# The domestic productivity effects of FDI in Greece: loca(lisa)tion matters!

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**ABSTRACT**

Despite an extensive empirical literature on the factors conditioning the size and prevalence of FDI productivity spillovers, the geographical dimension of these externalities remains relatively under-explored. In this paper we use firm level data from the Greek manufacturing sector to identify how three features of economic geography – spatial heterogeneity (location), spatial proximity (localisation) and spatial concentration (agglomeration) – influence the size and sign of FDI spillovers within and across industries. We find that FDI spillovers predominantly materialise at the sub-national level, with horizontal spillovers being more prominent at the regional scale (NUTS2) and vertical spillovers being highly localised (at the NUTS3 level). Furthermore, we find important synergies between spillovers from FDI and industry-region specific agglomeration. Also, FDI spillovers are found to be conditional on regional characteristics related to each region's manufacturing base, FDI concentration, urban agglomeration and aggregate productivity. These results highlight the important role played by geography for the materialisation of productivity spillovers accruing from FDI and suggest that these key geographical features (location, localisation and agglomeration) ought to be taken into account both in the study of FDI spillovers and in the design of FDI-promotion and regional development policies.

**Keywords:** FDI, Agglomeration, Regional Externalities, Spatial Heterogeneity, Greece

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# The domestic productivity effects of FDI in Greece: loca(lisa)tion matters!

## 1. Introduction

The attraction of foreign direct investment (FDI) is commonly linked to numerous direct positive effects in host economies, including capital investment, employment creation, multiplier effects and the generation of export revenues (Barba-Navaretti and Venables, 2004; Caves, 2007; McCann and Iammarino, 2013). Furthermore, there is a growing belief that FDI also creates important positive indirect effects in the form of productivity spillovers to domestic firms. Through a variety of possible channels, including demonstration effects, inter-firm labour turnover and input-output linkages between foreign-owned firms and their suppliers, domestic firms can obtain new technologies resulting in positive productivity effects (Blomström and Kokko, 1998; Görg and Greenaway, 2004).

In the belief that positive FDI spillovers are prevalent, many national and regional governments actively engage in attracting inward FDI, often offering generous benefits to new FDI firms. However, the body of empirical evidence on the common occurrence of these externalities is mixed and inconclusive (Hanousek et al., 2011; Irsova and Havranek, 2013; Havranek and Irsova, 2011). In response to this, recent studies have focused more on examining the range of possible factors that may foster or hinder the occurrence of FDI spillovers. Their findings indicate that firm heterogeneity, of both FDI and domestic firms, is a significant factor influencing the sign and size of these spillovers. Regarding FDI firms, aspects of this include the degree of foreign ownership (Girma and Wakelin, 2007; Monastiriotis and Alegria, 2011), the time of entry (Merlevede and Purice, 2015) and the nationality of foreign investors (Monastiriotis, 2014; Haskel et al., 2007; Javorcik and Spatareanu, 2011). As for domestic firms, factors found to influence FDI spillovers include firm size, productivity level, human capital and export status (Damijan et al., 2013; Blalock and Gertler, 2009; Abraham et al., 2010; Jordaan, 2008a).

Despite this developing focus towards contextual conditioning factors, the geographical dimension of FDI spillovers has received by comparison limited attention. For most of the literature, FDI spillovers are thought to have a predominantly sectoral dimension and thus the role of geography is usually only cursorily examined in relevant studies – if at all. This is striking, as it is very likely that geography can play an important role in the materialisation of such spillovers. It is well known from the literatures on innovation (Audretsch and Feldman, 2004) and agglomeration (Rosenthal and Strange, 2004) that geographical scale, proximity and density foster knowledge and productivity spillovers. Given the similarity of the underlying mechanisms of FDI spillovers (vertical linkages, labour pooling and demonstration effects; Blomström and Kokko, 1998; Smeets, 2008) and agglomeration economies (sharing, matching and learning; Puga, 2010), it is reasonable to expect that FDI spillovers are also more enhanced when FDI and domestic firms operate in the same regions (e.g. Blalock and Gertler, 2008). In other words, one could argue that it is more likely that these externalities materialise at sub-national rather than the national level in host economies (Jordaan, 2009). Furthermore, there may also be important *interrelations* between regional-industrial characteristics and FDI spillovers – in particular characteristics linked to the materialization of agglomeration economies, including employment density, industrial concentration and regional specialisation (Menghinello et al., 2010; Jordaan, 2009). In a similar fashion, it is also to be expected that FDI spillovers will be more prevalent in regions with other spillover-conducive characteristics, such as high levels of industrial and FDI concentration, productivity and urban agglomeration. However, a systematic examination of these issues is generally lacking from the literature.

The purpose of the present paper is to extend upon recent empirical research on drivers of FDI spillovers by focusing explicitly on the geographical dimension of these externalities. Using data for Greek manufacturing firms for the period 2002-2006, we concentrate our analysis on the following three issues. First, we assess the importance of spatial proximity for FDI spillovers by estimating the size of intra- and inter-industry spillovers at three different spatial scales: national (within/across sectors), regional (within NUTS2 regions) and local (within NUTS3 regions). Second, we present new evidence on the relation between agglomeration and (regional) FDI spillovers. To do so we examine whether industry-region specific factors related to density and specialisation affect intra- and inter-industry FDI spillovers at the regional (NUTS2) and local (NUTS3) level. Third, we link our study to the recent spillover literature that emphasises the importance of heterogeneity by investigating whether effects from FDI are subject to spatial heterogeneity. In particular, by estimating spillovers for regions that differ in terms of the overall scale of industrial concentration, urban agglomeration, level of inward FDI and aggregate productivity, we assess whether the effects of FDI are affected by spatial heterogeneity.

The paper is structured as follows. In section two we present a brief review of research on the geographical dimension of FDI spillovers and use this to motivate our empirical investigation. Section three discusses the data and model. Section four presents the main findings from our empirical analysis, which can be summarised as follows. First, both intra- and inter-industry FDI spillovers occur at the regional rather than the national level, confirming that spatial scale (localisation) matters. Second, we obtain clear evidence on the interplay or synergies between industry-region specific agglomeration characteristics and FDI spillovers. Several interaction variables between industry scale, inter-firm proximity and regional specialisation, on the one hand, and regional FDI one the other are significantly associated with firm level productivity, typically fostering positive externalities. The inclusion of these interaction variables renders unconditional regional FDI spillover effects insignificant, further indicating the importance of agglomeration for the materialisation of FDI spillovers. Third, we find that the effects of FDI are subject to spatial heterogeneity. Distinguishing between regions according to their scale of manufacturing concentration, urban agglomeration, level of inward FDI and relative productivity level, we find that the sign and scale of the FDI effects differ markedly, albeit not always favouring regions exhibiting favourable agglomeration characteristics. We discuss the implications of these findings in the concluding section.

## 2. Literature review and research questions

As noted already, there is a close similarity between the underlying mechanisms proposed in the literature for the materialisation of FDI spillovers and those described for the case of productivity spillovers in the literatures on externalities from innovation (Audretsch and Feldman, 2004) and agglomeration (Rosenthal and Strange, 2004). For instance, demonstration effects, where domestic firms learn about new technologies incorporated into FDI firms (technology dissemination), are facilitated when both types of firms are located in the same region. This is in line with the notion of 'learning' found in the agglomeration economies literature. Furthermore, the FDI literature has shown that domestic firms are more likely to experience knowledge spillovers by hiring local workers that were previously employed by FDI firms in the same region – this in turn relates to the notion of 'matching' in the agglomeration literature. More importantly, perhaps, the similarity concerns also the notion of 'sharing', which refers to the exploitation of common distribution networks, resource-sourcing, supply linkages and local knowledge. Studies in both the economic geography and international business literature have found that FDI firms create supportive linkages with local suppliers, generating important networks and knowledge spillovers at the regional level (e.g. Ivarsson and Alvstam, 2011; Domanski and Gwosdz, 2009; Jordaan, 2011, 2013).

