Understanding Connectivity to International Markets: a Systematic Review

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ABSTRACT *Improving freight connectivity is increasingly a topic at the centre of the international trade and transport policy agendas. An examination of available documents and studies in both the policy-making and the academic fields shows that the concept of freight connectivity has often been defined in different ways, and thus has taken a variety of meanings. This poses the question on what connectivity is and what are its determinants in the context of international trade. We are not aware of any studies that have analysed, in a systematic way, the different perspectives and determinants of freight connectivity so as to increase access to international markets. This paper seeks to fill this gap by performing a systematic literature review that spans disciplines such as Transport Engineering, Transport and International Economics, and Supply Chain Management. The outcome of this examination is a multi-disciplinary framework that hopefully will help stakeholders to understand freight connectivity to international markets better, as well as guide future research and analysis in policy-making.*

Keywords: connectivity; transportation; international trade; supply chain; logistics

1. Introduction

Connectivity for freight traded internationally is becoming a subject of increasing attention in international business and policy making contexts. Trade liberalization, delocalization of production activities, lower transportation costs, the use of information technologies, and the emergence of global value chains have increased the potential for firms located in a country to access new, broader markets (Bridgman, 2012; Hummels, 2007; Levinson, 2006). However, a wide range of barriers to international trade in goods still persist, reducing firms' ability to compete internationally. These barriers can take many forms, such as tariff and non-tariff barriers, currency exchange differences, distance, infrastructure and transport services, technological differences, and language, among others. In this context, both the private and public sectors are paying more attention to enhancing connectivity as a means to overcome barriers to international trade.

Improving connectivity for freight traded internationally is increasingly a topic at the centre of the international trade and transport policy agendas. In its 2012 Annual Summit, the International Transport Forum (ITF) included among its main recommendations the need to increase "connectivity across borders" by enhancing infrastructure, increasing information-sharing and providing the harmonization and standardization needed to smooth border crossing and reduce transit time (ITF, 2012, p. 30). The World Customs Organization (WCO) declared 2012 the year of connectivity and suggested that seamless trade could only be achieved through a high degree of connectivity between Customs agencies, their customers, and the various stakeholders involved in trade movements (WCO, 2012). A variety of national governments and regional and international organizations have supported reports, conferences, master plans, and programmes aimed at enhancing connectivity to international markets, evidencing policy-makers' growing interest in this subject (Asia-Pacific Economic Cooperation [APEC], 2010; Association of Southeast Asian Nations [ASEAN], 2010; Carruthers, Rajan, and Murray, 2008; United Nations Economic and Social Commission for Asia and the Pacific [UNESCAP], 2013). At the same time, research on connectivity has seen a strong growth in different academic fields.

An examination, however, of available documents and studies in both the policy-making and the academic fields shows that the concept of connectivity has often been defined in different ways, and thus has taken on a variety of meanings. This poses the question on what connectivity is and what are its determinants in the context of international trade in goods. We are not aware of any studies that have analysed, in a systematic way, the different perspectives and determinants of connectivity so as to increase access to international markets. Therefore, this paper seeks to fill this gap by performing a systematic literature review that spans disciplines such as Transport Engineering, Transport Economics,

and Supply Chain Management. The outcome of this examination is a multi-disciplinary framework to help understand connectivity to international markets, as well as to guide future research and analyses in policy-making.

The paper is structured as follows: Section 2 lays out the methodology and procedures followed to conduct the systematic literature review; Section 3 presents the results of the systematic literature review; Section 4 discusses the different domains and meanings of connectivity found in the literature; and Section 5 presents the conclusions of this research.

2. Methodology

In order to explore the concept of connectivity to international markets, the systematic literature review technique was applied. This technique uses systematic methods to identify, select, and critically evaluate the body of knowledge concerning clearly formulated topics (Tranfield, Denyer, and Smart, 2003). Unlike a traditional literature review, which might be influenced by the familiarity or preferences of the reviewer, a systematic review allows the researcher to gather, analyse and interpret a comprehensive body of available literature in a thorough and unbiased manner (Wang and Notteboom, 2014).

The systematic review technique is particularly relevant to the purpose of this paper. By avoiding the biases of conventional literature reviews, a systematic review allows the researcher to (1) summarize the accumulated body of knowledge concerning the topic of interest; (2) explore the topic through different perspectives; and (3) develop reliable knowledge from a pool of knowledge dispersed across a broad range of studies (Gligor and Holcomb, 2012; Tranfield et al., 2003). Therefore, a systematic review on the topic of connectivity allows us to explore available literature comprehensively, casting light on the meaning and determinants of connectivity to international markets, while bridging the gaps among different perspectives and developing a broad understanding of the research topic.

