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Cross-Sectoral Gravity for Bilateral Trade: Greek–Chinese Trade Prospects

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ABSTRACT

The traditional discouraging role of geographical distance on international trade is widely reported in the relevant literature. China is a major trading partner of the European Union and, at the same time, a distant market for European and, consequently, Greek products. The purpose of the present paper is first to capture the differentiated discouraging effect of distance on international trade of different product groups, focusing on the Greek export and Chinese import sectors during the 1995-2018 period. Second, to incorporate this product–differentiated effect of distance into a cross-sectoral gravity analysis of Greek merchandise exports towards the Chinese domestic market. The two-step methodological approach is based on the application of the augmented gravity equation and the Poisson Pseudo Maximum Likelihood (PPML) estimator. The hypothesis of the differentiated effect of geographical distance on trade of different products is confirmed in the present analysis. The empirical findings also highlight some of the factors lying behind Greek – Chinese bilateral trade and provide policy implications in the light of the current pandemic crisis. The Greek economy should focus on strengthening sectors related to the optimal utilization of high value-added natural resources and specific human capital intensive sectors. Policy makers should take into account that production verticalization strategies, such as in the agri-food processing industry, could certainly facilitate safe transport of products to distant markets while at the same time increasing their added value.

INTRODUCTION

The strengthening of Greek – Chinese trade relations is quite a recent reality, being the result of institutional and economic developments, as well as of the importance of the geographical position of Greece for the penetration of Chinese products in the European market. The adoption of the common reference framework for international trade by China in the context of the World Trade Organization (WTO), the accession of Greece to the Eurozone from 2002 onwards, the consolidation of the Chinese investments in the most important trading port of Greece, have been some of the main reasons for a

series of bilateral trade agreements among these two countries during the last decade. In the light of the inherent weaknesses of the Greek economy which came to the fore during the economic and the recent pandemic crisis, but also Greece's high dependency on the monoculture of tourism, it becomes clear that the country's economic strategy should devise alternative strategies in order to stimulate domestic economic activity.

The expansion of export activity is considered as a key policy for the Greek economy, at the same time raising questions about the growth prospects of the manufacturing sector. The ultimate strategic goal is to increase the added value of final products, such as giving particular emphasis on the optimal utilization of agricultural output together with the modernization of agricultural production. According to a recent study of the Hellenic Foundation for European and Foreign Policy, the top 10% of export-intensive firms in Greece are responsible for 92% of total exports (Kakoulidou et al, 2020). This is not surprising given the lack of a solid industrial base – which is partly justified by the economic size of the Greek economy, but also the relative absence of cooperative entrepreneurship. On the other hand, the constantly expanding Chinese domestic market, characterized by the gradually increasing needs of the urban households, seems an important opportunity not only for China's trading partners worldwide. The relevant literature has already reported on trade barrier issues for Western companies trying to enter the Chinese market (Lu et al, 2014; European Commission, 2019; Froese et al, 2019; Imran et al., 2018), which is partly due to linguistic and cultural factors (Simovic, 2020). Especially for European economies, one of the most decisive factors is the geographical distance from the Chinese market, a fact which certainly does not favour trade of the most sensitive products.

The gravity model methodology has become a common analytical tool for identifying the factors lying behind bilateral trade flows (Sohn, 2001; Felipe and Kumar, 2010; Karkanis, 2019; Petrova et al., 2021). The gravity equation has also been extensively employed for the study of China's trade with its major partners such as ASEAN countries (Zhang and Wang, 2015; Putra et al., 2019; Widarjono, 2020) or the European Union (Karkanis, 2018). The literature has highlighted the traditionally discouraging role of distance for bilateral trade representing the negative impact of transport costs on the intensity of trade flows (Bussière and Schnatz, 2006; Marimoutou et al, 2009; Magerman et al, 2015). However, this factor does not exert the same discouraging effect among the different tradable products (Yang et al., 2020). The nature of merchandise products is what also determines their safe transport to distant markets, while distance becomes less important when national economies have a strategic interest when trading specific products.

One of the main objectives of the present paper is to assess the differentiated role of distance depending on the nature of the Greek traded products, and further incorporating this effect in the case of Greek merchandise exports to China. Finally, there is an extensive discussion on the prospects of favourable policies in order to increase export activity towards China, depending on the prevailing scenarios of Greek and Chinese economic growth in the short term and in the midst of the pandemic crisis.

1. METHODOLOGICAL APPROACH

The added value of this paper lies largely in a two-step methodological approach. In the first step, the gravity analysis aims to assess the effect of specific factors on the evolution of i) Greek merchandise export flows towards 194 trading partners and ii) Chinese merchandise import flows from 197 trade partners worldwide (Equation 1). The value of Greek exports or Chinese imports during the 1995-2018 period, represented here by the *trade* dependent variable, refers to the trade values corresponding to each of the ten 1-digit level SITC product categories (SITC0, SITC1,..., SITC9).

$$\begin{aligned} \ln(trade)_{o,d} = {} & \beta_0 + \beta_1 \ln(distance)_{o,d} + \beta_2 (border)_{o,d} + \beta_3 (ethnic\ language)_{o,d} + \\ & + \beta_4 (landlocked)_d + \beta_5 \ln(GDP)_o + \beta_6 \ln(GDP)_d + \beta_7 \ln(GDPpc)_d + \\ & + \beta_8 \ln(p.c.\ GDP)_o + \beta_{10} (PCI\ exports)_o + \beta_{11} (PCI\ imports)_d + \\ & + \beta_{11} (export\ openness)_o + \beta_{12} \ln(import\ openness)_d + \varepsilon \end{aligned} \quad (1)$$

The first methodological step aims to evaluate the differentiated effect of geographical distance depending on the nature of the products traded. Berthelon and Freund (2004) disaggregate the effect of distance by using data at the 1-digit SITC level on bilateral trade between 73 countries and their 196 partners worldwide, showing that distance-related trade costs have remained unchanged during the period under study (1985-2000). In the present study, the values of the estimated weighted (*beta*) coefficients referring to the effect of the *distance* variable among the different SITC product groups (1-digit level) on Greek merchandise exports will be further employed in order to introduce a new interpretative value for bilateral trade modelling. The latter variable, named as *product sensitivity* variable, which takes values equal to the absolute value of the estimated weighted coefficients during the first methodological step, will be integrated into the cross-sectoral gravity model in the second methodological step (Equation 2). *Ceteris paribus*, the higher the weighted coefficient, the stronger the effect of geographical distance on the specific SITC product group.