Besides these notable similarities, the recognition that agglomeration creates productivity externalities suggests that this aspect of geography may have an additional influence on the productivity effects of FDI – in the form of interaction effects. Specifically, if agglomeration is a vehicle via which positive productivity spillovers materialise, FDI spillovers should be expected to be stronger in cases where agglomeration is more prevalent, i.e. in industries which are more heavily concentrated spatially (in one or more regions) and/or in regions which exhibit higher concentrations of firms (in one or more industries). Generalising, one could claim that the prevalence of FDI spillovers may be conditioned on spatial heterogeneity more broadly – depending on regional characteristics such as the scale of industrial concentration, the extent of urban agglomeration and others. Importantly, this may concern not only positive FDI spillovers but also cases where FDI firms may generate negative spillovers. For example, FDI firms may force domestic firms to operate at smaller production scales resulting in efficiency losses (Aitken and Harrison, 1999) or they may put an upward pressure on prices of inputs, resulting in crowding-out effects among domestic firms (Menghinello et al., 2010; Jordaan, 2008b). Again, such effects should be expected to be more pronounced at the regional rather than the national level.

Despite the relative intelligibility of this line of thought, studies that examine the geographical dimension of FDI spillovers and the spatial factors that may condition the size and prevalence of such spillovers form a small minority in the relevant literature. Indeed, it can be argued that the main thrust of this literature pays little attention to the geographical dimension. This is in some ways rather curious, as the recent literature on FDI spillovers has experienced a marked shift of focus towards the examination of contextual factors that may condition the occurrence, level and nature of these spillovers. Also, even in the limited literature that does examine issues of geography with regard to FDI spillovers the findings tend to be fragmentary and rather inconclusive.

Broadly speaking, evidence on the geographical dimension of FDI spillovers contains three sets of findings. The first set relates to the general prevalence of regional FDI spillovers and their diffusion across space. The results in this literature are generally mixed. Aitken and Harrison (1999) present a firm level analysis of manufacturing firms in Venezuela and find that, when controlling for both national and regional industry FDI participation, regional FDI does not create a significant productivity effect. Similar findings of insignificant regional FDI effects are presented by Yudaeva et al. (2003) for Russia, while for Portugal Crespo et al. (2009) report a negative association between regional FDI and productivity of domestic firms. In contrast, evidence that regional FDI generates positive spillovers has been presented by Wei and Liu (2006) for China, Blalock and Gertler (2008) for Indonesia, Peri and Urban (2006) for Italy and Monastiriotis and Jordaan (2010) for Greece.

Similarly inconclusive are the results concerning the extent of spatial diffusion of FDI spillovers. Javorcik and Spatareanu (2008) estimate intra- and inter-industry spillovers in Romania, examining separately the effect of FDI participation inside each region and in all other regions. Their findings indicate that at the intra-industry level (horizontal spillovers) both intra- and inter-regional spillovers are negative whereas the productivity effect of intra- and inter-regional inter-industry FDI (vertical spillovers) is positive. Jordaan (2008b) presents similar findings for Mexican regions; while for Hungary, Halpern and Muraközy (2007) present evidence of negative intra-regional and positive inter-regional intra-industry spillovers. In contrast, for the UK Girma and Wakelin (2007), Driffield (2006) and Kneller and Pisu (2007) find that intra- and inter-industry FDI spillovers only materialise within (and not across) UK regions, suggesting a high degree of localisation of spillovers and no spatial diffusion effects. In turn, significant spatial diffusion effects have been found in the studies by Mullen and Williams (2007) and Ke and Lai (2011).

A second set of findings concerns studies seeking to identify spatial heterogeneity in the spillover effects of FDI. For Indonesia, Sjöholm (1999) looks at the effect of regional size and finds that this affects both the level and sign of spillovers. Driffield (2004) and Girma and Wakelin (2007) examine the influence of state aid and regional incentives in the UK and find that positive FDI spillovers do not arise (or are at least smaller) in regions with assisted area status. For Italy, Menghinello et al. (2010) find that FDI spillovers differ between Northern and Southern regions and between regions with high or low FDI participation. Monastiriotis and Jordaan (2010) present similar findings of spatially heterogeneous effects for intra-industry FDI spillovers among Greek manufacturing firms. Finally, for Romania, Altomonte and Colantone (2008) identify a clear difference in the FDI spillover impact between core regions and the rest of the country.

Last, in a third strand of this literature, a limited number of studies have examined the interrelation between agglomeration and regional FDI spillovers. Barrios et al. (2006) estimate FDI spillovers for the Irish economy and find that positive spillovers only arise in industries where

FDI and domestic firms are co-agglomerated. Evidence that positive spillovers are larger in agglomerated industries is presented by Driffield and Munday (2001) for the UK and Jordaan (2005) for Mexico. In turn, Jordaan (2008a) estimates FDI spillovers in several core regions in Mexico and finds that industry agglomeration can foster both positive and negative spillovers. Related to this, De Propris and Driffield (2006) find for the UK that intra-industry FDI spillovers are of a positive nature in clustered industries and negative in non-clustered industries. Finally, Menghinello et al. (2010), in what is perhaps the most detailed study of the inter-relation between agglomeration and regional FDI, find several significant positive and negative effects from the interaction of FDI concentration with measures of regional and sectoral agglomeration in Italy. Spatial heterogeneity also appears to play a role, as the effects of these interactions are found to vary between different types of regions.

The three strands of empirical research, as briefly reviewed here, show that there is considerable evidence that the various dimensions of geography can play an important role for FDI spillovers. Having said this, it is also noteworthy that the majority of the studies focus on one or a limited number of these dimensions, thus providing only partial accounts of the geography of FDI spillovers and their spatial determinants. In the present paper, we attempt to capture more fully the effects of geography and space on FDI spillovers. Extending upon what is already offered in the literature reviewed here, we address the following three research questions. First, what is the spatial scale at which FDI spillovers materialise, i.e. are spillovers localised or do they instead accrue within/between sectors across the national economy? To answer this question, we estimate both intra- and inter-industry spillovers at three different geographical scales: national, regional (NUTS2) and local (NUTS3). Second, what is the relationship between agglomeration and FDI spillovers? To examine this, we account for industry-region specific characteristics related to industry agglomeration, regional specialisation and employment density and assess whether these characteristics affect FDI spillovers – either by introducing interaction terms or by examining the impact of FDI across relevant sub-samples. Third, are FDI spillovers subject to spatial heterogeneity? Rather than referring to the direct relation between industry-regional specific agglomeration characteristics and FDI spillovers, this question relates more to region-wide characteristics that may be linked to FDI spillovers. To identify the presence of spatial heterogeneity, we estimate FDI spillovers distinguishing between regions according to their overall level of agglomeration, inward FDI and productivity levels. Thus, our three research questions examine sequentially three central elements of the geographical dimension of FDI spillovers: their localisation, their relation to industry-region specific agglomeration characteristics, and their spatial (regional) heterogeneity. To our knowledge, ours is the first study to examine these dimensions in an integrated and focused fashion.

