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Sustainable Logistics and Supply Chains

Innovations and Integral Approaches

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Future-Proofing Supply Chains

Alex Van Breedam

Abstract Due to the rapidly changing environment and the changing customer behaviour, companies will have to rethink the way they deliver their products and services. Most companies are still operating a supply chain that was designed in times of cheap oil, before any trace of e-commerce. These supply chains now run up against their limits and they will definitely not stand the upcoming challenges of tomorrow, the biggest of which are probably societal and environmental. Twenty challenges are identified and their impact on supply chains is described. In order to be successful in a rapidly changing environment, companies have a strong interest to make their supply chains future-proof at all times. A future-proofing diagnosis is developed to assess the supply chain of a company and to evaluate the gap with the upcoming societal, consumer and logistics challenges. Companies who are future-proofing their supply chain will identify and seize much faster the supply chain opportunities to create a competitive advantage.

1 Introduction

Supply chains are operating in a rapidly changing global environment. Not only societal changes, but also changes in the way consumers behave, have or might have a direct impact on logistics. Consequently, the logistics environment is changing and will continue to change accordingly. This has a direct impact on supply chains of companies. If a company's supply chain cost and carbon footprint is increasing, while service level is continuously decreasing because of increased inventories, longer waiting times, badly aligned production processes, decreasing service levels, etc. . . then this could be interpreted as a sign that the current supply chain strategy might not be adequate anymore to the environment it is operating in.

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At first, it is important to try to understand how the environment in which supply chains operate is currently changing and how it will evolve in the future. Based on the expected changes and future challenges, a company needs to deploy a strong, but adapted supply chain strategy. Fundamental to a strong supply chain strategy is integration. The strength of a supply chain heavily depends on the internal integration among the subsequent supply chain departments procurement, production and distribution on the one hand and on the external integration with suppliers and customers on the other hand. Information availability, preferably as real-time as possible, and communication, i.e. the so-called supply chain visibility, is mandatory to pursue a strong integration.

Today, a lot of companies are still in the process of creating more supply chain visibility, internally and externally. Supply chain visibility is a key success factor for the customer-dominated and pull-oriented environment in which supply chain are currently operating. With the expected increase of the customer domination in the very near future, strongly boosted by the fast growing e-commerce, the real-time granularity should increase even more. An unwanted consequence is an expected acceleration of the demand for capacity. It is clear that society will not be able to swallow an unlimited capacity increase. Therefore, trend watchers are already announcing that we are approaching the tilting point of this “on-demand” customer dominance. As a result, the shift towards managing scarcity in a more fair society is starting slowly. This would impose other requirements to supply chains, including capabilities of sharing and pooling capacity, with a focus on more circular cradle-to-cradle concepts and reverse logistics.

Companies need a strong framework to assess their supply chain in the perspective of future trends and challenges. The aim thereof should be the clear identification of the gaps to bridge towards a future-proof supply chain. Such a diagnosis tool should be easy to use, maintain and understand. Ultimately, the diagnosis tool should be used to compare and benchmark companies with respect to their supply chain readiness for future challenges.

We developed the *Future-Proofing Supply Chain Diagnosis* framework as an integrated approach to diagnose supply chains in view of twenty future challenges with a substantial impact on logistics and supply chain management. This *Future-Proofing Supply Chain Diagnosis* framework is presented in this article. In the first part of this article, the twenty challenges are described and classified into three categories: changes in environment, changes in customer behaviour and changes in logistics. Next, a vision on the evolution of supply chains is developed. Subsequently, an insight in the methodological approach of the Future-Proofing Supply Chain Diagnosis is proposed. The main observations of the first pilots are reported and finally some conclusive remarks are formulated.

2 Changing Environment

The global environment in which companies are acting is changing and will continue to change even more substantially. Far and foremost, demography will change dramatically: the world population will grow from seven billion to nine billion in 2050 (United Nations 2013). The shift of the economic power and the development of emerging countries will give more people access to welfare. This will definitely require a performance increase of the current logistics systems, that should also be able to expand rapidly to new areas. Hence, logistics systems should be capable of absorbing substantial increase in freight volumes without a proportional increase in environmental impact. Companies should be able to roll out stable distribution systems, even from scratch, in emerging and developing regions in a fast but sustainable and lasting way. Also should the supply chain be capable of absorbing adequately substantial increases in volume.

In the meantime, urbanization is expected to increase from 54 % today to 66 % or more towards 2050 in the developed countries (United Nations 2014). It goes without saying that the increased urbanization means a real challenge for logistics, especially if e-commerce and home deliveries will continue to boost. Inversely, the consolidation potential that might result from a high degree of urbanization could be considered as an opportunity for logistics. Nevertheless, the physical accessibility of the customer will continue to deteriorate with the higher urbanization. As a result, the last mile cost will increase accordingly (Sullivan Research Service 2013). New stable and sustainable distribution channels and structures will have to be developed to guarantee reasonable lead times to the customer at a feasible supply chain cost.

The ongoing globalization, free trade and harmonization of legislation have been helpful for companies to make their supply chains more efficient, for instance through the geographical relocation of production. However, the rush to Asia was often driven by pure cost-cutting strategy, without considering the often negative impact on customer service. Moreover, from a total cost of ownership perspective, the long-term outcomes of off-shoring on supply chain responsiveness are most often negative, as observed by Stank et al. (2014). The total cost of ownership is a full cost accounting approach in which hidden costs, including cost of lead time, inflexibility, quality, lost sales, etc. . . , are made visible.