During the second step, the dependent variable (Regressions 1 and 2, Table 4) refers to the value of Greek merchandise exports i) towards its major destinations (mentioned in bold, Appendix III) and ii) towards China during the same time period (1995-2018). Two major methodological differences should be stressed out, compared with the first step. The dependent variable (*exports*) refers to an export value at a lower SITC classification level, namely at the 2-digit level. By further decomposing the product classification scale, this helps to better highlight the effect of the *product sensitivity* variable, but also to increase the number of observations in a regression where the only exporter is Greece and the only importer is China (Regression 2, Table 4). It becomes evident that the typical *distance* variable is well employed for assessing the evolution of Greek exports towards major destinations (Regression 1, Table 4), but loses significance when the only importer is China (Regression 2, Table 4). As a result, this methodological approach aims to incorporate the differentiated effect of distance, depending on the type of Greek products exported to the Chinese market, with the ultimate goal of providing new findings for modelling bilateral trade development prospects.

$$\begin{aligned} \ln(exports)_{o,d,i} = {} & \beta_0 + \beta_1 \ln(distance)_{o,d} + \beta_2 \ln(product\ sensitivity)_o + \beta_3 (border)_{o,d} + \\ & + \beta_4 (ethnic\ language)_{o,d} + \beta_5 (landlocked)_d + \beta_6 \ln(GDP)_o + \beta_7 \ln(GDP)_d + \\ & + \beta_8 \ln(p.c.\ GDP)_d + \beta_9 \ln(total\ exports)_{o,i} + \beta_{10} \ln(total\ imports)_{d,i} + \\ & + \beta_{11} (petroleum)_{o,d} + \beta_{12} (PCI\ exports)_d + \beta_{13} (RCA\ exports)_{o,i} + \varepsilon \end{aligned} \quad (2)$$

The *product sensitivity* variable is introduced in order to capture the discouraging effect of geographical distance, which takes the same value for all exported products belonging to the same 1-digit SITC group, and regardless of the observation year. The *petroleum* variable (Equation 2) represents the contribution of petroleum exports to the evolution of Greek merchandise exports, especially if taking into account that the petroleum exports' share into the total Greek merchandise exports is relatively very high. Product concentration indexes (PCI), either they refer to export or import activities, are employed in order to introduce any trade structure effects on trade flows in both Equations 1 and 2. A PCI value closer to the unity suggests that a country's exports or imports are highly concentrated on a few products. The next group of variables consists in evaluating the role of multilateral trade resistance effects on trade flows (De Bruyne et al, 2013; Shepherd, 2013; Shahriar et al, 2018). In this case, we introduce i) the typical export and import openness variables for origin and destination countries, respectively (Equation 1), and ii) two variables referring to the exporter's total export value and the importer's total import value, both of the latter at the 2-digit SITC classification level.

The UNCTADStat database provides estimates of the revealed comparative advantage (RCA) scores by SITC classification at the 2-digit level. A country's revealed comparative advantage in a given product means that the ratio of exports of this specific product to its total merchandise exports exceeds the corresponding ratio for the world as a whole (UNCTADStat, 2020). Apparently, the higher the comparative advantage of exports of a specific product to a trading partner, the higher the value of exports of the same product to the same destination is to be expected. The revealed comparative advantage index is used here as a measure for assessing Greece's export potential by 2-digit group. The highest performance scores for Greek merchandise exports (2018) are reported in Appendix II. The RCA is employed to reveal a country's process of extending the range of products, in which there exist trade potentials and

whether the index is greater or smaller than the unit, the country presents a revealed comparative advantage or disadvantage in the specific product group, respectively.

With regard to the choice of the statistical method, the Poisson Pseudo Maximum Likelihood (PPML) estimator is employed in both methodological steps, which is recommended in cases of regressions which include a non-negligible number of zero-value observations (Santos Silva and Tenreyro, 2006; Truong et al., 2019). In such cases, zero values are often replaced by the minimum observed value within the sample, as is the case in other similar studies (Figueiredo et al, 2015). The second methodological step also includes OLS estimations in both Regressions 1 and 2 for comparison purposes. The statistical results of all regressions presented in the following sections do not include elasticity coefficients which present collinearity issues. Data on geographical and cultural variables are derived from the CEPII database (Mayer and Zignago, 2011), while economic and trade flow data are extracted from the UNCTADStat database. A description of all variables included in Equations 1 and 2 is given in the Appendix I.

2. STRUCTURAL GRAVITY TRENDS

The statistical findings of the first methodological step are summarized in Tables 1 and 2. The negative relationship between the county's economic size and export flows can be justified by the fact that the intensification of export activities in Greece occurs as an urgent need given the sharp GDP contraction during the period of economic crisis (Table 1).

