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A new place for transport in urban network theory: The urban logistic network

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GQ2 **Abstract**

GQ4 Transport history has developed in close association with urban network theory. GQ5 However, this association has often remained implicit and not conceptualised. This article starts from an overview of the historiography on urban networks to question the limitations of historical urban network theory by highlighting the connection between an incomplete mapping of hinterlands and the prevalence of a neo-Christallerian model in the interpretation of their network shape. The concept of the "urban logistic network" is proposed as an alternative historical approach that focuses on the interaction between urban systems on the one hand, and transport and mobility on the other hand. In particular, it enables to clarify the conflated concepts of gateways and hinterlands and constructs a taxonomy that allows the examination of network patterns on a variety of geographical scales. It also identifies the variety of network shapes that are created in urban systems by different logistic connections.

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Keywords
Urban network theory, urban logistic network, logistics, hinterland, gateways

Introduction

Established in the mid-1980s, the *urban network theory* has been one of the main frameworks for analysing connections in urban systems in the field of urban history. While this framework relies on trade and transport connections as links between cities and makes constant reference to transport history, transport has not been considered an essential subject in historical urban network theory. This tendency has recently been strengthened because of urban history's shift towards (mega-)urbanisation on a global transnational scale, where the interrelationship has been highlighted between cities through capital, financial movements and migrations rather than through the traditional focuses of trade and transport.[1] Sassen and Castell's works on global cities networks were certainly the underlying trigger for these tendencies in both contemporary urban studies and urban history.[2]

However, in contemporary transnational urban network studies, developments such as the central flow theory by Derudder enabled elaborated discussions of flow, networks and interurban connectivity on a global scale as well as the incorporation of transportation as a constitutive factor.[3] In contrast, Derudder and Taylor criticised historical urban network analysis as represented by Hohenberg and Lees for being unable to cover interurban connectivity and flow at a transnational and global scale. They pointed out that historians involved in urban network analysis largely circumvented intercity relations because they conceptualised the external relations of urban places using the market principle in Christaller's central place theory. This theory pivots on urban centres and their immediate hinterlands, connected foremostly by networks displaying linear and hierarchical dendritic shapes.[4] According to Derudder and Taylor, this framework is difficult to apply for a process that transcends hinterlands in a non-local horizontal city-to-city pattern of links, like in the central flow theory. This remark subsequently highlights this same framework as the core reason the historical urban network analysis was unable to turn transport into a constitutive and coherent factor.

How can we enable historical urban network analysis to deal with interregional connectivity? How can we turn transport into a constitutive factor in analysing connections,

[1] Peter Clark (ed.), *The Oxford Handbook of Cities in World History* (Oxford: Oxford University Press, 2013) and Giovanni Favero, Michael-W. Serruys and Miki Sugiura (eds), *The Urban Logistic Network: Cities, Transport and Distribution in Europe from the Middle Ages to Modern Times* (Cham: Palgrave Macmillan, 2019).
[2] Manuel Castells, *The Rise of the Network Society* (Oxford: Blackwell, 1996) and Saskia Sassen, *The Global City: New York, London, Tokyo* (Princeton NJ: Princeton University Press, 1991).
[3] Peter J. Taylor, Michael Hoyler and Raf Verbruggen, "External Urban Relational Process: Introducing Central Flow Theory to Complement Central Place Theory", *Urban Studies* 47 (2010), 2803–2818.
[4] Ben Derudder and Peter J. Taylor, "Central Flow Theory: Comparative Connectivities in the World-city Network", *Regional Studies*, 52:8 (2018), 1029–1040.

networks and urban systems in a historical framework? In this article, we propose a new approach, the *urban logistic network,* by sorting out three essential components that have hindered the historical urban network analysis to demonstrate interurban connectivity on a larger scale. The urban logistic network sets transport, trade connections and their logistics to the forefront in the understanding of the dynamics of historical change in urban networks.[5]

First, a thorough review of the historiography related to urban network theory is needed to demonstrate the broader meaning and linkages to other urban network models. Within the long-term development of historical urban network theory, the initial central place theories have been revised, complemented and improved, so that they could be applied to interurban relationships and broader interregional geographical scales. Key concepts such as hinterlands and gateways have been re-conceptualised as key nodes of the flow network between urban systems.

At the same time, within this development, conceptual conflations occurred. Because of this, Derudder and Taylor, as well as other contemporary scholars, viewed the arguments proposed by historians as limited and not applicable on a broader scale. Therefore, the urban logistic network approach needs to clarify the boundaries of spatial key concepts, such as hinterlands and gateways, as well as their position in a multiscalar setting extending from the local to the interregional and global level, integrating the often separated maritime and land geospheres into *terraqueous spheres.*[6]

In short, the urban logistic network provides a coherent mapping of urban networks. This mapping integrates both the local urban systems based on hierarchical central place theory and the global network connected by gateways.[7] We solve thereby the dichotomic assumption that a hierarchical principle should always prevail at the local level whilst global networks are mostly horizontal and polycentric. As Taylor and other contemporary urban network analysts point out, global relationships are far from being horizontal. Hierarchical tendencies emerge giving (dendritic) shape not only to a core and a periphery, but also to more complex structures.[8] Our urban logistic network approach thus denies the ontological differences in the local and global urban systems. However, this does not imply that our approach ignores the various scales' importance in determining different contextual mechanisms. Rather it is a way not to exclude the multiple agents and practices that create city networks, not only at the world level, as

[5] Giovanni Favero, Michael-W. Serruys and Miki Sugiura, "Introduction", in Giovanni Favero, Michael-W. Serruys and Miki Sugiura (eds), *The Urban Logistic Network: Cities, Transport and Distribution in Europe from the Middle Ages to Modern Times* (Cham: Palgrave Macmillan, 2019), 1–20.

[6] Romain Grancher and Michael-W. Serruys, "Changes on the Coast: Towards a Terraqueous Environmental History", *Journal for the History of Environment and Society*, 6 (2022), 11–34.

[7] Paul M. Hohenberg and Lynn Hollen Lees, *The Making of Urban Europe 1000–1950* (Cambridge MA: Harvard University Press, 1985) and Paul M. Hohenberg and Lynn Hollen Lees, *The Making of Urban Europe 1000–1994*, 2nd edition (Cambridge MA: Harvard University Press, 1995), 242–244.