As a counterbalance to globalization, a lot of companies embrace the glocalization concept by thinking globally and acting locally and thus adapting their global products and services to the local market and cultures.

More globalization and free trade is often counterweighted by an increase of the regulatory pressure. This is particularly the case for some logistics top-regions in Western Europe. Clearly, this might hinder the further growth of logistic infrastructures. Hence, government and companies will be obliged to focus more on innovative concepts to better utilize the existing infrastructure instead of building new ones.

As a result of the globalization and the glocalisation, supply chains have become longer and more complex (Ballou 2004). In many cases, however, the risk exposure of companies has increased accordingly (Grandjot 2006). In general, supply chain

risks could be demand side (e.g. demand volatility, forecast inaccuracy), supply side (e.g. supplier and supply problems), process (e.g. machine breakdown), control (e.g. controlling mechanisms), relationship (e.g. opportunistic behaviour or leakages to competitors), environmental (e.g. socio-economic, political and legal), logistical (e.g. congestion) and catastrophic risks. The objective of Supply Chain Risk Management is for companies to understand what the effect is of each risk source on the supply chain risk exposure. Besides the substantial impact of supply and demand side risks, the catastrophic risks have showed to have a dramatic impact on supply chain performance (Sharma and Bhat 2014). Although surveys have demonstrated that most risks sources are inside the company (Jaberidoost et al. 2013), some events have shown how risks beyond the control of individual organizations can have consequences that cannot be mitigated by one organization alone. These events could include natural disasters, extreme weather, conflict and political unrest, terrorism, import/export restrictions and sudden demand shocks (World Economic Forum 2012). The disruptive impact of these possible risks on supply chains and transportation should force companies to assess and review their risk management procedures at the board level (Hendricks and Singhal 2005). Moreover, appropriate management of risks beyond the control of the individual company will require governments to take up their role through public-private partnerships.

Developed countries in the Western world will probably have to face a stagnation or even a drop of their wealth. Overall this could lead to a status quo of the handled flows of goods. However, given the evolution towards decreasing drop sizes and increased delivery frequencies, the capacity requirements will continue to grow. This will increase the pressure on the price of transport services. If, by that time, more intelligent and sustainable logistics solutions for better capacity utilization will not have been institutionalized, the logistics sector will suffer even more than today. Nevertheless, the logistics sector should start to explore and invest in new market and areas, as there are energy and water or humanitarian logistics (Von der Gracht and Darkow 2013).

Societal pressure, such as the demand for more environmentally-friendly products will force companies to rethink their supply chain accordingly (Finisterra Do Paço et al. 2009). It is clear that future supply chains will have to focus more on environmental concerns (Soni and Kodali 2008) and reduce CO₂-emissions and energy consumption (Piecyk and McKinnon 2010; GCI and Capgemini 2008). The World Economic Forum (2015) identified supply chains and the safe supply of energy as key factors that will fundamentally shape the world's future and are "central to the functioning of the world economy and to the well-being of global society". Consequently, future supply chains, especially regarding the long-term future, will not only have to be designed to minimize cost and maximize service level; environmental sustainability will become equally important (GCI and Capgemini 2008). Therefore, companies should start to implement an Environmental Management System to track and manage environmental performance and to track performance against regulatory requirements (Handfield et al. 2005). Corporate social responsibility has to evolve towards corporate social value creation. Supply chain improvements should be cost saving and beneficial for society at a time.

Finally, new types of economy are emerging. Three distinctive types might have an important impact on the supply chain: the sharing, the servitization and the circular economy. The sharing or collaborative economy is based on sharing resources to co-create, co-produce and co-distribute goods and services. Sharing supply chain capacity, e.g. shared manufacturing platforms, shared warehousing or transportation co-loading, is rapidly gaining ground in various industries. While a vast number of strong horizontal collaborations in logistics have already been reported (see CO³-Project 2014), supply chain collaboration is still not widely institutionalized so far. Mental thresholds, proper to pooling and sharing of capacity, still appear to be obstructing for a number of companies. External incentives, like a carbon tax or structural traffic pricing, could be instrumental in pushing companies towards more supply chain pooling and sharing.

Servitization is a total concept for manufacturers to offer services tightly coupled to their products. It's about moving from a transactional (just sell a product) to a relationship-based business model (delivering a capability) featuring long-term, incentivized, 'pay-as-you-go' contracts. Hence, supply chains should be focussed more on offering appropriate services to the customer throughout the lifecycle of the product than just delivering the product to its first-time buyer. Many manufacturers started this long before, say for examples Rolls-Royce offering Total Care on gas turbines for their airline customers based on a 'fixed dollar per flying hour'; Xerox delivering 'pay-per-click' scanning, copying and printing of documents etc. (Baines et al. 2009; Baines 2013).

Along with this, the circular economy will make business to rethink the entire process beyond today's linear approach. So there will be a shift from linear to circular where recycling is boosted and the loss of valuable materials is prevented. Many big firms already predicted this evolution and started to inject these strategic changes into their core business model, which shows that they are preparing themselves for the circular economy (World Economic Forum 2014).

