doi:10.1111/rsp3.12040

Public infrastructure investments and regional specialization: empirical evidence from Greece

Theodore Tsekeris[1], Klimis Vogiatzoglou[2]

[1] Centre of Planning and Economic Research (KEPE), 11 Amerikis, 106 72 Athens, Greece (e-mail: tsek@kepe.gr)
[2] Hoa Sen University, Faculty of Economics & Commerce, No. 8, Nguyen Van Trang street, HCMC, Vietnam (e-mail: klimis.vogiatzoglou@gmail.com)

Received: 21 August 2013 / Accepted: 29 April 2014

Abstract. The paper investigates the determinants of regional specialization for six broad sectors of economic activity in Greece, focusing on the effect of various types of public infrastructure investment. A system-wide model of panel regression equations is employed to recognize the significance of spatially fixed effects and that the covariates of specialization may vary with each sector. The role of market access on the specialization of manufacturing and main service activities is found to be conflicting with that of regional public investment, especially with regard to road expenditure. The results signify the potential of policy-makers to affect specialization patterns through reallocation of regional investment shares.

JEL classification: H54, O18, R12, R42, R58

Key words: Regional specialization, public investment, infrastructure networks, transport, market access

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). Conversely, diversity may arguably promote entrepreneurship, economic stability and long-term growth prospects (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). Therefore, as it was recently stressed in (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 new methodological approach, that is, a system-wide econometric analysis, to demonstrate 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 in (Brulhart and Mathys 2008; de Graaff 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, labour, 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). Within this approach, useful policy insights can be offered about how different forms of transport (and other infrastructure) improvement, concerning the local and inter-regional accessibility enhancement, may influence specialization patterns and, hence, various national and regional development objectives.

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, namely, those of traditional trade theory, more recent/non-comparative advantage trade theories, 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.

The more recent and non-comparative advantage trade theories (e.g., Krugman 1979, 1980; Helpman and Krugman 1985) focus on industry-specific characteristics and domestic market size. These theories predict 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 investment can have a significant impact on the specialization 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 favour the development of a system of specialized cities, whereas higher transport costs favour 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. inter-regional) scales interact with each other and influence the spatial economy of the regions. On the one hand, a reduction of the inter-regional transport cost has been found to increase polarization of the space economy, but a reduction of the local transport cost in less developed regions favours a more balanced development (Krugman 1991b; Vickerman et al. 1999; Martin 2000). On the other hand, it has been argued that improved inter-regional 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 (2013) demonstrated that enhancements in the inter-regional transport network accessibility have gradually led to a decrease in the regional specialization in the EU countries. This finding contradicts 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) significantly affect the distribution of production factors and induce considerable scale economies to the whole region. Firms across different sectors might require – to a varying degree – either ICT infrastructure as an input or to be involved in activities related to ICT. The digital broadband infrastructure and related facilities increase the connectivity of a region and its centrality within the national (and global) network of information and communication flows, which, in turn, enhances the integration, productivity, innovation and competitiveness of its economy. This process diminishes the effect of bottlenecks that hamper trade and facilitates the cooperation, data exchange/electronic transactions and promotion of local goods and services to other regions. Hence, 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 investment can promote knowledge spillovers, social interaction and learning processes which enhance the spatial agglomeration of industries (e.g., Gaspar and Glaeser 1998; Hong and Fu 2011). Thus, the state of ICT infrastructure of a region is relevant for explaining the location and geographical concentration of firms and, subsequently, its specialization levels and dynamics within a country.

Investment in R&D activities is typically associated with knowledge spillovers and other positive technological externalities, innovation and productivity gains of firms, which raise the level of industrial agglomeration in a region (Lovely et al. 2005). Specifically, there might be certain business/industrial/service activities requiring R&D either as a main input or even as an intermediate input. This mechanism acts as a factor that presumably reinforces specialization, as firms might find it useful to locate to regions where those inputs are available or relatively more abundant. The R&D investments are considered of high importance in the current EU regional policy framework to favour the smart specialization and promote labour market pooling. These processes attract firms to regions with readily available high-skilled labour force with increased productivity and competitiveness.

Human capital is also considered that affects the industrial development and specialization dynamics of a region and the whole country. It involves the theoretical knowledge and practical skills which are necessary for obtaining the appropriate expertise and boosting the productivity and competitiveness of a region. This is because the knowledge and skills of the labour force can enrich and advance the technological processes and facilitate the transfer of new technologies and organizational practices, which, in turn, enhance creativity and innovation. Therefore, investment in human capital will presumably grow the productivity of physical capital as well as labour productivity in some region. Except for the level of investment in such sectors as education, training and health, the improved organization and productivity of the educational system, in order to increase the efficiency of provided knowledge, is additionally regarded to strengthen the linkage between human capital and industrial/economic growth (OECD 2011).

