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Regional specialization and public infrastructure investments: Empirical evidence from Greece

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CENTRE OF PLANNING AND ECONOMIC RESEARCH

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Regional specialization and public infrastructure investments: Empirical evidence from Greece

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Abstract

This paper aims to disentangle the effects of various types of public infrastructure investments on the regional specialization of broad sectors of economic activity. The dataset originates from the Monitoring Information System of the Greek government concerning all public investment projects funded by the European Commission and national resources at the prefecture level during 2000-2008. A system-wide model of panel regression equations is employed so that to recognize the significance of spatially fixed effects and that the determinants of specialization vary with each specific sector. The role of market access on specialization is found to be conflicting with that of regional public investments, especially with regard to road expenditure. In particular, the reduction of specialization of manufacturing is associated with improved market access. However, increased regional investment shares on roads, airports and seaports are related to higher specialization of manufacturing. Last, reduced specialization of non-financial services is associated with more regional public investments in roads, but it is inversely related to more regional public investments in ICT and R&D, as well as higher market access.

Εμπειρική ανάλυση της επίδρασης των δημόσιων επενδύσεων στην περιφερειακή εξειδίκευση στην Ελλάδα

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Περίληψη

Η εργασία έχει ως κύριο στόχο να διαχωρίσει τις επιδράσεις των δημόσιων επενδύσεων ανά κατηγορία υποδομής στην περιφερειακή εξειδίκευση των ευρύτερων κλάδων οικονομικής δραστηριότητας στην Ελλάδα. Τα δεδομένα βασίζονται στο Ολοκληρωμένο Πληροφοριακό Σύστημα της Ελληνικής κυβέρνησης και αφορούν όλες τις πραγματοποιηθείσες δαπάνες για επενδύσεις που έχουν χρηματοδοτηθεί από Ευρωπαϊκούς και εθνικούς πόρους κατά την περίοδο 2000-2008, σε επίπεδο Νομού. Το πρόβλημα διαμορφώνεται ως ένα σύστημα έξι εξισώσεων με δεδομένα διαστρωματικών χρονοσειρών για κάθε κλάδο της οικονομικής δραστηριότητας. Σύμφωνα με την ΕΛ.ΣΤΑΤ., οι έξι κλάδοι αναφέρονται στον πρωτογενή τομέα, την μεταποίηση, τις κατασκευές, τις μη-χρηματοπιστωτικές υπηρεσίες, τις χρηματοπιστωτικές υπηρεσίες, και τις λοιπές υπηρεσίες. Η συγκεκριμένη οικονομετρική μεθοδολογία επιτρέπει τον καθορισμό της επίδρασης των χωρικά σταθερών παραγόντων στην εξειδίκευση κάθε κλάδου. Επίσης, αναγνωρίζεται η πιθανή ύπαρξη συσχετισμών μεταξύ των συναρτήσεων εξειδίκευσης κάθε κλάδου και ότι η επίδραση των προσδιοριστικών παραγόντων μεταβάλλεται ανάλογα με τα κλαδικά χαρακτηριστικά. Οι προσδιοριστικοί παράγοντες αφορούν, εκτός από τις δημόσιες επενδύσεις ανά κατηγορία υποδομής, την πληθυσμιακή πυκνότητα, το κατά κεφαλήν περιφερειακό ΑΕΠ, την πρόσβαση στην αγορά, που εκφράζεται ως συνάρτηση της δυνητικής αγοράς, και το ανθρώπινο κεφάλαιο. Τα αποτελέσματα δείχνουν την ύπαρξη μιας σημαντικής ανταγωνιστικής σχέσης μεταξύ της πρόσβασης στην αγορά και των δημοσίων επενδύσεων, κυρίως σε οδούς, όσον αφορά στην επίδρασή τους στην περιφερειακή εξειδίκευση. Η σχετικά χαμηλή εξειδίκευση στη μεταποίηση τείνει να συνδέεται θετικά με τη βελτιούμενη πρόσβαση σε αγορές, και αρνητικά με τα αυξανόμενα μερίδια επενδύσεων σε οδούς, λιμένες και αεροδρόμια. Ωστόσο, η σχετικά χαμηλή εξειδίκευση στις μη-χρηματοπιστωτικές υπηρεσίες τείνει να συνδέεται θετικά με τα αυξημένα μερίδια επενδύσεων σε οδικά έργα, και αρνητικά με τα αυξημένα μερίδια επενδύσεων σε τεχνολογίες πληροφορικής και επικοινωνιών και έργα έρευνας και τεχνολογικής ανάπτυξης, καθώς και με τη μεγαλύτερη πρόσβαση σε αγορές.

1. Introduction

Regional specialization typically refers to the relative specialization of a region in a specific (sub-)sector of economic activity (e.g., agriculture, manufacturing, services), with respect to the other regions of a given spatial economic entity (e.g., a country). Various theoretical frameworks have been developed to study and explain regional specialization patterns. Earlier attempts are dated back to the development of theories about external scale economies (Marshall, 1890), international trade (Ohlin, 1933) and industrial location (Isard, 1956). Henderson's (1974) theory explained specifically the optimal size and distribution of cities in relation to the specialization and the scale of external economies of each industry. Later, Krugman's (1991a) pioneering work has been an important step to bring international economics and regional economics closer together and to develop an integrated theoretical framework of industrial location that encompasses elements of trade theory, economic geography and urban economics.

Despite these theoretical developments, the explanation of the level and patterns of regional specialization (and diversity) has attracted the attention of the literature only since the last decade, mostly at the cross-country level (Kalemli-Ozcan et al., 2003; Stirboeck, 2004) and, at a lesser extent, at within-country, city (Duranton and Puga, 2000) or (sub)regional level (Bishop and Gripaios, 2007). At the regional level, (increased) specialization has often been found to make regions vulnerable to local or global recession of major activities. This is because it may 'capture' those activities into specific ways of production and limits their ability to adapt to changes (adaptive capacity) and innovate in a new economic environment (Martin and Sunley, 2003). In opposite, diversity may arguably promote entrepreneurship, economic stability and long-term growth prospects (Chapman et al., 2004; Siegel et al., 1995), particularly, if it facilitates Jacobs-type spillovers that arise from the interaction of firms in different sectors (Frenken et al., 2004).

Nonetheless, the regional technological specialization can be an asset when a critical mass is achieved, especially in smaller regions (Ejermo, 2005). Under certain circumstances, regional specialization may boost the industrial upgrade and technological progress (Zhou et al., 2011). But such agglomeration patterns are largely considered to be associated with industry growth and productivity in the short run, rather in the long run (Hanson, 2001). For the case of Greece, Fotopoulos et al. (2010) found that relatively more specialized regions grow faster, on average, in employment terms, than the less specialized ones, but this effect mostly relates to the growing economic sectors rather than the declining ones. Therefore, as it

was recently stressed by Prager and Thisse (2012), there is no clear-cut conclusion about whether more (less) specialization and less (more) diversification should be more appropriate for the development of a region.

In order to understand this relationship and design suitable policies, the main drivers of specialization should first be recognized by examining a multitude of factors, such as market access, human capital, agglomeration economies and economic performance in the region. Moreover, this paper concentrates on factors whose impact on specialization has been hitherto neglected or overlooked in the existing literature, and it suggests a methodological approach for taking them into account. Specifically, it performs a system-wide econometric analysis of how policy factors related to the regional allocation of public investments have jointly affected the specialization patterns of spatial economic activity in Greece, at the sub-regional level of prefectures.

In contrast with other relevant studies in the literature, the current one investigates the regional specialization of broad sectors of economic activity in the country, rather than the whole economy or only a specific sector (typically, manufacturing). This is because public infrastructure investments and other covariates can have diverse (non-uniform) effects on specialization across different sectors in a region (Beaudry and Schiffauerova, 2009). As explained by Brulhart and Mathys (2008) and de Graaf et al. (2012), these differences can be related to the nature and tradability of products versus that of services, the kind of services (financial vs. non-financial, private vs. public-sector) and the resource, labor, capital and knowledge intensities of sectors. Additionally, there can be systematic variations in the underlying technology, spatial resource mobility, industrial structure and competition conditions (Bishop and Gripaios, 2007; Billings and Johnson, 2012).

