

1 PAST, PRESENT, AND FUTURE OF SUPPLY CHAINS

Global supply chains have gone under substantial changes over the history. Different ways of exchanging materials, information, and money shaped the nature of supply chains, with profound implications on the people involved. The innovations that radically changed the nature of supply chains range from new transportation means like ocean vessels to containerization and computerization. In parallel with these technological innovation, societal changes and macro-economic transformations also had profound implications on the nature of supply chains. This chapter will provide an overview of the history of supply chains, from ancient times to modern times, and will discuss some trends that will determine the nature of the supply chains of the future.

1.1 ANCIENT TIMES

In ancient times, the vast majority of supply chains were local, limited to a city or a small region. The exchange of materials relied on a set of basic transportation technologies, such as horses or boats; the cost of moving materials was therefore relatively high. The exchange of information was quite efficient, since the customers could directly communicate with the producer and specify what they wanted. This was the case of the pre-industrial artisan manufacturing, including village weavers, potters, blacksmiths and cobblers. Similarly, in an agrarian supply chain, a farmer would cut the wheat, send it to a mill for grinding into flour, then send it to a baker to make into bread, and finally it would be sold at a market stall.

Because of the high transportation costs, long-distance supply chains only traded high-value items such as spices, weapons, and luxury goods. For these high value items, however, there are some noticeable examples of global supply chains that mirror the modern ones, at least in terms of geographical extension.

A noticeable example is the Olive Oil Supply Chain of the Roman Empire. This supply chain originated in North Africa, where people were effectively cultivating olive trees. These cultivations dramatically influenced the characteristics of the local landscapes, and traces of the roads, ditches, and waterworks used to support the cultivation of olives are still visible today. Oil warehouses were storing oil in shipping containers called “amphorae”. Large ships of the grain fleet would then carry wheat and olive oil from Africa to the port of Rome. The technology of the time facilitated the trade, with some examples of solutions like the cargo loading cranes that are surprisingly similar to the ones currently employed.

Other noticeable examples of global supply chain in ancient times are the Silk Road through Central Asia and the Spice Route over the Indian Ocean. The Silk Road was an ancient network of trade routes, formally established during the Han Dynasty of China, which linked the regions of the ancient world in

commerce between 130 BC-1453 AD (Ancient History Encyclopedia). The goods transported from West to East include wool, carpets, textiles, gold, silver, and camels. The goods transported from East to West included silk, tea, dyes, and precious stones. These ancient supply chains had already the power of influencing the imagination of artists: the Italian explorer Marco Polo travelled on the silk routes and described them in depth in his book “Il Milione”.

1.2 THE INDUSTRIAL REVOLUTION

The Industrial Revolution that started in the late 18th century radically changed the scale and the nature of global supply chains. Several technological shifts created radical changes in the way of producing and transporting goods.

In 1781 the inventor James Watt built the rotary action steam engine. This engine represented a breakthrough and provided an alternative power source for several industries, such as textile, coal and iron. The textile industry exemplifies well the changes that transformed the supply chains of the time. Textiles were initially slow to adopt the steam engine because of its costs and risks. However, in 1830 steam was the main source of power in the industry and it enabled the creation of new factories as well as large increases of productivity. A global supply network progressively emerged, and it involved shipping cotton from the United States to the mills in England. The finished cloth was then shipped out to the rest of the world. Similarly, the coal, iron, and steel industries used the new engines for deeper mines and greater coal production; these changes lowered the prices of fuel and steam, thus increasing the demand for coal.

Other innovations in the field of logistics also contributed to modify the scale and the nature of global supply chains. Railways enabled faster, easier, and cheaper transport of goods over longer distances. Rudimentary hand trucks and other tools made it easier to handle goods. Communications improved thanks to steamships and railways able to carry letters.

The industrial structure and the supply chains of the early 20th century were the results of all these innovations in manufacturing and logistics, with communication tools that were still relatively rudimentary. The difficult communication between the various echelons of the supply chains produced vertically integrated industrial structures, where Fordist production lines would mass manufacture goods, later centralised at major transportation hubs.