## 3. Data and model

The dataset that we use for the analysis consists of a large sample of manufacturing firms in Greece, comprising an unbalanced panel of 24,621 observations covering the period 2002-2006. The data was obtained from the Amadeus database of Bureau van Dijk, which is frequently used in empirical studies on FDI spillovers. The Amadeus database provides a range of firm-level information obtained from companies' balance sheets, including information on location, industry and type of ownership. More specifically, our dataset contains the following firm-level variables: turnover, number of employees, total fixed assets, ownership structure, location (NUTS2 and NUTS3) and NACE2 industry. With this information, we calculate a number of firm- and industry/area-level variables, which we use in our empirical analysis (see Table A.1 in the Appendix for the full list of variables).

The key variables of interest concern measures of intra- and inter-industry FDI participation. To measure the degree of intra-industry FDI, we follow common practice and take the ratio of the number of employees working for FDI firms over the total number of employees in the reference category. Given our focus on the question of scale (localisation), we measure intra-industry FDI participation at three different geographical scales: national (FDI employees in the sector nationally over total number of employees in the sector nationally), regional (FDI employees in the sector in each NUTS2 region over total number of employees in the sector in each NUTS2 region) and local (as above, but defined at the NUTS3 level). To capture the degree of inter-industry FDI participation there are two options. First, a weighted index which aggregates for each sector the levels of FDI employment across all other sectors using as weights the input (upstream) and output (downstream) shares of each sector, according to a national input-output table (see. e.g. Javorcik, 2004; Blalock and Gertler, 2008). Second, an unweighted index which takes a simple arithmetic average of FDI participation in all other sectors, without applying any weights (see

Girma and Wakelin, 2007; Menghinello et al., 2010). Intuitively, the first option is more appealing, as it captures 'actually expected' inter-industry linkages. In practice, however, these indicators of inter-industry FDI linkages are imperfect, as they are based on several assumptions that are unlikely to hold (Barrios et al., 2011). These include the assumptions that FDI firms have the same input sourcing and selling behaviour as domestic firms; that the FDI employment shares are reflective of their levels of sourcing and selling; that the input-output coefficients are themselves measured accurately; and, perhaps more importantly, that the coefficients of the national input-output table apply to all regions in a similar way. Given these shortcomings, we prefer to use the more broadly defined indicator of overall inter-industry FDI participation. For a given industry, we calculate inter-industry FDI as the share of FDI in total manufacturing employment, omitting the particular industry, at the three spatial scales (national, regional, local). Thus, for example, regional inter-industry FDI is measured as the share of FDI employment in all sectors in a region, except the sector of interest, over total employment in the same region and the same sectors.

The second set of variables that are of interest for our analysis concerns the measures of industry-region specific agglomeration characteristics. The literature offers a large number of indicators aiming at capturing the influence of agglomeration economies (Rosenthal and Strange, 2004; Melo et al., 2009). In our analysis we utilise three simple measures, each capturing a different dimension of agglomeration and each expected to exert a positive influence on firms' productivity and, presumably, on the size of productivity spillovers accruing from FDI. The first variable is a measure of absolute specialisation, capturing the dominance of a sector in the region where it is located (NUTS2 or NUTS3 region). The variable is calculated as the share of the sector in total regional manufacturing employment. The second variable is a measure of relative specialisation/dominance, whereby a sector's share in the region is standardised by the corresponding sector's share nationally. Menghinello et al. (2010) present this measure as a direct measure of localisation economies. The third indicator is calculated by dividing the total employment of a regional industry by the region's total area surface (in km2). This variable measures the density of a particular sector in its region and tries to capture intra-industry firm proximity, reflecting the theoretical intensity of interactions across firms within each sector.

A third set of variables concerns some firm-specific characteristics and some broader regional/industry-level characteristics which may account for a firm's productivity via other regional externalities not directly linked to agglomeration. 'Industrial scale' is a measure of region-industry size and captures the effect of sheer scale of an industry's presence in a region. It is calculated as the natural logarithm of the number of employees of the regional industry (calculated alternatively at the NUTS2 and NUTS3 levels). 'Small firms' captures the relative degree to which a regional industry consists of micro and small firms. We measure this variable as the ratio between the average firm size of a sector in a region and of the same sector nationally.[1] Finally, 'Industry Mix' is a variable representing the level of labour productivity that would be

[1] The effect of this variable may be positive or negative. Following the literature on industrial districts, a high share of small firms may generate positive productivity effects (Menghinello et al., 2010). On the other hand, micro and small firms are also known to use older and more standardised technologies, generating lower productivity effects (Jordaan, 2008b).

expected for any sector in a region, given the labour productivity of this sector's sub-divisions nationally and the employment composition of this sector (in terms of its sub-divisions) in the particular region.[2] Essentially, this captures the degree to which firm level productivity is affected by productivity dynamics at the industry level nationally, i.e., dynamics that occur at the general industry rather than the regional industry level (Rigby and Essletzbichler, 1997, 2000; Jordaan, 2008b). Among the firm-specific variables, the first ('Tech Gap') captures the degree of technological differences between a given domestic firm and the most productive FDI firm in its industry-region. Although not of direct relevance to the issues of agglomeration and regional heterogeneity, this is an important variable within the context of the FDI literature, as numerous studies have shown that the materialisation of FDI spillovers may depend heavily on the technology distance between foreign and local firms (Peri and Urban, 2006; Girma, 2005; Blalock and Gertler, 2009). The other two firm level variables are dummy variables controlling for firm size: one for firms with less than 10 employees ('Micro') and one for firms of over 30 employees ('Medium and Large').

Our data also contains the two standard production-function variables (log of firm-level employment and log of fixed assets[3], as a proxy for the firm's capital), which we use in order to derive our dependent variable, firm-level total factor productivity (TFP). Specifically, given that TFP is

[2] We calculate this variable as follows. For the national industry level, we calculate average labour productivity (turnover over employees) for all NACE4 manufacturing industries. Subsequently, for a given regional NACE2 industry, we sum the productivity indicators of the national NACE4 industries that are classified under the NACE2 industry, using the shares of regional NACE4 industries in the regional NACE2 industry as weights.
[3] All nominal variables are deflated by the national CPI and expressed in constant 2002 prices.

not directly observable, we estimate this econometrically through the following equation:

(1)

$$y_{i,s,r,t} - \bar{y}_{s,t} = \alpha_{s,t}\left(k_{i,s,r,t} - \bar{k}_{s,t}\right) + F_{i,s,r} + \varepsilon_{i,s,r,t}$$

where ***i*** indicates firms, ***s,r,t*** represent the sector, regional and time dimensions of the data; y and k are firm level turnover per worker and total fixed assets per worker; $\bar{y}$ and $\bar{k}$ are the industry-year averages of the same variables; $\alpha_{s,t}$ captures the elasticity of output to physical capital; and ***F*** is a firm level fixed effect which controls for unobserved time-invariant characteristics that are specific to the firm and affect its productivity. Following Peri and Urban (2006), we take the residuals from this regression as our measure of firm-level total factor productivity.