Table 1. PPML estimations: Greek exports by 1-digit SITC group

	Food and live animals	Beverages and tobacco	Crude materials	Mineral fuels	Animal & vegetable oils	Chemicals	Manufactured goods	Machinery & transport equipment	Miscellaneous manufactures	Commodities & transactions
PPML estimations										
distance $_{od}$	-0.319 [a]	-0.429 [a]	-0.440 [a]	-0.427 [a]	-0.427 [a]	-0.285 [a]	-0.255 [a]	-0.170 [a]	-0.255 [a]	-0.399 [a]
	(-28.93)	(-28.62)	(-27.19)	(-28.28)	(-20.92)	(-29.94)	(-28.92)	(-24.17)	(-29.67)	(-18.64)
border $_{od}$	-0.060	-0.068	-0.197 [a]	-0.096 [a]	0.266 [a]	-0.086 [b]	-0.041	0.006	0.010	0.038
	(-1.23)	(-1.35)	(-3.18)	(-2.67)	(3.05)	(-2.50)	(-1.14)	(0.22)	(0.25)	(0.53)
language $_{od}$	0.364 [a]	0.390 [a]	0.637 [a]	0.095 [a]	0.676 [a]	0.398 [a]	0.274 [a]	0.299 [a]	0.323 [a]	0.456 [a]
	(16.47)	(15.25)	(17.51)	(3.25)	(16.69)	(16.52)	(11.05)	(13.13)	(13.70)	(7.99)
landlocked $_{d}$	-0.245 [a]	-0.104 [a]	-0.329 [a]	-0.500 [a]	-0.067	-0.046 [b]	-0.130 [a]	-0.074 [a]	-0.162 [a]	-0.437 [a]
	(-7.02)	(-2.54)	(-7.36)	(-10.65)	(-1.41)	(-1.97)	(-5.13)	(-3.75)	(-6.03)	(-7.11)
GDP $_{o}$	-2.619 [a]	-1.377 [b]	-2.105 [a]	-0.153	-1.083	-1.981 [a]	-2.602 [a]	-1.048 [a]	-2.934 [a]	-4.252 [a]
	(-5.61)	(-2.42)	(-3.45)	(-0.26)	(-1.40)	(-5.31)	(-7.14)	(-3.21)	(-8.40)	(-5.76)
GDP $_{d}$	1.984 [a]	2.283 [a]	3.078 [a]	1.420 [a]	3.010 [a]	1.943 [a]	1.765 [a]	1.443 [a]	1.734 [a]	2.742 [a]
	(30.34)	(28.41)	(44.95)	(19.06)	(37.01)	(39.17)	(35.50)	(32.91)	(36.47)	(31.57)
GDPpc $_{d}$	0.014 [c]	0.011	-0.025 [b]	0.047 [a]	0.105 [a]	-0.053 [b]	-0.005	-0.016 [a]	0.017 [a]	0.093 [a]
	(1.79)	(1.06)	(-2.51)	(4.90)	(7.71)	(-8.02)	(-0.80)	(-3.00)	(2.60)	(6.92)
PCIexports $_{o}$	1.459 [a]	1.682 [a]	1.879 [a]	2.230 [a]	2.356 [a]	0.624 [a]	0.351 [a]	0.080	0.263	-0.200
	(6.91)	(5.61)	(5.36)	(5.36)	(8.26)	(5.29)	(2.70)	(0.59)	(1.52)	(-0.34)
PCIimports $_{d}$			0.304	1.986 [a]	0.226	0.490 [a]	0.621 [a]	0.942 [a]	0.659 [a]	1.281 [a]
			(1.40)	(15.38)	(0.90)	(3.55)	(5.12)	(9.34)	(5.23)	(4.27)
import openness $_{d}$	-0.094 [c]	0.731 [a]	1.324 [a]	-0.017	-4.247 [a]	0.187 [a]	0.060 [a]	0.071 [a]	0.098 [a]	0.194 [a]
	(-1.73)	(2.93)	(11.14)	(-0.66)	(-5.79)	(6.40)	(2.84)	(4.57)	(5.23)	(3.37)
export openness $_{o}$	0.001		0.023	-0.006	0.197	0.005	0.007	0.078 [a]		0.445 [a]
	(0.08)		(0.25)	(-1.02)	(1.20)	(0.21)	(0.45)	(2.92)		(4.12)
R^2 (adj.)	0.585	0.508	0.604	0.427	0.591	0.586	0.571	0.522	0.596	0.491
Obs.	3,296	3,296	3,296	3,296	3,296	3,296	3,296	3,296	3,296	3,296

Note: Poisson Pseudo-Maximum Likelihood (PPML) estimations. Robust t-Statistics are in parentheses. The superscript [a] means p<0.01, [b] means p<0.05, [c] means p<0.1.

Ceteris paribus, the lower the level of GDP per capita of the destination countries, the greater the intensity of Greek exports of crude materials, chemicals and machinery equipment. The opposite is true in the case of sectors that refer mainly to products for household consumption. Less developed economies need more raw materials either for supporting their domestic manufacturing activities or the construction industry, namely in countries undergoing rapid urbanization, which to some extent justifies the negative sign of the corresponding *per capita GDP* coefficient.

In terms of trade structures, the signs of the PCI coefficients reveal that the greater the degree of concentration of Greek exports and imports of destination countries in fewer products, the greater the intensity of Greek exports towards the latter. The variable representing the common ethnic language in the country of destination is directly related to the significant presence of the diaspora, as has been confirmed for example for olive oil trade (Vlontzos and Duquenne, 2008). In terms of trade openness, the signs of the *import openness* elasticities indicate competition effects to which the Greek exports of food products are subject. Except for mineral fuels, food & live animals, but also animal & vegetable oil product groups are the only ones in which there are no complementarity effects between imported products in the destination countries of Greek products. The issue, therefore, arises mainly in the organization of appropriate business strategies, which will contribute to boost the competitiveness of Greek food products, along with the increase of the added value of the final products and the expansion of the food export sector. The processing of agricultural products is already a significant share of the total manufacturing sector in Greece (PwC, 2018), which is characterized by high fragmentation with a large share of small and often family businesses.

The volume of Chinese imports is clearly larger than the volume of Greek exports, a factor being partly responsible for the comparatively higher interpretative values in all ten SITC product groups (Table 2). The geographical distance seems to lose its influence when it comes to the search for crude materials from the international markets. After all, it is a strategic goal of the Chinese economy to support both the construction industry to maintain the urbanization process and the supply of the domestic manufacturing industry with raw materials. This is clearly why in the crude materials industry the existence of a common border does not encourage the intensity of imports regarding this particular group of products.

