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Productivity in the private sector

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The goal of this review article is to provide a systematic overview of the drivers of productivity in the private sector from an angle which associates firms and sectors with regions. Such an association is meant to provide insights into specific characteristics of regions (urban versus rural at a macro-regional level and, at a less aggregated level, distinguishing between both cities and hinterlands of various types). After discussing the issues of productivity measurement and several relevant considerations, the paper proceeds in the following way. It first looks at research and development (R&D) as key drivers of the productivity of places and discusses the local shifters of technology and productivity. The next section reviews work on spillovers and addresses externalities rather than local shifters which could be attributed to specific innovation efforts directly. The discussion proceeds by considering the specific role that governments play in designing policies which enable high local productivity levels and growth. The last section provides some outlook into future developments.

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DISCLAMER

This paper was prepared as a background document for an OECD-EC high-level expert workshop on "Productivity Policy for Places - Productivity in the Private Sector" held virtually on March 24-25. It sets a basis for reflection and discussion. The background paper should not be reported as representing the official views of the European Commission, the OECD or one of its member countries. The opinions expressed and arguments employed are those of the author(s).

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The workshop is a part of the five-part workshop series in the context of the OECD-EC project on "Productivity Policy for Places". The five workshops cover the following topics: (1) Innovation-Productivity Paradox; (2) Productivity in the Private Sector; (3) Public Sector Productivity; (4) Inclusive Productivity? and (5) Productivity and Resilience.

The outcome of the workshops supports the work of the OECD Regional Development Policy Committee and its mandate to promote the design and implementation of policies that are adapted to the relevant territorial scales or geographies, and that focus on the main factors that sustain the competitive advantages of regions and cities. The seminars also support the Directorate-General for Regional and Urban Policy (DG REGIO) of the European Commission. The financial contributions and support from DG REGIO are gratefully acknowledged.

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1 Introduction

The goal of this review article is to provide a systematic overview of the drivers of productivity in the private sector from an angle which associates firms and sectors with regions. Such an association is meant to provide insights into specific characteristics of regions (urban versus rural at a macro-regional level and, at a less aggregated level, distinguishing between both cities and hinterlands of various types). Specific domains of in differences include the following:

- size classes of regions themselves (in terms of land area or population);
- the accessibility of transport means such as roads, railways, airports, seaports, etc., and the market access that comes with them regarding domestic versus foreign customers;
- the accessibility of production-factor bases in terms of labor, capital, or goods and services inputs, where the latter relates to the positioning in domestic/national versus foreign/global value chains.

The goal of such a topology will be to enable a nuanced view on the heterogeneity of effects of drivers of productivity in the private sector.

Before turning to the specific sections of the review, let me start with a brief outline of key premises of this paper's endeavor. In particular, I will address some of the challenges that come with the topic of the review. These will be the following:

- measuring productivity;
- measuring market access; and
- measuring agglomerations at the micro-regional level.

As these topics relate to the content of the paper, space constraints do not permit an in-depth treatment of them, but I will have to keep their discussion as short as to fit into the introductory section.

Measuring productivity

The measurement of productivity is difficult for data availability reasons. Denoting physical output and total-factor productivity of any output-generating unit i (which could be a firm, a region, a country, etc.) at time t by Q_{it} and A_{it}, respectively, and when using F_{it} to denote a vector of S different factor services (including ones of labor, capital, materials, etc.) economic models and textbooks postulate

$$Q_{it} = A_{it}\mathrm{f}(F_{it}), \qquad \text{Equation 1}$$

where $\mathrm{f}(.)$ is function whose parameters are not known to the empirical researcher nor to policy makers. What equation (1) states is that real output of unit (establishment, firm, city, region, etc.) i at time t is a (positive) function of total factor productivity A_{it} and of factor inputs in the aggregator $\mathrm{f}(F_{it})$. Clearly, A_{it} is a key object of interest not only to this paper but to all of economics. On the one hand, it determines how "wasteful" the production of output (goods or services) is in terms of using the "resources" captured by F_{it}, it is instrumental in knowing how much of a market share i will be able to capture relative to its competitors,

and it pins down how much, in a competitive market, the owners of factors (labor, capital, energy, etc.) which are used by i can earn (at least beyond the profit margin levied by the unit's owners). In a nutshell, A_{it} measures key elements of what is called the absolute and the comparative advantage of i relative to other units at t. But how can we learn A_{it} from data? It turns out that there are two key obstacles quantifying A_{it}:

(i) with few exceptions (in terms of countries or markets), we do not tend to observe the amount of physical output Q_{it} for arbitrary sets of units i, but we only observe sales, i.e., valued output, $P_{it}Q_{it}$,, where P_{it} is the market price of Q_{it};

(ii) with few exceptions, we do not observe the extent of factor services used in terms of some comparable unit (e.g., worker and machine hours), but we observe a mix of valued factor services (e.g., the aggregate material input purchases of i in t), valued factor stocks which are not converted into a service (e.g., fixed assets or capital stocks), and non-valued factor input in real units (number of workers or amount of working hours employed in i at t).

This creates a number of challenges for the two leading approaches in quantifying/estimating A_{it}, one relying on production-function estimation and one on demand-equation estimation.

Production-function estimates tend to rely on an approach where some form of $P_{it}Q_{it}$ is employed as a dependent variable. However, in models where firms charge a constant markup (of zero under perfect competition or some positive markup with monopolistic competition) it is the case that P_{it} is inversely-proportional to A_{it} due to cost minimization, whereas Oit is proportional in A_{it} as in (1) above. Hence, $P_{it}Q_{it}$ does not directly depend on total-factor productivity (TFP) as captured by A_{it} and the latter cannot be uncovered when using $P_{it}Q_{it}$ instead of Q_{it}, even if the function $f(.)$ can be estimated. Rather than using $P_{it}Q_{it}$ many researchers therefore use deflated data, where D_{it} is some deflator in t (which we allow to vary by i, because i may belong to a specific sector or region for which D_{it} is specific) and one uses $D_{it}P_{it}Q_{it} = P_{i0}Q_{it}$, with P_{i0} referring to some base-year price level. Clearly, this means that, because P_{i0} is inversely-proportional to initial-period TFP, A_{i0}, that at best A_{i0} or, when taking the ratio of sales between any pair of years, the ratio (index of change) A_{it}/A_{i0} but not the level of concurrent TFP A_{it} can be identified. Finally, the measurement is further complicated by imperfect competition in the market (which can be addressed as firm-level accounting data do provide information not only on sales but also on profitability (see Katayama, Lu, and Tybout, 2009); also estimation methods are available which permit estimating markups; see De Loecker, 2011; De Loecker and Goldberg, 2014), and that factor inputs are not measured in terms of real units and some (e.g., capital) are typically measured as stocks rather than flows. (Using input-price-deflated nominal input values cannot help to avoid the problem that deflated accounting data will not permit estimating current TFP levels.)

Demand-function estimates are often based on estimates of sales of i at t to various customers. A leading example of such estimates is the so-called gravity equation in international trade, which is based on the generic form

$$P_{ijt}Q_{ijt} = S_{it}C_{jt}T_{ijt} \qquad \text{Equation 2}$$

where the value of sales of unit (establishment, firm, city, region, etc.) i to unit j at time t, $P_{ijt}Q_{ijt}$, is a multiplicative function of the three components S_{it}, C_{jt}, and T_{ijt} , which capture supply potential of i at t, customer (or demand) potential of j at t, and transaction-(or trade-)freeness which captures the ease at which output can be shipped from i to j or purchased by j from i. Much could be said about the micro-foundations of these three components here, a discussion we have to suppress in the interest of brevity (see Eaton and Kortum, 2002, or Arkolakis, Costinot, and Rodríguez-Clare, 2012, for details). However, what is important here is that the valued supply potential is defined as

$$S_{it} = (A_{it}E_{it})^{\alpha}S_{it}$$ Equation 3

where α is a structural parameter that is often referred to as the trade elasticity or the (direct) price elasticity of demand (which is specific to sectors or products) and E_{it} is a composite production-factor-cost measure. What is frequently done in empirical and quantitative international economics is to estimate S_{it} as an exponentiated fixed it-specific effect (where i can be a firm, a region, or a country), use an estimated or literature-based value of α in conjunction with a measure of E_{it} (e.g. wages, or a composite of wages and material-input costs) and compute A_{it} as a residual (see, e.g., Eaton and Kortum, 2002, for countries; Egger and Erhardt, 2019, for countries and products; and Desmet, Nagy, and Rossi-Hansberg, 2018, for 1°-sized regions of the globe). Obviously, this approach has the advantage of principally being able to identify (up to a scalar) the distribution of TFP in levels, but it also requires solid data on the prices of factor-services.

In any case, I will assume throughout this review that a measure of TFP levels A_{it} or at least of TFP changes A_{it}/A_{i0} is available.

Relevant aspects of productivity

When thinking of how productivity matters for economic outcome and wellbeing, three aspects come to mind: productivity levels, productivity growth, and productivity volatility. In this survey, I will mostly focus on productivity levels and productivity growth, as existing work is much richer on these topics than on volatility. However, I will address the volatility of productivity wherever possible. It should be noted in this regard that, like productivity levels and growth, productivity volatility has an extensive margin component (aggregate, place-specific volatility is a function of the entry and exit of selected firms) and an intensive margin component (aggregate, place-specific volatility is a function of the volatility of productivity of the pre-existing and remaining firms in the place).

Measuring market access

Measuring market access in the context of the above means measuring T_{ijt} in equation (2). Apart from TFP, the latter is of paramount importance for benefitting from transactions both for factor-owner-customers and producer-sellers. Over the past two decades, we have seen a large body of work in quantitative international and, more recently, quantitative regional economics to devise structural models which are not only capable to identify market-access costs in a theory-consistent way but also to evaluate the quantitative importance for real consumption when taking into account international and/or interregional interdependencies in prices (of outputs and inputs).

However, what is important at a subnational level to quantify market access is some notion of the domestic transport system/infrastructure and the discontinuity in transaction frictions at international borders (e.g., Desmet, Nagy, Rossi-Hansberg, 2018, assume that such discontinuities are absent at international borders, while Egger, Loumeau, and Loumeau, 2000, or Jawoski, Kitchens, and Nigai, 2020, explicitly consider them analogous to quantitative trade models).

In any case, I will assume throughout this review that a measure of market-access costs is available.