[8] Peter J. Taylor, "World Cities and Territorial States: The Rise and Fall of their Mutuality", in Paul L. Knox and Peter J. Taylor (eds), *World Cities in a World System* (Cambridge: Cambridge University Press, 1995), 48–62 and Gran Therborn, "End of a Paradigm: The Current Crisis and the Idea of Stateless Cities", *Environment and Planning A: Economy and Space*, 43 (2011), 272–285.

Derudder and Taylor state,[9] but also at the "provincial level", which is usually neglected in theoretical debates on the nature of both contemporary urban and transport systems.[10]

Finally, to avoid a dichotomic opposition of hierarchical local hinterlands and horizontal global networks, we need – apart from mapping – also a better analysis of network shapes. Shapes are essential, as they serve as models for describing the dynamic configuration of urban systems and show the geographical varieties of that process. So far, the historical urban network analysis has adopted a combination of concentric or linear dendritic shapes in describing the dynamic configuration of urban systems. However, the identification of these simple patterns has also reinforced the city-hinterland setting and circumvented the exploration of flows within and between urban systems. To avoid that, the urban logistic network approach suggests using three shapes to describe urban systems: dendritic, polycentric and corridor.

The urban logistic network thus clarifies the conflated concepts of gateways and hinterlands, constructs a taxonomy that allows the examination of network patterns on a variety of geographical scales (from local to global), provides shapes for urban systems that are dynamic and time-sensitive and, finally, allows for a "scrutinous analysis at multiple points in time". We believe that this approach bridges urban history and transport history, which is essential in enhancing a new ontology of transport history that shifts the focus towards "movement as history".[11] For these purposes, the following sections provide reviews of historiography and taxonomy and subsequent proposals for the mapping of urban systems and network shapes.

Historiography of urban network theory

In 1933, the German geographer Walter Christaller created a model for urban systems with respect to three different principles (market, transport and administration), known collectively as the central place theory.[12] As Derudder has pointed out, this intraregional concept became the foundation of historical urban network theory. Christaller's model is based on the assumption that "consumers have to travel to the central place in order to buy the central goods".[13] Thus, transportation costs are crucial to determine the size of the sphere of influence. Christaller's market principle displays a number of nodes and central places that attract consumers from its "sphere of influence". This setting makes Christaller's model focus less on the interregional level. However, similarly important

[9] Derudder and Taylor, "Central Flow Theory", 1029–1040.

[10] Geoff Vigar, *The Politics of Mobility: Transport Planning, the Environment and Public Policy* (Abingdon: Routledge, 2002).

[11] Massimo Moraglio, "Seeking a (New) Ontology for Transport History", *The Journal of Transport History* 38:1 (2017), 3–10.

[12] Walter Christaller's *Die Zentralen Orte in Süddeutschland* was reprinted in English in 1966, see Walter Christaller, *Central Places in Southern Germany* (Englewood Cliffs NJ: Prentice-Hall, 1966). Christaller's predecessor von Thünen focused on logistics and the supply chain of agricultural products: Johann Heinrich von Thünen, *Der Isolierte Staat in Beziehung auf Landwirtschaft und Nationalikonomie* (Berlin: Hempel & Parey, 1875).

[13] Kathrin Fischer, "Central Places: The Theories of von Thünen, Christaller, and Lösch", in H.A. Eiselt and Vladimir Marianov (eds), *Foundations of Location Analysis* (New York NY: Springer, 2011), 471–505.

is the approach to urban systems by the American economist William Reilly in 1931, which included the dimension of urban hinterlands.[14] Both models discuss intraregional relations focusing mainly on land routes, explaining the mechanism by which a location/city grows in relation to other locations in the hinterland.

During the 1960s and the 1970s, James Vance Jr. broadened the urban systems' geographical scope by incorporating long-distance international trade flows.[15] He criticised the "mechanistic application of ahistorical central place concepts" and explained the historical development of the American urban system. Vance's model was vital in facilitating the transition from a "central place model" to a "network model".[16] Long-distance trade, in his view, was the result of producers trying to find a market for their products and consumers seeking access to these goods, helped by wholesalers and middlemen, who created a system of staples, depots, entrepôts and transport infrastructure to forward the flow of goods. Thus, urban nodes were incorporated into long-distance trade. Vance also assumed a heterogeneous terraqueous environment that included rivers and oceans, as well as nodes and infrastructure built upon commercial relations and historical dynamism. As such, wholesalers and merchants became the foremost promoters of transport. Vance also stressed the role of contemporary mercantile policies, presenting the possibility that parties involved in forming and using transport networks were asymmetrical.

Vance did not look at the evolution of urban systems from the standpoint of size or population, but more from the cities' accessibility to other cities. This model facilitated network analysis based on the historical development of transportation. Michael Conzen, for instance, applied Vance's model to the early nineteenth century interurban railroad network.[17] He developed a passenger analysis asserting that it was essential to track and analyse frequency, price, service content or route choice. In this way, hinterlands were redemonstrated from the point of view of transport development. In American urban historiography, both railway and airplane passenger analysis were developed in tandem. Interestingly, Vance's theory was applied in some extra-European contexts, but was barely mentioned in historical studies on European urban networks.[18]

Another model that focused on long-distance trade and transport development in the 1960s, was the interport (network) model by the Australian geographer Peter Rimmer.[19] In explaining the development of the Australian seaports, Rimmer did not adopt

[14] William J. Reilly, *The Law of Retail Gravitation* (New York NY: Knickerbocker Press, 1931).
[15] James E. Vance Jr., *The Merchants' World: The Geography of Wholesaling* (Englewood Cliffs NJ: Prentice-Hall, 1970).
[16] Zachary P. Neal, "From Central Places to Network Bases: A Transition in the US Urban Hierarchy, 1900–2000", *City & Community*, 10:1 (2011), 49–75.
[17] Michael P. Conzen, "A Transport Interpretation of the Growth of Urban Regions: An American Example", *Journal of Historical Geography*, 1:4 (1975), 361–382.
[18] Vance's approach is scarcely applied to European cases. One exception is Jan Jacob Trip, *What Makes a City? Planning for "Quality of Place": The Case of High-Speed Train Station Area Development* (Amsterdam: IOS Press, 2007).
[19] Peter J. Rimmer, "The Search for Spatial Regularities in the Development of Australian Seaports 1861–1961/2", in Brian S. Hoyle (ed.), *Transport and Development*. The Geographical Readings Series 7 (London & Basingstoke: Palgrave Macmillan, 1973), 63–86.