Table 2. PPML estimations: Chinese imports by 1-digit SITC group

	Food and live animals	Beverages and tobacco	Crude materials	Mineral fuels	Animal & vegetable oils	Chemicals	Manufactured goods	Machinery & transport equipment	Miscellaneous manufactures	Commodities & transactions
PPML estimations										
distance $_{od}$	-0.141 [a] (-9.19)	-0.072 [a] (-2.82)	0.005 (0.56)	-0.260 [a] (-10.12)	-0.114 [a] (-3.56)	-0.116 [a] (-7.82)	-0.048 [a] (-4.52)	-0.075 [a] (-8.13)	-0.109 [a] (-9.29)	-0.257 [a] (-7.84)
border $_{od}$	0.048 (1.45)	0.325 [a] (5.61)	-0.083 [a] (-3.84)	0.167 [a] (3.13)	0.360 [a] (4.80)	0.113 [a] (3.66)	0.063 [b] (2.55)	0.048 [b] (2.45)	0.063 [a] (2.62)	0.436 [a] (4.94)
language $_{od}$	0.091 [a] (3.05)	0.328 [a] (7.25)	0.134 [a] (7.93)	0.153 [a] (3.48)	0.192 [a] (2.63)	-0.030 (-1.09)	0.001 (0.02)		-0.065 [b] (-1.95)	0.588 [a] (8.13)
landlocked $_{d}$	-0.119 [a] (-4.37)	0.035 (0.84)	0.044 [a] (3.36)	-0.118 [b] (-2.20)	-0.569 [a] (-7.44)	-0.090 [a] (-3.73)	0.057 [a] (3.30)	0.019 (1.35)	0.045 [a] (2.79)	0.064 (0.75)
GDP $_{o}$	0.203 [a] (30.61)	2.470 [a] (27.17)	1.734 [a] (40.17)	3.611 [a] (40.75)	3.068 [a] (26.36)	2.014 [a] (38.37)	2.009 [a] (45.53)	1.332 [a] (36.38)	1.569 [a] (34.75)	3.427 [a] (21.82)
GDP $_{d}$	0.081 [a] (5.63)		0.649 [a] (8.58)	0.655 [a] (3.41)	1.319 [a] (3.92)					
GDPpc $_{o}$	-0.075 [a] (-9.19)	0.093 [a] (7.75)	-0.131 [a] (-25.17)	-0.059 [a] (-4.68)	0.019 (1.02)	-0.012 (-1.59)	-0.082 [a] (-14.33)	0.015 [a] (2.97)	-0.007 (-1.21)	0.042 [c] (1.72)
PCIexports $_{o}$	-0.507 [a] (-8.54)	-1.638 [a] (-14.75)	-0.062 [b] (-2.18)	0.337 [a] (2.87)	-2.043 [a] (-14.97)	-0.463 [a] (-9.46)	-0.181 [a] (-5.40)	-0.677 [a] (-21.05)	-0.878 [a] (-22.76)	-1.192 [a] (-7.57)
PCIimports $_{d}$									3.360 [a] (7.21)	9.328 [a] (4.85)
import openness $_{d}$	0.365 [b] (2.27)	18.962 [a] (14.10)	0.037 [a] (4.69)	-0.066 [a] (-3.55)	-0.585 (-1.32)	-0.070 [a] (-5.78)	-0.047 [a] (-7.10)	-0.019 [a] (-8.87)	-0.070 [a] (-5.85)	0.188 [a] (2.96)

export openness $_o$	**0.049** [a] (16.27)	**2.589** [a] (20.28)	**0.118** [a] (3.16)	**1.901** [a] (9.61)	**1.854** [a] (8.63)	**0.168** [a] (10.65)	**0.258** [a] (22.43)	**0.048** [a] (8.97)	**0.153** [a] (13.80)	**0.287** [a] (5.41)
R^2 (adj.)	**0.529**	**0.604**	**0.555**	**0.537**	**0.542**	**0.618**	**0.658**	**0.719**	**0.707**	**0.483**
Obs.	3,286	3,286	3,286	3,286	3,286	3,286	3,286	3,286	3,286	3,286

Note: Poisson Pseudo-Maximum Likelihood (PPML) estimations. Robust t-Statistics are in parentheses. The superscript [a] means p<0.01, [b] means p<0.05, [c] means p<0.1.

In contrast to Greek exports, the findings confirm the encouraging role of the economic size of both countries of origin and China. *Ceteris paribus*, the lower the PCI indices of the exporter countries, the higher the intensity of Chinese imports. China's main trading partners are located in East Asia, the European Union and North America, i.e. developed economies with a wide range of exported products and, consequently, low PCI scores over time. On the contrary, the findings showed that Greek exports were favoured by the high PCI scores, both for the exporting country (Greece) and for its partners (Table 1). The PCI index of Chinese imports is comparatively higher than that of its major trading partners, and this relationship seems favourable their bilateral relations. However, in terms of the Chinese import structure (PCI for imports), the statistical significance of the corresponding variable is confirmed exclusively in the case of miscellaneous manufactures and commodities & transactions.

With regard to the role of trade openness indicators, all ten regressions by SITC product group confirm complementarity effects between the countries that export to China. The same is true for China's import openness, but only in what concerns the food and beverage industry, as well as crude materials' imports. Consequently, there seem no competition effects in the case of these specific SITC product groups, which would facilitate the penetration of Greek products into the Chinese market. The steady increase of the urban population in China, new consumer needs that gradually rise inside the urban households, along with the rise of the income levels of Chinese citizens, can only contribute positively in this direction.

Table 3. Distance coefficients by industry

1-Digit level	*Greek exports (Table 1)*		*Chinese imports (Table 2)*	
	Unweighted coeff.	*Weighted coeff.*	*Unweighted coeff.*	*Weighted coeff.*
Food and live animals	-2.770 [a]	-0.332	-1.898 [a]	-0.143
Beverages and tobacco	-3.095 [a]	-0.381	-1.008 [a]	-0.082
Crude materials	-2.688 [a]	-0.322	-0.063	-0.005
Mineral fuels	-3.703 [a]	-0.428	-2.853 [a]	-0.176
Animal & vegetable oils	-1.912 [a]	-0.253	-0.912 [a]	-0.073
Chemicals	-2.847 [a]	-0.372	-2.011 [a]	-0.144
Manufactured goods	-2.697 [a]	-0.346	-1.065 [a]	-0.084
Machinery & transport equipment	-1.915 [a]	-0.287	-1.338 [a]	-0.114
Miscellaneous manufactures	-2.462 [a]	-0.336	-2.037 [a]	-0.170
Commodities & transactions	-2.037 [a]	-0.268	-1.650 [a]	-0.145

Note: The superscript [a] denotes 1% statistical significance.