Applying the systematic review technique involves five stages: (1) problem formulation; (2) literature research; (3) selection and evaluation of literature; (4) research analysis and interpretation; and (5) presentation of results (Denyer and Tranfield, 2009; Gligor and Holcomb, 2012). The problem addressed in this paper was formulated as follows: given the pool of knowledge on connectivity that is spread across a variety of academic disciplines, can we aim to develop an integrated framework to understand connectivity to international markets and its defining aspects? The literature was researched by interrogating the dataset Scopus, one of the largest repositories of academic articles. Literature research comprised five phases. In the first phase, key search was performed using the words ("connectivity") AND ("international trade" OR "international market") in papers and conference proceedings published between 1950 — the earliest available year in the dataset — and September 2014. In the second phase, studies were chosen and evaluated according to a set of specific criteria that referred to (1) the relevance of the study to the research problem; and (2) the quality of the study. In agreement with Wang and Notteboom (2014), the Critical Appraisal Skills Program (CASP) checklist was used to evaluate the quality of the studies. Selected studies were preliminarily analysed in order to identify shared patterns among them. The analysis showed that studies could be grouped into three domains: transportation, supply chain management and international trade. In the third phase, the dataset was further interrogated using key words that referred to such domains. In the fourth phase, search results were evaluated according to the relevance and quality criteria applied in phase two. In all queries, synonyms of connectivity such as 'connection' or 'connectedness' were considered as well. References included in the papers collected were used as guidance for further exploration of the literature. In addition, literature citing the papers collected were identified and analysed. In the fifth phase, the review of articles was complemented by searching: (1) the catalogue of the United States Library of Congress (the biggest library catalogue in the world) for books that could be related to the topic; and (2) Google search engine, using the same keywords that were used in the Scopus query, to account for working papers and reports relevant to the topic published by other sources, such as national and international organizations. Search results were evaluated according to the relevance and quality criteria applied in phase two.

3. Results

The first phase of the literature research resulted in 127 articles. In phase two, the 127 articles were evaluated according to the relevance and quality criteria, with 14 articles satisfying such criteria (Table 1). Next, the articles selected were preliminarily analysed with the objective of identifying shared characteristics that could be used to group and classify them into different categories. The analysis showed that the articles could be classified into three broad domains: (1) transportation, including studies with a focus on transport infrastructure and/or services in any transport mode; (2) supply chain management, including studies with a focus on planning and management of activities that integrate supply and demand within and across companies; and (3) international trade, including studies with a focus on the international exchange of goods and services. These categories were then used to further query the database, looking for articles relevant to the research problem.

Table 1. Papers that satisfied the relevance and quality criteria, by domain (1950–2014)

In the third phase, the database was interrogated by searching for words related to the three domains identified in the previous phase. The words ("connectivity") AND ("transport" OR "infrastructure") were selected for the transportation domain, resulting in 259 articles, among which 35 articles satisfied the relevance and quality criteria. The words ("connectivity") AND ("supply chain") were selected for the supply chain management domain, resulting in 136 articles, among which 24 articles satisfied the selected criteria. Finally, the words ("connectivity") AND ("markets" OR "trade" OR "economics") were selected for the international trade domain, resulting in 1188 articles, among which 36 satisfied the selected criteria. After applying the relevance and quality criteria to the results, 42 articles were selected, making up the basis for further analysis. The earliest article included in the dataset had been published in 2002 and the most recent in 2014. This time period is consistent with the exponential growth of academic interest in the subject of connectivity in general. Indeed, the simple keysearch for the term 'connectivity' on Scopus showed that the period 2002–14 concentrated 80% of academic publications (75 822 articles). In addition to the articles selected for analysis, both references contained in and literature citing these articles were analysed and included when they satisfied the selected criteria.

Table 2 shows the five journals with the highest number of articles selected for analysis after phases one through four of the literature search.

Table 2. Main sources of the articles selected

In the fifth phase, the literature research was complemented by querying the catalogue of the United States Library of Congress and Google search engine, using the same keywords from previous phases. As a result from the five phases of the literature research, 137 studies were selected and analysed (Figure 1).

Figure 1. Graphical illustration of the literature search process and results

4. Discussion

The analysis of the literature selected gave insights into the different perspectives on connectivity, according to the different domains the literature belonged to. Literature in the transportation domain defines connectivity as the availability and capacity of infrastructure and transport services. For some studies, connectivity also entails the effectiveness of trade procedures (Section 4.1). Literature in the supply chain management domain defines connectivity as the integration of information among different

supply chain actors (Section 4.2). Finally, literature in the international trade domain defines connectivity as the ability to access other markets, as a result of different factors (Section 4.3).

4.1 Connectivity, Infrastructure and Networks

Literature in the transportation domain includes studies in the fields of Transport Economics and Transport Engineering. In Transport Economics, there is extensive literature where connectivity is defined according to infrastructure availability and capacity. Marquez-Ramos Martinez-Zarsoso, Perez, and Wilmsmeier (2011, p. 557) refers to this as a "narrow" concept of connectivity, which focuses on the physical properties of a network. The available economic literature has applied this concept to investigate the effects that connectivity, resulting from a given infrastructure configuration, could have on economic activities, including international trade activities and access to international markets. For example, Wilmsmeier and Hoffmann (2008) and Marquez-Ramos et al. (2011) showed that the characteristics of port infrastructure affected port connectivity, which in turn impacted on maritime freight rates and maritime trade flows. Moreno and Lopez (2007) explored the spill over effects of increased connectivity for Spanish provinces as a result of transport infrastructure investments. Likewise, Bhattacharyay (2012) estimated transport infrastructure investment needs in Asia so as to increase connectivity among countries in the region, enhance intraregional trade and promote economic integration.

