The persistence of regional disparities in Italy through the lens of the European Union nanotechnology network

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The knowledge-based economy has created new opportunities for marginal regions, even though some areas in advanced economies still show unbalanced development patterns. This article uses the Italian partnerships created within the nanotechnology projects funded under the European Union’s Sixth (FP6) and Seventh (FP7) Framework Programmes to assess the spatial relationships and verify the impact of innovation dynamics on regional re-industrialization processes in the country. It shows the presence of centralized networks that have reinforced the polarization in innovation activities in the traditionally most advanced areas of the country and reveals how new high-technology industries – such as nanotechnology – are hardly a means for marginal regions to break away from their development paths.

Keywords: innovation networks; regional dynamics; clusters; European Union Framework Programmes; Italian regions

Introduction

The ‘path dependence’ concept emerged in contemporary discussions regarding the persistence of regional disparities in economic development (Martin & Sunley, 2010) referring to ‘an open system that evolves in ways shaped by its past development paths’ (Boschma & Martin, 2010, p. 8), even though processes preceding a specific socio-economic formation may substantially evolve and mutate over time (Boschma & Martin, 2007). For marginal regions, knowledge flows from both adjacent and distant regions are critical innovation determinants, creating new challenges and opportunities in the emerging knowledge economy. However, studies to date have failed to clarify how marginal regions’ industrial structures and related geographical and relational dynamics have been affected by current forms of re-industrialization (European Commission (EC), 2013). These increasingly involve new socio-economic dynamics created by novel inter-organizational linkages at intra- and inter-regional scales.

We here regard ‘re-industrialization’ as technological developments leading both to the emergence of new sectors alongside these new technologies penetrating traditional sectors and catalysing their innovative processes (Barta, Czirfusz, & Kukely, 2008). In this article we explore re-industrialization via nanotechnology, a sector the European Union (EU) identified as one of Key Enabling Technologies determining Europe’s global market position and, hence, a target for intensive investment to boost competitiveness, create jobs and support growth (EC, 2013). Nanotechnology...
is characterized by high interdisciplinary and an inter-sectoral nature allowing innovation and knowledge exchange scholars to study innovation dynamics across a broad selection of industries (EC, 2013). This in turn makes nanotechnology a very effective lens to study how these knowledge linkages relate to national re-industrialization processes (Barta et al., 2008).

Therefore, we ask the following research question: Can new high-tech industries such as nanotechnology help to break the path dependence of old industrial and more successful regions? We address this question in the context of Italy, whose socio-economic fabric is highly appropriate for a study aiming to answer this question. Since its unification in 1861, Italy has been characterized by evident disparities between advanced northern regions and marginal southern ones. Putnam (1993) attributed this divergent development to the diverse institutional ‘quality’ between Italian regions; other studies ascribed these regional disparities to the north’s geographical proximity to the European core (Malanima, 2002).

The north has been historically characterized by a strong industrial concentration in the so-called ‘triangle’ (Lombardy, Piedmont and Liguria) and the successful implementation of Marshallian small-firm-based districts in the 1970s and 1980s in Veneto, Emilia-Romagna and Tuscany (Sforzi, 1989). Conversely, southern regions both lacked human capital and were hindered by national trade policies aimed at stimulating agricultural specialization in the these regions (Gagliardi & Percoco, 2011). Finally, forces such as natural advantages and domestic and foreign market access have repeatedly benefited the north at different stages of Italy’s economic history, rather than as in other countries where different regions have benefited and thrived at different periods (i.e., France and the UK; A’Hearn & Venables, 2011).

We analysed all research projects involving Italian organizations funded by the EU under the Sixth (FP6 2002–06) and Seventh (FP7 2007–13) Framework Programmes within the theme ‘Nanosciences, Nanotechnologies, Materials and New Production Technologies’ (NMP). We explored whether current re-industrialization associated with nanotechnology – an interdisciplinary and inter-sectoral technology – has driven new geographical patterning in economic development in Italian regions and macro-regional areas.

