Mind the Gap: Advancing Evolutionary Approaches to Regional Development with Progressive Empirical Strategies

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ABSTRACT

Explaining the persistently uneven spatial patterns of development remains a central goal of economic geography and regional science. Recognizing that regional development is a process of ongoing change, many scholars now approach the topic from an evolutionary perspective that identifies knowledge recombination processes and institutions as key drivers of change. However, research has not yet fully integrated the various theoretical perspectives and empirical data streams that characterize evolutionary approaches. The present contribution identifies how an evolutionary approach centered on knowledge and institutions can be integrated with complementary forms of evidence gathered from a variety of sources to advance our understanding of regional development. Expanding and integrating the evidence base used to study regional change has important implications for making effective and responsive policy instruments.

Keywords: Economic Geography, Evolutionary Economic Geography, Research & Innovation, Data Structures, Regional Development

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1 | INTRODUCTION

Measuring, describing, and analyzing the persistently uneven spatial patterns of economic development and prosperity remains one of the central research goals in the fields of economic geography and regional science. However, identifying the interrelated, causal mechanisms of regional economic development is no small task because the individuals, firms, and institutions that shape the development of the space economy interact in intricate and context-specific ways that constantly change over time. Recognizing that regional development is a process where the economic landscape is in constant flux, many scholars have recently attempted to approach the topic by applying an evolutionary perspective (Nelson & Winter, 1982; Essletzbichler & Rigby, 2007; Kogler, 2016). Such an evolutionary approach recasts regional development as the continual transformation of the social and industrial structure of a region caused by the market-based selection of products, services ,and practices created when individuals recombine existing knowledge, capital, and labor under the influence of institutional constraints. Uneven spatial patterns of development are then the product of region-to-region differences in knowledge and institutions, and interactions that occur between these two factors during recombination and reconfiguration processes over time.

To determine how well, and in what contexts, the evolutionary approach, commonly referred to as Evolutionary Economic Geography (EEG), explains regional development, economic geographers, spatial economists, and regional scientists have pursued two related lines of inquiry. First, researchers have focused on building theoretical tools to explain how individuals, firms, and institutions interact and alter the development process at the regional scale (see Frenken & Boschma, 2009; Feldman & Kogler, 2010; Pike, MacKinnon, Cumbers, & Dawley, 2015). Guided by principles of Generalized Darwinism (Essletzbichler & Rigby, 2010) and several theoretical perspectives (e.g., orthodox, behavioral economics), this work identifies several explanations of development outcomes. Key concepts include notions of path-dependency, lock-in (Martin & Sunley, 2006), and various proximity perspectives (Boschma, 2005; Boschma & Frenken, 2010; Kogler, Essletzbichler, & Rigby, 2017). Second, EEG approaches have pursued an empirically driven strategy that aims to reconcile theoretical claims with observations of developmental processes (see Boschma & Frenken, 2011). The common approach adopted in empirical work is to identify a proposed evolutionary mechanism and analyze its impact in a specific regional context.

Despite significant theoretical and empirical advances in EEG research (Kogler, 2015), challenges remain attempting to explain regional development (Kogler, 2017). Within the theoretical stream, researchers frequently face the decision of how to coordinate and reconcile the importance that different perspectives place on alternative explanations within regional context. On the other hand, for empirically driven work, the internal validity of a study depends on matching the chosen research design to the selected theoretical framework, while then still facing the problem of carefully collecting and

analyzing appropriate data. While tailoring an empirical analysis to a regional context to raise internal validity is sensible, it may limit generalizability across regional settings.

Recognizing these concerns, scholars and practitioners are now pursuing deeper integration within and between each line of inquiry (Glückler & Doreian, 2016; Whittle & Kogler, 2019). On the theoretical side, scholars are addressing the challenge of coordinating explanations by developing research frameworks that identify and knit together the central insights of multiple theoretical perspectives (Storper, 2015; Huggins & Tompson, 2017). On the empirical side, scholars are addressing the need to coordinate data that allows for flexibility in analysis across regions by building customized information infrastructures designed to acquire, process, and link data on regional development from varied sources (Feldman & Lowe, 2017). The present challenge is to further integrate the efforts happening in each of these two streams around the critical dynamics of regional growth and change (Storper, 2017).

