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Abstract

Purpose – The purpose of the paper is to analyse how transport activities are embedded in supply chains and networks.

Design/methodology/approach – The paper is empirically grounded in a single case study that describes and analyses a supply chain of a particular product, Geocloth, focussing on how transport activities are organised in the supply network.

Findings – The paper concludes that transport activities are embedded in two related settings – the supply chain setting and the transport network setting – with implications for how adjustments can be made to increase transport performance. Furthermore, the paper shows how transport performance can be analysed as a function of how business relationships are connected vertically (i.e. how transport activities are sequentially connected within supply chains) and horizontally (i.e. how transport activities are connected across supply chains with regard to joint resource use).

Originality/value – The paper contributes to the understanding of how transport is integrated in supply networks by focussing on the connections between business relationships in supply chains and by pointing to how transport activities are embedded both in supply chain settings and in transport network settings.

Keywords Embeddedness, Transport, Activity, Interdependence, Supply chain, Coordination, Governance

Paper type Research paper

Introduction

Supply chain activities contribute immensely to environmental impact and related emissions (Carter *et al.*, 2019) and this is projected to increase (International Transport Forum, 2021). In particular, freight transport activities are challenging when it comes to improving supply chain sustainability (Hesse and Rodrigue, 2004; Coyle *et al.*, 2015; Ellram and Murfield, 2017). The European Union (EU) has set goals to reduce CO_2 emissions from the transport sector by 60% by 2050 compared to the 1990 level (European Environment Agency, 2019). McKinnon (2021) argues that freight transport (henceforth referred to as transport) is difficult to decarbonise due to its heavy dependence on fossil fuels and forecasted growth. One way to reduce the negative environmental impact of transport is to change the mix of transport modes applied, such as intermodal transport solutions (Bask and Rajahonka, 2017; Reis and Macario, 2019). Another way is to develop the production and use of renewable fuels (García-Olivares *et al.*, 2018;

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Teixeira and Sodré, 2018; Navas-Anguita *et al.*, 2019) and other transport-related technologies that reduce emissions (Arvidsson *et al.*, 2013). However, these solutions will not result in reaching the overarching goals (Johansson, 2009; Wehner, 2020). In addition, active measures must be taken that make transport more efficient (Castillo *et al.*, 2018; Evangelista *et al.*, 2018; Rogerson, 2016). Over time, considerations of the performance of transport activities have developed from a focus on efficiency (i.e. using transport resources as much as possible) to a focus on other aspects such as service effectiveness for shippers and consignees (Lai and Cheng, 2003), energy efficiency (Halldórsson and Wehner, 2020) and reducing emissions and cost (Ellram and Murfield, 2017). Regardless of the exact definition of transport performance, it can be argued that the ways in which transport activities are embedded in supply chains are vital to understand when analysing changes aimed at improving performance. Therefore, the purpose of the paper is to analyse how transport activities are embedded in supply chains and networks.

The paper is outlined as follows. The next section presents a brief literature review of transport as part of supply networks. The third section provides the conceptual framework by focussing on activity interdependencies, resources and the utilities they provide as well as coordination and governance. The fourth section presents the method, followed by the case study in section five and the case analysis in section six. The seventh section provides concluding remarks together with implications for supply chain and policy actors as well as suggestions for further research.

Transport as part of supply networks

Considering the increased attention on sustainability within the supply chain management (SCM) field, it is somewhat surprising that the focus on transport (Ellram and Murfield, 2017) and logistics (Swanson *et al.*, 2018) is relatively limited within the SCM literature. Nevertheless, several studies have highlighted the intrinsic and complex embeddedness of transport activities in supply chains and their impact on sustainability (Andersson *et al.*, 2019; Hedvall *et al.*, 2016; Jahre and Fabbe-Costes, 2005; Sternberg *et al.*, 2013; Vural *et al.*, 2019). Similarly, McKinnon (2021, p. 119) argues that even though "the switch to low carbon energy, particularly for road and rail modes, will ultimately deliver much of the required decarbonisation, this will need to be supplemented by a reconfiguration of supply chains". Hence, there is a need to analyse transport as a part of wider logistics and SCM contexts. McKinnon (2021, p. 120) states that when "set against the existential threat that climate change poses to mankind, this perhaps represents the most persuasive argument for researching freight transport within a logistical context".

Early on, Böge (1995) illustrated how transport activities related to "the well-travelled yoghurt pot" were embedded in a complex network of buying and selling firms in various locations. This vital aspect of how transport is embedded in supply networks relates to Hesse and Rodrigue's (2004) notion that transport should not (only) be regarded as a derived demand but as an integrated demand. In addition, Choi *et al.* (2021, p. 201) found that part "of the complexity associated with supply chains is that buying firms do not necessarily know with certainty from where a supplier (first-tier or further upstream) is sourcing or sending the material". Moreover, discussing the increasing attention on sustainability and the role of transport, Meqdadi *et al.* (2020) assert that sustainability performance is not just an issue for the focal actor and its direct counterparts, but also an issue for the broader network as many problems stem from actors situated farther from the focal actor such as the supplier's supplier or the customer's customer (Villena and Gioia, 2018). Similarly, Huge-Brodin *et al.* (2020), focussing on environmental alignment between logistics service providers and shippers, find that so-called secondary stakeholders play important roles in driving the adoption of green logistics initiatives. Amongst such secondary stakeholders, Huge-Brodin *et al.* identify the shippers' customers as having a strong influence on what is practically achievable.

Although the question of how sustainability should be resolved remains unanswered, interaction and organising amongst actors might "open avenues for major and behavioural changes that comprehensively diffuse sustainability" (Meqdadi *et al.*, 2020, p. 743). In addition, Fulconis *et al.* (2016) note that the actors involved in supply and demand of transport services are key to accomplishing more efficient transport. The buying firm's role in setting up sustainable and efficient transport solutions has been addressed by, for example, Lin (2019). In a case study of a Swedish retailer chain with retailing points in Scandinavia and Poland, Lin (2019) concludes that various measures such as upstream buyer consolidation and modal shift downstream could curb CO_2 emissions.