The paper is organized as follows: Section 2 presents the theoretical background and literature review. Section 3 describes the data used to represent regional specialization and the explanatory variables, and the specification of the system-wide econometric model. Section 4 demonstrates the patterns of regional specialization in Greece during the study period. Section 5 reports and discusses the results of the empirical analysis. Section 6 provides conclusions and policy implications.

2. Theoretical Background and Literature Review

Theoretical models of regional specialization can be broadly categorized into three distinct frameworks, i.e., those of traditional trade theory, new trade theory, and new economic

geography (NEG). In the traditional trade theory, industry location is determined exogenously by regional characteristics. From a regional science perspective, this theory underpins location advantage models, where the regional characteristics are the sources of the supply-driven (production factor-related) location advantages. In this framework, if there are no differences in the exogenous regional characteristics or if trade/transport costs are extremely high, then, economic activities will be perfectly dispersed across space.

New trade theory (e.g. Krugman, 1980; Helpman and Krugman, 1985) focuses on industry-specific characteristics and domestic market size. The theory predicts the "home market" effect, where regions specialize in and export those products in which they have a large domestic market. Here the interplay between economies of scale and trade/transport costs is crucial. Firms are spatially concentrated in one region (with the largest demand) in order to realize scale economies and minimize trade costs. The importance of the domestic market for location and specialization patterns is also emphasized in the central place models of the regional science and geography literature (Dewhurst and McCann, 2007).

In the NEG framework, regions are assumed to be identical in all aspects and the core-periphery pattern is determined endogenously. An initial "symmetric equilibrium" can result in a new locational equilibrium, where production and demand structures across regions are no longer identical. Industrial location becomes entirely endogenous, because of either market size spillovers (Krugman, 1991a) or vertical (input-output) linkages among industries (Venables, 1996), which can induce circular processes of agglomeration. First, closer economic integration can lead two identical regions to become differentiated into a manufacturing core and an agricultural periphery. Second, it can lead to the concentration of vertically linked industries in one location. The outcome in both cases is the creation of divergent regional specialization patterns.

Based on this framework, public policy measures such as those related to the amount, spatial allocation and composition of investments, can have a significant impact on the specialization (or diversification) of economic activities. Specifically, regional policy, according to the traditional location/trade theory, may focus on improving those determinants associated with the location advantages of a region. The NEG framework further suggests that regional policy must take into account various interrelated factors operating in the spatial economic system (Baldwin et al., 2005). Specifically, the same measure that has already been implemented in a given setting can produce a different outcome when implemented at another setting. Besides, relatively small policy interventions can produce a large impact on regional economic activity, in cases where no large differences exist in the spatial distribution of

industry and agglomeration economies. In such a scenario, a policy first implemented in a region can cause inward industry relocation and growing agglomeration economies.

Particularly with regard to the impact of public infrastructure investments, existing theoretical interpretations and a few empirical findings are rather ambiguous about whether such investments are linked with a more specialized or diversified economy in a region. Holl (2004) found that new road infrastructure first facilitates sectoral concentration, which is then accompanied by geographical dispersion of manufacturing, although this impact varies across industries. Horst and Moore (2003) showed the existence of a statistically significant positive association between road capacity/quality and industrial diversity. This relationship was attributed to the fact that investment for better highways fosters the industrialization process and increases the degree of diversity in the economy, for both rural and urban areas.

On the contrary, Anderson et al. (2010) used a shift-share analysis to demonstrate a process of transformation from a goods producing economy to a service economy along two US highway corridors. This outcome could be interpreted by the fact that transport cost reductions and service improvements expand the markets for firms, so that economies of different localities and regions are linked with each other and are shifted from local and regional autarky to increasing specialization and trade. Additionally, Kadokawa (2011) showed the influence of highways and other transport services on the formation of industrial specialization, especially in more traditional (light) types of industries, which are more dependent on raw material inputs, compared to other industries, such as those of high-technology, which are attracted to metropolitan areas that are better equipped with transport means.

The magnitude of the impact of some investment on specialization may vary according to the typology and scale of infrastructure, and the resulting changes in the attraction of economic activity or the accessibility, or both. Economic activity is arguably dispersed with high transport costs, as firms need to supply markets locally. By reducing transport costs, the connectivity between core and periphery increases and firms do not need to spread out to serve markets locally. In this sense, lower intraregional or inter-urban transport costs favor the development of a system of specialized cities, whereas higher transport costs favor the development of a system of diversified cities (Abdel-Rahman and Anas, 2004). Nonetheless, it is noted that different assumptions adopted in theoretical models of land use and transport may lead to divergent conclusions about the impact of transport cost and investment on regional specialization.

Furthermore, investments in different modes can yield varying reductions of transport cost through increasing network connectivity and interoperability, and interact with different aspects of market access in areas with different business mix (Alstadt et al., 2012). The higher density and lower cost of road and public transport connections can reduce transport input per unit of production, improve market demand and reliability of (just-in-time) good deliveries and diminish inventories and storage cost, leading to increased industry agglomeration and productivity gains (Shefer and Aviram, 2005; Graham, 2007; Chatman and Noland, 2011; Song et al., 2012). But new transport modes may compete with old ones and induce additional costs when they have to be integrated with the existing network and increase the total distance covered (Combes and Linnemer, 2000). Different types of infrastructure can act on different sources of market size and production cost asymmetries and, hence, lead to different spillover effects (Banister and Berechman, 2003; Ottaviano, 2008). In the case of transport hubs and gateways (e.g., airports and seaports), which can constitute part of wider infrastructure corridors, there are persistent lock-in effects of self-reinforcing agglomeration, as generated by the interaction between increasing returns and falling transport costs (Fujita and Mori, 1996). According to Fujita et al. (2001), there is a threshold beyond which these lock-in effects vanish and a shift of the existing pattern of specialization to a new one ("punctuated equilibrium") is triggered.

Moreover, investments on (transport) infrastructure across different (intraregional *vs*. interregional) scales interact with each other and influence the spatial economy of the regions. On the one hand, a reduction of the interregional transport cost has been found to increase polarization of the space economy, but a reduction of the local transport cost in less developed regions favors a more balanced development (Krugman, 1991b; Vickerman et al., 1999; Martin, 2000). On the other hand, it has been argued that improved interregional infrastructure can support a more even distribution of economic activities when the prices of non-tradables are much lower in less developed regions and when it promotes long-distance commuting (Puga, 1999; Ottaviano, 2008). Mora and Moreno (2011) demonstrated that enhancements in the interregional transport network accessibility have gradually led to a decrease in the regional specialization in the European Union (EU) countries. This finding contradicts with that of Martin and Rogers (1995), who argued that accessibility is associated with higher diversification at the first stages of the integration process and higher specialization at the later stages. Divergent patterns of spatial organization of industries between the international and domestic (and regional) levels may also appear due to

simultaneous dispersion and agglomeration forces acting at different geographical scales (Cutrini, 2010).

As far as other types of infrastructure investments is concerned, those on Information and Communication Technologies (ICT) can facilitate the long-distance communication at decreasing costs, which may imply a weakening of the attractiveness of the core region and reduced need for the geographical proximity of firms (e.g., Ioannides et al., 2008). However, ICT investments can promote knowledge spillovers, social interaction and learning processes so that enhance the spatial agglomeration of industries (e.g., Gaspar and Glaeser, 1998; Hong and Fu, 2011). Investments on Research and Development (R&D) activities are also typically associated with knowledge spillovers and innovation of firms, which increase the levels of industrial agglomeration in a region (Lovely et al., 2005).

Summing up, public investments in different categories of the transport sector and other infrastructure networks can significantly affect (either positively or negatively) the specialization of economic activity in a region. The present study jointly considers the impact of investment in various types of physical infrastructure (road, non-road transport and non-transport, such as energy, ICT and R&D) on the regional specialization of distinct economic sectors. The effects of several control factors are taken into account, including market access, human capital and agglomeration economies. The following section describes in detail the measurement of regional specialization and the explanatory variables used in the present study.

