World Seastems

Seventh Framework Programme (FP7) / European Research Council Starting Grant

GLOBALIZATION, REGIONALIZATION, URBANIZATION: AN ANALYSIS OF THE WORLDWIDE MARITIME NETWORK SINCE THE EARLY 18TH CENTURY

PROJECT ABSTRACT

The World Seastems project aims to map and to analyze the changing spatial pattern of the world economy across 300 years from a maritime perspective. It will exploit untapped vessel movement data on a world scale since 1734, date of the first publication of Lloyd's List. Such data offer disaggregated information on weekly inter-port flows with detailed descriptions of vessels as well as their dates of departure and arrival at world's ports. Despite the vital importance of maritime transport for economic development and international trade, no research has been done on the long-term evolution of the global maritime network.

There are three main goals of the project:

- First, it will map for the first time the spatial distribution of almost 300 years of maritime flows in a dynamic and interactive manner. A geomatics visualisation platform will also integrate advanced analytical tools to simplify the pattern of shipping routes and corridors, and to extract meaningful information from the original data, with both scientific and pedagogical outcomes.

- Second, the project will look at the topological and spatial structure of the global network of inter-port links with reference to graph theory, social network analysis, and complex networks. The global properties of the network can be compared with general models of networks, while the evolution of macroscopic measures will be explored in relation with wider structural and conjectural changes in the world system e.g. conflicts, revolutions, crises, territorial reconfigurations) in terms of network expansion, shrinkage, concentration and polarization. Internally, the search for tightly connected substructures (i.e. clusters, communities of ports, économies-mondes) will focus on the emergence of world regions and regional integration processes.

- Finally, we will examine the co-evolution of maritime flows and urban/regional development and compare the growth trajectories of port and non-port cities based on their situation in the combined sea-land network.

In a multidisciplinary fashion, the project questions both the contribution and the resilience of port activities and shipping routes to the transformations of the world system and economy from the local level to the global level. It will provide novel results about world systems theory, network theory, and location theory.

PROJECT OUTLINE

Being one of the oldest forms of human interaction, maritime flows are good indicators of economic circulation and a useful tool to "take the pulse of world trade and movement" (Ullman, 1949). We present this sector-specific approach to globalization and urban development at two complementary levels of analysis, global and local.

Dynamics of macro-structures and world regionalization

To date, the few existing empirical studies of global maritime flows remain rather static and focussed on specialized issues such as biological invasions (Kaluza et al., 2010), climatology (Herrera et al., 2003), container network structure, cost efficiency, and individual companies. While the ability of maritime flows to reveal wider economic and territorial structures has been argued by both geographers (Rodrigue et al., 1997) and historians (Lewis and Wigen, 1999), no study could have validated the materiality of such proposals. More likely in this perspective are studies of other global networks such as those shaped by airlines, multinational firms, trade, migration, knowledge, and communication flows (Van Hamme and Patris, 2011). Yet, the specificity of maritime flows is their early existence as long-distance transport and communication vectors. This sole fact justifies their high relevance to revisit the changing spatial pattern of global human interactions.

Early theories about the evolution of the so-called "world system" depict successive phases since the medieval times by which some regions of the world become dominant at the expense of others (Wallerstein, 1979; Braudel, 1985), the first being the "core" and the others the "peripheries". Although subsequent works have debated such ideas notably by studying longer time periods or focusing on new forms of global organizations, such as global commodity chains and production networks, a systematic analysis remains lacking. Notably, research on global production networks remain highly qualitative and "falls short of delivering a rigorous analysis that can give ‘the big picture’ of GPNs on a global scale" (Hess and Yeung, 2006: 1201). Studies of commodity chains and world city networks are more quantitative but often neglect the materiality of flows among locations by looking at advanced producer services (Leslie and Reimer, 1999; Hall and Hesse, 2012). The longstanding existence of maritime flows can thus offer strong evidence about the spatial patterns of trade dominance across the world (Vigarié, 1968; Vance, 1970) as well as on the impacts of cost and time fluctuations on such patterns (e.g. declining friction of distance).