In more general terms, Swanson *et al.* (2018, p. 113) argue that many scholars consider "relationships with customers, suppliers and logistics service providers as the most important focus of SCM". Furthermore, Johnsen (2018, p. 96) states that networks have become a key aspect in SCM theory and that the increasing awareness of sustainability "requires new thinking about how best to influence and manage supply networks". Hence, whilst (dyadic) collaboration between supply chain actors has been a prominent issue within SCM for a long time (Horvath, 2001; Matopoulos *et al.*, 2007; Huang *et al.*, 2020), SCM scholars note the need to expand the scope from dyadic business relationships to triads and/or networks (Braziotis *et al.*, 2013; Mena *et al.*, 2013; Carter *et al.*, 2015, 2017; Vlachos and Dyra, 2020).

Based on a systematic review of the conceptual and empirical literature in the area of environmental sustainability in freight transport (ESFT), Ellram and Murfield (2017) suggest several routes for further research. In this paper, we draw on some of these suggestions. First, Ellram and Murfield suggest applying network theory to understand collaboration in networks. Second, they suggest that case studies are needed to understand individual firm behaviour. Third, they point to a need for multiple levels of analysis to improve the understanding of outcomes. In addition, they stress the need for theory development:

> While the limited use of theory in the extant research supports the call for more theory-driven, theory-elaborating, and theory-building research [. . .] we also believe that there is an opportunity to explore additional theories, based on specific issues we observed in the literature. Linked with network theories, the notion of collaborating to improve sustainability and more specifically the role of networks [. . .]. Because so much transportation is outsourced across multiple levels in a supply chain, effective ESFT involves working with others to improve outcomes. (Ellram and Murfield, 2017, p. 284)

Following the suggestion by Ellram and Murfield (2017) to capture networks and collaboration, this paper draws on notions of business relationships and industrial networks (see, e.g. Håkansson and Snehota, 1995; Gadde *et al.*, 2010). This enables scrutiny of how transport is embedded in supply chains as well as in wider networks.

Conceptual framework

Considering transport as an integrated activity in supply chains, the conceptual framework first focusses on the interdependencies that transport activities are subject to in relation to other activities in supply chains. We identify two main types of interdependencies: vertical (i.e. interdependence between activities within a supply chain) and horizontal (i.e. interdependence between activities in different supply chains as a result of joint resource use) (Dubois *et al.*, 2004). The latter relates to the second part of the framework: how transport activities activate various transport resources that enable three types of utilities: time, place and form. The third part of the framework focusses on the governance of the activities subject to interdependence and the actors involved in the performance and coordination of the activities. Finally, we present two research questions.

Activities and interdependence

Vertical interdependence occurs between activities that are undertaken in sequence. Concepts such as supply chains and transport chains implicitly rely on the notion of sequential interdependence. Thompson (1967) defines *sequential interdependence* as the output of one activity being the input for the next activity. This type of interdependence requires coordination within as well as across firm boundaries (Richardson, 1972). Moreover, Richardson (1972, p. 889) distinguishes between two types of sequential interdependencies amongst activities: activities are *complementary* when they represent "different phases of a process of production and require in some way or another to be co-ordinated" and *closely complementary* when there is a need to "match not the aggregate output of a general-purpose input with the aggregate output for which it is needed, but of particular activities" (Richardson, 1972, p. 891). For close complementarity, plans need to be matched to coordinate the activities undertaken by different firms.

Horizontal interdependence concerns activity interdependence when activities activate common resources. That is, this type of interdependence concerns, for example, joint resource use, efficiency and economies of scale (Dubois *et al.*, 2004). Richardson (1972, p. 888) conceptualises this category of interdependence as *similar activities*, arguing that activities are similar if they "require the same capability for their undertaking'. Furthermore, some degree of standardisation is required to enable the use of common resources. Similarly, Thompson (1967, p. 54) identifies *pooled interdependence* as when "each part renders a discrete contribution to the whole and each is supported by the whole". For transport, horizontal interdependence concerns how individual transport activities in a certain supply chain are subject to interdependence with similar transport activities in other supply chains if they make use of the same transport resources such as vehicles or infrastructure.

Resources and utilities

When transport resources are activated, they provide form, time, and place utilities in supply chains (Emerson and Grim, 1996). Form utility relates to aspects such as the capacity of vehicles, terminals and handling equipment as well as technical features relating to, for example, weight, size and standards. Time utility relates to aspects such as delivery schedules, timetables and delivery windows, whilst place utility relates to aspects such as locations of facilities and routes.

Some transport resources may be regarded as fixed by the actors involved in supply chains (Heskett *et al.*, 1964). Examples of such fixed transport resources are infrastructure such as roads and railways and hubs for vessels, trains and trucks as well as logistics resources such as distribution centres and warehouses. According to Heskett *et al.* (1964), these *fixed resources* are connected through *connecting resources* such as various vehicles and load carriers. Adapting the features of an existing resource can lead to a better fit with the resources it is combined with. For example, changing the dimensions of load carriers can make them fit better with some vehicles and, therefore, improve their load factors. However, such changes can also result in resources that do not fit with other resources. For example, changing fixed resources, such as infrastructure, heavily impacts the connecting resources making use of the infrastructure.

The *products* subject to transport (typically referred to as goods in the transport domain) are the third type of resource related to transport activities. The features of the products to be transported such as weight and length affect the choice of transport resources used (Jahre *et al.*, 2006; Prenkert *et al.*, 2019). In sum, three types of resources – fixed resources, connecting resources and products – are important to consider when analysing how transport activities are embedded in supply chains. Furthermore, depending on how these resources are combined, they provide form, time and place utility.

Governance and coordination

Transport activities are most often carried out by transport service providers (Lammgård, 2007) specialising in performing and/or coordinating transport activities by use of connecting resources and fixed transport resources. Since these activities are subject to close complementarity (Richardson, 1972) regarding production and logistics activities taking place before and after the transport activity in the supply chain, *relational coordination* enabling *ex ante* matching of plans is required. *Business relationships* will be used as the concept capturing the business exchange including the coordination of activities between two firms (Håkansson and Snehota, 1995). The interaction that takes place in business relationships enables the actors to adjust their activities and adapt their resources to increase their joint performance. However, because each actor is also involved in other business relationships and supply chains, relational coordination is needed to coordinate vertical as well as horizontal interdependence. Horizontal interdependence regarding joint use of transport resources requires a combination of internal and relational coordination by the transport service providers.

