

# Technology spillover influence on regional growth: evidence from Italy

*L'influenza dello spillover tecnologico sulla crescita regionale in Italia*

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**Riassunto:** Lo sviluppo economico delle regioni italiane viene analizzato in riferimento alla componente di innovazione tecnologica. La forte interdipendenza tra le regioni è alla base della scelta di sviluppare un modello che consenta di valutare gli effetti di spillover tecnologico. La struttura della specializzazione settoriale risulta essere il fattore che influenza maggiormente la diffusione dell'innovazione tecnologica tra le regioni italiane.

**Keywords:** Interregional technology spillovers, Sectorial specialization, Convergence model.

## 1. A convergence model with spillover

Technology plays a central role in economic growth theory and represents a relevant factor in both theoretical models and empirical studies. Traditionally technology enters production function and growth model as a whole and aggregate factor, without taking spillover effects into account. A more recent approach (Mankiw, 1995; Quah, 1996) suggests to assume territorial units not as independent and isolated, but to explicitly include the interdependence among geographical partitions in the growth model.

In this paper economic convergence in the Italian regions is analysed by resorting to a growth model in which technology spillovers are allowed. As a starting point we follow the approach employed by Hall and Mairesse (1995) for the firm-level case and assume a certain innovation function for region  $i$  at time  $t$ :

$$A_{it} = A \cdot R_{it}^{\delta_0} \cdot R_{eit}^{\delta_1} \quad (1)$$

where  $A_{it}$  denotes the level of innovation in region  $i$  at time  $t$ ,  $R_{it}$  is the stock of technological knowledge developed until time  $t$ ,  $R_{eit}$  is the potential spillover from all other regions to region  $i$ ,  $\delta_0$  and  $\delta_1$  are the innovation elasticities, and  $A$  is a constant that captures all exogenous factors affecting the level of technology.

We assume that the potential spillover for region  $i$  is expressed in terms of other regions' stock of knowledge:

$$R_{eit} = \sum_{j \neq i}^n r_{ij} R_{jt}^{\rho} \quad (2)$$

where weights  $r_{ij}$ , in row standardized form, capture the influence on region  $i$  of technological knowledge,  $R_{jt}$ , developed in other regions and  $\rho$  represents the elasticity term. By substituting (2) into (1) and redefining  $\delta_1 = 1/\rho$ , we obtain an innovation function in which regional stocks of technological knowledge are complementary to conventional

inputs, but interact with each other in a constant elasticity of substitution:

$$A_{it} = A \cdot R_{it}^{\delta_0} \cdot \left( \sum_{j \neq i}^n r_{ij} R_{jt}^\rho \right)^{\frac{1}{\rho}} \quad (3)$$

The log innovation function can be expressed through a second order Taylor series expansion around the point  $\rho = 0$  of the regional spillovers component:

$$\ln A_{it} = \ln A + \delta_0 \ln R_{it} + \sum_{j \neq i}^n r_{ij} \ln R_{jt} \quad (4)$$

In order to analyze regional spillovers, we consider both localization effects, through geographic distance (Maurseth, 2001), and sectorial effects, through dissimilarity in sectorial specialization. By subdividing regions into similar and dissimilar with respect to region  $i$  in terms of geographic distance and sectorial specialization we obtain four groups: regions similar to  $i$  for both distance and specialization ( $G_{Si}S_{Si}$ ), regions similar to  $i$  only for distance ( $G_{Si}S_{Di}$ ), regions similar to  $i$  only for specialization ( $G_{Di}S_{Si}$ ) and, finally, regions dissimilar to  $i$  for both distance and specialization ( $G_{Di}S_{Di}$ ). Therefore the innovation function can be represented as:

$$\begin{aligned} \ln A_{it} = & \ln A + \delta_0 \ln R_{it} + r_{SS} \sum_{j \neq i}^{G_{Si}S_{Si}} \ln R_{jt} + r_{SD} \sum_{j \neq i}^{G_{Si}S_{Di}} \ln R_{jt} + \\ & + r_{DS} \sum_{j \neq i}^{G_{Di}S_{Si}} \ln R_{jt} + r_{DD} \sum_{j \neq i}^{G_{Di}S_{Di}} \ln R_{jt} \end{aligned} \quad (5)$$