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. Multi-modal land, sea and air networks, advanced information systems, knowledge sites based on R&D, telecommunication networks and the whole infrastructure of ancillary services are spatial networks whose geography is not the same, as they do not share the same nodes. These nodes underlie the formation of metropolitan regions that determine the local/global spatial structure of each country (Castells 2010). 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. This approach allows us to identify the differential role of

various types of infrastructure on the geographical concentration of economic activities. Hence, it enables policy-makers to find appropriate mixtures/schemes of multi-sectoral investment and related synergies to co-ordinate and promote the desired development pattern of each region. The effects of several control factors are also 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 investment 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. The MIS archives realized expenditure information (in actual spending euro) about all public investment projects co-financed by the funds of the European Union and national funds, namely, the Public Investment Programme (PIP), although the latter part is much smaller and declining over time. This database also offers detailed information about the budget of each specific project (assigned with a specific MIS code and title), the location (prefectures and regions that the project spans and corresponding shares of expenditure), the timing of investment (expenditure for a project may span one or more years), if the spending is state aid or not, the proportion of funding from national sources (PIP), the thematic categorization and specific category of investment, the responsible authority (e.g., ministry, region) for the project management, the project implementation agency and other financial/contract details.

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 3) 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. For instance, a project that comprises a total of 400 million euro spending for the construction of a 100 km highway, whose 80 km span prefecture 1 and 20 km span prefecture 2, allocates 320 million euro to prefecture 1 and 80 million euro to prefecture 2.

The study period covers 2000–2008, where data about the variables of interest were available. This period 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.[1] During the given period, main policy objectives underlying public investment encompass the promotion of regional productivity, innovation and competitiveness, while strengthening employment and social/territorial cohesion. Public infrastructure investment is considered as a tool to enhance the attractivity of the regions as location of employment and productive activities.

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):

1. Agriculture, hunting, forestry, fishing, mining and quarrying.
2. Manufacturing, including energy.

[1] It is noted that the 3rd CSF essentially spanned the period 2000–2008. The NSRF 2007–2013 actually started its implementation in 2009. Therefore, the investment data used in the model mostly refer to the 3rd CSF period.

3. Construction activities, including demolition and site preparation, general construction, installation and completion works, and renting of construction equipment.
4. 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.
5. Financial services: financial intermediation, real estate, renting and business activities.
6. 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) × 9 (years) = 459 × 6 (sectors) = 2,754 observations.

The location quotient (LQ) depicts the degree of the relative concentration of a sector in some region. The measure of LQ of sector i in region r in year period t is defined as:

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

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. It is noted that the GVA is used here because data on other appropriate measures typically adopted to construct the LQ index, such as employment, were not available at finer levels of spatial resolution (NUTS 3) by ELSTAT. Based on definition, 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 under-represented in region r. If LQ = 1, the specialization of sector i in region r equals the national average, which implies that local consumption can be satisfied by local production. Despite that, an extensive variety of alternative indices have been employed in measuring regional specialization (Bickenbach and Bode 2008), the LQ is a simple to understand, widely accepted and well interpreted index of regional specialization (Krugman 1991a; Glaeser 1992), whose metric allows to easily associate the relative concentration of economic activities by sector with the allocation of public spending among different types of infrastructure.

The determinants related to public investment correspond to different expenditure categories, depending on the type of (productive vs. non-productive, network-wide vs. point) infrastructure. The eleven types 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 noted 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 also be influenced by other factors, for which detailed data at the prefecture level are available. These

factors refer to: (*i*) 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. The initial proposal of a market potential variable dates back to Harris (1954). Since then, it has been widely used in international trade analysis to indicate how spatial proximity to large markets affects economic development and global trade patterns (e.g., Redding and Venables 2004; Head and Mayer 2011) as well as in the emerging field of geographical/spatial economics (e.g., Fujita et al. 2001; Crafts 2005; Hanson 2005). 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 neighbours 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 per cent. 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.

(*ii*) 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.[2] Compared to other relevant proxies, this definition can be considered that offers a more qualitative and theoretically sound linkage between human capital and talent, acquisition of basic skills, efficiency of the local education process and potential for highly qualified labour in that prefecture, which may foster the concentration of productive firms, due to benefits from knowledge spillovers. (*iii*) Density of population, as a proxy for the effect of agglomeration economies, and (iv) 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 modelling 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. On the one hand, in this short panel framework, unobserved factors attributed to the trade theory (e.g., regional comparative advantages due to factor endowments and labour productivities) and NEG (e.g., vertical linkages, input sharing and 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 through the fixed effects. On the other hand, the magnitude of public investment (funded by both EU and national resources) has been considerably changed during the given time period, with an average overall rate of

[2] 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.

increase that exceeds 21 per cent per year (from €861.4 million in 2000 to €4052.0 million in 2008).[3] 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.