The combination of vertical and horizontal interdependence entails that (dyadic) business relationships between customers and suppliers of transport services/activities form networks of connected business relationships. The first order of such connected relationships is the triads consisting of three actors and the relationships between them. For example, third-party logistics are inherently related to triads. Sengupta *et al.* (2018, p. 334) state that "outsourcing of logistics solutions to third-party providers, therefore, requires a major shift in focus from goods to services and from dyads to triads". Furthermore, the notion of transport service triads (Andersson *et al.*, 2019) is based on the business exchange between a buyer and supplier of a product and the business exchange between the supplier and buyer of the transport service related to the specific product (or goods). The authors argue that this connection "makes up a core unit of analysis as part of a wider supply network of actors and relationships" (Andersson *et al.*, 2019, p. 253). Hence, from a supply chain perspective, a way to capture networks of connected relationships is to identify the connections between the relationships in a specific supply chain. Analysis of such connections is instrumental in this case study, which focusses on how transport activities are embedded in supply chains and networks.

Analysis of how transport activities are embedded in supply chains and networks

To analyse how transport activities are embedded in supply chains and networks, we focus on the interdependencies of transport activities. Starting with identifying the transport activities in a focal supply chain, we address the four issues as follows: (1) how the transport activities are subject to vertical interdependence; (2) how they are subject to horizontal interdependence by sharing (transport) resources with other transport activities (across supply chains); (3) what actors are engaged in performing and coordinating the transport activities and (4) what roles these actors take in the supply chain regarding the transport activities. In addition, the features of the resources related to the form, time and place utilities are addressed in view of how these utilities impact the performance and coordination of the activities. Since the transport activities in a particular supply chain are related to transport activities in other supply chains, these connections between business relationships are identified. Two research questions are addressed as follows:

RQ1. What interdependencies are transport activities subject to in the supply chain and how are these coordinated?

RQ2. What business relationships within and beyond the focal supply chain influence the performance of the transport activities?

Method

The paper is based on a qualitative single case study that describes a supply chain of a particular product, Geocloth. Specifically, the case focusses on how transport activities are organised in this supply chain. The starting point of the case study is a technical wholesaler [here referred to as Wholesaler (W)] and its supply chain partners engaged in the focal product – i.e. the Contractor (C), Producer (P), LSP A/S [1], Haulier (H) and LSP. LSP also engages with several other partners in its network included in the case: Tracks, Railway, and Vessel.

Kull *et al.* (2018, p. 29) state that if we are interested in network-related issues "and our research questions and theoretical frameworks concern relational or supply network phenomena, then our unit of analysis is no longer a focal firm". In light of this and considering the call for research to go beyond the focus on single firms and dyads, the focal unit of analysis in this case study is the connections between business relationships in supply networks, including both the physical supply chain (i.e. of the focal product) and the transport chain (i.e. of the transport activities involved in the focal supply chain). Therefore, the focal unit of analysis follows the division between physical and support chains as suggested by Carter *et al.* (2015). A single case study was chosen as we sought a detailed exploration of how transport activities are embedded in a supply chain. The choice of this particular product supply chain was based on access as the supply chain was investigated in a previous study involving W and a desire to analyse the embeddedness of transport activities in a supply chain of a seemingly simple product from its origin to its point of use. Furthermore, the use of an intermodal transport solution in the case was also a decisive factor, since such solutions are seen as vital for transitioning to a more sustainable transport system. Intermodal transport solutions are promoted by regulatory bodies (e.g. the EU) as a way to introduce a more sustainable mix of transport modes (Bask and Rajahonka, 2017). In addition, it is in line with many firms' (buyers and providers) efforts to achieve operational efficiency, economies of scale and low-carbon transport alternatives (López-Navarro, 2014).

Case studies have proven to be a fruitful approach for studying business network phenomena (Dubois and Araujo, 2007; Easton, 2010), including investigations of contextual issues (e.g. understanding transport purchasing in an international setting) and dynamic issues (e.g. coordination of interdependencies in supply chains and networks). Different contextual and dynamic issues have recently been examined in case studies by Arroyo *et al.* (2018), who focus on supply chain integration, and by Akhavan and Zvezdov (2021), who address sustainability information in supply chains.

The empirical data were collected between 2016 and 2019. The data comprise 13 semi-structured interviews with 15 interviewees from four companies (Table 1). The interviews focussed on (1) how the transport activities were organised and managed, (2) what transport resources were used, (3) what actors and relationships were involved in the supply chain and (4) how these directly and indirectly influenced the transport activities. The interviews lasted between 30 and 180 min and were mostly recorded and transcribed. Additional data and information were collected through numerous project meetings and site visits at W and C. In addition, archival records such as publicly available firm reports and in-house documents were used.

Company	Role of interviewee
Wholesaler	Head of transport; transport developer; head of construction logistics; head of transport and two purchasers
Contractor	Category manager tools and light equipment; logistics manager and category manager transport
LSP	Product specialist intermodal solutions and head of road brokerage
Haulier	Transport manager; terminal manager; quality manager and vice president

Table 1.
Summary of the interviews carried out in the study

The research process was abductive as described by Dubois and Gadde (2002) and Kovács and Spens (2005). This research strategy permits interplay between theory and empirical fieldwork. In short, alternating between the theoretical domains inspires the search for empirical data, and new data open up for adjustments in the theoretical domain. In this study, we started by focussing on W and its operations related to delivering goods to its customers. As a result, we attained a detailed and focussed understanding of how W manages its customer-side operations, especially regarding sales, transport operations and customer relationship management. The importance of the triad consisting of W, H and C was identified and analysed.

However, during the data collection, it became apparent that W was chiefly unaware of the upstream transport of Geocloth (as well as other products in its assortment) from the supplier until it arrived at W's warehouse. Geocloth was chosen for the study because it is a frequently sold and standardised product with a relatively steady flow from the supplier and W knew that the transport included a mix of transport modes. Thus, the transport activities embedded upstream of the supply chain were considered interesting for further scrutiny. To understand the supply chain both upstream and downstream, we leapt from single triads to connected triads, leading to new data collection that bridged triads and connected triads. This strategy allowed us to analyse the complexity of the transport activities in the supply chain. This bridging also called for other theoretical notions. At first, we developed a framework for analysis of transport efficiency as dependent on how transport resources are utilised in the buying and supplying of goods and transport services in supply networks. The conceptual framework evolved in interaction with the data collection and case description. For example, additional data from some actors were required to explain certain aspects of the complexity of the intermodal transport arrangements that appeared in the case. We realised that the framework did not leverage the central aspects of the evolving case, the interdependencies and how these interdependencies are nested in the network. Furthermore, the processes of nesting the supply chain also revealed other aspects of embeddedness, and we wanted to highlight more of the embeddedness of the transport activities (as focal) in the supply chain. To analyse this complexity, we added a more focussed theoretical grounding within the industrial network approach and additional concepts related to vertical and horizontal interdependencies and coordination. In addition, the initial focus on transport efficiency was replaced with transport performance to broaden the view on the outcomes of various changes. In particular, the many changes that must be made to transform the transport system into a more climate neutral system require a wider range of performance aspects than efficiency alone. Thus, the final purpose of the paper was formed: to analyse how transport activities are embedded in supply chains and networks.