3 Changing Consumer Behaviour

As opposed to the more medium and long term perspective of the changing environment, the change in consumer behaviour, which is going on nowadays, might have an immediate impact on supply chains and logistic activities. The switch from the one-channel "brick and mortar" to an omni-channel buying behaviour of the consumer is already affecting a lot of companies today. While e-commerce, social networks and mobile channels were a nice to have until a few years ago, they have become a must-have today. The complexity of many companies' supply chain structures has more than proportionally increased since e-commerce and mobile sales were added to the current distribution structures. The challenge for most companies remains the supply chain integration of the different distribution channels (Tetteh and Qi 2014). On top of that, the internet sales have forced companies to adapt the speed and the performance of their ICT systems and tools (Lasserre 2004).

The e-commerce explosion has emphasized even more the consumer dominance in the supply chain, especially with regard to service level and lead times. Where “next day delivery” has become the rule, the big e-tailers have already started experimenting with the “next hour delivery”, however today still focussed on fresh products. And with this all and against all logic, transport is most often offered for free with internet purchases. How could you make the consumer aware of the value of transport if his parcel—with a price often inferior to that of the transport itself—is delivered at no cost? Apparently, e-tailers have made customer used to free transportation, while it is known that transport generates a lot of external costs to society. On top of this, some dominating e-commerce companies are even offering a free return, in order to realize an accelerated market penetration of e-commerce sales. This is particularly true for products that customers like to sense or try out before buying. The expected accelerated growth of internet sales in combination with the increased urbanization could become a real challenge for logistics, especially in relation to environmental issues and viability of cities.

The customer’s dominance in the supply chain appears also in the business-to-business segment, where suppliers are pushed to decrease their lead times and to supply smaller quantities more frequently within ever narrowing delivery-windows. As a result, logistic activities come more and more under pressure and additional capacity might be required, because existing capacity could be insufficient.

In the long run, it is almost certain that the 3D printing will have its effect on the consumer behaviour. By adopting this technology at home, the consumer becomes producer. Consequently, the buying profile of the consumer will evolve from finished products to print supplies, considered that he would be able to 3D print most of his needs and products. Advantageously, this might result in lead time relaxation for logistics. More generally, future supply chains should be supportive to new product innovation. Due to the continuously decreasing life-cycle of most products in combination with the increasing number of product innovations, the time-to-market for new products should be short. Hence, an agile supply chain is critical for a fast launch of new products to the market.

Finally, the speed of change in ICT technology remains an important enabler of supply chain management. Performing supply chains require excellent ICT. The faster the information flow of the supply chain, the more reactive and adaptive the flow of goods will be. The evolution of ICT technology shall be supportive to supply chain management, mainly at two levels: planning and monitoring. Supply chain planning requires powerful calculation and optimisation tools to compute the strategic forecasts down to the operational schedules. Supply chain monitoring should be supported by ICT tools offering end-to-end supply chain visibility. Evolutionary characteristics of these monitoring tools are their real-time granularity and their end-to-end span of control, far beyond the first-tier supplier and customer.

4 Changing Logistics

It is clear that the consumer's dominance in the supply chain leads to inefficiencies. In Europe, on average, one truck on four drives empty and the fill rate of the non-empty trucks is hardly 57 %. This results in an overall inefficiency of 43 % (World Economic Forum 2009). In combination with the fact that road transport is the largest contributor to the carbon emissions, the outcome of all this bad news might not be supportive to create a good public image of the sector. The logistics sector is squeezed between the increasing consumer demands and the push to a more environmental-friendly society. Unfortunately, with the business models currently in place in the logistics sector, there is no evidence that this situation is about to improve in the coming years. First, it is expected that the devastating impact of the congestion will not be stopped immediately, as illustrated by the distance per hour covered by a truck, which is ceaselessly decreasing year after year in Europe (Schürmann et al. 2002). Second, transport has evolved to a commodity with very low or even no value creation for the consumer. The free transport in e-commerce is self-explanatory for this. Hence, carriers operate in an extremely low margin business where a killing competition rules.

Today, the externalities caused by transport are not internalized in the price of transport. Consequently, the cost of transport is comparatively way too cheap. The effect of too cheap transport combined with the huge wage differences worldwide have led to the current configurations of the global supply chains, where the goods are manufactured in low wage countries and subsequently transported to distribution hubs on the continents, from where distribution to the final customer is organized. Only the direct tangible costs and not the total supply chain costs are definitely driving these supply chain configurations. In some cases, the drive to minimize cost might even lead to very strange or odd configurations: shrimps caught in the Wadden Zee in the Netherlands are transported back and forth by truck to Morocco for being peeled; Belgian chocolates, made in Belgium are sent on a truck roundtrip to the Czech Republic for being co-packed. This demonstrates that the cost of transport is comparatively much too low to avoid exploitations of differences in the cost of labour.

While today, on average, a truck drives hardly for 55 % of its busy time, it is expected that this will further deteriorate because of increasing congestion-based waiting times on the one hand and increasing stress due to narrowing delivery time-windows at the sites of the shipper on the other hand. Accumulation of waiting times on the road, at the sites and at terminals, will further deteriorate the quality, the reliability and the forecastability of the supply chain.

Most shippers make use of, or even worse, exploit the strong competition among carriers and organize every 2 or 3 years big tenders in order to further obtain better tariffs. However, most shippers don't realize that the savings in transportation tariffs they obtained, are often offset by more hidden costs, like quality and service level deterioration, longer lead times and higher buffer inventories. Shippers should

be encouraged to use the total supply chain cost principle to decide on supply chain wide, global savings instead of focussing on local improvements only.

