Agglomeration and Networks in Spatial Economies

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I. Introduction

The modern analysis of economic relationships in urban space emphasizes the importance of agglomeration. Of course, the concept of agglomeration is itself not new. Informal discussions of "external economies of scale" can be traced back as far as Marshall (1890), and the concept figures prominently in textbooks written more than fifty years ago (e.g., Hoover, 1948). The novelty of the external economy lies in our newly acquired ability to model it precisely. This owes much to the insight of Fujita (1988) who demonstrated how the monopolistic competition model of Chamberlin (1933) could be adapted to generate spatial agglomeration of economic activities. These models made it clear that standard market processes based on price interaction *alone* could generate increasing returns, the "external economies" of agglomeration. The economic advantages of proximity are now quite explicit.

The concept of networks in space has undergone a parallel treatment, as modern methods have made the efficiency gains from networks quite explicit. At first glance, it would seem that network developments are unrelated to agglomeration. After all, agglomeration describes a point while networks consist of nodes, and links connecting these nodes, in order to facilitate transactions among agents. Yet these latter connections may lead to precisely the same external benefits that arise from agglomeration, and for precisely the same reasons. Indeed, networks among economic actors dispersed over space may act as a substitute for agglomerations of actors at a single point, providing some or all of the utility gains and productivity increases derived from agglomeration.

This essay hints at the complementarities between agglomerations and networks in providing benefits to market participants – benefits that arise from standard market

processes but which are external to individual participants. Insights about networks first arose from considerations of the nature of the firm and its natural boundaries. At about the same time, insights about agglomeration first arose from considerations of the spatial linkages among those boundaries. In the spatial context, networks play a role in facilitating exchange both within and between regional agglomerations. One issue is how this role differs in intraregional and interregional contexts. Another issue is the distinction between the tangible physical networks and the intangible "economic networks" that include transaction agreements and routinized arrangements (Williamson, 1975).

Our perspective on networks and agglomeration stresses distinctions between public goods and private capital, and among institutional forms. We suggest that the formation and efficiency of agglomeration arises from its character as public capital; households and firms in the same agglomeration share its benefits in common. In contrast, an economic network is private capital shared primarily by the network participants. Agglomerations also rely on public institutions which aggregate individual decisions. In contrast, economic networks arise from a collective decision by group members, generating a private institution. Networks are clubs in which exclusion is possible and price discrimination is the norm. Agglomerations cannot exclude economic actors from receiving benefits nor can they price these benefits efficiently.

II. Some History

A. Agglomeration and markets

During the decade after World War I, a consortium of economists at Columbia led by Robert Murray Haig (1926) reported the first extensive analysis of the co-location of firms and industries in New York. They considered, for example, the garment industry. The pattern of interfirm contact among designers, fabricators and marketers destined the industry to remain spatially concentrated, according to the authors, so as to rely upon face-to-face, local contact. When the researchers considered other industries (e.g., cooperage), they concluded that standardization enabled firms to be widely dispersed throughout the metropolitan region. Presumably, a modern interpretation would highlight the fact that transactions costs between agents were sufficiently low for these standardized products, so that proximity and local networks of buyers and sellers offered little advantage over anonymous market transactions in space. In contrast, the complex interactions in the unstandardized fashion industry are more efficiently accomplished through local networks.

Three decades later, a second burst of empirical analyses of big cities – New York again, but also London and Stockholm – extended these primitive insights. In New York in the 1950s, a group of Harvard economists sought to project economic and demographic conditions three decades into the future, and this practical objective provided academic researchers with a golden opportunity for intensive study of the fundamental factors affecting the development of industry and the location of economic activity. A central finding of this large scale study was the importance of "external economies of scale," that is, the cost advantages some firms can achieve when they

operate in the context of a larger local economy. The summary volume of these studies by Raymond Vernon (1962) includes a chapter devoted to the "rise and spread of external economies" and to the impact of these externalities on firm location and the well-being of central cities. Simultaneously, empirical studies of the Stockholm economy emphasized the economies achieved by firms in the location of their activities in proximity to the sites chosen by suppliers of inputs and purchasers of output. Significantly, these studies also emphasized the economic returns to the co-location of retail establishments, producer and consumer services, in cities (Artle, 1959).