Christaller's central place system, but focused on the impact of inland transportation routes and maritime trade. Rimmer's model dynamically showed how transport routes, trade flows and ultimately the hinterland developed over time. His network model can be considered the most transport-driven, as it was further developed by linking shipping networks, supply chains and global urban centres.[20] Early modern trade historian Clé Lesger reintegrated Rimmer's model into a trade-driven historical model and explained the life cycle of harbours in the Low Countries during the sixteenth and seventeenth centuries. From there, he developed a specific concept of gateway, which was in stark contrast to the traditional staple market theory. Lesger highlighted the fundamental role of the inland interurban common carrier shipping system (*beurtveer*), emphasising the importance of tracking the dynamism of commodity flows rather than the accumulation at a central place.[21] In this way, his "gateway system" demonstrated how multiple levels of intraregional, interregional and international trade were mutually connected.[22]

Even if the models of Vance and Rimmer had a profound impact, Jan de Vries was the founder of historical urban network analysis.[23] De Vries' urban network theory is a model of urban systems based on flexibility and competitiveness rather than on the stability and hierarchical relationships demonstrated by the central place theory. His framework introduced key terms such as links, nodes, hinterlands and gateways. In urban network theory, cities are nodes; and each node is linked to another by trade/transport routes. The emergence and development of cities and their urbanisation/de-urbanisation processes are discussed in terms of how the urban network developed. This theory, combined with a surge of interest in the demographic history of urbanisation, succeeded in providing a comprehensive and interregional understanding of urban development in Europe.

De Vries substantially contributed to establishing urban network theory in a separate work, *Barges and Capitalism*, in which he demonstrated the operation of passenger towing-barge canal transport in the Dutch Republic between 1650 and 1850.[24] He incorporated the analysis of frequency through timetables and presented a route diagram or transport model. Additionally, comparing canal transport with railways (which were introduced at a later period), he discussed the background of consumer/passenger choices and decisions reflecting the social savings.[25] This work was highly welcomed

[20] Peter J. Rimmer, "Global Flows, Local Hubs, Platforms and Corridors: Regional and Economic Integration in Northeast Asia", *Journal of International Logistics and Trade* 1:2 (2004), 1–24.

[21] Clé Lesger, *Handel in Amsterdam ten tijde van de Opstand. Kooplieden, commerciële expansie en veranderingen in de ruimtelijke economie van de Nederlanden ca. 1550–ca. 1630* (Hilversum: Verloren, 2001).

[22] Miki Sugiura connected the model to the merchants divisions' functions and argued that the *beurtveer* shipping system went hand in hand with the growth of middle-layered specialised merchants: Miki Sugiura, "The Early Modern Dutch Distribution System: The Growth of Specialised Merchants in Amsterdam 1580–1750", *Socio-economic History* 70:1 (2004), 49–70 and Miki Sugiura, "Port Cities and Inland Distribution. Merchants' Functional Divisions between Early Modern Amsterdam and its Hinterlands", in Robert Lee and Paul McNamara (eds), *Port Cities and Hinterlands* (London: Routledge, 2021).

[23] Jan de Vries, *European Urbanization 1500–1800* (London: Methuen, 1984).

[24] Jan de Vries, "Barges and Capitalism: Passenger Transportation in the Dutch Economy, 1632–1839", *Bijdragen van de Afdeling Agrarische Geschiedenis*, 21 (1978), 33–398.

[25] This aspect was later elaborated in his discussion on "industrious revolution": Jan de Vries, *The Industrious Revolution: Consumer Behavior and the Household Economy, 1650 to the Present* (Cambridge: Cambridge University Press, 2008).

by both transport and economic historians, with transport historian Roderick Floud noting "every reader of this journal [the *Journal of Transport History*] should read this study".[26]

In contrast to de Vries, Paul Hohenberg and Lynn Hollen Lees provided a "dual system" or a model fusing both urban network and central place theory.[27] Covering the interactions and impacts of both long- and short-distance trade from a long-term perspective (1000–2000 CE), their model has become the most accepted method of describing urban systems. However, their work did not fully explain the issues associated with the integration of long- and short-distance trade and transport. Hohenberg even suggested in his later synthesis that the best way of fusing these theories is to apply them selectively according to the situation in which cities were positioned.[28] For example, cities that had long-standing reliance on water (more rarely caravan routes) transport would participate in network relations. The network system was described as "a spatially fluid system where distance as such counts for little". Similar to other economists, economic historians and geographers, Hohenberg defined the network in which cities participate as characterised by an "absence of distance" enabled by the development of transport.[29] From this perspective, Hohenberg stressed the critical role that water transport and railways played in the formation of urban networks by diminishing transport costs, but did not proceed to analyse the actual transport systems.[30]

Urban network theory was thus established through the evolution of theories from Riley (1931), Christaller (1933), Vance (1970), Rimmer (1973), de Vries (1981, 1984) and Hohenberg and Lees (1985). Riley and Christaller explored the relations between a city (central place) and its hinterland, whereas Vance, Rimmer, de Vries and Lesger focused more on historical developments, transport, commercial interplay and long-distance trade. Hohenberg and Lees suggested that both central place theory and network analysis were the underpinnings of urban systems.[31] In terms of transport, the

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[26] Roderick Floud, "*Barges and Capitalism* by Jan de Vries (Book Review)", *The Journal of Transport History*, 2:1 (1981), 75.

[27] Hohenberg and Lees, *The Making of Urban Europe 1000–1950*.

[28] Paul M. Hohenberg, "The Historical Geography of European Cities: An Interpretive Essay", in John Vernon Henderson and Jacques-François Thisse (eds), *Handbook of Regional and Urban Economics*. Handbooks in Economics 7 (Amsterdam: Elsevier, 2004), 3021–3052.

[29] Bert De Munck, "Re-assembling Actor-Network Theory and Urban History", *Urban History*, 44:1 (2017), 111–122, here 114.