In addition to this narrower perspective on connectivity, a large part of the literature in the area of Transport Economics has applied a broader perspective on connectivity, which refers to "features of the modes and co-ordination of various operators, as well as integration of services" (Marquez-Ramos et al., 2011, p. 557). Under this broader perspective, analytical work on connectivity has emphasized the importance of availability and capacity of transport services. This approach has been extensively used in order to assess airport (Alderighi, Cento, Nijkamp and Rietveld, 2007; Malighetti, Paleari, and Redondi, 2008; Paleari, Redondi, and Malighetti, 2009; Redondi, Malighetti, and Paleari, 2011) and port connectivity (Cui, 2014; Ducruet and Lugo, 2013; Kaluza, Kolzsch, Gastner, and Blasius, 2010; Notteboom, 2006; Pais, Freire, and Gonzalez, 2012). In these studies, which apply concepts and methods from complex systems theory, connectivity is defined and understood within a given network configuration of transport services. Specifically, connectivity is defined as the degree to which nodes in a network are connected to each other (Burghouwt and Redondi, 2013) or, similarly, as the degree to which actors in the network can be reached or can reach all other actors in the network.

Studies use different variables in order to estimate connectivity (Lin and Ban, 2013). In air transportation, studies have used variables such as number of direct and indirect connections between two airports; capacity of aircraft deployed in direct connections between two airports; minimum and maximum connecting time; average travel time; travel cost; and shortest path length (Burghouwt and Redondi, 2013; Lordan, Sallan, and Simo, 2014; Reggiani, Nijkamp, & Cento, 2010; Wang and Wang, 2011; Wang, Mo, and Wang, 2014). In maritime transportation, studies have used variables such as vessel movements (Ducruet, Rozenblat and Zaidi, 2010; Kaluza et al., 2010; Gonzalez, Freire, and Pais, 2012; Pais et al., 2012); capacity and number of vessels deployed on direct services between two ports (Ducruet and Lugo, 2013; Ducruet and Notteboom, 2012; Ducruet and Zaidi, 2012); number of shipping possibilities between two ports (Wilmsmeier and Hoffmann, 2008); service frequency; number of port calls; distance between ports; and vessel speed (Low, Lam, and Tang, 2009; Lam and Yap, 2011; Marquez-Ramos et al., 2010 and 2011). A few studies have also taken into account port infrastructure capabilities such as number of cranes, storage area, berth and water depth, and inter-modal connections (Lam and Yap, 2011).

The review of literature in the field of Transport Engineering also suggests the presence of both a narrow and a broader concept of connectivity. Under the narrow perspective of connectivity, research in Transport Engineering has focused on the physical properties of the network and interoperability enhancement across modes (Van Geenhuizen, 2000). Under the broader perspective, the focus has been

placed on the cohesiveness of networks (Frybourg and Nijkamp, 1995), encompassing connections between modes, transport services, and different nodes, from an integrated, door-to-door management perspective, to ensure high quality and minimum costs to move persons and freight from an origin to a destination (Rietveld, 1995; Van Geenhuizen, 2000). In this field, connectivity has been applied to the study of coordination within and across modes (Fuller, Robinson, Fraire, and Vadali, 2011; Alstadt and Weisbrod, 2012), and defined as "a form of 'access' between two systems" and, broadly, as the "ease, time or cost of traveling between different transportation route systems or modal systems" (Alstadt and Weisbrod, 2012, p. 3). Based on such definitions of connectivity, a large body of literature in Transport Engineering has focused on assessing intra and inter-modal connectivity, applying metrics related, for example, to the quality — in terms of time and cost — and the quantity — in terms of number and capacity — of the travelling opportunities at the connection (Hadas and Ranjitkan, 2012). Among this literature, many studies have analysed intra and inter-modal connectivity in passenger transport networks (Derrible and Kennedy, 2011), including bus (Jin, Tang, Sun, and Lee, 2014; Kaplan, Popoks, Prato, and Ceder, 2014; Shafani and Khani, 2010;), metro (Guo and Wilson, 2011), airline (Burghouwt and de Wit, 2005; Li, Miyoshi, and Pagliari, 2012; Veldhuis, 1997), and rail networks (Seaton and Hackett, 2004; Wang, Jin, Mo, and Wang, 2009). Other studies have analysed intra and inter-modal connectivity in freight transport networks including, for example, road-rail connectivity (Bathel and Woxenius, 2004; Bontekoning, Macharis, and Trip, 2004; Schonharting, Schmidt, Frank, and Bremer, 2003), port-road connectivity (de Langen and Sharypova, 2013), port-rail connectivity (Wanke, Garcia and Hijjar, 2011), and airline connectivity (Kim and Park, 2012).

In agreement with the broader perspective on connectivity, the concept of integrated transport systems has recently emerged in the Transport Engineering field, and is getting increasing attention from the academic, public and private sectors (International Transport Forum, ITF, 2012). An integrated transport system can be defined as a scalar system (Potter, 2010), which integrates different transport aspects such as infrastructure, services, information, tariffs, and policies (Preston, 2012). The aim of integrating all transport-related aspects, beyond those of infrastructure and services, is to maximize connection and coordination at different levels (ITF, 2012). According to the ITF (2012), a modern, integrated, seamless transport system requires at least four levels of connections: (1) the infrastructure connection, to minimize transfer time between modes; (2) the management connection, which consists of the coordinated planning of service times in order to minimize waiting times; (3) the tariff connection, allowing users to move using multiple modes of transportation with a single ticket or contract; and (4) the information technology connection, which consists of integrating information systems to monitor, manage and optimize the entire transport system. By including different features related to transportation, the integrated transport systems concept provides a more comprehensive, holistic understanding of connectivity, so as to achieve a more effective connection of people and markets.