In some part, the current emphasis on externalities and the growth of urban areas can be traced to the stylized facts about Stockholm, London and New York uncovered in the late 1950s. These developments emphasized the intrametropolitan location patterns of activity, the intensity of use, and the contribution of these factors to the growth of cities and metropolitan regions.

For example, *Made in New York*, a compendium of descriptive case studies of manufacturing in New York, includes the following passage (Hall, 1959):

> Rubbing elbows with others of their kind and with ancillary firms that exist to serve them, [firms] satisfy their variable wants by drawing upon common pools of space, labor, materials, and services. In more concise language, they can take advantage of external economies.
>
> The economies are external in the sense that the firm obtains them from outsiders, and they are economies in the sense that the firm can satisfy its variable or part-time needs in this manner more cheaply than it could satisfy them from within. The outsider, in turn, can afford to cater to the firm's fractional needs because he also caters to many other firms. The external economy may derive from an electrician or a sewing machine repairman or a free-lance photographer, responding to the call of a firm which does not need him full-time. ... It may even grow out of a revolving supply of specialized labor, such as garment workers accustomed to seasonal cycles, printers, staff writers, editors, or electronic engineers. Such a supply enables a firm to pick up employees quickly and let them go

> with equal suddenness, and makes it unnecessary to maintain a stable force of workers for an unstable demand.
>
> Thus, it is obvious that external economies reduce the cost of doing business just as labor and transport [savings] do. Indeed, there is no real line of demarcation.

This description seems surprisingly close to recent economic models in which the production of individual firms is competitive, with constant returns to scale, but there are socially increasing returns as aggregate production rises. In the world of these recent models, investment in real capital can have social benefits not reaped by private investors. The private investors are guided only by profitability, but the economy of the urban area is more productive due to the external effects arising from the location of investment.

The original applications of the modern endogenous growth models emphasized the "stock of accumulated knowledge." Ideas can clearly benefit others as much or even more than they benefit the inventor of the idea. Knowledge or human capital may be the most important example of the application of the theory of endogenous growth. Nevertheless, the real capital stock in cities has other important attributes which affect the growth of the economy in analogous ways – most especially their capacity for differentiation and diversity.

As noted above, the standardization of barrel manufacturing in the 1920s was associated with its decentralization to outlying parts of the metropolitan area. A central conclusion of the Hall (1959) volume, published almost 40 years later, detailing trends in the apparel, publishing, and electronics industries was the following:

> The chief common denominator in these manufacturing operations that were attracted more strongly to other places than to the [New York] region appears to be standardization. The rest of the country gained relative to New York in products whose specifications could be planned in advance with reasonable assurance. Large numbers of identical copies – house dresses, magazines, radio sets – could be poured out of the plants without making any changes in the design... But the fact remains that the manufacture of standardized products ... has shown pervasive tendencies ... to prefer locations far from New York.

Of course, this statement referred only to a single metropolitan region and only to a small number of industries studied intensely. But within these limits, the evidence showed that firms producing nonstandardized differentiated output were more strongly attracted to the urban core than those firms producing homogeneous products.

Empirical interpretations of agglomeration economies, including the studies mentioned above, are often incapable of distinguishing between different mechanisms or sources of the agglomeration benefits described. There are at lease three basic cases to be distinguished – although they may be interconnected in many concrete situations. In the first place, an entire industry may benefit from agglomeration, since the size of the agglomeration provides sufficient demand to allow individual firms with internal scale economies to develop differentiated products. Second, an individual firm may benefit from the option to buy more specialized inputs at lower transactions costs from differentiated input suppliers within the region. Third, an individual firm may benefit from information spillovers outside the market that arise from proximity within an agglomeration.

The economic consequences in the first two cases are generated through the market. The cases are symmetrical in the sense that benefits (or externalities) are generated simultaneously on the supply and demand side. In the third case, the productivity of an individual firm or of the entire region increases without affecting the availability of inputs or outputs within the region.

B. Networks and markets

More than six decades ago – shortly after the influential work of Haig and his associates analyzing spatial location in New York – Ronald Coase (1937) suggested a set

of criteria to indicate when it is efficient to decompose an organization into subunits that may interact through a market instead of interacting as part of the same entity. Coase's insight did not involve space, but it helped explain why organizations, under specified conditions, develop as distinct firms and why firms so integrated can perform more efficiently than subunits that interact through a market. The modern answer is that when interaction via the market makes transactions costs "too large," it becomes advantageous to organize interactions as processes that take place inside the firm.