3. Data and Econometric Methodology

3.1. Description of data for specialization and explanatory variables

The principal aim of the study is to identify the impact of different types/categories of public investments on regional specialization. For this purpose, a unique and comprehensive dataset is constructed, as originated from the Monitoring Information System (MIS) of the Greek government, which archives realized expenditure information (in actual spending euro) about all public investment projects funded by the European Commission and the Public Investment Program (PIP) of the country. The realized expenditure offers a precise metric of the public investment activity, with detailed information about its temporal and spatial distribution. The analysis is carried out at the administrative sub-regional (NUTS III) level of prefecture. Expenditures concerning large-scale infrastructure investments spanning more than one

prefecture are geographically approportioned according to the area covering in each prefecture. The study period spans between 2000-2008, which encompasses the third programming period 2000-2006 of the Community Support Framework (CSF) and the first years of implementation of the National Strategic Reference Framework (NSRF) 2007-2013 of the European Union.

Based on the Hellenic Statistical Authority (ELSTAT), six broad economic sectors are distinguished here, according to the statistical classification of economic activities in the European Community (NACE, Rev. 1.1):

(i) Agriculture, hunting, forestry, fishing, mining and quarrying.

(ii) Manufacturing, including energy.

(iii) Construction activities, including demolition and site preparation, general construction, installation and completion works, and renting of construction equipment.

(iv) Main non-financial services: wholesale and retail trade, repair of motor vehicles, motorcycles and personal and household goods, hotels and restaurants, transport, storage and communications.

(v) Financial services: financial intermediation, real estate, renting and business activities.

(vi) Other non-financial services: mainly encompass the public-sector services, such as those concerning public administration and defence, social security, education, health and social work, sports, entertainment and culture.

Namely, there is a total number of 51 (prefectures) x 9 (years) = 459 x 6 (sectors) = 2754 observations.

The Location Quotient (LQ) is a widely accepted and well interpreted index of regional specialization, which depicts the degree of concentration of a sector in some region (Krugman, 1991a; Glaeser, 1992). The measure of LQ of sector i in region r in year period t is defined as:

$$\mathrm{LQ}_{\mathrm{irt}} = \frac{V_{irt}/V_{rt}}{V_{it}/V_{t}}, \qquad (1)$$

where V_{irt} denotes the gross value added (GVA) of sector i in region r, V_{rt} the total GVA (of all sectors) in region r, V_{it} the national (of all regions) GVA in sector i and V_t the national GVA of all sectors. If $LQ > 1$, the clustering of firms of sector i in region r is larger than the national average; hence, sector i is relatively specialized in that region. If $LQ < 1$, sector i is relatively underrepresented in region r. If $LQ = 1$, the specialization of sector i in region r equals the national average.

The determinants related to the public investment variables correspond to different expenditure categories, depending on the type of infrastructure. The eleven categories of public investment (and their country-wide period-average expenditure shares) are: (i) roads, including bridges (24.6%), (ii) railways (6.3%), (iii) airports and aviation (1.1%), (iv) seaports and maritime transport (1.6%), (v) urban public transport (2.3%), (vi) energy production and distribution infrastructure (0.7%), (vii) ICT (4.1%), (viii) R&D projects for promoting innovation and product quality (1.7%), (ix) environmental projects, including water supply, sanitation, wastewater treatment, flood prevention, site regeneration, and upgrading of cultural and leisure areas (16.4%), (x) agri-food industry projects, including livestock, fishing, forest restoration, aquaculture and alternative farm investments (9.9%), and (xi) social infrastructure and services, including education, training and employment, health and social welfare, public safety and security (31.3%). The various types of transport investments, together with those of energy and ICT, constitute the main sources of planning, design and operation of infrastructure networks in the country. However, it is mentioned that, given the peculiar geomorphology of the country and a multitude of other factors (Tsekeris, 2011), their expenditure shares present significant variations across regions.

In addition to the various types of public investments, regional specialization can be also influenced by other factors, for which detailed data at the prefecture level are available. These factors refer to:

(a) Market potential, as a measure of market access (or market size), which reflects the importance of scale economies and transport costs. It recognizes that the location of firms in a sector may be differentially dependent on their proximity to customers or output markets, to have the largest possible market for selling their products/services. Following Harris (1954), the market potential MP_r is expressed as a function of the

weighted average of the gross regional product (GRP) of the region r itself as well as its neighbors r', where the weights are inverse to the bilateral distance $D_{rr'}$:

$$\mathrm{MP_r} = \sum_{r' \neq r} \frac{GRP_{r'}}{D_{rr'}} \tag{2}$$

The above definition adopts the rough but reasonable approximation that one percent increase in the bilateral distance causes the market access to region r to fall by one percent. The distance $D_{rr'}$ relates to the road network length between the centroid (capital) of each prefecture. In the case of island prefectures, the coast-wise shipping network length is taken into account.

(b) Human capital endowment level, which is here proxied by the ratio of the students graduated from the secondary education with excellent grade to the total number of school graduates in a prefecture[1]. This definition relates human capital with talent and the potential for highly qualified labor in that prefecture, which may foster the concentration of firms of a sector, due to benefits for knowledge spillovers.

(c) Density of population, as a proxy for the effect of agglomeration economies, and

(d) Regional level of development, which may depict the total economic performance of the region, proxied by the per-capita GRP.

3.2. System-wide econometric modeling of regional specialization

Due to data unavailability at a detailed sub-regional level, we cannot include variables reflecting some determinants associated with the models of general trade theory and NEG, further than those of market potential and human capital. These unobserved variables, together with other ones not related to public policy, help to produce unbiased (from omitted variables) and precise coefficient estimates (in terms of the magnitude of the effect) of the investment variables, which are the primary focus of investigation.

Specifically, the panel structure and limited time period (spanning over relatively few years) of the study are exploited here. In this short panel framework, unobserved factors attributed to trade theory (e.g. regional comparative advantage due to factor endowments or

[1] The specific human capital index was selected for use here because it was found to yield a coefficient with (higher) statistical significance than other relevant metrics, such as the school enrollment and graduation ratios.

labor productivities) and NEG (e.g. vertical linkages or market size) may be plausibly assumed as remaining unchanged (or only slightly changed), as considerable time has to pass for those changes to occur. Hence, they can be treated as constants in the panel regression equations, in which they are captured by the fixed-effects. On the other hand, the magnitude of public investments (funded by both EU and national resources) has been considerably changed during the given time period, with an average overall rate of increase that exceeds 21% per year (from €861.4 million in 2000 to €4052.0 million in 2008)[2]. Therefore, the inclusion of unobserved omitted factors (fixed effects) helps to avoid an upward bias in estimating the impact and statistical significance of the public investment variables on regional specialization.

In order to take into account the fact that the impact of public investments and other factors may vary across sectors, a system-wide modeling approach is proposed here. This approach explicitly recognizes the three-way variation of determinants, with respect to region, time and sector. It also addresses the cross-sectoral equation residual correlation, which accounts for possible inter-industry linkages among regional specialization patterns (Lanaspa Santolaria et al., 2012). The explanatory variables are introduced as lagged one period so as to avoid contemporaneous bias. The presence of dynamics and correlated group-effects, as the result of particular regional advantages sought by each industry, and time-specific effects in the model structure increases the precision and consistency of parameter estimates. Hence, for the causal analysis of regional specialization, in terms of the LQ, a system of fixed-effects panel regression equations is specified, as follows:

$$
\begin{aligned}
&\mathrm{LQ}_{1\mathrm{rt}} = a_1 + \sum\nolimits_{\mathrm{k}}^{\mathrm{K}} b_{1\mathrm{k}}\, Z_{1\mathrm{krt}-1} + c_1\, \mathrm{MP}_{1\mathrm{rt\text{-}1}} + d_1\, \mathrm{HC}_{1\mathrm{rt\text{-}1}} + e_1\, \mathrm{GRP}_{1\mathrm{rt\text{-}1}} + f_1\, \mathrm{PD}_{1\mathrm{rt\text{-}1}} + g_{1r}\, \boldsymbol{\delta}_{\mathrm{r}} + h_{1t}\, \boldsymbol{\theta}_{\mathrm{t}} + \varepsilon_1 \\
&\vdots \qquad \vdots \qquad \vdots \qquad \vdots \qquad \vdots \qquad \vdots \qquad \vdots \qquad \vdots \qquad \vdots \qquad \vdots \\
&\mathrm{LQ}_{\mathrm{irt}} = a_i + \sum\nolimits_{\mathrm{k}}^{\mathrm{K}} b_{\mathrm{ik}}\, Z_{\mathrm{ikrt}-1} + c_i\, \mathrm{MP}_{\mathrm{irt\text{-}1}} + d_i\, \mathrm{HC}_{\mathrm{irt\text{-}1}} + e_i\, \mathrm{GRP}_{\mathrm{irt\text{-}1}} + f_i\, \mathrm{PD}_{\mathrm{irt\text{-}1}} + g_{ir}\, \boldsymbol{\delta}_{\mathrm{r}} + h_{it}\, \boldsymbol{\theta}_{\mathrm{t}} + \varepsilon_i \qquad (3) \\
&\vdots \qquad \vdots \qquad \vdots \qquad \vdots \qquad \vdots \qquad \vdots \qquad \vdots \qquad \vdots \qquad \vdots \qquad \vdots \\
&\mathrm{LQ}_{6\mathrm{rt}} = a_6 + \sum\nolimits_{\mathrm{k}}^{\mathrm{K}} b_{6\mathrm{k}}\, Z_{6\mathrm{krt}-1} + c_6\, \mathrm{MP}_{6\mathrm{rt\text{-}1}} + d_6\, \mathrm{HC}_{6\mathrm{rt\text{-}1}} + e_6\, \mathrm{GRP}_{6\mathrm{rt\text{-}1}} + f_6\, \mathrm{PD}_{6\mathrm{rt\text{-}1}} + g_{6r}\, \boldsymbol{\delta}_{\mathrm{r}} + h_{6t}\, \boldsymbol{\theta}_{\mathrm{t}} + \varepsilon_6
\end{aligned}
$$

In this system of six panel regression equations, one for each broad economic sector $i = 1,\ldots,6$, there are K types of public investment variables Z_{ikrt}, with $\mathrm{k} = 1,\ldots,\mathrm{K}$, at each prefecture r and time (year) t, and b_{ik} are the corresponding coefficients. The expression of

[2] All prices have been deflated in constant values using the 2005 base year.

these variables as shares of the total public spending in prefecture r and time t signifies that their magnitude can relatively change between each other and the existence of budget constraints. For robustness purposes, the effect on regional specialization of public investment variables in real terms (i.e., constant 2005 year prices) is also tested (Section 5). The other explanatory (control) variables refer to the market potential (MP), human capital (HC), per-capita gross regional product (GRP) and population density (PD), where c_i, d_i, e_i and f_i are their corresponding coefficients for sector i.

Moreover, $\boldsymbol{\delta}_{\mathrm{r}}$ are time-invariant prefecture-specific dummies, with g_{ir} the corresponding spatial dummy coefficients for sector i, which account for unobserved or omitted heterogeneity, and $\boldsymbol{\theta}_{\mathrm{t}}$ the prefecture-invariant time-specific dummies, with h_{it} the corresponding time dummy coefficients for sector i. The former dummies may capture the influence of factors that do not vary over time, e.g., geographical location, land morphology and climate conditions, while, the latter ones the influence of factors that do not vary across regions, e.g., technological changes, and EU and national fiscal policies for the whole country. The term $\varepsilon_i \sim N(0, \sigma^2)$ denotes the serially uncorrelated random disturbance of the regional specialization of each sector i.

The present system comprises a set of Least-Squares equations with Dummy Variables (LSDV) that leads to asymptotically efficient estimators, unlike Ordinary Least Squares (OLS) which do not guarantee efficient estimates of the model coefficients (Baltagi, 2005). It constitutes a three-way model, which can appropriately treat the sector-region interactions and panel effects of the dataset and provides robust estimates. The estimator which is used to solve the model, that is linear in parameters, refers to the iterative method of Seemingly Unrelated Regressions (SUR) with fixed effects, which enables to capture time- and prefecture-invariant effects specific to each sector on specialization.

4. Patterns of Regional Specialization

This section briefly investigates the patterns of regional specialization in Greece and their trends over the study period 2000-2008. The exploratory analysis is based on the calculation of the LQ indices in each region (prefecture) in each of the six broad economic sectors. Before examining the regional specialization in relative terms, i.e., in terms of the LQ, it is informative to look first at the spatial distribution of economic activities in the six sectors

across the 13 NUTS II regions. The analysis, which uses the GVA per sector, indicates the extent of absolute concentration or specialization of the regions in specific activities within the country. The results are illustrated in Figures 1 and 2 for 2000 and 2008, respectively.

Figure 1. Spatial distribution of the total sectoral GVA in the six broad sectors across 13 NUTS II regions in 2000

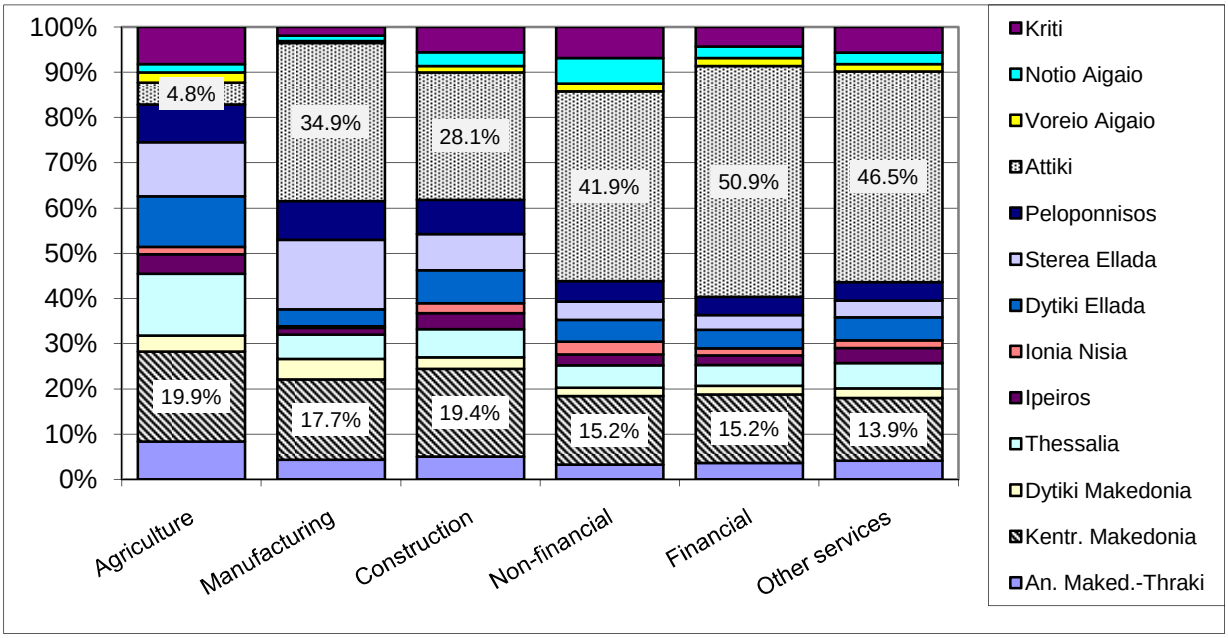
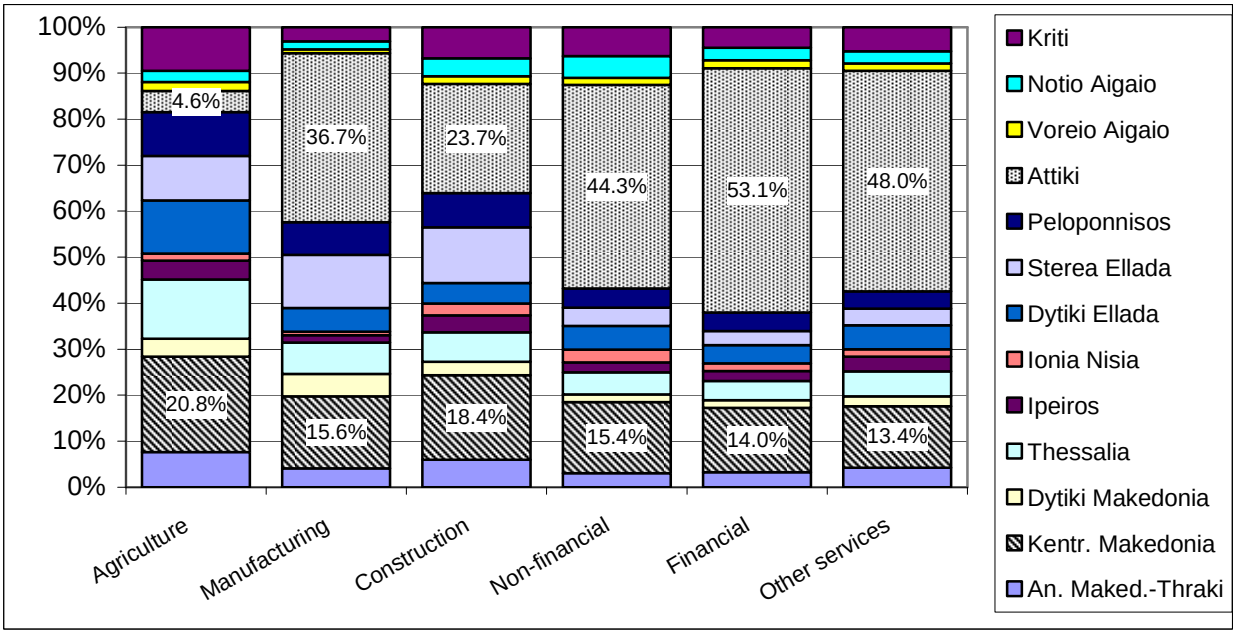