The objective of this paper is to provide an overview and examples of how the evolutionary perspective can be advanced by further coupling theoretical foundations with empirical evidence derived from the coordination of multiple datasets. As such, the specific aim is to highlight how the integration of socio-economic indicators at the regional-, firm-, and individual-level can be linked together, and with theory, to enhance the EEG framework. It is expected that the suggested approach will indeed provide EEG scholars with an ample opportunity to further test and push the theoretical frontier via more comprehensive and detailed measures on the central actors and mechanisms that are considered most important in shaping regional development pathways. In addition, because most of the highlighted data sources are available across a multitude of regional and metropolitan settings, this approach offers an opportunity for cross-spatial assessment of the factors that contribute to the evolution of the space economy. Finally, while the present focus mainly falls within the realm of regional economic development analysis, the suggested approach might also prove highly relevant for associated fields that tend to incorporate spatial considerations in their analysis, i.e. management, organizational and innovation studies, among others.

In the following section, we discuss two mechanisms identified as central to the development process - the endogenous accumulation of knowledge capital and the influence of institutions. After outlining the theoretical foundations of each mechanism, Huggin's (2016) growth systems framework is used to illustrate how the mechanisms interact within firms, between firms, and within regions. We then demonstrate how different forms of empirical data, which serve as proxy measures of knowledge capital and institutions, can be mapped onto to the growth systems framework and subsequently coordinated to address questions about the development process. Central to this approach is a focus on knowledge and the capability of actors in a region to recombine existing knowledge or generate new knowledge that can be used to reorganize production in ways that continuously create value to society.

2 | REGIONAL DEVELOPMENT, INSTITUTIONS, AND ENDOGENOUS CAPITAL ACCUMULATION

Evolutionary approaches to regional development identify knowledge and institutions as central determinants of change in the regional economic landscape (Boschma & Martin, 2010; Cortinovis, Xiao, Boschma, & van Oort, 2017). As individuals working within the institutional constraints of firms, and regions use their knowledge to recombine and reconfigure capital and labor, they develop new products and methods of production that must then compete in the marketplace. Traditionally, regional development is defined as occuring when that recombination process creates forms of production that increase the output of a region. To follow the evolutionary approach and to maintain focus on the recombination process (Schumpeter, 1934; 1942) (i.e., the individuals that drive it and the accumulated knowledge and institutions that constrain it), we adopt a related process focused definition. Building on Feldman and Storper (2018), we define regional development as the development within a region of knowledge and institutions that increase the ability of economic actors in that region to generate recombinations of capital and labor that create value to society. Because knowledge and institutions are central to this definition of regional development and evolutionary explanations of regional change, we first review their theoretical foundations before moving to integrate them with empirics.

2.1 | Endogenous capital accumulation

The emphasis on knowledge as a central determinant of regional development is rooted in endogenous growth models that establish scale economies and intentional investments in human and research capital as the principal determinants of long-run growth (Stimson, Stough, & Nijkamp, 2011; Huggins & Thompson 2014). Endogenous growth models set out the internal mechanisms of economic growth. In these models, knowledge—the cumulative stock of available information—is unlike other inputs of production. Knowledge is at least partially non-rival, non-excludable, and cumulative, which makes it potentially subject to increasing returns (Arrow, 1962). By using knowledge to create technical changes that improve the productivity of other inputs of production that are not subject to increasing returns, the economy can continue to grow (Romer 1986; 1990; Lucas 1988). Because of the unique properties of knowledge, investments in human capital have the potential to also create spillover effects that reduce the diminishing return of capital accumulation and foster further growth. The Geography of Innovation literature (Feldman & Kogler, 2010; Cooke et al., 2011) highlights that these processes are rooted in space, and that they evolve along regional trajectories of specialization and competence building.