The effect of geographical distance is a function of the type of product being traded and of the importing or exporting country. The discouraging role of geographical distance is stronger when it comes to tradable products such as mineral fuels, and this is confirmed in both regression groups. The coefficients at least partially incorporate supply and demand patterns from partner countries (Table 1). The role of distance is comparatively weaker with regard to Greek exports of animal and vegetable oils, and this is reasonable given the significant share of olive oil exports being exported to neighbouring Italy. In the case of China, the impact of distance on raw material imports seems virtually eliminated if taking into account that the country imports raw materials from all over the world in order to support the domestic industrial production and the construction of infrastructure projects.

3. BILATERAL TRADE MODELLING

In the second methodological step, regressions 1 and 2 (Table 4) aim to capture the determinants of Greek merchandise exports towards its 20 major destinations and especially towards China, respectively, by SITC product group at the 2-digit level (Equation 2), but also to validate the statistical significance of the introduced *product sensitivity* variable. The moderate interpretative value of both regressions - the adjusted R^2 range from 0.437 to 0.510 – can be considered quite expected. That is because the analysis at the 2-digit level trade flows should include a wider range of product-related factors, for which no data are available (degree of sensitivity of products, bilateral agreements between specific partners for specific traded products, among others). There seem no differences between the OLS and PPML estimates with regard to the sign of the coefficients, except in the *petroleum* variable. The traditional effect of geographical distance has no meaning when the trading partner is exclusively China (Regression 2, Table 4), since bilateral trade concerns only these two partners. In cases where there are no exports of Greek products to a country for the entire period under study, these are not taken into account. Factors that cannot be included in the gravity equation (for example, poor diplomatic relations, self-sufficiency of certain importers in specific products) contribute so that the Greek economy does not perform export activities over time with regard to certain products towards specific importer countries. After excluding observations related to zero-value exports of Greek products to specific countries throughout the whole period under study, in the final sample, the number of zero observations constitutes 13% of the total observations (3,998 out of 30,464).

Table 4. Results at 2-digit level: Major destinations and China

	Major destinations (Regr. 1)			China (Regr. 2)		
	OLS		PPML	OLS		PPML
$(distance)_{od}$	**-1.528** [a] (-34.534)	-0.232	**-0.158** [a] (-37.76)			
$(product\ sensitivity)_{o}$	**-2.334** [a] (-2.928)	-0.017	**-0.221** [a] (-2.928)	**-16.092** [a] (-3.605)	-0.114	**-1.108** [b] (-2.41)
$(border)_{od}$	**2.219** [a] (28.263)	0.146	**0.167** [a] (24.17)			
$(ethnic\ language)_{od}$	**4.660** [a] (55.212)	0.162	**0.422** [a] (51.79)			
$(landlocked)_{d}$	**-1.677** [a] (-14.428)	-0.058	**-0.132** [a] (-13.11)			
$(GDP)_{o}$	**-0.999** [a] (-9.780)	-0.040	**-0.092** [a] (-10.31)	**-0.254** (-0.393)	-0.010	**-0.035** (-0.55)
$(GDP)_{d}$				**0.540** [a] (2.920)	0.070	**0.025** (1.22)
$(p.c.\ GDP)_{d}$	**0.284** [a] (9.599)	0.053	**0.013** [a] (4.59)			
$(total\ exports)_{o,i}$	**1.162** [a] (47.499)	0.418	**0.123** [a] (64.71)	**1.455** [a] (8.291)	0.495	**0.194** [a] (16.43)
$(total\ imports)_{d,i}$	**0.694** [a] (44.164)	0.374	**0.081** [a] (48.68)	**0.391** [a] (6.443)	0.207	**0.081** [a] (9.27)
$(petroleum)_{o,d}$	**-1.014** [a] (-5.891)	-0.024	**-0.275** [a] (-20.19)	**0.585** (0.866)	0.013	**-0.377** [a] (-5.49)
$(PCI\ exports)_{d}$	**-2.587** [a] (-14.997)	-0.085	**-0.191** [a] (-11.20)	**-26.762** (-1.042)	-0.028	**-1.772** (-0.70)
$(RCA\ exports)_{o,i}$	**4.299** [a] (10.642)	0.126	**0.181** [a] (10.17)	**4.864** [a] (4.991)	0.193	**0.314** [a] (5.39)
DW	1.905			1.971		
Adjusted R^2	**0.510**		**0.477**	**0.445**		**0.437**
Observations	30,464		30,464	1,088		1,088

Note: Poisson Pseudo-Maximum Likelihood (PPML) estimations. Robust t-Statistics are in parentheses. The superscript [a] means $p<0.01$, [b] means $p<0.05$, [c] means $p<0.1$.

Beyond the effect of geographical distance on exports to major destinations, the coefficient of the elasticity referring to the *product sensitivity* effect is negative and statistically significant for both major destinations and China in particular. The geographical and cultural variables (*border, landlocked, ethnic language*) also exert the expected effect, as they do once again the variables representing the effect of the economic masses. Exports towards third partner countries seem complementary to exports towards the key destinations. Similarly, Chinese imports from other countries are not in competition with imports from Greece. This fact proves strong potential for expanding Greek exports as a whole, as well as towards China. Certainly these complementarities relate to the period under study and it is not certain that it will progressively become competitive relationship in the medium future. Until then, however, the prospects for the expansion of Greek exports appear favourable.

Ceteris paribus, the lower the PCI index referring to exports of destination countries of Greek products, the greater the intensity of Greek exports. These latter are mainly directed to large economies worldwide, which in turn are characterized by a relatively wider range of tradable products and, consequently, relatively low PCI scores for exports, such as China. The weakness of the Greek export sector is not the country's competition with other exporter countries, and this is evidenced by the positive sign of the coefficients for the *total exports* and *total imports* variables. Finally, the findings related to the effect of a revealed comparative advantage (RCA) in certain product groups should not be different, since the existence of a relative comparative advantage in a product group (2-digit level) can only be a favorable condition for the expansion of the Greek exports to that product group.