In line with the emergence of a more systemic, comprehensive approach to transportation so as to ensure better and seamless connection, some recent studies on airport connectivity and logistics corridors have expanded the notion of connectivity understood as the availability and capacity of infrastructure and transport services so as to cover the full range of interactions among all network nodes (Arvis, Mustra, Ojala, Shepherd, and Saslavsky, 2010; Ruiz and Calatayud, 2012). For instance, in their development of an Air Connectivity Index, Arvis and Shepherd (2011) defined connectivity as "the importance of a country as a node within the global air transport system" (p. 3) and included, apart from infrastructure components, existing indicators of trade and transport facilitation outcomes ('beyond-the-border' metrics such as the Logistics Performance Index or the Doing Business Trading Across Borders data). These outcomes are primarily endogenous and not tied to the geography of the network (Arvis et al., 2010). Likewise, Srivastava (2011) suggested that trade facilitation measures were an important factor increasing or decreasing the range and performance of a corridor, since they could lower or increase the cost of using the infrastructure belonging to the corridor. Gekara and Chhetri (2013) called for collaboration among governments so as to improve harmonization of transport policies and customs procedures, which would in turn lead to increased corridor performance and seamless flow of freight along the corridor.

Bhattacharyay (2012) suggested that, together with infrastructure investments, achieving seamless transport connectivity required improving 'soft' infrastructure, which included the policy, regulation, trade facilitation, and institutional frameworks that support the development and operation of physical or 'hard' infrastructure. Although there is still very little work available on this perspective, it shows growing attention towards broadening the perspective of connectivity in order to cover variables not only referring to infrastructure and transport services. This is in agreement with a more holistic view of transport systems as the one proposed by Preston (2012) and ITF (2012). With particular reference to international trade, a broader concept of connectivity implies addressing the different trade-related factors that affect "connectivity across borders" (ITF, 2012, p. 30) and that increase costs and time to move goods and "connect (…) markets" (ITF, 2012, p. 38).

4.2 Connectivity and Supply Chain Management

A second body of literature on the concept of connectivity falls within the field of Supply Chain Management. A review of literature in this field shows that the term connectivity is used to refer to "the collaborative electronic linkage of partners up and down the supply chain" (Poirier, 1999, p. 16). Closs and Swink (2005) refer to this as information connectivity, which relates to information-sharing and collaboration among supply chain partners. The importance of information connectivity has been well documented in the literature (Bowersox, Daugherty, Droge, Rogers, and Wardlow, 1989; Cachon and Lariviere, 1999; Golicic, Davis, McCarthy, and Mentzer, 2002). Advances in information technology have changed modern business models (Fawcett, Osterhaus, Magnan, Brau, and McCarter, 2007). Geographic location no longer restricts firms to markets and suppliers (Golicic et al., 2002). Technological advances and information-sharing allow firms to look for new suppliers, outsource activities and reach new customers, and at the same time making it possible to reduce costs and increase efficiency through increased supply chain collaboration.

Golicic et al. (2002) identified two components of connectivity in supply chain management: (1) interaction among firms and (2) market access. The former refers to the ability to remove technological barriers among supply chain members, allowing for complete visibility and enabling operations to be managed more effectively. The latter refers to the ability to build multi-directional flows of information through electronic platforms, overcoming the unidirectional communication of traditional business and allowing firms to establish closer relations with clients (Golicic et al., 2002). Through these electronically built networks, "connectivity provides for a level of interaction that is not as efficiently achieved in the traditional business environment" (Golicic et al., 2002, p. 859).

This concept of connectivity — the collaborative electronic linkage of partners throughout the supply chain — present in the literature on supply chain management relates to an important research stream focused on supply chain integration. Indeed, as stated by Sanders, Autry and Gligor. (2011, p. 179), "the very foundations of the supply chain integration concept rest upon the assumption that collaboration takes place between supply chain partners, which is only made possible through bidirectional flows of voluminous, rich information, including operations and planning data". Literature on supply chain integration suggests that the higher the degree of integration among partners across the supply chain, the better a firm performs (Frohlich and Westbrook, 2001; Narasimhan and Jayaram, 1998; Song and Panayides, 2008), and that the presence of information technologies and information connectivity is crucial to facilitate integration across the supply chain (Gosain, Malhotra, and El Sawy, 2004; Lewis and Talalayevsky, 1997; Song and Panayides, 2008). Among the benefits of enhancing connectivity, and thus integration along the supply chain, are better inventory control and visibility (Fawcett et al., 2007; Christopher, 2000; Narasimhan and Kim, 2001; Poirier, 1999); shorter order fulfilment lead times and product development cycles (Erhun and Tayur, 2003; Fawcett et al., 2007; Sahin and Robinson, 2002; Sanders and Premus, 2002); better monitoring of customer behaviour (Fawcett et al., 2007); enhanced capacity to design, monitor, and implement logistics plans (Gunasekaran and Ngai, 2004a and 2004b);

and greater logistics flexibility and improved delivery and logistics assets performance (Closs and Swink, 2005; Gosain et al., 2004). An empirical study conducted by Fawcett et al. (2007) showed that there was a strong relationship between a company's information-sharing capability and its performance, understood as its ability to reduce costs and increase service levels. They found that connectivity, along with the will to exchange information, accounted for over one third of the variance in operational performance in the firms analysed. Similarly, Sanders et al. (2011) found that increased information connectivity between a buyer and a supplier was beneficial not only to the supplier, but also to the buyer. Sanders et al. (2011) characterized this as a 'win-win' situation where information connectivity enhanced firms' competitiveness through lower costs, better delivery performance and greater flexibility.