Resource availability might become a serious problem in the next years. A shortage of drivers and warehouse workers could create a real problem of guaranteeing the necessary capacity for supply chain operations. The inflow of foreign labourers might not suffice to compensate retirement in the sector, especially in Western Europe. However, the first experiments with drones (e.g. DHL in 2013), unmanned trucks and platooning (i.e. The Netherlands in 2015), and with robotics in warehouses, especially those focussed on e-commerce, turned out to be very promising. Inversely, the risks related to this type of innovations is that at a certain point in time they would start to outperform traditional logistic service providers. Ultimately this might then lead to massive layoffs of human resources in logistics combined with severe cost cutting.

Capacity shortage is considered as a recurrent problem in logistics. Very often, capacity shortages are the result of unbalanced flows. Capacity expansion is often the simple, but ineffective response of the carriers in that case. However, this has shown repeatedly to be counterproductive and to create more inefficiencies and a further price deterioration.

Some specific sectors might be faced with a substantial decrease of their flows in the future. The digital availability of newspaper, magazines, documents, etc. will continue to reduce the need for often time-critical transport of hardcopies and documents. In the longer run, it can also be expected that 3D printing on an industrial scale would remove the need to transport some type of products, like spare parts or other printable items.

Finally, the environmental impact of transport is significant because it is a major user of energy, and burns most of the world's petroleum (World Economic Forum 2009). Transport, and more particularly road transport, is still the fastest-growing emission sector. Inversely, it goes without saying that any future emission tax imposed by public authorities will have a tremendous impact on transport and existing transport systems.

5 From Supply Chain 1.0 to 2.0

From the above future scenarios, it's clear that the supply chain world is standing at the eve of important, even disruptive, changes. Moreover, these changes will have a severe impact on the supply chains of many companies. As Keith Harrison, former Chief Product Supply Officer of Procter & Gamble, once said: *"Soaring energy costs are forcing P&G to re-think how to distribute its products... A lot of our supply chain work was implemented when oil was \$10 a barrel... I could say that our supply chain design is now upside down... What is our business going to look like in 2015?"* It is clear that today, a lot of supply chains are not even ready to tackle the current problems and challenges adequately. This is simply illustrated by

the struggle of some companies to embed the delivery of e-commerce shipments into their current distribution structures. Some other companies have been confronted with supply chain disruptions as a result of geopolitical problems in certain regions. These companies insufficiently or even never assessed the possible risks that might disrupt their deliveries. Most supply chains are not configured as resilient enough to manage this kind of disruption appropriately.

Very few companies have already prepared their supply chain for what is going to happen in the near future. It is to be expected that under societal and political pressure the cost of transport, and more precisely road transport, will increase through carbon taxes, traffic pricing mechanisms, higher excises, etc... Most probably, this will lead to more local sourcing and near shoring manufacturing and would require a major re-design and re-configuring of many supply chains that are not agile enough to digest change of this kind.

Nevertheless, a lot of companies start to realize that they have reached the limits of the Supply Chain version 1.0 on the supply chain maturity scale (see Fig. 1). The Supply Chain 1.0 is one with very limited integration between procurement, production and distribution and where an overall total supply chain cost concept is inexistent. This type of supply chain profile emerged during the *technology wave* at the end of last century and is characterized by being almost unilaterally cost-driven, sometimes even at the expense of service level concessions. Environmental sustainability is not really an option in Supply Chain 1.0. A good illustration of the working principle of this type of supply chain is the two-yearly tender processes for transport services launched by many global companies, in order to benchmark their transportation cost or to replace an existing carrier by a cheaper one. The result of such a process is often another 5–10 % savings on transportation cost. These cost savings are absorbed by the carriers and the logistics service providers, who are asked to provide the same service for less cost. In many cases the result of this all is

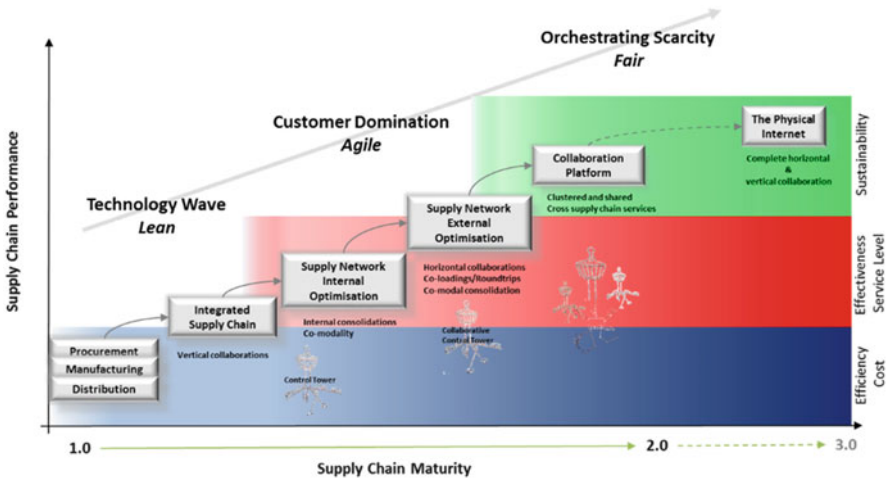


Fig. 1 The supply chain maturity in societal and global perspective

a degradation of the service level offered by the carriers and logistics service providers. Finally, the 5–10 % transport cost savings is more than offset by an increase of other, hidden supply chain costs (longer lead times, more safety stocks, ...) mainly due to a worsening of the service level. The subcontracting relation and not the long lasting partnership relation is another characteristic of the Supply Chain 1.0.

