_5\, ln\, PdC_{it} + \beta_6\, ln\, PdT_{it} + \beta_7\, ln\, ConcRt_{it} + \beta_8\, ln\, PdCH_{it} \\ & + \beta_9\, ln\, PdTH_{it} + \beta_{10}\, Acclibr_j + \beta_{11}\, Fr_i + \beta_{12}\, lang_j \\ & + \delta_{ij} + \varepsilon_{ij} \end{aligned} \quad \text{[Eqn 3]}$$

Where:

- $i = 1 \rightarrow N$
- $j = 1 \rightarrow J$
- $t = 1 \rightarrow T$

N is equal to 1 since we consider Tunisia as the only exporting country, specifically exports from the port of Rades (X_{ijt}) to destination country *j* during year *t*.

J equals 8, since we consider Tunisia's top eight importing countries: Algeria, Germany, Belgium, Spain, France, Italy, Libya, and Morocco. The eight importers account for 80% of Tunisian exports.

T, we considered the period between 2011 and 2017 since we have data for this period (Jean-Francois et al. 2018).

In this sense, X_{ijt} denotes exports from the port of Rades to the destination country (importer *j* in year *t*).

Y_{ijt} is the product of the gross domestic product (GDP) of exporter *i* and importer *j* for year *t*. Indeed, GDP_p is included in the gravity model as a control variable. On the importer side, it indicates that the economic environment favours investment, production, and trade. On the exporter side, the GDP_ tun variable is included because exporters are likely to react positively to the economic growth of their trading partners and, therefore, respond to expected increases in demand for goods and services by increasing their exports. Growth in the trading partner may also reflect higher income.

D_{ij} indicates the distance between Tunisia and the destination countries. Distance has traditionally been included in the gravity model. Generally, it measures transport costs (Gani 2017; Hausmann, Lee & Subramanian 2013; Puertas, Martí & García 2014).

LPI_{it} is an index that measures the performance of logistics in Tunisia. We have chosen to focus on the dimension of competence and quality of logistics services. On the one hand, this dimension, in the Tunisian case, follows the same variation as the global LPI over the period studied (Figure 1). This index reflects the contribution of the private logistics sector (Çelebi 2017; Puertas et al. 2014). Figure 1 shows that the competence and quality of logistics services represent the lowest dimension during the period studied.

On the other hand, LPI_{jt} measures the logistics performance of importing countries using the World Bank's LPI, specifically the level of competence and quality of logistics services. We added labour productivity: PdT_{it} of capital (for LSPs located in the platform) in order to better understand the effect of the productive efficiency of these LSPs on exports (the impact of this geographical concentration of LSPs [platform] on the activity of the Port of Rades, as we only considered exports from the Port of Rades).

$PdCH_{it}$ and $PdTH_{it}$ are, respectively, the capital and labour productivity of LSPs located outside the platform located in the governorate of Ben Arous.

$ConcRt_{it}$ is a road infrastructure density index, which measures the level of development of road infrastructure expressed in km of road in the region studied, and are dummy variables that take the value 1 respectively if there are free trade agreements between Tunisia and the importing country, if they share the same language, and if they share the same border.

We start by doing a descriptive analysis of our data, which relates to the explanatory and endogenous factors and is shown in Table 1.

The descriptive analysis of the variables (Table 1) shows that Tunisian exports X_{ijt} vary between a minimum of 228.38 MD (with Morocco in 2011) and a maximum of 7887.53 MD (with France in 2017) during the period 2011–2017. Note that this variable shows an average of 1930.14 MD. For Tunisia's LPI, the statistics (Figure 2) show that the average is 2.49, which remains lower than the average for the other countries in the sample (3.33). This indicator has a minimum of 2.2 (2011) and a maximum of 3.12 (2014). Germany is at the top of the list for the entire period, with a maximum of 4.32 (2011), while Algeria has a minimum throughout the period of 1.92 in 2012.