Increasing connectivity along the supply chain has become a critical factor within the current trend in supply chain management towards outsourcing logistics activities. The adoption of information and communication technologies makes it possible to experience high levels of visibility, control and connectivity across the entire supply chain (Coronado, Lalwani, Coronado, and Coronado, 2009), resulting in higher levels of agility and, ultimately, higher business performance (Swafford, Ghosh, and Murthy, 2008). Information-sharing and, in general, the ability to integrate and coordinate complex networks of business relationships via electronic linkages are key sources of competitive advantage (Lam and van de Voorde, 2011; Song and Panayides, 2008).

Improving supply chain performance also requires partners to increase information-sharing — 'connectivity' — with infrastructure nodes and operators (Panayides and Song, 2013). In the case of international trade, ports and airports are central infrastructure nodes and gateways to international markets. With the emergence of global value chains and the fragmentation of global production, ports and airports have become strategic nodes in the larger logistics chain and a key part of global distribution channels (Carbone and De Martino, 2003; Mangan, Lalwani, & Fynes, 2008; Panayides and Song, 2008; Wang and Cullinane, 2006). Because of this critical role, leanness, agility and seamlessness in supply chain management require an increase in information connectivity between port and airport facilities and other supply chain nodes (Panayides and Song, 2008; Woo, Pettit, and Beresford, 2013).

The literature on port-supply chain integration suggests that information-sharing between the port and supply chain actors contributes to reduced order cycle times, a cut in inventories and more flexible systems (Woo et al., 2013). Song and Panayides (2008) identified three facilitators so that information can be shared effectively between the port and supply chain actors: (1) the use of electronic data interchange to communicate with shipping lines; (2) the presence of integrated information technology platforms to share data with shipping lines; and (3) the presence of computerized port service systems for operations with shipping lines. Nevertheless, they suggest that further research is needed in order to empirically assess the impact of port-supply chain integration on supply chain efficiency. There is evidence however that supply chain integration has a strong impact on port performance, since it helps port terminals to better accommodate the growing capacity of maritime transportation and the other relevant trends in a highly fluctuating, competitive, low-margin industry (Panayides and Song, 2013; and Woo et al., 2013). The integration of supply chain information with port management and systems is consonant with the emerging interest from public, private and academic sectors in moving towards integrated transport systems, so that the integrated management of infrastructure, services, policies and information results in a more efficient and seamless movement of people and goods.

4.3 Connectivity, Access to Markets and International Trade

The third domain of the literature explored gathers studies in the fields of International Trade and Economics. There is an emerging research trend in these fields that applies complex systems theory to international trade and explores connectivity from a network perspective (Bhattacharya, Mukherjee, Saramaki, Kaski, and Manna, 2008; De Benedictis and Tajoli, 2011; Duenas and Fagiolo, 2013; Fagiolo, Reyes, and Schiavo, 2009; Garlaschelli and Loffredo, 2005; Reyes, Schiavo, and Fagiolo, 2008; Serrano

and Boguna, 2003). These studies have cast light on the distortive patterns in the 'International Trade Network' (ITN), showing some countries being connected with many trade partners while others with only a few (Garlaschelli and Loffredo, 2005). Furthermore, they have provided evidence on the hierarchical arrangements existing in the ITN, where countries with high intensity of trade (those connected with many trade partners) are better connected with each other than countries with low intensity of trade (those with few trade partners) (Duenas and Fagiolo, 2013). In spite of these interesting conclusions on connectivity patterns within the ITN, these studies do not explore the factors influencing connectivity — or the size and distribution of international trade flows — in the ITN.

Research in the areas of Economic Geography, Regional and Urban Economics, International Trade and Economics, and to some extent in Transport Economics, has provided significant advances in understanding international trade flows and their determinants. Literature in Economic Geography and Regional and Urban Economics has studied the location preferences of firms and economic activities, which in turn influence international trade flows. This literature has evidenced the importance of factors such as infrastructure availability; factor endowment; proximity to suppliers, competitors or clients; benefits from agglomeration economies; the size of spatial units; and regulatory or institutional characteristics in the decision process of firms' location (Iammarino and McCann, 2013; Fujita, 2007; McCann and Acs, 2011). In the context of globalization and the rise of inter-industry trade, location decisions influence the directionality and size of international trade flows, creating an intricate array of global linkages among different spatial scales (Helpman, Marin and Verdier, 2008). 'Connectivity' among such spatial scales can be "manifested via a variety of different mechanisms such as corporate headquarter functions, corporate decision-making linkages, human capital mobility patterns, trade linkages, transport linkages, financial linkages, and asset management roles" (McCann and Acs, 2011 p. 26; Sassen, 2006; Taylor, 2004).