The World Seastems project thus aims at providing a systematic analysis of the path-dependency of hierarchical structures affecting global interactions, by measuring and mapping the unequal integration, concentration, and connectivity of maritime flows across space and time as well as their changing geographic coverage. Main efforts will be put on trying to untangle the respective influence of territorial and network factors. Territorial factors are those outside the maritime and port industry such as market location and trade relations, which are in turn affected by major political and economic evolutions (e.g. rise and fall of empires and nations, industrial revolutions, wars and crises, production shifts). Network factors are more internal and better relate with technological progress (i.e. wind, steam, combustion, containerization, mega-carriers, intermodalism), freight costs and navigation constraints. The combination of those factors confer maritime flows a different role in shaping the world economy and the links among its components according to the context. Their distribution will reflect but also transgress or contradict major spatial structures and dynamics in terms of core-periphery and polycentric configurations. The project will also examine the potential to discuss future evolutions based on the improved knowledge of past and current patterns and the identification of "symptoms" by which maritime flows incorporate but also anticipate upcoming events.

Co-evolution of urban development and maritime flows

On a local level, main efforts will be put on further understanding the co-evolution of maritime transport and urban development, thereby providing novel evidence about the evolution of cities in general and port cities in particular. Earlier contributions about the evolution of cities and regions from a maritime perspective remain theoretical (Murphey, 1989; Hoyle, 1989; Fujita and Mori, 1996) as a large-scale validation is lacking. Successive phases of synergy and separation between port and urban spaces and functions are often attributed to the impact of several factors such as technological change fostering port competition and traffic concentration, urban diversification towards more advanced functions, with respective planning decisions and imperatives to sustain or relocate port activities within the urban space. Port cities thus provide a perfect example of how certain locations evolve by absorbing innovations in specific sectors (Pumain et al., 2009) that in turn reinforce or modify their rank and specialization in the hierarchy of urban places. The World Seastems project thus wishes to reveal the path-dependency of urban development in relation to maritime flows and the uneven adaptability of cities to technological and economic changes. It will revisit earlier models of transport network evolution (Taaffe et al., 1963) by shedding more light on the long-term dimension of port dynamics, in terms of concentration and competition.

Because cities and systems of cities are often studied from a continental perspective (see Bretagnolle and Pumain, 2010), the combined analysis of maritime networks and land-based transport networks will challenge existing models of urban systems and their evolution (e.g. Christaller's central place theory) as well as the specificity of "gateway cities" (Bird, 1977). The project will thus provide a more complete picture of the centrality of cities while elucidating the difference between port cities and non-port cities. Although some recent efforts have been made to calculate the multimodal accessibility of cities on a world or European level, the results remain highly static (European Union, 2010). The local impacts of lowering spatial friction over hinterlands and lowering maritime transport costs are not yet sufficiently understood. As stated by Slack (1993), ports belong to a global transport system where gateways focus on hinterland accessibility and intermediate hubs target maritime transhipment (Rodrigue et al., 2009). This analysis shall focus dominantly on the post-1890 period when industrial and transport revolutions really started to influence continental communication systems such as roads, railways, canals, warehousing, and related industrial developments and also due to the difficulty accessing detailed land network information.

Mapping and modeling maritime flows

The first research direction is the elaboration of a geomatics platform with strong emphasis on Geographic Information Systems (GIS) methods of data representation and analysis. Flows will be represented in diverse forms such as 2D and 3D representations on a world map and sphere using various cartographic projections. This is in itself an innovation of the project that has many pedagogical outcomes. Each port of call is a location (node) and each voyage is a link between two or more ports of call at a given period. Each vessel circulation creates both a "chain" (successive stops) and a "complete graph" (all stops connected directly and indirectly). The global maritime database is thus built from successive port-to-port matrices to be analyzed as a non-planar, weighted, and directed graph on various levels of node aggregation (e.g. port, port city, country, macro-region, continent) and where nodes and links have several attributes based on vessel characteristics (i.e. flag nationality, vessel size and type) and movements (i.e. duration, length, frequency).