It is clear that such an attempt to carry out an alternative, cross-sectoral, gravity analysis, by employing observations on trade flows at the 2-digit SITC classification level, would yield better statistical results, if it were possible to introduce additional interpretative variables related to the particular characteristics of the productive industry in Greece. The moderate interpretative value of both OLS and PPML regressions may also be due to the fact that the intensity of trade between Greece and China is clearly more limited compared to exports from other EU countries to China (Germany, France, the Netherlands).

4. TRADE PROSPECTS AND POLICY IMPLICATIONS

A recent report is that of the Organization for Economic Co-operation and Development (OECD, December 2020). It turns out that the negative impact of the pandemic crisis on the economy has been significantly reduced in China even in 2020 (Table 5). During the pandemic, China has adopted a number of measures in order to facilitate imports of agri-food products, equipment and raw materials by ensuring faster approval procedures, to boost transport capacity by supporting the construction of transport hubs, as well as to strengthen international cooperation on epidemic control (Ugaz and Sun, 2020).

Estimates suggest that China's GDP will grow by at least one percentage point in 2020, with the most recent report setting the growth rate at 1.8% (OECD). As for 2021, the recovery of the growth rate to the levels of previous years (at least 6%) seems a given. Similar are the Chinese per capita GDP trends (ADB, 2020). With regard to imports of goods and services, the data indicate a significant contraction in 2020 (-7.2%), followed by a subsequent recovery of positive rates for 2021 and 2022. The ongoing gradual increase in Chinese household incomes and the stimulation of domestic consumption can only be an opportunity for China's partners to export. At the same time, wage increases are gradually reducing China's comparative advantage in offering cheap labour-intensive goods (Garcia-Herrero et al, 2020) and that means a lot for China's comparative advantage, given the entry of new developing countries into international competition.

The Bank of Greece has recently reported estimations with regard to the Greek GDP growth levels for the years 2020 and 2021 (Bank of Greece, 2020), based on three scenarios (mild, basic, adverse scenario). At the time of publication of the report (December 2020), the percentage GDP reduction is estimated between -9 and -11% in 2020, showing clear recovery trends for 2021 (3-5%) and 2022 (4.5-5%). The wide divergence between the different scenarios for the year 2021 is clearly due to the still high degree of uncertainty regarding the impact of the pandemic crisis on Greece's economic recovery.

The recent estimates of the Greek GDP growth rate for 2020 reflect exactly the significant impact of the pandemic crisis on the EU economies. The Greek GDP shrinkage is estimated at around -10%, which is virtually no different from the performance of other EU countries during the same year. A relative recovery of the Greek economy is estimated for 2021 and 2022. The large contraction observed in 2020 (-23.8%) is expected to continue to a lesser extent in 2021 (-5.2%), accompanied by a strong increase and a corresponding rate at the level of 19% (2022). Based on the available data from the Hellenic Statistical Authority (EL.STAT.) for the year 2019, it appears crucial for the national governments to implement support policies for enterprises operating in the food sector and manufactured products (SITC0 and SITC6, respectively).

These two sectors account for the largest share of Greek exports either for intra-EU or extra-EU trade, both in terms of value and volume of exports (Table 6). In particular for third countries, including China, the ratio of value per volume of Greek exports is significantly lower compared to intra-EU exports (47.6 / 64.8 compared to 52.4 / 35.2), however, it should not be underestimated that third countries are the destination of about half the value of Greek exports.

Table 5. Estimates on real GDP and per capita GDP growth: China and Greece

	Estimate	*2018*	*2019*	*2020*	*2021*	*2022*
China, Real GDP growth (annual %)	IMF	6.7	6.1	1.9	8.2	
	World Bank	6.6	6.1	1.0	6.9	
	OECD (2015 prices)	6.7	6.1	1.8	8.0	4.9
	United Nations	6.6	6.1	6.0	5.9	
China, Per capita GDP growth (annual %)	ADB	6.2	5.7	1.8	6.8	
China, Imports of goods and services (annual %)	OECD	5.7	0.2	-7.2	2.1	4.6
Greece, Real GDP growth (annual %)	IMF	1.9	1.9	-9.5	4.1	
	United Nations	1.9	1.7	1.9	2.0	
	OECD (2010 prices)	1.6	1.9	-10.1	0.9	6.6
	Bank of Greece	Mild scenario		-9	4.8	5.0
		Basic scenario		-10	4.2	4.8
		Adverse scenario		-11	3.2	4.5
Greece, Exports of goods and services (annual %)	OECD	9.1	4.8	-23.8	-5.2	19.1

Sources: a) World Economic Outlook, IMF, October 2020, b) Global Economic Prospects, World Bank Report, June 2020, c) World Economic Situation and Prospects, UN DESA 2020, d) ADB Data Library, 2020, e) OECD Economic Outlook 108 database, December 2020.

Table 6. Greek merchandise exports in value and volume (% of total), 2019-2020

Year 2019	SITC0	SITC1	SITC2	SITC3	SITC4	SITC5	SITC6	SITC7	SITC8	SITC9	Total
Total value	14.2	2.2	4.4	31.5	1.2	12.1	14.9	9.4	8.5	1.6	100.0
Intra-EU value	9.8	1.2	1.3	8.7	0.9	8.2	9.3	5.9	6.3	0.8	52.4
Intra-EU volume	5.7	0.5	4.4	13.0	0.3	4.4	5.5	0.5	0.7	0.2	35.2
Third countries - value	4.5	1.0	3.1	22.8	0.3	4.0	5.6	3.4	2.2	0.8	47.6
Third countries - volume	3.0	0.2	8.9	36.7	0.1	2.3	13.0	0.4	0.2	0.1	64.8

Source: EL.STAT, Division of Business Statistics, Section of International Transactions Statistics, extracted: 10/12/2020.

The earliest possible resurgence of Greek exports would be a major challenge for national trade policy. However, beyond the optimistic signs of an even faster recovery of economic indicators in the Chinese case, the questions that arise also concern the possible scenarios of changing the balance of power between the world's largest trading partners. The US-China Economic and Trade Agreement (February 2020) is expected to help boost Chinese imports from the United States, a shift which is projected to a reduction of EU exports to China. European exports of vehicles and aircraft are expected to be hit hardest (Chowdhry and Felbermayr, 2020). On the other hand, differences in trade terms between the EU and China have not led, at least not yet, to serious confrontations compared to other major trading partners. The anti-dumping cases that China and the European Union allege against each other are relatively limited, compared to other major trading partners such as the United States and India, the majority of which relate to the base metal and pharmaceutical sector (Felbermayr and Sandkamp, 2020).