Within the broader array of relationships among different spatial scales and the different connectivity mechanisms available, academic work in the area of International Trade and Economics, and Transport Economics, has studied the determinants of the physical flow of freight traded internationally, which is the focus of this paper. For the past two decades preferential agreements, multilateral negotiations, and unilateral trade liberalizations have significantly reduced tariff barriers, whereas less visible trade deterrents have emerged to the physical flow of freight traded internationally. Studies have shown that infrastructure inefficiencies, inadequate regulatory environments, inconsistent standards and control procedures, and cumbersome customs clearance processes were among the main factors increasing trade costs and time to reach international markets. For example, Mesquita-Moreira, Volpe, and Blyde (2008) showed that the costs of physical barriers to trade could cancel the benefits derived from trade liberalization. Limao and Venables (2001) estimated that a deterioration of infrastructure from the median to the 75th percentile raised transport costs by 12% and reduced traded volumes by 28%. Djankov, Freund, and Pham (2010) estimated that each day that a product was delayed reduced the possibility of it being traded by 1% (6% when products were time-sensitive, e.g. perishable products) and that such a delay was equal to increasing a country's distance to its trade partners by 70 km. Hummels (2001) and Hummels and Schaur (2013) estimated that each additional day of transport was equivalent to imposing an ad valorem tariff of 0.6-2.3% and that it reduced the possibility of a country to export to the USA by between 1.0% and 1.5%. Nordas, Pinali and Geloso (2006) estimated that a 10% delay in transport time as a result of inefficient trade-related procedures reduced the value of trade between 8% and 40%. Hoekman and Nicita (2011) found that behind-the-border measures to improve trade facilitation were likely to have a comparable, if not larger, effect on expanding trade flows than preferential access programmes. Therefore, improvements in transport infrastructure and services and in trade facilitation procedures can help reduce cost and time to reach international markets, and increase trade flows (Djankov et al., 2010; Hummels, 2001; Mesquita-Moreira et al., 2008; Wilson, Mann, and Otsuki, 2005).

Within these studies, there is an emerging body of literature that explores the impact of connectivity for freight traded internationally. Such studies focus mainly on the role of infrastructure and transport networks in determining connectivity and increasing access to markets. Access to markets is defined as "the

ability of transportation facilities and services to provide households and businesses with access to opportunities that they desire", while connectivity is referred to as the possibility and ease of accessing such markets, based on the given characteristics of transportation facilities and services (Alstadt et al., Weisbrod, 2012, p. 2). In other words, access to markets can be defined as the ability of a product to reach a specific market demanding it, while connectivity relates to the transport infrastructure and services that physically move products from their origin to their destination markets. From this perspective, studies have shown, for example, that higher connectivity in air transportation — measured as the number of connections at a given airport — increased access to markets and stimulated economic growth (Tam and Hansman, 2002); that the loss of connectivity for certain areas in Europe due to airport closures had severely affected market access (Redondi et al., 2013); that increased road connectivity for rural areas enhanced access to technology, fostering crop productivity and output growth (Dorosh, Wang, You, and Schmidt, 2012); and that infrastructure investment was needed in order to strengthen the urban-rural, centre-periphery connection (Carruthers et al., 2008), as well as regional markets integration (Bhattacharyay, 2010). Moreover, available studies suggested that the characteristics of maritime transportation services had a significant effect on transport costs, the impact of which was higher than that of geographical distance and port infrastructure (Wilmsmeier and Martinez-Zarzoso, 2010), and that trade routes more centrally located in the maritime liner service network had lower average transport costs and higher trade flows (Marquez-Ramos et al., 2011).

A number of studies make a distinction between the concepts of connectivity and accessibility (Jenkins, 2011; Lam and Yap, 2011; Mishra, Welch, and Jha, 2012; Redondi, Malighetti and Paleari, 2013; Salgado and Cea, 2012; Weber, 2012; Wittman and Swelbar, 2013). Although tightly related according to these studies, accessibility can be defined as the ability to be reached by others, measured in terms of cost and time (Redondi et al., 2013; Salgado and Cea, 2012). Instead, connectivity is more related to the configuration and characteristics of infrastructure and transport services, as a result of which nodes obtain different positions within a network and access to other nodes in the network (Mishra et al., 2012). In the context of international trade and transportation, connectivity can be thought of as the "possibility to establish means of communication or connection between different places in the world" (Salgado and Cea, 2012). In general, according to this body of literature, connectivity can be thought of as a supply-side measure that indicates how well a node is integrated into a larger network and can reach other nodes, while accessibility can be seen as a demand-side measure that indicates how easily a population or market can be accessed or reached (Jenkins, 2011; Wittman and Swelbar, 2013).

In spite of the difference being clearly stated in the literature, there are a few studies that use connectivity and accessibility interchangeably or refer to them as synonyms (Yeo, Roe and Dinwoodie, 2008; Yu et al., 2013). While connectivity has different meanings in different contexts, accessibility also lacks a universally accepted definition. Geurs and van Wee (2004) reviewed literature in a variety of fields and concluded that the concept of accessibility is often misunderstood and poorly defined, leading to a range of different meanings. This range of meanings may explain the interchangeable use of accessibility and connectivity in the literature. Due to this fact, and in order to cover studies that may refer to connectivity to international markets but using the word accessibility instead, the authors searched for papers in Scopus using the keywords ("accessibility") OR ("access") AND ("international trade"), during the period 1950-2014. The search resulted in 132 papers, two of which were considered relevant to this study. Ramli and Ismail (2014) provide evidence on the impact that infrastructure provision has on trade costs and access to markets, and concludes that improvements in basic infrastructure can increase the accessibility of goods from producers to consumers. Thill and Lim (2010) analyse the performance of the US intermodal freight network by applying accessibility metrics. They define accessibility as "the attractiveness of the place in question, taking into account the trade and interaction opportunities offered (…) by the transport network" (p. 536).

