Spatial Effects of Foreign Direct Investment in US States

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Abstract

This paper estimates the aggregate productivity effects of Marshallian externalities generated by foreign direct investments (FDI) in the US. In contrast to earlier work, this paper puts special emphasis on controlling for Marshallian externalities and other intra- and inter-regional spillovers generated by domestic firms. The productivity effects of these externalities may, if not accounted for appropriately, be falsely attributed to FDI. This paper also deals with the potential endogeneity of FDI and the presence of spatial lags by employing a system generalized method of moments (GMM) estimator. We use a regional production function framework that models Marshallian externalities and other intra- and inter-regional spillovers explicitly as determinants of total factor productivity, and test several empirical specifications of this model, using data for US states from 1977–2003. The results indicate that FDI does, in fact, generate positive externalities, while those from domestic firms are negative.

Keywords: Foreign Direct Investment, US States, Spatial Econometrics, Marshallian Externalities.

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1 Introduction

Foreign direct investment (FDI) in the United States is located mainly in relatively advanced states and where agglomeration economies can be reaped (e.g., Coughlin, Terza and Arromdee 1991; Head, Ries and Swenson 1995; Bobonis and Shatz 2007). In turn, the concentration of FDI within the United States may have contributed to the spatial density of economic activity which, according to Ciccone and Hall (1996), explains much of the variation of productivity across US states. In contrast to location choice by foreign investors, however, the role of spatial factors in shaping the effects of FDI at the level of US states has received hardly any attention in previous literature.

In order to improve our understanding of the productivity and income effects of inward FDI in advanced host countries like the United States, we apply spatial econometric techniques that have recently been introduced into the literature on FDI determinants. The assumption that the decisions to locate in one particular host economy are independent of any other location has been relaxed in several contributions to this literature. The modified gravity model of Blonigen et al. (2007) on outward US FDI differentiates between two spatial effects: the surrounding market potential and the spatially lagged dependent FDI variable.[1] Garretsen and Peeters (2008) perform a similar analysis for Dutch FDI. Baltagi, Egger and Pfaffermayr (2007) augment the knowledge capital model of Carr, Markusen and Maskus (2001) and consider the characteristics of neighboring countries with respect to market size, relative factor endowments and investment risk. Using distances as weights, spatially weighted third-country determinants turn out to be important for the location of outward US FDI. Hall and Petroulas' (2008) take a similar route for FDI from various source countries.

Spatial econometric techniques have also been applied to assess location choice within large

[1] In another paper, Blonigen et al. (2008) analyze FDI in the United States from a sample of 20 OECD source countries. They show that the amount of FDI from a particular source country depends on the presence of other source countries and the proximity to large third-country markets.

host countries of FDI. The pioneering study is Coughlin and Segev (2000), showing that FDI in a Chinese province has positive effects on FDI in neighboring provinces. Ledyaeva (2007) on FDI determinants in Russian regions as well as Bobonis and Shatz (2007) on location choice of foreign firms at the level of US states are more recent examples. Bobonis and Shatz include remoteness among geographic FDI determinants, but FDI in adjacent states represents simply the sum of stocks in all adjacent states, without applying more refined spatial weighting schemes as we do below.

These studies on FDI determinants suggest that models ignoring spatial effects are likely to suffer from omitted variable bias (Baltagi, Egger and Pfaffermayr 2007).[2] This may also apply to studies assessing the effects of FDI in host economies. FDI-related spillovers of technological and managerial knowledge to local firms are widely believed to provide the major transmission mechanism through which FDI may promote productivity and economic growth. FDI may be the source of productivity-enhancing spillovers if foreign firms have superior technology or management know-how, enabling them to compete successfully with local firms on their home turf, and foreign proprietary knowledge creates externalities benefiting local firms, notably those in the proximity to foreign firms.

While the potential of spillovers should be particularly large for FDI in less advanced host countries, domestic firms in advanced host countries may be better able to exploit FDI-related spillovers due to higher absorptive capacity, for example in terms of human capital. Indeed, several studies find support for FDI-related spillovers in advanced host countries.[3] It is rarely taken into account, however, that FDI spillovers are highly likely to have a spatial dimension, i.e., the relevance of spillovers can be expected to decline with distance.[4] For the United States as a host

[2] However, Blonigen et al. (2007: 1322) find traditional FDI determinants to be "surprisingly robust to inclusion of terms to capture spatial interdependence."

[3] Several firm-level analyses focus on manufacturing industries in the United Kingdom; e.g., Harris and Robinson (2004); Haskel, Pereira and Slaughter (2007); Girma and Wakelin (2007).

[4] Girma and Wakelin's (2007) analysis of the UK electronics industry represents an exception. They address the regional dimension of FDI-related spillovers at least tentatively, by considering the foreign employment shares within as well as outside the particular region. In contrast to FDI-related spillovers within the region, spillovers from outside

country of FDI, Keller and Yeaple (2008) find strong (intra-industry) spillover effects stemming from FDI, accounting for about 14 percent of productivity growth in US manufacturing. In contrast to industry characteristics (technology intensity) and firm characteristics (size, productivity), regional characteristics are not taken into account. Branstetter (2006) resembles Keller and Yeaple (2008) in that spatial aspects are ignored; but he addresses another limitation that is common to the aforementioned studies on FDI-related spillovers: Spillovers are typically assumed to work one way, from foreign to local firms. However, both foreign and local firms may be the source of spillovers – at least in advanced host countries such as the United States. Indeed, Branstetter (2006) finds evidence that FDI increases the flow of knowledge spillovers from the Japanese investors to local US firms, and vice versa. As shown in Section 2, our analytical framework thus accounts for the spatial dimension of externalities arising from both foreign and local firms.

While spatial considerations are largely lacking in firm-level studies on FDI spillovers, the literature on regional growth determinants in the United States has hardly taken note of FDI until recently. Crain and Lee (1999) employ extreme bounds analysis to assess the sensitivity of "numerous control variables" identified in earlier studies as potentially relevant for growth in US states, but do not list FDI. Mullen and Williams (2005) estimate a neoclassical model of conditional convergence, augmented by FDI as an additional determinant of the steady state income. Employing fixed effects panel regressions, FDI has a significantly positive impact on state income growth. Ajaga and Nunnenkamp (2008) subject state-level FDI measures and outcome variables (value added and employment) to Granger causality tests within a panel cointegration framework, finding two-way causality between FDI and economic outcomes. Bode and Nunnenkamp (2007) employ a Markov chain approach to show that (i) both quantitative and qualitative FDI characteristics affect per-capita income growth, and (ii) FDI has tended to slow down income convergence among US

the region do not play a significant role - indicating narrow geographical limits to the impact of FDI.

states. According to Ford, Rork and Elmslie (2008), US states have to be well endowed with human capital to derive benefits from FDI, similar to what Borensztein, DeGregorio and Lee (1998) found across developing host countries.[5] However, none of these studies take spatial interdependencies into account.

Against this backdrop, the present paper proceeds as follows. In the next section, we present a theoretical model of Marshallian externalities on which the subsequent estimations are based. The estimation strategy as well as the data are discussed in Section 3. Our results, presented in Section 4, indicate that foreign firms generate positive externalities, in striking contrast to domestic firms. Section 5 concludes.