The paper is structured as follows. We first introduce the major literature on knowledge flows, innovation networks and path dependence (in the second section) and then argue that analysing collaborations between nanotechnology organizations at the intra- and inter-regional levels – using this EC database – is an adequate method to capture national innovation activity dynamics (third section). The fourth section maps Italian nanotechnology activities, revealing an uneven pattern with a concentration of private and public bodies in the 20 Italian constitutional regions and three macro-regions (North, Centre and South). By considering two distinct periods of collaborations in the two Framework Programmes (fifth section) we determine in and between which areas of the country the strongest relationships at the regional level were established. Finally, we demonstrate that the location of innovation activities and knowledge flows among organizations involved in innovation networks are undoubtedly ‘path dependent’ (sixth section). They are unevenly distributed among regions and macro-regional areas and remain influenced by the overlapping historical economic-production spatial models and the long-lasting evolutionary path of the country.
Theoretical framework

Knowledge dynamics are only one driver of regional industrial development, which may also be influenced by other (equally significant) factors, including the availability of investment funds, infrastructures and human capital. However, knowledge exchange created by collaborations among organizations is a very good proxy to capture the wider dynamic effects of industrialization in a spatial perspective (EC, 2013). Our empirical study is based on a dataset including all the collaborations established among organizations involved in nanotechnology throughout the two latest FPs. We justify this choice by the fact that temporary and direct contacts seem to matter more than the mere geographical proximity in the EU nanotechnology network (Calignano, 2014) and by suggesting that nanotechnology innovation primarily takes place in global innovation networks or technological innovation systems.

Previous studies have stressed that the interaction frequency between actors within knowledge networks has increased drastically in recent decades and that long-distance collaborations have increased over time (Autant-Bernard, Billand, Frachisse, & Massard, 2007). Other contributions have also shown that innovation at the regional level can be determined by significant long-distance knowledge flows, even in those regions not characterized by an innovative structure, sparse companies, lack of investments in research and development (R&D) or geographical marginality (Fitjar & Rodriguez-Pose, 2011).

However, our aim is to assess if these transnational partnerships could show spatial relationships, providing additional insights into the regional impact of current forms of re-industrialization on a specific country’s industrial structure. Therefore, distance must be carefully considered in terms of geographical proximity (Boschma, 2005) with both intra-regional (Sonn & Storper, 2008) and inter-regional (including transnational; Uyarra, Sörvik, & Midtkandal, 2014) collaborations mattering to innovation dynamics.

If we argue that space matters, then one might expect the persistence of a spatial division of labour. We base this presupposition upon the extent to which a territorial innovation system is anchored to specific regional knowledge assets measureable by looking at those regional knowledge assets’ transnational connections. Hassink (2010) argues that regional lock-in is influenced by both intra- and extra-regional factors, one factor being the lack of renewal in past development paths potentially addressed which firms can now successfully tackle by focusing on innovation and diversification. We argue that the shape of nanotechnology networks in one country is indicative of the overall regional development effect; extremely centralized networks would suggest a reinforcing of polarization in innovation activities, whereas more diffuse network structures might indicate more widespread benefits (EC, 2013).

Methodology

We analysed all 1271 NMP projects funded under FP6 and FP7 to reconstruct the intra- and inter-regional networks created by the Italian organizations. We selected FP6 and FP7 nanotechnology projects with at least two Italian participants and grouped each project’s partners into pairs, checking whether each pair belonged to the same or different regions. The obtained pairs matrix was applied to a map of Italian regions to determine where there were regional concentrations of these partnerships. Nanotechnology’s high interdisciplinary and inter-sectoral nature – and particularly the
collaborations encouraged by the FPs – interact with a diverse range of sectors (EC, 2013) and enabled us to capture innovation dynamics across a very broad selection of industries.

Of course, focusing exclusively on the EU-funded projects entails neglecting other equally relevant projects that do not benefit from EU support. However, the transcalarity of the EU nanotechnology network enabled us to capture relational dynamics at various geographical levels and allowed us to project our findings in a dynamic perspective (considering two distinct periods, 2002–06, FP6 and 2007–13, FP7) by assessing if significant changes occurred among organizations involved in nanotechnology at intra- and inter-regional levels between the two programmes.

Previous studies have highlighted how Italy is one of the countries that profited most from EU research funds allocated under the two latest FPs and how Italian organizations involved in nanotechnology consider EU funds to be a crucial source because of the high availability of financial resources counterbalancing the lack of investments at the national level (for a detailed report on the characteristics of the Italian organizations involved in the two latest FPs as well as on the economic and scientific effects of their presence at the national level, see Calignano, 2014). We thus contend that in constructing the dataset and collaboration network distinguishing intra- and inter-regional ties, respectively, we can reveal research and development (R&D) mechanisms and thereby assess several knowledge exchange features – and consequently innovation dynamics – from a national spatial perspective. This in turn provides a means to answer our overarching research question: whether re-industrialization is breaking the existing ‘path dependence’ in Italy, for reasons intrinsically related to the previously outlined spatial innovation dynamics, the characteristics of the nanotechnology sector and our dataset.