[30] Masahisa Fujita, Hideaki Ogawa and Jacques-François Thisse, and subsequently Paul Krugman, vigorously developed the field of new economic geography and reincorporated the classic central place theory models into spatial economics modelling. New economic geography succeeded in establishing a theoretical logic of the dynamism of spatial allocations covering multiple levels of scales that range from intraurban to global, see Masahisa Fujita, Hideaki Ogawa, and Jacques-François Thisse, "A Spatial Competition Approach to Central Place Theory: Some Basic Principles", *Journal of Regional Science* 28:4 (1988), 477–494. Here again, diminishing transport cost is emphasised as a force for city formation as well as for industry cluster formation. In this approach, transportation and logistics industry are themselves analysed through clustering in multiple levels of scales, most prominently at the international level, see Paul Krugman, "Increasing Returns and Economic Geography", *Journal of Political Economy* 99:3 (1991), 483–499 and Paul Krugman, "On the Number and Location of Cities", *European Economic Review* 37:2–3 (1993), 293–298. However, this spatial economics model is usually not counted as an urban network model.

[31] Evert Meijers, "From Central Place to Network Model: Theory and Evidence of a Paradigm Change", *Tijdschrift voor Economische en Sociale Geografie* 98:2 (2007), 245–259 and Pim Kooij, "Het stedensysteem in België. Observaties van 'over de grens'", in Crédit communal (ed.), *Le réseau urbain en Belgique dans une*

Hohenberg and Lees double setting led to a generalised a priori understanding of the role of transport in the creation of urban systems/networks.

A new mapping: Reconsidering hinterland, foreland and gateways

As noted, conflation of key concepts (hinterlands, gateways and forelands) occurred when urban network theory was expanded to larger geographical scales. In this paragraph, we trace the development of these key concepts within the historiography, point out their problems and address these issues by proposing a new cohesive mapping. It was not until de Vries (1981) or Hohenberg and Lees (1985) that the term "gateway" became widely used in urban network theories. This term also stressed the concepts of hinterland and foreland.[32] The importance of these three key concepts is paramount in the aforementioned theories of Vance (1970) and Rimmer (1973), even if they did not rely on these terms.[33] Nevertheless, these key concepts opened up urban network theory to a global scale.

The urban density within this global network of cities is not homogeneous and de Vries called the denser parts, or the parts rich with cities, "urban archipelagos".[34] The cities within these urban archipelagos are linked to each other by a myriad of roads, rivers, canals, railroads, and motorways. It is these transportation lines – or their transport geography – that make, shape and structure urban systems.[35] The different urban systems are connected to each other through a handful of transportation lines bridging the less dense part of the network. The city or node in the urban system from which a transportation line departs to another urban system is called a gateway.[36] Gateways are thus transport-geographical concepts. On the one side of the gateway is the hinterland, which is an urban system, or as the Austrian-American geographer Guido Weigend puts it, an "organized and developed space which is connected with a port by means of transport lines, and which receives or ships goods through that port".[37] The French

perspective historique (1350–1850). Une approche statistique et dynamique. Actes du 15e Colloque International. Spa, 4–6 September 1990. Collection histoire Crédit communal 86 (Brussels: Crédit communal, 1992), 509–520, here 514.

[32] Hohenberg and Lees, *The Making of Urban Europe 1000–1994*, 63–65; Kooij, "Het stedensysteem in België", 514 and Lesger, *Handel in Amsterdam*, 183.

[33] Both authors described for instance gateway functions as port functions. The notion of gateways was already mentioned by Roderick Duncan McKenzie, *The Metropolitan Community* (New York NY & London: McGraw-Hill, 1933).

[34] Jan de Vries, "Problems in the Measurement, Description, and Analysis of Historical Urbanization", in Ad van der Woude, Jan de Vries and Akira Hayami (eds), *Urbanization in History. A Process of Dynamic Interactions* (Oxford: Clarendon, 1990), 43–60, here 49.

[35] Wim Blockmans, "Des systèmes urbains: pourquoi?", in Crédit communal (ed.), *Le réseau urbain en Belgique dans une perspective historique (1350–1850). Une approche statistique et dynamique. Actes du 15e Colloque International. Spa, 4–6 September 1990*. Collection histoire Crédit communal 86 (Brussels: Crédit communal, 1992), 243–248, here 245.

[36] According to the British geographer James Bird gateways can be described as places "that link a home region […] to the rest of the world via international transport". James Bird, "Gateways: Slow Recognition but Irresistible Rise", *Tijdschrift voor Economische en Sociale Geografie* 74 (1983), 196–202, here 196.

[37] Guido G. Weigend, "Some Elements in the Study of Port Geography", *Geographical Review* 48 (1958), 185–200, here 192–193 and 195.

maritime transport geographer André Vigarié called this relation from hinterland to port to maritime transport the *triptyque portuaire* or port tryptich.[38] In 1958, Weigend added forelands to Vigarié's triptych. Forelands can be described as "land areas" or urban systems lying "on the seaward side of a port, beyond maritime [or ocean] space".[39] By adding the foreland on the other side of maritime transport, Weigend turned Vigarié's triptych into a double triptych.[40]

By adopting this double triptych, Hohenberg and Lees differentiated themselves from Christaller and were able to establish interregional trading relations. However, the only interregional relations that exist in their theory are of a maritime nature, and are those between the hinterland and the foreland. Hohenberg and Lees explain: "A city in the Network System functions as a gateway for the towns in its regional *hinterland* and is linked to the larger network via its *foreland*".[41]As such, hinterlands in the urban network theory can be described either as an endless dendritic organised isotropic plain or as a limited cluster of cities which is only connected to the larger network through its gateway's maritime activities.

When describing long-distance trade in coastal areas dominated by a major port, such as Venice, Amsterdam or Hamburg, the urban network theory works relatively well. But as soon as more continental cities, such as Milan, Vienna or Frankfurt, have to be positioned in the global network, Hohenberg and Lees are unable to explain interregional (or long-distance) overland trade. Indeed, the urban network theory simply incorporates every inland city, whether a metropolis or a small hamlet, in a geographically deterministic dendritic-shaped network leading to one specific port city/gateway. In other words, Hohenberg and Lees have transferred all of the central places' attributes to maritime gateway cities. Port cities have thus become the primordial players in the urban network theory, and inland cities have been viewed as if they can only trade with other urban systems through port cities or maritime gateways.[42] Hohenberg and Lees' dendritic network of transport lines turns hinterlands into *cul-de-sacs* or dead ends, leaving only a well-defined geometrical territory for each inland city to cater for.[43] Dominated by maritime gateways, the urban network theory has been remodelled into a new kind of central place system, with little room for geographical variety (shapes), agency (for both the network's builders and users) and games of scale. To break with this deterministic and neo-Christallerian outlook, it is necessary to link the urban

[38] Jacques Charlier, "Le tryptique aéroportuaire Lyonnais: une analyse géographique des installations, du trafic, des horizons aériens et de l'aire de desserte terrestre de l'aéroport de Lyon-Satolas", *Revue de géographie de Lyon* 56 (1981), 115–163, here 131–132 and Delphine Dubreuil, "Le triptyque portuaire est-il toujours pertinent? L'exemple des services maritimes du cabotage", *Flux* 59 (2005), 46–58, here 46–47.