Subsequently, we regress this TFP indicator on variables capturing intra- and inter-industry FDI participation to identify FDI spillovers. To do so, we specify the following baseline regression model:

(2)

$$TFP_{i,s,r,t} = \beta_0 + \beta_1 IntraindustryFDI_{s,r,t} + \beta_2 InterindustryFDI_{s,r,t} + \beta_3 Agglomeration_{s,r,t} + \beta_4 AISV_{s,r,t} + \beta_5 FSV_{i,s,r,t} + D_t + F_{i,s,r} + \varepsilon_{i,s,r,t}$$

This model makes TFP a function of intra-and inter-industry FDI; several variables capturing elements of agglomeration economies; two vectors of area/industry-specific variables (AISV) and of firm-specific variables (FSV), as discussed above; as well as a vector of year dummies (***D***) and a vector of firm-level fixed effects (***F***). By having subtracted the industry-year averages from firm level turnover and fixed assets in equation (1), industry-year effects are controlled for. By estimating equation (2) with firm level fixed effects, time invariant regional effects also drop out. To control for heteroscedasticity and autocorrelation, we estimate the model with clustered standard errors at the regional-industry level. As noted earlier, our FDI variables are measured at three different scales. Thus, when we measure FDI at the national-sectoral level, the index $r$ for the FDI variables is dropped; while when we measure FDI at the regional (local) level, $r$ indexes NUTS2 (NUTS3) regions. Additionally, given our interest in how agglomeration forces may influence intra- and inter-industry FDI spillovers (coefficients $\beta_2$ and $\beta_3$), in several regressions we add interactive terms between the agglomeration and FDI variables and/or estimate equation (2) for sub-samples of firms, split along a number of dimensions related to the prevalence of agglomeration forces. We explain this in more detail together with the presentation of our results, which follows in the next section.

# 4. Empirical findings

## 4.1 The spatial scale of spillovers: localisation versus sector-wide effects

A key question for our analysis, relating to the importance of spatial scale and proximity, concerns the degree to which FDI spillovers are localised. To examine this, we estimate equation (2) defining our intra- and inter-industry FDI participation variables alternatively at the national, regional (NUTS2) and local (NUTS3) levels. The findings are presented in Table 1.

**Table 1. The spatial scale of FDI spillovers**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| **FDI variables** | | | | |
| National Intra-industry | 0.272** | 0.118 | 0.187 | 0.138 |
| | (0.118) | (0.117) | (0.121) | (0.117) |
| National Inter-industry | 0.616 | 0.601 | 0.328 | 0.334 |
| | (0.675) | (0.695) | (0.666) | (0.673) |
| NUTS 2 Intra-industry | | 0.180** | | 0.215* |
| | | (0.0696) | | (0.125) |
| Nuts 2 Inter-industry | | 0.242 | | 0.0587 |
| | | (0.161) | | (0.160) |
| Nuts 3 Intra-industry | | | 0.126** | -0.0345 |
| | | | (0.0599) | (0.109) |
| Nuts 3 Inter-industry | | | 0.828*** | 0.794*** |
| | | | (0.218) | (0.225) |
| **Firm controls** | | | | |
| Micro-firms | 0.617*** | 0.616*** | 0.616*** | 0.616*** |
| | (0.128) | (0.127) | (0.127) | (0.127) |
| Medium and large firms | -0.326*** | -0.325*** | -0.326*** | -0.325*** |
| | (0.0589) | (0.0590) | (0.0588) | (0.0588) |
| Tech Gap | -0.0186*** | -0.0178*** | -0.0178*** | -0.0176*** |
| | (0.00426) | (0.00412) | (0.00413) | (0.00410) |
| **Regional controls** | | | | |
| Industry scale | -0.0359 | -0.0244 | -0.0324 | -0.0284 |
| | (0.0269) | (0.0280) | (0.0266) | (0.0274) |
| Industry Mix | 0.000790** | 0.000822** | 0.000903*** | 0.000910*** |
| | (0.000347) | (0.000323) | (0.000294) | (0.000292) |
| Small firms ratio | -0.0471 | -0.0585 | -0.0480 | -0.0511 |
| | (0.0393) | (0.0413) | (0.0392) | (0.0399) |
| **Agglomeration variables** | | | | |
| Absolute specilisation | -1.107 | -1.417* | -0.332 | -0.410 |
| | (0.767) | (0.819) | (0.800) | (0.915) |
| Relative specialisation | -0.00151 | -0.00140 | 0.00371 | 0.00486 |
| | (0.0246) | (0.0265) | (0.0254) | (0.0265) |
| Employment density | 0.0606 | 0.0508 | 0.0475 | 0.0441 |
| | (0.0406) | (0.0381) | (0.0358) | (0.0354) |
| Constant | 0.437 | 0.415 | 0.134 | 0.122 |
| | (0.333) | (0.336) | (0.331) | (0.343) |
| Fixed effcets | Firms & Years | Firms & Years | Firms & Years | Firms & Years |
| Clustered s.e. | Industry Nuts 2 | Industry Nuts 2 | Industry Nuts 2 | Industry Nuts 2 |
| Nobs | 24,588 | 24,588 | 24,588 | 24,588 |
| R-square (within) | 0.024 | 0.025 | 0.025 | 0.026 |

Notes: standard errors in parentheses. *** p <0.01, ** p < 0.05, * p < 0.10. The agglomeration variables are measured at the NUTS-2 level.

The first column reports the results from the sector-wide (national-level) measures of FDI. At this level, FDI participation is found to have a positive effect on the productivity of domestic firms located in the same sector (intra-industry spillovers), which is significant at the 5% level. The inter-industry (across sectors) effect is also positive but it is not significant statistically.[4] On this piece of evidence, it would appear that FDI produces positive horizontal (intra-industry) but no vertical (inter-industry) productivity spillovers in Greece; with the former effect being quite sizeable and larger than those estimated in other studies for the case of Greece (Dimelis, 2005; Monastiriotis and Jordaan, 2010). Our remaining results, however, show that these spillovers are generally rather localised and that, moreover, significant vertical spillovers also exist – but at a much finer spatial scale. Specifically, in column 2, where we control for FDI presence simultaneously at the national and regional (NUTS-2) levels, we find that intra-industry spillovers are only significant within regions, while inter-industry spillovers remain non-significant statistically at both geographical scales. The coefficient on the regional-level intra-industry effect is smaller than the national-level effect estimated in col.1 (0.18 versus 0.27), suggesting that positive horizontal spillovers may diffuse in part across regions albeit to an extent that cannot be precisely estimated in our data (the coefficient for the national-level intra-industry effect remains positive but is insignificant). In turn, when we control for FDI presence simultaneously at the national and local (NUTS-3) levels (col.3), we find not only a significant local-level intra-industry effect but also, this time, a highly significant (at 1%) local-

[4] As a form of robustness check, following Peri and Urban (2006), we also estimated the model with alternative TFP indicators: a version of our current indicator but estimated without the use of firm-level fixed effects (OLS) and the 'superlative' index as developed by Caves et al. (1982). The results with the TFP(OLS) indicator are in line with those presented in table 1. The findings with the superlative index are more varied, as the effects are estimated less precisely. Furthermore, the results are stable when we use temporal (one- and two-year) lags of the FDI variables and when we instrument the FDI variables to control for the possible selection of foreign firms into high-productivity sectors and regions (endogeneity). In these regressions, the FDI coefficients become less positive and less significant statistically, showing that, to some degree at least, selection is present. However, they do not change the thrust of the results and analysis presented here. As our focus is not on the issue of selection or TFP measurement, we do not report these results here but we note that all results can be made available upon request.

level inter-industry effect, which is moreover of a much larger magnitude. This local-level inter-industry effect remains strong and of a similar magnitude when we examine the effects of FDI at all three geographical scales simultaneously (col.4); but in this case, the local-level intra-industry effect disappears and intra-industry spillovers appear to be strongest at the regional level.