The advent of mass production also created strong social tensions. From 1800 to 1850, the population of England and Wales doubled, from nine million to eighteen million. At the same time, the proportion of people living in cities rose from 10 percent to 50 percent. The flow of rural people into cities overwhelmed the physical facilities. Poorly built houses were hosting crowded masses of people, and

suburbs lacking adequate facilities could not keep pace with the growth in population. In 1845 Engels published “the Condition of the Working Class in England”, a study that denounced the poor living conditions of the industrial working class in Victorian England, suffering from long hours, monotonous labour, widespread employment of children, and low wages. Serious environmental changes also started to emerge. Coal was the universal fuel to power factories and heat homes and burnt coal covered English cities, turning many buildings black over time and contributing to air pollution, both inside poorly ventilated factories and outside.

Supply Chains became very important during World War II, as military organizations needed efficient supply chains. Supply chains manufactured military hardware and supplies, and the demands from the war pushed a consolidation of industrial engineering and operations research into supply chain engineering.

1.3 SUPPLY CHAINS FROM POST WAR TO CURRENT: FROM OFF-SHORING TO RE-SHORING TO RIGHT-SHORING

1.3.1 Off-shoring

After the Second World War the decline in barriers to the free flow of goods and services and important technological changes determined the beginning of the Globalization phenomenon. Globalization implied a shift toward a more interdependent and integrated global economic system, the merging of historically separate national markets into one huge global marketplace, and the possibility of sourcing good and services from locations around the globe. The internationalisation of business activities implied the creation of institutions to govern the global marketplace such as the International Monetary Fund and the World Bank, both created in 1944, and the General Agreement on Tariffs and Trade (GATT), created in 1948. Industries worldwide thus entered a new era of intense global competition. Manufacturers in particular had to achieve world-class status to compete effectively in global markets, and they had to interlink and incorporate marketing strategy and manufacturing strategy with the corporate strategy (Skinner, 1969 cited in Deshmukh, 2001). In this context, manufacturers also started to recognise the strategic importance of factory location decisions, also called “shoring decision” (Kinkel and Maloca, 2009). Off-shoring, namely the relocation of parts of production processes to own locations abroad irrespective of the ownership mode (Kinkel & Maloca 2009), progressively became one of the most popular location strategies. The outsourced processes were initially operational or supporting processes such as manufacturing or accounting; however, after some time companies started to offshore also technical and administrative services.

Historically, most outsourcing has been directed at the developed nations of the world as firms based in advanced countries invested in others’ markets. During the 1980s and 1990s, the United States was

often the favourite target for Foreign Direct Investment (FDI) inflows. Investors include firms based in Great Britain, Japan, Germany, Holland, and France. The developed nations of Europe have also been recipients of significant FDI inflows, principally from the United States and other European nations. These developed nations still account for the largest share of FDI inflows (te Velde, 2006; UNCTAD, 2019).

The outsourcing location had a different direction for manufacturing companies with non-advanced manufacturing technologies that perceived labour cost as a large proportion of overall manufacturing cost. Several of these companies started to relocate their manufacturing plants to a Far Eastern locations, where the labour cost was a fraction of the one in the original locations in developed countries. FDI into developing nations and the transition economies of Eastern Europe and the old Soviet Union progressively increased. The majority of FDI inflows into developing nations had been targeted at the emerging economies of Southeast Asia. Recently, the world economy saw a growing importance of China as a recipient of FDI, since the country attracted about \$60 billion of FDI in 2004 and rose steadily into a record of \$139 billion in 2018 (UNCTAD, 2019).