The public infrastructure investment may be thought of as a significant input to the production function in some sectors, such as manufacturing, but this may not be true for other ones. Namely, the public infrastructure capital can be considered as a factor of production, in addition to various forms of private productive capital invested by firms. There might be a varying degree of significance and impact of the public infrastructure capital on the (geographical concentration of) production of firms and sectors. For this reason, a system-wide modelling approach is adopted here to represent the relationship between specialization and public investments (and other factors) across broad sectors of economic activity. This approach explicitly recognizes the three-way variation of determinants, with respect to region, time and sector, and it addresses the cross-sectoral equation residual correlation. The use of such panel data modelling techniques can mitigate the problem of biased estimates and misleading conclusions resulting from the short time span of the study period, given that regional specialization constitutes a relatively long-run process. The covariates are included in the system as time-lagged variables, which significantly reduces contemporaneous bias and, hence, problems associated with a potential endogeneity issue.

It is noted that, sometimes, might be true that certain public infrastructure investments may need a long time period to have a true effect on a country's economic restructuring and regional specialization patterns. However, in the case of Greece and during the period under investigation, public infrastructure investments were mostly large scale and the (peripheral) regions were substantially lacking infrastructure. The creation of infrastructure had a considerable impact on the local accessibility and the connectivity between regions. In such circumstances, it can be regarded that the effect of public investment on the regional specialization dynamics was more immediate, that is, one time lag is adopted here, as the landscape changed significantly within a relatively short time period, and the regions experienced transformations in their economy following the improvements in infrastructure networks. The presence of correlated group-effects, as the result of particular regional advantages or peculiarities sought by each industry, and time-specific effects in the model structure increase the degrees of freedom, reduce collinearity among explanatory variables and enhance the efficiency 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:

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

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 these variables as shares of the total public spending in prefecture r and time t signifies that

[3] All prices have been deflated at 2005 constant values using the government expenditure deflator of ELSTAT.

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, $\boldsymbol{\delta}_r$ 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 $\boldsymbol{\theta}_t$ 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, for example, geographical location, land morphology and climate conditions, while, the latter ones the influence of factors that do not vary across regions, for example, 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 it 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.

Despite that, the effect of public infrastructure investment is arguably underestimated when ignoring spatial interactions between (neighbouring) regions, the current panel data modelling framework does not involve the estimation of spatial autocorrelation or spillovers, typically considered through the use of *a priori* contiguity-based spatial weight matrix. In contrast, it implicitly recognizes that expenditure externalities may diffuse quite far within and across sectors. Greece is included among those countries where contiguity weight matrices evidently present definitional/accuracy problems (Ioannides and Petrakos 2000; Prodromidis 2009). This is because the existence of several regions that are non-contiguous, separated by physical 'borders', such as the Aegean and Ionian Sea and large mountainous blocks in the mainland. Recent findings of Monastiriotis and Psycharis (2014), who carried out a spatial exploratory analysis of public investments in Greece using various definitions of neighbourliness and different spatial scales, also suggest that proximity or contiguity-based spatial autocorrelation is generally not statistically significant and, where this appears, it may considerably vary among types of investment.

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, that is, 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 2 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 the years 2000 and 2008, respectively. It is immediately evident that many sectors are concentrated in Attiki (the Athens capital region), especially in financial services (>50%). In contrast, agriculture in the capital region exhibits a very small share (<5%) in the total agricultural production of the country. This observed linkage

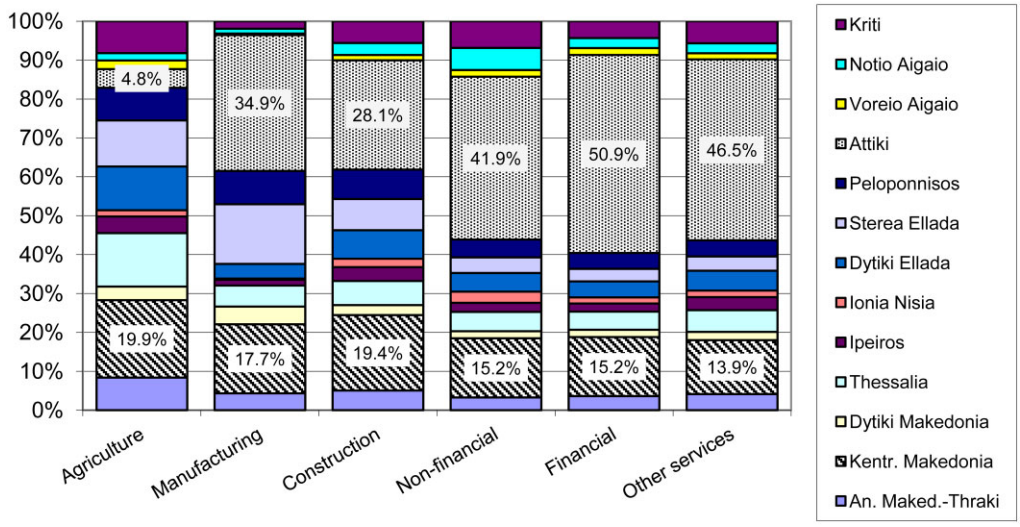

Fig. 1. Spatial distribution of the total sectoral GVA in the six broad sectors across 13 NUTS 2 regions in 2000