Since the beginning of this century, the world has entered the *customer-domination era*. Faster, smaller but more frequent on demand deliveries have become the new normal. Supply chains have been tuned to pay much more attention at customer service levels. A strong vertical integration with all supply chain partners, including suppliers and customers was a typical characteristic of this type of supply chain. With the ongoing boost of e-commerce, it is expected that the customer dominance might lead to excess. The “next day” and even “next hour” deliveries offered by e-tailers are pushing the supply chains to their limits with the uninterminated request of the individual consumer for faster, fresher, cheaper, safer and complete on demand deliveries. However, nowadays, people start to realize that these supply chains are unable to provide appropriate solutions to relevant and major societal issues, like the scarcity of raw material, the spread of welfare, the world’s food and water supply, the growth and aging of population and the urbanization. As the individual excess economy is now reaching its tilting point, the world has already started to shift towards a “share and circular economy”. Environmental sustainability is there to become an at least equally important decision criterion as compared to efficiency and effectiveness. In this era, the scarcity needs to be orchestrated by means of highly performant cross-company supply chains and collaborative platforms. The so-called Supply Chain 2.0, should be able to manage gain and cost sharing in a circular economy. Already today, the collaboration platform is considered as one of the most optimal supply chain designs. A collaboration platform is a partnership in which logistic activities are clustered and resources are shared and pooled. Collaboration platforms can be industry specific, as in the case of the Belgian chocolates manufacturers who consolidate their warehousing, transport and co-packing activities. In other cases, the logistics of complementary products, like heavy with voluminous (e.g. heavy spare parts with voluminous baby drapers) can be consolidated, to optimize the fill rate of trucks, ships and trains.

It is clear that Supply Chain 2.0 is still only a target on the agenda of a lot of companies today. Unfortunately, most companies are closer to 1.0 than to 2.0. Consequently, they need to bridge a gap to become future-proof for the upcoming challenges. However, with the companies the awareness grows that it is absolutely necessary to start the journey towards Supply Chain 2.0 as soon as possible to have their supply chain adapted on time. Companies will have to plan their road to 2.0 carefully in order to seize all opportunities at improving their supply chain performance while they are evolving to a higher maturity level. These supply chain performance improvements will provide them a competitive advantage in the market.

Some authors expect that Supply Chain 3.0, or the Physical Internet, should be the ultimate supply chain maturity level in the long run. The Physical Internet

applies the concepts of internet data transfer to real-world shipping processes, thus improving global logistics efficiency and sustainability (Montreuil 2011). Just like sending an e-mail through the internet, from provider to provider and hub to hub, by means of protocols, the same could be applied to freight transport. Sender and receiver of the goods don't care about the transport and warehouse providers alongside the trajectory, as long as the goods are delivered in the appropriate conditions, at the lowest cost and in the most sustainable way. Goods are transported in π -containers that are modular, eco-friendly, smart and standardized worldwide. The Internet of Things (IoT) guarantees the real-time track and trace of the containers in an interconnected network of certified infrastructure, protocols, logistics centres, hubs, information systems, regions, etc. (Sarraj et al. 2013).

6 Future-Proofing Diagnosis of the Supply Chain

As stated previously, a lot of companies are faced with a supply chain that would require an urgent re-design to cope with the upcoming problems and challenges described above. The starting point of such a strategic redesign would be a diagnosis of the status of the current supply chain in order to determine its maturity level.

In literature, only a few supply chain maturity models have been reported. The Supply Chain Management Process Maturity Models of Lockamy and McCormack (2004a, b) and McCormack (2001) measure the degree of process integration in the supply chain and are based on the Supply Chain Council's SCOR framework The Supply Chain Council (2010). The Supply Chain Capability map of Srai and Gregory (2005, 2008) evaluates the maturity of a multinational company's supply chain capabilities. A third model, proposed by Van Landeghem and Persoons (2001), is an audit scheme for logistical operations based on 84 best practices. Finally, Netland and Alfnes (2011) developed a maturity test for supply chain operations, based on 48 questions.

A somewhat different framework for performance measurement and benchmarking is offered by the Dow Jones Sustainability Index (DJSI). The DJSI is used to evaluate corporate economic, environmental and social performance, and to assess issues such as corporate governance, risk management, branding, climate change mitigation, supply chain standards and labour practices. The calculation of the DJSI and its geographic and industry-specific variants is based on a company assessment by means of an annual self-completed questionnaire and personal contact of a third party. A company gets listed on the DJSI and it is monitored daily. The index itself is a weighted average of scores on some economic, environmental and social dimensions (Dow Jones Sustainability Indices 2015). Searcy (2009) observed that in supply chain management sustainability indicators are still not widely used.

The test proposed here is different to the ones mentioned above. It is a diagnosis of the current state of the supply chain in the perspective of the upcoming trends and

Table 1 The challenges with impact on the supply chain

	Challenge
Changing environment	Demography
	Urbanization
	Globalization-glocalization
	The sharing economy
	The servitization economy
	The circular economy
	Corporate social value creation
	Supply chain risks
Changing customer behaviour	On demand
	Omni-channel
	Product innovation
	Speed of change in ICT technology
Changing logistics	Supply chain as a competitive advantage
	Manufacturing and process innovation
	Labour force
	Capacity shortage
	Co-modality
	Hybrid distribution structures
	Big data
	The physical internet

challenges in order to determine in how far a supply chain is future-proof against the major challenges.