At the medium- and long-term level, the re-establishment of ancient trade routes between Europe and China will diversify the framework for EU-China trade cooperation, including the Greek-Chinese trade relations. The implementation of the Belt and Road Initiative (BRI) is expected to increase the interconnection between the EU and China, as well as the countries along the Eurasian Trade Corridor, some of which are indebted to China. Reducing transport costs will make a significant contribution to boosting international trade, combined with the conclusion of free trade agreements between China and Asian countries involved in the BRI initiative (Garcia-Herrero et al, 2020). The strengthening of cooperation between the countries of Central and Eastern Europe (CEE) and China, through the "17 + 1" initiative will help in this direction, of which Greece is now a member (2019).

Greece's trade strategy certainly depends on bilateral negotiations between the EU and China. The conjuncture of the pandemic intensified the negative consequences of the dependence of the Greek economy on the monoculture of tourism. In an environment where economic activity related to tourism has been significantly reduced due to the pandemic, even temporarily, it becomes clear that economic policies should focus on supporting alternative productive sectors with significant growth prospects in Greece. Efforts to increase the added value of agricultural products are a strategy that has been implemented for decades in other Mediterranean countries (e.g. France, Italy) and should now be stepped up in practice. This implies reforms both in the level of the country's educational policy for the staffing of agricultural processing companies, the research on food technology, the application of innovative cultivation methods, as well as the promotion and promotion of Greek agricultural products both towards EU and third countries.

This does not mean that appropriate measures should not be taken to strengthen other strategic sectors, such as the manufactured products sector (SITC6) or even the pharmaceutical sector, i.e. human capital intensive sectors. What differentiates the agri-food sector is that it is a productive sector that can operate in addition to the tourism product: The contact of tourists with Greek agri-food products can potentially contribute to the intensity of exports to the countries of origin of tourists, while high quality agricultural products can contribute positively to the upgrading of the tourist product. In this context, the recent increase in the mobility of Chinese tourists beyond the border of the Chinese territory may be an important opportunity to further strengthen the Greek exports to China.

CONCLUSIONS AND DISCUSSION

The added value of the present paper was to create and introduce a new variable in the augmented gravity analysis, with a view to capturing the role of geographical distance even in bilateral, cross-sectoral trade between Greece and China. The burden of transportation costs can be lower in economies that present a higher comparative advantage in trade of specific products, which may be due either to high technical expertise or availability of inputs for their mass production activities. Part of the criticism with regard to the methodological choice of the gravity analysis lies in the frequent lack of variables in the gravity equation, which relate to the national economies' domestic production potential. We argue that the introduction of the revealed comparative advantage variable (*RCA exports*) is at least a way to compare the countries' productive capacity for specific goods, by employing an index that weighs the exportability of products both domestically and internationally. The statistically significant coefficient of the corresponding elasticity in both OLS and PPML estimations simply confirms the expected.

The Greek economy cannot significantly focus on a wider range of strategic economic sectors in order to expand export activities, and this is because it has neither a comparative advantage in labour-intensive production sectors, nor, of course, has unlimited natural resources. It can, however, focus on sectors related to the optimal utilization of high value-added natural resources and specific human capital intensive sectors. Production verticalization strategies – such as in the agri-food processing industry – will certainly facilitate safe transport of products to distant markets while at the same time increasing their added value. This is also confirmed in the case of China as an importer of Greek products, where the available data reveal a high degree of complementarity in the field of agricultural products, food and beverages. The findings also confirmed that export activities towards the Chinese domestic market is not so much a matter of competition between Greek and third country companies, but rather a matter of penetration in a market environment with increased domestic protectionism.

It is certain that such a cross-sectoral gravity analysis for modelling bilateral trade between partners with similar economic and trade volume sizes would be of greater interest in terms of empirical results. This certainly does not negate the interest in analysing the prospects of expanding the exports of an EU member state with the huge Chinese market, a process which seems to be in full swing. The conjuncture of the pandemic crisis does not facilitate safe predictions about the prospects of Greek export growth towards China, even in the short term, which was one of the initial objectives of the present study. Greek exports are those that have been hit hardest by the imposition of restrictions on the mobility of both persons and goods, as this becomes evident from the aforementioned international and national institutions' reports.

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Appendix I. Variable description: Regressions 1 and 2

Variable	*Description*	*Source*
$(trade)_{o,d}$	Chinese import or Greek export flows by partner, in US dollars	UNCTADStat
$(distance)_{o,d}$	Geographical distance between trading partners	CEPII
$(border)_{o,d}$	Common border between trading partners (1/0)	
$(ethnic\ language)_{o,d}$	Common ethnic language in importer country (1/0)	
$(landlocked)_{d}$	Landlocked exporter country (1/0)	Own calculations
$(GDP)_{o}$	Exporter GDP, in US dollars	UNCTADStat
$(GDP)_{d}$	Importer GDP, in US dollars	
$(p.c.\ GDP)_{o}$	Exporter per capita GDP, in US dollars	
$(PCI\ exports)_{o}$	Product Concentration Index for exporter countries	
$(PCI\ imports)_{d}$	Product Concentration Index for importer countries	
$(export\ openness)_{o}$	Export openness of exporter country	
$(import\ openness)_{d}$	Import openness of importer country	
$(exports)_{o,d,i}$	Greek exports by trading partner and by sector (2-digit level), in US dollars	UNCTADStat
$(distance)_{o,d}$	Geographical distance between Greece and trading partner	CEPII
$(border)_{o,d}$	Common border between Greece and trading partner (1/0)	
$(ethnic\ language)_{o,d}$	Common ethnic language in importer country (1/0)	
$(product\ sensitivity)_{o}$	Distance beta coefficient (Table 3)	Own calculations
$(landlocked)_{d}$	Landlocked importer country (1/0)	
$(GDP)_{o}$	Greek GDP, in US dollars	UNCTADStat
$(GDP)_{d}$	Importer GDP, in US dollars	
$(p.c.\ GDP)_{d}$	Importer per capita GDP, in US dollars	
$(total\ exports)_{o,i}$	Greek exports by sector (2-digit level)	
$(total\ imports)_{d,i}$	Major destinations' or Chinese imports by sector (2-digit level)	
$(petroleum)_{o,d}$	Petroleum exports, US dollars	
$(PCI\ exports)_{d}$	Product Concentration Index for Greece	
$(RCA\ exports)_{o,i}$	Revealed Comparative advantage of Greek exports by sector (2-digit level)	