Notwithstanding the importance of available studies in Transport Economics and International Economics and Business as a step forward in understanding the relationship between connectivity and trade, and between connectivity and accessing international markets, the literature review shows that the

available studies are still few and that there is still a knowledge gap regarding the role of connectivity in reaching international markets. Moreover, available work focuses on a narrow perspective of connectivity, referring only to the availability and capacity of infrastructure and transport services. However, the systematic review of the literature reported in this paper also suggests that there are broader perspectives on connectivity — including, for example, trade facilitation measures so as to cover the full range of interactions in a network — as well as alternative perspectives — namely the supply chain research stream where connectivity is understood as the ability to share information among supply chain members — that could be useful to understand the full interaction between connectivity and international trade, and the determinants of connectivity to international markets. A broader approach is also present in recent reports and projects supported by the public and private sectors aimed at improving "connectivity across borders" (ITF, 2012, p. 30). In addition to improving infrastructure and transport services, connectivity can be enhanced by increasing information-sharing and coordination of supply chain activities. Connectivity can also be strengthened by providing the necessary regulation and infrastructure to speed up the flow of goods and better "connect (…) markets" (ITF, 2012, p. 38). This is in line with the evidence provided by the literature in International Economics, which shows the importance of trade procedures and the negative impact of policy-related processes not only on international trade flows, but also on infrastructure and transport services performance.

Indeed, there is evidence in the literature that shows the importance of streamlining trade facilitation procedures in order to improve the efficiency of infrastructure and transport services. For example, in the case of road transportation, Srivastava (2011) suggested that trade procedures could lower or increase the cost of using the infrastructure belonging to a transport corridor. Therefore, trade facilitation measures are necessary to increase the range and performance of a transport corridor. Other literature with a focus on dry ports showed that trade-related procedures affected dry ports performance, intensifying their bureaucratic roles while undermining their logistics functions (Ng, Padilha, and Pallis, 2013). In particular, these studies showed that the complexity of customs clearance processes — including multiple duties, taxes, trade restrictions and regimes — created an environment where uncertainty led to higher inventory levels, increased time of cargo at ports, and higher port congestion (Ng and Gujar, 2009; Ng and Cetin, 2012; Ng et al., 2013). Similarly, academic work investigating seaport performance showed that specific institutional settings constrained port development, performance and growth (Hall, 2003; Jacobs and Hall, 2007; Ng and Pallis, 2010). In particular, a number of studies evidenced the negative impact that trade-related policies had on seaport performance. For example, Suarez, Trujillo, and Cullinane (2014) identified customs and other trade-related procedures among the elements that were positively correlated with port inefficiency. Wilmsmeier, Hoffmann and Sanchez (2006) showed that the delay of cargo during customs procedures had an impact on port performance and maritime freight rates, suggesting that a 1% increase in the time to clear customs raised maritime transport costs by 0.051%. Therefore, improving trade facilitation procedures can not only enhance connectivity to international markets — as the broader definition of connectivity suggests — but it can also improve the performance of infrastructure and transport services, the factors traditionally identified by the literature as the main determinants of connectivity.

5. Conclusion

The systematic literature review showed that there is little academic work available on the relationship between connectivity and international trade, and that the available literature evidences a positive impact of connectivity on international trade flows. This literature focuses on a definition of connectivity based on the availability and capacity of infrastructure and transport services. Indeed, as suggested by the literature in International Economics and Transport Economics, infrastructure and transport services are important determinants of international trade, since trade flows need infrastructure and transportation to reach destination markets. However, besides infrastructure and transport services, the literature also gives insights into the effect that trade-related procedures have on international trade flows. Such procedures

can affect the time and costs to reach destination markets, severely restricting trade flows. In line with this evidence, an emerging broader perspective on connectivity includes trade facilitation procedures, aside from infrastructure and transport services.

The analysis of the connectivity concept has shown that there are different definitions, belonging to different fields and with different degrees of focus. This suggests that connectivity, rather than being an absolute concept, is defined within the field and the context that it is being applied to. The literature review on the concept of connectivity encompassed studies in multiple disciplines including Economics, Engineering, and Supply Chain Management. The analysis presented in this paper showed that, similar to the diverse viewpoints present in national and international policy-making arenas, in the academic literature there is no harmonized definition of connectivity but different approaches to it, depending on the theoretical perspective and discipline involved. This can be attributed to the fact that the topic of connectivity does not fall into a discrete subject area but it is relevant to many disciplines, which in turn has given birth to different theoretical approaches.

Although the literature is spread over a large variety of academic fields, our analysis suggests three main theoretical perspectives on connectivity: (1) a narrow perspective focused on the availability and characteristics of infrastructure and transport services; (2) a broader perspective that includes trade facilitation procedures; and (3) a supply chain management perspective. Table 3 provides a summary of our findings.

Table 3. Connectivity to international markets:
summary of theoretical perspectives and literature review

In spite of being different in scope and focus, these perspectives are not mutually exclusive. The perspective on connectivity that includes trade facilitation procedures also encompasses infrastructure and transport services and therefore can be thought of as an expansion of the narrower perspective that focuses only on infrastructure and transport variables. In turn, and although less evident in the literature, there is a shared feature between the infrastructure and transport services perspective and the supply chain management perspective; this refers to the aspect that information-sharing is becoming critical for transport and logistics chains to perform effectively and, conversely, it is increasingly important to include information on infrastructure and transport services performance in supply chain information-sharing platforms, for supply chains to achieve efficiency.

This paper contributes to the literature not only by providing a systematic analysis of the concept of connectivity in the context of the international movement of freight, and thus provides a critique on the different perspectives and determinants suggested by the literature. It also contributes by proposing that the three different perspectives on connectivity identified via this systematic literature review — the narrow perspective that focuses on infrastructure and transport services; the broader perspective that also includes trade facilitation procedures; and the supply chain management perspective — can be combined in a multi-disciplinary framework so as to understand the determinants of connectivity to international markets. A comprehensive and more precise understanding on the factors affecting connectivity for freight can provide better guidance for academic research and policy-making. With particular reference to the international trade and transport policy arenas, where the concept of connectivity has been used in different ways, a comprehensive and more precise understanding of the determinants of connectivity can contribute to identify and design more effective policies to address barriers impeding the fast, smooth access of freight to international markets.