The labour productivity (PdT) of co-located LSPs on the Rades platform ranges from 0.71 MD to 0.97 MD, while the capital productivity (PdC) ranges from 0.08 MD to 0.099 MD. The labour productivity of LSPs located outside the platform ranges from 0.57 MD to 0.64 MD, while the capital productivity for these firms ranges from 0.0029 MD to 0.005 MD. We also note that the difference in average between PdT and PdTH is not as important if we compare it to that between PdC and PdCH.

Ethical considerations

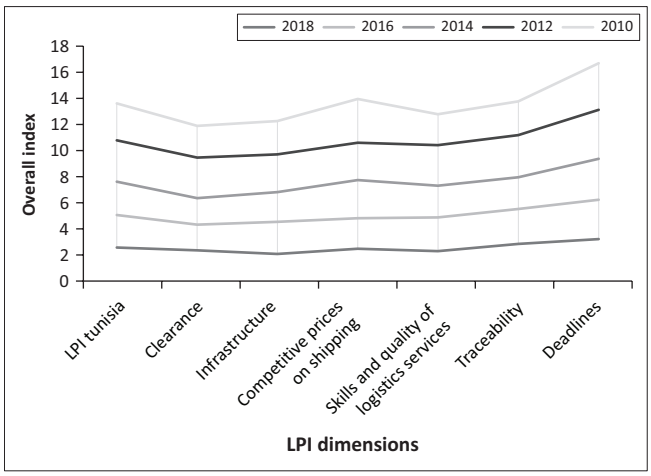
This article followed all ethical standards for research without direct contact with human or animal subjects.

Results

The first regression is performed using the ordinary least squares (OLS) method to assess the quality of our model. This method appears inadequate because we have both temporal and individual dimensions. It is necessary to verify whether there are individual effects or, more precisely, country-specific characteristics. We then perform the Hausman test to determine whether the model is random or fixed:

Hausman specification test

After choosing the specific effects model, a second specification test must be performed to determine whether



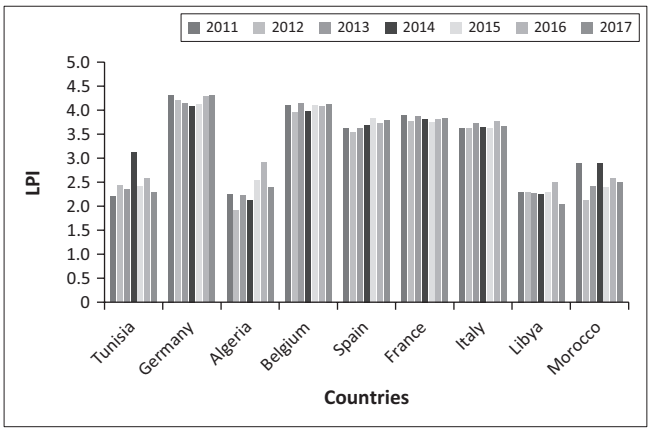
LPI, logistics performance index.

FIGURE 1: Variation of dimensions in relation to the overall index.

TABLE 1: Descriptive analysis of variables.

Variable	Number of observations	Mean	Ecart type	Min	Max
X	56	1930.14	2028.25	228.38	7887.53
GDP_p	56	17 096.24	2.93	2875.26	48 142.95
Lpi	56	3.33	0.77	1.92	4.32
GDP_tun	56	3988.66	1.08	3494.32	4305.47
Lpi_tun	56	2.49	0.28	2.20	3.12
PdT	56	0.86	0.08	0.71	0.97
PdC	56	0.0085	0.0003	0.0080	0.0099
concRt	56	0.46	0.05	0.39	0.51
D	56	1083.63	469.75	508.00	1868.00
pdCH	56	0.0039	0.0007	0.0029	0.0050
pdTH	56	0.61	0.02	0.57	0.64
lang	56	0.25	0.44	0.00	1.00
acclibr	56	1.00	0.00	1.00	1.00
Fr	56	0.25	0.44	0.00	1.00

Min, minimum; Max, maximum; X, exports; GDP_p, GDP of the importers; LPI, logistics performance index for importers; GDP_tun, tunisian GDP; Lpi_tun, logistics performance index for Tunisia; PdT, labour productivity for logistics providers colocated on the logistics platform of Rades seaport; PdC, capital productivity for logistics providers colocated on the logistics platform of Rades seaport; concRt, Road Density; D, straight-line distance (in km) between the city of Radès (Port of Radès) and the cities hosting the main destination ports; pdCH, the capital productivity of LSPs located outside the platform located in the governorate of Ben Arous; pdTH, Labour productivity for logistics providers located outside the logistics platform; lang, language; acclibr, free trade; Fr, shared borders.