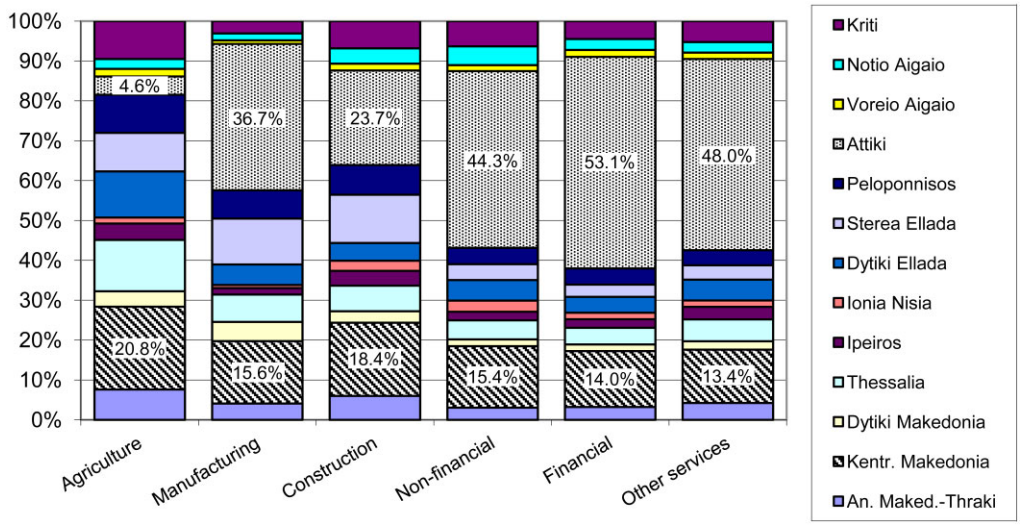

Fig. 2. Spatial distribution of the total sectoral GVA in the six broad sectors across 13 NUTS 2 regions in 2008

denotes the ability of urban agglomerations with large market size, high accessibility and industrial diversity to cluster economic activities in space.

The region of Kentriki Makedonia, in which the metropolitan city of Thessaloniki, the second largest city of Greece is located, also has significant shares of the total activity in Greece in several sectors, including agriculture (about 20–21%). This NUTS 2 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, most notably the Attiki region 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.

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). Despite their relatively small size, these three prefecture are considered to operate as satellites for the industrial activity of the Attiki region, during the last two decades, due to a combination of investment incentives and environmental restrictions as well as the lower land rent and relatively easy access to amenities, thus hosting a substantial part of the Athens metropolitan manufacturing activity (Petrakos and Psycharis 2004; Petrakos et al. 2012). Similarly, but to a lesser degree, this relationship exists between the Thessaloniki metropolitan region and its neighbouring prefecture of Kilkis.[4] These spatial interaction patterns can largely explain why the regions of Thessaloniki (in 2008) and, particularly, Attiki do not appear in the top 10 of specialized regions in manufacturing (Table 2), although Attiki accounts for a significant proportion (37% in 2008) of total manufacturing in Greece.

Also, relatively high LQ indices in manufacturing are observed in some prefectures with large cities, such as Magnisia (with the capital city of Volos) and Achaia (with the capital city of Patras), and in other prefectures of mainland Greece. Hence, the proximity to large markets and labour force supply, as proxied by the variable of market potential, can be regarded as one among a multitude of factors that influence the location of manufacturing in the country. Other influencing factors refer to geographical/environmental constraints, institutional arrangements and existence of/closeness to

[4] Although the presumed existence of neighbourhood effects on the leading metropolitan regions, the spatial resolution of public expenditure shares at the prefecture level is necessary to disentangle the impact of investment funding by sector on regional specialization. This is because EU co-funded public investment is spatially allocated according to certain criteria (relevant to the regional product), which differentiate the allowable expenditure shares among regions/prefectures. These criteria refer to the distinction between the convergence regions, phasing-out regions and phasing-in regions. Hence, even neighbouring prefectures with increased interaction between each other may be eligible for different investment allocation shares, such as Attiki, which belongs to the phasing-out regions (as Kentriki Makedonia), Viotia and Evia, which belong to the phasing-in regions, and Korinthia, which belongs to the convergence regions, in the fourth programming period.

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

natural resources, which are captured by the prefecture-specific fixed effects, the availability of local skilled labour force and physical infrastructure capital, the existence of agglomeration economies and the structure and amount of local production (see subsection 3.1).

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 tourism 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). It can also be related to the high degree of inertia and lack of a traceable strategy in the regional allocation of public investment in the study period (Monastiriotis and Psycharis 2014). 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.