Within endogenous growth models, regional differences in economic growth are the result of differences in policy and regional investments in knowledge. Investment in knowledge production can increase the stock of regional knowledge, but geographic variation in investment levels can also create differences in regional knowledge stocks that result in spatially varying potentials for knowledge recombination and growth (Stimson, Stough, & Nijkamp, 2011, 2011; Neffke, Henning, & Boschma, 2011). To the extent that the non-excludable and non-rivalrous nature of knowledge is geographically

bounded, regions investing in knowledge production may also benefit from short-run monopoly rents deriving from innovation activities (Storper, 2015; 2017). However, as the new knowledge produced in a particular region is recombined with other existing forms of expertise and progressively incorporated into production, that knowledge tends to become codified. This codification in turn facilitates the diffusion of what had previously been geographically constrained capabilities across regions (Johnson, Lorenz, & Lundvall, 2002; Gertler, 2003; Asheim, Grillitsch, & Trippl, 2017).

Krugman (1991, 2005) further develops the geographic implications of scale economies and knowledge by examining the location choices of mobile firms and labor facing nonzero transportation costs and monopolistic competition. By concentrating production in a small number of locations, firms can better capitalize on the increasing returns of knowledge production. When scale economies are also external, an additional incentive exists to concentrate production in successful locations. As workers and firms follow one another into regions with large home markets, or specialized forms of knowledge unavailable in other locations, the growth effects of economic activity become circular and cumulative. Duranton and Puga (2004) identify at least three sources of spatial concentration related to knowledge and scale economies: (i) sharing, the regional trading of intermediate goods; (ii) matching, the rapid pairing of labor and firms during economic transformation, and (iii) learning, the spillover of knowledge within regions; something that echoes earlier arguments made by Marshall (1920). Counteracting the drive toward agglomeration and regional differentiation through sharing, matching, and learning are regional market adjustments in the form of rising land rents and the immobility of some factors of production, among others (Storper 2013; Storper, Kemeny, Makerem, & Osman, 2015).

While endogenous growth models lay out internal mechanisms of economic growth, they fail to identify the initial impetus of development or the regional characteristics that differentiate the success of regions in exploiting knowledge and creating growth. Therefore, although these models incorporate the insights of Schumpeter (1942), Marhsall (1920), and Jacobs (1969) concerning variety, search, competitive selection, and path dependence, they say less about how those processes interact to shape regional development. In reality, the determinants of growth identified by endogenous capital accumulation models are shaped by the political, social, and economic institutions that are not the same in all locations. It is here where Economic Geography broadly, and specific sub-fields, like EEG (Boschma & Frenken, 2006, Martin & Sunley, 2006) as well as the Geography of Innovation approach (Feldman, 1994; Feldman & Kogler, 2010) have made significant contributions to further our understanding of drivers of change and spatial differentiation.

2.2 | Institutions

Institutions, which are the formal and informal rules that people create to structure incentives in their societies, enable or constrain economic growth by (i) influencing the decision-making of economic actors (North, 1990; 2005), or (ii) altering the structure of market transactions (Martin 2000; 2010). The prevailing view is that local differences in these ‘rules of the game’ shape the regional economic growth

process (Acemoglu, Johnson, & Robinson, 2005; MacKinnon, Cumbers, Pike, Birch, & McMaster, 2009; Rafiqui, 2009; Gertler, 2010; Farole, Rodriguez-Pose, & Storper, 2011). Institutions that enable growth often do so by facilitating forms of capital accumulation that lead to knowledge development. However, the overall impact of institutions and public entities depends on region-to-region variations and trajectories in local knowledge characteristics and availability, the historic institutional fabric in a multi-level context, as well as a variety of other place-specific characteristics (Arthur, 1989; Essletzbichler & Rigby, 2007, Feldman & Kogler, 2008; Boschma & Frenken, 2009).

Growth enabling institutions exist at several organizational and spatial and temporal scales. Martin (2000; 2010) usefully separates the impact of institutions operating in the short-run, which affect decision-making, from those operating in the long-run, which affect market structure. Martin argues that within a broader institutional environment that is largely fixed in the short-run, economic actors can create new configurations that can pressure institutions in the broader environment into change. Localized differences in the development or operation of institutions can then create regionally different institutional environments. Regions with institutional environments that enable economic growth are more likely to accumulate the human and research capital necessary for future growth (Rodriguez-Pose, 2013; Huggins 2017). Institutional approaches therefore also stress the evolutionary, circular, cumulative, and geographically differentiated nature of the development process. Institutions may limit growth when exogenous change creates new economic opportunities or shifts in the broader market structure (Huggins and Izushi, 2007). Institutions may also enable growth by facilitating local development of new industries closely related to those already operating in a region (Nelson, 1994; Frenken, van Oort, & Verbung, 2007, Boschma, 2015).