LPI, logistics performance index.

FIGURE 2: Comparison of logistics performance index (2011–2017).

the specific effects are random. This primarily involves applying the Hausman test.

It is based on the following assumptions:

$$H_0 : E\left(a_i / X_i\right) = 0$$
$$H_1 : E\left(a_i / X_i\right) \neq 0$$

Under the first hypothesis, we must retain the generalised least squares (GLS) estimator since the model can be specified with random effects. On the contrary, and under the alternative hypothesis, we must retain the estimator for which the model is specified with fixed effects.

The results of the Hausman test, which follows a chi-square distribution with 4 degrees of freedom (Chi-square = 0.9999), show that we accept the hypothesis of no correlation between the random term and the independent variables.

The random-effects model better represents the structure of our sample because it is more suitable than the fixed-effects model, given that the test probability exceeds the 5% threshold. Based on these results, the final model to be estimated will be a random-effects panel.

Correlation test

After choosing the random-effects model, we must verify two essential assumptions: homoscedasticity and correlation. In other words, before validating the model, we should determine whether it satisfies the assumptions of homoscedasticity and the absence of autocorrelation between the residuals.

We proceed with a correlation test, and the results are as shown in Table 2.

Based on the correlation matrices, a high correlation coefficient (close to 1 in absolute value) indicates a strong correlation between the variables used. This primarily refers to the correlation between all the variables in the model. However, a low correlation coefficient (close to 0) indicates a weak correlation between the model's variables. The results show that some variables exhibit a correlation exceeding the 0.7 threshold (Evrard et al. 2003). Multicollinearity occurs when correlations between variables are high. We calculated the variance inflation factor (VIF) values for all variables in our model. The results showed that some variables had VIFs greater than 5 (GDP, GDP tun [tunisian GDP], Road Density (km/100 km²) in the Governorate of Ben Arous [Road Density], language [lang] and shared borders [fr]), indicating significant multicollinearity. To mitigate this multicollinearity, we decided to exclude those redundant variables. Indeed, problems can exist for correlations greater than 0.7 (Evrard et al. 2003; Jolibert & Jourdan 2006). Table 2 shows a multicollinearity problem between GDP of the importers (GDPp) and logistics performance index for importers (LPIp) and Labour productivity for logistics providers colocated on the logistics platform of Rades seaport (PdT); capital productivity for logistics providers colocated on the logistics platform of Rades seaport (PdC) and the capital productivity of LSPs located outside the platform located in the governorate of Ben Arous. (PdCH), Labour productivity for logistics providers located outside the logistics platform (PdTH) and PdCH and PdTH and ConRT.

Then, in order to verify the homoscedasticity hypothesis, we conducted a Breush–Pagan test.

Breush–Pagan heteroscedasticity test

The result of the Breush–Pagan test rejects the hypothesis of the absence of heteroscedasticity at the 5% threshold (Chi-square [1] = 4.87) with $p = 0.0274$). We are then in the presence of a heteroscedastic model; the variance of the errors is not constant. Indeed, the null hypothesis of the Breusch–Pagan test is that the residuals are independent across individuals. It verifies that the sum of the squares of the correlation coefficients between contemporaneous errors is close to zero, since it is only necessary to test those below the diagonal. If the obtained value exceeds the critical value, we reject the null hypothesis that the errors are contemporaneously uncorrelated. To do this, we used the xtgls function, which corrects for both heteroscedasticity and autocorrelation. Finally, we used the panel-corrected standard errors (PCSE) estimator, which provides an accurate estimate of the standard error and also corrects for heteroscedasticity and autocorrelation. The final estimation results are obtained in Table 3. We also present the results of the Hausman RE test. We remind that the equation is estimated for Tunisia's exports to the top eight importers: Algeria, Germany, Belgium, Spain, France, Italy, Libya, and Morocco during the period from 2011 to 2017. Table 3 shows the results of the different estimations of model [Eqn 2]. The first column of this table shows the results obtained by estimating the reference model using a Hausman random-effects (RE) approach, the second column using the PCSE method and the third using feasible generalised least squares (FGLS).