2 Theory

2.1 A Model of Spatial Externalities

This section sketches a formal model of Marshallian externalities arising at the firm level and spreading spatially, where we distinguish between those originating at domestic and those at foreign-owned firms. The following subsection discusses reasons why spatial effects may differ for these two types of firms. We assume that each firm, foreign or domestic, potentially generates Marshallian externalities that affect the productivity of all firms in its proximity. These Marshallian externalities may enhance productivity due to shared inputs, thick labor (or other factor) markets, or knowledge spillovers (Marshall 1890). The extent of Marshallian externalities is modeled as generally depending on the number of workers, and as decreasing with increasing distance. A firm's productivity is thus a function of the number of workers in all firms close by, ceteris paribus. The model distinguishes between foreign and domestic firms in a fairly general way. While both groups of firms

[5] Several states that offered substantial subsidies to lure foreign investors failed to pass the estimated human capital threshold.

are assumed to share the same production technology, they are allowed to differ in terms of the extent to which they generate Marshallian externalities. Importantly, we allow for externalities not only from foreign firms, as in most of the FDI literature, but also from domestic firms. Ignoring the latter may yield unreliable estimates because the estimated productivity effects of externalities generated by foreign firms may partly reflect externalities generated by domestic firms.

Marshallian externalities may spill over across regional borders. In fact, we treat Marshallian externalities within a state not fundamentally different from those spilling over across state borders. Analyzing the location choices of Japanese MNEs in the United States, Head, Ries and Swenson (1995: 243) find that US "state borders do not define the relevant economic boundaries for agglomeration effects; border-state activity has up to two-thirds of the attractive power of in-state activity."[6] The intensity of Marshallian externalities between two points in space (at a given distance from each other) is assumed to be the same irrespective of whether or not there is a state border in-between.

We assume that the production function of a representative firm k ($k = 1, ..., N_{it}$) in state i ($i = 1, ..., N$) at time t is given by

$$Y_{kit} = A_{it} K_{kit}^{\alpha} L_{kit}^{1-\alpha}, \tag{1}$$

where Y, K and L denote output, physical capital input and labor input, and A_{it} total factor productivity (TFP). We eliminate physical capital inputs from (1) because reliable data on these are not available for US states. Assuming that the rental rate of capital is the same for domestic and foreign firms in equilibrium, and that the US capital market is perfectly integrated such that, at any point in time, the rental rate of capital is the same in all states, we substitute the first-order

[6] This assertion is not undisputed, though. Differences in state legislations, such as taxation rules for example, may impact the characteristics of firms situated in different states. These differences in the characteristics of the firms may affect the benefits they are able to draw from each other.

conditions for profit maximization, $\alpha Y_{kit}/K_{kit} = r_t$ for K_{kit} in (1). Concentrating output on the left-hand side, aggregating over all firms in state i, and dividing by the labor force in state i, L_{it}, yields

$$y_{it} = \frac{Y_{it}}{L_{it}} = \left(\frac{\alpha}{r_t}\right)^{\frac{\alpha}{1-\alpha}} A_{it}^{\frac{1}{1-\alpha}}, \tag{2}$$

where Y_{it} and y_{it} denote aggregate output and average labor productivity in state i at time t.

TFP is assumed to depend on the extent of Marshallian externalities generated by domestic and by foreign firms, the human capital intensity of the workforce in state i, and some general locational advantages and disadvantages of state i and its neighboring states.[7] We model TFP as

$$A_{it} = A_{0it} \left(\prod_{j=1}^{N} D_{jt}^{\delta_D w_{Dij}}\right) \left(\prod_{j=1}^{N} F_{jt}^{\delta_F w_{Fij}}\right). \tag{3}$$

The variables D_{jt} and F_{jt} measure the potentials to which domestic and foreign firms in state j generate Marshallian externalities. Proxying these potentials by the amount of employment in foreign and domestic firms, we will set $F_{jt} = L_{Fjt}$, and $D_{jt} = L_{Djt}$.[8] As detailed below, w_{Dij} and w_{Fij} are bilateral spatial weights that depend on the distance between states j and i; δ_D and δ_F are the output elasticities of the potentials of Marshallian externalities generated by domestic and foreign firms, which will be estimated in the empirical part of this paper; and A_{0it} is a region- and time-specific productivity parameter that will also be specified in more detail below. The terms in parentheses represent the productivity effects of Marshallian externalities generated by domestic or foreign firms in the whole country.

[7] Since we do not observe the output of domestic and foreign firms separately, we have to assume that domestic and foreign firms benefit to the same extent from Marshallian externalities. This assumption does not appear to be too unrealistic for the US, where FDI inflows mostly originate from other highly developed countries with roughly similar technological levels. Yet it may be interesting to explore in future work whether or not domestic and foreign firms benefit differently from externalities.

[8] Other characteristics such as aggregate capital stock or output are conceptually feasible, but data on those are unavailable at the state level for our sample period.

In addition to the Marshallian externalities, we assume TFP to be affected by technological progress, the human capital intensity of the local workforce, TFP in neighboring states, and a variety of time-invariant factors of location that are not specified in detail here. More specifically, we assume A_{0it} to be given by

$$A_{0it} = A_{0i} e^{\mu t} h_{it}^{\gamma} \prod_{\substack{j=1 \\ j \neq i}}^{N} \left(A_{0jt}\right)^{\rho w_{Aij}} . \tag{4}$$

The first term in (4), A_{0i}, represents the productivity effects of time-invariant location factors. The second term, $e^{\mu t}$, represents the productivity effects of exogenous technological progress, with the rate of technological progress, μ, being assumed to be the same in all regions. The third term, $h_{it} = \frac{H_{it}}{L_{it}}$, represents the productivity effects of the human capital intensity of the regional workforce, which is proxied by the share of high-skilled workers. Finally, $\Pi_j \left(A_{0it}\right)^{\rho w_{Aij}}$stands for inter-regional productivity spillovers. The intensities and spatial reaches of these productivity spillovers, which are given by the spatial weights w_{Aij}, are assumed to generally decrease with increasing distance between any states i and j, and are standardized for each state i such that they sum up to one across all regions, i.e., $\Sigma_j w_{Aij} = 1$. All own-state weights, w_{Aii}, are zero. The term $\Pi_j \left(A_{0it}\right)^{\rho w_{Aij}}$ is consequently equal to the distance-weighted average productivity in all neighboring states. The parameter ρ, which will be estimated below, is the output elasticity of inter-regional productivity spillovers.

Before we substitute (4) into (3) and the resulting expression into (2), we need to determine the reduced form of this TFP component, i.e., concentrate A_{0it} on the left-hand side of (4). This is done in a similar way as in Ertur and Koch (2007). Taking logs of (4) and expressing it in matrix notation gives

$$\mathbf{A}_{0t} = \mathbf{A}_0 + \mu t + \gamma \mathbf{h}_t + \rho \mathbf{W}_A \mathbf{A}_{0t}, \tag{5}$$

where $\mathbf{A}_{0t} = (\ln A_{0it})$ is the $(N \times 1)$ vector of the state-specific logged productivity parameters, $\mathbf{A}_0 = (\ln A_{0i})$ an $(N \times 1)$ vector of the state-specific constants, t a time trend, and $\mathbf{h}_t = (\ln h_{it})$ the vector of state-specific logged human capital intensities. $\mathbf{W}_A = (w_{Aij})$ is a row-standardized $(N \times N)$ spatial weights matrix with main diagonal elements, w_{Aii}, equal to zero and off-diagonal elements $0 \leq w_{Aij} \leq 1$, $i \neq j$. Concentrating $\mathbf{A}_{0t}$ on the left-hand side gives

$$\begin{aligned}
\mathbf{A}_{0t} &= (\mathbf{I} - \rho\mathbf{W}_A)^{-1}[\mathbf{A}_0 + \mu t] + \gamma(\mathbf{I} - \rho\mathbf{W}_A)^{-1}\mathbf{h}_t \\
&= \frac{\mu}{1-\rho}t + (\mathbf{I} - \rho\mathbf{W}_A)^{-1}\mathbf{A}_0 + \gamma(\mathbf{I} - \rho\mathbf{W}_A)^{-1}\mathbf{h}_t. \qquad (6)
\end{aligned}$$