A key reason for offshoring was the possibility of exploiting national differences in the cost and quality of factors of production such as labour, energy, land, and capital. The cost of labour has always been among the most important drivers for offshoring among manufacturing firms. A survey of 1664 German companies by Kinkel & Maloca (2009) revealed that the cost of wages was the most popular driver for offshoring in emerging markets in the period 1999-2006. The Access to new markets and the vicinity to foreign markets were two other key reasons for offshoring. The United States has been an attractive target for Foreign Direct Investment because of its large and wealthy domestic markets, its dynamic and stable economy, a favourable political environment, and the openness of the country to FDI. The reasons for the strong flow of investments into emerging markets and into China are similar, considering that China represents the world's largest market with its population of more than 1.3 billion people. The presence of related and supporting industries was another important reason for offshoring, since manufacturing companies are often dependent on alliances and partnerships with other companies in order to create additional value for customers and become more competitive. Especially suppliers were crucial to enhancing innovation through more efficient and higher-quality inputs, timely feedback and short lines of communication. Other offshoring drivers included the access to skilled labour force, access to new technologies, capacity constraints in the home country, increasing speed to market, vicinity to foreigner customers.

1.3.2 The Global economic crisis and the emergence of reshoring

Since 2005 some changes in the business environment started to call into question the paradigm of offshored manufacturing. Firstly, the Global Economic Crisis implied a significant increase in the price of major commodities, raw materials, and oil. Therefore, the transportation costs for long-distance

deliveries increased significantly. Secondly, a survey conducted by Manning (2014) revealed that companies were starting to feel the difficulty of dealing with communication barriers and cultural differences generated by their offshoring strategy. Thirdly, the macro-economic situation of some offshoring destinations changed, and increases in labour wages reduced the cost related advantages of offshoring. Fourthly, the business environment saw an increased attention for customer satisfaction, with supply chains forced to be more flexible and responsive, in opposition to the cost advantages given by offshoring strategies (Fratocchi et al., 2011).

As a result, Offshoring had lost many of its initial strategic advantages. An increasingly high number of firms started to question the real benefits of their “offshoring” strategies (Holweg, Reichhart and Hong, 2011) and they started to move their offshored production back to their original countries (Kinkel and Maloca, 2009).

This was the beginning of the phenomenon called “reshoring”. Fratocchi et al. (2014) defined it as “*the back relocation of earlier off-shored production activities, and one of the strategic options available to manufacturing firms in terms of international relocation of manufacturing activities irrespective of the ownership mode (in-sourced and out-sourced)*” (pp. 56). Simply put, Right-Shoring is “the placement of a business' components and processes in localities and countries that provide the best combination of cost and efficiency” (Investopedia). In this context, companies make location decisions trying to achieve the best combination of a set of production factors, rather than moving factories overseas to profit from economies of scale or reduction in the cost of the workforce.

Since reshoring started, many manufacturing companies in the US and in Europe have announced the return to the home countries of all or part of their off-shored production (Fratocchi et al., 2014). These manufacturing companies include industrial giants such as Caterpillar, Bosch, and Philips.

Some data can help estimating the entity of the reshoring phenomenon. Data from 2007 and 2009 have shown that there were 249 companies involved in reshoring activities in US and in Europe (Ancarani et al., 2015). Similarly, the “European Manufacturing Survey” revealed that offshoring activities of the German manufacturing firms area declined by 17% from the mid-1900s to 2012 (Kinkel, 2014; Kinkel and Maloca, 2009). A report from EEF (2014), confirmed that some companies are bringing production closer to the UK, either to Western Europe (9%) or Eastern Europe (12%). Similar studies confirm that the phenomenon has started. Fratocchi et al. (2015) have analysed secondary data revealing that there are 377 companies engaged in reshoring globally, 177 in North America and 194 in Western Europe. However, it is necessary to highlight that despite the emergence of reshoring, offshoring is still the choice of the majority of firms.

Reshoring decisions can have direct and important implications on the competitive position of a firm. A well-formulated reshoring decision implies an analysis of the reasons for reshoring, the content of the re-shored activities, the reshoring location, and the re-shoring mode.