**Nanotechnology in Italy: an overview**

Italy invests approximately US$135 million annually in nanotechnology, substantially less than Germany, the European leader, with US$800 million. Nevertheless, nanotechnology is a rising field in Italy: in 2010, 103 public institutions and 86 private organizations were directly engaged in nanotechnology – a figure that quadrupled in 2004–2010 – although these activities’ location is not geographically homogenous (Airi Nanotec, 2011) (Figure 1).

Most Italian nanotechnology activities are located in Lombardy (31 public and private organizations), followed by Lazio (19), Veneto (16), Emilia Romagna (13), Tuscany (11) and Piedmont (10). The overall number of nanotechnology organizations in southern Italian regions is 26 (fewer than just Lombardy) and most are classified as ‘Other University Research Units’ (10), and the presence of other types of entities is even more limited (Figure 2).

Classifying by macro-areas (North, Centre and South) showed the higher number of private organizations located in northern Italy (32). Most large companies are in Lombardy, with the highest number of small and medium-sized enterprises (SMEs) being in Veneto. These figures confirmed that a high-technology field such as nanotechnology replicates more traditional economic and geographical characteristics of Italian industrial development. The other two macro-regions host only a total of 15 private organizations (nine in central and six in southern Italy).
Public bodies’ locations do not differ substantially from private activities: 54 are in northern Italy (>50% of the total), 29 are in central Italy and 20 are in southern Italy. These figures show clearly how the presence of nanotechnology activities is stronger in northern areas, with a shortage of nanotechnology activities being particularly acute in southern Italy (Figure 2).

Figure 1. Public and private nanotechnology organizations (Italian regions). Source: Authors’ elaboration from Airi Nanotec (2011).
Regional dynamics of the Italian organizations within the EU nanotechnology network

For dynamic and geographical purposes a grid was built to reconstruct the EU nanotechnology network and to assess whether each pair of Italian collaborating organizations belonged to the same or to different regions. In total 320 Italian organizations participating in FP6 and 488 participating in FP7 were surveyed.

Table 1 clearly shows that regions scoring above the national average are the same in both FP6 and FP7, and are located in northern Italy. The first southern region is Campania, with an overall number of pairs equals to about 9% of Lombardy (the top-ranked region). Between FP6 and FP7 the overall number of Italian pairs increased by 17%, but intra-regional pairs increased even more, from 220 to 366 (an increase of 66%). Lombardy’s value is particularly significant as it doubled its number of intra-regional collaborations, although every northern region with the highest scores in absolute terms increased its intra-regional partnerships. Conversely, the southern regions were largely disappointing as they increased their presence by only 16 pairs between FP6 and FP7. The whole southern macro-region’s score was 99 (FP6) and 115 (FP7), i.e. 27% (FP6) and 24% (FP7) of the values for Lombardy. In central Italy, Tuscany retained its third position between FP6 and FP7, consolidating its centrality in both FPs.

Figure 3 shows the relational and spatial dynamics among the Italian regions within the EU nanotechnology network. Specifically, the spheres’ location corresponds to the region, and the radius of the overall number of intra-regional partnerships. Lines’ thickness and colour shade (ranging from grey to black) indicate the strength of the ties between regions (thicker/darker lines correspond to greater ties intensity). Line length illustrates geographical distance between each regional pair.

These diagrams revealed the dynamic evolution of the relationships between intra-and inter-regional organizations, showing clearly that the strongest relationships were established between organizations in northern regions and secondarily between organizations in northern and central regions (relationships between Tuscany and the northern regions being particularly intense). Conversely, relationships among organizations located in southern Italy and between southern Italy regions and the two other areas were very limited/absent.
Figure 3. Pairs of partners in and between Italian regions. Source: Authors’ design from Cordis (2014).
These figures clearly demonstrate both a process of ongoing agglomeration in which regional entities active in nanotechnology and operating in northern regions consolidated and fostered relationships with partners belonging to the same region yielding knowledge flows involving primarily organizations located in northern regions. This corresponds to centralized networks reinforcing innovation polarization benefiting the traditionally most advanced areas of the country.