The results show that adjusting for heteroscedasticity and autocorrelation eliminated certain variables whose effects on exports were not determined. We can now note the following findings for the significant variables in the model.

Discussion

According to the results in the second and third columns, the GDP of the importing country is significant and positive. A 10% increase in the GDP of the importing country

TABLE 2: Correlation coefficients.

Variable	lnx	l_GDPtun	l_GDP_p	l_lpi	l_lpitun	l_pdt	l_pdc	l_pdch	l_pdth	l_concrt	lnD	lang	*f*
lnx	1	-	-	-	-	-	-	-	-	-	-	-	-
l_GDPtun	-0.03	1.00	-	-	-	-	-	-	-	-	-	-	-
l_GDP_p	0.59	-0.02	1.00	-	-	-	-	-	-	-	-	-	-
l_lpitun	-0.01	0.49	-0.02	-0.02	1.00	-	-	-	-	-	-	-	-
l_pdt	-0.03	0.85*	0.00	-0.12	0.58	1.00	-	-	-	-	-	-	-
l_pdc	0.01	0.25	-0.04	-0.09	0.28	0.50	1.00	-	-	-	-	-	-
l_pdch	0.04	0.05	-0.10	-0.03	0.13	0.02	0.74*	1.00	-	-	-	-	-
l_pdth	0.01	0.55	-0.09	-0.06	0.43	0.55	0.74*	0.75*	1.00	-	-	-	-
l_concrt	0.04	0.13	-0.10	0.02	0.41	0.01	0.35	0.75*	0.60	1.00	-	-	-
l_lpi	1.00	0.90*	1.00	-0.02	-0.12	-0.09	-0.03	-0.06	0.02	0.46	-	-	-
lnD	-0.22	-0.03	0.34	0.57	-0.02	-0.03	-0.03	-0.03	-0.04	-0.03	1.00	-	-
lang	-0.20	0.06	-0.59	-0.77*	0.04	0.06	0.06	0.05	0.07	0.05	-0.72*	1.00	-
fr	-0.20	0.06	-0.59	-0.77*	0.04	0.06	0.06	0.05	0.07	0.05	-0.72*	1.00	1.00

ln & l_, natural logarithm of exports; l_GDPtun, tunisian GDP; l_GDP_p, GDP of the importers; l_lpi, logistics index; l_lpitun; logistics index for Tunisia; l_pdt, labour productivity for logistics providers colocated on the logistics platform of Rades seaport; l_pdc, capital productivity for logistics providers colocated on the logistics platform of Rades seaport; l_pdch, the capital productivity of LPSs located outside the platform located in the governance Ben Arous; l_pdth, labour productivity for logistics providers located outside the logistics platform; l_concrt, Road Density; lnD, natural logarithm of distance; lang, language; fr, shared borders.

*, The results show that some variables exhibit a correlation exceeding the 0.7 threshold.

TABLE 3: Results of model estimations (2011–2017).

Variables	Hausman RE		PCSE		FGLS	
	Estimated coefficient	*t*-statistic	Estimated coefficient	*t*-statistic	Estimated coefficient	*t*-statistic
l_GDPtun	-1.2513000	-1.32000	0.1283952	1.35	-1.2618400	-0.24
l_GDP_p	0.3782974***	3.15000	0.4701411***	4.98	0.4701411*	1.76
l_lpitun	-0.2669900	-1.18000	-0.3708820***	-6.57	-0.3159000	-0.25
l_pdt	1.9883900	1.61000	0.1709700	0.53	2.1921600	0.31
l_pdc	-4.7899690*	-1.87000	-	-	-5.1669000	-0.36
l_pdch	1.4097830***	2.80000	0.3473070**	2.28	1.5424600	0.54
l_pdth	-1.9838500	-1.40000	-0.8287600	-0.95	-2.0857700	-0.26
l_concrt	-	-	0.6513100	4.02	-	-
l_lpi	-	-	1.0013660*	1.88	-	-
lnD	-1.6503200	-1.12000	-1.6187000	-28.24	-1.6186900***	-4.92
lang	-0.7824300	-0.53000	-0.5326600	-5.06	-0.5326600	-1.30
fr	-	-	-	-	-	-
acclibr	-	-	-	-	-	-
constante	-	-	13.915630	26.13	6.6130500	0.26