The key feature of this institutional framework is that it allows changes in the trajectory of regional development to emerge not only from exogenous shocks but also from the micro-level actions of economic actors. Building on the work of sociologist and political scientists (Schickler, 2001; Boas, 2007), Martin (2010) outlines three mechanisms of endogenous, micro-level institutional change. Institutions may change through a layering process, wherein new rules are added to existing structures; through a conversion process, where existing rules are reoriented to new purposes; or, as outlined above, through the recombination of existing rules and structures. Each of these three mechanisms is predicated on a different pattern of change, which should be identifiable in empirical data. For example, layering should be characterized by new streams of data emerging, where recombination might be characterized by new connections emerging among already existing data. However, researchers are only now beginning to use data in this way (see the Appendix for a specific example of a potential database architecture in this regard). A related and unsettled question is what specific kind of new knowledge or technological capabilities enable each of these processes of institutional coevolution, and who are the creative agents that are able to shape these processes?

3 | INTEGRATING EMPIRICAL DATA TO CONNECT WITH THEORY

In practice, regional economic growth requires the investments in human capital and knowledge identified by endogenous growth theory and the enabling rules and incentives emphasized by institutional approaches. Combining elements of both the institutional approach and the endogenous capital accumulation approach, Huggins (2016) introduces a growth systems framework that links different institutions with different forms of capital accumulation at three levels of economic activity – within firms, between firms, and within regions. At each level of the approach, different institutions influence the accumulation and recombination of economic valuable knowledge. Within firms, institutions in the form of organizational structures and practices shape the incentive and ability of firms to use knowledge and human capital. Between firms, imperfect information and imperfect contracts motivate firms to form business networks that facilitate access to knowledge and associated knowledge spillovers. In sectors at the leading edge of the economy, the rarity of selected knowledge inputs, their accumulation in certain locations, and access to those assets through localized networks motivates regional clustering (Henderson, 1997; Hausmann & Klinger, 2007; Hidalgo, Klinger, Barabasi, & Hausmann, 2007; Balland & Rigby, 2017). At the regional-level, political economies and governance structures enable or constrain capital ownership and the recombination of capital toward productive ends. Operating in combination the actions of individuals and firms alter future economic development pathways by changing the distribution of knowledge capital and the function of institutions (Huggins, 2016).

While the growth systems framework connects endogenous capital accumulation to institutional constraints, it provides less guidance on how to link the micro-level foundations of each approach, or how to trace those foundations with empirical data. Using empirical data to link the sharing, matching, and learning mechanisms of regional capital accumulation to the layering, conversion, and recombination mechanisms of institutional change has the potential to provide insight into the endogenous emergence of new regional trajectories over time. For example, identifying new rules (layering) that emerge between-firms as they trade newly developed intermediate goods (sharing) would help explain the coevolution of new development paths. Similarly, researcher could use within-firm data to track how companies reorient existing structures (conversion) as they continually seek to incorporate new knowledge (learning). Returning to our capability-based definition of regional development, examining the coevolution these micro-level processes will help us to understand how regional factors endogenously influence the ability of economic actors to create societal value over time.

Building on the growth systems approach and its underlying theoretical frameworks presented above, we demonstrate how a variety of datasets (Table 1) that measure activity at the within-firm, between-firm, and within-region levels, and that are frequently available as longitudinal time series, can be integrated to examine the role that institutionally influenced knowledge accumulation plays in the

development of regional capacities that expand the capabilities of local economic actors. Our approach links heterogeneous individuals, firms, and regions using a nested structure in which individuals are linked to firms, and firms are linked to regions (Figure 1)[i]. At each level, panel data sources measuring knowledge, individual, firm, and regional characteristics are positioned along the left side of the figure, while institutional measures are along the right.