Measuring agglomerations at the micro-regional level

A key ingredient of spatial or regional models is that subnational units of analysis—called spatial or regional units—differ in terms of the density of the local consumers and the mobile production factors they can employ (some of the factors are local while others commute or are traded). Such measurement requires

two ingredients: a delineation of the boundaries of the spatial/regional units of interest and one of the consumers and factors available there. Clearly, one might be tempted to say that this sounds easy, as there is an official, multilayer nomenclature of subnational regional units available already for most national and even supranational conglomerates. E.g., for the European Union, Eurostat considers the so-called NUTS to distinguish administrative units which at the NUTS1 level correspond to countries, at NUTS2 to something equivalent to states, at NUTS3 to correspond to something equivalent to counties and at NUTS4, etc. However, there are two issues with such delineations in general. First, they assume that the reality of agglomeration lives and happens within the confinements of statutory or administrative borders. One does not even need to think about metropolitans such as Paris, Madrid or Munich to see that this is problematic. The examples clearly indicate that actual agglomerations may often be larger and encompass the borders and sometimes even cross the borders of administrative regional units. Conversely, there are peripheral spatial units, whose extensions are much larger than the residential or business areas inside their boundaries. There are many attempts to part with administrative nomenclatures of subnational regional aggregates. The City-Clustering Algorithm based, e.g., on night-light data as used in Egger, Loumeau, and Püschel (2017) or the population-density measurements as in the OECD's Metropolitan Area Statistics are examples to establish borders of agglomerations beyond administrative ones. Second, such administrative delineations of regions are still relatively coarse, in particular, for areas outside of the core of metropolitan areas.

While the forces behind and obstacles to agglomeration are relevant at different scales (macro- meso- and micro-regions), the focus on macro- (countries or states/provinces) or meso-regions (departments/counties and even metropolitan areas or cities) is often not sufficient to explain patterns of interaction between the agents within or between spatial units which ultimately also determine the interdependencies of these spatial units at various degrees of granularity. The reason is that within larger spatial aggregates micro-regional substructures emerge through clusters of activity (firm location, a concentration of production factors, etc.) which are the smallest nuclei at the root of agglomeration economies, and focusing on larger units may mask important details and—akin to an aggregation bias—mislead the conclusions drawn when looking at data.

In this review, I will partly abstract from the aggregation problem and assume that the delineation of spatial units is appropriate for the purpose of the analysis of the reviewed work. I will report on evidence pertaining to the smallest possible level of spatial granularity, where needed and possible.

Overview

The remainder of the text will be organized in four sections. In the subsequent section I will review work on research and development (R&D) as key drivers of the productivity of places. Hence, the following subsection will be devoted to discussing the local shifters of technology and productivity. In Section 3, I will review work on spillovers. Hence, that section will address externalities rather than local shifters which could be attributed to specific innovation efforts directly. In Section 4, I will consider the specific role that governments play in designing policies which enable high local productivity levels and growth. And in the last section I will provide some outlook into future developments.

2 R&D and innovation as own drivers of private-sector productivity in the spatial economy

Preamble: Reasons for the agglomeration and dispersion of economic activity

Before turning to a more detailed portrait of various spatial aspects of private-sector productivity, let us fix some basic ideas about agglomerations by way of a preamble. The quantitative economic literature on agglomerations pinpoints the two key principles for why multiple agglomerations happen in space: that agglomeration forces exist and that they find a balance with dispersion forces. Key agglomeration forces are *localization economies* which build on externalities within industries and *urbanization economies* which build on externalities between industries (see Duranton and Kerr, 2015; Behrens and Robert-Nicoud, 2015).

In some sense, firms are attracted to agglomerations, because they can get access to factors that are immobile in the long run (land) or the medium run (capital, education institutions, cooperation partners). And firms face reduced incentives to locate in agglomerations due to ever higher costs associated with higher densities. Unless firms are then sufficiently productive, their propensity to compete successfully in the market is low (e.g., in Ricardian-type models with perfectly-competitive producers as in Ahlfeldt, Redding, Sturm, and Wolf, 2015; or Desmet, Nagy, and Rossi-Hansberg, 2018), or they may not survive at all and are forced to exit (e.g., in Dixit-Stiglit-Krugman-Melitz-type models with imperfectly competitive producers which face fixed market-entry costs as used in Pkubo, Picard, and Thisse, 2010; or Ottaviano, 2011).

Apart from factors that are location-specific and at least in the short to medium run unchangeable such as land endowments or amenities and the surrounding geography, policy makers can affect the attractiveness of locations (micro-regional units, cities, hinterlands, meso- and macro-regions, etc.) by using policy instruments to change endogenous factors. Among those the attraction of mobile production factors (capital, labor, energy suppliers, etc.)—or the environment for such factors to emerge and be accumulated otherwise—and the establishment or improvement of transport systems (for goods, services, and people) for better market access are most important.

Innovation and productivity in agglomerations

Agglomerations such as metropolitan areas or cities amass a lot of everything: employment, production, housing, etc. From this viewpoint, it is not surprising that they also account for much of the recorded

innovations. Overall several main reasons for an excess density of innovative and high-productivity in agglomerations can be identified. Specifically, agglomerations

- attract a disproportionate amount of mobile factors (per unit of land), and, in particular, they disproportionately attract the high-skilled labor force;
- exhibit a greater thickness of markets both on the demand side as well as the supply side or the relevant factors which trigger productivity advances so that better matching and re-matching of the two sides of the market enables a more efficient sorting;
- attract to a disproportionate extent entrepreneurs with promising and high-productivity ideas;
- provide above-average market access through the availability of transport and communication infrastructure;
- provide externalities which exacerbate the positive productivity effects from the above due to education and public investments.

E.g., a recent geocoding effort by de Rassenfosse, Kozak, and Seliger (2019) led to an (almost) exhaustive assignment of the patents in Patstat to “locations” (latitude-longitude grid points) on the globe. The associated data base suggests that, when focusing on Europe, particularly large and densely populated agglomerations and metropolitan areas feature at the top when measuring innovations by patent activity.[1] The data suggest that the top-10-ranking European cities and metropolitan areas regarding patent applications between 2010 and 2014 are located in only four countries—Germany, France, United Kingdom, and Sweden—and these areas are (in descending order) Munich (DEU), Stuttgart (DEU), Paris (FRA), Berlin (DEU), London (GBR), Hamburg (DEU), Nuremburg (DEU), Erlangen (DEU), South Cambridgeshire District Council (GBR), and Stockholm (SWE). The top-10-ranking cities and metropolitan areas all over the world in the same time window are also located within just four countries—South Korea, Japan. China, and the United States. And the respective areas (in descending order) are Seoul (KOR), Tokyo (JPN), Beijing (CHN), Santa Clara County (USA), Shenzhen (CHN), Shanghai (CHN), Daejeon (KOR), Suwon (KOR), Seongnam (KOR), and Suzhou (CHN). All these places feature at the top in Europe regarding the aforementioned critical factors (the density of the work force, specifically, the high-skilled one, the share of research-and-development-active relative to other activity, the access to transport systems and market access, and the extensive use of public spending to provide complementary factors such as education systems and amenities. Note also that mentioned metropolitan areas around the mentioned cities also exceed by far the administrative-city nucleus.

From the viewpoint of researchers, planners and economic agents, it is important to distinguish between localization and urbanization factors in this regard.

While ***localization factors*** emerge due to the local availability of other firms (e.g., input suppliers and other complementary actors), economic and social institutions, ***agglomeration or urbanization factors*** exist beyond those direct externalities which are inherently tied to the activity in agglomerations (institutions, platform effects, infrastructure and other provisions of public goods). Originally the evidence on the importance of these factors had been mixed. More recent research attests to both localization and urbanization factors to be important for explaining the disproportionately high degree of innovations in agglomerations. E.g., while using survey data Harrison, Kelley, and Gant (1996) found that, after conditioning on a host of firm characteristics (which may have been a function of productivity themselves), not much was left for localization and urbanization factors to explain the spatial pattern of innovation. However, Kelley (1993, 1994, 1995) and subsequent research attributes an important role to play for both localization factors (also referred to as clustering of the co-location of firms and factor owners) and urbanization factors to explain spatial patterns of innovation and productivity.

[1] The database can be downloaded from here: https://kof.ethz.ch/en/data/patentdaten.html.

Clearly, the above indicates that innovations are particularly dense in urban centers. This is to be viewed as one reason, a mediation effect, as to why productivity tends to be higher in more densely populated areas. The latter fact is documented in a series of papers as, e.g., by Ciccone and Hall (1996) or Saito and Gopinath (2009), and many others.

Availability of skilled labor in agglomerations

The driving force behind the growth of real consumption in dynamic regional economic models is productivity growth (see, e.g., Desmet, Nagy, and Rossi-Hansberg, 2018; Egger and Loumeau, 2019). While the steady-state growth rate is (and, for a long-run equilibrium, has to be) the same across the places, growth rates vary after a shock in transition to a new equilibrium. The reason for this is that productivity is a conglomerate of two parts: an exogenous, innate part and an endogenous "hired" part. The latter is established from access to the innovating part of the workforce, researchers, which are mobile between places akin to the rest of the non-innovating workforce. Hence, such models build on the idea that better access to researchers on the part of a region or place guarantees higher technology and productivity levels and in transition where more researchers move to a place even higher productivity growth than on average. In a nutshell, the latter implies the following. First, there is two-way causation between productivity growth and agglomerations. Agglomerations start out because of "luck" being distributed unequally in space. Here, "luck" refers to a good initial productivity draw where productivity needs to be viewed as a mix of technology (good initial ideas and innovations) and transport infrastructure (the local access to waterways or international transport routes, etc.). But, due to the opportunities of specialization due to scale, agglomerations are capable in exploiting specialization gains at the person level and a better exploitation of talents than less densely populated areas. The latter creates gains from residing in agglomerations as individual productivity can be remunerated more adequately than when being wasted on diversified and subsistence production at the household level. Hence, while agglomerations may start out with high initial productivity levels, they enforce productivity subsequently by attracting more people whose specialization gains they allow to exploit. Not only the most productive and talented physicists but also the best painters and composers already between the medieval ages and the art déco periods always resided in agglomerations and courts. This is not different for engineers or chemists in modern times. In turn, the location of better talent and more productive workers—due to sorting as well as the specialization of labor—in agglomerations generates benefits in terms of taxes and other rents associated with scale economies which allow agglomerations to exacerbate the gains from initial luck.

There is widespread evidence supporting the following claims. First, more mobile employees and researchers tend to be more productive than less mobile ones on average. This result is partly owed to the benefit of seeking better matching with high-profile employers for better job opportunities and pay (i.e., the sorting of top-quality workers and researchers; see Eekhout, Pinheiro, and Schmidheiny, 2014). However, it may also be owed to a relatively high willingness to move for such individuals (see OECD, 2017).

Recent research points to three separate channels through which a high density of skilled labor promotes innovation. The first one is a mere scale effect—a bigger mass of talented high-skilled workers increase the propensity of any innovation, including break-through innovations. The second one is rooted in the aforementioned theory of search and matching and sorting: a higher density of both employers and skilled workers leads to an ever better matching between the two, whereby the best-innovating individuals can be employed to their most-productive uses (see Eekhout, Pinheiro, and Schmidheiny, 2014). Third, there is an externality owed to the co-location of high-skilled employees which may have to do with competition, effort, or the benefit of communication among peers. According to the latter, an increase in the density of high-skilled labor in agglomerations raises the productivity of high-skilled labor (in terms of innovation and otherwise) ceteris paribus (see Liu, 2014).