Note: No stars or significance, not statistically significant ($p > = 0.05$) – cannot reject the null hypothesis, the effect might be due to chance; *, statistically significant ($p < 0.05$) – confident, less than 5% probability of error; **, highly significant ($p < 0.01$) – high confidence, less than 1% probability of error and ***, highly significant ($p < 0.001$) – very high confidence, less than 0.1% probability of error.

RE, random-effects; PCSE, panel corrected standard errors; FGLS, feasible generalised least squares; l_GDPtun, tunisian GDP; l_GDP_p, GDP of the importers; l_lpi, logistics index; l_lpitun; logistics index for Tunisia; l_pdt, labour productivity for logistics providers colocated on the logistics platform of Rades seaport; l_pdc, capital productivity for logistics providers colocated on the logistics platform of Rades seaport; l_pdch, the capital productivity of LPSs located outside the platform located in the governance Ben Arous; l_pdth, labour productivity for logistics providers located outside the logistics platform; l_concrt, Road Density; lnD, natural logarithm of distance; lang, language; fr, shared borders; accilibr, free trade; ln&l_, natural logarithm of exports.

increases Tunisian exports by 47%. In the same context, a recent study by Ha, Chung and Seo (2016) showed that income elasticity had a significant positive effect on Korea's trade volume with the ASEAN-5 countries. In another study on international grain trade, Yip (2012) found that the importer's GDP led to a much faster growth in grain trade than the exporters' GDP. A 10% increase in the importing country increases trade flows to 4% according to the empirical work of Iwanow and Kirkpatrick (2009); to 8.2% for the work of Puertas et al. (2014), to 0.2% for the study of Gani (2017), and to 9.5% for the work of Hausman et al. (2013). Indeed, an increase in the partner country's GDP raises purchasing power and consumption, which in turn increases foreign demand for imports from its trading partners, including Tunisia. This means imports translated into an increase in Tunisia's exports. In 2017, importers accounted for 71% of the total value of Tunisia's exports, approximately 24 483.6 million dinars. Indeed, most of it is devoted to EU countries, mainly France, Italy, and Germany. In the Maghreb, Algeria is better positioned than Morocco and Libya to receive Tunisia's exports. We did not consider the value of Tunisia's imports to these countries, given the potential of exports to influence growth. However, we should not overlook the role of imports in the trade balance. For example, the latter is as follows for 2017 (million dinars): Germany (−21.7); Algeria (−680.9); Morocco (157.1); France (2964.8); Belgium (−17.9); Italy (−2118.7); Spain (500); and Libya (866.4). The product groups exported to these countries are (in descending order of value): mechanical and electrical products; textiles, clothing, and leather products; energy and lubricants; mining and phosphates; and agricultural and agri-food products. Indeed, for textiles (hosiery, clothing, artisanal carpets, shoes, etc.), only 20% of exports are under the general regime, and the rest (80%) are under the offshore regime. On the other hand, there is no offshore regime for the export of energy products and lubricants (including crude oil and refined products). The same is true for mining products and phosphate (crude phosphate, phosphoric acid, salt, etc.). In addition, the export of agricultural and agri-food industry products (olive oil, fish industry, dates, and citrus fruits) is 95% for the general regime. Finally, 40% of mechanical and electrical products are exported under the offshore regime. The evolution of exports to these countries by product group shows that the market share of mechanical and electrical products has been gradually decreasing since 2011 among the main importers, namely France, Italy, and Germany. We also report a drop in imports since 2014 in the market shares of Libya and Algeria, which