[39] Weigend, "Some Elements in the Study of Port Geography", 192–193 and 195.

[40] To describe this relation the Belgian geographer Jacques Charlier introduced the term "double triptych". Charlier, "Le tryptique aéroportuaire Lyonnaiss", 131–132. Bird referred to Weigend's model as the "extended triptych". See Bird, "Gateways: Slow Recognition but Irresistible Rise", 200.

[41] Hohenberg and Lees, *The Making of Urban Europe 1000–1994*, 63.

[42] It is interesting to note that quite a few of those authors who have developed urban network theories over the years were predominantly coming from maritime nations.

[43] Bird, "Gateways: Slow Recognition but Irresistible Rise", 197–199; Hohenberg and Lees, *The Making of Urban Europe 1000–1994*, 63–65 and Lesger, *Handel in Amsterdam*, 188–189.

system/hinterland's landward side by long-distance overland transport connections to other urban systems or hinterlands. By creating multiple in- and outlets for long-distance trade, the urban system or hinterland's transport network will lose its dendritic form. This allows for a far more diverse urban landscape.

We suggest two modifications to the existing spatial setting: mapping the hinterlands' borders and introducing new concepts such as land space, rearland and continental gateways.[44] Firstly, hinterlands should be limited in space. Whereas Christaller demarcated his *umlands* by well-defined hexagons, Hohenberg and Lees' urban network theory has a lack of boundaries. Drawing borders is not an easy task, as it is contingent on the research's scope. According to Lesger the borders of both urban systems/hinterlands can be interpreted in various ways, depending on the discussed commodities, modes of distribution and means of transportation.[45] But only by limiting urban systems/hinterlands in geographical space, it is possible to consider interregional scale.

Secondly, after delineating urban systems/hinterlands, it is important to describe what lies outside their boundaries. Rimmer (1973) showed that urban systems/hinterlands can be surrounded by an urban void or at least by an area less dense in urban settlements. A good example is the Rhodanian urban system (France's Rhône valley) and the North Italian plain separated by the Alpine urban void. Over time, however, urban systems/hinterlands can grow towards each other, and in the end, they can merge and form a single system, but they can also subsequently break apart.[46] The latter stage is well illustrated by dense areas separated by tightly controlled international borders, such as the Hannover-Magdeburg urban corridor by the Inner German border or the Iron curtain during the Cold War. Disappearing borders, expanding transport networks, growing interdependent economies, etc. can make urban systems unite, creating new and larger systems such as the European Blue Banana (Benelux–Rhineland–Milan axis).[47]

We suggest calling these peripheral areas that separate urban systems/hinterlands from one another: land space. This is by analogy to ocean space. Even if it remains connected to the global network, land space is characterised by a lower level of human activity and is transport-wise less well-structured. Most of the land space consists of mountain chains, deserts, forests, marshes, moorlands, etc., but also less densely populated and extensive agricultural regions, such as the Champagne-Picardy plains in Northern France (which separate the Lower Seine-Parisian urban system from the Blue Banana) must be considered.[48] In addition, we introduce the concept of rearlands, as an urban system/hinterland beyond the periphery or land space. Like the foreland or the hinterland, the rearland exports and imports goods to and from other systems by maintaining overland long-

[44] Favero, Serruys and Sugiura, "Introduction", 8–9.
[45] Lesger, *Handel in Amsterdam*, 20.
[46] Rimmer, "The Search for Spatial Regularities", 64 and Vance, *The Merchants' World*, 151.
[47] Roger Brunet, "Lignes de force de l'espace européen", *Mappemonde. Revue trimestrielle sur l'image géographique et les formes du territoire* 17 (2002), 14–19, here 15 and 19.
[48] Lesger referred briefly to continental gateways. Clé Lesger, *Hoorn als stedelijk knooppunt. Stedensystemen tijdens de late Middelleeuwen en vroegmoderne tijd*. Hollandse studiën 26 (Hilversum: Verloren, 1990) 15 and Lesger, *Handel in Amsterdam*, 19–20.

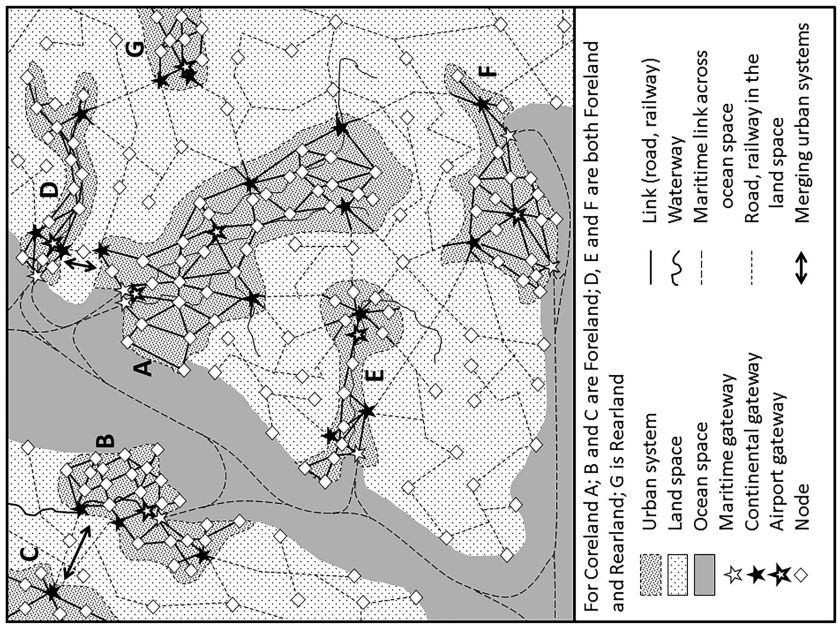

Figure 1. The "rearland–hinterland–foreland" relation or triple triptych.

distance trade relations and transport routes. When adding the rearland to Weigend's double triptych we obtain a new chain of urban relations. We call this the triple triptych:

REARLAND ←→ Land space ←→ CORELAND ←→ Ocean space ←→ FORELAND (Referential Hinterland)

In this triple triptych, hinterland is replaced by the term "coreland". The coreland is not more central or more important than other urban systems/hinterlands. It is the core because it is the researcher's referential hinterland. By introducing the coreland, we can see the foreland as the urban system/hinterland across the ocean space, and the rearland as the one on the other side of the land space. Theoretically, all forelands, corelands (referential hinterlands) and rearlands are identical and equivalent structures. Of course, in historical reality, the specific assets and liabilities of each of those urban systems/hinterlands will depend on their economic, political, social, geographical, etc. features (Figure 1).

