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## Abstract

This chapter provides an overview of current theories and empirical research on cities and the knowledge economy. Two recent and interrelated streams of literature are discussed: the first focusing on agglomeration economies related to increasing returns and knowledge spillovers of firms in cities and the second highlighting the role of knowledge workers and creativity in identifying new and innovative growth opportunities in cities. We argue that analyses using knowledge production functions to capture knowledge flows in cities do not, as of yet, provide true insight into the generation and transfer of different kinds of knowledge. Only recently are various conceptualizations of distance and knowledge transmission channels able to address the heterogeneity of the actors and processes involved in capturing the respective role of cities in knowledge creation. We conclude that the mechanisms that create and diffuse knowledge in cities should be better embedded into both streams of literature. The current discourse on agglomeration externalities obviously needs such conceptual and

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methodological views to address current impasses. In particular, evolutionary economic geographical concepts are promising in explaining the innovative behavior of growing firms and organizations in cities, carefully addressing the heterogeneity of the actors involved, spatial scale, selection and survival, as well as time and path dependency.

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## 25.1 Introduction

In the 1980s, many people were convinced that cities as centers for social and economic dynamism were disappearing. Wealthier people wanted to live outside the cities, in larger villages, or in suburban areas. The widespread use of the car and the rise of information and communication technologies (ICT's), as well as the concentration of the socially and economically disadvantaged, made many observers think that we would see a complete transformation of communication, spatial configurations, and social and economic structures. The end of distance and spatial concentration seemed near (Gaspar and Glaeser 1998). The current view is completely different; today, views on urban development hold that distance still matters and that urban concentration still continues (Glaeser 2011). At first glance, it seems easy to understand why cities are increasingly the preferred mode of human settlement. They save on infrastructure, reduce trade costs, and enhance interaction. In developing countries, there's nothing particularly new about urbanization as an expression of development. At second glance, however, cities are associated with many costs – land, pollution, and other externalities. We once believed that suburbanization combined the primary advantages of urbanization with these lower land costs and other externalities, but density has returned to many parts of the world.

Examining the arguments behind this modern urbanization view, we find two major approaches. The first is based on the theory of agglomeration economies with increasing returns and easy access to knowledge (Jacobs 1984; Krugman 1995), and the second is based on the idea that (larger) cities are strong because they claim to be the physical concentration of skilled knowledge workers and the creative class (Glaeser 1999; Florida 2002). Both approaches lead to the hypothesis of an expected higher labor productivity. This raise of productivity seems to be the case, although the explanation can differ. In Europe, the largest urban areas, in particular the London-Randstad-Paris-Frankfurt-Milan axis, contribute much more to their national GDPs than could be expected judging by their population sizes (Ciccone 2002). The same conclusion was reached by Glaeser (2011) for the USA.

The question that can be raised is whether knowledge is a decisive factor in explaining (a) higher productivity and (b) the stronger attraction of knowledge workers, or more general, of the creative class. In urban economics, knowledge receives increasing attention as a source of growth. Apart from knowledge, urban growth is explained by many other variables, and by the concentration of creative people, with the expected concomitant development of new knowledge and innovations (Combes et al. 2008). Urban economics focus on properties associated with

agglomeration advantages, external economies of scale, increasing returns, and the development of a variety of producers and consumers. Knowledge, its generation, and its use in innovations are perceived as the principal variables. However, the concept of knowledge in itself is not entirely clear, and neither are the mechanisms of its impact on productivity. It can be seen as a separate production factor or as an attribute, in one way or another, linked to capital goods and labor. Most economic studies emphasize the second interpretation. In endogenous economic growth theory, knowledge is seen as an output of investment in research and development (R&D). This kind of investment can be defined more broadly, as knowledge-intensive inputs, such as in new capital goods and new labor, to increase R&D. To make things more difficult, in the aforementioned case, knowledge can be both an input and an output.