The starting point of the study was the focal triad involving W, H and C and the connections to other triads. However, interesting side-tracks were identified, which sparked an interest to dig deeper into the supply network that the business relationships and transport activities in the focal triad were embedded in. The supply chain and transport networks identified involve many actors beyond the focal triad. In addition to the interviews, additional Internet searches for information about the involved parties, including news articles and insights from other studies, were used to gain a broader view of the intermodal operations in central Europe. Altogether, the steps described above resulted in an iterative process between the empirical description and the analytical framework as part of the evolving case, resulting in a case that illustrate the embeddedness of transport activities in supply networks.

The Geocloth case: transport activities in a supply chain context

The case focusses on the supply chain of a specific geotextile product, Geocloth. This product is produced in Italy by P and is distributed by the Swedish-firm W to one of its key customers, C, in Sweden. The case also involves the following firms: the transport provider, H; the LSPs, LSP and LSP A/S; the rail operators, Railway and Tracks; the ferry operator Vessel, the subcontractors to C and the suppliers to W. W is a large wholesaler of installation products with operations mainly in Sweden. The company has around 100,000 products available in stock and buys a wide array of products from about 3,000 suppliers.

W handles transport services in three ways. First, the suppliers of goods use W's agreements with transport service providers. Second, the suppliers of W manage the purchase of transport services and include transport in the price of the goods. Third, W contracts transport providers to pick up products at suppliers.

C is a large construction company with operations across Sweden and is one of W's primary customers. W and C have had a business relationship for 30 years, and W is one of C's preferred suppliers. H is a small transport provider with local operations comprising terminal handling and haulage of goods. H is contracted by W to handle all deliveries to its customers in Stockholm. W and H have been involved in a 30-year business relationship, and the companies work closely together. W is H's only customer. These three companies comprise the end of the downstream supply chain since C uses purchased material from W in its construction projects and the materials are transported by H.

LSP is a large pan-European logistics service provider that W uses when sourcing products upstream from suppliers in Europe and Asia. When W sources products from Europe, the Swedish part of LSP administers the orders and sends them to one of its offices close to where the supplier is located. W is one of LSP's most important customers in Sweden.

LSP has an extensive network of transport firms. First, Railway is a German rail logistics company that focusses mainly on the central European network. Second, Tracks is an Italian rail logistics company that operates in 11 European countries with a focus on the north–south rail route. In Sweden, Tracks operates rail transport between two locations, Trelleborg and Eskilstuna. Third, Vessel is a large shipping operator providing short-sea-shipping services between major ports. By working with several logistics operators, Vessel connects, for example, Germany and Sweden. LSP's intermodal solution comprises rail, sea and road transport, but the customers tend to favour road transport, as it offers flexibility with fewer limitations in infrastructure and capacity compared to rail and sea. LSP has three principal offerings for transport of goods in Europe: (1) packages; (2) part load, often referred to as less than truckload (LTL) and (3) full truckload (FTL). Goods up to 2.5 tonnes are shipped as packages, goods between 2.5 and 19.4 tonnes are shipped as LTL and goods above 19.4 tonnes are shipped as FTL.

Figure 1 illustrates the supply chain of Geocloth, focussing on the nodes and transport legs involved from P in northern Italy via W in Örebro to C in Stockholm. Nodes 1–9 denote a facility or a hub in the sequence of transport activities, and legs 1–8 denote transport by road, rail or sea. A summary of the transport legs is found in Table 2.

The transport sequence from nodes 1–7 is coordinated by LSP, and most goods to and from Sweden go through the main transport corridor connecting Italy and Sweden. This transport corridor is characterised by high availability of goods and capacity utilisation northbound but low availability southbound (e.g. from Sweden to Italy). To mitigate this north–south balance issue, LSP and its competitors collaborate by frequently buying transport capacity from each other. For LSP, this collaboration reduces the need to reposition empty trailers. LSP has customers spread across Europe, which helps balance the transport flows. However, they still need to handle both peaks and valleys related to demand at different locations and times. To manage this balancing issue, LSP pre-books capacity in certain slots each week on the trains and vessels operated by Railway and Vessel, respectively.

From wholesaler to contractor

The supply of Geocloth is triggered by a demand in one of C's projects. In this specific case, the buyer of the Geocloth is positioned at a construction site in Stockholm (nodes 7–9 and

Figure 1. The nodes and transport legs in the supply chain of Geocloth

legs 7 and 8). The order is placed using W's web portal. When W's warehouse in Örebro receives the order and the Geocloth is picked, packed and transferred to the outbound transport area. The Geocloth is then loaded on a truck together with other products directed to the Stockholm area.

LSP A/S operates about eight fully loaded dedicated trucks daily from W's warehouse in Örebro to the terminal operated by H in Stockholm. LSP A/S has other customers that enable them to utilise the truck capacity from Stockholm to Örebro. This was the main reason for W to choose LSP A/S as the carrier on this leg. Before starting to work with LSP A/S, W also worked with LSP on this leg. However, LSP had problems balancing this distance as it was considered too costly to pay for empty loads, resulting in the change of carrier.

When the Geocloth arrives at the terminal, it is sorted and loaded on a truck together with other products from W going to the same geographical area in Stockholm. H then transports the Geocloth to the construction site of C the day after the order is placed. W has a day-after-order-delivery guarantee for its customers, as it desires to maintain a high-service level. Since orders are placed to W by different customers (C and its subcontractors) operating at the same construction site and these customers may have different requirements of delivery time windows, H might need to deliver to the same construction site several times a day. Moreover, there are possibilities for customers to receive deliveries earlier than guaranteed for an extra fee or to require a specific truck, for example, with a crane. However, there is no possibility to postpone deliveries after the day the order is placed.