Table 1. Empirical data sources

Dataset	Data Source	Measure	Key Variables	Level
Scientific Knowledge	WoS, Scopus	Scientific knowledge	Author, institution, research area	Within Firms
Technical Knowledge	PATSTAT, USPTO	Technical knowledge	Inventor, assignee, technology	Within Firms
Commercial Knowledge	Trademark Data	Commercial knowledge	Assignee, sector	Within Firms
Firm Institutions	Interviews	Rule inside the firm, internal conventions, organizational practices	Internal process and policy indicators	Within Firms
Firm Characteristics	Orbis	Firm indicators	Revenue, profit, R&D spending	Between Firms
Firm Collaboration	Dunn & Bradstreet	Joint ventures, collaborative agreements	M&A, joint ventures, alliances	Between Firms
Network Rules	Industry & Trade Reports	Industry & sector specific regulations	ISO9000, anti-trust laws	Between Firms
Regional Indicators	EUROSTAT	Socio-economic indicators	Employment, occupational data	Within Regions
Regional Policies	Legislative Archives, Public Record	Institutional indicators	Quality of government, regional laws & regulation	Within Regions

3.1 | Within firms

Within firms, individuals create and recombine scientific, technical, and commercial knowledge to create products and processes of economic value. How individuals accumulate and recombine knowledge within a firm is constrained and enabled by the practices, guidelines, and rules of their organizations. To assess these processes, the usual route is to utilize scientific journal publications retrieved from services such as the Web of Science as a proxy measure of an individual's scientific knowledge, and patent data retrieved from PATSTAT or PATENTSVIEW[ii], among other sources, as a proxy measure of an individual's technical knowledge. In the case of PATSTAT, this panel dataset provides a continuous measure of recombinant knowledge production over a nearly 40-year period (for a specific example see Kogler, Essletzbichler, & Rigby, 2017). Employing the classification

system of Waltman and Van Eck (2012), the scientific knowledge of individuals may be classified into granular subfields based on citation frequency between publications. The knowledge contained in patents can likewise be distinguished into categories following the harmonized Cooperative Patent Classification (CPC) scheme jointly developed by the United States Patent and Trademark Office (USPTO) and the European Patent Office (EPO). In turn, this classification system for technology classes can be translated into Standard International Trade Classification (SITC) and International Standard Industrial Classification (ISIC) categories following he concordance tables provided by Lybbert and Zolas (2014).

Building on recent efforts to disambiguate the names and locational information of authors, inventors, and assignees in the EPO PATSTAT and the Web of Science databases (Fleming & Sorenson, 2001; Morrison, Riccaboni, & Pammolli, 2015; Pezzoni, Lissoni, & Tarasconi, 2014) it is possible to link scientific and technological knowledge through individuals. This connection creates an opportunity to move the analysis beyond traditional examinations of scientific citations listed on patents (Meyer, 2000), to the direct examination of the prior knowledge inventors have available for recombinant knowledge production at the time of invention. Capitalizing on co-authorship and co-inventor data, network measures and visualizations provide the opportunity to put the accumulation and recombination of knowledge in a collaborative context. Using assignee and institution information from both datasets, individuals can similarly be placed in the context of the firms and organizations with which they work. Building on such efforts, it would then be possible to use targeted surveys and interviews to differentiate institutional layering, conversion, and recombination processes that lead or lag knowledge accumulation and recombination activities within firms. Examining different forms of institutional change through time may be particularly interesting when studying the commercialization of inventions catalogued in trademarks that are assigned to firms (Nam & Barnett, 2011), because this approach allows us to capture knowledge production beyond just scientific and technical advances. One of the main criticisms of patent data is that they only capture a specific segment of overall economic activity; for example, ignoring advances made in the service sectors that usually do not engage in patenting as much as manufacturing sectors. One needs to be aware that although the data sources highlighted (Table 1), and especially their simultaneous use (Figure 1), have the potential to significantly advance scientific inquiry, a certain element of uncertainty concerning unobservable characteristics, like the tacit knowledge embedded in individuals (Gertler, 2003), will remain.