The $(N \times N)$ matrix $(\mathbf{I} - \rho\mathbf{W}_A)^{-1}$ is a spatial multiplier that reflects all direct and indirect spillovers from all regions. (6) shows that these productivity spillovers are mainly driven by the human capital intensities in this model. Substituting (6) into (3) and the resulting expression into (2) finally gives, in matrix notation,

$$\begin{aligned}
\mathbf{y}_t &= \frac{1}{(1-\alpha)}\left(\alpha\ln\alpha + \frac{\mu}{(1-\rho)}t - \alpha r_t\right) \\
&\quad + \frac{1}{(1-\alpha)}(\mathbf{I} - \rho\mathbf{W}_A)^{-1}\mathbf{A}_0 \\
&\quad + \frac{\gamma}{1-\alpha}(\mathbf{I} - \rho\mathbf{W}_A)^{-1}\mathbf{h}_t + \frac{\delta_D}{1-\alpha}\mathbf{W}_D\mathbf{D}_t \\
&\quad + \frac{\delta_F}{1-\alpha}\mathbf{W}_F\mathbf{F}_t, \qquad (7)
\end{aligned}$$

where $\mathbf{y}_t = (\ln y_{it})$, $\mathbf{D}_t = (\ln D_{it})$ and $\mathbf{F}_t = (\ln F_{it})$ are $(N \times 1)$ vectors of state-specific productivity and employment, r_t a time-specific constant, and $\mathbf{W}_D$ and $\mathbf{W}_F$ $(N \times N)$ matrices that comprise all spatial weights w_{Dij} and w_{Fij} such that the rows correspond to the state of destination (index i) and the columns to the state of origin (index j) of the Marshallian externalities. The first row of the right-hand side of (7) collects time-specific constants that will go into time fixed effects in the estimation. The second row is a vector of unobserved time-invariant state-specific constants that will be captured by state fixed effects. The third row consists of control variables that account for productivity effects of Marshallian externalities generated by domestic firms and of human capital in all states. The fourth row gives the variable of main interest in the present paper, the productivity effects of Marshallian externalities generated by foreign firms.

2.2 Externalities and the Costs of Agglomeration

While the model in the previous section is motivated by positive Marshallian externalities, there is a literature that points to the costs and trade-offs that agglomeration and spatial concentration tend to involve, which in turn could result in negative externalities. The congestion costs of agglomeration may encourage the relocation of routine tasks, for which there is less need for close personal contacts, to relatively remote regions. Declining transaction costs due to improved transportation and communication systems render the fragmentation of value chains easier. The relocation of routine, unskilled labor-intensive tasks from areas with a higher density of economic activity will tend to increase aggregate value added per worker but decrease employment. It may thus create a negative correlation between our dependent variable and our measure of externalities from domestic firms.

The literature on spatial economic developments in the United States provides various indications of this effect. Carlino and Chatterjee (2002) report a declining share of urban employment accounted for by particularly dense metropolitan areas where congestion costs tend be highest. According to Simon (2004), subsequent employment growth is relatively low where initial presence of an industry was strong and wages were high. Duranton and Puga (2005) argue that declining costs of remote management encourage deeper functional specialization so that production facilities cluster increasingly in smaller US cities. Similarly, Davis and Henderson (2008) observe spatial separation of high-skilled, white-collar services provided by headquarters in economic centers from production plants in remote areas.

However, the case for negative externalities of domestic firms could even be made with unabated spatial agglomeration. This applies especially to industries that attract FDI. Aitken and Harrison (1999) argue that the productivity of domestic firms may decline even though they tend to benefit from superior foreign technology. When entering an industry with relatively high fixed costs, foreign competitors with lower marginal costs tend to crowd out domestic production, which adversely affects the productivity of domestic producers if economies of scale can no longer be realized fully. Arguably this competitive effect matters particularly in spatially clustered oligopolistic industries with a significant foreign presence such as the chemical and automobile industries, both of which have attracted considerable amounts of FDI in the United States.[9]

3 Estimation Approach and Data

3.1 Overview

The most convenient way of estimating (7) is to premultiply both sides of (7) by the matrix $(\mathbf{I} - \rho \mathbf{W}_A)$, which, after some manipulations, yields the linear regression model

$$\begin{aligned} \mathbf{y}_t &= \psi + \boldsymbol{\iota}_t + \boldsymbol{\iota}_i + \rho \mathbf{W}_A \mathbf{y}_t + \gamma_0 \mathbf{h}_t \\ &\quad + \delta_F^* \mathbf{W}_F \mathbf{F}_t - \beta_F \mathbf{W}_A \mathbf{W}_F \mathbf{F}_t \\ &\quad + \delta_D^* \mathbf{W}_D \mathbf{D}_t - \beta_D \mathbf{W}_A \mathbf{W}_D \mathbf{D}_t + \mathbf{u}_t, \end{aligned} \tag{8}$$

[9] Domestic and foreign automobile producers are clustered in the so-called "auto corridor." With respect to the auto supplier industry, not only parts plants operated by the assemblers themselves but also independent parts suppliers continue to be highly spatially concentrated in the Eastern United States (Klier and McMillen 2008). Texas and Louisiana produce about 70 percent of all primary petrochemicals; Ohio, New York, New Jersey and Pennsylvania form another cluster of chemical production, with several foreign chemical producers having plants in New Jersey (http://www.eia.doe.gov/emeu/mecs/iab/chemicals/page3.html).

where $\delta_F^* := \frac{\delta_F}{1-\alpha}$ and $\delta_D^* := \frac{\delta_D}{1-\alpha}$.[10] While we do not formally impose the parameter restrictions $\beta_F = \delta_F^* \rho$ and $\beta_D = \delta_D^* \rho$ in the estimation below, we do check whether they are satisfied. The constant term $\psi = \frac{1}{(1-\alpha)} (\mathbf{A}_0 + \alpha (1-\rho) \ln \alpha)$, the time fixed effects $\boldsymbol{\iota}_t = \frac{1}{(1-\alpha)} (\mu \mathbf{t} - \alpha (1-\rho) \mathbf{r}_t)$ and $\boldsymbol{\iota}_i = \frac{1}{1-\alpha} (\mathbf{I} - \rho \mathbf{W}_A) \mathbf{A}_0$ is a set of state fixed effects that capture the time-invariant state-specific characteristics. $\mathbf{W}_A \mathbf{y}_t$ is a spatially lagged dependent variable. (8) will be estimated by the system GMM procedure proposed by Arellano and Bover (1995) and Blundell and Bond (1998), which has been shown to have good small sample properties for spatial dynamic panel models (Kukenova and Monteiro 2009). It also allows us to address the potential endogeneity of some regressors, which we discuss in more detail below. We ignore for simplicity that the transformation of the regression model introduces a moving average process into the residuals and estimate (8) under the assumption that $(\mathbf{I} - \rho \mathbf{W}_A) \mathbf{u}_t$ is i.i.d.

Note that the productivity effects of FDI, δ_F, estimated from model (8) are not directly comparable to the corresponding elasticities reported in earlier studies. In contrast to studies focusing only on the productivity effects of FDI within a region and not taking into account the differences in the sizes of regions, we capture the productivity effects of FDI in all regions and control explicitly for the sizes of the regions by the way we define the spatial weights, which is further discussed below.