From producer to wholesaler

W buys the Geocloth from P in Milan. W buys around 500,000 m^2 (one trailer can carry 60,000 m^2) of Geocloth per month in different sizes ranging from 1 to 6 metres wide. The assortment of Geocloth comprises 20 articles. When the minimum stock level of Geocloth in W's warehouse is reached, it triggers an order to P. At P's facility in Italy, the order is processed and prepared for shipment. Meanwhile, W sends a transport order to LSP, which coordinates several transport arrangements across Europe with weekly deliveries to and from Sweden. In general, there are two set-ups possible regarding the shipments; either the order is a part load (LTL) or a FTL. In the case of Geocloth, FTL is used from P. This implies that it is in the interest of W to utilise the capacity by loading each trailer as much as possible. In LTL situations, the order is packed so that it can be combined with orders from other LSP customers. Hence, in the case of LTL, LSP picks up goods from various customers within a specific geographical area until a minimum weight of 24 tonnes or the maximum weight of 28.5 tonnes is reached. If there are not enough customer orders in a specific area to reach the minimum weight, the trailer is transferred to LSP's terminal in Milan for additional loading of goods until the minimum weight is reached.

The total time from order placement by W to delivery is 32 days according to the agreement, including 10 days for transport from P in Italy to W in Sweden. According to the transport agreement between W and LSP, LSP has fixed times for pick up of the goods at P's facility to make sure that the trailers do not miss the departure of the train. The responsibility of P ends when the goods are made available at the loading platform.

Table 2.
Summary of the transport legs in the Geocloth case

Leg	Start	End	Mode
Leg 1	Milan, Italy (Factory)	Domodossola, Italy (Terminal)	Truck
Leg 2	Domodossola, Italy (Terminal)	Karlsruhe, Germany (Terminal)	Train
Leg 3	Karlsruhe, Germany (Terminal)	Rostock, Germany (Terminal)	Train
Leg 4	Rostock, Germany (Terminal)	Trelleborg, Sweden (Terminal)	Vessel
Leg 5	Trelleborg, Sweden (Terminal)	Eskilstuna, Sweden (Terminal)	Train
Leg 6	Eskilstuna, Sweden (Terminal)	Örebro, Sweden (Warehouse)	Truck
Leg 7	Örebro, Sweden (Warehouse)	Stockholm, Sweden (Terminal)	Truck
Leg 8	Stockholm, Sweden (Terminal)	Stockholm, Sweden (Construction site)	Truck

W buys the transport from LSP in Sweden which contacts its local office in Italy. That is, W connects its supplier of goods, P, with its supplier of transport services, LSP, through a so-called routing order. The routing order enables P to book the transport from LSP on behalf of W. Hence, the contract and all documentation are negotiated and managed between W and LSP. Moreover, W pays the shipping fee, and LSP's local business unit in Italy is responsible for the transport arrangements.

LSP is responsible for the entire transport from P's premises in Italy to W's warehouse in Sweden. To achieve this, LSP works closely with other actors, such as Railway, which operates the train transport between Domodossola and Rostock via Karlsruhe, Vessel, which operates the sea transport between Rostock and Trelleborg, and Tracks, which operates the train transport between Trelleborg and Eskilstuna in Sweden. Consequently, the order from W activates several transport resources from P's premises to W's warehouse. Table 3 describes the transport legs (1–6) coordinated by LSP.

Case analysis

Based on the case description, we start by identifying three related chains of transport activities and business relationships (Figure 2). First, the supply chain illustrates the business relationships involved in buying and selling of Geocloth, including the three supply chain actors: C, W and P. Second, the chain of transport activities illustrates the eight transport legs involved in transporting Geocloth from P's facility in Italy to C's construction site in Sweden. The chain of transport activities involves three modes of transport – i.e. truck, train and vessel – together with nine physical nodes connecting the transport legs. Third, the business relationships involved in performing and coordinating the chain of transport activities include all the actors involved in buying, selling and coordinating the transport activities in the case. At first glance, the two chains to the left look rather uncomplicated and straightforward. The third chain, however, points to a more complex picture. In the next section, we elaborate further on how these chains are related by analysing two settings: the supply chain setting and the transport network setting.

First, relating to the supply chain actors in Figure 2, the business relationship between P and W sets the conditions for the transport activities in Transport leg 1, organised by LSP (L) and executed by a local haulier (referred to as Local truck in Figure 2). Depending on the agreements within the business relationship between P and W, two options are viable: (1) If W buys a FTL from P, it is W's responsibility, in dialogue with P, to see to that the transport resource (the trailer) in Transport leg 1 is utilised in the best possible way, and (2) if W buys

Leg	Description
Leg 1	LSP picks up the goods (FTL) at Producer and transports it to the intermodal terminal in Domodossola in northern Italy. Domodossola is a large railway hub where many trailers, both FTLs and LTLs, await northbound transport
Leg 2	The FTL containing the Geocloth is loaded on a train and transported by Railway to a terminal in Karlsruhe in southern Germany
Leg 3	In Karlsruhe, the train might change tracks or the trailer might be moved to another train, but there is no reloading or unloading of the trailer. After the stop in Karlsruhe, the trailer is transported by train by Railway to LSP's European railway hub in Rostock in northern Germany
Leg 4	In Rostock, the trailer is moved from the train to a vessel heading for Trelleborg in southern Sweden
Leg 5	In Trelleborg, the trailer is moved from the vessel to a train heading to an intermodal terminal in Eskilstuna. Tracks is responsible for this part of the transport
Leg 6	In Eskilstuna, the trailer is unloaded from the train to a truck and then transported by LSP to Örebro, where Wholesaler's warehouse is located