In this chapter, a (non-exhaustive) survey of theories and empirical applications on research focused on cities, knowledge, and innovation is provided. We structure the theories using two recent and interrelated streams of literature: the first focusing on agglomeration economies related to increasing returns and knowledge spillovers of firms in cities and the second highlighting the role of knowledge workers and creativity in identifying new and innovative growth opportunities in cities. [Section 25.2](#) provides an overview of historical and current conceptualizations of knowledge and knowledge diffusion. [Section 25.3](#) provides a discussion on knowledge production function methodologies applied to cities, and concludes, consistent with [Sect. 25.2](#), that future research should increasingly and explicitly focus on the transfer mechanisms of knowledge diffusion. [Section 25.4](#) focuses on the related literature of agglomeration externalities and its link to innovation and urban economic growth. [Section 25.5](#) confronts the central plea for a better embedding of knowledge transfer mechanisms in agglomerations with current agglomeration discourse and methodologies. Conclusions on new and necessary conceptual and methodological views are presented in [Sect. 25.6](#).

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## 25.2 Knowledge Creation and Diffusion

A useful distinction is the one in “data” (facts or unstructured information), “information” (structured data and standardized knowledge) that can be easily transferred via markets, “practical knowledge” (dispersed over economic actors and belongs to particular individuals) that can be used in commercial activities or applied directly in production processes, and “scientific knowledge” that can be applied after further research and development. Knowledge is acquired through the interactive process of learning, based on the cognitive competencies and experiences of the actors. A distinction can be made between “tacit” and “codified” knowledge. Tacit knowledge can be defined as the person-specific knowledge that people have developed through a process of learning-by-doing or learning-by-using, meaning that a person is able to use it but is not, or is not yet, able to codify it in a transferable form, such as a book, patent, or a mathematical formula.

It has to be emphasized that these kinds of knowledge are not fixed. Nonaka and Takeuchi (1995) have emphasized that tacit knowledge and codified knowledge have to be perceived as dynamic attributes that can be transformed into one other. After a period of application, tacit knowledge can be codified and, vice versa; sometimes, codified knowledge can be developed further and can become tied to individuals. The ways in which learning and the transfer of knowledge across organizations and in spatial settings can be investigated and measured have triggered much debate and research.

Codified knowledge (like patents and books) can be transferred to other users and is most often sold in markets. Tacit knowledge is person and context specific; hence, it has to be transferred or sold connected to a person, as with labor mobility. In some instances, knowledge is transferred for free, as in certain teaching situations or in networks, based on friendship. Tacit knowledge can develop into codified knowledge. This happens when, through research, certain skills, feelings, or capabilities are formalized or defined by rules, as has been performed with chess programs and in medical research. The reverse also occurs when codified knowledge becomes “embedded” in behavior and becomes tacit through its implementation in new situations, through experience, or by sharing within a group. Recent questions on the subject involve the possibilities of transferring tacit knowledge not only via interpersonal contacts but also via modern tools such as TV, the Internet, and mobile phones. Another question is whether the use of knowledge for economic goals and its transfer are related exclusively to production and consumption. Additionally, the question arises regarding whether wider opportunities to increase welfare emerge, for instance, in the arts, or whether measures to increase the sustainability of cities are implemented (Glaeser 2011). Finally, the link between knowledge, skills, and creativity is important. The use of knowledge and, in a broader sense, creativity is not always directly related to economic goals of production and consumption. Creativity can be used for solving personal or family problems, or expressed in the arts. However, this also can lead to higher satisfaction or even to the rise of certain forms of consumption, through which the production of goods and services can increase. There are also many indirect links between creativity, knowledge development, and economic growth.

In endogenous growth theory, the generation of new knowledge and innovations is explained by increased investment in R&D. This concept was also described in Schumpeter’s 1942 book, in which he saw the entrepreneurial function of management replacing the risk-taking and innovative individual hero-entrepreneur. In this view, it is possible to create a knowledge production function (KPF), with investments in R&D as input and knowledge and patents as an output. Recent applications at the regional and urban level show that this line of thinking is fruitful for explaining urban growth differentials (Acs 2002; Breschi and Lissoni 2009). However, in this KPF approach, the important other causality, the line starting from the demand side, is often neglected. The failure to meet the preferences and needs of users has been consistently stressed as a major cause of unsuccessful R&D for over 30 years. This is especially important in urban agglomerations, as is emphasized in studies on consumer cities. In modern urban agglomerations,