In general and in order to guarantee the mass adoption of such a maturity test by industry, it should satisfy some requirements, including simplicity, not take too long to complete, not require large amount of detailed data, being industry-generic, using balanced dimensions of performance and being based on qualitative parameters (Netland and Alfnes 2011). These characteristics were taken into account while conceiving the test.

The framework of the test proposed here is designed to be dynamic and flexible. Table 1 represents the 20 challenges that have been selected to have a major future impact on supply chains. These challenges and their expected impact have been extensively described in this article. For every challenge, a sets of 10–14 questions have been developed to evaluate the impact on five possible supply chain areas:

1. Strategy
2. Organisation
3. Process
4. Control
5. Information

Hence, each question of the Future-proofing test is a combination of a challenge and an impact area, i.e. the level at which the challenge will impact the supply

Challenge					Corporate Social Value Creation		IMPACT	5
Description					Value creation not only for the company shareholders, but more and more also for the various company stakeholders.			
Questions	Question N°	Efficiency	Effectiveness	Sustainability	Best or Future Practice		SCORE	
Strategy	1	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	General CSR focus	Corporate Social Responsibility and Health Security and Environmental issues are focussed, i.e. our company strives to understand and respond to the expectations of all stakeholders.	3	<div><div></div></div>
Strategy	2	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	CSR focus in SCM	Corporate Social Responsibility is explicitly mentioned in the supply chain strategy	4	<div><div></div></div>
Process	3	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	EMS (SCOR)	Our company has implemented an Environmental Management System (comparable to TQM) to track and manage environmental performance and to track performance against regulatory requirements.	2	<div><div></div></div>
Process	4	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	Emissions in transportation decisions (SCOR)	Our company integrates environmental emissions considerations to transportation decisions. Feature: implement Environmental Management System.	3	<div><div></div></div>
Process	5	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	Emission valuation	Emissions of supply chain activities are measured and recalculated in a mono...		
Process	6	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	Environmental collaboration	Supply chain partners collaborate in ...		

Fig. 2 Screen shot of the a set of questions of the future-proofing diagnosis

chain. The impact area is comparable to the decision area as defined by some other supply chain tests (Alfnes 2005; Lowson 2002; Netland and Alfnes 2011).

Each question needs to be answered with a score from 1 to 5. The use of a such a Lickert scale guarantees a sufficient level of nuance in the answers. This scale has been adapted from Netland and Alfnes (2011).

Figure 2 shows an example of a few questions of the challenge “Corporate Social Value Creation”.

7 Implementing the Future-Proofing Diagnosis

The key characteristics of the implementation scheme for the Future-Proofing Diagnosis are the previously mentioned requirements of simplicity, not take too long to complete, not require large amount of detailed data, being industry-generic, using balanced dimensions of performance and being based on qualitative parameters.

It is preferable, even recommended to have this diagnosis test conducted by a third party, external to the company. It can be either a consultant or an academician, for example. However, it is mandatory that the conductor should have sufficient expertise and moderator skills to lead the inspiration session.

Starting from Pendlebury et al.’s (1998) description of successful change management, based on the test process of Netland and Alfnes (2011)) and based on feedback of the validation study, this five-steps implementation scheme is proposed:

- 1. Inspire;
- 2. Prepare;
- 3. Complete;
- 4. Analyse;
- 5. Recommend.

The *Inspire* session is conceived as an interactive workshop with a panel composed of the company's key supply chain people. The aim of this session is to present all the challenges, to discuss them with the participants and finally to decide with the panel what the relevance and impact is of each challenge on the company's supply chain. Hence, at the end of the session each challenge is rated with a score:

1. No impact
2. Low Impact
3. Medium Impact
4. High Impact
5. Very High Impact
- Not Applicable

During the *Prepare* session only the company's supply chain leader is asked to determine for each challenge, its level of ambition and that of its feasibility. This implies that for each challenge the following two questions need to be answered:

1. *Should we* be prepared to cope with this challenge, because it is important for our company?
2. *Would we* be able to prepare our company for this challenge?

The answer on both questions should be either "yes" or "no". At the end of the *Prepare* session, the example of Table 2 could be the outcome.

At this moment perceived mismatches, like a challenge of which the "IMPACT" is high or very high (score 4 or 5), the "We SHOULD" and the "We WOULD" are both at "NO", should be discussed and, if necessary, rectified in agreement with the supply chain leader.

The *Complete* session encompasses the actual scoring of the questions by the participants. Different configurations and setups could be envisaged, ranging from individual completion by each participant separately to a joint workshop sessions where each answer should be the consensus of all participants. Whatever setup is chosen, it is recommended to have the conductor reading and explaining each question to guarantee an appropriate and aligned interpretation by each participant. All questions are scored with a value from 1 to 5 and a Not Applicable category:

1. Never/Does not exist/Not at all
2. Sometimes/To some extent/Aware
3. Frequently/Partly exist/Under consideration
4. Mostly/Often exist/In use
5. Always/Definitely exist/Strong focus
- Not Applicable

During the *Analyse* phase, the scores are aggregated, analysed and interpreted by an expert. Basically, the outcome of the test computes a "COULD WE?" score for