Table 3. Description of transport legs 1–6 coordinated by LSP

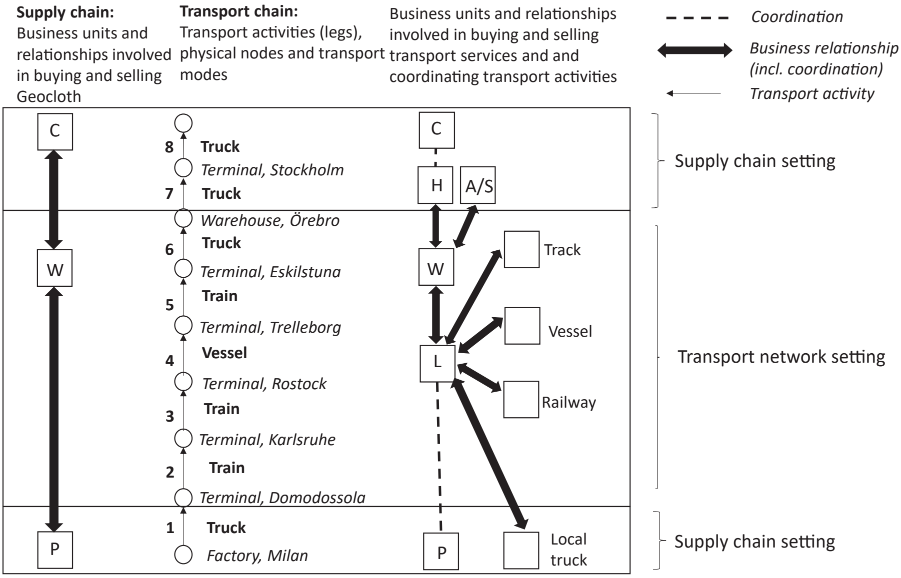

Figure 2.
Firms and business relationships involved in the supply chain and the chain of transport activities

less than a truckload from P, LSP is responsible for ensuring the best possible utilisation of transport. In the latter case, LSP does so by coordinating this shipment with shipments of other customers. Hence, the agreements within the business relationship between W and P determine how LSP can coordinate and make use of the resources in the network and, therefore, create form (capacity utilisation of the truck), time (specific delivery times) and place (specific locations for delivery) utilities. Second, at the other end of the supply chain, C and W are involved in a business relationship where agreements set the conditions for the transport activities in Transport leg 8 executed by H. The day-after-order-delivery guarantee determines H's use of its transport resources in Transport leg 8 regarding specific time and place requirements. However, adjustments in the agreements within the business relationship between W and C – e.g. by removing or enabling more flexibility in the delivery windows to C – could enable H to better utilise its trucks. Furthermore, if H and W can coordinate deliveries across W's customer relationships (i.e. including the subcontractors operating on the same sites), this could lead to better utilisation of H's trucks.

For Transport leg 7, LSP was replaced by LSP A/S since LSP A/S could better combine vertical and horizontal interdependence amongst transport activities on this leg. Unlike LSP, LSP A/S could make better use of its transport resources by connecting the business relationship with W with its other customer relationships. Hence, by combining the shipments to several customers balancing the flow of goods in both directions, LSP A/S could enhance the form utility (capacity utilisation of trucks) in view of the place and time requirements.

Based on the analysis of the chain of transport activities and the related business relationships, we identified two settings regarding how transport activities are embedded in supply networks. In both these settings, the conditions for efficient use of transport resources are decided by (1) the conditions set in the agreements within the business relationships and the possibilities to adjust within these agreements and (2) the degree the transport service provider can combine and coordinate shipments across its customer relationships. These settings relate to how supply chain actors deal with and influence these conditions.

First, we identify a setting that allows for influence by the supply chain actors (in our case C, W and P) and refer to this as the supply chain setting. In this setting, the use of the transport resources, controlled by the transport service providers (in our case H, LSP A/S and LSP), can be agreed upon in interaction between the transport service providers and the supply chain actors. This setting is illustrated in the first (leg 1) and last legs (legs 7 and 8) of the Geocloth supply chain.

Second, we identify the transport network setting. For the supply chain actors in Figure 2, W buys the transport services carried out in Transport legs 2–6 by LSP that, in turn, buys and coordinates the actual transport activities in these transport legs from Track, Railway and Vessel (Figure 2). This part of the transport network relies on large-scale operations that make use of heavy infrastructure such as rail tracks and ports in combination with predetermined timetables. Hence, this part of the transport network is beyond the scope of influence for the supply chain actors and can be regarded as a black box from the perspective of W. Instead, the supply chain actors (such as W) need to adapt to the existing resources and their utilities in this setting. For example, they need to relate to the resources and their form utilities such as size and weight of transport resources; the place utilities in terms of locations of railway tracks and hubs, intermodal terminals and seaports and the time utilities determined by timetables. That is, from the supply chain actors' perspective, the resources in the transport network setting are fixed.

In Figure 2 and in the text above, we illustrated the business relationships involving the exchange of transport services embedded in the focal supply chain. Below, we focus on the business relationships involving the exchange of both products/goods and transport services beyond the focal supply chain impacting the use of transport resources in the focal supply chain. For example, in the supply chain setting, both the transport buyer's (W's) other customer relationships (e.g. subcontractors operating on the same sites as C and buying goods from W) impact the possibilities of making use of H's transport resources. Furthermore, the logistics service provider LSP A/S combines the orders from W with orders from their other customers so that LSP A/S's transport resources can reach a high-capacity utilisation in both directions. At the other end of the supply chain, the logistics service provider, LSP, combines the order from W with orders from their other customers. Hence, resource utilities can be improved by coordinating transport activities across business relationships involving the supply chain actors. In addition, in the transport network setting, the various transport providers contracted by LSP need to match various customer orders to utilise the capacity of their connecting resources such as vessels and trains in relation to the existing infrastructure of fixed resources. The supply chain actors need to adapt to the fixed resources in the infrastructure, such as ports, intermodal terminals and rail. This, in turn, results in a need to adjust other activities to fit with, for example, specific timetables and conditions relating to capacity restrictions. Altogether, this sets the conditions for how resource utilities in terms of form, time and place can be achieved.

To summarise, the case illustrates how transport activities are embedded in supply chains and networks of connected business relationships and how coordination of the transport activities needs to address both vertical and horizontal coordination to tackle transport performance. Figure 3 illustrates the embeddedness of transport activities in the case of Geocloth, integrating the two settings in which the transport activities are embedded.