Turnover of the workforce: matching and sorting of workers and employees in agglomerations

When considering all types of workers and employees, Bleakley and Lin (2012) established the stylized fact that individuals change their occupation and sector less frequently in densely populated and metropolitan areas than otherwise. This observation is interesting in the context of the Economic and Financial Crisis of 2007-2008, where we saw that the amplitudes of economic volatility were also higher in such densely populated places. E.g., Egger and von Ehrlich (2019) document that, when using night-light data as recorded by satellites, the volatility of light emissions—which they document to be systematically positively correlated when micro-regionally matching them on less-exhaustively available accounting data of firms—was much bigger in the metropolitan areas around Europe and North America in response to the shock than in less-densely-populated areas. However, the recovery was relatively quick and strong as well in those places. Hence, it appears to be the case that agglomerations enjoy higher levels of productivity and activity as well as a higher volatility thereof on average. However, returning to the volatility of job contracts, Bleakley and Lin (2012) demonstrate as well that the said greater stability of work contracts cannot be observed for younger workers and employees. They interpret their result as to support the view of increasing-returns-to-scale matching in labor markets. Overall, it appears to be the case that strong matching and re-matching (sorting) forces are at play in the early stages of workers' and employees' careers. Bleakley and Lin (2012) document two bits of specifically relevant evidence: a particular set of skills becomes less likely and less quickly obsolete in agglomerations than elsewhere; and specific skills are an important component of the overall productivity of workers and employees. This has a number of important consequences for the progression of careers and wage profiles in agglomerations and cities versus peripheral places: (i) specific skills become less rapidly obsolete in agglomerations, and (ii) wages grow more quickly there. They attribute more than one-third of the faster wage growth in cities and agglomerations to this mechanism alone. They also point out that their finding may also be one factor in explaining why the investment in formal skills and education is higher in cities and agglomerations than elsewhere.

When zooming in on the interior of cities rather than a comparison between agglomerations and peripheral places, the type of employment and the work force one talks about is very different. While a comparison of cities and metropolitan areas and other places covers a wide range of economic sectors, services clearly dominate, and the retail sector—apart from the tourism including services in connection with the operation of hotels, restaurants, bars, and cafes– is an important employer in cities. Han, Håkansson and Lundmark (2019) focus on the retail sector. I mention this here, because they mention a nexus between job turnover and productivity growth (without alluding to it in the context of the retail sector) and they emphasize a pattern of job turnover within retail and subspaces of the city:[2] Han, Håkansson and Lundmark (2019) document for Örebro in Sweden, a medium-sized city of today some 150,000 inhabitants, that at least the replacement labor turnover rate (somewhat less so the crude turnover rate) in the retail sector increases consistently as one moves from the "downtown" area outwards to the "edge-of-town" and the "out-of-town" areas in a city. The just-mentioned increasing gradient in job turnover as one moves from the city center outwards is inversely related to the declining gradient in retail productivity per worker (see Öner, 2018).

[2] They lean towards assuming a negative nexus between a high job turnover rate and productivity levels and growth. This is consistent with the evidence provided by Bleakley and Lin (2012).

Economies of scale and scope (clusters, fixed costs, and factor prices)

In a regional and agglomeration context, three dimensions of scale economies matter: (i) ones that are **internal to firms or at least plants** and merely relate to the size of operations of the firm; (ii) ones that are **external to the firm** and relate to the **localization factors** whereby a better or more efficient and cheaper sharing of inputs (labor, capital, energy, but also transport and communications infrastructure) is possible; and (iii) other factors that are external to the firm and relate to what is referred to as **urbanization factors** which subsume all factors that cannot be associated with localization per se and emerge specifically with a greater density of location and activity in space and in the environment of cities. The existence of certain institutions and the possibility of spillovers (which are involuntary to individual firms) are examples which are frequently mentioned in this context.

Gill and Goh (2010) provide an excellent overview of the key related stylized facts. E.g., light industries tend to be characterized by low internal scale economies (suggesting relatively small plant and branch sizes), and, due to prevailing regulations regarding emissions, high land prices as well as for reasons of transport infrastructure requirements light industries tend to be particularly prevalent in city centers.[3] By way of contrast, heavy industries tend to display big economies of scale at the level of both plants and firms, and for the aforementioned reasons they are more likely to be found in the outskirts of metropolitan areas or their hinterland.

It lies in the nature of external scale economies that their extent increases with the density of firms and factors. Moreover, it is hard if not impossible to exclude parties from partaking in them so that they disseminate between economic agents. Spillovers are one particular example of factors which feed into external scale economies, and they as well as other such factors tend to increase with greater vicinity and decay with greater distance to agglomerations. Gill and Goh (2010) point out that while scale economies of the internal type prevail in small cities and agglomerations, localization economies dominate in medium-sized cities, and urbanization economies are particularly important in large metropolitan areas and their neighboring hinterland.

The key consequences of the three types of scale economies together regarding the density of economic activity are two: spikiness and stickiness. Spikiness means that the distribution of populated locations in countries, meso-regions and even within cities is extremely concentrated. Stickiness means that this pattern does not change much over short horizons and it takes big and long-lasting shocks to change it (see Owen III, Rossi-Hansberg, and Sarte, 2020, with reference to the case of Detroit). Both the spikiness and stickiness of the geographical density bear good and bad news for policy makers: on the positive side, it takes more than a small mistake in policy making on average for an established agglomeration to meet the peril of dissolution; on the negative side, it takes a lot of effort in policy making to put a place or city on the map when it was not there in the first place. Gill and Goh (2010) provide numerous examples of countries and agglomerations from all over the globe to substantiate this claim. Two particular reasons for the inertia in the geography of places is that agglomerations serve different—and complementary—purposes in the macro-regional economic context, and these purposes are to some extent but not perfectly correlated with agglomeration size (see Henderson, 1974). Changing this specialization on specific purposes or the supply of an environment is difficult and takes time as does the specialization on specific outputs of an economy. Moreover, as agglomerations grow, a continued effort in policy making is necessary to establish markets and regulations to support growth in view of the growing dispersion forces with greater agglomeration (congestion, building regulations, pollution, etc.).

[3] However, light industries—in particular, some of the services industries such as retail—are characterized by small internal scale economies at the plant but big internal scale economies at the firm level (we might refer to those as multi-plant economies of scale) due to the relative importance of trademarks and advertisement.

Internal scale-economy factors

Economic work on the role of fixed costs and on price-cost markups provides a substantive rationale for thinking of most industries as to exhibit internal scale economies. Consistent with this—though not only with this—argument, we see a disproportionate occurrence or density of firms where at least some specific types of fixed costs and operating profits are high in agglomerations, and these are firms where headquarters fixed costs are high and where the operation is one that involves multiple production sites so that multi-plant economies of scale arise (see Markusen, 2002) and ones which face high fixed costs associated with the entry of multiple markets, of which exporters are a prominent example (see, e.g., Melitz, 2003). As the operating profits of such firms are higher than those of other firms—because they are more productive—we observe a sorting of firms such that more so ones with above-average productivity will be represented in expensive (due to high land but also other factor prices) locations and agglomerations than firms that are randomly drawn from the population in a country. This phenomenon is referred to as **sorting**, and it entails that firm which do not exhibit a high-enough level of productivity (or which exhibit too high fixed and factor costs otherwise) may not survive in (expensive) agglomerations and will either have to exit or not enter in the first place. This is one reason for why the list of retail stores in the major shopping streets of the capital and other important cities on the globe is relatively similar and features well-known brands some of which sell produce that may be classified as luxury goods.

Localization factors

Localization economies are one form of agglomeration economies at the root of private-sector productivity growth, economies which are external to a single firm (as well as to private factor owners). As localization economies rest on the idea of the co-location of factor owners and firms, they should not be expected to be important in small towns and small agglomerations but only in medium-sized to large cities. While traditionally they are associated with intra-sectoral network effects (in a broad sense) complementarities which should be classified as to stem from localization economies can arise also across sectoral boundaries. Broadly speaking, localization economies should be associated with external scale economies that emerge from benefits of a proximity of producers (of the same or other products or services) to each other and/or to benefits from the co-location of specific factor owners and firms. In that sense, co-locating firms in clusters (induced by policy or self-induced) of similar output producers that can tap into a large local labor market whose work force is specifically trained and suited for them (e.g., as in Silicon Valley) can be linked through voluntary as well as involuntary spillovers through joint research and development projects and worker flows between them. This type of localization economies might be dubbed ***horizontal*** in nature because the localization economies would be bound within sectoral boundaries. Conversely, input suppliers up the stream and input customers (sometimes called producers) down the stream could benefit from a co-location as it enables just-in-time production and lower other (communication, transport, etc.) frictions to business interactions (see, e.g., Pisch, 2020). The latter type of localization economies might be dubbed ***vertical*** in nature because the localization economies would be across sectoral boundaries.

Urbanization factors

Urbanization economies are the other form of agglomeration economies at the root of private-sector productivity growth, and akin to localization economies they are external to the firm (as well as to private factor owners). Specifically, urbanization economies emerge due to the availability of institutions or services—often and typically but not necessarily provided by the public sector—to the actors (firms but also factor owners) which incentivize them to locate there and make them more productive than otherwise. The reason for these beneficial urbanization economies should be seen in the lack of opportunity of coordination or the need of exuberant expenses relative to the size of the operations among the beneficiaries to establish such institutions on their own. Examples of urbanization factors are the availability

of particular types of training programs, schools, and universities to a specific type of sector. E.g., the availability of a strong academic research base in software engineering and the opportunity of joint development projects encourage software producers to co-locate with universities that have such characteristics. The co-location of software and hardware producers in Silicon Valley in the vicinity of Stanford University is one example, and the location of Google in Zurich in the vicinity of ETH Zurich, one of the major technical universities on the globe, is another one. Universities with strong programs in the sciences and engineering themselves are important generators of private-sector offspring through start-up companies. Again, Stanford University in Palo Alto and ETH Zurich in Switzerland are good examples for that. For being financially viable, star-ups and highly-innovative firms in the early phase of their life cycle do not only need innovation and excellent personnel but also a financial industry which is capable of judging the prospect and quality of innovations and savvy to finance them in spite of a high rate of failures. This is why a successful innovation industry does not only involve a co-location of high-end training in universities and a close collaboration with the private sector but also of a financial and banking industry which engages in venture-capital investments. Again, the Bay Area in California and Switzerland come up as examples. Clearly, there are further factors which play a role in such co-location economies which are not directly associated with what we think about in terms of value chains (which I mentioned in the context of localization factors). Associated activities would be management consulting, legal-service provision and accounting, but also certain (complementary) activities. Many of those services live on a large scale in the sense that universities with an emphasis on the sciences and engineering need to be sufficiently large to have punch, and then they will generate a sizable number of quite diversified start-ups. They will train a large number of scientists and engineers who will have a preference for staying in the neighborhood as long as employment opportunities exist and amenities are ample. And co-locating consulting and financing industries will need to be big to entertain enough diversification. In general, urbanization economies are associated with the diversified use and complementarities of certain institutions or activities by a host of different businesses, factors, and sectors. All of those will require large-enough agglomerations so that urbanization factors should be expected to become relevant mostly in big metropolitan areas and cities on the globe.