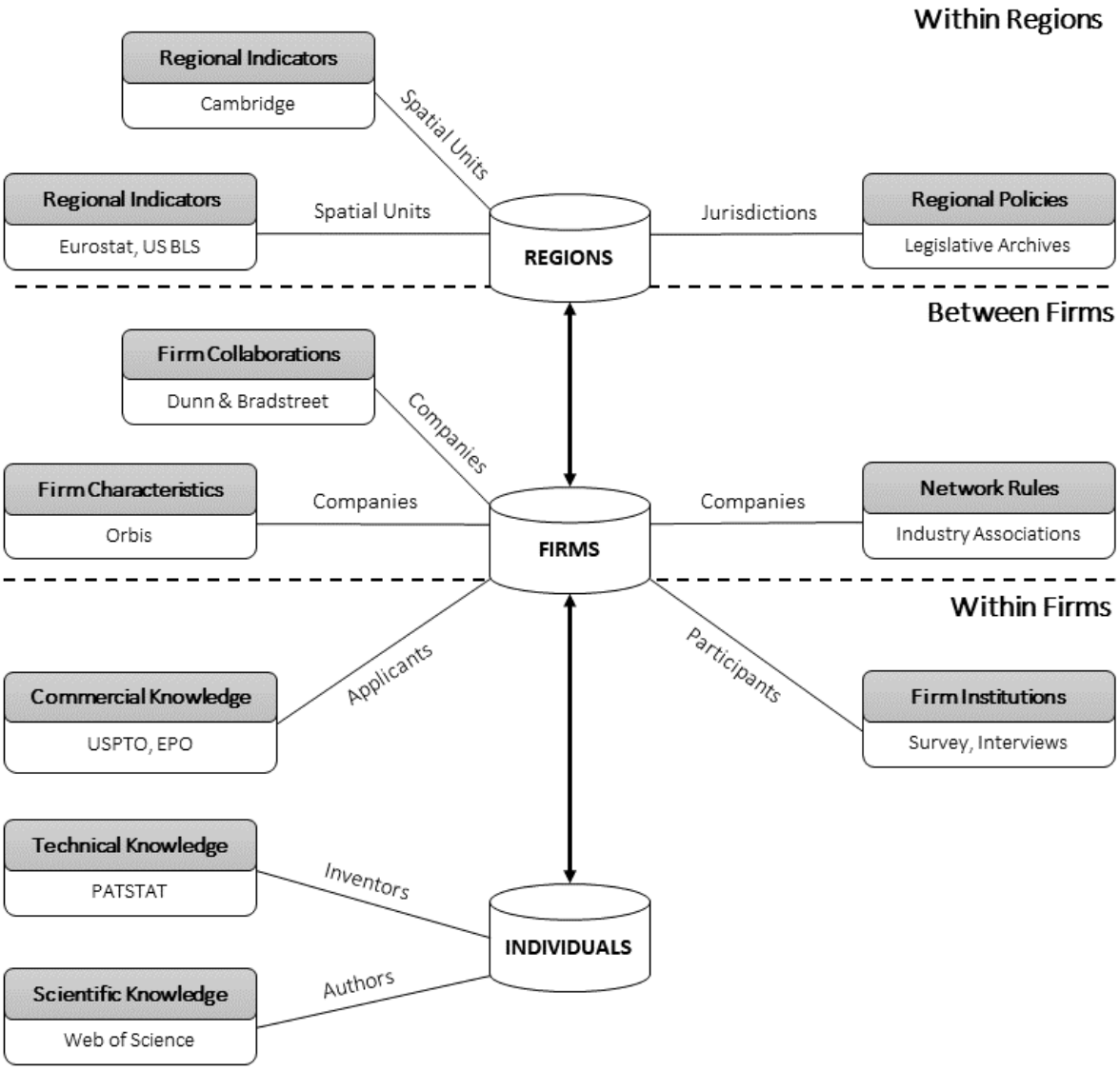

Figure 1. Linking Complex Datasets for Socio-Economic Spatial Data Analytics

3.2 | Between firms

Between firms research often focuses on networks of inter-firm exchange, in which the flow of knowledge is shaped by contractual obligations and industrial practices. Studying these processes, researchers can draw data on the characteristics (e.g., financial accounts, corporate structure) of firms from the Orbis database maintained by Bureau Van Dijk (2019). The formal network of connections between firms can be traced using data from the Dunn and Bradstreet database to construct a network of formal corporate collaborations (e.g. joint ventures, acquisitions) worldwide. Capitalizing on the connection to individual data presented earlier linkages between firms can be identified by tracing the