was previously due to smuggling along the border. The results also show that the capital productivity of LSPs at the Rades platform is significant and negative. Indeed, if this productivity increases by 10%, this would reduce trade by 47% to the eight countries. Furthermore, if the productivity of capital increases, this means that capital becomes more productive, and therefore its contribution to the production of LSPs increases throughout the study period. We recall that this variable was calculated based on the ratio of turnover to logistics space. It represents the fixed capital which constitutes the essential determinant of the productivity of the capital of an LSP, given the nature of the activity. Indeed, for the first sample, these are service providers that carry out basic logistics activities such as transport, warehousing, grouping, and ungrouping. This can be explained by the fact that, in a stable logistics environment, turnover continues to increase from 1 year to the next, resulting in improved logistics activity and associated revenues for the company. The turnover, composed of two essential elements (the selling price and the number of units of goods or services), increased; this can be explained by an increase in the selling price of logistics services, by an increase in output, or by both at the same time. The increase in capital productivity can also be explained by the simultaneous increase in turnover and logistics spaces, except that the logistics spaces increase at a slower rate than turnover. Then we found that a few LSPs invested in expanding logistics capacity. Indeed, the government developed enormous logistics spaces to establish LSPs near the port. We highlighted the problem of oversized logistics spaces, which may explain the negative effect of capital productivity on exports. We noticed that when demand increases, LSPs resort to seasonal labour. We also note that the contribution of logistics space does not only lie in its size (space) but rather in the adaptation of its layout (warehouse zoning, number of docks, etc.) to the activity of the LSPs. In addition, this result can be explained by the logistics and customs policies implemented in Radès LP, the restrictive regulations or bureaucratic procedures which can limit the efficiency of capital productivity, leading to negative effects on exports. The capital productivity of LSPs located outside the LPs is significant and positive. If it increases by 10%, exports amount to 3.4%. Indeed, the second sample includes LSPs located in industrial zones. The increasing capital productivity of LSPs generally implies a growth in their logistics activities in quantitative terms (tonnage transported, tonnage stored, number of pallets processed in grouping or ungrouping, etc.) and qualitative terms (deadlines, etc.). This improvement in productivity makes the LSP services in this sample more profitable, more attractive and highly sought after by Tunisian exporters. The main sources of the improvement in the productivity of these firms (Courlet 2008) can be linked to internal economies of scale which are explained by the decrease in unit production costs due to the increase in production volume, and this increase is mainly linked to the production factors internal to the firm. These factors can be external to the company, and in this case, we speak of agglomeration economies; they are interpreted by Catin (1997) as being economies external to the firms and internal in relation to their geographical locations. In addition, the providers of the 2nd sample can benefit from agglomeration economies. Co-located providers near industrial centres have operational advantages resulting from the sharing of tangible assets such as transport capacity, equipment and warehouse space, as well as intangible assets such as knowledge and information. In the same context and in the case of the logistics sector, co-location offers additional benefits resulting from the reduction of transport costs, the