Competitive pressure and sorting (entry and exit)

While economies of scale—internal to the firm or external to the firm and particularly associated with agglomerations—emphasize advantages of locating in a dense place such as a mega-city of large metropolitan area, there are also disadvantages which contribute to what regional economists call dispersion forces that counteract agglomeration. As said before, localization economies create benefits by enabling large factor markets and large customer markets in the vicinity of production. This facilitates access to well-suited employees and to identify customers to businesses. However, it requires more refined contracting and training strategies for the workforce to ensure that training costs are not wasted on an ever more mobile workforce that can find outside options for work in the close vicinity. E.g., we observe that firms are changing their strategies in how and when in a career to administer training on the job to be able appropriate the fruits of the training expenses (see Loewenstein and Spletzer, 1997).

Moreover, with existing co-location benefits there is bigger churning in the local market. On the one hand, universities and large enterprises continuously generate start-up companies. But many of those exit the market in the medium turn while only few grow large. Hence, dense places are innovative because many small, innovative firms enter the market. Such firms tend to hire young employees. Many of those businesses will not survive the fierce competition in the market and exit, whereby a small share of a well-educated workforce will have to be re-matched with other employers in the market. This is consistent with job turnover being small in dense places, because the said businesses are small, and they co-locate with large enterprises in dense agglomerations.

The few firms that grow large will reach an international scale—through exporting or multinational firm set-up—at greater probability than on average. Note that the share of exporting firms as well as of headquarters of multinational firms in metropolitan areas is far higher than on average. Multinational firms establish headquarters or foreign affiliates in only a small fraction of cities in a country, and they locate primarily in the area of the large cities and metropolitan areas (see Becker, Egger, and Merlo, 2012, for evidence from Germany).

Evidence

The evidence on the extent of urbanization economies for productivity is mixed and, in particular, how important the individual forces behind productivity are is not clear-cut.

Henderson (2003), analyzes a large panel data-set of U.S. plants in machinery and high-tech manufacturing and finds that specialization gains for productivity are particularly emerging from industry specialization and much less so from urbanization.

Martin, Mayer, and Mayneris (2011) use a pane of French firms and plants but a wider range of sectors and find evidence of positive localization (or co-location) economies on productivity, at least in the short run.

Accetturo, Di Giacinto, Micucci, and Pagnini (2018) provide a decomposition. Specifically, they distinguish between agglomeration forces (a combination of urbanization and localization forces), selection (i.e., the survival of more productive and the exit of less productive firms due to competitive pressures in agglomerations), and dilation (the disproportional productivity gains of large and highly productive firms in agglomerations). They focus on 13 manufacturing sectors in Italy and assess the question to which extent agglomeration, selection, and dilation forces affect the productivity of firms. Their findings suggest that dilation effects are by far the most important ones on productivity followed first by agglomeration and finally by selection effects. Hence, agglomerations are the wakes of super-star firms: extremely productive firms in the right tail of the sectoral productivity distribution tend to benefit by far the most in terms of productivity growth effects induced by densely populated areas.

Marrocu, Paci, and Usai (2013) document heterogeneous agglomeration effects between Old Europe (defined as the EU15 plus Norway and Switzerland) and New Europe (the accession countries of the EU enlargements of 2004 and 2007). They distinguish altogether 276 regions and 8 manufacturing and 7 services sectors, and they find that agglomeration economies are particularly strong for total factor productivity levels in the knowledge-intensive services sectors in Old Europe whereas they are particularly strong in the low-tech manufacturing sectors in New Europe.[4] Hence, agglomeration economies on productivity are found for both manufactures and services, but they appear to emerge for manufactures at an earlier and for services at a later economic development stage.

Brunow and Blien (2015) provide another study using German microdata. The advantage of this study is that it does not only cover manufacturing but also services firms (more precisely, the cross-sectional unit in their analysis are establishments rather than firms). However, they select firms with the consequence of an underrepresentation of financial institutions, and they eliminate relocating firms from the data which has consequences for the magnitude of selection effects. However, what their results suggest is that there are strong agglomeration forces within a sector and (NUTS3) region. While a greater diversity of sectors within a region is less relevant, a larger number of establishments within a sector pushes the productivity of individual plants very strongly. They propose an analysis of the heterogeneity of average productivity

[4] The dependent variable in their econometric analysis is the growth of total factor productivity (TFP). However, since they condition on the initial TFP level on their right-hand side, the parameters reflect responses of TFP levels to (shocks in) the explanatory variables. Note that my interpretation of the results differs from theirs, as they appear to disregard the latter.

effects, distinguishing four types of regions: core cities, densely populated areas, populated areas, and rural areas. Their findings suggest that the productivity levels are particularly significantly higher in core cities followed by densely populated areas. Note that these effects are averages for manufacturing and services sectors.

Overall, this evidence suggests that agglomeration economies vary across locations and sectors. The evidence is consistent with a pattern of development. Specialization gains appear to matter throughout, but the effects of agglomeration economies may be stronger for manufacturing in earlier and for services in more mature development stages of economies. Also, agglomeration economies appear to matter most strongly to the most densely populated areas and core cities.

3 Spillovers in the spatial economy

Although the two are not completely independent of each other, I will discuss spillovers and their relevance for cities and places along two lines, between firms and in the aggregate. The reason is that not all spillovers are ones that happen explicitly between firms, even though they have inter-firm consequences. However, some spillovers may emerge due to factor-market interdependencies and other market and non-market interdependencies so that they are clearly-enough separate from inter-firm spillovers, warranting a separate discussion.

Interfirm spillovers and their channels

Knowledge spillovers between firms are an involuntary transfer from innovators to other entities. The latter may utilize this knowledge either to produce an **imitation** of existing products or processes or combine them with other (own or not) knowledge to generate an **innovation** of their own. Typically, in particular, when the knowledge to be integrated is relatively advanced, the in-taking firms need to provide effort to productively use that knowledge. Then, the knowledge-using firms have to display a sufficient level of absorptive capacity, which they can achieve by employing or hiring well-educated and –trained personnel and by undertaking a sufficient level of investment for adaptation (see Cohen and Levinthal, 1989).

Spillovers between firms—first in terms of research and development and innovation and ultimately in productivity—can be delineated along various lines. One line of differentiation are vertical (in the value chain between sectors/products) versus horizontal (within sectors/products) spillovers. Another line of differentiation is among domestic versus from foreign to domestic (or vice versa) firms.

In the literature, six main channels of knowledge (and productivity) spillovers between firms are mentioned:

- labor mobility (Almeida and Kogut, 1999; Fosfuri, Motta, and Ronde, 2001; Glass and Saggi, 2002; Görg and Strobl, 2005),
- communication and joint voluntary, inter-firm research efforts (Zucker, Darby, and Armstrong, 1998; Singh, 2005; Guan and Chen, 2012; Di Cagno, Fabrizi, Meliciani, and Wanzenböck, 2016),
- industry linkages (Smarzynska Javorcik, 2004; Girma and Gong, 2008; Badinger and Egger, 2016; Peng and Hong, 2016),
- exports (Aitken, Hanson, and Harrison 1997; Clerides, Lach, and Tybout 1998; Greenaway, Sousa, and Wakelin 2004; Hu and Tan, 2016; Baltagi, Egger, and Kesina, 2017, 2019),
- foreign direct investment (Findlay, 1978; Wang and Blomström 1992; Aitken, Hanson, and Harison, 1997; Aiten and Harrison, 1999; Smarzynska Javorcik, 2004; Görg and Strobl, 2005; Girma and Gong, 2008; Baltagi, Egger, and Kesina, 2019), and
- demonstration effects (Findlay 1978; Koizumi and Kopecky 1977; Wang and Blomström 1992).

As the above list already suggests, these channels are not completely separable from each other. The main sources of spillovers are large firms, and those are often exporters as well as multinational firms.

Such firms are big in every regard and they are, hence, also important sources of worker outflows at all skill (including management) levels and they induce significant demonstration effects.

The evidence on the importance of some of these channels is mixed. E.g., regarding worker flows Görg and Strobl (2005) report that firms which employ workers that had worked for a multinational firm before tend to be more productive than other ones. However, it may be that workers who work(ed) for multinational firms are more productive than on average in the first place (i.e., there is sorting in the labor market whereby bigger and internationally competing firms tend to screen for and hire workers which are more productive than on average). Regarding involuntary spillovers through inter-firm flows of workers employed in research and development (R&D), Almeida and Kogut (1999) document such flows through employment changes of engineers even to an interregional (not only an inter-firm) degree—though only to a and among a few regions. However, Maliranta, Mohnen, and Rouvinen, (2009) find with linked employer-employee data that there is no strong evidence supporting knowledge dissemination through this channel. But also the latter result needs to be seen in context: Geroski, Van Reenen, and Walters (2002) identify the large difference in the frequency of R&D efforts as an innovation input (investment, employment, etc.) and innovation output, patents in their case, as one reason for why it is hard to identify the consequences of (stable) research input on (volatile) research output and other measures of firm outcome. The latter means that finding consequences of hiring R&D personnel by a firm from another firm will unlikely show in drastic responses, at least not in the short term, neither in actual innovations (which are rare) nor in productivity (which responds only sluggishly). This is the case unless such an employment transfer happens on a very big scale—examples of the latter are the clustered cross-hiring of engineers and technicians for display, battery and other developments at leading cell phone producers.

Regarding spillovers through communication and collaboration, the view is relatively uncontested that they exist. They appear to be a key factor to explain why knowledge is strongly bound not only in geography but also within firm boundaries (see Zucker, Darby, and Armstrong, 1998; Singh, 2005). More specifically, the respective work helps explaining why important (break-through) innovations are infrequent not only across firms but also across places and are concentrated in relatively few agglomerations on the globe. The respective spillovers provide one justification for governments to facilitate the formation of clusters to enable the respective spillovers which then may be dubbed to stem from a mix of urbanization factors (due the cluster policy) and localization factors (due to communication and collaboration externalities).

Also the view that not only horizontal linkages but vertical linkages are important is uncontested, as worker flows, research collaborations and demonstration effects are not bound to happen only horizontally (within sectors) but also vertically (between input suppliers and producer-customers which are eventually associated with different sectors).