consumers are increasingly seen as a source of changing demand and new ideas (Glaeser et al. 2001). However, it is not yet clear how the lines of knowledge generation and application can be connected to producers and consumers in urban contexts. It is particularly necessary to investigate the relative importance of markets (prices) and formal and informal networks as carriers of knowledge. Krugman (2009, p. 567) also emphasized the unclear role of spillovers: “it’s not at all clear how to think about the spatial limits of spillover. Do you have to be in the same city to reap positive externalities from other producers in the same industry?” However, for cities with a wide variety of different kinds of economic activities and international relations, this question becomes even more important. The analysis incorporating production functions does not provide us with insight of the generation and transfer of different kinds of knowledge (yet). The investigation of knowledge in cities, as well as other kinds of knowledge, such as scientific knowledge, practical knowledge, and Polanyi’s tacit knowledge, is in need of receiving greater attention. The generation and diffusion of these heterogeneous kinds of knowledge can vary and need to be considered as having different effects on urban economic variables. In turn, urban contexts can be perceived as having effects on the generation and diffusion of the various kinds of knowledge. Cities can cumulatively specialize in certain kinds of knowledge connected to different economic specializations (Duranton and Puga 2005).

It is generally accepted that geographical contexts, such as agglomerations, influence the generation and dissemination of knowledge, although other mechanisms besides markets are not always included in explanations of urban development. In urban economics, the role of geographical distance as such is reflected in transport costs (both in the old and in the new economic geography), in the impact on social relations, and in the availability of knowledge embedded in labor, as in the popular view on the development of industrial clusters. In theories of urban hierarchy, distance costs are seen as a decisive factor explaining the differences of the quality of services and amenities in centers of different size. Distance is generally translated in terms of costs or in missed opportunities, stemming from the failure to note chances to produce, sell, or purchase goods or services.

Boschma (2005) emphasized that the word “distance” can be interpreted in different ways. Geographical distance is not the only important factor; social and cultural distance can also be important. This distinction is especially relevant in analyzing the geographical sources of knowledge and innovation because in a globalizing world many researchers have connections with people in other places. Nevertheless, it seems that distance costs and perception barriers are important factors in the analysis of agglomeration advantages because closer distance, no matter how it is measured, seems to foster the development of knowledge and innovations (Breschi and Lissoni 2009). One of the strong attributes of closer distances is the easier transfer of knowledge. This is related to the uncertainties that are inherent to the economic process and to the rapid changes that knowledge development has shown in our time. Such changes in knowledge cause the need for continuous adaptations by economic actors and hence the tendencies to locate

generators of knowledge locally, such as in universities and other R&D organizations (Audretsch and Feldman 1996).

The dynamic properties of knowledge are associated with various forms of dissemination and with their applications as innovations, with concomitant changes in supply and demand conditions. Through this process, continuously disturbing effects on equilibrium exist. Markets have to respond quickly to rapidly changing contexts. Metcalfe (1998) even argued that capitalism is restless because knowledge is restless. Innovations can also change market structures by creating new monopolies, as in the case of radical new technologies, especially GPTs (general purpose technologies).

The consequences of the application of knowledge for innovations are important. However, it is also important to examine the sources of knowledge (or its generation), where the cognitive attributes of economic actors and the organizational capacities of entrepreneurs are decisive properties of a knowledge-enhancing urban society. Economic actors vary considerably in their cognitive capacities and other attributes. This heterogeneity is one of the strengths of cities and an important reason for their continuous creativity. Situations involving heterogeneous actors and conditions lead to continuous uncertainties, which offer “gaps in information” for the existent markets, and this, in turn, can give entrepreneurs opportunities for innovative actions. This is particularly the case when new knowledge leads to pecuniary external effects (Metcalfe 1998).