To reach this modern formulation, economics had to pass through its "transactions-costs revolution" in the 1970s, with contributions by Alcian and Demsetz (1972) and Williamson (1979). One implication of this new approach to the analysis of market formation is a distinction among types of products: for some products, transactions costs may be inherently high, while for others, these costs may be negligible. An obvious question arises: How will the transaction arrangements vary across products for which transactions costs are high and those for which transactions costs are low? A systematic answer to this question brings us to the analysis of transaction networks.

The costs of economic transactions may be categorized as those of exclusion and those of interaction. The latter may be related to describing, inspecting and measuring the object of the interaction. Other aspects of a transaction that affect costs include search, negotiation, contract formulation, legal advice and documentation. It is evident that if the same pair – a buyer and a seller – is involved in similar transactions regularly and frequently, the pair will have an incentive to organize the transaction procedures and processes so that costs are reduced. They may routinize this interaction, thus forming a

transaction link between them. The buyer and seller represent nodes connected by a specified linkage. This, of course, reflects Coase's insight about the nature of the firm.

When a firm is established – with Coasean motivation – the action is nothing but the formation of a network internal to the organization for interaction among a set of interdependent subunits. The internal network is one extreme solution to the exchange problem. The other extreme solution is the pure market interaction with no transaction links. The latter has two components of infrastructure: a system of prices; and system of information dissemination about available options and their associated prices. In between these two solutions – intrafirm and the anonymous market – one can find agreements and established transaction links between and among actors. These nodes and links may form networks which reduce transactions costs. Their continued existence may reflect lumpy investments in transaction links. Absent any network, buyers and sellers can find each other at low transaction costs in "proximity markets," i.e., markets where the distances, perhaps spatial, between buying and selling are short. Such markets can be found in urban regions, and they become more ubiquitous as the urban size increases. This is a consequence of the structure of space, and it represents one aspect of the spatial externality described in the agglomeration literature.

From the transactions costs perspective, the nature of a transaction link or a more complex economic network is an empirical issue. In general, an economic network is an organization of interlinked agents combining some features of a firm and of the pure market. It internalizes some interaction costs and includes, at least implicitly, contingency agreements of the kind we find in market contracts. The incentive to form such economic networks comes from possibility to reduce transaction costs. When transaction costs are

distance dependent, transaction links have the potential of overcoming distance. At the same time, there are costs of establishing a network, and these transaction costs may be lower inside an agglomeration.

III. Some Theory

A. Agglomeration Theory

The heavily empirical research sketched out above emphasizes diversity and heterogeneity. The heterogeneity of products and the diversity of consumers lead to increases in well being. Interesting and powerful economic models of diversity and heterogeneity have been around for only about fifteen years and are still under development. These models are based upon the Chamberlinian perspective on competition and product diversity developed by Dixit and Stiglitz (1977), and first applied to space by Fujita (1988). This influential work considered explicitly the tradeoff between the output of goods and their variety.

Consider consumers: household well being depends on consumption of traded goods, housing, and a variety of local goods. The markets for traded goods and housing are competitive, while the differentiated local goods are sold in a monopolistically competitive market. If there is less differentiation among local goods, then variety is less important in household well being; greater differentiation means that variety improves consumer utility. Under reasonable conditions, the well being of a household in the city will be positively related to the aggregate *quantity* of local goods it consumes and to the *number* of types of these goods which are available in the economy.

Consider producers: the importance of a variety of locally produced inputs operates in a parallel fashion. Suppose that the output depends on labor, space, and a set of specialized inputs. Again, the markets for labor and space are competitive, while the differentiated local inputs are purchased in a monopolistically competitive market. If there is less differentiation among inputs, then variety loses its impact on output; greater differentiation means that variety has a greater effect on output. For example, the general counsel of a firm may operate alone. However, she may be more productive if assisted by a general practice law firm, and even better served by firms specializing in contracts, regulation, and mergers. Again, under reasonable conditions, output in the city will be related to quantities of labor, space, and also to the number of different producer inputs available in that city.