It is noted that some of the changes which have occurred in the given period may not be directly attributed to the macroeconomic conditions, but to other events, such as those associated with the distinction between the core and periphery, and the fact that certain regions have increased their proximity to Attiki or Thessaloniki, as described above. Also, in the study period, the more recent crisis and recession was not present, which means that it has not contributed to the changing specialization patterns. Following the outbreak of the crisis in 2008, almost all sectors of the economy were adversely affected, but particularly those economic activities which involve the production of non-tradable goods and services, are more introverted and mostly focused on covering domestic needs (e.g., construction and trade). On the contrary, a relative increase has been observed in the total added value share of sectors related to the production of tradable goods and services, such as in agriculture and manufacturing. This change has arguably favoured peripheral regions with higher shares in those sectors, compared to large metropolitan regions, in the sense that the former ones have been generally less affected by or have shown to be more resilient to the economic crisis.

5 Empirical results

In the econometric analysis, several models are employed to help to disentangle the impacts of various types of infrastructure investment shares on regional specialization patterns. This is because, as explained before, public investment can be regarded as an input to the production function of only some sectors and for specific categories. Hence, the results for different infrastructure categories are presented for purposes of comparison and robustness analysis, as well as for providing detailed information about the effects of those public investments 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

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

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

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

including prefecture-specific fixed effects. The rejection of the joint Wald test hypothesis of the non-significance of spatial dummy variables verifies their importance on disentangling the effects 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 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.

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 generally strengthen the diversification of economic activities in the country. Especially in terms of the manufacturing activity, this outcome may be related to the fact that smaller (lower-density) neighbouring regions host a considerable part of the manufacturing activity of the high-density metropolitan regions, particularly Attiki, as explained in Section 4.

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. Conversely, human capital is found to significantly reduce the regional specialization of financial, real estate and business sector. The latter finding may possibly denote that the human capital variable is poorly proxied here (due to lack of relevant data at the prefecture level). In the case of Greece, students with excellent grades tended during the given period to finish their studies in Attiki (where the capital city of Athens is situated) or Thessaloniki and, then, sought to work in those regions, where higher quality and better paid jobs are found. Hence, as a high rate of this index can be related to increased outflow of high quality

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

Variables	Agriculture, forestry and fishing	Manufacturing (incl. energy)	Construction	Trade, tourism and transport	Financial, real estate and business	Other Service activities
Population density	0.0019	**–0.0034**	**–0.0140**	0.0009	–0.0009	**–0.0046**
	(0.751)	**(0.054)**	**(0.028)**	(0.540)	(0.270)	**(0.000)**
Per capita GRP	**–0.0504**	**0.0090**	**0.0643**	0.0053	**–0.0159**	**–0.0224**
	(0.004)	**(0.081)**	**(0.001)**	(0.235)	**(0.000)**	**(0.000)**
Market potential	–0.3251	**–0.5664**	–0.2459	**0.6052**	0.1058	**–0.2850**
	(0.631)	**(0.005)**	(0.737)	**(0.001)**	(0.280)	**(0.024)**
Human capital	**1.2953**	**0.3100**	–0.1769	–0.1324	**–0.2688**	0.0993
	(0.054)	**(0.094)**	(0.808)	(0.443)	**(0.006)**	(0.428)
Transport	–0.0012	**0.0011**	–0.0003	**–0.0008**	**0.0007**	0.0003
	(0.356)	**(0.005)**	(0.828)	**(0.038)**	**(0.000)**	(0.191)
Energy	–0.0017	0.0021	0.0050	–0.0015	0.0002	0.0002
	(0.747)	(0.184)	(0.373)	(0.270)	(0.799)	(0.844)
ICT	–0.0061	–0.0018	–0.0096	**0.0041**	–0.0004	–0.0016
	(0.336)	(0.334)	(0.160)	**(0.012)**	(0.690)	(0.167)
RandD	0.014	–0.0025	**–0.0522**	**0.0122**	0.0009	–0.0016
	(0.381)	(0.584)	**(0.002)**	**(0.003)**	(0.686)	(0.584)
Environment	–0.0008	0.0003	–0.0004	–0.0006	0.0004	0.0006
	(0.722)	(0.968)	(0.851)	(0.916)	(0.242)	(0.155)
Agri-food sector investment	–0.0015	**–0.0009**	0.0012	–0.0005	0.0003	0.0002
	(0.332)	**(0.050)**	(0.475)	(0.193)	(0.148)	(0.447)
				(0.041)		
Time trend	0.0283	**0.0206**	0.0290	**–0.0291**	**0.0099**	**0.0338**
	(0.222)	**(0.003)**	(0.247)	**(0.000)**	**(0.003)**	**(0.000)**
Constant	**2.1382**	**0.6281**	**1.541**	**1.1497**	**1.037**	**1.5698**
	(0.007)	**(0.007)**	**(0.069)**	**(0.000)**	**(0.000)**	**(0.000)**
Adjusted R^2	0.913	0.986	0.661	0.907	0.940	0.923
Wald χ^2(overall)	5096.47	3452.88	974.51	4706.36	7545.51	5618.32
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Wald χ^2(FE)	3238.98	2127.15	744.54	3651.77	4958.76	2690.48
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

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

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

human capital from a peripheral prefecture, this proxy may not reflect in a sufficient way the effect of human capital endowment on the specialization pattern. It should be further noted that the effect of human capital (and other covariates) on regional specialization is expressed in relative terms, namely, how it influences one sector relative to the others, and this effect may vary to a significant degree across sectors. Thus, the present result can also suggest that certain sectors may be more sensitive to the level of human capital endowment than others.