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### **25.3 Mechanisms of Knowledge Production and Diffusion in Cities**

Knowledge and innovation are closely associated. Knowledge is not just “given” but has to be generated. Schumpeter (1934) emphasized that the generation of knowledge is the result of a process of wider social significance. The generation of knowledge is important for the development of the quality of labor and capital goods and is decisive for innovation and economic growth. However, the direction of the causality of the relationship between knowledge, innovation, and economic growth is not always clear. Knowledge can be the result of investment in growing sectors of the economy, but it can also be developed by people with inquisitive minds, without the purpose of commercial application. Knowledge and innovation do not only start at the supply side with research and investment. Rather, the causality may sometimes start with changing demand because certain cultural developments alter the structure of demand through concomitant changes in sectoral structures. This can also happen if wealth increases due to the expansion of foreign markets with already-existing kinds of products. All types of change can lead to the demand of new knowledge, products, and production technologies. This section provides a discussion of production function methodologies and concludes by recognizing the need to explicitly focus future research on the transfer mechanisms of knowledge diffusion. The argumentation is neo-Schumpeterian in character.

Being that knowledge is hard to appropriate, as we argued in the previous section, it generates benefits to other agents through several spillover mechanisms. Understanding the geographical structures that underlie these spillover benefits is necessary for any evidence-based innovation policy to stimulate a region's (or collection of regions, such as Europe) transformation toward a knowledge-based society. Recent years have seen many macro studies on the effect of knowledge spillovers on innovation. Such studies generally apply a knowledge production function to differentiate regional innovation outputs from regional knowledge inputs, as well as from knowledge spillovers from other regions. The strength of interregional knowledge flows is generally assumed to decrease rapidly with geographical distance (Acs 2002), while others have attempted to measure spillovers directly by patent citations (Breschi and Lissoni 2009). Despite the fact that previous research has produced a certain degree of empirical coherence (Fritsch and Slavtchev 2007), it has proven difficult to distinguish between different channels of knowledge spillovers; this has subsequently led scholars to rely on specifications that are suggestive of knowledge spillovers without explicitly modeling the mechanisms through which they occur in practice. Understanding the mechanisms that are behind knowledge spillovers is obviously of the greatest importance for designing effective innovation policies.

The step forward to be taken in empirical research on knowledge production and diffusion in cities and city regions is to correctly model spillover mechanisms of knowledge (correctly). This means that, conceptually speaking, one should take into account via a single framework both geographically localized knowledge spillovers (by examining the extent to which regions profit from regions knowledge inputs nearby) and knowledge spillovers stemming from research collaborations (by examining the extent to which regions profit from network connections to other regions). Put differently, one can analytically distinguish between the "space of place" creating geographically localized knowledge spillovers and the "space of flows" creating spillovers in global networks (Castells 1996). In contrast to geographically localized channels of knowledge spillovers, such as spin-off dynamics and informal networking (Breschi and Lissoni 2009), two promising networked channels of knowledge diffusion come to the fore: research collaborations between firms and universities that are increasingly taking place over longer distances and the mobility of globally operating knowledge workers.

The presence of both private and public research organizations, such as universities and the laboratories of multinational corporations, is generally assumed to have a large impact on urban innovation due to their ability to attract knowledge workers and generate localized knowledge spillovers resulting from their research (Acs 2002). Various empirical studies have suggested the presence of localized academic knowledge spillovers for the USA and various European countries. It has been stressed that highly skilled workers can be regarded as carriers of knowledge diffusion and key drivers of regional innovation and growth. Individuals impact knowledge diffusion through two main and complementary channels: on the one hand, their ability to move from one place or one organization to another and, on the other hand, their ability to enter networks. The mobility patterns seem to be

predominantly local, though some evidence indicates that, due to the intrinsic universality of science, researcher's labor markets – in particular academic researchers' mobility – tend to be more international than other labor markets. Motivations for labor mobility could be related to scientific, economic, cultural, and personal factors. It is expected that nonpecuniary scientific factors, such as the quality of the university, the availability of research budgets, personnel and material research infrastructure, and institutional reputation, are more important than economic factors (Jons 2007). Due to the rising demand of specialized scientific labor, a reputation for scientific quality and openness is a critical factor for attracting excellent researchers. However, differences in wage levels, career opportunities, and concentration effects (talent is attracted by talent) are also thought to be relevant. There also exists a relation to soft factors, for example, language, cultural affinity, living environment, and personal motives (Florida 2002). In line with these insights, many countries have implemented regional innovation policies based on the presence of universities and research institutes in a city or region. In particular, initiatives have been set up to attract skilled workers and facilitate their movement. Systematic research on this kind of labor mobility and migration is lacking.