What is particularly relevant in the present context is that the same firms (multinationals and exporters) occur at a disproportionately high frequency in big agglomerations and cities and the spillovers they induce tend to be geographically bound and tend to decay with greater geographical distance (see Baltagi, Egger, and Kesina, 2015, 2016, 2019, on both for China). Moreover, these firms engage in continued high innovation efforts and tend to employ relatively large groups of personnel which is specifically devoted to innovation and development. These insights together have the following implications for cities. Large firms—including exporting and multinational firms—are a big factor in the demand of skilled labor and a big source of innovation and productivity levels and growth in cities. They are an equally big source of innovation and productivity spillovers and knowledge spillovers with a broader definition (e.g., about specific domestic and foreign markets, etc.). By this token, they are a prime source of spillovers both to each other (between exporters, between multinationals) as well as to other firms (domestic players), at least ones which invest enough in absorptive capacity. Because of the aforementioned geographical scope of spillovers due to the communication, collaboration, and worker-flow channels knowledge and high productivity levels were historically bound to be found in few firms which were concentrated in few places between as well as within regions. Of course, recent advancements in communication technology and the

acceptance and take-up of such technologies for work may have deep effects in the geographical gradient and scope of knowledge concentration and its effects on productivity.

In any case, at this point the scale of cities and metropolitan areas is a statistical fact, and it can be argued that a certain degree of diversity—of professions, knowledge, ideas, etc.—in itself, as is only established in large-enough systems and networks, provides an important source of productivity which cannot simply be substituted and decoupled of scale. The latter is established by Bettencourt, Sammaniego, and Youn (2014) in a study of the diversity of U.S. metropolitan areas in terms of professions and employment and the resulting city-level productivity. This study provides a statistical rationale for the existence of urbanization economies beyond mere localization effects.

However, the results in Li and Liu (2018) based on 306 Chinese cities suggest that the (endogenous) spatial structure and polycentricity of cities is systematically related to their productivity. They report that the link between monocentricity and productivity is nonlinear: while smaller cities tend to have a higher productivity the more monocentric their structure is, (arguable due to congestion effects and dispersion forces) at some point a larger city size will entail a lower productivity if the monocentric city structure is maintained. Hence, as cities grow, a need of diversification within cities emerges in order to maintain ever higher productivity levels and productivity growth. In other words, for agglomeration economies to play out, it may be necessary to provide for some diversification of the type and spatial concentration of activity within cities. However, I mentioned before that these results need to be read with caution: after all, they are conditional on the chosen structure and location of infrastructure provision and other aspects of city planning.

Spillovers to firms from sources other than firms within agglomerations

One key player in generating spillovers of various kinds to firms is the education sector. Specifically, the real economic value of higher education and economic work for private businesses is a big economic question which looks back onto several decades of research effort. One of the eminent original contributions on this topic is the one by Jaffe (1989), who assessed time-series data on corporate patents, corporate R&D and university research at the U.S. state level. At the time, a particularly strong impact of academic, university-level research on more applied research in business was found in sectors where big front-end investments in general research were necessary, and examples of such technologies were identified to be of the pharmaceutical and medical kind, the electronics, optics, and precision instruments kind, and the nuclear kind. In the data analyzed by Jaffe (1989), R&D expenditures in the university sector of the average state amounted to only about one-sixth of corporate expenditures, but the direct elasticity to patents (which account only for a small share of innovations) of university research was about 0.1, an effect that should be deemed large. The overall (direct plus indirect) elasticity of university-research-induced corporate patenting was even found to be six-fold the direct one. A further bit of evidence in the same work also suggested that concentrated (as opposed to dispersed) university funding on research was more productive in triggering corporate innovations measured by patents.

What appears to be important in this regard is that the interaction between universities and industry is not one-way but multi-ways. On the one hand, academic research has become more open to applied research and basic and applied research are now stimulating each other in a way that was much less common only a few decades ago within universities (see Bentley, Gulbrandsen, and Kyvik, 2015). This and the orientation towards new funding opportunities have led universities to seek more actively collaborations with private industry, and the outcomes of such collaborations appear to be both ways beneficial (see Lee, 2000). Such collaborations stimulate industry innovations of the process and product kind, and they provide academic researchers with a pool of practical problems some of which require new basic research to be solved. There is evidence that academic researchers as well as applied researchers tend to become more

productive when measured in terms of research output through university-industry collaborations (as well as university-government collaborations) than otherwise (see Landry, Traore, and Godin, 1996).

On a more fine-grained micro-level scale, Furman and MacGarvie (2007) demonstrated that university research was instrumental for the set-up of laboratories, and, hence, applied research efforts by industry, in the pharmaceutical sector of the United States prior to and up until the end of World War II. One route through which such positive effects of universities can emerge are joint research collaborations through face-to-face interaction (see Mansfield, 1995). A second channel of influence happens through the set-up of start-up and spin-off companies as an offspring of university laboratories (see Rosegrant and Lampe, 1985; Rosenberg, 1990; Rosenberg and Nelson, 1994; Miner, Eesley, Devaughn, and Thekla Rura-Polley, 2001; Powers, 2003). However, while such success stories are sufficiently frequent, they are not guaranteed and ubiquitous, as the relatively poor performance of some significant academic institutions suggest (see Miner, Eesley, Devaughn, and Rura-Polley, 2001, on Johns Hopkins University for an example of low applied impact effects).

In any case, what appears to be important to consider here are two aspects. First, to the extent that universities engage in knowledge dissemination through publications and open-source solutions to programming and technology, they establish a dispersion force in terms of agglomeration economies. Hence, the public and open-source aspect of general and open-source applied research works against agglomerations. However, to the extent that universities engage in face-to-face interactions with industry, participate in applied research projects of private industry in the closed-source domain, train people with local preferences, and generate local start-up and spin-off companies, they generate agglomeration economies and benefit neighboring places, in particular, neighboring agglomerations and metropolitan areas (see Xue, 2006). In the latter regard, Wu (2007) portrays how the local government in Shanghai successfully used the strategic development of two universities to assist the metropolitan development. Moreover, Wu (2007) quotes Abdullateef (2000), Appleseed (2003), Mayer (2003) and Wu (2005) in providing wider evidence for universities as a conduit of the formation of dynamic industrial clusters within metropolitan areas.

Spillovers and small and medium-sized enterprises (SMEs)

The innovations and productivity of SMEs deserve some special attention in the spatial economy. After all, the growth potential–in terms of productivity as well as sales and profits—of SMEs is largest in comparison. Also the number of jobs as well as the amount of revenues—and taxes paid—dominates the business sector in most of the OECD countries and elsewhere.

SMEs appear to be particular beneficiaries of a co-location and, hence, of cluster policies with regard to sales and productivity, at least in some sectors and contexts. However, the evidence regarding the mechanisms driving the associated benefits is mixed, at least when concerning innovation and associated activities such as own and collaborative R&D efforts (see Davenport, 2005; Karaev, Koh, and Szamosi, 2007). Unfortunately, much of the earlier evidence on clusters did not pay specific attention to the heterogeneity of firms (SMEs versus other; exporters versus non-exporters; firm classes of particular types across sectors, etc.) so that future research will be needed to shed further light on their effectiveness and the role of spillovers. One specific missing element in the explanation of the heterogeneity in productivity, sales, and employment growth among SMEs appears to be the inclination towards modernizing production processes through information and communication technologies (ICT) as well as the ability to participate in global markets rather than relying only on domestic demand potential (see Ballestar, Díaz-Chao, Sainz, and Torrent-Sellens, 2020). Clearly, the latter is something that is reserved to SMEs in manufacturing and in selected services sectors.

The mixed evidence on the drivers—in terms of fundamentals, spillovers, and policy instruments—of the growth of SMEs suggests that it may be too short to look for independent workhorses of growth but that

intricate interactions drive the abnormally high returns to a few players and take them on the road to become superstars. One uncontested factor seems to be location as a driver of success, though, primarily also for access to global markets (see Forte and Sá, 2020). For policy making, the latter means that one might have to think in terms of instrument bundles rather than singular measures. However, the fact that the successful few are rarely catering to a domestic-only customer base (see Ballestar, Díaz-Chao, Sainz, and Torrent-Sellens, 2020; Kashiwagi and Iwasaki, 2020), and that they are users of modern technology makes transport and ICT infrastructure (and, apart from that, explicit trade-policy instruments for goods as well as services) in conjunction with research and education as well as training-oriented policies good candidates to look for synergies in policy making (see Marchese, Giuliani, Salazar-Elena, and Stone, 2019). An isolated place-based (or cluster-oriented) policy approach appears to be insufficient to target productivity and sales growth of SMEs.

Spillovers between agglomerations and their channels

When using a very broad notion of spillovers for any kind of interdependence in technology and productivity, one could add general equilibrium effects to the list of direct spillover channels above , as they cannot be controlled neither by actors (firms, households, factor owners, and even local governments). General equilibrium effects, factor mobility and, in general, the actions and choices either by large individual or a large mass of small actors induce changes not only at the location where these actions or choices are made but also elsewhere. As such, inter-regional spillover effects need to travel either with production inputs and outputs (including goods, services, capital, energy, etc.) or with people or other factors. Obviously, places that are better connected by way of infrastructure for transport in a broad sense (including railways, roads, ports, airports but also power lines, pipelines, etc.) face a larger degree of interdependence.

Earlier work suggests that such interdependencies decline with distance, but they do so in a nonlinear and even a non-monotonic way in geographical distance. The coexistence of relatively sparse high-speed and high-volume travel routes (highways, high-speed railways, long-distance overland power lines, etc.) with relatively dense low-speed and low-volume routes (local roads, regular-speed railways, local power-grid lines, etc.) generates a complex system of edges in the network of connections between places which is not simply proportional to distance. E.g., some metropolitan areas in China or France are geographically very distant but can be much faster reached by high-speed trains than some other locations which are one-third as distant. Also highways connect some more distant places so that one can reach them faster than closer ones. However, in big metropolitan areas the locations of access points to high-speed and high-volume transport systems generate nonlinearities in the land-value maps for housing and commercial use, and they create complex complementarities with other factors and attributes including the marginal value of low-speed and low-volume infrastructure investments.

On an interregional scale, it appears that transport networks induce the strongest spillovers through enabling goods and services trade followed by technology spillovers (see Egger, Loumeau, and Loumeau, 2020). Transport networks also create spillovers through amenities. The latter is the case, as they make high-amenity places better accessible from metropolitan areas that do not have specific amenities. E.g., Marseille on the Mediterranean coast of Provence can be reached from Paris by high-speed trains within about three hours, bridging a distance of more than 770 kilometers. Moreover, they induce subnational migrations. However, the latter two channels appear less important quantitatively than the transport of output and technology spillovers, at least in China. Hence, goods and services input-output-related (or production-side) spillovers appear stronger than mobility-related (or household-side) ones (see Egger, Loumeau, and Loumeau, 2020). It is important to consider that in the transport network, the low-speed and low-volume subsystem plays an integral and important role not only directly but also indirectly, as it provides access to the high-speed and high-volume routes. Therefore, the quantitative effect of the low-speed and low-volume transport system on spillovers is large.