These results point to a very important conclusion, which to our knowledge has not been proposed in the literature in the form and with the level of detail offered here. For both intra-industry and inter-industry spillovers geographical proximity matters significantly, but whereas intra-industry spillovers are stronger at meso-level geographical scales (as captured by our NUTS-2 classification), inter-industry spillovers are of a very localised nature (NUTS-3). A tentative interpretation of these findings would be that, for vertical spillovers, sharing (networks, sourcing, supply linkages) plays a more prominent role, while competition for market shares does not apply. If so, close geographical proximity is of the utmost importance for facilitating inter-firm linkages between FDI and domestic firms and enhancing the productivity of the domestic firms. In contrast, in the case of intra-industry spillovers, learning (in the form of imitation or demonstration effects) and labour pooling (matching) seem to take place at larger (but still sub-national) geographical scales, whereas negative competition effects may be more prevalent at the very local scale[5]. As a result, positive horizontal FDI spillovers accrue predominantly to firms at meso-geographical scales

[5] See Martin (1999) and Parr (2002) for similar notions on the possibility that the varying spatial scales of different types of agglomeration economies may be linked to how their underlying mechanisms are affected by geographical space.

(NUTS2) whilst positive vertical FDI spillovers accrue almost exclusively to firms within very narrow geographical areas (NUTS3).

The significance of these results notwithstanding, the remaining results of those presented in Table 1 are also worthy of discussion. Starting with our controls for firm-level heterogeneity, we note that all appear to be highly significant. Interestingly, micro-firms (less than 10 employees) and small firms (less than 30 employees) seem to have a productivity advantage over medium and large firms, a result which is very consistent across a range of specifications that we have examined (not shown but available upon request). The technology gap also returns a highly significant effect (at 1%), showing that firms located further away from the technology frontier (represented by the most productive FDI firm in the relevant region-industry) have an additional disadvantage in terms of total factor productivity – or, alternatively, that the presence of highly advanced FDI firms in an industry-region hampers the productivity of domestic firms.

In turn, among our variables controlling for regional characteristics/heterogeneity, only the industry mix is statistically significant (very strongly at 1%), with its positive coefficient indicating that part of firm level productivity is caused by non-spatial industry-level developments. Industrial scale and the relative share of small firms are both insignificant across models, showing that these factors are of limited relative importance for firms' productivity performance. Last, concerning the performance of our agglomeration variables, it is quite noticeable that, at this level of analysis, none of them appears statistically significant. The indicator of absolute specialisation enters with a negative sign, suggesting if anything the presence of congestion diseconomies; while the indicator of relative specialisation, which tends to be positive (especially when, in results not reported, absolute specialisation is dropped from the model), has extremely large standard errors and is almost precisely estimated to be equal to zero (p-values are in the area of 0.8). Only employment density, our proxy for inter-firm proximity and intensity of interactions, returns a consistently positive and only marginally insignificant effect – which, notably, becomes statistically significant when the effects of FDI are not controlled for (not shown). These findings that indicate an extremely limited effect of agglomeration on firm-level performance in our sample are quite surprising and certainly at odds with findings for other countries, although not fully inconsistent with previous evidence for the case of Greece (Louri, 1988; Monastiriotis and Psycharis, 2014; Skuras et al, 2011; Petrakos et al, 2012; Vogiatzoglou and Tsekeris, 2013). In any case, as our interest here is not with the role of agglomeration per se but rather with the influence that agglomeration has on the materialisation and size of FDI spillovers, we take the limited direct agglomeration effect found here as a motivation for the analysis that follows in the next sub-section.

### 4.2 The influence of agglomeration on FDI spillovers

To examine the link between agglomeration and FDI spillovers we follow two estimation strategies. First, we augment the regression model with a set of interaction terms between the agglomeration variables and the indicators of FDI participation. Second, we estimate the regression model for subsamples of industries, where we distinguish between industries with a low or high degree of agglomeration, based on our three alternative measures.

**Table 2. Agglomeration and FDI spillovers: interaction effects**

| FDI measure | National | | Regional | | Local | |
|---|---|---|---|---|---|---|
| | *β* | *s.e.* | *β* | *s.e.* | *β* | *s.e.* |
| *Direct effects* | | | | | | |
| Absolute specialisation | -1.611** | (0.777) | -2.088** | (0.931) | 0.515 | (0.822) |
| Relative specialisation | -0.0674 | (0.063) | -0.0163 | (0.027) | -0.00084 | (0.026) |
| Employment density | -0.101 | (0.090) | -0.0603 | (0.104) | -0.0581 | (0.053) |
| Intra-industry FDI | -0.148 | (0.246) | -0.143 | (0.122) | -0.154 | (0.106) |
| Inter-industry FDI | 0.638 | (0.956) | -0.0156 | (0.412) | 0.527 | (0.416) |
| *Interaction effects* | | | | | | |
| Intra-industry (x) AbsSpec | 0.0526 | (0.643) | 0.0453 | (0.373) | 0.296 | (0.349) |
| … … … (x) RelSpec | 0.150* | (0.0781) | 0.225** | (0.112) | 0.158* | (0.0918) |
| … … … (x) Density | 0.564** | (0.268) | 0.184 | (0.162) | 0.118 | (0.150) |
| *Joint significance (F-test)* | 6.62*** | *0.000* | 4.96*** | *0.001* | 4.57*** | *0.002* |
| Inter-industry (x) AbsSpec | 3.786** | (1.675) | 1.757* | (1.089) | 1.652 | (1.628) |
| … … … (x) RelSpec | 0.269 | (0.314) | 0.0122 | (0.188) | -0.0945 | (0.168) |
| … … … (x) Density | -0.0767 | (0.238) | 0.0564 | (0.193) | 0.223 | (0.198) |
| *Joint significance (F-test)* | 3.21** | *0.014* | 1.71 | *0.166* | 6.22*** | *0.000* |
| *Marginal effects* | | | | | | |
| Intra-industry FDI | 0.622*** | (0.228) | 0.341*** | (0.111) | 0.252** | (0.101) |
| Inter-industry FDI | 2.008*** | (0.853) | 0.568** | (0.226) | 1.109*** | (0.281) |
| Constant | 0.322 | (0.346) | 0.648** | (0.259) | -0.0379 | (0.299) |
| Observations | 24,588 | | 24,588 | | 24,588 | |
| R-squared (within) | 0.026 | | 0.026 | | 0.026 | |

Note: standard errors in parentheses. *** p <0.01, ** p < 0.05, * p < 0.10. All regressions include additional controls for firm-level and regional characteristics similar to those depicted in Table 1. Also included are year dummies and firm-specific fixed effects. Standard errors are clustered at the industry-region level.

The findings from estimating the regression models with the interaction variables at the national, regional (NUTS 2) and local (NUTS 3) level are presented in Table 2. As can be seen, an important difference with the previous findings of Table 1 is that the inclusion of the interaction terms renders the direct spillover effects from FDI insignificant at all spatial scales. This indicates the importance of the interplay between FDI and agglomeration for spillovers from foreign firms. Subject to this interplay (interaction effects), the direct effect of absolute specialisation becomes now significantly negative in the national- and regional-level regressions while the direct effects of relative specialisation and employment density remain insignificant but turn negative. In contrast, the coefficients of the interaction terms are almost always positive and in around a third of the cases statistically significant. Absolute specialisation (at the NUTS2 level) appears to enhance inter-industry FDI spillovers at the national and regional levels but its effect on intra-industry spillovers and on local-level spillovers of any kind, albeit also positive, is not statistically significant. Relative specialisation is found to raise the size of intra-industry spillovers from FDI at every spatial scale (and especially at the regional level) but seems to have no effect on the size of inter-industry FDI spillovers at any scale. Employment density also has no identifiable effect on inter-industry FDI spillovers but it appears to have a strong positive effect on the size of intra-industry FDI spillovers only at the national level; at the two sub-national scales the coefficients remain positive but are not significant statistically.