Besides the importance of local labor markets and spin-off dynamics, a growing body of research stresses the role of networks between individuals and between organizations as mechanisms for knowledge spillovers. Informal networking often takes place at the regional level and, as a result, knowledge spillovers are localized to the extent of these networks. Formal networks of research collaboration are an additionally important mechanism of knowledge spillovers; however, empirical research on the spatial dimension of these networks has suggested that they largely occur at the national or even international scale (Ponds et al. 2010; LeSage et al. 2007). The structure of collaboration networks thus needs to be taken into account to fully understand the impact of researchers' knowledge spillovers (Barber et al. 2011). Despite the increase in literature analyzing knowledge flows in different organizations and geographical contexts, little is known about actual knowledge circulation and its impact on community, as well as urban and regional knowledge creation, diffusion, and quality. At least two weaknesses in the existing studies stand out. First, most studies on localized knowledge spillovers claim that knowledge does not circulate freely across regional boundaries because it is tacit; on the other hand, these studies remain elusive on the specific mechanisms of diffusion of tacit knowledge (Audretsch and Feldman 1996). Studies of knowledge diffusion, with some exceptions, tend to focus only on codified forms of knowledge and on formal channels of transmission (i.e., patents, patent citations, publications, R&D). Second, studies on migration and mobility offer important insights into the motivational factors behind the decision of scientists to move. However, this literature is mostly based on anecdotic or only qualitative evidence. Quantitative evidence instead focuses only on selected groups of skilled workers (e.g., graduates, star scientists) and is limited to cases by country. Future research should shift attention from codified toward more tacit forms of knowledge and from stocks of knowledge toward flows and networks of knowledge.



## 25.4 Agglomeration, Variety, and Pecuniary External Effects

Agglomeration advantages have been connected with increasing returns to scale, external effects, and with the variety of producers and consumers (Combes et al. 2008). New knowledge changes markets, market structures, and production technologies (including organizational structures). Cities can be perceived not only as locations with agglomeration advantages but also as locations of interacting producers and consumers. Interaction occurs not only via markets but also via social networks, sometimes indicated with “buzz” (Storper and Venables 2004). Baumol (2002) argued that markets are predominant in the process of knowledge creation and diffusion, even when other mechanisms of dissemination also exist, such as social networks, labor mobility external effects (externalities), spillovers, and spin-offs. In various publications, the transfer of knowledge is assumed to be different from other goods and services, most often because it is perceived as a public good, freely accessible to anyone, or as given. In traditional growth accounting literature, “technological knowledge” was accepted as exogenous. Most often, the transfer of knowledge, especially codified knowledge such as books and patents, has a price and occurs via markets. This is also the case for labor mobility, where a higher wage is paid to newly attracted experts. The prices do not always completely cover the costs created by the generators of knowledge; subsequently, in many cases, we can highlight market failure or even more pecuniary external effects. In other cases, one could even address unpaid positive external effects; Alfred Marshall indicated this latter effect by asserting that “it is in the air.”

In the case of technological development and expanding or changing demand, new opportunities are created. This can change the relations between firms in different sectors, which are all confronted with an expanding or changing supply and demand. This requires new production methods and products, a good base for an endogenous process of increasing demand for new knowledge and innovations. Adam Smith and Alfred Marshall emphasized the interrelations between firms with the division of labor and industrial districts. In cities, changes could have their origin in new (technological) knowledge, increasing wealth, or new trade relations, leading to new supply and demand and hence to a larger economic base. As Adam Smith said, “the size of a town depends on the size of the market.” The interrelations between trade, the differentiation of consumers, different kinds of firms, and the development of increasing returns have experienced a resurgence in new trade economics and new economic geography. The economic process is influenced by these factors, but in cities, we can also observe the special influence of positive and negative external effects, which in economic theory has been defined as market failures. However, in the case of increasing market size (growing demand within cities and regions through increasing wealth and trade effects) positive pecuniary external effects are related to increasing returns. This leads to the conclusion that pecuniary external effects are not merely market failures but dynamic opportunities for innovators. Allyn Young (1928), then president of the American Economic Society, emphasized the positive impact of the interrelatedness of firms in the production process. In this structure of relations, as well as in the case of the

