9. **Conclusions**

9.1 **Summary of the main findings and lessons learned**

Research on proximity economics has come of age. Several theories now discuss in detail the microfoundations of the reduction in production costs and the productivity gains that stem not only from the co-location of individuals and firms in space, but also from two actors, and, as in the case of the empirical studies discussed in this dissertation, two regions being close in relational, social, cognitive, and technological space. Moreover, theoretical and empirical research have also steadily demonstrated that the effects of non-geographic proximity extend to enhancing learning processes, this taking place both locally, as suggested by several regional development theories, as well as inter-regionally, as argued in Parts B and C of this dissertation.

This dissertation took stock of the research that has so far been undertaken in the field of proximity economics, and moved a step forward in this line of research by providing new empirical results on the inter-regional proximity effects determining the strength of knowledge diffusion and the impact of knowledge on regional growth in European regions.

To this aim, a critical review of the existing regional development theories underlying proximity effects has been presented, and a methodological discussion of the indicators following the conceptual rationale of such proximity effects has followed. Three logical steps in this first part of the dissertation led to the empirical verifications discussed in Parts B and C.

First, the existing literature on proximity and knowledge diffusion is classified as encompassing two main lines of research:

- Works that deal with the territorial preconditions for inter-regional knowledge diffusion. These represent the proximity effects proper, and in this dissertation the effects of geographic, relational, social, cognitive, and technological proximity are discussed;

- Literature focusing instead on the channels through which these preconditions may exert their effects. In fact, once proximity effects are at work also in the absence of co-location (i.e., when moving from an intra-regional to an inter-regional definition of the concept of proximity), they may become stronger in presence of one or more vehicles that potentially channel them.

Second, among the concepts of proximity that have been discussed in the theoretical literature, five have been selected as potentially amenable to empirical measurement as preconditions for knowledge diffusion: these include geographic, relational, social, cognitive, and technological proximity.
Finally, these five concepts have been conceptually defined as seen from an inter-regional knowledge diffusion perspective. Thus, throughout the first part of the dissertation, an inter-regional perspective on knowledge diffusion has been adopted. The analysis is thus focused on the ways in which knowledge travels across regions, and how this process enhances regional growth. For many of these concepts of proximity, this represents an element of novelty: most notions of proximity are in fact microufounded in local development theories, and therefore most often deal with the local preconditions for enhancing productivity and dynamic efficiency.

The theoretical part of the dissertation has thus made some limitations of the presently available studies explicit, and these gaps have led to two main research questions (Chapter 1):

RQ1 What is the joint role of non-geographic proximities in inter-regional knowledge diffusion?

RQ2 Through which types of proximity does knowledge impact regional growth?

These research questions paved the way for five applied contributions, that empirically assess the intensity of proximity effects in the process of inter-regional knowledge diffusion (Part B of the dissertation) and the way geographic and non-geographic proximity enhance regional growth processes by means of more effective knowledge diffusion (Part C).

From the empirical analyses performed in Part B and Part C the following three main messages emerge:

- While the role of geographic proximity in enhancing knowledge diffusion is found to be less relevant once other, non-geographic types of closeness are taken into account, geographic proximity still represents a crucial precondition for knowledge diffusion.

- The impact of both geographic as well as non-geographic proximity on knowledge diffusion is characterized by remarkable non-linearities. This result provides evidence of possible optimal levels of proximity between regions; this implies that excessive proximity could engender knowledge lock-ins that regional actors may want to avoid, lest they reach sub-optimal outcomes in terms of both productivity and knowledge generation.

- Different forms of proximity can complement each other: their effects thus display relevant synergies, that have so far been relatively neglected in both the theoretical and the empirical debate.