This setting allows for continental gateways.[49] Continental gateways are cities providing transportation (and all the necessary requirements) to push along trade flows across land space, just as maritime gateways do for ocean space. Good examples are Milan and Innsbruck for the Alps or Timbuktu for the Sahara. Quite like maritime gateways, these cities are centres of innovation with a global or at least interregional perspective. Until the twentieth century, maritime and continental gateways were necessarily situated

[49] Favero, Serruys and Sugiura, "Introduction", 8.

on the urban system's outer rim, that is either next to the ocean or land space. The advent of the flight made it possible to enter or exit an urban system on the condition of having an airport. Some cities, such as Madrid, which played an important role as nexus (e.g. capital, industrial city, etc.), but did not have gateway functions prior to the invention of flight, have now joined the ranks of gateway cities. Some cities can feature different kinds of gateways at once. Barcelona is for instance a maritime (Port of Barcelona), a continental (crossing of the Pyrenees) and an airport gateway (El Prat international airport). By linking maritime and overland trade, as well as airborne transportation, this urban logistic network approach enables the land-locked cities to play a fundamental role in the organisation and generation of long-distance transport flows. In the same way, port cities are now connected to more continental areas. As such we can thoroughly speak of a terraqueous or global urban network.

Moreover, this approach enables us to see urban systems and hinterlands as the two sides of the same coin. The hinterland tends to explain the dynamic, day to day dealings of the commercial interplay within the interurban tissue. It is the *courte durée* canvas on which merchants, middlemen, wholesalers, etc. organise the shipment or transport of commodities from producers to consumers with regard to the marketing forces of supply and demand. As part of an extended network, it is possible to tag the nodes (cities) and hereby describe their function in the supply and commodity chains, for instance, entrepots, staple markets, industrial, retailing, wholesale, and distribution centres. On the other side of the coin, the urban systems reflect the more static, but nevertheless ever-changing, *longue durée*. Its focus is more on the nodal urban structure or on how transportation and communication lines connect and turn different cities into an integrated urban nebula. The cities can be described with regard to their role in the network's transportation process. Tags such as junction, relais, crossroad, bottleneck, transhipment point, terminus, etc. explain how each city plays a role in the urban system by steering transport flows.[50] By looking at both the short-term commercial interplay and the long-term transport structure the urban logistic network (re) connects urban and transport history.

Identifying three shapes of flow in the urban networks

The identification of the different morphological intertwining patterns in urban systems can be a powerful tool for explaining their transformation in time, as they provide a tangible signal of the inertia of logistic structures and of the way they change.[51] However, historical urban network theories mostly discuss the evolution of *dendritic* (or star-shaped) systems catering to either urban centres or maritime gateways. Together with the lack of coherence in taxonomy and mapping, the reliance on dendritic shapes at both the local and regional scales explains why the historical urban network theory was considered too rigid to extend to larger geographical areas. Because of these dendritic patterns, it became increasingly

[50] *Ibid*., 9.
[51] Jean-Paul Rodrigue, *The Geography of Transport Systems* (Abingdon & New York NY: Routledge, 5th edition, 2020) 56–74.

difficult to conceive a larger regional network with multiple port cities and continental gateways connecting different hinterlands with each other.[52] There is a need for a theory of urban networks that is more consistent with the historical and geographical organisation of urban regions, with its multiplicity of hinterlands connected through both ocean and land space, in order to see the evolution of intertwining patterns in urban networks and hinterland dynamics. The study of the urban logistic network should then not discard dendritic shapes, but rather analyse the way they combine with other patterns. These may be classified as *polycentric* and *corridor* shaped patterns (Figure 2). By doing so, it becomes possible to explain the formation and development of transport flows in the urban network in its varying frequency, density and centrality.

Although the term dendritic is rarely explicitly used for describing an urban network, many scholars and urban practitioners adopt dendritic shapes in describing transport flows. Christaller's central place system is the best-known example. It can be described as a "full" dendritic model, as it expands in all directions around a city.[53] De Vries also implicitly adopted dendritic models in his analysis of early modern European urbanisation. In his "partial" dendritic model, all transport flows follow the river system's course towards a port city along the coast.[54] Dendritic shapes also recur in historical studies of Western European "Parisian"-like urban systems. These developed in "feudal" regions where a city imposed its political control in the late Middle Ages. Today these regions still pivot around the same capital city.[55] This historical literature has highlighted the strong hierarchical relationship between the centre and periphery underpinned by dendritic urban networks. In modern times, central place dynamics mingled with State-driven policies resulting in centralised transport networks. These reinforced the hierarchical nature of the urban system. The most renowned example is the "Étoile de Legrand", the star-like construction plan for the French railway network approved in 1842. It was named after its conceiver Alexis Legrand, director of the *Corps des ponts et chausséees* at the time, and it followed the road network pivoting on Paris that was built under Jean-Baptiste Colbert in the seventeenth century.[56] The same structure was replicated for both the motorway and the high-speed rail system.

[52] The possible coexistence of multiple maritime gateways in the same region and its connection with inland areas has been mentioned by Lesger, *Handel in Amsterdam*. A mention of continental gateways in historical research on urban networks can be found in Michael-W. Serruys, "Ypres, la Flandre rétrocédée et la politique de transit au XVIII^{e} siècle", in Rik Opsommer and Olivier Ryckebusch (eds), *Guerre, frontière, barrière et paix en Flandre. Études transfrontalières à l'occasion du tricentenaire des paix d'Utrecht et de Rastatt* (Ypres: Stadsarchief Ieper, 2014), 187–231, here 190–191.

[53] Christaller, *Central Places in Southern Germany*.