This analysis yields a remarkable conclusion: *Diversity and variety in consumer goods or in producer inputs can yield external scale economies, even though all individual competitors and firms earn normal profits.* The intuition works in this way: The size of the city and its labor force will determine the number of specialized local consumer goods and the number of specialized producer inputs, given the degree of substitutability among the specialized local goods in consumption and among specialized inputs in production. A larger city will have a greater variety of consumer products and producer inputs. Since the greater variety adds to consumer well being, it follows that larger cities are more productive, and the well being of those living in cities increases with their size. This is true even when all firms in these cities all earn a normal rate of profit.

The theoretical perspective outlined above includes two principal models. The first and the most highly developed is the core of urbanization economies. In demand, it emphasizes diversity and consumers' taste for variety; in supply, it emphasizes the productivity of specialized inputs in production. The second model is derived from quite another perspective, distinct from models that emphasize diversity. In this latter framework the focus is on firms or producers, and how their efficiency is enhanced by proximity and linkages achieved through agglomeration. At the firm level, the perspective is shifted from input diversity to forward and backward linkages among agents. These linkages may be of a pure-market type or may involve transaction links. These models inspired by Marshall are indeed models of agglomeration. However, these agglomerations representing linkages among firms may provide gains to smaller regions, as well as large urban areas. They can be termed localization economies as accurately as urbanization economies.

If we consider externalities arising from these linkages, two cases can be distinguished: input-cost externalities; and delivery-cost externalities. Both cases emphasize the consequences of proximity for transaction costs. A typical backward-linkage or input-cost externality arises from a firm's spatial location relative to input suppliers, providing inputs with lower transaction costs and potentially at lower prices. The same argument applies to the supply of labor inputs to the firm. The essence is that input supply at short distances reduces total costs of producers, and these linkages form an agglomeration. Producers can be better off locating where input suppliers are clustered.

Proximity advantages apply also to forward linkages. With proximity, transaction or delivery costs can be lower inside an agglomeration than they are when the product is delivered to buyers outside the region. Again, firms have an incentive to locate in an agglomeration where the demand from input-buying firms is large, and this reinforces the tendencies towards agglomeration.

In summary, within a market, agglomeration provides two sources of efficiency gains. In the first place, a diverse set of products are only exchanged inside the agglomeration, i.e., those products whose transactions costs increase strongly with distance. Distance-sensitive transaction costs imply that diversity is fostered in agglomerations. In the second place, transactions and transportation costs are lower with proximity. Firms with forward and backward transactions and transportation cost advantages have incentives to co-locate and to form an agglomeration.

B. Network Theory

The agglomeration economies described above emphasize the Chamberlinian model of monopolistic competition in which diversity plays a central role. The size of a market (or city) determines the diversity of inputs available to firms and the variety of consumer products offered to households. In this framework, the externality operates through well-defined anonymous market interactions.

A more comprehensive set of external economies, following Marshall, includes both pecuniary, market based, and non-market based externalities. Spillovers, a prominent example of the latter, may not be reflected in market prices. Are networks and transactions links unpriced spillovers, inefficiently supplied in the market? Not at all.

The key to pricing is the transactions costs associated with establishing specific links. Absent transactions costs, Radner's (1968) results are transparent. A competitive equilibrium with complete contracts exists for a network economy. This result provides the framework for pricing link-specific transactions costs in a network equilibrium (Nagurney, 1999). More complex and problematic network pricing issues arise when links involve set-up costs incurred by transacting parties. In this case, markets may remain incomplete and efficient prices need not be linear.

The prevalence of fixed costs for transactions links has consequences for dynamic adjustments in the market. Transaction patterns may be slow to change, or they may even appear rigid; this provides a motivation for interregional input-output models of trade (Isard, 1956). Of course, input-output coefficients and interregional trade coefficients are analytically meaningful only when they are fixed or when they change according to some systematic evolution. Thus, the path dependencies of trade patterns and regional coefficients (e.g., Sonis and Hewings, 1998) may reflect the structure of transactions costs.