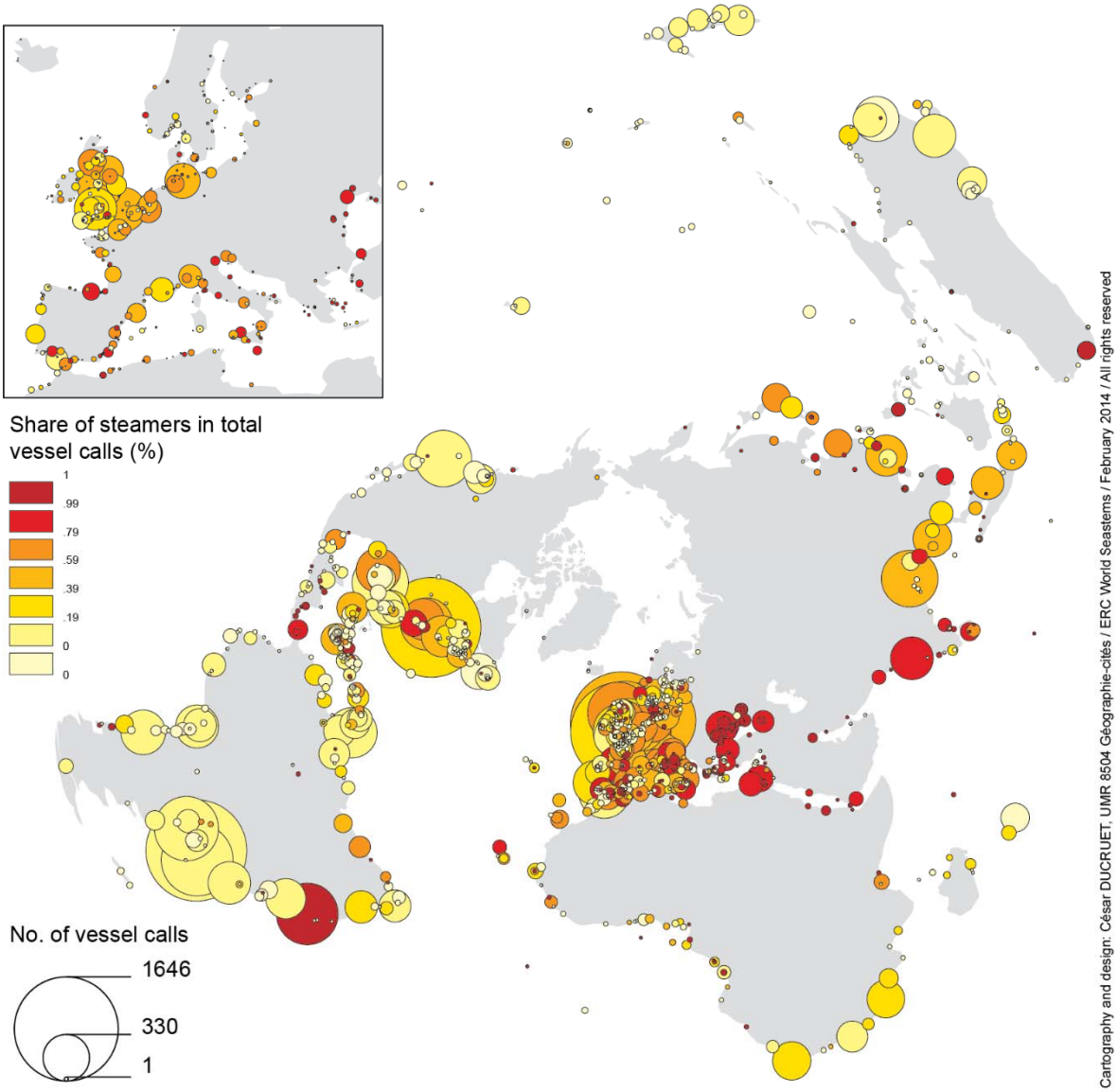
At the global level, the project will measure the size of the network (i.e. number of nodes and links, total tonnage) as well as the changing structure of flows through various statistical and network analytical tools. Classic concentration measures (e.g. Gini coefficient, HHI) will be completed by network-specific ones such as those provided by graph theory, social network analysis, and complex networks. The changing size and properties of the network will be one