[54] de Vries, *European Urbanization 1500–1800*. For an analysis of Chinese urbanization along river basins, see George William Skinner (ed.), *The City in Late Imperial China* (Stanford CA: Stanford University Press, 1977).

[55] Hohenberg and Lees, *The Making of Urban Europe 1000–1994*, 245, highlight the similarity between the regional typology elaborated for medieval Europe by Michael Hechter and William Brustein, "Regional Modes of Production and Patterns of State Formation in Western Europe", *American Journal of Sociology*, 85:5 (1980), 1061–1094, and the classification proposed by Étienne Juillard and Henri Nonn, *Espaces et regions en Europe occidentale* (Paris: Éditions du CNRS, 1976).

[56] Hohenberg and Lees, *The Making of Urban Europe 1000–1994*, 222 and Georges Reverdy, *Histoire des routes de France* (Paris: Presses Universitaires de France, 1995).

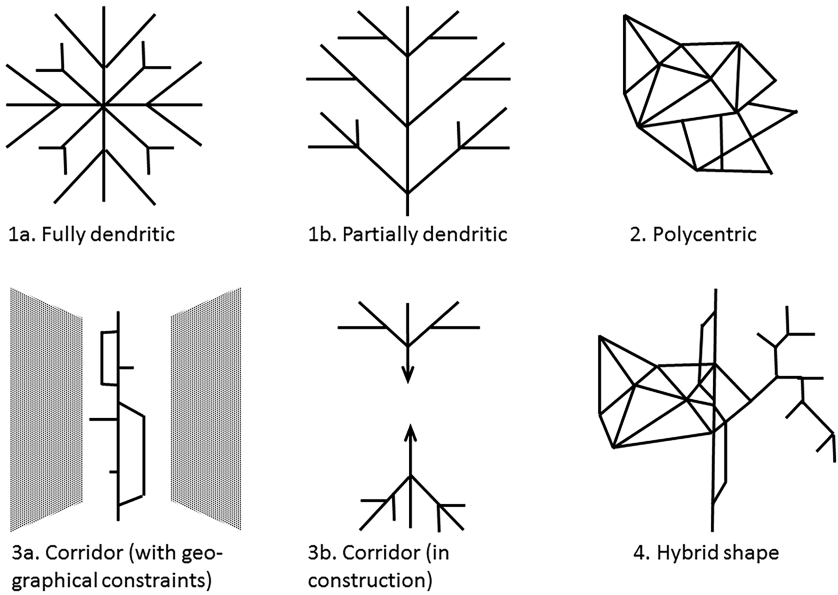

Figure 2. Shapes of urban logistic networks.

Dendritic networks are heavily affected by bottlenecks arising in the central node, which connects all the other nodes to each other. Dendritic-shaped systems may then eventually become more polycentric as far as direct connections among the peripheral nodes are built, but this evolution usually requires an intervention that actively counters the inertia of its centripetal flows.

Historical urban network studies do not explicitly discard the variety of urban systems' shapes, but their theoretical framework implicitly privileges dendritic structures as characterising the hinterland of any maritime gateway. As a result, every element, such as flow formation, centrality or frequency, is explained on the assumption of the development of dendritic shapes. Such a limited perspective makes it impossible to detect other patterns of transport or flow dynamics in urban networks.

Historical urban network studies have for instance not paid much attention to polycentrism. A "polycentric"-shaped urban network is a structure where nodes of similar size are dispersed throughout a region either at the local, continental or global level. The Randstad Holland has often been used as a model for the comparative study of polycentric regions.[57] Contemporary urban network studies have shown that small cities are more dependent on polycentric networks than larger ones.[58] However, polycentrism does not

[57] Ben Derudder *et al*, "Polycentric Urban Regions: Conceptualization, Identification and Implications", *Regional Studies* 56 (2021), 1–6.
[58] David Bell and Mark Jayne, "Small Cities? Towards a Research Agenda", *International Journal of Urban and Regional Research* 33:3 (2009), 683–699.

necessarily constitute an urban system, it might also reflect a lack of coherence. Only when the spatial organisation operates accordingly, it is possible to identify the proper features of a polycentric urban system. This is more evident when there is a clear division of functions among the polycentric organised nodes, but this is not necessarily always the case.[59]

Ironically, it is the historical analysis of transport and trade flows that allowed researchers to uncover the reasons and processes that gave polycentric regions their shape and to assess the formation of network relations among the nodes. Historical research on European urbanisation linked this structure with the "Rhenish" model or with the intensively urbanised area that stretches from Northern Italy to the Low Countries including Switzerland, Eastern France and Western Germany.[60] Following these studies, polycentrism is the result of the long-term development of small and medium cities, connected by means of a dense and stratified transportation network that goes back to Roman times. These cities resisted for a long time to the central state's consolidation process.[61] In Italy and Germany, this process only took place in the nineteenth century and, even then, the state did not pursue the construction of a centralised transport network. It rather focused on supporting industrialisation by building strategic connections to the existing industrial districts, coal basins and major ports.[62] Although Hohenberg and Lees mentioned the dense Rhenish polycentric network, they did not take it into account when they elaborated their urban network theory. They view all hinterlands as dendritic structures, hereby ignoring the essence of what shapes polycentric urban networks.[63]

Polycentric transport networks are less affected than dendritic ones by bottlenecks, but competition among the different nodes is strong. Minor nodes can be bypassed and this, in turn, can destabilise the system. Bypassing is a historically dynamic process that urban network studies can investigate through the analysis of shapes. This is particularly important because, over the last two centuries, transportation and distribution means have increasingly converged into larger and fewer hubs. This process has usually involved the bypassing of smaller cities because of the discrepancy between the necessary effort to create more efficient and direct connections and the growing complexity of the gateway's functions and services. In preindustrial times, goods that flowed from producers to consumers generally passed through a multitude of nodes. With the elimination of middlemen brought about by railways, motorways, steamships and other factors related to industrial revolutions, some nodes were bypassed, which resulted in a streamlined flow.[64] Bypassing is closely associated with urbanisation, de-urbanisation, centralisation and the emergence of megacities, but it can also create new polycentric shapes. Dendritic shapes on the other hand cannot explain this process, as they are rather connected to the bottleneck issues that bypassing aims at solving.

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[59] Evert Meijers, *Synergy in Polycentric Urban Regions: Complementarity, Organising Capacity and Critical Mass* (Amsterdam: IOS Press, 2007), 145.