Equation (5) is based on two key assumptions. First, spillovers are assumed to vary only according to the geographic distance and the similarity in sectorial specialization, while the second hypothesis is that weights  $r_{ij}$  assume only 4 values ( $r_{SS}$ ,  $r_{SD}$ ,  $r_{DS}$  and  $r_{DD}$ ) corresponding to the 4 groups in which the regions are subdivided. Consequently, weights  $r_{ij}$  result constant for all spillover-receiving regions from a given group of spillover-transmitting regions.

It is worth to note how weights  $r_{ij}$  can be interpreted as the innovation elasticity of spillover, which is not scale neutral. In this framework innovative regions are implicitly assumed to receive from spillovers a proportionately higher advantage than less innovative regions.

In order to evaluate spillover influence on regional growth the conditional convergence approach is used and therefore each region is assumed to converge to its own steady-state with a convergence velocity defined by the parameter  $\beta$ :

$$\Delta \ln y_{it} = \beta(\ln y_{it-1} - \ln y_{it}^*) + \varepsilon_{it} \quad (6)$$

where  $\Delta \ln y_{it}$  is the growth rate of labour productivity from time  $t - 1$  to time  $t$ ,  $\ln y_{it-1}$  is the labour productivity at time  $t - 1$ ,  $\ln y_{it}^*$  is the steady-state labour productivity and  $\varepsilon_{it}$  denotes an I.I.D. disturbance.

Let  $\phi$  be the effect of the level of technology on steady-state labour productivity, it is possible to express  $\ln y_{it}^*$  as:

$$\ln y_{it}^* = \phi \ln A_{it} + \mu_i \quad (7)$$

where all other factors affecting steady-state are captured by the region-specific constant  $\mu_i$ . Substituting equations (5) and (7) into (6) leads to the following specification for the spillover-augmented convergence model:

$$\begin{aligned} \Delta \ln y_{it} = & \alpha + \tilde{\mu}_i + \beta \ln y_{it-1} + \gamma_0 \ln R_{it} + \gamma_{SS} \sum_{j \neq i}^{G_{Si} S_{Si}} \ln R_{jt} + \gamma_{SD} \sum_{j \neq i}^{G_{Si} S_{Di}} \ln R_{jt} + \\ & + \gamma_{DS} \sum_{j \neq i}^{G_{Di} S_{Si}} \ln R_{jt} + \gamma_{DD} \sum_{j \neq i}^{G_{Di} S_{Di}} \ln R_{jt} + \varepsilon_{it} \end{aligned} \quad (8)$$

where  $\alpha = -\beta \cdot \phi \cdot \ln A$ ,  $\tilde{\mu}_i = -\beta \cdot \mu_i$ ,  $\gamma_0 = -\beta \cdot \phi \cdot \delta_0$ ,  $\gamma_{SS} = -\beta \cdot \phi \cdot r_{SS}$ ,  $\gamma_{SD} = -\beta \cdot \phi \cdot r_{SD}$ ,  $\gamma_{DS} = -\beta \cdot \phi \cdot r_{DS}$  and  $\gamma_{DD} = -\beta \cdot \phi \cdot r_{DD}$ .

In order to overcome possible problems related to the endogeneity of domestic stock of technological knowledge,  $R_{it}$ , we resort to a two-stage estimate procedure, where at the first stage human capital is used as an instrumental variable for  $R_{it}$ , and at the second stage the convergence model (8) is estimated.

## 2. Empirical evidence

The influence of technology spillover on regional growth is investigated for the twenty Italian regions on the basis of geographic distance and sectorial specialization. Annual regional data from 1986 to 1996 are obtained from ISTAT. Stock of technological knowledge is approximated by R&D stocks, applying the perpetual inventory method to annual R&D expenditures with a 15% depreciation rate, while human capital is measured by mean years of schooling for the labour force.