Instead of premultiplying, one can approximate the matrix $(\mathbf{I} - \rho \mathbf{W}_A)^{-1}$ by the first p elements of its expansion, $(\mathbf{I} - \rho \mathbf{W}_A)^{-1} = \sum_{i=0}^{\infty} \rho^i \mathbf{W}_A^i = \mathbf{I} + \boldsymbol{\rho} \mathbf{W}_A + \rho^2 \mathbf{W}_A^2 + \rho^3 \mathbf{W}_A^3 + ...$, which exists for $|\rho| < 1$. Ignoring parameter restrictions, we can then estimate

[10] Recall that $1 - \alpha$ is the elasticity of uneducated labor. While we could fix it to a particular value, we instead re-define our parameters of main interest. For notational convenience, we subsequently drop the $*$.

$$\begin{aligned}
\mathbf{y}_t &= \psi + \boldsymbol{\iota}_t \\
&+\gamma_0 \mathbf{h}_t + \beta_1 \mathbf{W}_A \mathbf{h}_t + \beta_2 \mathbf{W}_A^2 \mathbf{h}_t + ... + \beta_p \mathbf{W}_A^p \mathbf{h}_t \\
&+\delta_F \mathbf{W}_F \mathbf{F}_t + \delta_D \mathbf{W}_D \mathbf{D}_t + \mathbf{u}_t. \qquad (9)
\end{aligned}$$

where the optimal polynomial for $\mathbf{W}_A$ was chosen such that omitting the last one would have resulted in significant coefficients on all the polynomial terms. We estimate (9) via system GMM as well for comparability reasons and because it allows us to take into account the possible endogeneity of several of the regressors.

3.2 Endogeneity

When estimating (8) and (9) for a space-time panel it has to be taken into account that the human capital intensity, $\mathbf{h}_t$, the potentials of domestic and foreign firms to generate Marshallian externalities, $\mathbf{W}_{Dt}\mathbf{D}_t$ and $\mathbf{W}_{Ft}\mathbf{F}_t$, as well as the spatially lagged dependent variable, $\mathbf{W}_A\mathbf{y}_t$, may be endogenous and need to be instrumented. In addition to the time fixed effects, we use two types of instruments. The first type is the usual GMM instruments, i.e. the serial lags of the endogenous explanatory variables, which are valid instruments in the absence of serial correlation in the residuals. We also use the spatial lags of the endogenous explanatory variables. They are calculated using exogenous spatial weights that are not population-weighted but depend only on distances between counties. Secondly, we use historical data on the number of phones per 1000 population in 1932, the average value of farms in 1930 and the average value of an acre of land in 1930. The reasoning behind the use of these instruments is that they can be assumed truly exogenous. Moreover we need to instrument out the consequences of spatial sorting, i.e., the fact that high-skilled workers or firms are attracted by, and move to high-productivity regions. The historical factors we use can be assumed exogenous with respect to the distribution of skilled workers or firms in 1977, the beginning of our sample period. We also note that all historical instruments are highly correlated with our measures of human capital as well as of employment in domestic and foreign firms.

3.3 Definition of Spatial Weights

The empirical models (8) and (9) comprise three spatial weights matrices: $\mathbf{W}_A$ determines the intensity and spatial reach of general inter-regional productivity spillovers, including spillovers related to the human capital intensities in other states; $\mathbf{W}_D$ and $\mathbf{W}_F$ determine the intensities and spatial reaches of Marshallian externalities generated by domestic and by foreign firms both within and outside a state. $\mathbf{W}_A$ is row-standardized, as is common in the literature, the other matrices are not.

All spatial weights in these matrices are assumed to decrease with increasing distance because larger distances usually make it more difficult, or costly, for firms to maintain close personal (face-to-face) contacts to suppliers, customers and competitors, learn from them, or hire their workers. They also make it more difficult or costly for workers to regularly meet and learn from each other. In analogy to iceberg transport costs, the spatial weights w_{Aij}, w_{Dij}, and w_{Fij} should assume the value of one at a distance of zero, and decrease continuously towards zero with increasing distance.[11] Accordingly, we model our spatial weights as inverse exponential distances, which generally can be written as $w_{ij} = e^{-\tau S_{ij}}$. S_{ij} denotes the distance between states i and j, and τ is a constant distance decay parameter that determines the percentage diffusion loss per unit of distance. In terms of the iceberg analogy, τ is the fraction of the remaining mass the iceberg looses while traveling another

[11] It should be close to zero at very high distances because spatial proximity between agents is a defining characteristic of those forms of localized externalities the present paper is seeking to identify. This does certainly not preclude the existence and economic relevance of externalities or other interdependencies between specific firms across long distances. One prominent example of long-distance interdependencies is competition among producers of tradable goods. Another example is contacts and other interdependencies between plants that are situated in different parts of the country but belong to the same corporation.

mile. The negative exponential form of the spatial weights implies that the distance losses are, in absolute terms, higher for the first miles than for subsequent miles. This can be justified by the high importance of personal contacts for Marshallian externalities.

The bilateral distances from which the spatial weights are calculated may just be chosen to be the geographical distances between the economic centers or the centroids of the US states. We prefer, however, to use population-weighted average distances between the centroids of all counties in the respective states instead. This allows us to better account for uneven distributions of economic activities within states.[12] Moreover, using population-weighted average distances between counties allows us to take into account changes over time of the relative distributions of the populations within the states. We thus calculate the distance between states i and j $(i, j = 1, ..., N)$ at time t as

$$S_{ijt} = \sum_{i'=1}^{C_i} \sum_{j'=1}^{C_j} \frac{P_{i't} P_{j't} \Delta_{i'j'}}{\sum_{i'=1}^{C_i} \sum_{j'=1}^{Cj} P_{i't} P_{j't}}, \tag{10}$$

where C_i and C_j are the numbers of counties in states i and j, $P_{i't}$ and $P_{j't}$ are the populations of county i' in state i and county j' in state j, and $\Delta_{i'j'}$ is the great circle distance between the centroids of the two counties. S_{ijt} can be interpreted as the average of the distances from each inhabitant of state i to each inhabitant of state j, if all inhabitants were concentrated in their respective counties' centroids.[13] (10) defines both intra- and inter-regional distances. Unlike most earlier studies, where the intra-regional distances are set to 0, the intra-regional distances are positive here. They will, ceteris paribus, be higher the larger the state.

In summary, the spatial weights in the matrices $\mathbf{W}_D$ and $\mathbf{W}_F$ are defined as time-specific inverse exponential distance weights $\mathbf{W}_{Dt}$ and $\mathbf{W}_{Ft}$ with elements

[12] In New York state, for example, economic activity is heavily concentrated in the southern part around New York City while upstate New York is for the most part rather remote.

[13] Notice that S_{ijt} is almost invariant to the number of counties in a state. Doubling the number of counties in a state (while keeping the population constant) will affect S_{ijt} only insofar as the counties' centroids will be different.

$$w_{mijt} = \exp\left(-\tau_m S_{ijt}\right), \qquad m = D, F. \tag{11}$$

The spatial weights in the matrix $\mathbf{W}_A$ are defined as row-standardized time-invariant inverse exponential distance weights,

$$w_{Aij} = \begin{cases} 0 & \text{for } i = j \\ \frac{\exp\left(-\tau_A S'_{ij}\right)}{\sum_{j=1}^{N} \exp\left(-\tau_A S'_{ij}\right)} & \text{for } i \neq j \text{ and } S'_{ij} \leq 800\text{mi} \\ 0 & \text{for } S'_{ij} > 800\text{mi.} \end{cases} \tag{12}$$

The distances entering S'_{ij} are calculated using (10), after setting $P_{i't}P_{j't} = 1$ for all county pairs. The spatial weights w_{Aij} exclude intra-regional productivity spillovers, which are part of the states' own productivity parameters (A_{0i}), and are subjected to a distance cutoff at 800 miles on productivity spillovers. The distance cutoff implies that productivity spillovers over distances of more than 800 miles are negligible (zero). Its main purpose is to prevent the corresponding parameter to pick up implausibly high spillovers across long distances.[14]

Since the spatial weights (11) depend on the states' population sizes, they may be correlated with the errors. A productivity shock in state i may induce migration to or out of this state, which in turn will change the spatial weights. We therefore define all spatially lagged instruments in our instruments set using similar spatial weights calculated from distance data only.