first evidence of the globalization process and its ongoing trend of transformation. The capacity of flows to reflect and/or anticipate major global events will be examined in terms of the network's robustness and vulnerability, with reference to major works on scale-free / small-world networks and their cumulative dynamics. Preferential attachment can be tested to explore whether newly added ports generally connect to already established and larger ports. Innovation diffusion in the maritime and ports sector has been highly selective at different stages; many ports were dropped from the network, but new ports were also created or reactivated. Other global indicators can be produced such as the average duration and distance of links so as to verify the concept of time-space shrink in world exchanges. Simulation experiments will be tested with the help of other institutions in order to forecast future changes and confront past dynamics with some models of network evolution, but this is not a core objective and competency of the principal investigator. Another important dimension of the analysis will be the search for coherent substructures in the network, with reference to the buoyant research field on clusters and communities. Various methods such as single linkage analysis, hierarchical clustering, modularity, trajectory analysis, blockmodeling, and structural equivalence (see for instance Snijder and Kick, 1979) will reveal in different ways the emergence and resilience of subsystems in the pattern of flows. The idea is to map the cores and the peripheries as well as to examine the influence of various proximities in their internal and external links (e.g. spatial, commercial, political). The role of physical distance in the evolution of connectivity can also be tested with reference to small-worlds where only a few nodes act as connectors between different and/or distant communities within which most links are local. This will contribute to the fast growing research field on spatial networks where territorial embedding plays an important role (see Barthélémy, 2010 for a review).

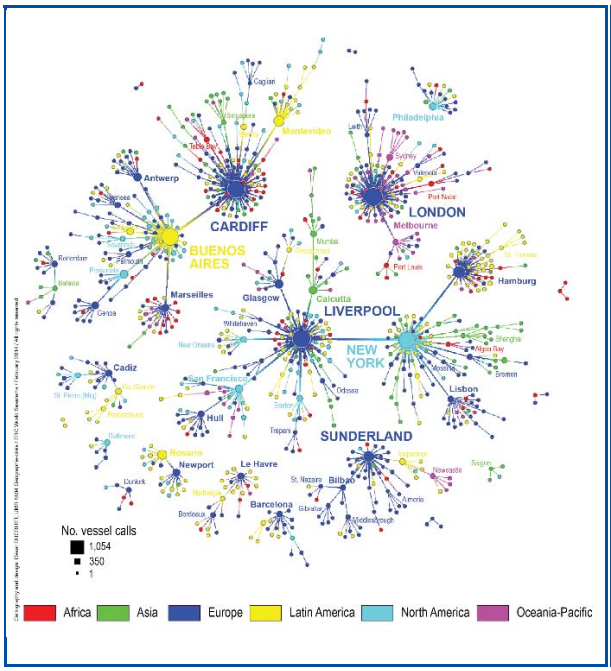
At the local level, comparing the evolution of maritime flows and urban population data (i.e. the most widely, if not the only, accessible indicator of urban importance on a world level and over time) will allow for comparing and categorizing individual trajectories of port cities. The interdependence between port growth and urban growth will be analyzed by measuring the changing statistical correlation between city size and traffic size as well as through applying other methods such as Granger causality tests. Traffic flows per location will be normalized for the comparison of local dynamics (e.g. London vs. New York 1734-2010). The specialization of cities' traffic will also be measured in terms of commodities and vessel types (e.g. raw materials vs. manufactured goods, steamers vs. sailing vessels) as well as geographic coverage (e.g. European vs. Asian forelands, long-range vs. short-range connections) and centrality (i.e. accessibility measures, degree, closeness, betweenness, etc.). An example of cartography based on one Lloyd's register in published in 1890 (next figure) is provided for illustrating possible treatments. Specific GIS methods can be used to map the results such as cartographic distortions (e.g. dynamic anamorphic visualization of traffic distribution), traffic isochrones to/from certain centres (tributary areas), edge aggregation based on Kernel density, etc. This will help to determine the dominance of certain cities not only in terms of traffic volume but also in terms of the geographic reach of their maritime connections. A complementary approach will be to measure the centrality of cities on the level of a combined sea and land network, where port cities act as connectors between the two spaces (foreland and hinterland). Based on the modelling of land-based transport networks, such an approach will better assess the role of hinterlands on the emergence of some gateways as opposed to maritime hubs as well as regional particularities in this interdependence (e.g. North European gateways having wide hinterlands, Asian port cities being more maritime-oriented). This will complement and challenge current works on the structure and dynamics of coupled and interdependent infrastructure networks (Vespignani, 2010).