the collaboration networks of inventors and authors. To measure the codified rules that structure the function of networks and the exchange of knowledge within them, it is possible to examine corporate agreements and related industry standards. While industry standard data are available, information on corporate agreements can be more difficult to access. Where available, these data allow us at least a partial view into the interactions of firms through the markets and networks they create within regions. Studying these networks within regions has traditionally been a route to understanding the sharing and matching mechanisms that shape the accumulation process (Dosi, 1982; Fritsch & Kauffeld-Monz, 2010). Extending that form of analysis across time by examining how industry standards or corporate governance change would again give deeper insight into the institutional processes outlined by Martin (2010). Inter-firm networks, and especially specific details regarding collaboration and knowledge exchange processes, are difficult to measure due to the lack of publicly available data. While this is a significant hindrance in terms of the suggested framework, there are also a number of underutilized opportunities. However, some of the listed sources can indirectly capture some of this information. For example, while most patents listed in PATSAT are developed by a single assignees, (i.e. firm, university, public research institutes), some patents are also developed in collaboration, which is recorded as multiple assignees (Shu-Hao, 2017; Agostini and Caviggioli, 2015).

3.3 | Within regions

To understand whether the capability of individual economic actors is being enhanced by emerging regional capacities and institutional changes, research must also link firms and individuals to data that measures their regional context. Information about regional policies and institutional histories provides one context to between- and within-firm processes. Legislative and administrative records of government agencies contain specific information about legal and monetary inducements and constraints on knowledge accumulation. Huggins (2016) suggests that these institutions are particularly influential in defining the ownership structure of firms and related flows of knowledge capital between them. To place these processes in the context of aggregate measures of development, researchers can draw on measures like regional total factor productivity or GDP from Eurostat, the US Bureau of Labor Statistics, and the European Regional Dataset (ERD) from Cambridge Econometrics. In addition to linking firms to regions, researchers can directly tie individuals to regions using location information contained in patents and publication data as a means of placing knowledge in space (Almeida, 1996; Jaffe, Trajtenberg, & Henderson, 1993). Simultaneously linking individuals to firms and regions creates an opportunity to study nested or hierarchical relationships that may help clarify the mechanisms of regional capital accumulation and institutional change. For example, a researcher could examine how institutional layering taking place within firms and within a region affects the knowledge recombination of individuals. Using survival analysis, a researcher could invert this analysis and examine how knowledge recombination, measured through patenting of individuals within-firm, impacts the length of time it takes for firm-level institutions to adopt or exit specific capabilities (Kogler,

Rigby, & Tucker, 2013; Feldman, Kogler, & Rigby, 2015), and how region specific knowledge spaces and maps of technological inventiveness change in an evolutionary fashion over time (Kogler, Essletzbichler, & Rigby, 2017; Kogler, Heimeriks, & Leydesdorff, 2018).

4 | OPPORTUNITIES AND CHALLENGES

By integrating data available within firms, between firms, and within regions we create opportunities to empirically examine how sharing, matching, and learning processes operate in regional economies under the enabling and constraining influence of institutions that together shape the capability of local economic actors over time. A more careful accounting of the knowledge recombination activities, network membership, and institutional context in a region will allow us to examine the sequential and intertwined development of regional capacities and individual capabilities. This form of detailed retrospective analysis will allow us to not only understand how regional clusters function and evolve, but why they form in particular locations at particular times. The analysis of the spatial diffusion and adoption of rDNA methods conducted by Feldman, Kogler, & Rigby (2015) that traces the origins and growth of the modern biotechnology industry across US metro areas over time provides one example of how this approach can be operationalized; essentially providing an example of how advanced empirics can inform and progress current theoretical debates in this line of inquiry. Furthermore, the Appendix that accompanies this paper offers an example of a specific research project that employs a database structure to the analysis of regional economic development trajectories in line with what has been discussed so far, and with the objective to couple advanced empirical evidence with theoretical debates and progress. The benefits of spatially localized sharing, matching, and learning appear to increase with uncertainty about the trajectory of technological development. Uncertainty about the direction of technological change makes it difficult to identify and codify the combinations of knowledge critical to production, while also hindering the development of internal economies of scale as firms continually reorganize production during a process of trial and error. Empirically tracking the progression of knowledge recombination over time in regions as technologies and markets standardize will provide insight into what initiates sharing, matching, and learning processes that collectively lower the cost of knowledge coordination and reorganization.