Moreover, evidence on the role of transport systems for interregional economies suggests that high-speed and high-volume systems create strong interdependencies for regional hubs not only within countries, as they link places and agglomerations across national borders. Specifically, through the aforementioned springboard or facilitator effect, the national road system is a key element for cross-border spillovers not only in landlocked countries but also in ones that are mainly participating in global production through sea ports (see Jaworski, Kitchens, and Nigai, 2020).

One specific type of spillovers which connect large agglomerations and metropolitan areas is direct innovation spillovers. On the one hand, researchers and technicians involved in breakthrough innovations are mainly mobile between institutions in a few hubs of a country and in few large companies. On the other hand, highly-specialized knowledge is transferrable only or much easier between frontier companies and those locations which provide the complementary factors necessary to make their operations viable. In that sense, breakthrough and frontier innovations may generate spillovers at greater intensity between large centers in spite of big distance between them (see Simme, 2003).

A novel and specific feature of modern production is the organization of production in global value chains which almost seamlessly integrate agents (within and outside the boundaries of firms) across national borders. The reduction of not only shipping but also of communication costs has made the sourcing not only of material components but also of services inputs at long distance cheaper and easier. From a technological point of view, this means that the scope of specialization gains at the plant and firm level have increased for these technological (as well as policy) reasons. While there is a vast body of research on the gains from specialization and agglomeration at large, this body of work has not paid much attention to the specific role of global value chains, because research on the latter is in itself relatively young and vibrant. To that end, the results in Brancati, Brancati, and Maresca (2017), based on survey data on Italian industry, show that the organization of relationships within GVCs shape the extent of innovation of the involved firms, which is consistent with the evidence of Pietrobelli and Rabellotti (2011), suggesting that GVC participation boosts firms' innovation and technological upgrading. The early studies of Coe and Helpman (2015) and Coe, Helpman, and Hoffmaister (2017) established that trade and of Smarzynska Javorcik (2004) that multinational operations were important sources of technology and productivity spillovers between countries. In line with the macro evidence in Coe, Helpman, and Hoffmaister (2017), some recent research looked into the particular role of sourcing in global value chains as a means of technology and productivity spillovers. Yang, Hong, Wang, and Liu (2020), using data for China, find evidence of a differential effect of GVC participation and GVC positioning (upstream relative to downstream) on innovation performance: GVC participation exerts a U-shaped impact but GVC upstream positioning has a uniformly positive effect on innovation performance. Moreover, agglomerations tend to further impact these U-shaped and positive effects of GVC participation and upstream positioning, respectively, positively. Clearly, the evidence on positive technology and productivity spillovers—particularly, the international ones—is especially strong for developing and transition economies. However, the results of Coe, Helpman, and Hoffmaister (1997) and Yang, Hong, Wang, and Liu (2020) could be read in a way to suggest that input sourcing and GVC involvement can broaden the exposure to leading technologies. And in conjunction with internal scale economies at the firm level and with external scale economies at the regional level, this can have particularly strong effects on both innovativeness and productivity gains. However, further evidence will be needed to provide robust evidence for this hypothesis. Moreover, the role of GVCs for SMEs and of SMEs for GVCs will be an interesting object of study to better understand heterogeneous effects of agglomeration and co-location economies.

4 Roles of the public sector

The public sector serves three key roles in promoting productivity in agglomerations. First of all, it creates directly urbanization factors by financing institutions and amenities which work as attractions for mobile production factors and firms themselves. I view this service of the public sector quite broadly so as to include a framework of regulations (including regulations regarding buildings and transport facilities) which directly affect firm and factor location. Second, the public sector promotes specific types of location choices on the part of firms but also factor owners, e.g., by creating a tax environment and breaking specific local deals with individual firms to locate and co-locate. The latter includes the promotion and development of specific cluster programs to enhance productivity growth in particular economic areas and sectors. Third, the public sector affects urbanization and localization factors indirectly by providing specific regulations and policies which affect existing urbanization and localization factors (sometimes even in an unintended way). In this section, we will address these aspects separately.

Education and other institutions

The major education institutions at all levels (kindergartens, schools, colleges, universities) tend to be located in large metropolitan areas, at least, they occur there at a much greater density than elsewhere. However, there is an intricate direct relationship between the public sector through education and private-sector innovation and productivity which emerges through the following channels: the colocation of general and applied research through the training and employment of innovators; the explicit collaboration between colleges and universities and the private sector in applied research projects; and the foundation of spin-off and start-up companies by (the researchers employed in) colleges and universities. Moreover, there is an indirect relationship between the public sector and private-sector innovation and productivity through the use of policy instruments (tax instruments, land-use subsidies, the new denomination of land for commercial use, local and global transport-infrastructure investments, etc.) on the part of the (local and national) government to attract specific firms (multinationals, exporters, innovators, etc.).

With new developments—working from home and the digitization as well as robotization (see the subsequent section on this)—that might have repercussions for the intensity and type of the use of space in the core of cities, localization and urbanization factors may change in their geographical scope. If the benefit of colocation and location in the core of a metropolitan area or city has a wider geographical scope, it will be harder for some city governments to appropriate their advantages and easier for adjacent governments to partake in them. This will introduce a new dimension of a coordination problem and of competition between jurisdictions. In some jurisdictions, such problems emerged in the last few decades and they were solved by a horizontal integration of local governments through the merger of mega cities with towns and smaller cities in their hinterland. However, it is foreseeable that new developments might strengthen the position of cities' and metropolitan areas' outskirts and hinterlands to attract highly productive businesses that hitherto were compelled to locate in cities' cores. This might induce a new impetus for tax and expenditure competition and have far-reaching consequences for the tax bases of mega cities as well as their willingness to provide the basic financing at the root of urbanization factors.

Place-based taxes and other fiscal policies

The role of place-based tax policies for innovation on the one hand and agglomerations on the other hand has to be viewed through two lenses: the one on effects on the volume and structure of investments and the one on firm entry and incorporation and their interplay with agglomeration forces.

First of all, three layers of taxes are particularly relevant here, the ones on personal incomes, the ones on profits and business operations, and the ones on land. Many tax systems in the OECD are such that the tax code on these bases is homogeneous throughout the national jurisdiction, but not all of them are. E.g., tax codes on personal incomes exhibit three layers of jurisdiction from the federal to the state down to the county or municipality level in Switzerland and the United States. There are elements through which taxes on businesses vary by state in Switzerland and by municipality in Germany. And taxes on land vary across municipalities in Germany or the United States. Such variation helps local governments to obtain compensation for some specific provisions of public goods they undertake. Such variation in the tax code entails a variation in the level of taxes paid across subnational places in many countries. With the tendency of taxes to be higher in bigger agglomerations, place-based tax elements add to the dispersion forces in agglomerations and reduce the attractiveness of big metropolitan areas for factor owners as well as firms to reside there. Following higher land prices in bigger agglomerations, higher taxes and other fees in larger agglomerations may be the second-most-important cost-based factor to reduce the attractiveness of agglomerations to mobile economic actors.

Egger, Loretz, Pfaffermayr, and Winner (2009a) illustrate that corporate tax rates display a large degree of variation across firms not only between but also within countries. The reason for this heterogeneity is not primarily the one of the tax code itself but the heterogeneity of firm-level investment and financing structures. Typical corporate profit tax codes contain specific provisions regarding the deductibility or super-deductibility of specific types of tangible investments (in buildings, apparatus and machines, etc.) and intangible investments, primarily in R&D. Moreover, corporate profit tax codes contain provisions regarding the deductibility of debt and other forms of financing. The typical technology across sectors varies substantially, so that not only the share of intangible in tangible plus intangible investments but also the structure of financing due to the heterogeneity of collateral varies. Beyond that, firms with large internal capital markets such as multi-plant domestic firms and in particular multinational firms have extended choice sets relative to smaller and local players, respectively, in using internal capital markets and even capital markets across different countries due to large equity and a large volume and distribution (across jurisdictions and sectors) of collateral they can offer to external investors. Multinational firms are affected by yet another layer of the tax system which adds to the heterogeneity of corporate taxes, namely bilateral investment treaties, which contain provisions regarding royalties, debt financing, and profit repatriations (see Egger, Loretz, Pfaffermayr, and Winner, 2009b).

This heterogeneity of firms in their fundamental set up—which has a big sectoral component—leads to vastly heterogeneous tax rates across firms even if the tax code is homogeneous (see Egger and Loretz, 2010). The variation of personal-income relative to corporate-income taxes across places within a country leads to unintended effects on the incorporation decisions of firms (see Goolsbee, 1998). It is not neutral for the financing choices of firms. Da Rin, Di Giacomo, and Sembenelli (2011) demonstrate that higher (relative) local corporate tax rates reduce the local entry of incorporated firms all over Europe. Moreover, the variation in effective corporate income tax rates across firms with different R&D intensity and collateral has important consequences for the R&D investment choices and the related innovation output and ownership (see Bösenberg and Egger, 2017). All of these aspects together with the fact that agglomerations and big metropolitan areas host disproportionately more skilled labor and large, innovation-intensive, including exporting and multinational, firms as well as much of the financial sector, financing- and innovation-related profit-tax provisions are important place-relevant aspects even if they do not explicitly contain a place-specific component. A laxer treatment of innovation-related depreciation features in the tax code (through financing or intangible-investment provisions) benefits not only firms with a more

intensive use of such investments but also places that specialize in hosting such firms because of the relevance of urbanization and localization effects for them. And a laxer place-specific treatment of such investments due to place-based tax components may be justified if the colocation of such firms also generates external economies to other firms and the urban environment at large.

Place-based innovation policies

Akin to but apart from local tax policies, place-based innovation policies must be mentioned, as they share with tax policies that on the one hand they are faced with a business-steeling and beggar-thy neighbor critique (see Kline, 2010), but on the other hand with agglomeration economies they find some justification in the existence of externalities rooted in urbanization and (co-)localization externalities. There are limits in the extent to which place-based tax policy, if existent in a country at all, can be regulated (note that the OECD's Base Erosion and Profit Shifting initiative is an attempt to limit the extent to which such policies contain a country-specific element without addressing place-based components in some of the systems). However, the discipline regarding place-based investment and, in particular, innovation policies is stronger. E.g., the European Union regulates to which extent place-based funding policies (e.g., to foster convergence and cohesion among the subnational regions within and across countries) can be used. Specifically, it is regulated where geographically and for which targeted objectives most of the funding can be used (see Becker, Egger, and von Ehrlich, 2010, 2012, 2013), and it is specified under which conditions funding can be administered centrally out of the European Union's budget relative to local co-financing.