Preliminary results: maps and networks

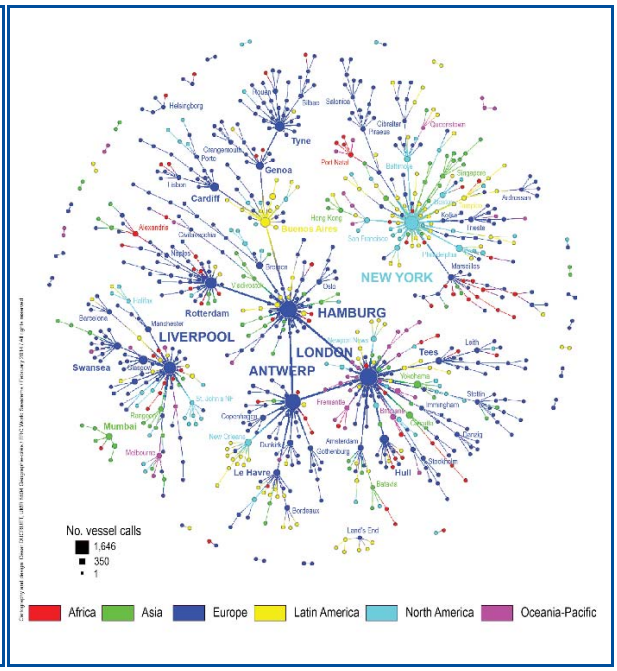
Figure 1: World port hierarchy and share of steamer vessel traffics in 1890



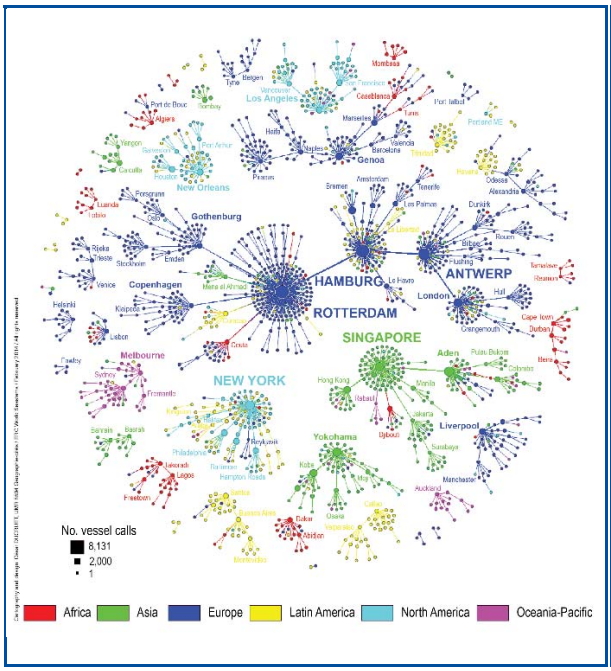
Figures 2-5: Regionalization of world maritime flows (1890, 1925, 1961 and 2004)