As outlined, employing multi-scalar datasets can also shed light on how the different economic actors (within the firm- between the firms and within the regions), individually or collectively, can change institutions; and analyse co-evolution of technologies, industries and institutions at various spatial scale. However, despite improvements in the spatial, temporal, and attribute resolution of regional data, a number of challenges continue to hinder progress. Although extensive, the datasets integrated here still present a partial view of any regional economic system. For example, using patent and Web of Science data as measures of knowledge captures an important subset, but they are a necessarily incomplete portion of the regional knowledge pool. These types of data limitations are

compounded by difficulties in valuing knowledge. Trademark data is particularly noisy in this regard. The low cost of obtaining a trademark creates little barrier to entry for firms, which leads to a proliferation of trademarks that have little economic value. Moreover, understanding institutional context appears critical to understanding the conversion process that translates knowledge recombinations to products and processes of economic value. However, data on institutions within firms, between firms, and even within regions is the most difficult to obtain. While some systematic sources exist, institutional arrangements are typically highly localized between- or within-firms and obscured by proprietary agreements. Indeed, this localization is likely responsible for much of the heterogeneity observed in the activities of individuals and firms. While incapable of addressing all these challenges, the integrated framework presented here does provide a conceptual and empirical scaffolding, which can be used to develop further theoretical concepts and data sources in relation those already in use.

4 | CONCLUSION

Increasing recognition among academics and policy makers that regions are a critical site of economic development has created a proliferation in the number conceptual tools and empirical datasets available to individuals interested in identifying the causal mechanisms of growth. However, these conceptual and empirical developments can be further coordinated to accelerate progress toward an understanding of the evolution of the spatial distribution of heterogeneous methods of production. While we have some understanding of how regional economies benefit from the colocation of individuals and firms, we know less about the sequencing of knowledge recombination, colocation, and the institutional factors that shape this process. Overcoming this hurdle requires that researchers move backward and forward between theory and empirics with a constant eye on understanding causality and change in regional economic systems. Pursuing these ends begins by coupling existing datasets with existing theories within frameworks that recognize the uneven and multi-scalar nature of the development process.

In this paper, we provide one example of how empirical data may be linked to a framework that encapsulates conceptual insights from several academic fields, but highlights important linkages between institutions and knowledge accumulation within firms, between firms, and within regions. We then discuss how the linkages outlined in our example may be used to examine open questions about the development of regions. Following theoretical advances in economic geography and regional science, we take an evolutionary perspective centered on mechanisms of regional capital accumulation and institutional change that shape the recombination of knowledge by heterogeneous actors.

Expanding our empirically-based understanding of the mechanisms of knowledge formation, technological change, and regional growth will contribute directly to our ability to develop relevant and effective policy. Deepening our understanding of existing regional knowledge spaces would allow policy makers to tailor existing policies such as “Smart Specialization Strategies” to local contexts.

Innovation and economic policy relevancy and effectiveness begin with identification of areas of specific regional expertise. To produce economic returns, policies should reshape regional incentives for knowledge production and innovation in ways that direct effort toward the generation of regionally coherent innovations at or near technological frontiers. Broadening our understanding of how those regional knowledge spaces interact and compete within wider industry and inter-regional networks over time is essential for ensuring that regionally focused policies do not lose sight of their competitive context and the structural forces that shape economic change.

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[i] In practice many alternative dataset linkages are possible. For example, individuals may be directly linked to regions without connection to their firm context. There are also a wide variety of additional datasets available that are relevant to the regional development process. Feldman et al. (2012) provide a useful list of such data sources in the US context. We omit these sources and connections for clarity, not to suggest their lack of importance.

[ii] Both, the PATSTAT and PATENTSVIEW databases cover information on patent applications and grant documents for the past several decades, are regionalized by inventor addresses, and offer harmonized applicant names, all of which is suitable for a variety of socio-economic analyses at various spatial scales.