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Table 1. Papers that satisfied the relevance and quality criteria, by domain (1950−2014)

No.	Domain	Author	Title	Year
1	Transportation	Cui	The complex properties of Chinese ship-transport networks	2014
2	Transportation	Gekara and Chhetri	Upstream transport corridor inefficiencies and the implications for port performance: a case analysis of Mombasa Port and the Northern Corridor	2013
3	Supply Chain Management	Regmi and Hanaoka	Location analysis of logistics centres in Laos	2013
4	Transportation	Salgado and Cea	External connectivity analysis of the ports of Chile as a factor of competitiveness	2012
5	Transportation	Marquez-Ramos et al.	Maritime Networks, Services Structure and Maritime Trade	2011
6	Transportation	Kaluza et al.	The complex network of global cargo ship movements	2010
7	International Trade	Barigozzi et al.	Multinetwork of international trade: A commodity-specific analysis	2010
8	International Trade / Transportation	Wilmsmeier and Martinez-Zarzoso	Determinants of maritime transport costs - A panel data analysis for Latin American trade	2010
9	Supply Chain Management	Wilson and Duffy	Improved information connectivity and visibility throughout the global supply base	2010
10	Transportation / Supply Chain Management	Coronado et al.	Facilitating multimodal logistics and enabling information systems connectivity through wireless vehicular networks	2009
11	International Trade	Fagiolo et al.	Dynamics and evolution of the international trade network	2009
12	Supply Chain Management	Gosain et al.	Coordinating for flexibility in e-business supply chains	2004
13	International Trade	Kikuchi	Time zones, outsourcing and patterns of international trade	2006
14	International Trade	Moodley	Connecting to global markets in the Internet age: The case of South African wooden furniture producers	2002

Table 2. Main sources of the articles selected

Journal	No. of articles selected
Journal of Transport Geography	16
Maritime Policy & Management	7
Maritime Economics & Logistics	5
Int. Journal of Physical Distribution and Logistics Management	5
Transport Reviews	5

Table 3. Connectivity to international markets: summary of theoretical perspectives and literature review

Theoretical perspective	Definition	References	Main argument regarding connectivity
Narrow perspective with focus on infrastructure and transport services	Availability and capacity of infrastructure and transport services and their ability to link supply and demand markets	Batthacharyay (2012); Carruthers et al. (2008); Dorosh et al. (2012); Meijers et al. (2012) ; Moreno and Lopez (2007).	Connectivity is determined by the availability and capacity of transport infrastructure. Infrastructure enables spatial connectivity between markets.
		Air transportation: Alderighi et al. (2007); Burghouwt and Redondi (2013); Malighetti et al. (2008); Paleari et al. (2009 and 2010); Redondi et al. (2011); Reggiani et al. (2010); Wang et al. (2011). Maritime transportation: Cui (2014); Ducruet and Lugo (2013); Ducruet and Notteboom (2012); Ducruet et al. (2010); Ducruet and Zaidi (2012); Gonzalez et al. (2012); Kaluza et al. (2010); Marquez-Ramos et al. (2010 and 2011); McCalla et al. (2005); Notteboom (2006); Pais et al. (2012); Salgado and Cea (2012); Wilmsmeier et al. (2006).	Connectivity is a network property and refers to the degree to which nodes are connected to each other as a function of the characteristics of transport services.
		Passenger transportation: Burghouwt and de Wit, (2005); Derrible and Kennedy (2011); Guo and Wilson (2011); Jin et al. (2014); Li et al. (2012); Shafani and Khani (2010); Veldhuis (1997); Wang et al. (2009). Freight transportation: Bontekoning et al. (2004); Bathel and Woxenius (2004); de Langen and Sharypova (2013); Kim and Park (2012); Schonharting et al. (2003).	Connectivity refers to the interoperability and coordination within and across transport modes.
Broader perspective including trade facilitation	Availability and capacity of infrastructure and transport services, and efficiency of trade procedures	Arvis et al. (2010); Arvis and Shepherd (2011); Gekara and Chhretri (2013); ITF (2012); Ruiz and Calatayud (2012); Srivastava (2011).	Connectivity is determined not only by infrastructure and transport services, but also by trade-related procedures that affect the performance of infrastructure and transport services.
		Djankov et al. (2010); Gonzalez et al. (2007); Hummels (2001); Hummels and Schaur (2013); Wilson et al. (2005).	International trade flows are negatively affected by trade policy barriers that increase costs and time to reach international markets.
Supply chain perspective	Degree of information-sharing among supply chain members	Christopher, (2000); Closs and Swink (2005); Erhun and Tayur (2003); Fawcett et al. (2007); Golicic et al. (2002); Gunasekaran and Ngai (2004 a and b); Poirier (1999); Narasimhan and Kim (2001); Panayides and Song (2013); Sahin and Robinson (2002); Sanders and Premus (2002); Sanders et al. (2011); Song and Panayides (2008); Woo et al. (2013).	Increasing connectivity with suppliers and customers is critical for better inventory control and visibility; shorter order fulfilment lead times and product development cycles; better monitoring of customer behaviour; and enhanced capacity to design, monitor and implement logistics plans, among others.

Figure 1. Graphical illustration of the literature search process and results