Concluding discussion and implications

In this paper, we have presented and discussed a case of a supply chain from the producer in Northern Italy to the end customer in Stockholm. Based on the case study, we identify two main settings in which transport activities are embedded in supply networks: the supply chain setting and the transport network setting. As in Carter *et al.* (2015), this distinction

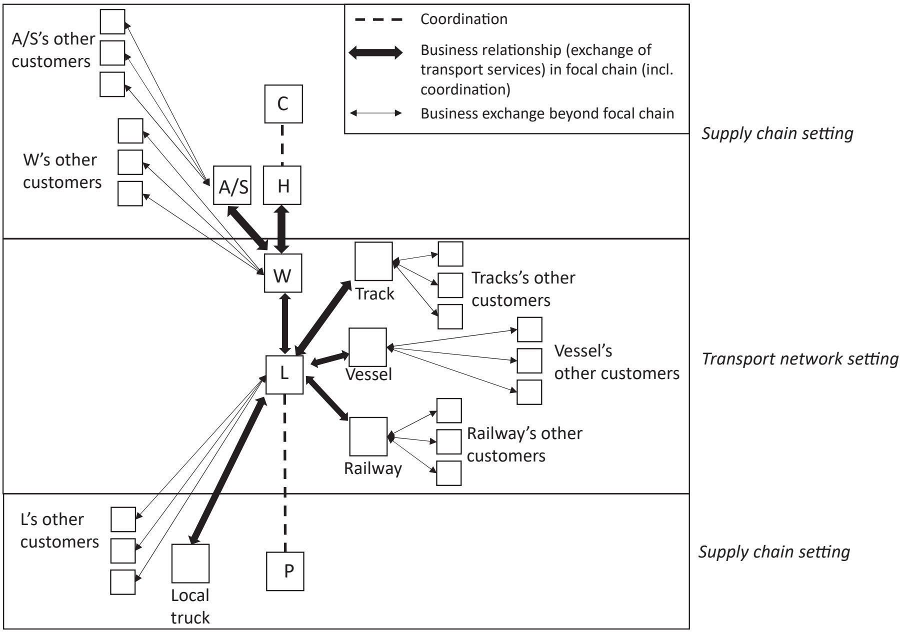

Figure 3. Transport activities embedded in the supply network of Geocloth

separates the physical supply chain and the supporting supply chain in which transport is an important part. The focal supply chain in our case study only involves three actors (i.e. a producer, a wholesaler and a customer) and two business relationships (i.e. producer–wholesaler and wholesaler–customer). Moreover, the product is a standardised item used in large quantities and in a predictable way so that plans can be made well in advance of its demand and use. In contrast to the supply chain, the transport activities supporting the supply chain involve many actors and business relationships both directly and indirectly. By identifying the directly involved actors and their business relationships, we identify connections with indirect business relationships (i.e. beyond the focal supply chain) that impact transport performance in the focal supply chain. Transport performance is analysed as a function of how the business relationships are connected vertically (i.e. how transport activities are sequentially related in supply chains) and horizontally (i.e. how transport activities are connected across supply chains in their joint use of transport resources). The connections between the focal chain of transport and supply chains other than the one in focus are immense and impossible to capture in their totality. Nonetheless, these connections have significant impact on transport performance. In view of this complexity, we will, in the remainder of this concluding discussion, focus on implications for (1) buyers and suppliers of transport services, (2) policy actors, and (3) further research.

Implications for buyers and suppliers of transport services

For transport buyers (shippers) considering how to improve the transport performance in a particular supply chain, there is a choice of either adjusting the transport solution to the needs of the supply chain or adjusting other activities in their supply chains to enable the best possible use of transport resources in the transport network setting. Such choices naturally depend on the conditions in specific supply chains (e.g. regarding the perceived need for flexibility) as well as on the different situations and perspectives of the other actors involved. The latter relates to a recent paper by Jazairy *et al.* (2021), who discuss collaboration mechanisms for green logistics in view of the different perspectives of buyers of transport services (shippers) and LSPs. Similarly, Huge-Brodin *et al.* (2020, p. 598) focus on this dyad, and they conclude that "shippers' customers have a strong influence on what is practically achievable in terms of green logistics, which in turn underlines the importance of taking a supply chain perspective". Hence, the embeddedness of transport entails that all efforts to enhance transport performance require the involvement of and collaboration with other actors.

In the case study, we took a starting point in one of the supply chain actors: W buying the transport services. From this actor's perspective, flexibility in the last part of the supply chain – the so-called last-mile delivery to customers – is important, whereas the deliveries of standard products to their warehouse do not require the same level of flexibility. Therefore, the transport provider can coordinate these transport activities in relation to the transport network setting without continuous adjustments to the focal supply chain. The networking role played by transport providers relies on their ability to coordinate transport activities across their customer relationships (i.e. beyond the scope of individual supply chains and supply chain actors) and with other transport service providers. The fewer the restraints in terms of specific adjustments to individual supply chains, the better the conditions for them to utilise the resources in the transport network setting.

Continuing the transport service providers' perspective, Borgström *et al.* (2021) find that third-party logistics actors (TPLs) are currently challenged by a strong price pressure together with digitalisation, e-commerce and servitisation. The authors suggest that this puts them in a position where they can either focus on developing standardised offerings featured by simplicity, minimalism and functionality or become more responsive to supply chain complexity – i.e. to develop more customer-specific solutions. In addition, Huge-Brodin *et al.* (2020) find that small LSPs tend to be more willing to create unique solutions to specific shippers, whereas large LSPs, due to their more standardised operations, tend to require that shippers adapt to these operations. Based on the notion of transport as embedded in both supply chain and transport network settings, such decisions relate to the combinations of transport resources and business relationships that the transport providers build their transport services on. These combinations include features such as to what extent their customers' needs complement one another and to what extent they can interact with their customers to negotiate what adjustments and adaptations are needed to make the best use of their resources as well as their relationships with other complementary transport service providers. In this way, the transport service providers act as intermediaries (Spulber, 1996), connecting relevant buyers and sellers in both the supply chain setting and in the transport network setting.

To enhance transport performance, interaction between actors is needed to make the right adjustments of activities and adaptations of resources in view of the vertical and horizontal interdependencies that transport activities are subject to. To enable such interaction, firms need to identify the relevant scope of collaboration in the supply chain setting and/or the transport network setting. Hence, the development of sustainable transport solutions, including efforts to make better use of transport resources, requires collaboration amongst actors within as well as across supply chains. Such collaborations can result in performance enhancements in different ways such as through more efficient use of existing resources or use of more sustainable transport resources and/or by enabling transport providers to better combine transport modes in their networks. Horizontal collaboration amongst transport buying companies that permits them to take advantage of complementarities amongst their transport needs is an interesting type of collaboration that seems to have great potential (Holmberg *et al.*, 2014; Basso *et al.*, 2019). Buyers of transport services can put pressure on their transport providers to facilitate such collaborations. Also, horizontal collaboration amongst transport, or logistics, providers may provide significant economic and environmental benefits (Basso *et al.*, 2019; Pan *et al.*, 2019;

Sheffi *et al.*, 2019). However, previous studies point to a number of issues that may hinder such collaboration including ones that can be explained by interdependencies across supply chains and the need for interaction amongst the parties involved.