### Discussions and conclusions

We have sought here to assess if high-tech industries such as nanotechnology can break the path dependence and create new development opportunities for peripheral areas. Our Italian nanotechnology case study was built on a theoretical framework concerning the importance of intra- and inter-regional knowledge flows in innovation dynamics. Firstly, analysing regional relational and geographical organizational dynamics in the transnational nanotechnology innovation network revealed that Italian’s nanotechnology development dynamic is consolidating northern regions’ success by binding the historical ‘Industrial Triangle’ (Lombardy, Piedmont and Liguria) with the areas that saw the flourishing of industrial districts of SMEs in the 1970s and 1980s (Veneto, Emilia-Romagna and Tuscany). Moreover, following the EC’s concern with well-balanced innovation diffusion (EC, 2013), our findings back the existence of ‘two speeds’ in Italian economic growth, emphasizing disparities related to nanotechnology activities’ location (Airi Nanotec, 2011).

### Table 1. Intra- and inter-regional pairs – FP6 and FP7 ranking.

| Region                     | Total pairs | Only intra-region | Region                     | Total pairs | Only intra-region |
|----------------------------|-------------|-------------------|----------------------------|-------------|-------------------|
| Lombardy                   | 365         | 66                | Lombardy                   | 484         | 134               |
| Piedmont                   | 319         | 65                | Piedmont                   | 323         | 88                |
| Tuscany                    | 202         | 30                | Tuscany                    | 217         | 41                |
| Emilia-Romagna             | 131         | 19                | Emilia-Romagna             | 195         | 40                |
| Liguria                    | 125         | 13                | Liguria                    | 122         | 26                |
| Veneto                     | 86          | 9                 | Veneto                     | 115         | 11                |
| Italian average            | 75.7        | 11                | Italian average            | 88.6        | 18.3              |
| Friuli-Venezia Giulia      | 65          | 5                 | Friuli-Venezia Giulia      | 82          | 6                 |
| Lazio                      | 51          | 6                 | Lazio                      | 61          | 10                |
| Campania                   | 32          | 1                 | Campania                   | 42          | 1                 |
| Apulia                     | 32          | 0                 | Apulia                     | 30          | 3                 |
| Marche                     | 29          | 2                 | Marche                     | 29          | 2                 |
| Trentino-South Tyrol       | 23          | 1                 | Trentino-South Tyrol       | 25          | 2                 |
| Sicily                     | 17          | 3                 | Sicily                     | 21          | 0                 |
| Umbria                     | 14          | 0                 | Umbria                     | 9           | 1                 |
| Abruzzo                    | 7           | 0                 | Abruzzo                    | 6           | 0                 |
| Sardinia                   | 6           | 0                 | Sardinia                   | 5           | 0                 |
| Aosta Valley               | 5           | 0                 | Aosta Valley               | 4           | 0                 |
| Calabria                   | 5           | 0                 | Calabria                   | 2           | 1                 |
| Molise                     | 0           | 0                 | Molise                     | 0           | 0                 |
| Basilicata                 | 0           | 0                 | Basilicata                 | 0           | 0                 |
| Italy                      | 1514        | 220               | Italy                      | 1772        | 366               |

Source: Authors’ elaboration from Cordis (2014) (see [http://cordis.europa.eu/home_it.html](http://cordis.europa.eu/home_it.html)).
This study revealed the rise (FP6) and strengthening (FP7) of a real nanotechnology macro-regional area in the north, which also includes central regions such as Tuscany in its gravitational sphere. One of our most important findings is that innovation activities connected to a new emerging innovative sector (in this case nanotechnology) exacerbate geographical concentration in core regions, with nanotechnology unlikely to drive economic convergence between Italy’s advanced and peripheral regions. The southern regions continue to pay an increasing price, not only suffering from unequal distribution of nanotechnology actors but also developing fewer regional networks around nanotechnology in the two latest FPs. What could have been an opportunity for southern Italy to narrow the gap in terms of industrial development and trigger re-industrialization processes has proven to be another lost bet for the Italian entrepreneurs, researchers and policy-makers.

This is highly relevant, suggesting a new explanation about why peripheral regions may not benefit from reindustrialization, with core regions dominating newly formed networks and their associated innovative potential. Nanotechnology has proven to be a sensitive and reliable indicator of knowledge dynamics revealing regional industrial development processes. Analysing nanotechnology partnerships at a transnational level allows scholars the opportunity to assess regional innovation dynamics because of their intrinsic characteristics of transcalarity. Finally, consistent with network studies approaches, our method transcends static representations of nanotechnology in a single country, offering a relational and dynamic approach for portraying networked knowledge exchange and diffusion.

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No potential conflict of interest was reported by the authors.

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