To estimate our empirical models (8) and (9), the spatial weights and, thus, the distance decay parameters must be known. To begin with, we assume, somewhat arbitrarily, $\tau_A = \tau_D = \tau_F = 0.02$. As detailed below, we will assess the sensitivity of our main results to variations in these parameter values. In particular, it seems plausible that Marshallian externalities originating from domestic

[14] This may happen in the presence of row-standardized weights in cases when states have only a few neighbors close by. Notice that row-standardization implies a redefinition of distances from absolute to relative distances. The standardized weight assigned to, say, a state 800 miles away consequently depends on the number of states at shorter distances.

firms decay somewhat faster than those originating from foreign firms. A decay parameter of 0.02 (0.015, 0.025) implies that 86.5% (77.7%, 91.8%) of the iceberg is gone after 100 miles.

3.4 Data

Our preferred dependent variable is state real GSP divided by total employment. The alternative is real personal income, also divided by total employment. For the measures of domestic and foreign firm activity, we have information on total employment in foreign firms for all states as well as total state employment. Employment in domestic firms is constructed as total employment less employment in foreign firms. The shares of the primary (agriculture and mining) and manufacturing sector by state are also computed using employment. Human capital is measured as the fraction of a state's population that holds a bachelors degree or higher. Missing values are linearly interpolated. All data come from the Bureau of Economic Analysis and we have complete data for the period 1977-2003. The historical data on phones per 1000 population and average values of farms and an acre of land are from the Census Bureau at the Department of Commerce. Table 1 shows summary statistics for the main variables for our basic sample of 47 states (excluding Alaska, Hawaii, Delaware and Washington, D.C.).[15]

4 Results

4.1 Basic Results

Table 2 shows results from estimating equations (8) and (9) via system GMM with gross state product per worker as the measure of productivity. In order to illustrate the importance of considering both domestic and foreign firm externalities, we start by estimating an equation without

[15] Washington, D.C. and Delaware both report far higher GSP than personal income for all years, presumably due to the presence of the federal government in the former and the large share of financial services headquarters located in the latter. In our basic specification, we therefore omit both, but report results from including them as a robustness check.

accounting for domestic ones, the results of which are shown in column (1). While the spatially lagged dependent variable, which reflects general productivity spillovers from other states, is positive and highly significant, the foreign employment term is not. In Column (2) we include both domestic and foreign activity, both of which have a statistically significant effect on productivity. The effect of foreign activity is positive, whereas the effect of domestic activity is negative. The first result is consistent with the hypothesis that foreign firms are sufficiently superior that their combined local and regional effect on state productivity is positive. However, as demonstrated by comparing the result to the one in column (1) that considered only foreign employment, this positive effect crucially depends on accounting for domestic activity as well. The negative effect of domestic activity suggests that deconcentration, negative competition or market-stealing effects dominate any positive externalities.

One might suspect that domestic and foreign employment to some extent proxy for a state's industry composition. In order to rule that out, we include a state's share of the primary and secondary sectors as control variables in column (3). The results are virtually unchanged while the newly included variables are not statistically significant. However, as they are significant in other specifications, we include them in many of the following variations of our basic specification. The other variables included in these regressions have the expected signs and almost all are statistically significant. Intra-state human capital is positive, but only marginally significant. While the sign is as expected, there may not be sufficient variation over time in this variable so that some of the human capital effect may be picked up by the state fixed effects.

In order to check more formally for the appropriateness of this specification, we report the results of the Arellano and Bond (1991) test for first and second-order autocorrelation in the differenced residuals. It reveals that there is some indication of first order serial correlation (which is expected) and none of second-order serial correlation (which would be problematic). We also note that while we did not impose the parameter restrictions implied by theory, $-\beta_F = \delta_F \rho$ and $-\beta_D = \delta_D \rho$, they are very nearly satisfied. For example, in column (3) $-\beta_F = 0.213$ and $\delta_F \rho = 0.299 \cdot 0.751 = 0.225$.

In columns (4) - (6), we run the same GMM regressions for our alternative specification (9), which was derived by approximating the matrix $(\mathbf{I} - \rho \mathbf{W}_A)^{-1}$ by the first p elements of its expansion. We tried several values for p, selecting the one where omitting the highest polynomial would have resulted in the remaining terms being statistically significant. In any case, results for other variables of interest are not affected by this choice. This equation does not include a spatially lagged dependent variable. The results for our main variables of interest are virtually unchanged. When including both foreign and domestic activity, the former remains significantly positive and the latter significantly negative. One slight difference to the results of estimating (8) is that both the primary and the manufacturing share of industry in a state are found to have a negative effect on productivity (column (6)), suggesting that a high share of service activity is productivity-enhancing.

4.2 Separating Intra- from Inter-state Effects

Up until now, we have taken into account spatial effects but have not attempted to separately estimate the intra- and the inter-state effects. We do this now by splitting up the total externalities from foreign and domestic firms into those from within the same state ($\mathbf{W}_{Ft,intra}\mathbf{F}_t$, $\mathbf{W}_{Dt,intra}\mathbf{D}_t$) and those from outside ($\mathbf{W}_{Ft,inter}\mathbf{F}_t$, $\mathbf{W}_{Dt,inter}\mathbf{D}_t$). In addition to results from these two regressions, Table 3 also presents the results of two control regressions where intra-regional distances are completely neglected, i.e., where $\mathbf{W}_{Ft,intra} = \mathbf{W}_{Dt,intra} = \mathbf{I}_{(NT)}$, while the regressors for inter-regional effects contain weights constructed with the same distances as before. These control regressions are to shed light on the question of whether spatial proximity plays an important role for Marshallian externalities within states at all, or whether the fact that firms are located within the same state is sufficient for their productivity being enhanced by these externalities. Traditional estimates that do not take into account spatial effects usually do not weigh intra-state activity. Our approach, however, adds a spatial dimension to intra-state activity as well, which allows us to, realistically, consider that effects in states with concentrated activity, such as New York, are different from those in states with dispersed activity, such as Wisconsin. Table 3 presents the results for equation (8) in columns (1) and (3), and for equation (9) in columns (2) and (4).

Columns (1) and (2) show that the parameters for the two intra-state variables, $\mathbf{W}_{Ft,intra}\mathbf{F}_t$, $\mathbf{W}_{Dt,intra}\mathbf{D}_t$, are estimated to be significant and larger in (absolute) magnitude than the parameters of the combined intra- and inter-state effects (see Table 2), while the parameters of the two inter-state variables, $\mathbf{W}_{Ft,inter}\mathbf{F}_t$, $\mathbf{W}_{Dt,inter}\mathbf{D}_t$, are estimated to be insignificant and small in magnitude. This implies that the positive aggregate effects from foreign-owned firms and the negative effects from domestic firms on labor productivity identified in Table 2 originate exclusively from within the same state but, on aggregate, not from other states. It does, however, not imply that there are no productivity spillovers between states at all. The parameter (ρ) of the spatially lagged dependent variable in column (1) is estimated to be positive and highly significant. It is, apparently, important to control for these interdependencies between states that are not directly related to firms in order to not falsely attribute them to FDI.