Figure 2. Spatial distribution of the total sectoral GVA in the six broad sectors across 13 NUTS II regions in 2008



It is immediately evident that many sectors are concentrated in Attiki (the Athens region), particularly financial services (>50%). In contrast, agriculture in the capital region exhibits a very small share (<5%) in the total agricultural production of the country. Kentriki Makedonia, in which the metropolitan city of Thessaloniki is located, has also significant shares of the total activity in Greece in several sectors, including agriculture (about 20-21%). This NUTS II region is more diversified compared to Attiki, wherein financial and other services are very important. The remaining regions, which population wise are much smaller than the above two 'central regions' of the country, exhibit low shares in most sectors with a few exceptions, especially in the case of agriculture, manufacturing and construction. Regarding the temporal trends of specialization between 2000 and 2008, Attiki notably strengthens its dominant position in the various service sectors, as well as in manufacturing.

Table 1. Average level of regional specialization level (LQ **) by sector, 2000-2008**

Year	Agriculture	Manufacturing	Construction	Non-Financial	Financial	Other Services
2000	1.841	0.832	1.271	0.981	0.832	0.950
2001	1.916	0.887	1.269	0.982	0.811	0.893
2002	1.924	0.959	1.180	0.998	0.812	0.902
2003	1.930	0.961	1.172	0.983	0.821	0.927
2004	1.937	0.959	1.195	0.965	0.824	0.970
2005	1.930	0.959	1.352	0.947	0.814	0.964
2006	1.955	0.985	1.389	0.935	0.825	0.979
2007	1.960	0.999	1.383	0.937	0.830	0.987
2008	1.964	0.990	1.439	0.954	0.832	0.987

As an overview of the extent of regional specialization in each of the six sectors, Table 1 presents the average specialization levels per sector, calculated from averaging the LQ indices across prefectures. Furthermore, Table 2 reports the LQ indices of the top 10 prefectures in each sector in 2000 and 2008. It is evident that the sectors of construction and, particularly, agriculture show the highest extent of regional specialization, relative to the other sectors. This outcome possibly suggests, among other things, that either many prefectures exhibit relatively high LQ indices or that a few prefectures are highly specialized, exhibiting very high LQ indices in those sectors. Careful examination of the descriptive analysis reveals in the fact that a relatively large number of prefectures exhibit high LQ indices in agriculture, relative to other sectors (Table 2). Besides, in the above two sectors, there is an apparent upward trend in specialization during 2000-2008.

Table 2. Most specialized prefectures (top 10) by sector in years 2000 and 2008

Year	Agriculture		Manufacturing		Construction	
2000	Ilia	4.30	Viotia	4.16	Thesprotia	2.55
	Karditsa	3.76	Korinthia	3.20	Halkidiki	2.34
	Pella	3.70	Kozani	2.70	Pieria	2.13
	Serres	3.37	Kilkis	1.92	Etoloakarnania	2.05
	Pthiotida	2.97	Evia	1.81	Pthiotida	2.01
	Rothopi	2.95	Xanthi	1.74	Fokida	1.74
	Larisa	2.93	Arkadia	1.64	Arkadia	1.72
	Arta	2.83	Magnisia	1.44	Kefallonia	1.69
	Grevena	2.80	Thessaloniki	1.26	Evros	1.62
	Imathia	2.69	Pthiotida	1.24	Grevena	1.55
2008	Ilia	5.51	Viotia	3.88	Pthiotida	4.55
	Pella	5.07	Kozani	3.07	Grevena	3.09
	Imathia	4.26	Korinthia	2.62	Messinia	2.16
	Larisa	3.57	Kilkis	2.22	Kefallonia	2.11
	Lakonia	3.43	Arkadia	2.12	Kilkis	1.98
	Lasithi	3.23	Magnisia	2.01	Evros	1.96
	Argolida	3.12	Evia	1.74	Halkidiki	1.90
	Florina	3.11	Xanthi	1.64	Lefkada	1.88
	Serres	3.06	Florina	1.63	Korinthia	1.81
	Preveza	2.82	Achaia	1.20	Kavala	1.72
Spearman		0.857		0.925		0.360
p-value		0.000		0.000		0.010
Year	Non-Financial		Financial		Other Services	
2000	Dodecanisa	1.80	Kastoria	1.37	Ioannina	1.54
	Kerkyra	1.69	Attiki	1.26	Lefkada	1.34
	Zakynthos	1.61	Lesvos	1.20	Evritania	1.26
	Cyklades	1.59	Chios	1.15	Trikala	1.17
	Rethymno	1.42	Samos	1.08	Grevena	1.17
	Lasithi	1.39	Thessaloniki	1.07	Attiki	1.15
	Evritania	1.36	Fokida	1.01	Chania	1.14
	Samos	1.32	Lakonia	1.00	Drama	1.13
	Iraklio	1.28	Messinia	0.99	Iraklio	1.13
	Lefakda	1.26	Kavala	0.99	Lesvos	1.13
2008	Kerkyra	1.59	Chios	1.27	Evritania	1.63
	Zakynthos	1.58	Attiki	1.22	Ioannina	1.34
	Dodekanisa	1.47	Lesvos	1.12	Thesprotia	1.29
	Cyclades	1.34	Kastoria	1.09	Lefkada	1.24
	Kastoria	1.26	Kefallonia	1.06	Drama	1.21
	Iraklio	1.24	Thessaloniki	1.03	Grevena	1.21
	Rethymno	1.21	Samos	1.02	Arta	1.18
	Pieria	1.10	Lakonia	1.02	Preveza	1.15
	Thessaloniki	1.10	Cyklades	0.98	Florina	1.12
	Etoloakarnania	1.09	Messinia	0.97	Fokida	1.12
Spearman		0.789		0.886		0.825
p-value		0.000		0.000		0.000

On the other hand, the manufacturing sector generally exhibits relatively lower LQ indices, although they increase on average over time, reaching a value close to unity (Table 1). The prefectures of Viotia, Korinthia and Evia, which are either close to or bordering Attiki, present very high LQ indices in the manufacturing sector (Table 2). Relatively high LQ indices in the same sector are observed in some prefectures with large cities (Thessaloniki, Magnisia and Achaia) and other prefectures of mainland Greece. Hence, the proximity to large markets is only one among a multitude of factors (e.g., geographical constraints and closeness to natural resources) that influence the location of manufacturing in the country. The remaining sectors have on average LQ indices below unity (with non-financial services and other services to exhibit a higher LQ than financial services), and show a relatively stable trend. Some of the most specialized regions in non-financial services (including wholesale and retail trade, transport, hotels and restaurants) are strongly related to tourism, namely, they are important tourist destinations (island prefectures).