What properties make the links of a network different from the market interaction? Link transactions often involve firms both as seller and buyer, making repeated and similar transactions. Importantly, transaction-link partners are identifiable and distinct. The interaction is not anonymous, and the agents can take prior interactions into account in each new transaction. Anonymity provides less information. Moreover, for a network, the institutional capital is private, distributed among the participating entities, each of whom may have made specific investments. The existence of this capital has consequences: Once the participants have invested in a network, future interactions

are affected by the sunk cost. However, before capital has been committed, the decision to form a link will take capital costs into consideration. Following Williamson, the profitability of a linkage is more likely if it is expected to be used during a longer time period, or more intensively.

Often the relevant transactions are repetitive variants on a specific kind of interaction. Typical examples are: modern production systems organized as supply chains; product assembly with a network for timing and delivery of components; wholesale producers who have links to firms supplying products and to retailers who are distributors of the final product.

Arrangements like these not only facilitate transactions across regional boundaries, but they also make it possible for firms to make location decisions that reflect advantages – sometimes dispersion in space, sometimes co-location (Polenske, 2002).

The formalization of network problems in spatial economics took two basic forms during the 1950s. One is derived from the regional and interregional input-output framework, which has the character of a pure network model in which everything – including the structure of prices – is determined by fixed delivery coefficients. But empirical applications of the interregional model have awkward interpretation. In principle, regions specialize in certain types of products and export excess supply to other regions. However, observations on trade flows invariably indicate that cross-hauling of the same products is the rule rather than an exception. When the input-output model is applied in the study of international trade, the results are invariably similar. Products, even when finely described, are recorded as two-way flows between nations at the same level of development. This embarrassment gave rise to the so-called Armington

assumption – a product is always differentiated from similar products by its origin. A similar product produced in and supplied in two different regions cannot be identical (Armington, 1969).

The second network model that was formalised early is the spatial price equilibrium model (Samuelson, 1952). For each product in this model, there is a set of supply regions and a second set of demand regions. The regions (agglomerations) are nodes in a trade network. Associated with each trade link connecting two nodes is a product-specific transaction cost. In equilibrium, a product flows only one way on any trade link. As noted above, this contradicts existing empirical observation that two-way flows are a generic phenomenon. But there is an alternative, modern solution – the Dixit-Stiglitz model of monopolistic competition with differentiated products developed in an international trade context by Krugman (1979). With this formulation, two trading regions will quite naturally exchange similar but differentiated products. Note the completely parallel way that network and agglomeration models have developed a common platform.

Intellectually, the gulf between international economics and urban and regional economics has, until recently, been large. The new ideas needed a decade or more to become intertwined. In retrospect, of course, these things are clear. Interregional and international trade flows are artifacts of an accounting system for flows. The statistical records of flows represent trade between firms located in different agglomerations or between different establishments of a multi-location firm. These flows arise from long distance deliveries that, to a large extent, are organised in networks. A part of these trade flows reflect standardized and homogenous products, such as basic foodstuffs,

chemicals, oil, electricity, which are traded anonymously. But these types of products do not dominate value of interregional and global trade. Paradoxically, international trade is characterized by differentiation which reveals a taste for variety.

Thus, we observe large agglomerations of diversified economies trading with other diversified urban agglomerations. This suggests two things. First, urban agglomerations with all their diversity still remain specialized vis-à-vis each other. Second, two-way flows of diversified products between urban regions provide even greater benefits to consumers and producers in urban regions. In this sense, the demand for differentiated products shows no sign of saturation. Trade development inside the European Union confirms these trends: intra-industry trade of diversified products continues to expand, even across large agglomerations (Balassa and Bauwens, 1988; CEC, 1996).

The story could end here. We have seen that agglomeration economies and network economies are two different, complementary ways of solving problems of market exchange. There is a clear relationship between the alternates, and diversity plays a key role. There is, however, another relationship between agglomeration and networks, focusing on the role of spillovers or communication externalities. Again, there are two basic approaches to these externalities, the pure market agglomeration and the pure network solution.

In the course of ordinary transactions between firms, information about technical solutions and product attributes can spill over between them. The firms learn from each other. The very fact that there exists private information, which can diffuse among firms, is in sharp contrast to a model where all relevant information is already available. The

diffusion mechanism is related to proximity. This implies firms can benefit by clustering together in an agglomeration or an industrial district. Empirical testing and verification often focuses on innovations – development activities as distinct from production activities. This is again different from the monopolistic competition model discussed earlier, in which new product varieties are available without cost.