Columns (3) and (4) of Table 3 show that the parameters of the two inter-state variables, $\mathbf{W}_{Ft,inter}\mathbf{F}_t$, $\mathbf{W}_{Dt,inter}\mathbf{D}_t$, are larger in (absolute) magnitude and turn significant (with only one exception), if the two intra-state variables, $\mathbf{W}_{Ft,intra}\mathbf{F}_t$, $\mathbf{W}_{Dt,intra}\mathbf{D}_t$, are specified such that spatial proximity is irrelevant for Marshallian externalities within states. The parameters of the latter are, by contrast, much lower than in columns (1) and (2), and even lower than in our baseline model (see Table 2). In addition, the parameter ρ that captures interdependencies between states not directly related to firms is also lower than in column (1). Thus it appears that spatial proximity shapes Marshallian externalities within states significantly. A neglect of the role of spatial proximity leads to a significant underestimation of the true productivity effects of foreign-owned and domestic firms within states. Part of these unexplained productivity effects are then captured falsely by the parameters of the inter-state variables. In addition to the need for controling for other sources of externalities between states, there is thus also a need for specifying the variables for intra-state externalities between firms correctly in order to not overestimate the effects from firms in other states. This need for correct specification includes taking into account Marshallian externalities among firms that are subject to distance decay.

4.3 Robustness

There are several ways in which we further check the robustness of our results. We first check our choice of dependent variable and states included in the sample. Secondly, we check the sensitivity of our results to the way we compute the weight matrices, including the choice of the decay parameters τ_A, τ_D and τ_F. Finally, we randomly assign our distances in which case we should not be able to find any effects, intra- or inter-state.

As we explain above, we believe that our measure of GSP per worker is the best available state-level measure of productivity. However, since we also have data on personal income per capita, we use that as the dependent variable. Table 4a shows results for variations of our baseline model and Table 4b again separates intra- and inter-state effects. Columns (1) and (2) of Table 4a show that while the magnitude of the spatially lagged dependent variable increases, all our other results are hardly affected. In particular, foreign firms continue to generate positive, domestic firms negative externalities. Table 4b confirms that these largely originate within a state rather than in neighboring states. In columns (3)-(6), we re-run the regressions for GSP and income using a sample of 49 states that includes Delaware and D.C. As noted earlier, these are the two areas where personal income and GSP differ the most, due to the large presence of financial firms and the federal government. Not surprisingly, the results of the effect of foreign as well as domestic activity are weaker for this sample when GSP per capita is used as the dependent variable. Nonetheless, the signs remain the same and are significant at least at the 10, though when using equation (9) still at the one percent level. The results using personal income per worker as the dependent variable are virtually unchanged from our results in Tables 2 and 3. Thus, there is solid evidence that foreign activity (in the same state) has a significantly positive and domestic activity a significantly negative effect on states' productivity once spatial effects are properly accounted for.

Since our main innovations are to account for inter-state effects of domestic and foreign activity and more generally spatially dispersed productivity effects, but apply weights to intra-state activity as well, we conduct a large number of robustness checks concerning the weights. This is all the more important as the existing literature does not offer much guidance for their appropriate construction. First, we run our basic specification from Table 2, column (3), for a large number of different combinations of the decay parameters τ_A, τ_D, and τ_F. Appendix Tables A1 and A2 (separate intra- and inter-state effects) show the coefficients on our main variables of interest as well as the spatially lagged dependent variable for combinations around our chosen value of 0.02. While the magnitude of the coefficients varies a bit across these, the signs and significance levels are largely unaffected by the choice of the decay parameters, which makes us confident that the choice of these is not responsible for the results we obtain.

Results in Table 5 are shown for a couple of different exercises. First, we choose the very simple weights that Blonigen et al. (2007) use in their study of the determinants of FDI, namely inverse distances with a distance decay parameter of 1. While we have argued above that our more sophisticated choice of weights is plausible and theoretically consistent with the iceberg concept, checking to what extent the results hinge on these is useful. Estimation of equation (8) with spatial weights redefined as $w_{mijt} = S_{ijt}^{-1}$, $m = D, F$ (w_{Aij} accordingly), yields qualitatively the same results as estimation of our baseline model for both our central variables of interest and the control variables (column 1) although the coefficients are much larger. Moreover, when we separate intra- from inter-state effects, we retain the signs found before, but the standard errors become much larger and render most coefficients on the variables of interest insignificant.

Finally. we randomize distances. That is, we randomly assign intra-state distances (reverting to our original weights) to states as well as shake states up in a way that assigns random neighbors to them. In this case, we should not find any effect of firm activity, domestic or foreign, since it is not the "true" one. Indeed, the results in columns (3) and (4) confirm that all weighted variables have completely insignificant coefficients, while for example human capital, which remains at the "true" level, is statistically significant and positive. In summary, we have conducted a large number of robustness checks that confirm our results, namely that foreign activity has a positive effect on state productivity whereas domestic activity does not.

5 Conclusion

This paper focused on regional interdependencies and Marshallian externalities from domestically and foreign-owned firms in US states. We apply spatial econometric techniques that have recently been introduced into the literature on FDI determinants. Spatial factors are expected to matter for FDI effects, too. FDI-related externalities of technological and managerial knowledge to local firms - that are widely believed to provide the major transmission mechanism through which FDI may promote economic growth - are highly likely to have a spatial dimension, i.e., their relevance should decline with distance.

Our results indicate that foreign-owned firms generate positive externalities. This is in striking contrast to domestic firms that generate negative externalities. The former finding is consistent with the view that foreign firms have ownership advantages from which other firms can derive benefits so that local and regional effects on state productivity are positive – even in advanced host countries such as the United States. Negative externalities from domestic firms can be attributed to deconcentration, crowding out and market-stealing effects that dominate over any positive agglomeration effects.

We also find that spatial proximity shapes Marshallian externalities within US states significantly. Indeed, separately estimating intra- and inter-state effects, we find that positive externalities from foreign-owned firms and negative externalities from domestic firms originate almost exclusively from within the same state but not from other states. Hence, ignoring the role of spatial proximity may seriously bias the true productivity effects of both foreign and domestic firms within states. In particular, productivity effects may then be falsely attributed to inter-state variables.

Apart from avoiding biased results by appropriately controlling for different sources of externalities and accounting for proximity at the state level, the dominance of intra- over inter-state effects has interesting policy implications. The findings validate to some extent policymakers at the state level who are attempting to lure foreign firms into their state, at least unless the subsidies granted to foreign investors exceed the FDI-related externalities at the state level.

In order to arrive at stronger policy conclusions, it would be desirable to extend the analysis in several directions as more data become available. First, we had to assume that domestic and foreign firms benefit to the same extent from Marshallian externalities. This restriction could be relaxed if the output of domestic and foreign firms were observed separately. Second, the heterogeneity of foreign firms that has received considerable attention in recent firm-level studies may be captured if foreign firm activity can be observed for specific industries at the regional level. Moreover, FDI-related externalities may depend on the home country of the foreign firm. Third, it is open to question whether our findings would carry over to host countries other than the United States. The ownership advantages of foreign firms may still be more pronounced in less advanced host countries, while the local absorptive capacity of local firms to benefit from externalities tends to be weaker in those countries. At the same time, host countries with less pronounced regional agglomeration may find it easier to prevent negative externalities resulting from domestic firm activity. We leave these questions for future work.