More in detail, the main results of the empirical work carried out in this dissertation can be represented as in Table 61, which is based on two founding principles:
Table 61. Summary of the main empirical findings related to proximity effects in the dissertation

<table>
<thead>
<tr>
<th>Proximity concept</th>
<th>Impact on inter-regional knowledge diffusion</th>
<th>Impact on regional growth via knowledge spillovers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geographic proximity</strong></td>
<td>Competition effects affect regions characterised by geographic proximity (Chapter 4)</td>
<td>Geographic proximity enhances inter-regional knowledge spillovers, in turn stimulating regional growth (Chapter 7 and Chapter 8)</td>
</tr>
<tr>
<td></td>
<td>Geographic proximity fosters inter-regional scientific cooperation, with non-linearities in its impact, and synergies with cognitive, technological and social proximity (Chapter 5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>International skilled labour mobility is more intense between countries being geographically close (Chapter 6)</td>
<td></td>
</tr>
<tr>
<td><strong>Inter-regional relational proximity</strong></td>
<td>Inter-regional knowledge diffusion processes require relevant knowledge generation in both the knowledge-producing region and other regions linked by relational proximity (Chapter 4)</td>
<td>Nonlinear positive spillover effects are generated by relational proximity between couples of regions (Chapter 8)</td>
</tr>
<tr>
<td></td>
<td>Scientific cooperation (inter-regional relational proximity) is fostered by inter-regional geographic, social, technological and cognitive proximity, with relevant non-linearities and synergies between geographic proximity and cognitive, technological and social proximity (Chapter 5)</td>
<td>Synergies between relational proximity and geographic proximity –driven spillover effects in regional growth (Chapter 8)</td>
</tr>
<tr>
<td></td>
<td>The existence of previous collaborations and common ties between country pairs&lt;sup&gt;145&lt;/sup&gt; fosters international skilled labour mobility (Chapter 6)</td>
<td>Synergies between relational proximity and social proximity –driven spillover effects in regional growth (Chapter 8)</td>
</tr>
<tr>
<td><strong>Inter-regional social proximity</strong></td>
<td>Insignificant effects of social proximity in knowledge diffusion processes (Chapter 4)</td>
<td>Nonlinear positive spillover effects are generated by social proximity between couples of regions (Chapter 8)</td>
</tr>
<tr>
<td></td>
<td>Social proximity fosters inter-regional scientific cooperation, with non-linearities in its impact, and synergies with geographic proximity (Chapter 5)</td>
<td>Synergies between social proximity and geographic proximity –driven spillover effects in regional growth (Chapter 8)</td>
</tr>
</tbody>
</table>

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145 Having formerly been part of the same colonial empire.
### Low social proximity hampers international skilled labour mobility (Chapter 6)

| **Inter-regional technological proximity** | Inter-regional knowledge diffusion processes require relevant knowledge generation in both the knowledge-producing region and other regions linked by technological proximity (Chapter 4)  
Inter-regional technological proximity stimulates scientific cooperation, with increasing returns and synergies with geographic proximity (Chapter 5) | Insignificant spillover effects are identified for technological proximity between couples of regions (Chapter 8) |
| **Inter-regional cognitive proximity** | Competition effects affect regions characterised by high inter-regional cognitive proximity (Chapter 4)  
Inter-regional cognitive proximity fosters inter-regional scientific cooperation, with non-linearities in its impact, and synergies with geographic proximity (Chapter 5) | Intra-regional cognitive proximity represents a positive externality making interactions between individuals for the aim of generating knowledge more productive, in turn fostering regional growth (Chapter 7)  
Intra-regional cognitive proximity in other regions further enhances knowledge spillovers, thus providing evidence on synergic effects between cognitive and geographic proximity (Chapter 7) |

Source: Author’s elaboration
• a conceptual breakdown in the two theoretical streams of works followed in Parts B and C of this dissertation, respectively (proximity and knowledge diffusion, and proximity and regional growth);

• the three main messages just summarized, concerning the simultaneous role of geographic and non-geographic proximity, and the possible non-linearities and synergies characterizing proximity effects.

While providing evidence about several theory-based forecasts, and shedding more light on the relative strength of the knowledge diffusion preconditions, these results pave the way for further future research, rather than saying the last word on proximity economics. In fact, while the relevance of geography appears indeed diminished with the inclusion of some of the underlying non-geographic proximity mechanisms, geographic proximity still represents a major factor for the production and diffusion of activities, knowledge included, in space. Besides, in the future the relevance of inter-regional characteristics summarized here under the non-geographic proximity umbrella will likely shape even more than presently the way knowledge will be produced, and will diffuse.