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, the findings are important because there is (and, in the past, there has been to a larger extent) a lack of important productive infrastructure and general infrastructure stock. Such infrastructure investment is necessary for a modern economy to function efficiently. The level of investment spending, but also how this is allocated among regions and sectors of the economy, has important implications for the development prospects of the country as well as of individual regions, especially those which are less developed and in the periphery.

Specifically, it is shown that the effects of market access, which signifies the inter-regional accessibility, and region-specific public investment, particularly with regard to roads, on the specialization of local economies is conflicting. On the one hand, improvements in market access are expected to diminish the relative concentration of manufacturing activity in some region. This impact possibly entails higher industrial diversity and a declining need for geographical concentration of manufacturing firms by favouring 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 investment in roads may lessen the relative concentration of the main non-financial services, in contrast with the regional investment in ICT and R&D, and higher market access, which increase their specialization. The latter finding indicates the importance of the increased multi-modal and digital networking of regions on their transition from a goods producing economy to a service economy. Region-specific transport (particularly road) infrastructure investment can act as fiscal stimulus to strengthen manufacturing activity and business services. The above outcomes denote the existence of a tradeoff mechanism between the supply of local infrastructure (especially road) capacity and market access at the prefecture level, in accordance with the spatial resource mobility of each sector and the degree to which is affected by each type of investment.

Moreover, given the ongoing crisis and the state of the economy during the last years, Greece requires a severe restructuring of its economic production paradigm. Public infrastructure investment can certainly be a crucial driving force to help the attraction of private investment and this restructuring and development to occur. Such investment provides an opportunity for Greek regions to find a niche and specialize in certain industries which are better suited with the local natural and human resources and the changing social and economic landscape. Specifically, it can help the regions to better exploit or create new comparative/competitive advantages, which, in turn, can improve the overall competitiveness and openness of the Greek economy.

The results involve useful implications for deploying an integrated strategic planning and impact assessment process for the regional and sectoral allocation of public investment. This process should suitably prioritize and convey national and EU funds to those infrastructure types whose expected benefits from enhancing the specialization of certain sectors are the largest for the regional economy, in terms of producing higher rates of return and multiplier effects. The benefits may encompass the strengthening of the regional economic base, increase of export activities and localization economies, and higher productivity. The suggested process may promote a more balanced growth in the periphery, through the geographical concentration of firms/activities producing tradable goods and services with high added value and knowledge intensity, and creating significant scale economies and positive network externalities. The identification of synergies among investment categories to support those activities and create a targeted specialized and adequately interconnected production base should be an integral part of the future growth plan of the country.

Particularly relevant with the impact of the current economic downturn is the ability of the 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. Public investment cuts have been a priority in the ongoing fiscal adjustment programme, while the gradual transition from expansionary fiscal policies to consolidation tends to be intensified in the new programming period 2014–2020. In this prospect, the results stress the importance of financing public capital through reallocation of infrastructure spending within the limited budget, or a more extensive use of EU funds, compared to the fiscal austerity measures, to support the recovery and help to achieve regional development and territorial cohesion objectives. Last but not least, the benefits from utilisation of reallocated investment resources would be reinforced by removing administrative barriers and deficiencies of the past.

Appendix

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

Notes: 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 and fishing	Manufacturing (incl. energy)	Construction	Trade, tourism and 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)
RandD	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)

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

References

Abdel-Rahman H, Anas A (2004) Theories of systems of cities. In: Henderson JV, Thisse J-F (eds) *Handbook of regional and urban economics*, Vol. 4. Elsevier, Amsterdam

Alstadt B, Weisbrod G, Cutler D (2012) The relationship of transportation access and connectivity to local economic outcomes. Proceedings of the Transportation Research Board 91st Annual Meeting, Washington, DC

Anderson WP, Song Y, Lakshmanan TR (2010) Employment growth in two US highway corridors: an extended shift-share analysis. Proceedings of the Transportation Research Board 89th Annual Meeting, Washington, DC

Baldwin R, Forslid R, Martin P, Ottaviano G, Robert-Nicoud F (2005) *Economic geography and public policy*. Princeton University Press, Princeton, NJ

Baltagi BH (2005) *Econometric analysis of panel data*, 3rd edn. Wiley and Sons, Chichester

Banister D, Berechman J (2003) *Transport investment and economic development*. Routledge, New York

Beaudry C, Schiffauerova A (2009) Who's right, Marshall or Jacobs? The localization versus urbanization debate. *Research Policy* 38: 318–337

Bickenbach F, Bode E (2008) Disproportionality measures of concentration, specialization, and localization. *International Regional Science Review* 31: 359–388

Billings SB, Johnson EB (2012) A nonparametric test for industrial specialization. *Journal of Urban Economics* 71: 312–331