Appendix II. Revealed Comparative Advantage (RCA) by product group: Greek exports to major destinations

Destination	2-digit	Product group	2002	max (year)		2018
China	27	Crude fertilizers other than division 56 / crude minerals	0,56	3,67	(2017)	3,50
Italy	42	Fixed vegetable oils and fats, crude, refined or fraction.	4,30	6,68	(2005)	2,85
Turkey	26	Textiles fibres and their wastes	2,96	4,49	(2009)	1,22
North Macedonia	35	Electric current	0,00			1,05
Italy	21	Hides, skins and fur skins, raw	0,44	1,38	(2017)	0,97
Italy	35	Electric current	0,00	1,50	(2012)	0,95
Germany	02	Dairy products and birds' eggs	0,81	1,15	(2016)	0,94
Italy	03	Fish, crustaceans, molluscs and preparations thereof	1,06	1,78	(2007)	0,92
Egypt	26	Textiles fibres and their wastes	0,15	1,40	(2008)	0,83
Belgium	12	Tobacco and tobacco manufactures	0,29	1,26	(2017)	0,83
Slovenia	35	Electric current	0,00	1,76	(2012)	0,72
Germany	05	Vegetables and fruits	1,69			0,71
Italy	68	Non-ferrous metals	1,01			0,69
Bulgaria	12	Tobacco and tobacco manufactures	0,21	1,27	(2016)	0,66
Libya	12	Tobacco and tobacco manufactures	0,03	1,40	(2015)	0,51
Turkey	21	Hides, skins and fur skins, raw	0,93	1,51	(2011)	0,45
Israel	27	Crude fertilizers other than division 56 / crude minerals	0,18	2,33	(2006)	0,20
Bulgaria	06	Sugar, sugar preparations and honey	0,08	1,22	(2010)	0,15
United States	12	Tobacco and tobacco manufactures	0,96	1,44	(2005)	0,11
Germany	84	Articles of apparel & clothing accessories	0,95	1,03	(2003)	0,11
Russian Federat.	27	Crude fertilizers other than division 56 / crude minerals	0,02	3,76	(2006)	0,03

Note: UNCTADStat data.

Appendix III. The 197 importer/exporter countries or territories included in the sample

Afghanistan	Cuba	Kuwait	Rwanda
Albania	**Cyprus**	Kyrgyzstan	Saint Kitts and Nevis
Algeria	**Czechia**	Lao People's Dem. Rep.	Saint Lucia
Andorra	Denmark	Latvia	St Vincent and the Grenadines
Angola	Djibouti	**Lebanon**	Samoa
Anguilla	Dominica	Lesotho	Sao Tome and Principe
Antigua and Barbuda	Dominican Republic	Liberia	**Saudi Arabia**
Argentina	Ecuador	**Libya**	Senegal
Armenia	**Egypt**	Lithuania	Seychelles
Aruba	El Salvador	Luxembourg	Sierra Leone
Australia	Equatorial Guinea	Madagascar	**Singapore**
Austria	Eritrea	Malawi	Slovakia
Azerbaijan	Estonia	Malaysia	**Slovenia**
Bahamas	Eswatini	Maldives	Solomon Islands
Bahrain	Ethiopia	Mali	Somalia
Bangladesh	Fiji	**Malta**	South Africa
Barbados	Finland	Marshall Islands	**Spain**
Belarus	**France**	Mauritania	Sri Lanka
Belgium	French Polynesia	Mauritius	State of Palestine
Belize	Gabon	Mexico	Suriname
Benin	Gambia	Micronesia (Fed. States)	Sweden
Bermuda	Georgia	Mongolia	Switzerland
Bhutan	**Germany**	Morocco	Syrian Arab Republic
Bolivia (Plurin. State)	Ghana	Mozambique	Tajikistan
Bosnia and Herzegovina	Greece	Myanmar	Thailand
Botswana	Greenland	Namibia	Togo
Brazil	Grenada	Nauru	Tonga
British Virgin Islands	Guatemala	Nepal	Trinidad and Tobago
Brunei Darussalam	Guinea	**Netherlands**	Tunisia
Bulgaria	Guinea-Bissau	New Caledonia	**Turkey**
Burkina Faso	Guyana	New Zealand	Turkmenistan
Burundi	Haiti	Nicaragua	Turks and Caicos Islands
Cabo Verde	Honduras	Niger	Tuvalu
Cambodia	Hungary	Nigeria	Uganda
Cameroon	Iceland	**North Macedonia**	Ukraine
Canada	India	Norway	**United Arab Emirates**
Cayman Islands	Indonesia	Oman	**United Kingdom**
Central African Republic	Iran (Islamic Republic)	Pakistan	United Republic of Tanzania
Chad	Iraq	Palau	**United States of America**
Chile	Ireland	Panama	Uruguay
China	**Israel**	Papua New Guinea	Uzbekistan
China, Hong Kong SAR	**Italy**	Paraguay	Vanuatu
China, Taiwan Province	Jamaica	Peru	Venezuela (Bolivarian Rep.)
Colombia	Japan	Philippines	Viet Nam
Comoros	Jordan	**Poland**	Yemen
Congo	Kazakhstan	Portugal	Zambia
Cook Islands	Kenya	Qatar	Zimbabwe
Costa Rica	Kiribati	Republic of Moldova	
Côte d'Ivoire	Korea, Dem. People's Rep.	**Romania**	
Croatia	Korea, Republic of	**Russian Federation**	

Note: Greece's major trading partners (exports) denoted in **bold** characters