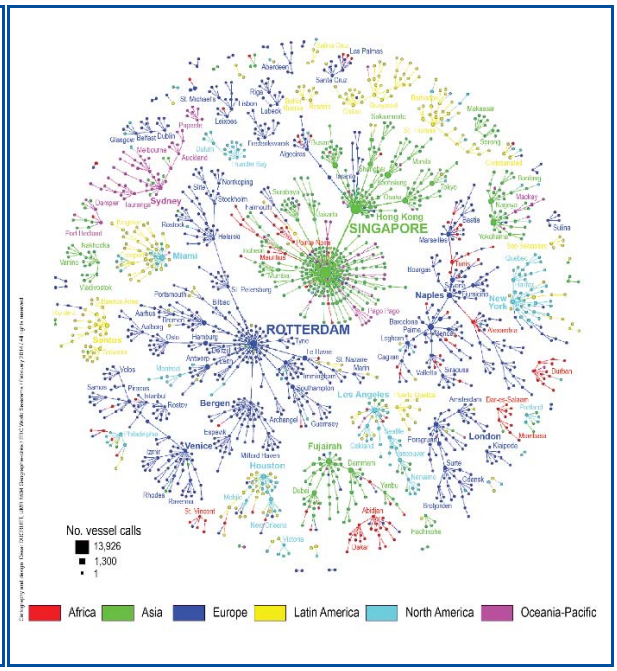
1890



1925

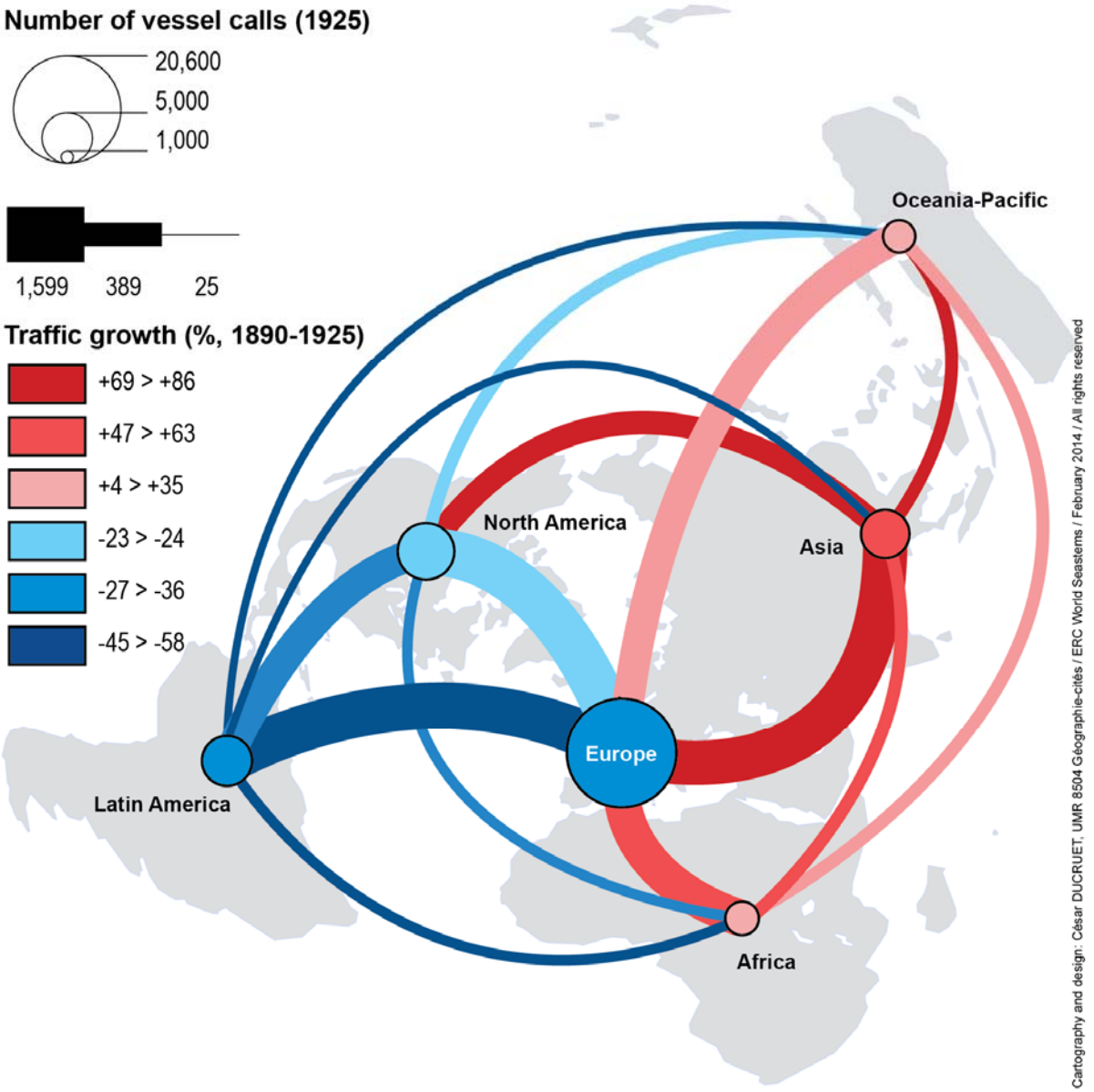


1961



2004

Figure 6: World interregional maritime routes, 1890-1925



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WORLD SEASTEMS: AN ERC FUNDED PROJECT

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