Bearing in mind that interpretation of interaction effects in models that contain multiple interaction terms may be problematic (Kam and Franzese, 2009), we do not attempt to offer a further interpretation of these findings. What is important for the question that we set out to analyse in this sub-section is that the evidence clearly points to the conclusion that FDI spillovers are indeed conditioned by the extent of industrial agglomeration, both regionally and locally. In Table 2 we document this in two complimentary ways. First, by looking at the joint significance of the interaction terms for the two types of FDI spillovers. Second, we report in the lower panel of Table 2 the marginal effects for the two FDI variables, calculated at the mean values of the agglomeration variables.[6] Starting from the marginal effects, as can be seen, these are significant statistically at all spatial scales and for both FDI variables. Consistent again with our earlier findings, horizontal (intra-industry) spillovers are stronger at the national level and lose significance as we move down to smaller spatial scales. In contrast, vertical (inter-industry) spillovers are stronger at the local (NUTS3) level. Similarly, on the measure of joint significance, the estimated intra-industry spillovers from FDI are statistically significant at all geographical scales, while the estimated inter-industry spillovers are mainly significant at the local scale (NUTS3). These findings are fully consistent with what was shown in the analysis of Table 1 but in this instance they show that the effect of FDI is intermediated through forces of agglomeration at the local and regional levels (given that the estimated direct effects of FDI in these interaction-terms models are not statistically significant).

Another way of depicting the influence of agglomeration forces is by examining the prevalence of FDI spillovers across separate groups of industries. We separate the regional industries into low and high agglomerated groups on the basis of our three agglomeration variables and re-estimate for these sub-groups the full model as presented in col.4 of Table 1, which includes FDI controls for all three spatial scales simultaneously but without the interaction terms. We present these results in Table 3, focusing only on the estimated coefficients for the FDI variables and reporting regression results from models that split the

[6] We have used the command – margins, dydx – in Stata 13. Marginal effects at different values of the agglomeration variables are available upon request.

sample across industries defined as low/high agglomeration on the basis of both the regional-level and local-level measures of agglomeration.[7]

The results are fully consistent with what we found earlier, but offer a more intimate picture on the interplay between agglomeration and FDI spillovers. When agglomeration is measured at the region-industry level (top panel of Table 3), we find consistently (with the exception of the case when the sample is split on the basis of the density measure) that intra-industry FDI spillovers accrue at the regional level while inter-industry FDI spillovers accrue at the local level. However, this concerns exclusively industry-region groups with above-average levels of agglomeration. For the others, no statistically significant effect is found. The only exception to this is the case of local-level inter-industry spillovers on the basis of the relative specialisation split (col.3), where the effect seems to be independent of the level of relative regional industrial specialisation. These results change somewhat when we measure agglomeration at the NUTS3-industry level (bottom panel of Table 3), but the general thrust of the findings still holds. Both types of spillovers (intra- and inter-industry) are still found to be stronger in high-agglomeration areas; intra-industry spillovers are always weaker at the local level and in the case of the density-based split they appear to be negative in a statistically significant sense, while inter-industry spillovers are always and exclusively stronger at the local level.

[7] As our measures of industry agglomeration are area-specific, we repeat the analysis for both the regional (NUTS2) and local (NUTS3) scales.

**Table 3. Agglomeration and FDI spillovers: regressions for sub-samples**

| | Specialisation (absolute) | | Agglomeration (rel spec) | | Density | |
|---|---|---|---|---|---|---|
| | Low | High | Low | High | Low | High |
| **Agglomeration variables defined at the NUTS2 level** | | | | | | |
| **Intra-industry** | | | | | | |
| **National** | 0.0100 | 0.189 | -0.165 | 0.237 | 0.0594 | 0.254 |
| | (0.233) | (0.124) | (0.225) | (0.163) | (0.183) | (0.280) |
| **Regional** | 0.0524 | 0.323** | 0.0957 | 0.219* | 0.118 | -8.73e-05 |
| | (0.152) | (0.153) | (0.276) | (0.127) | (0.134) | (0.169) |
| **Local** | 0.0611 | -0.169 | 0.128 | -0.0972 | -0.0757 | 0.0679* |
| | (0.145) | (0.126) | (0.240) | (0.112) | (0.104) | (0.0382) |
| **Inter-industry** | | | | | | |
| **National** | -0.419 | 0.142 | 0.159 | -0.444 | 0.0447 | 0.764 |
| | (1.040) | (0.749) | (0.928) | (1.069) | (0.959) | (0.605) |
| **Regional** | -0.0553 | -0.0578 | 0.385 | 0.0420 | -0.118 | -0.370 |
| | (0.182) | (0.378) | (0.343) | (0.181) | (0.188) | (0.394) |
| **Local** | 0.325 | 1.408*** | 0.991** | 0.855*** | 0.424 | 0.276 |
| | (0.292) | (0.439) | (0.391) | (0.245) | (0.287) | (0.523) |
| **Agglomeration variables defined at the NUTS3 level** | | | | | | |
| **Intra-industry** | | | | | | |
| **National** | -0.188 | 0.418** | -0.0420 | 0.205 | -0.125 | 0.251 |
| | (0.226) | (0.180) | (0.207) | (0.180) | (0.247) | (0.178) |
| **Regional** | 0.189 | -0.261 | 0.261 | 0.245 | 0.144 | 0.463*** |
| | (0.146) | (0.264) | (0.166) | (0.185) | (0.141) | (0.153) |
| **Local** | -0.103 | 0.318 | -0.0857 | -0.124 | -0.0127 | -0.315*** |
| | (0.108) | (0.234) | (0.143) | (0.157) | (0.135) | (0.119) |
| **Inter-industry** | | | | | | |
| **National** | -0.669 | 0.668 | -0.363 | 0.541 | -1.124 | 0.751 |
| | (0.889) | (0.907) | (0.901) | (1.147) | (1.161) | (0.813) |
| **Regional** | -0.0787 | -0.300 | 0.325 | -0.117 | 0.0298 | -0.148 |
| | (0.216) | (0.436) | (0.237) | (0.219) | (0.231) | (0.281) |
| **Local** | 0.555* | 1.411** | 0.451 | 0.876*** | 0.242 | 0.784** |
| | (0.287) | (0.655) | (0.480) | (0.245) | (0.304) | (0.381) |

Notes: standard errors reported in parentheses. *** p <0.01, ** p < 0.05, * p < 0.10. All regressions include additional controls for firm-level and regional characteristics similar to those depicted in Table 1. They also include year dummies and firm-specific fixed effects. Standard errors are clustered at the industry-region level. Industries are classified into “low” and “high” industries based on whether their levels of absolute specialisation, relative specialisation and density are lower or higher than the sample median.

On the whole, our results from this exploration of the link between FDI spillovers and agglomeration are unambivalent: agglomeration plays an important role for the realisation of FDI spillovers. Controlling for the extent of agglomeration does not change the nature and incidence of these spillovers (i.e., the fact that they are localised at different geographical scales), but it rather reveals that agglomeration is a key factor conditioning their materialisation – as the direct effects (Table 2) and the effects in low-agglomeration cases (Table 3) are systematically non-significant. In that, we are confident that our evidence demonstrates convincingly that for FDI spillovers both localisation and agglomeration matter.