[60] Hechter and Brustein, "Regional Modes of Production".

[61] Brunet, "Lignes de force de l'espace européen", 15–16.

[62] Allan Mitchell, *Great Train Race: Railways and the Franco-German Rivalry, 1815–1914* (New York NY: Berghan Books 2000).

[63] Hohenberg and Lees, *The Making of Urban Europe 1000–1994*, 244–247.

[64] On transport infrastructures as instruments to foster urban logistic functions, see Fabien Bartolotti *et al* (eds), *Les outils de l'activité portuaire en Europe méditerranéenne et atlantique, XVII^{ème}-XX^{ème} siècle* (Aix-en-Provence: Presses Universitaires de Provence, 2021), 5–17.

The corridor is another morphological pattern. It can be described as an urban system along a transport axis.[65] Tracing the shape of corridors allows researchers to detect the inertia of geographical constraints or the dynamic regional transformations activated by new transport connections. Quite a few urban systems are corridors due to the geographical constraints of their neighbouring area. The elongated Rhodanian urban system is squeezed between the land spaces of the Massif Central and the Alps. In the same way, the Ligurian urban system stretches itself on a narrow coastal strip betwixt land space (the Maritime Alps) and ocean space (Mediterranean).[66] But corridors can also be very dynamic features. This is the case when urban systems grow towards each other along a new transport axis, such as a railway (e.g. the Milan–Venice railway line in the nineteenth century).[67] The intermediate nodes can play a very dynamic role, for instance, as a local gateway providing access to the main transport axis, but they can also be bypassed. The outcome depends on many factors, such as the network's shape or the convergence of different urban systems. Corridors are multi-scalar patterns as their effect can be identified at different geographical levels, from the local development expected from the construction of a new road connection to continental infrastructures, such as the Chinese Belt and Road Initiative (or New Silk Road).[68]

By integrating dendritic patterns with polycentric networks and corridors, it becomes possible to see the dynamism and the multi-scalar effects of transport flows in urban networks. The combined use of these shapes allows the researcher to see the complex and reciprocal relationship between transport and urban systems. The consequences of the introduction of a new transport infrastructure can be completely different depending on the underlying urban network. Polycentric urban systems may require a very specific organisation of transport to facilitate the construction of an actual urban network, whereas in dendritic structures and corridors transport infrastructure may exploit and extend the natural morphology, as it grows organically in the direction provided by maintenance and use.[69]

Conclusion

This discussion of the different historical approaches to the study of urban networks contributes to the scientific debate by highlighting the connection between the incomplete mapping of hinterlands and the prevalence of hierarchical dendritic models in the

[65] John R. Yarwood, *The Dublin-Belfast Development Corridor: Ireland's Mega-city Region?* (London: Ashgate, 2006).

[66] Roger Brunet, "Le Languedoc-Roussillon en modèle", *Mappemonde* 3:4 (1994), 1–4 and Fabio Poggi and Antida Gazzola, "Trasformazioni metropolitane e reti formali e informali tra città dell'Arco Latino", *Futuribili* 9:1/2 (2004), 110–128.

[67] Giovanni Favero, "Gateways as Inter-Modal Nodes in Different Ages: The Venetian Region, Eighteenth to Twentieth Centuries", in Giovanni Favero, Michael-W. Serruys and Miki Sugiura (eds), *The Urban Logistic Network: Cities, Transport and Distribution in Europe from the Middle Ages to Modern Times* (Cham: Palgrave Macmillan, 2019), 173–190, here 181.

[68] World Bank, *Belt and Road Economics: Opportunities and Risks of Transport Corridors* (Washington DC: The World Bank, 2019).

[69] Thomas Vanoutrive, Greet De Block and Ilja Van Damme, "Nature's order? Questioning causality in the modelling of transport networks", *Geoforum* 97 (2018), 324–334, here 324–326.

theoretical interpretation of their network shape. The adoption of the historical urban network theory of a simplified paradigm focusing on maritime gateways with exclusive hinterlands makes it unavoidable to identify the connections converging on port cities as the most significant. But if continental gateways and land space are included in the urban network analysis, the variety of patterns created by different logistic connections becomes at the same time visible and interpretable through the identification of the different logics that underpin their development.

This approach opens a dialogue between transport history and historical urban network theory, with multiple implications for further research. For instance, the development of urban logistic networks can be analysed as the historical result of a dialectic interaction between the impact of transport engineering on human geography and the resilience of routes that are "cultivated" by means of their everyday use. The role of users has been traditionally neglected in historical studies of urban networks. If the political agency (policymakers and elites) is clearly at the forefront of large infrastructural projects that radically transform urban patterns, the consideration of other actors, such as merchants, businesses, urban residents, commuters or passengers, is indispensable to understanding the operations of multiple and intermodal logistic patterns. Private sources such as travel diaries and letters may then help urban and transport historians to highlight the role of users and their mobility in shaping urban networks.

The issue of agency is crucial to question the deterministic implications of formal network analysis, which can go so far as to reject the attributes of individual or collective actors, especially when network models are constructed through the analysis of the large datasets now available on transport flows, making theoretical interpretation apparently useless.[70] If the use of different natural metaphors in network modelling may, in fact, support interpretations that identify specific actors as the State or the market as crucial, it is however up to the historian to assess retrospectively the different roles and motivations of actors in different political and economic contexts.[71] What is crucial here is the radical difference between the social scientific methods using data constructed from direct observation in the present, and the historical approach to sources that are just a partial and biased trace of the past.[72] The necessity of interpretation, deriving from the partial and scattered evidence on which urban and transport historians rely, forces them to focus on multiple causalities and on complex and contingent contexts to construct possible interpretations of historical change. From such a historical perspective, the search for more complex and realistic shapes and scales of theoretical network modelling remains relevant to assess its validity.

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GQ3 The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

[70] Mustafa Emirbayer and Jeff Goodwin, "Network Analysis, Culture, and the Problem of Agency", *American Journal of Sociology* 99:6 (1994), 1411–1454, here 1414.
[71] Vanoutrive, De Block and Van Damme, "Nature's order?", 324–326.
[72] Kenneth J. Lipartito, "Historical Sources and Data", in Marcelo Bucheli and Rohit Daniel Wadhwani (eds), *Organizations in Time: History, Theory, Methods* (Oxford: Oxford University Press), 284–304.

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