9.2 Policy implications

Because inter-regional proximity effects are by nature unintended, it is rather awkward to derive policy implications from the empirical studies presented in this dissertation. And yet, the relevance of these topics deserves at least an attempt in this direction.

The first strong result that emerges from the empirical work in the chapters of this dissertation is related to the fact that the effects of geography on knowledge diffusion processes are far from dead. As a consequence, managing the chain of production and diffusion of knowledge should take this first point into account.

In fact, the last two decades have witnessed a vast process of delocalization and geographic fragmentation of knowledge production (Ernst and Kim, 2002); regions have been striving to get a significant share of the global chain of knowledge value creation. It becomes increasingly important to activate supply-side policies enhancing territorial attractiveness, thus overcoming those limitations that derive, for instance, from an unfavourable geographic position: “Regional institutions can promote the value enhancement activities of focal firms in global production networks. This occurs when regional institutions are prepared to invest in developing the infrastructure and human resources required for value enhancement (e.g. highly stable power supply and skilled engineers for wafer fabrication)” (Coe et al., 2004, p. 475). Especially in single-currency areas, this process represents a real global competition, based on absolute, and not relative, competitive advantage (Camagni, 2002).
A second topic to be discussed could be defined, borrowing from Arrow’s impossibility theorem,\textsuperscript{146} as the "proximity impossibility theorem". This refers to the fact that it may not be feasible to alter any positioning of an area not only in terms of geographic location (which is by definition given, and cannot be altered\textsuperscript{147}), but also in terms of relational, social, cognitive, and technological space. In fact, it may be beyond reach for policymakers to deeply affect the behavior of individuals from whose aggregation the relative positioning of regions emerges. As a consequence, while proximity effects have proven to be relevant in the process of knowledge diffusion, their management would not be feasible for local and national policymakers, which in turn would cause hysteresis in the location of regions in terms of relational, social, cognitive, and technological space.

A third major point, assuming that the "proximity impossibility theorem" does not hold strictly, pertains to the nonlinearities of proximity effects. This dissertation provided consistent evidence about the complexity of inter-regional proximity effects, which often act nonlinearly in enhancing knowledge diffusion. Further, too much proximity between different areas may be detrimental for the ease and speed with which knowledge can be absorbed, decoded, and exploited in an area. Following the metaphor by Putnam and co-authors\textsuperscript{148}, the problem of nonlinearities in proximity effects could be defined as the "dark side of proximity".

In fact, although each typology of proximity can be difficult to be managed by policymakers, a limited degree of control is still left for local and (supra-) national authorities. For instance, in light of the evidence supporting the importance of inter-regional relational proximity presented in this dissertation, with the aim to enhance such knowledge flows, EU authorities may further strengthen the scientific cooperation relations that are structurally formed by means of financing FP and Horizon 2020 projects.

However, such relations should not reach the threshold beyond which they become excessively strong. National and regional authorities, especially those in areas that are not strong in endogenous knowledge production, may instead focus on the (admittedly, difficult) task of fostering social proximity with areas that are stronger in this respect, once again without running into social proximity lock-in. Finally, industrial policy may also be aimed at providing incentives for the development of those industries that would enhance industrial and cognitive proximity with areas that can generate positive knowledge spillovers.

Managing intangible development assets clearly presents relevant problems, and yet investing in geographic and non-geographic proximity cannot be ignored. Returns from this

\textsuperscript{146} Arrow (1951).
\textsuperscript{147} It is nevertheless worth stressing that even geographic proximity is actually not fully exogenous; in fact, geographic accessibility can be (even dramatically) improved by means of transport infrastructure investment. This point also lies behind the crucial relevance of infrastructure expenditure in several national and local public budgets.
\textsuperscript{148} “The dark side of social capital” is discussed in Putnam (2000), Ch. 22.
type of investment tend to mature in the long run, and this poses a further challenge: long-run investments tend to be less attractive for policymakers, because of the short length of the average political cycle. However, the payoff of investing in the quality of norms and institutions, in social and relational proximity to knowledge-intensive areas, in cognitive and technological proximity to regions specialized in advanced industries could make a major difference.