### 4.3 Spatial heterogeneity

To conclude our exploration of the geographical dimension of FDI spillovers, we now turn our attention to the issue of spatial heterogeneity. To do so, we follow a similar approach to that depicted in Table 3 and re-estimate our FDI spillovers model, this time splitting the sample across sets of regions by using four classification criteria drawing upon relevant literature[8]. Similar to Menghinello et al. (2010), we divide the regions depending on their degree of geographical concentration of manufacturing activity and their level of regional FDI participation. Additionally, we distinguish between core and peripheral regions (Altomonte and Colantone, 2008; Menghinello et al., 2010).[9] Finally, following Merlevede and Purice (2015), we also divide regions based on

[8] We use NUTS3-level measures to produce our categorical variables on which to split the sample, so as to have a finer disaggregation of space and maximum heterogeneity across our spatial units.

[9] We take the NUTS2 regions of Central Macedonia and Athens as core regional economies. For the years covered by the sample, these two regions have an aggregate share in total manufacturing employment of 70% and their share in the total number of workers employed by FDI firms is about 80%. Using this core-periphery distinction also captures the effect of agglomeration, as the core regions contain large shares of manufacturing activity and the highest population densities in the country.

whether their aggregate level of productivity is above or below the median level of regional productivity.[10]

Table 4 presents our results, following the same format as in Table 3 (only estimates for the variables that involve intra- or inter-industry FDI are reported, at all three spatial scales). Starting with the estimates for intra-industry spillovers, we see that again these are statistical significant only for FDI measured at the regional level. This type of spillovers appears to materialise in core, rather than peripheral, regions and in regions of high, rather than low, productivity. This is consistent with findings elsewhere in the literature. Specifically, the core-regions effect reflects the importance of urban agglomeration and density for productivity spillovers (Altomonte and Colantone, 2008). In turn, the effect for the high-productivity regions indicates possibly a positive absorptive capacity effect, whereby firms located in more productive regions are able to benefit more from the presence of FDI firms as argued by Merlevede and Purice (2015).

Contrary to expectations, however, we find no statistical difference in the intra-industry effect of FDI between regions of high and low FDI concentration (and no statistically significant effect in any of the cases there). Read in conjunction with our other findings (a significant intra-industry effect exists but not when we split our sample on the basis of FDI concentration), this seems to suggest a strong threshold effect for FDI: within regions of high (low) FDI concentration, marginal differences in FDI concentration among different industries-regions do not seem to

[10] To obtain an indicator of the aggregate regional level of productivity, we follow the approach by Foster et al. (2001). For a given region, this involves calculating a weighted sum of TFP of all the manufacturing firms, where we use the firms' share in regional output as weight.

affect firm-level productivity. By implication, the impact of FDI concentration for the case of intra-industry spillovers is more of a 'between-groups' character (between firms located in high versus low FDI concentration regions). Also contrary to expectations is the effect we obtain in the case of the manufacturing split: our results indicate that intra-industry FDI spillovers accrue mainly to domestic firms located in regions with low concentrations of manufacturing – presumably reflecting an elevated role of foreign presence in areas exhibiting a relatively thin manufacturing base or, inversely, that FDI presence is less beneficial in areas with dense manufacturing activity.[11]

**Table 4. Spatial heterogeneity and FDI spillovers**

| | **Manufacturing** | | **Centrality** | | **FDI concentration** | | **Productivity** | |
|---|---|---|---|---|---|---|---|---|
| | Low | High | Periphery | Core | Low | High | Low | High |
| **Intra-industry** | | | | | | | | |
| **National** | -0.0937 | 0.147 | 0.0242 | 0.189 | -0.0990 | 0.211 | 0.252 | -0.155 |
| | (0.408) | (0.124) | (0.232) | (0.124) | (0.266) | (0.143) | (0.233) | (0.176) |
| **Regional** | 0.283* | 0.214 | 0.0519 | 0.323** | 0.199 | 0.214 | -0.116 | 0.579*** |
| | (0.159) | (0.139) | (0.153) | (0.153) | (0.180) | (0.156) | (0.174) | (0.164) |
| **Local** | -0.167 | -0.0255 | 0.0613 | -0.169 | -0.143 | -0.0598 | 0.157 | -0.164 |
| | (0.313) | (0.119) | (0.146) | (0.126) | (0.253) | (0.151) | (0.149) | (0.148) |
| **Inter-industry** | | | | | | | | |
| **National** | -3.671** | 0.859 | -0.474 | 0.141 | -0.370 | 0.478 | 1.341 | 0.167 |
| | (1.534) | (0.676) | (1.041) | (0.749) | (0.989) | (0.855) | (1.075) | (0.926) |
| **Regional** | -0.331 | 0.0935 | -0.0540 | -0.0600 | -0.167 | 0.138 | -0.0686 | 0.232 |
| | (0.285) | (0.206) | (0.182) | (0.378) | (0.231) | (0.271) | (0.288) | (0.209) |
| **Local** | 1.366** | 0.753*** | 0.324 | 1.409*** | 0.472 | 0.834** | 1.019** | 0.613** |
| | (0.538) | (0.247) | (0.292) | (0.440) | (0.366) | (0.323) | (0.432) | (0.304) |

Notes: standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. All regressions include additional controls for firm-level and regional characteristics similar to those depicted in Table 1. They include additionally year dummies and firm-specific fixed effects and clustered standard errors at the industry-region level. The categorical variables on which the sample is split are measured at the NUTS3 level. A region is classified as manufacturing intensive if the share of manufacturing in its total regional employment is larger than the sample median. Regions classified under Core are NUTS-3 regions located in Athens or Central Macedonia. A region is classified as having a high FDI concentration if its level of regional FDI participation in

[11] It is also possible that this finding captures the threshold effect of FDI concentration – if FDI presence is more sizeable, proportionately, in regions of low manufacturing concentration. We do not formally test this in our analysis, but we leave it as an issue that merits further exploration in future work.

its total number of manufacturing employees is above the sample median. A high productivity region is a region with an above sample median level of aggregate productivity.

The case of the manufacturing-based split is also interesting with regard to the inter-industry spillovers. For these, we find that firms located in regions with low concentrations of manufacturing benefit strongly from close proximity (within NUTS3 areas) to FDI firms operating in other industries; but that, specifically for this type of firms, the presence of higher shares of FDI in upstream and downstream industries nationally has a very strong negative effect on their productivity. In contrast, for firms located in regions of high manufacturing concentration the national share of inter-industry FDI has no detrimental effect and thus the strong positive effect linked to local-level concentration of upstream and downstream FDI dominates. A similar positive local-level inter-industry FDI effect is found selectively for the cases of firms located in core regions and in regions with high FDI concentrations, suggesting again an elevated role of urban agglomeration for productivity spillovers and possibly a non-linear effect of FDI on firm-level productivity.[12] In the case of the productivity split, the local-level inter-industry spillover effect is significant statistically for both groups of regions but it is sizeably larger for firms located in low-productivity regions. Following the line of argument put forward earlier for the case of intra-industry spillovers, this would seem to suggest that in the case of inter-industry spillovers absorption capacity is less relevant and, instead, local-level concentration of upstream and downstream FDI appears to benefit more (but not exclusively) firms located in low-productivity regions.

[12] For similar evidence of non-linear scale effects, see, inter alia, Gersl et al. (2007) and Monastiriotis and Alegria (2011).