Information and knowledge diffuse quite easily among firms that belong to the same transaction network. In this case, the spillover may be a by-product of transactions between firms in a network. As a consequence, a link or a network can function as a substitute for proximity in the process of knowledge diffusion. Moreover, networks can be designed to include spillover mechanisms. Thus, network links between firms can develop inside an agglomeration, and the existing literature offers one model depicting explicit linkages between firms in the form of so-called industrial complexes, and another model that focus on social networks related to firms in an agglomerations (Gordon and McCann, 2002).

Two hypotheses are associated with the knowledge-spillover model (Baptista, 1998; Glaeser, *et al*., 1992). The first is the so-called Marshall-Arrow-Romer proposition that knowledge diffuses between firms within the same industry. Hence, this mechanism can operate in smaller agglomerations. The alternative hypothesis presumes that innovation is especially stimulated by spillovers across industries (Jacobs, 1969). In this latter case, large urban regions are not only more efficient than smaller regions, they have an advantage in innovation, and their economies can thus grow faster.

The analysis of spillovers due to proximity and spillovers in networks suggests that agglomerations will have a more rapid development of technology, and hence faster

productivity growth. But the case is unproved. It may be true that innovations occur more frequently in regions that allow spillovers, but the value of an innovation is reduced when knowledge diffuses quickly to other firms. The current literature on innovation and growth in agglomerations and networks thus present an unfinished and inconsistent picture.

IV. Integration and Communalities

How can the benefits of agglomeration be achieved? If economic actors are sufficiently close in space, the anonymous market may achieve everything – shared inputs purchased on a market; retail firms separately owned, but located together to reduce shopping costs and to increase variety; efficient forward and backward linkages among firms. At a single point, of course, there is no distinction between a network relationship and an anonymous market relationship. All actors can make economic decisions with full information about alternatives, and nodes are simply co-located without linkages between them.

But suppose this spatial proximity cannot be achieved – for economic, political or technical reasons. Can any of the external benefits be realized anyway? The answer, of course, is that for many transactions, an established network reduces the effective distance between nodes, reducing the transactions (or transport) costs that would otherwise be prohibitive. When co-location is infeasible, networks may substitute for agglomeration.

This possibility of substitution means that small regions may survive and prosper – to the extent that networks can substitute for geographically proximate linkages, for

local diversity in production and consumption, and for the spillouts of knowledge in dense regions.

The technical developments which have facilitated networks are quite impressive, and clear examples of these substitution possibilities abound. Consider the diversity in consumption. In the recent past, outside of francophone countries it required a city of reasonably large size to offer a decent selection of French films. Now the universe of French language films is only a keystroke away from any isolated consumer – as are out-of-print books, jamon iberico, and participation in competitive chess tournaments. Many of the historical advantages in consumption arising from the specialization afforded by dense agglomerations can be achieved by networks in smaller urban regions or even rural areas.

Technical advance has meant that transaction conditions have improved over time, and this means that market agents can increasingly substitute agglomeration proximity for network contacts and vice versa. Improvements in technology alter the tradeoff between agglomeration and network solutions, and current cost conditions provide a stimulus for efforts to develop new routines.

How does this substitution function? Technology permits goods and services to become standardized. Standardization of complex commodities makes it possible to rely upon network solutions to achieve diversity in consumption and production.

The potential for substitution between dense agglomeration and network solutions in facilitating diversity is apparent beyond consumption activities. Analogies in the diversity of producer inputs, in linkages among producers and suppliers, and in knowledge spillouts are ubiquitous. Consider knowledge spillouts and externalities, for

example. This very conference and the organization being celebrated here in Philadelphia is a concrete example of the scope for substituting networks for physical agglomeration in diffusing useful knowledge. All the papers in this volume have been produced by collaborations, mostly intercontinental, using the informal networks and routinized interactions fostered by modern technology. The RSAI, the club facilitating this exchange, is a network which reduces the transactions and transport cots of producing knowledge. Information generated in networks of collaborators is diffused in face-to-face meetings, and the spillouts from these activities are inputs into further collaborations using network technology.

The emergence of agglomerative economies and the spread of these external economies by networks is the hallmark of regional development in the twenty-first century.

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