The regional specialization dynamics in the study period are calculated through the Spearman rank correlation coefficients between the LQ indices in 2000 and 2008 for each sector (using all prefectures, not just the top 10). A positive and high Spearman correlation indicates that ranking has largely remained the same, that is, the most specialized prefectures in the initial period (2000) are also the most specialized in the final period (2008) in a specific sector. On the contrary, a significantly high and negative Spearman correlation indicates a complete restructuring of a specific sector, that is, the least specialized prefectures have become the most specialized ones, and vice versa. The analysis reveals that, in most sectors, a restructuring of specialization has not occurred (Table 2). This is especially true in the manufacturing sector, where the Spearman rank correlation is 0.925. The latter outcome verifies the lack of large structural changes in the manufacturing activity of the country in the past decade (Vogiatzoglou and Tsekeris, 2013). However, in the construction sector the Spearman rank correlation is low (0.360), indicating that there has been a partial restructuring of that sector during the given period of large infrastructure project development. This change is also evident by comparing the top 10 prefectures in 2000 and 2008.

5. Results of Econometric Analysis

In the econometric analysis, several models are employed to help to disentangle the effects of various types of infrastructure investment shares on regional specialization. Table 3 presents the results of the determinants of specialization by considering the net effect of infrastructure investment, specified as a grouped variable, allowing for prefecture-specific fixed effects. For comparison purposes, Table A1 in the Appendix shows the results of this model without including prefecture-specific fixed effects. The rejection of the joint Wald test hypothesis of the non-significance of spatial dummy variables verifies the importance of recognizing these idiosyncratic effects on disentangling the impacts of market access, public investments and other determinants on regional specialization. Moreover, the comparison indicates that the omission of the spatial fixed effects is associated with a significant reduction of the statistical performance (goodness-of-fit) of the model. This outcome signifies that other region-specific factors not included in the model can control for the problem of unobserved omitted variables and explain to a large extent the variability of regional specialization patterns. Consequently, the model parameter estimates must be derived from a fixed-effects SUR model.

Table 4 presents the results by considering the net effect of transport investment, specified as a grouped variable, and the effect of all other infrastructure investment shares (for energy, ICT, R&D and environment) separately, specified as distinct variables. Table 5 presents the results by considering the effect of each transport category (for roads, railways, airports, seaports and urban public transport) separately, specified as a distinct variable, as well as the other infrastructure investment shares. For comparison purposes, Table A2 in the Appendix reports the results of the estimated effects of all categories of transport and other infrastructure investments in real (absolute) terms. The investment expenses for social welfare purposes are also included in the latter model as an explanatory variable. The social expenditure relates to redistributive social policies and provision of public goods, which may improve the operational environment of firms and increase the attractiveness of industry location, not only at the country (Görg et al., 2009) but also at the regional level.

By and large, the results demonstrate the existence of considerable differences in the statistical significance and direction of impact (sign) of coefficients related to investment variables on specialization. Specifically, the total infrastructure investment share has a statistically significant impact on promoting the regional specialization of the manufacturing and the financial and other (public-sector) service activities, while it diminishes the regional specialization of the main non-financial services (Table 3). The direction of the significant

impacts of market potential on regional specialization is found to be opposing with that of regional infrastructure investments. Particularly, the market potential has an adverse statistically significant effect on the specialization of manufacturing. This finding is consistent with that of Mora and Moreno (2010), according to which regions with higher accessibility cost need to be more specialized in one or a few manufacturing sectors than those regions lower accessibility costs. However, the opposite holds for the main non-financial services, which become less specialized with the increase of market access. This outcome arguably denotes the flexibility of the main services sector to adapt its structure to changes in the passenger and freight flows from and to some region due to improvements in accessibility conditions.

Table 3. Results of the determinants of regional specialization with the infrastructure investment as a grouped variable

Variables	Agriculture, forestry & fishing	Manufacturing (incl. energy)	Construction	Trade, tourism & transport	Financial, real estate & and business	Other service activities
Population density	0.0015 (0.791)	**-0.0037** **(0.027)**	**-0.0184** **(0.003)**	0.0024 (0.105)	-0.0011 (0.194)	**-0.0052** **(0.000)**
Per-capita GRP	**-0.0498** **(0.003)**	**0.0106** **(0.0365)**	**0.0674** **(0.000)**	0.0029 (0.521)	**-0.015** **(0.000)**	**-0.0218** **(0.000)**
Market potential	-0.2581 (0.698)	**-0.4703** **(0.018)**	0.0279 (0.970)	**0.4663** **(0.008)**	0.1410 (0.143)	**-0.2468** **(0.047)**
Human capital	**1.2506** **(0.058)**	0.2371 (0.228)	-0.5996 (0.406)	0.0023 (0.895)	**-0.2900** **(0.002)**	0.0477 (0.698)
Infrastructure investment	-0.0013 (0.296)	**0.0011** **(0.002)**	0.0010 (0.470)	**-0.0010** **(0.002)**	**0.0007** **(0.000)**	**0.0004** **(0.063)**
Agri-food sector investment	-0.0012 (0.392)	-0.0006 (0.168)	**0.0026** **(0.096)**	**-0.0110** **(0.004)**	**0.0004** **(0.045)**	0.0004 (0.124)
Time trend	0.0314 (0.150)	**0.0153** **(0.018)**	0.0107 (0.655)	**-0.0213** **(0.000)**	**0.0081** **(0.010)**	**0.0329** **(0.000)**
Constant	**2.1201** **(0.006)**	**0.5791** **(0.027)**	**1.7535** **(0.038)**	**1.1440** **(0.000)**	**1.004** **(0.000)**	**1.592** **(0.000)**
Adjusted R^2	0.913	0.988	0.654	0.903	0.940	0.923
Wald χ^2*(overall)*	5076.53 (0.000)	3492.95 (0.000)	961.68 (0.000)	4452.54 (0.000)	7481.18 (0.000)	5740.28 (0.000)
Wald χ^2*(FE)*	3285.85 (0.000)	2951.36 (0.000)	811.30 (0.000)	3652.86 (0.000)	5033.09 (0.000)	2764.18 (0.000)

Note: The number in parenthesis indicates *p*-values. Figures in bold show statistical significance at $p \leq 0.10$.

Table 4. Results of the determinants of regional specialization with the transport investment as a grouped variable

Variables	Agriculture, forestry & fishing	Manufacturing (incl. energy)	Construction	Trade, tourism & transport	Financial, real estate & and business	Other Service activities
Population density	0.0019 (0.751)	**-0.0034** **(0.054)**	**-0.0140** **(0.028)**	0.0009 (0.540)	-0.0009 (0.270)	**-0.0046** **(0.000)**
Per-capita GRP	**-0.0504** **(0.004)**	**0.0090** **(0.081)**	**0.0643** **(0.001)**	0.0053 (0.235)	**-0.0159** **(0.000)**	**-0.0224** **(0.000)**
Market potential	-0.3251 (0.631)	**-0.5664** **(0.005)**	-0.2459 (0.737)	**0.6052** **(0.001)**	0.1058 (0.280)	**-0.2850** **(0.024)**
Human capital	**1.2953** **(0.054)**	**0.3100** **(0.094)**	-0.1769 (0.808)	-0.1324 (0.443)	**-0.2688** **(0.006)**	0.0993 (0.428)
Transport	-0.0012 (0.356)	**0.0011** **(0.005)**	-0.0003 (0.828)	**-0.0008** **(0.038)**	**0.0007** **(0.000)**	0.0003 (0.191)
Energy	-0.0017 (0.747)	0.0021 (0.184)	0.0050 (0.373)	-0.0015 (0.270)	0.0002 (0.799)	0.0002 (0.844)
ICT	-0.0061 (0.336)	-0.0018 (0.334)	-0.0096 (0.160)	**0.0041** **(0.012)**	-0.0004 (0.690)	-0.0016 (0.167)
R&D	0.014 (0.381)	-0.0025 (0.584)	**-0.0522** **(0.002)**	**0.0122** **(0.003)**	0.0009 (0.686)	-0.0016 (0.584)
Environment	-0.0008 (0.722)	0.0003 (0.968)	-0.0004 (0.851)	-0.0006 (0.916)	0.0004 (0.242)	0.0006 (0.155)
Agri-food sector investment	-0.0015 (0.332)	**-0.0009** **(0.050)**	0.0012 (0.475)	-0.0005 (0.193)	0.0003 (0.148)	0.0002 (0.447)
Time trend	0.0283 (0.222)	**0.0206** **(0.003)**	0.0290 (0.247)	**-0.0291** **(0.000)**	**0.0099** **(0.003)**	**0.0338** **(0.000)**
Constant	**2.1382** **(0.007)**	**0.6281** **(0.007)**	**1.541** **(0.069)**	**1.1497** **(0.000)**	**1.037** **(0.000)**	**1.5698** **(0.000)**
Adjusted R^2	0.913	0.986	0.661	0.907	0.940	0.923
Wald χ^2*(overall)*	5096.47 (0.000)	3452.88 (0.000)	974.51 (0.000)	4706.36 (0.000)	7545.51 (0.000)	5618.32 (0.000)
Wald χ^2*(FE)*	3238.98 (0.000)	2127.15 (0.000)	744.54 (0.000)	3651.77 (0.000)	4958.76 (0.000)	2690.48 (0.000)

Note: The number in parenthesis indicates *p*-values. Figures in bold show statistical significance at $p \leq 0.10$.