Besides these individual effects, the results obtained for the case of inter-industry spillovers are once again consistent with the general thrust of our results. Positive inter-industry spillovers have been found to materialise exclusively at the very local level and thus to have a different geographical dimension compared to intra-industry spillovers which appear to accrue to firms across larger spatial scales (regional level). In both cases, spatial heterogeneity (type of location) is found to play a role – although not always in the direction one would expect, i.e., not being always stronger in regions with characteristics that are commonly perceived to be favouring externalities (large manufacturing and FDI concentrations, urban agglomeration, and high productivity). Still, this confirms our expectations about the third geographical dimension of FDI spillovers: together with spatial proximity (localisation) and spatial concentration (agglomeration), spatial heterogeneity (location) is an important factor conditioning both the size and the incidence of FDI spillovers both across and within sectors. We discuss the implications of these findings in the next section.

# 5. Conclusions and policy implications

In response to the inconclusive nature of the evidence on the general prevalence of positive FDI spillovers, recent research is concentrating on identifying factors that foster or even condition the materialisation of these externalities. The majority of this research places a strong focus on the identification of effects of firm level characteristics on FDI spillovers at the sector-country level. In comparison, the geographical dimension of FDI productivity effects is often overlooked or only partially accounted for. This omission is particularly striking given the strong similarities between the mechanisms that underlie agglomeration economies and FDI spillovers, similarities that strongly suggest that the geographical dimension is likely to play an important role also in the case of FDI. In our paper, we respond to this gap in the literature by conducting a comprehensive analysis of the spatial dimensions of FDI spillovers. In particular, we examine empirically whether and how spatial heterogeneity (location), spatial proximity (localisation) and spatial concentration (agglomeration) affect the size and sign of these externalities among domestic firms in the Greek manufacturing sector.

Our main findings can be summarised as follows. First, when controlling for national, regional (NUTS-2) and local (NUTS-3) FDI participation, we find that FDI spillovers occur at sub-national levels. In particular, intra-industry spillovers materialise at the regional level, whereas inter-industry spillovers are maximised at the much finer local level. This marked difference suggests that the mechanisms that underlie these two types of spillovers have different relations with geographical space, presumable due to the different role that proximity, intensity of interactions and market competition play for the materialisation of these spillovers. In any case, our findings clearly raise questions about approaches that do not take into account the geographical elements of proximity and localisation in the estimation of FDI spillovers.

Second, we present a range of findings that show that agglomeration also plays a vital role. Our empirical investigation of the interactions between intra- and inter-industry FDI and regional absolute specialisation, relative specialisation and employment density shows that these interactions are jointly significantly associated with domestic firm productivity. The inclusion of these interaction terms also renders the unconditional effects of intra- and inter-industry FDI insignificant at all three spatial scales, underlining the importance of the synergies between agglomeration and regional FDI. Furthermore, the examination of the marginal effects of FDI under the presence of the interaction terms confirms that inter-industry FDI spillovers are pronounced at the local (NUTS-3) level. Further evidence for this is obtained from estimating the regression model for different sets of industries, classified according to their region-industry specific level of agglomeration. Collectively, these findings clearly show that positive regional intra-industry and local inter-industry FDI spillovers are most pronounced in industries with a relative high degree of agglomeration.

Third, our findings also confirm that spatial heterogeneity needs to be accounted for when examining FDI spillovers. When estimating the regression model for different sets of NUTS-3 regions where we distinguish between regions based on their overall degree of agglomeration, productivity level and FDI participation, we find that regional intra-industry FDI spillovers materialise in Greece's core regions and in regions with relatively high aggregate productivity levels. As for local inter-industry FDI spillovers, we also find that these materialise in core regions as well as in regions with a high overall degree of FDI participation.

We derive the following three policy implications from our findings. The first is that, in a general sense, FDI-attracting policies that aim to foster economic and technological development in a host economy need to incorporate explicitly the recognition that the geographical dimension of FDI spillovers is likely to influence any externalities accruing to domestic firms. Notwithstanding the importance of research findings that show that firm level characteristics may also foster or hinder the materialisation of FDI spillovers, our findings clearly indicate the importance of carefully considering the location of FDI - within wider (NUTS 2 regions) and finer (NUTS 3 regions) local areas, as well as between areas of different profiles and degrees of urban agglomeration and industrial concentration – when designing and implementing development policies.

Second, our findings also suggest that development policies that are based on the attraction of new FDI need to be embedded in policies that aim to address regional growth and/or spatial imbalances in host economies. As our findings indicate, FDI spillovers occur at sub-national levels. This means that the benefits from new inward FDI are to a large extent spatially confined within host economies. Furthermore, our finding that the degree of spatial containment differs between intra- and inter-industry spillovers shows that regional policies need to examine carefully how the underlying spillover mechanisms function, as they may be affected to different degrees by spatial decay effects. In other words, policies that aim to influence the mechanisms that transmit FDI spillovers need to be based on the appreciation and understanding that the effects of such policies will be affected by varying degrees of spatial proximity.

Third, our results reflect the limitations or strong challenges that regional policy making faces when trying to foster regional growth by attracting new FDI into lagging regions. It is likely that the characteristics of regional industries that foster positive externalities (agglomeration, specialisation, proximity) are not prominent among industries in these regions. Similarly, lagging regions are less likely to share the broader regional characteristics that appear conducive to FDI spillovers, as identified in our analysis. This means that, to promote the growth of lagging regions, FDI-based regional policy interventions will need to be combined with a range of additional measures that try and compensate for the absence of geographically-based externality-inducing characteristics which have been found in the present analysis to play a vital role in the materialisation of FDI spillovers. In the absence of such supporting policies, it is likely that the geographical dimension of FDI spillovers will severely lower or prevent any spillovers accruing to domestic firms in less advanced regions, even if FDI-attraction policies are successful in directing new foreign investments into such regions.

# Appendix

**Table A.1. List of variables and definitions**

| Variable | Definition |
|---|---|
| **FDI variables** | |
| Intra-industry FDI | $\frac{\mathrm{employeesFDI}_{s,r,t}}{\mathrm{employees}_{s,r,t}}$ |
| Inter-industry FDI | $\frac{\sum_s \mathrm{employeesFDI}_{r,t} - \mathrm{employeesFDI}_{s,r,t}}{\sum_s \mathrm{employees}_{r,t} - \mathrm{employees}_{s,r,t}}$ |
| | |
| **Regional variables** | |
| Industry scale | $\ln(employees)_{s,r,t}$ |
| Industry mix | $\sum w \frac{turnover_{s,t}\,(nace4)}{employees_{s,t}(nace4)}$ <br> w = $\frac{employees_{s,r,t}\,(nace4)}{employees_{r,t}\,(nace4)}$ |
| Small firms ratio | $\frac{firms_{s,r,t} / employees_{s,r,t}}{firms_{s,t} / employees_{s,t}}$ |
| **Agglomeration variables** | |
| Absolute specialisation | $\frac{employees_{s,r,t}}{employees_{r,t}}$ |
| Relative specialisation | $\frac{employees_{s,r,t} / \sum_s employees_{r,t}}{\sum_r employees_{s,t} / \sum_r employees_t}$ |
| Employment density | $\frac{employees_{s,r,t}}{km^2{}_r}$ |
| **Firm level variables** | |
| Micro | 1 if firm has less than 10 employees, 0 otherwise |
| Medium and large firms | 1 if firm has more than 30 employees, 0 otherwise |
| Tech Gap | $\frac{maxTFPFDI_{s,r,t}}{TFP_{i,s,r,t}}$ |

Note: i,s,r,t capture firm, sector, region and time dimensions of the data. All data are calculated for NUTS-2 and NUTS-3 regions. Intra- and Inter-industry FDI are also calculated for the national level.

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