Table 2 Example of the rating after the inspire and prepare sessions

	CHALLENGE	IMPACT	We SHOULD	We WOULD
Changing environment	Demography	4	YES	YES
	Urbanization	5	YES	YES
	Globalization-glocalization	3	YES	NO
	The sharing economy	3	YES	NO
	The servitization economy	#N/A	#N/A	#N/A
	The circular economy	#N/A	#N/A	#N/A
	Corporate social value creation	5	YES	YES
	Supply chain risks	5	YES	NO
Changing customer behaviour	On demand	3	NO	NO
	Omni-channel	3	NO	NO
	Product innovation	2	YES	NO
	Speed of change in ICT technology	3	YES	NO
Changing logistics	Supply chain as a competitive advantage	5	YES	YES
	Manufacturing and process innovation	#N/A	#N/A	#N/A
	Labour force	2	YES	NO
	Capacity shortage	4	YES	YES
	Co-modality	2	YES	NO
	Hybrid distribution structures	4	YES	YES
	Big data	2	NO	NO
	The physical internet	1	YES	NO

each challenge between 1 and 5, as the calculated average score of the applicable questions for that challenge. An example of an outcome table is proposed in Table 3. A gap analysis is performed by evaluating the “COULD WE?” score of each challenge in the perspective of its impact and its answers for the “We SHOULD” and “We WOULD” questions.

The analyst should pay special attention to challenges showing a gap. In general, a challenge with a low “COULD WE?” score while “We SHOULD” is YES and/or a high or very high “IMPACT” needs to be addressed. The answers to the questions for that challenge should be analysed in detail in order to identify the reason why the company is actually lagging behind on that challenge. The analyst should try to determine from the questionnaire whether the poor performance is due to a lack of strategy, organisation, process, control or information, or a mix of these. Additional and more in-depth analyses might be required to obtain a complete and clear image of each gap. A spider graph, comparable to that of Fig. 3, might be supportive for identifying the reasons of the poor performance of the company on the challenge considered.

Table 3 Example of the resulting scores of the future-proofing diagnosis

	CHALLENGE	IMPACT	We SHOULD	We WOULD	Could We?
Changing environment	Demography	4	YES	YES	3.3
	Urbanization	5	YES	YES	3.8
	Globalization-glocalization	3	YES	NO	2.0
	The sharing economy	3	YES	NO	1.0
	The servitization economy	#N/A	#N/A	#N/A	#N/A
	The circular economy	#N/A	#N/A	#N/A	#N/A
	Corporate social value creation	5	YES	YES	3.1
	Supply chain risks	5	YES	NO	3.0
Changing customer behaviour	On demand	3	NO	NO	3.0
	Omni-channel	3	NO	NO	4.0
	Product innovation	2	YES	NO	1.0
	Speed of change in ICT technology	3	YES	NO	3.0
Changing logistics	Supply chain as a competitive advantage	5	YES	YES	4.0
	Manufacturing and process innovation	#N/A	#N/A	#N/A	#N/A
	Labour force	2	YES	NO	3.0
	Capacity shortage	4	YES	YES	3.0
	Co-modality	2	YES	NO	2.0
	Hybrid distribution structures	4	YES	YES	3.0
	Big data	2	NO	NO	1.0
	The physical internet	1	YES	NO	1.0

The importance of the gap analysis should not be underestimated, because it provides the basis for the recommendations and could be fundamental to subsequent adaptations of the company's supply chain strategy.

In order to test whether there is a significant difference between the perceived importance of a challenge, reflected by its "IMPACT"-score and the company's readiness to cope with this challenge at this moment, represented by the "COULD WE?" score, a Wilcoxon signed rank test could be used.

The final stage of the Future-Proofing Diagnose encompasses the *Recommend* phase. The analyst interprets and translates the results of the gap analyses in a set of recommendations to the company. The *Recommend* deliverable includes a general statement, the so-called majors and minors and an overall estimation of the Supply Chain Maturity of the company. The general statement contains a reflection on the current status of the supply chain of the company and its readiness to cope with the upcoming challenges. Minors are quick wins that can be implemented immediately, while majors require a project-based approach to bridge one or more gaps.

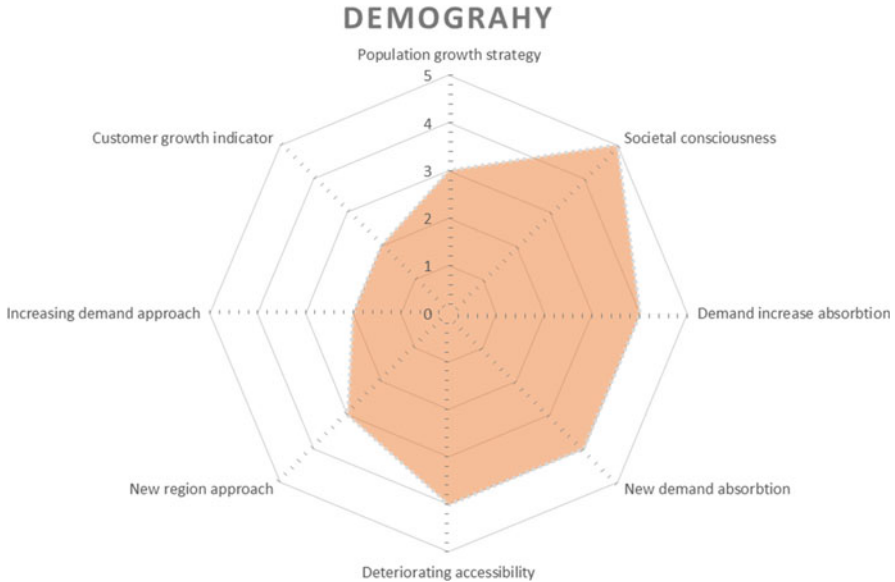


Fig. 3 Example of a spider graph for the challenge “Demography”

The overall estimation of the Supply Chain Maturity is translated by the expert in a kind of estimated score between 1.0 and 2.0, representing the position of the company on the Supply Chain Maturity axis of the evolutionary graph of Fig. 1. The Supply Chain Maturity score is not a calculated value, but rather a global appreciation of the company’s supply chain readiness to cope with the future challenges.