increase in the level of customer service, according to Masson et al. (2007), the collaborative organisation of transport activities is not only a matter of minimising costs, but also of improving service levels and satisfaction of the end customer, sharing of resources, increasing the value of additional services (repair services, etc.) and high levels of employment (Rivera, Sheffi & Welsch 2014; Sheffi 2012; Van den Heuvel et al. 2013). The results also show that distance is significant and negative. A 10% decrease in distance increases exports by 16% (9.5% and this coefficient decreases with the increase in the country's income (Çelebi 2017); 15% (Iwanow & Kirkpatrick 2009); 4% (Puertas et al. 2014); 13% (Hausman et al. 2013); 25% (Limao & Venables 2001). This is explained in the literature by the fact that where distance increases, transport costs also increase, which decreases trade flows. Other authors criticise this approach because, on the one hand, the distance between countries is a variable that does not vary over time, which means that the assessment of the contribution of variations in transport costs to the evolution of trade flows is brutal (Jacks & Pendakur 2010). On the other hand, distance is not a sufficient variable to translate transport costs, there are other opinions on the parameter of geographical distance including the attempt to include geographical factors in the gravitational equation such as the area of a country, whether it is landlocked or has access to navigable water bodies, as well as the colonial relationship and the common language because these variables are considered determinants of trade costs (Behar & Manners 2008). Nowadays, innovation and ICT can reduce the effect of distance (sharing the same information platform, same information systems, traceability, etc.). But since distance is considered as a proxy for transport costs, the improvement in this measure can be interpreted as efforts to reduce the freight rate (in dollars per km) for bilateral trade. Freight costs could be reduced by deregulating transport, expanding ports to increase their capacity, and promoting the growth of 3PL services for better consolidation of freight flows. Processing time and cost can be improved by process reengineering to eliminate waste and streamline other operations (e.g. introducing more parallel processing than sequential processing), introducing advanced information technologies (such as electronic customs clearance and document flow), using data mining and filtering methods to identify only high-risk containers for security inspections, and adopting advanced scanning (Hausman et al. 2013). The competence and quality of logistics services is significant and negative. Indeed, a 10% increase in this index decreases trade by 3.7%. Indeed, an improvement in the quality of services translates into an improvement in customer satisfaction. The latter should be accompanied by an increase in trade flows to these customers. However, these results clearly show that this improvement is not enough to satisfy our foreign partners, which leads to a loss of market share, resulting in a decrease in exports to these countries. The aim is to improve the quality of logistics services while focusing on international competitiveness. This result can also be interpreted by the fact that the logistics performance is inefficient because the private logistics sector is incompetent and represents the weakest link in terms of logistics performance. Indeed, the main Tunisian export sectors have not yet exceeded the 1PL and 2PL quality level for LSPs, and only offshore firms have more developed logistics service quality (3PL). Authors show that service quality is a key element of logistics performance for both developing and developed countries. A 10% increase in the exporter's logistics services competence index increases developing country exports by 22% (Turkson 2011); 1.2% (Puertas et al. 2014); and 2.5% (Gani 2017); 9.7% (Çelebi 2017). Furthermore, the competence and service quality index of partner (importing) countries is significant and positive. A 10% increase in this index increases Tunisian exports by 10%, confirming previous findings. Hence, Tunisia derives significant benefits in terms of exports if it establishes trade with high-income (importing) countries. An increase of 3.9% (Çelebi 2017); an increase of 3.5% (Puertas et al. 2014). While the LPI is a global performance index, and most authors have analysed this index in detail, across its six dimensions, we have already mentioned that we focus our study on the competence and quality of the private sector logistics service. This is the dimension that best represents the logistics sector.

Conclusion

To measure the contribution of the Rades LP, particularly its LSPs, to Tunisian exports to the top eight importers between 2011 and 2017, we estimated a gravity model that shows an inverse relationship between the capital productivity of LPs co-located on the platform and Tunisian exports. In contrast, LSPs located near industrial zones are more productive and effectively contribute to increasing Tunisian exports. Furthermore, we report insufficient service quality from the private logistics sector, which does not contribute to increasing exports. However, the role of government is not limited to the development of enormous logistics spaces but also involves preparing the necessary infrastructure that corresponds to the activity of investors and also fostering collaboration between the various stakeholders co-located in the platform.

Limitations and future research avenues

The limitations of research on the impact of logistics clustering on exports include the difficulty of measuring the direct impact of the cluster compared to other economic factors. Future work on the collaboration or alliance between co-located LSPs will probably give us more clarity.

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Competing interests

The authors, Ahlem Hamri; Rafaa Mraihi and Noomen Guirat, declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

CRediT authorship contribution

Ahlem Hamri: Data curation, Formal analysis, Funding acquisition, Investigation, Resources, Software, Visualisation, Writing – original draft, Writing – review and editing. Rafaa Mraihi: Conceptualisation, Methodology, Supervision, Validation, Writing – review and editing. Noomen Guirat: Supervision, Writing – review and editing. All authors reviewed the article, contributed to the discussion of results, approved the final version for submission and publication, and take responsibility for the integrity of its findings.

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Data availability

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