Empirically, this dissertation has also provided evidence about the interrelations between the effects of various types of proximity. Because of these synergies, any investment in a unique type of proximity may mean obtaining a sub-optimal outcome. This point clearly resonates Ragnar Nurkse’s balanced growth theory (Nurkse, 1959), whereby investment in the simultaneous development of different industries must be pursued lest a developing country achieves ‘un-balanced growth’, thus failing to fully reap the benefits of such investment. The policy implications stemming from these empirical analyses thus suggest an updated version of Nurkse’s work, in particular stressing the need for a balanced path of proximity in order to maximize knowledge diffusion processes.

Despite the evident difficulties, therefore, policies aimed at managing proximity represent a possible fertile soil for future research.

9.3 Limitations of this work and future research avenues

Nitwithstanding the relevant recent advances, work to be done in the field of proximity economics is still significant.

The literature that was initially born within regional development schools has now produced a limited set of concepts of non-geographic proximity, whose microfoundations are however yet to be fully explored. In this dissertation, because of the mainly empirical focus of this work, the rationale for each type of mechanism determining proximity effects has only been partially discussed, and not fully delved into. In fact, several proximity concepts share commonalities, most importantly in terms of the practical preconditions leading two regions to cooperate and exchange knowledge. This promises to be a relevant future research avenue in the field of proximity economics.

One major advancement would imply a theoretical reflection of the ways non-geographic proximity comes about, and, in particular, how it accumulates or decumulates. Much like social and human capital, and other forms of non-material growth determinants, proximity – with the notable and partial exception of pure geographic proximity – evolves over time and follows the continuous flow of change that affects the characteristics that underlie each
concept of proximity. Therefore, a better understanding of the accumulation/decumulation mechanisms would be beneficial.\(^{149}\)

This second point is strongly linked to a third potentially fertile field of analysis, which relates to proximity dynamics. Recently, Balland et al. (2015) have proposed to follow up on Boschma (2005a), identifying in the processes of learning, integration, decoupling, institutionalization, and agglomeration, the ways in which cognitive, organizational, social, institutional, technological, and geographic proximity respectively can evolve over time. Beyond this initial classification and proposal for theoretical and empirical research, this literature needs a sound reflection on the ways non-geographic proximity can evolve over time, and to what extent this process can be actually governed.

A fourth possible field of analysis concerns the theoretical discussion and the empirical assessment of the shape of the functional form describing possible non-linearities in proximity effects. This point could represent a possible research avenue for anyone interested in these topics, in particular with the aim to identify possible threshold effects in the role played by non-geographic proximity in shaping knowledge diffusion processes.

A fifth point whose analysis may help shedding light into proximity economics is related to the endogeneity of proximity effects. Relational, social, cognitive, and technological proximity may be endogenous to the incentives and choices of individuals and firms (see also Ch. 2). If, at least partially, proximity endogeneity would be demonstrated, then the floor would be open for policymakers to provide incentives for individual actors (households and firms) towards actions and decisions that enhance, from an aggregate perspective, inter-regional proximities. A better understanding of this point would thus be conducive not only to a better scientific understanding of proximity economics, but also to the emergence of sounder and more conscious proximity policies.

Potentially, a further difficulty in dealing with proximity from a policymaking perspective may stem from an imperfect overlapping of the timing of proximity dynamics and proximity formation policies. Conceptually related to this first issue, the empirical analyses here discussed also suggest to at least potentially conceive of new approaches to policymaking, possibly incorporating in a structural way uncertainty about system and policy outcomes in the design of regional policies, in turn giving greater emphasis on adaptive learning (Walker et al., 2003).

\(^{149}\) A more subtle point to be tackled could be related to the currently imperfectly differentiated concepts of inter-regional technological and cognitive proximity. While the latter is based on similarities in cognitive maps and lays its foundations in the evolutionary economic geography tradition, the former is more based on an industrial approach to the analysis of knowledge diffusion processes. However, clearly these concepts share several commonalities, most importantly in terms of the practical preconditions leading two regions to cooperate and exchange knowledge. This once again promises a relevant future research avenue in the field of proximity economics.
Whether proximity dynamics can usefully match the political cycle, and whether policymakers can reasonably invest in an adaptive and evolutionary way in the accumulation of something whose return will accrue to later generations, remains an unanswered question, and promises to be an exciting new field for future research.