Implications for policy actors

Recognition of how transport activities are embedded in supply chains and transport networks is important when trying to improve transport performance at all system levels. The behaviours of individual transport buying firms at the micro-level of the transport system and how they respond to policies aiming at changing their behaviours are crucial to understand when developing policies with expected outcomes at the macro level of the system. Hence, the embeddedness of transport in supply chains and transport networks suggest a complex interplay between the micro- and macro-levels of analysis.

Several aspects of transport performance are highlighted at the societal level in the EU as well as in individual countries (Tsoi *et al.*, 2021; Eftestøl-Wilhelmsson *et al.*, 2019; Aditjandra, 2018; Bask and Rajahonka, 2017). For example, increasing fill rates can reduce the climate impact as well as the cost of transport and relates to joint use of transport resources (Halldórsson and Wehner, 2020). The incentives (beyond cost reductions) that can make companies adjust their supply chain activities to enable better resource utilisation will probably receive more attention as a result of increasing pressures to reduce the climate impact of the transport sector. Utilisation of large-scale standardised intermodal solutions, including rail as in the case of Geocloth, requires network coordination and collaboration involving various actors performing different parts of such transport solutions as well as customers (Islam and Blinge, 2017). Also, new transport technologies such as electric roads or fuel cell vehicles developed to make transport more sustainable all have other features compared with existing transport resources and may, therefore, need to be embedded in new ways in both supply chains and transport networks. Analysis of what these technologies imply for transport networks, in view of interdependencies and connected relationships, is required to assess, for example, how to achieve sufficient scale in these operations. In such analyses, the potential utilities (form, time and place) of transport resources require scrutiny as well as how supply chain actors together with transport providers can take advantage of these new transport resources.

The heterogeneity of transport is important when considering the consequences of the embeddedness of transport in supply networks at the policy- or macro-level. That is, the value of transport varies a lot amongst supply chains and supply chain actors, including the share of total cost or the costs resulting from slow or late deliveries. For example, the cost of transport activities embedded in supply chains of highly refined products such as electronic equipment is insignificant compared to supply chains of products such as pulp or timber. In addition, there are differences between standardised and customised products as well as between high- and low-volume products. However, analyses of such differences amongst product features at an aggregated macro-level of the transport system do not seem fruitful as these cannot capture how products with different characteristics are integrated into supply networks in different ways. Moreover, the transport-related characteristics of products (as goods) such as weight, volume and temperature requirements differ from their supply chain characteristics. Consequently, policies that entail, for example, transport cost increases in general or regarding specific transport modes will have very different effects on different supply chains and may, therefore, result in very different responses from supply chain actors at the firm or micro-level. Hence, considering the vertical and horizontal interdependencies that transport is subject to, the embeddedness of transport has widespread and not easily predictable consequences. The embeddedness of transport that we have elaborated on in this paper relates to what Hesse and Rodrigue (2004) refer to as its integrated nature. Hesse and

Rodrigue argue that as transport is a component of integrated demand, the traditional notion of transport as a derived demand needs to be challenged:

> Once freight transport and logistics are analyzed as a derived demand, they appear accordingly: segmented and flexible, highly adjusted to the specialized demand of shippers and receivers, representing functional and organizational compartments rather than an all-embracing structure. (Hesse and Rodrigue, 2004, p. 182)

Their claim seems to capture the essence of the troublesome link between micro- and macro-aspects of transport demand for policymakers.

Implications for research

Research on supply chains and on transport seems, for the most part, to be divided into strictly separated fields of research. SCM studies, often focussing on the firm-level perspective, seldom address transport issues, whereas transport studies often focus on different parts of the transport system such as individual modes of transport, particular geographies or last mile issues. All these pieces of research contribute in-depth knowledge in these specific areas, but the division does not contribute to an understanding of how change or transformation of the wider transport system can be made and/or what effects different policy measures that span various system boundaries will have. Hence, we argue that studies of supply chains and transport need to revise their scope and embrace both parts of the complex. Since transport activities, on which all supply chains depend, are also embedded in transport networks, system transformation requires approaches that can relate to or combine several fields of research. As with changes in supply chains, this requires collaborations across boundaries. More research is needed that captures the links between the micro- and macro-levels of the transport system as well as the links between supply chains and transport networks. Maintaining the division of research within specific and well-delimited research areas will not contribute to an understanding of what it will take to transform the transport system nor will it contribute to how various actors can deal with or support the transformation.

Returning to Ellram and Murfield's (2017) call for approaches that capture network aspects of the transformation to sustainable transport solutions, we suggest that different kinds of system descriptions are needed that relate to and supplement one another. Hence, detailed accounts of the system actors' perspectives and behaviours, the interdependencies amongst their activities and the interfaces amongst their resources need to be captured, together with macro-accounts of the transport system in terms of, for example, shipment volumes and carbon emissions. Hence, to understand the effects of policy measures, combinations of inside-out and outside-in descriptions of the multi-dimensional transport system are needed. In this paper, our starting points are business relationships and connections between relationships, and we argue that these units of analysis are vital for capturing the continuous operations going on in supply chains and transport networks. In addition, relationships also represent possibilities in terms of collaboration and interaction needed to change or replace transport resources and their use. The interplay between the supply chain setting and the transport network setting highlights the importance of interaction between buyers and suppliers of products/goods together with transport providers. Therefore, the transport service triad (Andersson *et al.*, 2019) seems to be an important unit of analysis for a more complete understanding of the micro-level as it captures the connection between the two settings. However, although further studies acknowledging the embeddedness of transport will not provide any simple answers to questions regarding how the micro-level produces effects at the macro-level of the transport system and vice versa, they may result in more relevant questions for further scrutiny.

Note

1. This paper uses A/S to differentiate between two large LSPs (LSP and LSP A/S). The abbreviation stems from the Danish word "Aktieselskab"; it is used in this paper since the parent company is from Denmark. Please note that the word A/S has no other meaning.

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