Bishop P, Gripaios P (2007) Explaining spatial patterns of industrial diversity: an analysis of sub-regions in Great Britain. *Urban Studies* 44: 1739–1757

Brulhart M, Mathys NA (2008) Sectoral agglomeration economies in a panel of European regions. *Regional Science and Urban Economics* 38: 348–362

Castells M (2010) Globalisation, networking, urbanisation: reflections on the spatial dynamics of the information age. *Urban Studies* 47: 2737–2745

Chatman DG, Noland RB (2011) Do public transport improvements increase agglomeration economies? A review of literature and an agenda for research. *Transport Reviews* 31: 725–742

Combes P-P, Linnemer L (2000) Intermodal competition and regional inequalities. *Regional Science and Urban Economics* 30: 131–184

Crafts N (2005) Market potential in British regions 1871–1931. *Regional Studies* 39: 1159–1166

Cutrini E (2010) Specialization and concentration from a twofold geographical perspective: evidence from Europe. *Regional Studies* 44: 315–336

Dewhurst JHLL, McCann P (2007) Specialisation and regional size. In: Fingelton B (ed) *New directions in economic geography*. Edward Elgar, Cheltenham

de Graaff T, van Oort FG, Florax RJGM (2012) Sectoral heterogeneity, accessibility and population-employment dynamics in Dutch cities. *Journal of Transport Geography* 25: 115–127

Duranton G, Puga D (2000) Diversity and specialisation in cities: why, where and when does it matter? *Urban Studies* 37: 533–555

Ejermo O (2005) Technological diversity and Jacobs' externality hypothesis revisited. *Growth and Change* 36: 167–195

Frenken K, Van Oort FG, Verburg T, Boschma RA (2004) Variety and regional economic growth in the Netherlands. Final report to the Ministry of Economic Affairs. University of Utrecht, The Netherlands

Fujita M, Krugman P, Venables AJ (2001) *The spatial economy: cities, regions, and international trade*. MIT Press, Cambridge, MA

Fujita M, Mori T (1996) The role of ports in the making of major cities: self-agglomeration and hub-effect. *Journal of Development Economics* 49: 93–120

Gaspar J, Glaeser E (1998) Information technology and the future of cities. *Journal of Urban Economics* 43: 136–156

Glaeser EL (1992) Growth in cities. *Journal of Political Economy* 100: 1126–1152

Görg H, Molana H, Montagna C (2009) Foreign direct investment, tax competition and social expenditure. *International Review of Economics & Finance* 18: 31–37

Graham DJ (2007) Variable returns to agglomeration and the effect of road traffic congestion. *Journal of Urban Economics* 62: 103–120

Hanson GH (2001) Scale economies and the geographic concentration of industry. *Journal of Economic Geography* 1: 255–276

Hanson GH (2005) Market potential, increasing returns and geographic concentration. *Journal of International Economics* 67: 1–24

Harris C (1954) The market as a factor in the localization of industry in the United States. *Annals of the Association of American Geographers* 44: 315–348

Head K, Mayer T (2011) Gravity, market potential and economic development. *Journal of Economic Geography* 11: 281–294

Helpman E, Krugman P (1985) *Market sructure and foreign trade*. MIT Press, Cambridge, MA