Table 5. Results of the determinants of regional specialization with the investment in each transport category as a distinct variable

Variables	Agriculture, forestry & fishing	Manufacturing (incl. energy)	Construction	Trade, tourism & transport	Financial, real estate & and business	Other Service activities
Population density	0.0021 (0.723)	**-0.0034** **(0.050)**	**-0.0110** **(0.083)**	0.0004 (0.775)	-0.0011 (0.220)	**-0.0049** **(0.000)**
Per-capita GRP	**-0.0545** **(0.002)**	**0.0096** **(0.069)**	**0.0588** **(0.002)**	0.0062 (0.173)	**-0.0151** **(0.000)**	**-0.0214** **(0.000)**
Market potential	-0.2189 (0.747)	**-0.6032** **(0.003)**	-0.2464 (0.791)	**0.6057** **(0.001)**	0.0867 (0.376)	**-0.3111** **(0.014)**
Human capital	**1.1109** **(0.099)**	**0.3338** **(0.096)**	0.2261 (0.754)	-0.1948 (0.261)	**-0.2535** **(0.010)**	0.0754 (0.550)
Roads	-0.0008 (0.573)	**0.0010** **(0.014)**	0.0005 (0.730)	**-0.0009** **(0.014)**	**0.0007** **(0.001)**	0.0002 (0.342)
Railways	0.0018 (0.558)	0.0002 (0.839)	**-0.0100** **(0.002)**	0.0008 (0.305)	0.0006 (0.198)	**0.0011** **(0.053)**
Airports	**-0.0085** **(0.018)**	**0.0025** **(0.017)**	0.0039 (0.314)	-0.0013 (0.152)	**0.0017** **(0.001)**	0.0006 (0.396)
Seaports	-0.0014 (0.741)	**0.0023** **(0.078)**	**-0.0086** **(0.064)**	0.0006 (0.616)	**0.0010** **(0.097)**	0.0012 (0.150)
Urban public transport	-0.0027 (0.845)	-0.0008 (0.837)	-0.0056 (0.697)	0.0024 (0.488)	0.0005 (0.783)	-0.0026 (0.303)
Energy	-0.0027 (0.610)	0.0023 (0.143)	0.0061 (0.270)	-0.0017 (0.212)	0.0003 (0.684)	0.0002 (0.843)
ICT	-0.0054 (0.392)	-0.0018 (0.338)	**-0.0109** **(0.097)**	**0.0043** **(0.008)**	-0.0004 (0.640)	-0.0016 (0.172)
R&D	0.0149 (0.345)	-0.0026 (0.579)	**-0.0474** **(0.005)**	**0.0113** **(0.005)**	0.0007 (0.768)	-0.0019 (0.508)
Environment	-0.0011 (0.602)	0.0001 (0.887)	-0.0005 (0.826)	-0.0001 (0.928)	0.0004 (0.179)	0.0006 (0.122)
Agri-food sector investment	-0.0013 (0.377)	**-0.0009** **(0.049)**	0.0010 (0.530)	-0.0005 (0.199)	0.0003 (0.162)	0.0002 (0.393)
Time trend	0.0270 (0.242)	**0.0213** **(0.002)**	0.0320 (0.193)	**-0.0297** **(0.000)**	**0.0101** **(0.003)**	**0.0338** **(0.000)**
Constant	**2.2439** **(0.004)**	**0.6207** **(0.008)**	1.234 (0.141)	**1.196** **(0.000)**	**1.0305** **(0.000)**	**1.5930** **(0.000)**
Adjusted R^2	0.927	0.988	0.723	0.922	0.949	0.935
Wald χ^2*(overall)*	5173.38 (0.000)	3433.12 (0.000)	1028.37 (0.000)	4801.07 (0.000)	7629.55 (0.000)	5692.31 (0.000)
Wald χ^2*(FE)*	2844.57 (0.000)	1865.68 (0.000)	768.14 (0.000)	2886.11 (0.000)	4554.56 (0.000)	2550.09 (0.000)

Note: The number in parenthesis indicates *p*-values. Figures in bold show statistical significance at $p \leq 0.10$.

The population density is found to have a significant adverse effect on the regional specialization of manufacturing, construction and other (public-sector) service activities. Namely, the agglomeration forces strengthen the diversification of economic activities in the country. Human capital is generally found to significantly enhance the regional specialization of the primary and secondary production (non-service) sectors. This outcome may suggest that high levels of human capital endowment allow increased transferability of skills, which promotes the specialization in some agricultural and manufacturing sectors. On the contrary, human capital significantly reduces the regional specialization of the financial, real estate and business sector. Regarding the statistically significant effects of the per-capita GRP, these are found to be negative on the specialization of the primary sector and non-main (financial and public-sector) service activities, but positive on the specialization of manufacturing and construction activities. The regional investment share of the agri-food sector is not found to statistically significantly influence the specialization of the primary production sector. However, its impact is statistically significant and negative on the regional specialization of the main service activities, and positive on the specialization of the construction and financial service sectors.

Focusing on the effects of transport investments on specialization, these are generally found to act complementary with each other. Specifically, as far as the investment shares are concerned (Table 5), the road, airport and seaport infrastructure expenditures statistically significantly enhance the specialization of manufacturing and financial/business activities. Rail expenditure significantly enhances the regional specialization of other service activities. Positive and statistically significant is also the effect of time trend on the specialization of those sectors. On the contrary, rail and seaport expenditures statistically significantly reduce the specialization of construction activities. Furthermore, airport and road expenditures significantly diminish the regional specialization of the primary-sector activities and main services, respectively. Regarding the other infrastructure investments, the ICT and R&D investment shares have a statistically significant positive effect on the regional specialization of the main non-financial services, and negative effect on the regional specialization of construction activities.

In general, the findings concerning the impact of investment expenditures in real terms (Table A2) are found to be consistent with those of investment shares (Table 5), with regard to the sign of the statistically significant variables. In particular, both the energy infrastructure and agri-food investment expenditures significantly reduce the regional specialization of primary-sector activities and enhance the specialization of construction activities, the same as

the road infrastructure expenditure. Furthermore, the R&D and environmental investment expenditures significantly reduce the regional specialization of other (public-sector) service activities, the same as the road infrastructure expenditure. Social expenditure is not found to significantly influence the regional specialization pattern of any economic sector in the country.

6. Conclusions

Regional specialization is well regarded as a crucial, although ambiguous, spatial attribute pertaining to the structure and performance of local economies. At the same time, public infrastructure investments have been long considered in the EU and elsewhere as the principal policy tool for leveraging the local economic base and regional convergence. The findings underline that the linkages among regional specialization and public investment may considerably vary with the type of infrastructure, geographical factors and the sector of economic activity. In particular, for the case of Greece, they signify the conflicting role of market access, which signifies the interregional accessibility, and region-specific public investments, especially with regard to roads, on the specialization of local economies.