However, some place-based investment and innovation policies come under the umbrella of general innovation promotion, sector development, sustainable investment, and the transition towards smarter and more resilient (to environmental and other shocks) cities. In view of the regulations regarding regional subsidy programs within countries but even in supranational conglomerates such as the European Union in order to avoid beggar-thy neighbor externalities, place-based innovation policies emerge mostly by way of policy mixes which target explicitly the avoidance of environmental and other adverse externalities. They usually involve not only a mix of instruments but also of processes and provide an indirect support of sectors and places (see Magro and Wilson, 2019).

Most countries run place-based innovation programs of some kind. E.g., Germany has one in place which is called the Innovative Regional Growth Cores program (IRGC), which combines a set of policy instruments to foster a structural catching up in East German regions by fostering the ramifications to enable innovative processes. Rather than supporting individual actors (such as firms or local governments) in their private or public investments, it explicitly targets collaborative innovation efforts in pre-specified regions. Falck, Koenen, and Lohse (2019) use confidential firm-level survey data of mostly qualitative nature to quantitatively assess the causal effects of this program. They produce a number of interesting findings in this regard. For instance, they identify positive effects of R&D expenditures as intended by the program. However, these effects appear to be short-lived. Hence, very much aligned with the findings in Becker, Egger, and von Ehrlich (2010, 2012, 2013) regarding the European Union's Structural Funds program, regional assistance at large does not have lasting effects neither on the targeted regions nor on the targeted outcomes, at least not after a few decades of its application, and at least not to the extent (the volume) applied. Specifically, while Becker, Egger, and von Ehrlich found that at least at the margin and on average (though not everywhere) the EU's regional assistance program pays off and is not a wash, Falck, Koenen, and Lohse (2019) find that the induced spending on R&D by the program under their study was less than the costs of the program, in particular, when acknowledging the private co-financing on the subsidized firms' part. Hence, there crowing-out (i.e., substitution) effects of public funding in private investments appear to be the quantitatively important. Akin to the findings of Becker, Egger, and von Ehrlich (2012) on the EU's Structural Funds program, the findings in Falck, Koenen, and Lohse (2019) on Germany's IRGC program are nonlinear, and bigger funding amounts can be more likely a wash and waste. Finally, the externality on other, untreated firms appear to be negligible so that (co-)location factors do not

seem to be a good justification at least not for the program under their investigation (a view much shared by other studies with a focus on cluster policies at large). Among the factors which may be at the root of the low outcome of the assistance they indicate that the design of the program and its implementation may be key: there is (perhaps too) little regulation and monitoring as to which personnel expenses firms can use the assistance funding for. Hence, the governance of the particular IRGC program regarding the use of the funds on the firms' part may be a key reason for its low effectiveness.

A focus on innovation and, in particular, on the "Smart Specialization" was in itself an integral part the European Union's regional assistance and cohesion policy during the 20014-2020 programming period. The idea behind this agenda in this last programming period was to enhance the regional competitiveness through a focus on specific industries that draw on cutting-edge scientific knowledge and ones that are targeting sustainable and environmentally friendly technologies. E.g., the focus on promoting renewable energy as a growth engine in the Austrian state of Burgenland and on one enhancing green areas for territorial integration in the Porto Region of Portugal serve as examples here (see Solly, 2016). However, innovation-based policies may be even harder to evaluate than other ones, because of the public-good characteristic of (non-tacit) knowledge (see Barca and McCann, 2011). Yet, we need to be careful with concluding that the lack of locally contained large effects of innovation policy automatically mean that large global effects are induced. In the latter case, we would expect good reasons for administering such policies at a particular regional level were absent.

Overall, the targeted and on-demand generation of agglomeration externalities appears to be hard. The design of associated policies requires a rich set of rules regarding the implementation and monitoring to ensure that funding is used in a justifiable way, that externalities are generated beyond the recipients of funds, and that the effects are not short-lived. In any case, altering the extent and nature of agglomeration effects through local expenditures and subsidies appears difficult. While the focus on specific narrow initiatives seems tempting for reasons of policy communication and packaging, the evaluation literature suggests that narrow policies may be better suited for small to medium-sized places and broader ones for larger places like metropolitan areas. The reason is that policy stimuli for being effective require complementary investments and factors, and only if the latter are sufficiently abundant will a policy bear fruits that net out the costs and are longer lasting. The evidence on the nonlinearity (hump-shapedness) of the European Union's Structural Funds expenditures in terms of GDP and employment and growth outcome in Becker, Egger, and von Ehrlich (2012) appears to have over-arching implications on subsidies for outcomes from micro regions to countries.

City planning and infrastructure

As cities grow, they require a continued adjustment not only of the scope but also the type and mix of infrastructure provided by local governments. The old German school of public finance formulated two stylized facts—cast as laws—which establish a progressivity of public spending with population size, Brecht's law and Wagner's law (see Kaehler, 1982). In particular, Wagner's law emphasizes the need of restructuring and a disproportionate increase in public activity (specifically, funding) as agglomerations grow. The specific reasons for such disproportionate growth of public spending and, in general, efforts were seen in the challenges related to greater population density, urbanization, and economic restructuring. Regarding population density, an increased involvement of local governments appear justified as the aggregate sum of agglomeration externalities may grow with an increasing population level and population density in cities and metropolitan areas. According to Wagner's law, a higher population density puts external economies under the magnifying glass so that they become more obvious. As the process of urbanization goes hand in hand with a change towards a higher and supply of skilled labor and communication as well as a larger degree of inequality of incomes, living standards, profits, etc., across the economic agents within agglomerations, there is ever bigger demand on local governments to reduce the adverse effects of the associated polarization. Finally, the costs of land and need for the reduction of

emissions and congestion forces lead to a restructuring of economic activity in the agglomeration process. Also the latter requires an active local government to avoid adverse effects associated with employment churning and volatility.

In particular, local governments can engage in this process by delivering resources to the planning of cities, ranging from land denomination and zoning laws for the occupation of land for agriculture, commerce, housing, and recreation, the set up and location of public facilities such as administrative offices of the local government, courts and law-enforcement facilities, schools and universities, cultural institutions such as museums, theaters, and concert halls, monuments, health facilities including hospitals and pharmacies, etc. All of those do not only matter regarding their volume but also in terms of their location in conjunction with the public transport infrastructure which covers roads, tramways, subways, busses, walkways, pedestrian zones, bicycle lines, etc. In some sense, such planning involves a choice about the centricity of a city as well as the minimization or at least the optimization of the demand for transport in a metropolitan area for reasons of time savings, cost savings, and environmental concerns.

Overall, the planning locations of elemental institutions, transport systems and access points, and land dedication for specific uses are intricately related to the structure of cities in terms of their centricity (see Ke, Song, and He, 2009; Jiao, Wan, and Jin, 2017; Zhang, Sun, and Li, 2017; Li and Liu, 2018).

A dominant view in work on urban economies is that there is a U-shaped relationship between agglomeration-related scale benefits and city size (see Henderson, 1974; Fujita, 1989; Black and Henderson, 1999). In this regard, e.g., Au and Henderson (2006a; Chen and Zhou, 2017) document that, e.g., Chinese cities, in spite of the large average absolute size by European and North American standards, are too small, an effect which is largely owed to the local scarcity of complementary factors, in particular, well-suited labor (Au and Henderson, 2006b).

Taking stock, for the productivity of cities to grow sufficiently with agglomeration appropriate planning is key and, in particular, infrastructure investments which enable tapping not only the factor supply but also demand in other locations may be important (see Malmberg, Malmberg, and Lundquist, 2000).

Two important issues with mapping the skill-residence and income distribution in cities with the one of local infrastructure features are that until recently high-resolution infrastructure details combined with high-resolution skill and income distribution details were not available or available only for selected cities. The big-data revolution has changed this fact. In this regard, Glaeser, Kominers, Luca, and Naik (2018) document that prediction algorithms can be trained not only to predict the distribution of incomes and skill as a function of locally measurable attributes but the same algorithms can predict these outcomes also well outside their city-training environment.

A further note is warranted regarding the specialization gains for cities through Baldwin's (2016) "second and third unbundling". The ever further slicing of value chains and the concentration of production within plants and firms on high-relative-productivity segments of the value chain enabled growth through the second unbundling in both the developed and the less developed or transition parts of the world. For cities, the second unbundling is important for the following reason. In spite of an increasing diversity of the factor and output landscape within city and metropolitan boundaries as cities grow, the sorting of firms across cities will lead to a mismatch of local supply and local demand of both output and required inputs for superstar firms. Hence, the opportunity of tapping factor resources outside of the city boundaries as well as of customer bases elsewhere becomes key in enabling granularly large firms to grow beyond the bounds they could otherwise. This puts pressure on the infrastructure for the transport of tangible outputs and factors.

Apart from the importance of infrastructure in providing market access and allowing firms to super-specialize, it serves as a means of insurance against adverse local shocks in input supply and demand and enables a more stable market environment than with firms which have to absorb local shocks in full.

Baldwin's third unbundling through communication infrastructure and services provides for an additional source of specialization gains and permits firms to tap even immobile or less mobile (for preference reasons) skill resources.

Clearly, these unbundlings can be exploited only with coordination between local planners and governments in designing appropriate infrastructure environments and large companies which need them to exploit the mentioned super-specialization gains.

5 A glimpse into the future

Working from home and the reorganization of the workplace as a consequence of "guns and germs"

The recent past had been overshadowed by two types of incidents against which agglomeration and densely populated places are particularly vulnerable: violent and terror-type attacks on the one hand and infectious diseases on the other hand. For the standards and the number of large agglomerations, the frequency had not been persistent and the intensity not gravid enough yet to induce lasting and visible effects on agglomeration forces in cities. However, for diseases and after the temporary and localized Ebola, Dengue Fever, SARS, and MERS epidemics in previous years, Covid-19 induced a lasting and deep effect on human society which made a reorganization of the workplace inevitable for some businesses to avoid deep cuts in sales and budget and, eventually, not drop out of the market in the short term. One of the most notable changes in this regard was everything which relates to working from home: its acceptance and perception both on the part of employers and employees; its effects on the demand for travel to work (including public versus private means of transport, roads versus railways versus airplanes, etc.), its effects on the demand of work versus home-office infrastructure and associated (firm as well as private) investments; and, with regard to cities and agglomerations, the demand of office space and its type as well as the space within metropolitan areas; and, finally, its effect on productivity itself.

Collecting survey data on more than 15,000 individuals in the U.S. from the Covid-19 phase, Barrero, Bloom, and Davis (2020) provide evidence on the following facts. Their results suggest that all of the aforementioned effects are large temporarily, and many of them will not fully disappear even once the pandemic is overcome. They demonstrate that, while working from home had been looked down upon prior to the Covid-19 pandemic and crisis, its acceptance rose drastically since the spring of 2020 in the United States. This acceptance roots in a number of observations, which have to do with the experience. Specifically, they report on the following results.