In order to evaluate the impact of geographic distance on spillovers, we employ road distances between regions and consider 600 kilometers as a limit value to distinguish between near and distant regions.

In order to measure the similarity in sectorial specialization between region  $i$  and region  $j$  we resort to:

$$s_{ij} = 1 - \frac{1}{2} \sum_k |s_{ik} - s_{jk}|$$

where  $s_{ik}$  represents region  $i$ 's share of product in sector  $k$ . Index  $s_{ij}$  ranges from zero to one: a value of one denotes that the two regions are perfectly similar in sectorial specialization, while a value of zero denotes that they are completely dissimilar. In order to distinguish between similar and dissimilar regions we use  $\tilde{s} = 0.86$  as a limit value.

After defining the 4 groups stock variables it is possible to estimate the convergence model (8). Table 1 shows within-two-stage-least-squares estimates with and without spillover factors.

Convergence parameter  $\beta$  estimate is significant in both models, but when spillover effects are considered, the speed of convergence is quite higher. The parameter  $\gamma_0$  related to domestic stock of technological knowledge is significant only in the reduced model, thus emphasizing the role of spillover components, which represent the main source of technology in the less innovative regions.

In order to evaluate the importance of sectorial specialization, we compare coefficients related to sectorially different groups, that meet the same geographic criterion. The comparison of  $\gamma_{SS}$  (significant at 1%) to  $\gamma_{SD}$  (not significant) indicates that spillover from

**Table 1:** *Within-two-stage-least-squares estimates*

|               | without<br>spillover   | with<br>spillover       |
|---------------|------------------------|-------------------------|
| $\beta$       | -0.1178773*<br>(0.047) | -0.2620065**<br>(0.055) |
| $\gamma_0$    | 0.0307852*<br>(0.012)  | 0.0058411<br>(0.013)    |
| $\gamma_{SS}$ |                        | 0.0056031**<br>(0.001)  |
| $\gamma_{SD}$ |                        | 0.0018951<br>(0.001)    |
| $\gamma_{DS}$ |                        | 0.0025493**<br>(0.001)  |
| $\gamma_{DD}$ |                        | 0.0015740<br>(0.001)    |

\*: signi cant at the 5%; \*\*: signi cant at the 1%. Standard errors in parenthesis.

geographically similar regions is strongly attenuated by dissimilarity in sectorial specialization. This result holds for geographically dissimilar groups as well and suggests that similarity in sectorial specialization positively affects interregional spillover regardless of geographic distance.

Analogously, the role of geographic similarity can be assessed by comparing spillover coefficients that meet the same criterion in sectorial specialization. The comparison of  $\gamma_{SS}$  to  $\gamma_{DS}$  shows that spillover from regions similar in sectorial specialization is in some way attenuated by geographic dissimilarity. On the other hand, when regions dissimilar in sectorial specialization are analysed, geographic distance does not influence technology spillover. Tests for the hypothesis  $\gamma_{SS} = \gamma_{SD}$ ,  $\gamma_{SS} = \gamma_{DS}$ ,  $\gamma_{SS} = \gamma_{DD}$ ,  $\gamma_{SD} = \gamma_{DS}$ ,  $\gamma_{SD} = \gamma_{DD}$  and  $\gamma_{DS} = \gamma_{DD}$  indicate a significant difference, thus reinforcing the specification proposed.

The convergence model with spillover components is also estimated using different boundaries in geographic and sectorial similarity. The previous results are generally confirmed but by increasing  $\tilde{s}$ : since sectorial specialization seems to be the dominant spillover factor, a reduction in the similarity boundary leads to a downward biased estimate of  $\gamma_{SS}$  coefficient.

By taking technology spillover effects into account, it is possible to obtain a significant improvement in the analysis of regional convergence in Italy, either in the direction of a more accurate measurement of the convergence parameter and in the identification of the factors which mainly influence regional growth.

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