On the one hand, improvements in market access are expected to diminish the specialization of manufacturing activity. This impact possibly entails higher industrial diversity and a declining need for geographical concentration of manufacturing by favoring the proximity of local economies to output markets. Increased regional investment shares on roads, airports and seaports can promote the specialization of manufacturing, which may suggest improved efficiency and competitiveness in specific industries. On the other hand, regional investments in roads may lessen the specialization of the main non-financial services, in contrast with those in ICT and R&D, and higher market access, which increase their specialization. The latter finding indicates the importance of the increased intermodal and digital networking of regions on their transition from a goods producing economy to a service economy. Region-specific transport (particularly road) infrastructure investments can act as fiscal stimuli to strengthen manufacturing activity and business services. The above outcomes denote the existence of a tradeoff mechanism between local supply (especially road) capacity and market access of each region, in accordance with the spatial resource mobility of each sector and the degree to which is affected by each type of infrastructure.

The results involve useful implications for deploying an integrated strategic planning and impact assessment process for the regional and sectoral allocation of public investments.

This process should suitably prioritize and convey national and EU funds to those infrastructure types whose expected benefits from enhancing the specialization of specific sectors are the largest for the regional economy. These benefits may include the strengthening of the regional economic base, increase of export activities and localization economies, and higher productivity. Besides, the suggested process should promote a more balanced industrial growth in the periphery, based on the relative comparative advantages of each region. Particularly relevant with the impact of current economic crisis is the ability of regions to be resilient, in terms of enhancing their adaptive capacity, through their specialization in more than one sector, instead of becoming over-reliant on a single sector. Such investments will support Greece's recovery from the economic downturn, by making the fiscal adjustment / consolidation and reduction of debt easier to be achieved. Besides, they will make the EU policy makers more supportive for the greater role of the investment-driven growth, compared to the fiscal austerity measures.

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Table A1. Results of the determinants of regional specialization with the infrastructure investment as a grouped variable and without prefecture-specific fixed effects

Variables	Agriculture, forestry & fishing	Manufacturing (incl. energy)	Construction	Trade, tourism & transport	Financial, real estate & and business	Other service activities
Population density	**-0.0012** **(0.000)**	-0.0002 (0.500)	**-0.0007** **(0.001)**	0.0001 (0.898)	**0.0004** **(0.000)**	**0.0002** **(0.002)**
Per-capita GRP	**-0.1352** **(0.000)**	**0.0739** **(0.000)**	0.0034 (0.688)	**0.0162** **(0.000)**	**-0.0078** **(0.001)**	**-0.0321** **(0.000)**
Market potential	**0.7559** **(0.001)**	**1.5142** **(0.000)**	**0.2924** **(0.038)**	**-0.3678** **(0.000)**	**-0.2860** **(0.000)**	**-0.2849** **(0.000)**
Human capital	0.5660 (0.614)	0.2151 (0.789)	**-1.308** **(0.064)**	**-0.5689** **(0.066)**	**0.4522** **(0.022)**	**0.6014** **(0.002)**
Infrastructure investment	0.0019 (0.507)	**0.0071** **(0.001)**	**0.0064** **(0.001)**	**-0.0032** **(0.000)**	**-0.0017** **(0.001)**	0.0004 (0.273)
Agri-food sector investment	**0.0114** **(0.003)**	0.0035 (0.214)	**0.0047** **(0.052)**	**-0.0030** **(0.006)**	**-0.0013** **(0.049)**	-0.0009 (0.194)
Time trend	**0.0616** **(0.003)**	**-0.0744** **(0.000)**	**0.0290** **(0.024)**	-0.0005 (0.930)	**0.0127** **(0.000)**	**0.0334** **(0.000)**
Constant	**3.0127** **(0.000)**	**-1.2400** **(0.000)**	**0.7504** **(0.000)**	**1.2196** **(0.000)**	**1.0995** **(0.000)**	**1.4305** **(0.000)**
Adjusted R^2	0.315	0.359	0.094	0.150	0.298	0.475
Wald χ^2*(overall)*	197.63 (0.000)	238.67 (0.000)	39.69 (0.000)	77.65 (0.000)	182.70 (0.000)	359.02 (0.000)

Note: The number in parenthesis indicates *p*-values. Figures in bold show statistical significance at $p \leq 0.10$.

Table A2. Results of the determinants of regional specialization with all the investment categories (in real terms, including social expenses)

Variables	Agriculture, forestry & fishing	Manufacturing (incl. energy)	Construction	Trade, tourism & transport	Financial, real estate & and business	Other Service activities
Population density	-0.0057	-0.0028	0.0014	-0.0018	**-0.0026**	**-0.0066**
	(0.583)	(0.375)	(0.896)	(0.520)	**(0.082)**	**(0.001)**
Per-capita GRP	**-0.0467**	**0.0100**	**0.0485**	0.0027	**-0.0138**	**-0.0195**
	(0.008)	**(0.063)**	**(0.007)**	(0.564)	**(0.000)**	**(0.000)**
Market potential	-0.2451	**-0.4600**	-0.1232	**0.4744**	0.1572	**-0.2601**
	(0.712)	**(0.024)**	(0.857)	**(0.007)**	(0.105)	**(0.034)**
Human capital	**1.1691**	0.2227	-0.4006	-0.0365	**-0.2855**	0.0477
	(0.073)	(0.268)	(0.550)	(0.834)	**(0.003)**	(0.693)
Roads	**-0.0024**	0.0003	**0.0062**	-0.0003	-0.0002	**-0.0006**
	(0.042)	(0.361)	**(0.000)**	(0.346)	(0.169)	**(0.003)**
Railways	0.0001	-0.0009	0.0031	0.0001	-0.0001	0.0005
	(0.956)	(0.118)	(0.114)	(0.821)	(0.952)	(0.157)
Airports	-0.0112	0.0019	0.0076	-0.0029	0.0012	0.0031
	(0.277)	(0.702)	(0.472)	(0.299)	(0.422)	(0.109)
Seaports	-0.0017	0.0020	-0.0187	-0.0026	**0.0034**	0.0034
	(0.890)	(0.467)	(0.130)	(0.426)	**(0.052)**	(0.130)
Urban public transport	-0.0007	-0.0045	-0.0044	0.0001	0.0003	0.0001
	(0.785)	(0.398)	(0.110)	(0.838)	(0.389)	(0.889)
Energy	**-0.0326**	0.0019	**0.0417**	-0.0014	-0.0016	-0.0002
	(0.041)	(0.702)	**(0.011)**	(0.742)	(0.498)	(0.952)
ICT	0.0029	0.0021	-0.0133	0.0007	0.0018	0.0007
	(0.753)	(0.467)	(0.154)	(0.765)	(0.173)	(0.692)
R&D	0.0120	-0.0045	**-0.0304**	**0.0118**	-0.0009	**-0.0075**
	(0.491)	(0.398)	**(0.090)**	**(0.016)**	(0.731)	**(0.020)**
Environment	-0.0025	-0.0007	0.0026	0.0011	-0.0008	**-0.0014**
	(0.534)	(0.570)	(0.528)	(0.301)	(0.190)	**(0.055)**
Agri-food sector investment	**-0.0105**	-0.0021	**0.0208**	-0.0008	-0.0015	-0.0004
	(0.097)	(0.283)	**(0.001)**	(0.633)	(0.119)	(0.708)
Social spending	0.0022	-0.0003	0.0008	-0.0006	-0.0001	0.0007
	(0.490)	(0.797)	(0.819)	(0.458)	(0.959)	(0.218)
Time trend	**0.0424**	**0.0208**	-0.0065	**-0.0225**	**0.0104**	**0.0352**
	(0.064)	**(0.003)**	(0.781)	**(0.000)**	**(0.002)**	**(0.000)**
Constant	**2.7162**	0.5270	**0.2956**	**1.5032**	**1.1625**	**1.6948**
	(0.017)	(0.132)	**(0.003)**	**(0.000)**	**(0.000)**	**(0.000)**
Adjusted R^2	0.914	0.985	0.695	0.900	0.938	0.924
Wald χ^2*(overall)*	5238.80	3213.42	1153.62	4437.09	7428.91	5824.82
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Wald χ^2*(FE)*	2889.31	1935.32	747.01	2859.73	4691.57	2386.53
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: The number in parenthesis indicates *p*-values. Figures in bold show statistical significance at $p \leq 0.10$.

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