First, while work from home was used only in 5% of the cases prior to the Covid-19 pandemic, its use rose to about 60% during the pandemic and is expected to stay at about 25% after the pandemic.

Second, productivity rose—quite contrary to the expectation of not only the directly involved parties but also of outsiders—in conjunction with work from home rose quite substantially on average, by about 13% during the pandemic. Barrero, Bloom, and Davis (2020) estimate that the lasting effect after the pandemic will still be about 2.3% ceteris paribus, which corresponds to about two-years real per-capita-income growth in an average recent year for the U.S. The roots of this productivity growth are largely time savings from commuting and (sunk) up-front investments to enhance the digital communication technology.

Some of the lasting effects will have material effects on cities as work and consumption places. Barrero, Bloom, and Davis (2020) conjecture that the lasting increase in work from home and the reduction of physical presence at the employer's address will have a number of consequences for city centers. E.g., the demand for transport means to go there will decline. The frequency and volume of shopping there will decline. They conjecture that spending might drop by 10% in Manhattan and the down-town area of San Francisco. As much of the shopping of produce in city center involves services intensively, this inevitably

means that the productivity of retail stores will decline in city centers. (The frequency at which shoppers visit stores is a key driver or productivity in retail and it may be the most important reason for the productivity gradient as one moves from the periphery to the core of a city consistent with Öner, 2018.) Moreover, the demand for office space will face change: whereas many offices were and are located in high-rise buildings, the future demand may likely shift from skyscrapers in the central business district where land prices and rents are high to office parks in less central places of a city where land prices and rents are lower. Such a change should go hand in hand with a substantial drop in rental rates in the central business district and relative land prices across places within a city. Barrero, Bloom, and Davis (2020) conjecture that we might see a substantial drop of everything—work presence, employment, consumption, spending on land and rents—in the core of cities relative to less central places in them.

Servitization and robotization

Servitization

Under servitization, economists understand a phenomenon which leads to an expansion of the intensity of services of produce, mostly manufactures. The idea is that pre-production, production, sales, support and maintenance as well as knowledge of how to best use a product and post-sales product upgrades are bundled as a package around a product so that what is understood as the "product" becomes transformed and turned into something more services-intensive. Clearly, this affects mostly manufacturing but also the associated upstream (tangible and intangible) input sourcing as well as the downstream wholesale, retail and post-sales service activities.

Think of the smile curve in value chains (see, e.g., Bösenberg, Merlo, Egger, and Wamser, 2018; Meng Ye, and Wei, 2020) which addresses the fact that the value added and contribution to profits is highest in the pre- and post-production slices of a value chain. These are the parts of production which (i) are most services intensive (including research and innovation in the upstream segments and marketing, advertisement, sales, repairs, upgrades and support in the downstream segments) and (ii) due to their low level of emissions and high profitability they are most suited to be located in city centers. Hence, a greater diversification of the respective service-intensive activities in the upstream and downstream parts of manufacturing's value chain does not only transform the demand for particular jobs but it also alters the demand for space in the periphery versus the core of cities, at least when thinking of such demand for space in pre-Covid-19 terms.

With the aforementioned aspects, the consequences for productivity and agglomeration are complex and extensive. E.g., Pinto, Morales Fedoruk, Kovaleva and Diemer (2019) outline a number of avenues through which the servitization of the steel industry alone may help transforming cities, inter alia by making them more sustainable. Specifically, they list energy production and supply, housing as fields through which servitization of the steel industry may transform the nature and type of supply but also the productivity of supply of cities in their transition to a more sustainable state.

However, the results in Desmarchelier, Djellal, and Gallouj (2020) clearly indicate that it would be too short to focus on manufacturing alone when thinking about the consequences of servitization. They emphasize two important aspects of the servitization. First, that even pure services activities—in their case, innovation—will be deeply affected by a greater servitization. They indicate that this is particularly true for the nature and setup of innovation networks. Second, they indicate that a closer interaction between the private and the public sector in developing servitization strategies and tools will be necessary. With a view on servitization as a key aspect in the transformation of private-sector productivity, the latter means that a delineation of private and public sector roles and contributions to productivity levels and growth will be more and more difficult if not impossible, and a more integrated view of private and public investments and provisions in determining private-sector productivity will be necessary. The latter could be particularly

important in the context of agglomerations and cities, as a greater servitization may transform the nature and extent of localization and urbanization externalities.

One issue that the Covid-19 pandemic brought to the limelight is that the deep specialization opportunities induced by the set-up of global value chains—which are arguably one driver behind the increasing trend in the specialization on services in many of the OECD countries in the new millennium—impose some threat to the resilience of local goods supply. The fact that the waiting times for certain appliances (washing machines, dryers, refrigerators, even certain cars) climbed to several months, at least between 2020 and 2021, speaks to the vulnerability of a world economy that relies on specialized inputs, whose production is heavily concentrated in small areas around the globe. We will have to see whether and to which extent firms and economies will be inclined to give up some specialization gains at some higher costs in the interest of greater resilience in the future. The latter will be important for the degree to which the servitization of the leading economies in the OECD will progress and continue or change its pattern. This will also impact the nature and organization of cities and the eventual need to redefine production zones for industry, therefore, something that runs against the experience of the past decades.

Robitization and the smart city

While factor scarcity is clearly one factor at the root of robotization, the term is associated with a fear of loss of control over structural change and the transition of particularly labor-intensive services sectors towards more capital-intensive production (see Costinot and Werning, 2018). The notion of factor scarcity in some sectors is widespread. Some of the sectors where apprenticeships are part of the career, at least, in Europe (carpenters, plumbers, electricians, roofers, etc.) have long-lasting traditions of training and education (typically over a period of three years) and a subsequent examination before obtaining a formal job title which allowed one working as a professional in a particular occupation.[5] Additional experience, training, and examinations are required before such individuals could open their own business in the respective occupation.

Factor scarcity is prevalent in professions that organize the mentioned occupations in apprenticeship trainings (e.g., in Austria, Germany, and Switzerland) but also elsewhere (e.g., in the United States), and such scarcity extends to service-sector jobs which require similar types (e.g., nursing and care in health) or even longer and higher types of education (e.g., engineers and medical doctors). A positive aspect of robotization of the respective professions and jobs—and such robotization ranges from plumbing, nursing, caretaking, and coffee-making and meal-serving robots to software-developing software, long-distance digital surgery, and digital medical diagnoses) is a relieve of factor scarcity with the consequence of more timely and comprehensive coverage of the potential customer base. Clearly, as the examples given already illustrate, the professions and jobs potentially affected by this change cannot be delineated by the requirement of formal skills nor the divide between manufacturing and services (see already Blinder, 2006a,b, on this point). The issue becomes particularly relevant for the topic of this survey, when recognizing that the robotization is already and will be getting involved more deeply in the very generation of innovation on the one hand (see, e.g., the progress in computer-aided software development in Spampinato, Fabregat-Traver, Bientinesi, and Püschel, 2018), and it will likely affect jobs and professions which are currently intensively demanded and supplied in agglomerations and cities. Together with the potential structural change on the magnitude and nature of demand on space and of jobs in core versus peripheral sites within cities due to the increasing use of work from home, the robotization has the potential to transform cities substantially and impose a need for structural change on the channeling of investments triggering localization and urbanization factors.

[5] Historically, from the medieval ages onwards those professions were largely organized in guilds which formulated their own rules regarding training, experience, and examination before specific job titles could be earned and awarded. The reason for this system at the time was the control of quality as well as of entry (and sales/profits).

On the way to developing smart versions of cities the automatization of transport as well as other services whose supply is limited not only for reasons of factor scarcity but also because of labor and working-hour regulations have the potential to experience a productivity boost and may induce subsequent productivity enhancements in linked private-sector domains.

Taming volatility and enabling resilience

The Economic and Financial Crisis and the battle against Covid-19 stimulated new public concerns regarding the exposure not only of countries but also of subnational locations and places. The most significant adverse shocks were recorded in large, and particularly well-connected places (see Egger and von Ehrlich, 2019, on evidence regarding the Economic and Financial Crisis) which were deeply integrated on a global scale and dependent on goods and services from elsewhere. In both crises, voices were raised to call for greater local resilience against shocks and for a better insurance against the break of production-chain links which could disable vital goods and services to the local economy. While the two mentioned crises were very different as one entailed an uncertainty-led demand shock (with the Economic and Financial Crisis) and the other one entailed a goods-supply shock (with the Covid-19), both evoked sentiments against globalization in a broad sense and an increasing debate about reducing the dependence on foreign demand as well as supply.

What is interesting with regard to the spatial economy is that the subnational places which are mostly dependent on and involved in global demand and supply networks are clearly cities and metropolitan areas. These areas had been exposed to the stimuli during the two crises in an above-average way. But while the amplitude of adverse shocks appears large in agglomerations, their recovery is relatively fast as well. At least, this had been the lesson after the Economic and Financial Crisis (see Egger and von Ehrlich, 2019). After all, it must not be forgotten that a lesser degree of network embeddedness is always good if shocks happen elsewhere (as shocks then cannot travel to a given place) but the opposite is true if adverse local shocks happen (as these will then not be shared with and cushioned by other nodes in the network). As an insurance against adverse shocks, diversity in specialization and production as well as demand appears to be a key factor. And this is exactly what large metropolitan areas tend to provide more amply than smaller places do.

In terms of output and productivity volatility, earlier work suggests that stable conditions fostering innovation are important as a remedy. And such conditions are typically provided exactly in big cities and metropolitan areas.

Moreover, another important topic related to volatility and resilience is the design of structures which permit reducing the exacerbation of but also the greater insulation from adverse climatic developments. Indeed, a large majority of efforts connected with and research on the topics “smart city” and “resilience” revolves around this very theme. On the one hand, cities face obstacles to adjust quickly to a restructuring in order to become more environmentally friendly, less dependent on pollution and emissions, and more resilient against shortages of traditional energy resources for mere scale reasons. However, they are endowed and can attract the human capital needed to implement pilot projects which could not be tested or realized in the green field. Moreover, many cutting-edge technologies related to sustainable resource and waste management require sufficiently dense populations to become effective. Hence, a few handfuls of cities and large agglomerations can for the latter reason be expected to be the key drivers of change in terms of sustainability with global repercussions.

Finally, the aforementioned digitization in connection with Baldwin’s third unbundling may induce a shift away from some energy-intensive activities (e.g., commuting and physical transport) to others (e.g., ones involved with the establishment of digital networks and infrastructure). Also the latter structural change might enhance the change towards a more sustainable resource use as the dependence on specific energy sources for the different purposes is heterogeneous to some extent, because travel and physical transport require to some extent mobile energy sources while the digitization does so to a much lesser extent. In

any case, these topics will be largely driven by cities and their planners and managers, as the provision of grid lines and related technical change undeniably benefits from the density of activity which is absent in peripheries.

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