development of new technologies, pecuniary external effects could develop because entrepreneurs detect new opportunities for higher profits with new products or new technologies. He stressed that in this case, the opportunities to invest in new technology could result in pecuniary external effects and in increasing returns to scale for the entire structure of related firms. Pecuniary external effects offer new opportunities for entrepreneurs by creating “gaps” in the market. Entrepreneurs can establish new firms and produce new products (physical goods or services). Schumpeter (1934) emphasized that innovation is related to this entrepreneurial function of seeing the gaps in the relation of demand and supply by establishing new firms and improving the allocation of resources.

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## 25.5 Knowledge Spillovers in the Urban Agglomeration Literature

Despite this complex and nuanced way of conceptually linking innovation – the introduction and the application of new or existing knowledge – with growth and cities, an ever-growing body of empirical literature on urban externalities remains rather inconclusive on the exact agglomeration circumstances that optimally enhance growth and innovation in cities. In such literature it is argued that externalities or spillovers occur if an innovation or growth improvement implemented by a certain enterprise increases the performance of other enterprises without the latter benefiting enterprise having to pay (full) compensation. Spatially bound externalities are related to enterprise’s geographical or network contexts and are not related to internal firm performance. All discussions of spatial externalities can be linked to a twofold classification in which the sources of agglomeration advantages are grouped. *Localization economies* usually take the form of Marshallian (technical) externalities whereby the productivity of labor in a given sector of a given city is assumed to increase with total employment in that sector. In short, they arise from labor market pooling, the creation of specialized suppliers, and the emergence of technological knowledge spillovers. The strength of local externalities is assumed to vary, such that they are stronger in some sectors and weaker in others. The associated economies of scale comprise factors that reduce the average cost of producing commodities. External scale economies are applicable when the industry to which the firm belongs (rather than the firm itself) is large. An urban system is composed of (fully) specialized cities, provided that the initial number of cities is large enough; such systems occur contingent on further assumptions on crowding (congestion costs that increase with population triggers dispersion), perfect product, and labor mobility within and between locations, not to mention the influence of large agents. Once cities exist, *urbanization economies* that apply to all sectors become equally important. Urbanization economies are often interchangeably mentioned with Jane Jacobs’ diversity externalities, as (sectoral) diversity tends to be larger in cities than outside them. Frenken et al. (2007) showed that a distinction between variety and diversity externalities and urbanization economies is necessary. A large body of empirical literature has grown around testing

these types of externalities in relation to knowledge spillovers using sectoral specialization, sectoral diversity, and density data from cities. The assumption is that if knowledge spillovers are important to growth and firm dynamics, they should be more easily identifiable in cities where many people are concentrated into a relatively small and confined space where knowledge is transmitted more easily. This literature has evolved in a rather polarized discussion on the question of whether sectoral specialization (clusters) or sectoral diversity matter for economic growth and innovation in cities. Three recent meta-analyses and overviews clearly show the limitations of this empirical approach (De Groot et al. 2009; Melo et al. 2010; Beaudry and Schiffauerova 2009); the outcomes of the many empirical analyses using the Glaeser et al. (1992) framework on agglomeration externalities appear to be highly dependent on spatial scale, sectoral detail, time frame, institutional context, and the construction of indicators and variables. Twenty years of research have not convincingly answered the question “Who was right, Marshall or Jacobs?” (Beaudry and Schiffauerova 2009). The answer is ambiguous; both specialization and diversity are related to growth in different aspects and ways.