Henderson JV (1974) The sizes and types of cities. *American Economic Review* 64: 640–656
Holl A (2004) Manufacturing location and impacts of road transport infrastructure: empirical evidence from Spain. *Regional Science and Urban Economics* 34: 341–363
Hong J, Fu S (2011) Information and communication technologies and the geographical concentration of manufacturing industries: evidence from China. *Urban Studies* 48: 2339–2354
Horst T, Moore A (2003) Industrial diversity, economic development, and highway investment in Louisiana 1839: 136–141
Ioannides Y, Petrakos G (2000) Regional disparities in Greece: the performance of Crete, Peloponnese and Thessaly. *EIB Papers* 5: 30–58
Ioannides Y, Overman H, Rossi-Hansberg E, Schmidheiny K (2008) The effect of information and communication technologies on urban structure. *Economic Policy* 23: 201–242
Isard W (1956) *Location and space-economy*. MIT Press, Cambridge, MA
Kadokawa K (2011) The role of infrastructure support and regional specialization in the Japanese manufacturing sector. *The Industrial Geographer* 8: 86–113
Kalemli-Ozcan S, Sørensen BE, Yosha O (2003) Risk sharing and industrial specialization: regional and international evidence. *The American Economic Review* 93: 903–918
Krugman P (1979) Increasing returns, monopolistic competition, and international trade. *Journal of International Economics* 9: 469–479
Krugman P (1980) Scale economies, product differentiation, and the pattern of trade. *American Economic Review* 70: 950–959
Krugman P (1991a) *Geography and trade*. MIT Press, Cambridge, MA
Krugman P (1991b) Increasing returns and economic geography. *Journal of Political Economy* 99: 483–499
Lovely M, Rosenthal S, Sharma S (2005) Information, agglomeration, and the headquarters of US exporters. *Regional Science and Urban Economics* 35: 167–191
Marshall A (1890) *Principles of economics*. Macmillan, London
Martin P (2000) The role of public policy in the process of regional convergence. *EIB Papers* 5: 69–79
Martin P, Rogers CA (1995) Industrial location and public infrastructure. *Journal of International Economics* 39: 335–351
Martin R, Sunley P (2003) Deconstructing clusters, chaotic concept or policy panacea? *Journal of Economic Geography* 3: 5–35
Monastiriotis V, Psycharis Y (2014) Between equity, efficiency and redistribution: an analysis of revealed allocation criteria of regional public investment in Greece. *European Urban and Regional Studies* doi:10.1177/0969776412455990
Mora T, Moreno R (2010) Specialisation changes in European regions: the role played by externalities across regions. *Journal of Geographical Systems* 12: 311–334
Mora T, Moreno R (2013) The role of network access on regional specialization in manufacturing across Europe. *Regional Studies* 47: 950–962
OECD (2011) *Education policy advice for Greece, strong performers and successful reformers in education*. OECD Publishing, Paris
Ohlin B (1933) *Interregional and international trade*. Harvard University Press, Cambridge, MA
Ottaviano G (2008) Infrastructure and economic geography: an overview of theory and evidence. *EIB Papers* 1: 8–35
Petrakos G, Fotopoulos G, Kallioras D (2012) Peripherality and integration: industrial growth and decline in the Greek regions. *Environment and Planning C: Government and Policy* 30: 347–361
Petrakos G, Psycharis Y (2004) *Regional development in Greece*. Kritiki, Athens
Prager J-C, Thisse J-F (2012) *Economic geography and the unequal development of regions*. Routledge, Oxford
Prodromidis PI (2009) The spatial distribution of male and female employment and unemployment in Greece. KEPE Studies 66, Centre of Planning and Economic Research, Athens
Puga D (1999) The rise and fall of regional inequalities. *European Economic Review* 43: 303–334
Redding S, Venables AJ (2004) Economic geography and international inequality. *Journal of international Economics* 62: 53–82
Shefer D, Aviram H (2005) Incorporating agglomeration economies in transport cost-benefit analysis: the case of the proposed light-rail transit in the Tel-Aviv metropolitan area. *Papers in Regional Science* 84: 487–507
Siegel PB, Johnson TG, Alwang J (1995) Regional economic diversity and diversification. *Growth and Change* 26: 261–284
Song Y, Lee K, Anderson WP, Lakshmanan TR (2012) Industrial agglomeration and transport accessibility in metropolitan Seoul. *Journal of Geographical Systems* 14: 299–318
Stirboeck C (2004) A spatial econometric analysis of regional specialisation patterns across EU regions. ZEW – Centre for European Economic Research Discussion Paper 04–044

Tsekeris T (2011) Public expenditure competition in the transport sector: inter-modal and spatial considerations for Greece. *Environment and Planning A* 43: 1981–1998

Venables AJ (1996) Equilibrium locations of vertically linked industries. *International Economic Review* 37: 341–359

Vickerman R, Spiekermann K, Wegner M (1999) Accessibility and economic development in Europe. *Regional Studies* 3: 1–15

Vogiatzoglou K, Tsekeris T (2013) Spatial agglomeration of manufacturing in Greece: sectoral patterns and determinants. *European Planning Studies* 21: 1853–1872

Zhou Y, Sun Y, Wei YHD, Lin GCS (2011) De–centering 'spatial fix'-patterns of territorialization and regional technological dynamism of ICT hubs in China. *Journal of Economic Geography* 11: 119–150

doi:10.1111/rsp3.12040

Resumen. Este artículo estudia los determinantes de la especialización regional de seis amplios sectores de la actividad económica en Grecia, centrándose en el efecto de distintos tipos de inversión en infraestructura pública. Se emplea un modelo para todo el sistema de ecuaciones de regresión de panel con el que reconocer la importancia de los efectos espacialmente fijos y mostrar que las covariables de especialización pueden variar para cada sector. Se encontró que el papel del acceso a los mercados en la especialización de las actividades manufactureras y de las principales actividades de servicios está en conflicto con el de la inversión pública regional, especialmente con respecto a los gastos en carreteras. Los resultados señalan la posibilidad de que los responsables políticos puedan afectar los patrones de especialización a través de la reasignación de cuotas de inversión regional.

要約: ギリシャにおける6つの産業セクターの経済活動の地域特化の決定要因を、様々なタイプの公共インフラ投資の効果に注目して、分析する。パネル回帰方程式のシステムワイド・モデルにより、空間的な固定効果の有意性と特化の共変量が各セクターで変動する可能性を調べる。製造業や主たるサービス業の特化における市場アクセスの役割は、地域的公共投資の役割、特に、道路関連支出の役割と相反するものであることが分かった。この結果は、地方投資のシェアの再配分を通じて、自治体が特化パターンに与える影響の大きさを示している。