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Table 1: Descriptive Statistics

Variable	Description	Mean	Median	Stdev.	Min	Max
$\mathbf{y}_t$ [ln(GSP/worker)]	log of gross state product per worker	10.76	10.75	0.156	10.40	11.24
$\mathbf{y}_t$ [ln(Income/worker)	log of personal income per worker	10.62	10.59	0.151	10.24	11.13
$\mathbf{W}_A\mathbf{y}_t$ [ln(GSP/worker)	GSP/worker weighted	10.76	10.74	0.124	10.47	11.14
$\mathbf{W}_A\mathbf{y}_t$ [ln(Income/worker)	Income/worker weighted	10.62	10.59	0.129	10.32	11.01
$\mathbf{h}_t$	log of share of population with a Bachelor's	2.967	2.969	0.256	2.285	3.627
$\mathbf{F}_t$	log of foreign employment	10.63	10.68	1.311	6.593	13.53
$\mathbf{W}_{Ft}\mathbf{F}_t$	log of foreign employment weighted	2.999	1.754	3.830	0.097	18.02
$\mathbf{D}_t$	log of domestic employment	14.41	14.48	0.956	12.34	16.77
$\mathbf{W}_{Dt}\mathbf{D}_t$	log of domestic employment weighted	3.999	2.337	5.071	0.139	22.92
Primary	share of employment in agriculture and mining	0.046	0.036	0.036	0.003	0.193
Manuf.	share of employment in manufacturing	0.138	0.134	0.057	0.031	0.291

Notes:
All values for the basic sample (47 states, 1977-2003 = 1269 observations).
All variables with weighting matrices use τ=0.02.

Table 2: Basic Results from equations (8) and (9)

	(1)	(2)	(3)	(4)	(5)	(6)
Equation	(8)	(8)	(8)	(9)	(9)	(9)
$\mathbf{W}_A\mathbf{y}_t$	0.919***	0.785***	0.751***			
	(0.103)	(0.137)	(0.155)			
$\mathbf{h}_t$	0.151	0.145*	0.124	0.264	0.249	0.255*
	(0.104)	(0.086)	(0.088)	(0.212)	(0.158)	(0.151)
$\mathbf{W}_{Ft}\mathbf{F}_t$	0.007	0.263***	0.299***	0.005	0.273***	0.240***
	(0.016)	(0.093)	(0.102)	(0.008)	(0.053)	(0.058)
$\mathbf{W}_{Dt}\mathbf{D}_t$		-0.196***	-0.222***		-0.204***	-0.173***
		(0.065)	(0.072)		(0.039)	(0.044)
$\mathbf{W}_A\mathbf{W}_{Ft}\mathbf{F}_t$	-0.008	-0.178**	-0.213**			
	(0.015)	(0.072)	(0.088)			
$\mathbf{W}_A\mathbf{W}_{Dt}\mathbf{D}_t$		0.132**	0.157**			
		(0.051)	(0.064)			
$\mathbf{W}_A\mathbf{h}_t$				0.934	0.276	-0.045
				(1.111)	(0.621)	(0.381)
$\mathbf{W}_A^2\mathbf{h}_t$				0.647	0.277	-0.035
				(0.526)	(0.394)	(0.338)
$\mathbf{W}_A^3\mathbf{h}_t$				-1.724	-0.563	-0.326
				(1.295)	(0.818)	(0.680)
Primary			-0.437			-1.312*
			(0.490)			(0.698)
Manuf.			-0.295			-1.341***
			(0.327)			(0.472)
Observations	1,269	1,269	1,269	1,269	1,269	1,269
Wald	5,434	5,957	5,554	3,217	4,286	4,207
Prob > χ^2	0.00	0.00	0.00	0.00	0.00	0.00
AR(1), p-value	0.13	0.05	0.05	0.49	0.12	0.06
AR(2), p-value	0.77	0.86	0.92	0.46	0.59	0.51

Notes:
Robust standard errors in parentheses. ***, **, * denote significance at the one, five, and ten percent level, respectively. All results from system GMM, including time and state fixed effects.
See the text for details. 'Primary' indicates the share of employment in agriculture and mining.
'Manuf' indicates the share of employment in manufacturing. AR(1) and AR(2) are the Arellano-Bond tests for first- and second-order serial correlation, respectively, under the null of no serial correlation.

Table 3: Separating Intra- and Inter-state Effects

	(1)	(2)	(3)	(4)
Equation	(8)	(9)	(8)	(9)
Intra-state weighted?	Yes	Yes	No	No
$\mathbf{W}_A\mathbf{y}_t$	0.622***		0.462***	
	(0.138)		(0.123)	
$\mathbf{h}_t$	0.195**	0.245*	0.113	0.130
	(0.090)	(0.137)	(0.076)	(0.107)
$\mathbf{W}_{Ft,intra}\mathbf{F}_t$	0.502***	0.386***	0.094***	0.078**
	(0.123)	(0.136)	(0.033)	(0.040)
$\mathbf{W}_{Ft,inter}\mathbf{F}_t$	-0.130	0.087	0.189*	0.195***
	(0.157)	(0.089)	(0.111)	(0.064)
$\mathbf{W}_{Dt,intra}\mathbf{D}_t$	-0.387***	-0.291***	-0.016	0.035
	(0.085)	(0.098)	(0.043)	(0.046)
$\mathbf{W}_{Dt,inter}\mathbf{D}_t$	0.120	-0.051	-0.126	-0.138***
	(0.122)	(0.065)	(0.083)	(0.050)
Primary	-0.295	-1.221*	0.875*	1.008
	(0.544)	(0.700)	(0.505)	(0.659)
Manuf.	-0.564	-1.324***	-1.372***	-1.493***
	(0.344)	(0.436)	(0.357)	(0.403)
Observations	1,269	1,269	1,269	1,269
Wald	7,018	6,082	6,533	9,923
Prob > χ^2	0.00	0.00	0.00	0.00
AR(1), p-value	0.10	0.05	0.40	0.24
AR(2), p-value	0.97	0.54	0.14	0.38

Notes:
See Table 2 Notes.
Additional terms in equations (8) and (9) included, but coefficients not shown.

Table 4a: Robustness: Sample Size and Dependent Variable - Basic Specification

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. var	Income	Income	GSP	GSP	Income	Income
States	47	47	49	49	49	49
Equation	(8)	(9)	(8)	(9)	(8)	(9)
$\mathbf{W}_A\mathbf{y}_t$	0.963***		0.677***		0.552*	
	(0.148)		(0.177)		(0.289)	
$\mathbf{h}_t$	0.170**	0.190	0.160	0.165	0.209**	0.180
	(0.078)	(0.165)	(0.103)	(0.177)	(0.102)	(0.198)
$\mathbf{W}_{Ft}\mathbf{F}_t$	0.229***	0.194***	0.083*	0.167***	0.266***	0.192***
	(0.077)	(0.047)	(0.047)	(0.028)	(0.053)	(0.034)
$\mathbf{W}_{Dt}\mathbf{D}_t$	-0.164***	-0.137***	-0.055*	-0.117***	-0.217***	-0.154***
	(0.053)	(0.036)	(0.033)	(0.019)	(0.035)	(0.023)
$\mathbf{W}_A\mathbf{W}_{Ft}\mathbf{F}_t$	-0.170***		-0.026		-0.167***	
	(0.064)		(0.068)		(0.062)	
$\mathbf{W}_A\mathbf{W}_{Dt}\mathbf{D}_t$	0.115**		0.013		0.139***	
	(0.045)		(0.048)		(0.046)	
$\mathbf{W}_A\mathbf{h}_t$		0.056		-0.667		0.345
		(0.274)		(0.491)		(0.556)
$\mathbf{W}_A^2\mathbf{h}_t$		0.252		-0.065		0.066
		(0.294)		(0.394)		(0.462)
$\mathbf{W}_A^3\mathbf{h}_t$		-0.617		0.619		0.261
		(0.509)		(0.850)		(0.836)
Primary	-0.722*	-1.961***	-0.503	-1.026	-0.645	-0.448
	(0.438)	(0.431)	(0.474)	(0.729)	(0.516)	(0.776)
Manuf.	0.119	-0.871**	-0.449	-1.465***	0.115	1.062**
	(0.312)	(0.370)	(0.320)	(0.350)	(0.460)	(0.540)
Observations	1,269	1,269	1,323	1,323	1,323	1,323
Wald	12,930	7,993	4,590	6,779	21,159	10,085
Prob > χ^2	0.00	0.00	0.00	0.00	0.00	0.00
AR(1), p-value	0.23	0.19	0.18	0.15	0.89	0.41
AR(2), p-value	0.73	0.86	0.89	0.35	0.52	0.38

Notes:
See Table 2 Notes.