8 Validation Study

Before using the Future-Proofing Diagnosis as a full-fledged test tool for supply chains, some pilots were conducted at various companies in order to fine-tune the test. The major issues that were observed throughout the pre-tests are reported in this paragraph. The Future-Proofing Diagnosis has been fine-tuned accordingly.

The *Inspire* session turned out to be an eye-opener in many cases. The success and the interaction was largely dependent on the inspirer-conductor. Therefore, as this is the opening session and the first contact with the company’s key supply chain people, it is mandatory to have an experienced and high qualified inspirer, who is able to stimulate and encourage the interaction while keeping an eye on the interaction-balance among the participants. To a certain extent, the size of the group did matter. The best interactive sessions were obtained with groups of four to eight people.

The inspirer should be able to explain in detail the impact of each future challenge on the supply chain in general and on the company’s supply chain in

particular. The participants of the pilots repeatedly expressed their interest in the insights and explanation given by the inspirer on how a particular challenge could really have an effect on the supply chain. This aspect of the inspiration session was really considered as valuable knowledge transfer by the companies.

The major issues observed during the *Prepare* session, were mainly related with the supply chain leader's interpretation of the difference between the "WE SHOULD" and the "WE COULD". In some cases, it took some time before the supply chain leader was able to make a clear distinction between both. Here too, the multiple roles of the conductor vis-à-vis the supply chain leader as peer, sounding board and counsellor should be underlined.

The observations made during the *Complete* sessions were mainly focussed on the way the questionnaires were filled out. Ideally, the same audience of the Inspiration session is asked to complete the questionnaire. New participants or substitutes should be avoided, as well as a too long delay between the Inspiration and the Complete sessions. Ideally, the delay should be no more than 1 week. However, this is not always feasible in global or big companies where the staff comes from different sites. It has been observed that the longer the delay between Inspire and Complete, the more the conductor is asked to give additional explanation for some of the questions. Inversely, organizing the Complete session immediately after the Inspire session is conceivable as long as the Prepare session could be intercalated.

The fill out of the questionnaire could be performed in different setups. Three major configurations could be envisaged:

- *Joint Workshop*: all participants are gathered in one room and the conductor processes the questions one by one. The participants should agree on a joint score for every question.
- *Individual Workshop*: all participants are gathered in one room and the conductor reads and, if necessary, comments the questions one by one. Each participant scores each question individually.
- *Individual*: each participant is asked to score all questions individually, before a certain deadline.

The Individual Workshop configuration should be the preferred configuration, because the support of the conductor guarantees the appropriate interpretation of the questions and the participants are totally free to score on each question. Moreover, variations in the scores of the questions among the participants could reveal additional insights during the analysis phase.

The anonymity of the participants can be best guaranteed in the Individual Workshop and the Individual setup. The Joint Workshop does not only result in less information because every question is rated only once, it could also be biased by the opinion of the leading persons in the group. The two workshop setups are highly time-consuming for the staff and is therefore sometimes difficult to realize in companies. For both workshop setups, almost a full day is required to complete the full diagnosis. During the pilots, a number of companies were in favour of the

individual fill out of the questionnaire. A web-based questionnaire is recommended in these cases.

The *Analyse* session of the pilots was used to further check the validity and the integrity of the questionnaire. Besides, the relevance of some formal statistical tests was evaluated. As a result, the Wilcoxon signed rank test has been retained to measure the difference between the perceived importance of a challenge, reflected by its “IMPACT” score and the company’s readiness to cope with this challenge at this moment, represented by the “COULD WE?” score. The ordinal Friedman test turned out to be useful to measure differences between the participants’ scores in case of the Individual Workshop or the Individual configuration.

The gap analysis for each challenge appeared to contain the most valuable information for the supply chain leaders. During the *Recommendation* phase, the appropriate interpretation of the gap analysis by the conductor was considered as key for the supply chain leaders. Here again, the role of the conductor, his qualifications and experience were extremely important in the interpretation of the gap analysis and the subsequent discussions.

In short, the role of the inspirer-conductor turned out to be key during the pilots. It is highly recommended to keep the same person from start to finish, throughout the diagnosis project. Seniority, qualification, inspiration and presentation skills, and practical supply chain experience should be the required characteristics of the inspirer-conductor.

9 Conclusion

The accelerated rate of change in society and customer behaviour today enforces logistics and supply chains to transform accordingly. Today’s customer on-demand dominance is becoming excessive, pushing the companies’ supply chains to their limits, requiring more and more capacity and infrastructure. However, society is increasingly unwilling to further accept more logistics capacity and infrastructure that would cause irrevocable damage to people and planet. Consequently, future volume growth should be further accommodated with the existing logistics capacity and infrastructure, thus requiring much smarter supply chain management and logistics. The speed and intensity at which this evolution will take place depends on the impact of a number of challenges with which supply chains have to cope as from today. Twenty important challenges with an impact on supply chains have been identified. In order to help companies to prepare their supply chains for these challenges a methodological and dynamic framework is proposed, the Future-Proofing Supply Chain Diagnosis. The diagnosis gives a clear picture of the maturity level of a company’s supply chain and its readiness to cope with the upcoming challenges.

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