In principle, this answer is rather unsatisfactory scientifically for understanding the relation between urban growth, spillovers, and innovation. It is very plausible that the prevailing static urban economic modeling approach, confronting the Marshallian versus the urbanization externalities approach, falls short both conceptually and methodologically, and in its present form is unable to test this important issue satisfactorily. In its conceptual sense, this was previously noted by Lambooy and Van Oort (2005), who suggest four heterodox aspects attached to urban and regional economic growth that are currently (still) relatively unaccounted for in research and should be taken more seriously. These are (a) the importance of the life stages and time frames of firms, technologies, and sectors, or development paths of firms, sectors, cities, and systems of cities; (b) specific spatial networks not showing (clear) relations to the forces of contiguous economic agglomeration; (c) specific urban and regional factors explaining why and through which transmission channels agglomeration forces influence sectors and firms differently, depending on the period of economic development and the various technological trajectories; and (d) factors related to forces that cannot be explained using equilibrium approaches, for example, the relation with institutional structures, path-dependent development, the way selection works out for new technologies and firms, innovation, the rise of new technologies and new regional concentrations of firms, spillover mechanisms, and (co-)evolution. These four heterodox aspects of economic theory and empirics are attached to evolutionary economic development trajectories in a wide range of cities, regions, and countries in the same manner (McCann and Van Oort 2009). In the evolutionary geographical research tradition, much more emphasis is placed on the interaction of the relevant urban and regional environment, with locational choices being made by individual firms and investors (Boschma and Martin 2010). In these traditions, a strong preference exists to allow for the differentiation of firms and types of behavior and locations, addressing the heterogeneity in actors and innovation in cities that were signaled in the previous section. The concept of related variety, indicating that successful sectors in regions diversify over time, though mostly in relation to existing competences and

specializations, is an important exponent of new conceptualizations in the agglomeration, innovation, and growth discussion (Frenken et al. 2007).

Together with these conceptual issues, methodological issues arise as well. More emphasis on a firm or consumer's personal agglomeration circumstances requires a modeling approach that takes firms and consumers as starting point. Duranton and Overman (2005) and Combes et al. (2008) argue that many measures of concentration use arbitrary spatial units (such as provinces, municipalities, or postcodes), which may be problematic, as they may lead to biases. Continuous space specifications of agglomeration circumstances of individual firms therefore become more important in present and future research, avoiding the problems of modifiable areal units signaled in the three review articles. Furthermore, issues of causality, endogeneity, selection, and sorting have to be addressed more thoroughly to ensure that the econometric analyses produce reliable outcomes. Both conceptual and methodological renewal are needed to investigate the nature and origin of knowledge creation and diffusion (transfer mechanisms and absorptive capacity of actors), addressing the central issue of heterogeneous actors as well as the varying contexts in the organization of sectors and networks.

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## 25.6 Conclusions

We have provided an overview of historical and current conceptualizations of knowledge, knowledge diffusion, and innovation in cities. We have argued that knowledge is based on processes of learning as well as research and development, that it is both person specific as well as context specific, and that it can be codified and included in the quality of capital and labor. Recently, much empirical research has focused on the creation and transfer of knowledge across organizations in spatial contexts. We argue that analyses using knowledge production functions to capture these flows generally do not provide us with true insight into the generation and transfer of different kinds of knowledge. Only recently have various conceptualizations of distance and knowledge transmission channels been empirically related to knowledge creation and diffusion, addressing heterogeneity in related actors and processes, and capturing the role of cities in them. Our discussion of knowledge production function methodologies applied to cities has concluded that future research should increasingly and explicitly focus on the transfer mechanisms of knowledge diffusion. This is especially true for research on the mobility of (star) knowledge workers and on the evidently fruitful collaborations between firms and universities. To incorporate this in empirical modeling, econometrical knowledge and innovative applications are needed in this field of research. The chapter has further argued that markets remain the most important kind of interaction for economic actors, even in the case of knowledge. This nuances the large focus on nonmarket factors as put forward in the growing literature on urban competitiveness and innovation. We confronted the plea for a better embedding of the mechanisms that create and diffuse knowledge in agglomerations with current agglomeration discourses and methodologies. We conclude that to address the

apparent impasse on the measurement and interpretation of agglomeration externalities, new conceptual and methodological views are needed here as well. In particular, evolutionary economic and geographical concepts are promising for explaining the innovative behavior of growing firms and organizations in cities, carefully addressing the heterogeneity in the actors involved, spatial scale, selection and survival, and time and path dependency. For this, accompanying econometric tools have to be applied, such as continuous space modeling and causality analysis. The future of urban agglomeration research is thus in the interplay of conceptual and methodological renewal, in close relation to already-established insights: what is needed is renewed and related variety in conceptualization and testing.

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