Table 4b: Robustness: Sample Size and Dependent Variable - Intra- and Inter-state Effects

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. var	Income	Income	GSP	GSP	Income	Income
States	47	47	49	49	49	49
Equation	(8)	(9)	(8)	(9)	(8)	(9)
$\mathbf{W}_A\mathbf{y}_t$	0.947***		0.725***		0.660***	
	(0.147)		(0.158)		(0.179)	
$\mathbf{h}_t$	0.170**	0.149	0.135	0.162	0.138	0.266*
	(0.074)	(0.139)	(0.091)	(0.192)	(0.090)	(0.160)
$\mathbf{W}_{Ft,intra}\mathbf{F}_t$	0.436***	0.340***	0.193**	0.163***	0.274***	0.250***
	(0.104)	(0.105)	(0.086)	(0.048)	(0.083)	(0.074)
$\mathbf{W}_{Ft,inter}\mathbf{F}_t$	-0.194*	0.059	0.096	0.164***	-0.110	0.046
	(0.115)	(0.078)	(0.144)	(0.053)	(0.134)	(0.058)
$\mathbf{W}_{Dt,intra}\mathbf{D}_t$	-0.324***	-0.253***	-0.139**	-0.115***	-0.242***	-0.234***
	(0.073)	(0.073)	(0.061)	(0.027)	(0.055)	(0.042)
$\mathbf{W}_{Dt,inter}\mathbf{D}_t$	0.157*	-0.031	-0.070	-0.114***	0.102	-0.011
	(0.090)	(0.059)	(0.101)	(0.038)	(0.100)	(0.045)
Primary	-0.675	-1.842***	-0.336	-0.878	-0.910**	-0.929*
	(0.480)	(0.414)	(0.579)	(0.710)	(0.455)	(0.558)
Manuf.	-0.168	-0.814**	-0.714*	-1.436***	-0.027	0.261
	(0.349)	(0.359)	(0.375)	(0.397)	(0.351)	(0.456)
Observations	1,269	1,269	1,323	1,323	1,323	1,323
Wald	10,304	11,155	4,427	6,012	33,866	21,144
Prob > χ^2	0.00	0.00	0.00	0.00	0.00	0.00
AR(1), p-value	0.13	0.30	0.13	0.17	0.47	0.86
AR(2), p-value	0.80	0.98	0.92	0.42	0.96	0.95

Notes:
See Table 2 Notes.
Additional terms in equations (8) and (9) included, but coefficients not shown.

Table 5: Robustness: Inverse Distance Weights and Random States

	(1)	(2)	(3)	(4)
	Inverse Distances		Random States	
$\mathbf{W}_A\mathbf{y}_t$	0.695***	0.721***	-0.011	-0.488**
	(0.227)	(0.203)	(0.197)	(0.220)
$\mathbf{h}_t$	0.138**	0.127*	0.270**	0.204*
	(0.070)	(0.068)	(0.131)	(0.122)
$\mathbf{W}_{Ft}\mathbf{F}_t$	3.287**		-0.026	
	(1.601)		(0.051)	
$\mathbf{W}_{Ft,intra}\mathbf{F}_t$		3.889		0.997
		(2.477)		(0.695)
$\mathbf{W}_{Ft,inter}\mathbf{F}_t$		-1.418		-0.039
		(1.879)		(0.081)
$\mathbf{W}_{Dt}\mathbf{D}_t$	-2.365**		0.015	
	(1.105)		(0.037)	
$\mathbf{W}_{Dt,intra}\mathbf{D}_t$		-2.927*		-0.789
		(1.746)		(0.495)
$\mathbf{W}_{Dt,inter}\mathbf{D}_t$		1.393		0.027
		(1.418)		(0.060)
Primary	-0.534	-1.484**	-0.908*	-1.470*
	(0.452)	(0.745)	(0.539)	(0.872)
Manuf.	-0.646	-1.184***	-0.534	-0.799**
	(0.413)	(0.369)	(0.336)	(0.405)
Observations	1,269	1,269	1,269	1,269
Wald	6,781	11,550	5,329	8,389
Prob > χ^2	0.00	0.00	0.00	0.00
AR(1), p-value	0.04	0.05	0.02	0.02
AR(2), p-value	0.16	0.20	0.46	0.37

Notes:

See Table 2 Notes.

Results from additional terms in equations (8) and (9) included, but not shown.

Table A1: Basic specification results for various values of decay parameter τ

τ_A	τ_F	τ_D	$\mathbf{W}_{Ft}\mathbf{F}_t$	$\mathbf{W}_{Dt}\mathbf{D}_t$	$\mathbf{W}_A\mathbf{y}_t$
0.020	0.020	0.020	0.299***	-0.222***	0.751***
0.020	0.015	0.015	0.287***	-0.213***	0.731***
0.020	0.015	0.020	0.122***	-0.102***	0.561***
0.020	0.020	0.025	0.190***	-0.161***	0.656***
0.020	0.025	0.025	0.310**	-0.232**	0.763***
0.025	0.020	0.020	0.307***	-0.230***	0.725***
0.025	0.020	0.025	0.187***	-0.160***	0.647***
0.025	0.025	0.025	0.320**	-0.240**	0.736***
0.015	0.015	0.015	0.276***	-0.204***	0.772***
0.015	0.015	0.020	0.126***	-0.104***	0.575***
0.015	0.020	0.020	0.285***	-0.211***	0.797***

Notes:
***, ** denote significance at the one and five percent level, respectively.
All coefficients from the basic specification in column (3) of Table 2 for the specified values of the decay parameters.

Table A2: Basic specification results for various values of decay parameter τ, intra- vs. inter-state effects

τ_A	τ_F	τ_D	$\mathbf{W}_{F,intra}\mathbf{F}_t$	$\mathbf{W}_{F,inter}\mathbf{F}_t$	$\mathbf{W}_{D,intra}\mathbf{D}_t$	$\mathbf{W}_{D,inter}\mathbf{D}_t$	$\mathbf{W}_A\mathbf{y}_t$
0.020	0.020	0.020	0.502***	-0.139	-0.387***	0.120	0.622***
0.020	0.015	0.015	0.451***	-0.057	-0.345***	0.054	0.596***
0.020	0.015	0.020	0.185***	0.075**	-0.167***	-0.038	0.487***
0.020	0.020	0.025	0.133	0.231***	-0.128*	-0.196***	0.581***
0.020	0.025	0.025	0.542***	-0.220	-0.414***	0.181	0.648***
0.025	0.020	0.020	0.489***	-0.098	-0.375***	0.087	0.611***
0.025	0.020	0.025	0.138*	0.226***	-0.131*	-0.194***	0.583***
0.025	0.025	0.025	0.504***	-0.142	-0.383***	0.119	0.638***
0.015	0.015	0.015	0.443***	-0.067	-0.341***	0.063	0.631***
0.015	0.015	0.020	0.183***	0.084**	-0.167***	-0.045	0.486***
0.015	0.020	0.020	0.511***	-0.173	-0.396***	0.149	0.650***

Notes:
***, ** denote significance at the one and five percent level, respectively.
All coefficients from the basic specification in column (3) of Table 3 for the specified values of the decay parameters.