The reasons for reshoring include a blend of internal competitive priorities, external incentives, and risk mitigation. A recent study of Godsell et al. (2019) demonstrated that companies that have re-shored focused on the competitive priorities of time and flexibility, while also considering other factors such as the access to qualified personnel, skills, technology, innovation, and the reduction of risk. The proximity to a main market triggered 38% of direct and 37% of indirect reshoring decisions.

The re-shoring decisions can affect the full production volume or a percentage of it, and the re-shored activities can range from the production of a finished product to the production of a component. The finished products or the components that are re-shored can belong to new or consolidated product lines. Similarly, also the selection of the re-shoring location implies the consideration of several factors such as the proximity to R&D facilities, the country of registration, or a main market. Regarding the reshoring mode, the company can offshore production capacity back to the home country (Direct reshoring) or increase capacity at home instead of abroad (Indirect Reshoring).

The reshoring decisions have an impact on the performance of the company and of the supply chain. The study of Godsell et al. (2019) focused on the impact of reshoring at a firm and supply chain level and analysed the implications of direct and indirect reshoring. Regarding the firm level, the study highlighted that 57% of companies that directly reshored saw an increase in production output and 75% of companies that indirectly reshored saw an increase in production output. The study also suggests that reshoring provides benefits in terms of flexibility and delivery times, based on the analysis of data collected from companies operating in the automotive industry. Regarding the supply chain level, the study highlighted that the impact on the supply base was not as extensive as expected, with 66% of the 144 companies that reshored reported no impact on their supply base as a result.

At a macro-economic level, some preliminary evidence suggests that reshoring has several advantages for the home countries, especially in terms of employment. PWC (2014) estimated that in the UK reshoring could create up to 200,000 jobs and boost GDP by 0.8% in the next decade.

Researchers also started to look beyond the difference between reshoring and offshoring scope, to consider the “right-shoring” decision, namely the location of the the SC assets around the globe (Ellram et al., 2013; Gray et al., 2013; Tate, 2014). The factors considered for the right-shoring decision partially overlap with the factors for considered for reshoring, and they include input/product, cost, labour, logistics, SC interruptions risk, strategic access, country risk, and government trade policies (Ellram et al., 2013).

Change seems to be the only constant today for Supply Chains. Christopher and Holweg (2011) observed that supply chains had entered into the “era of turbulence”, characterised by an unstable business environment and a range of crises or shocks. The classic SC managerial models are unfit for this turbulence age. The offshoring location strategy, based on the economies of scale, is one of these dated SC practices. New SC archetypes are emerging, such as the idea of moving from “dynamic flexibility” to “structural flexibility”. There is a difference between structural flexibility and dynamic flexibility. Dynamic flexibility reflects the agility of a supply chain and its ability to respond rapidly to variations in volume and mix. This is the traditional measure that characterised the flexibility of supply chain in the dichotomy between the lean and the agile supply chain. Structural flexibility on the other hand is the ability of the supply chain to adapt to fundamental change. An example of fundamental change is the modification of the ‘centre of gravity’ of a supply chain, that is the ideal location for a distribution center that minimizes the transportation cost. A dynamically flexible supply chain is able to modify its structure after a change of the ‘centre of gravity’.

The achievement of Structural Flexibility requires five key steps.

The first step consists in considering the SC assets needed in the network, namely the number and the nature of the production and distribution plants.

The second step consists in understanding where to position the SC assets. In making this decision, managers typically use the mentioned criteria for right shoring.

The third step consists in deciding what is the best ownership model for the assets. There are two polar choices regarding the ownership model. On the one side, there is the vertically integrated supply chain, or the “make” model in the make/buy dichotomy. In this model the OEM also own the assets to produce components or for the supporting functions for their production processes. This model emphasises functional integration, protection from market pressure, and information integration. On the other side, there is the market-based supply chain, or the “buy” model in the make/buy dichotomy. In this model the OEM buys in the market the components or the supporting functions for their production processes. This model emphasises functional specialism and market efficiency. Figure (2) highlights the difference between the vertically integrated and the market-based supply chain.

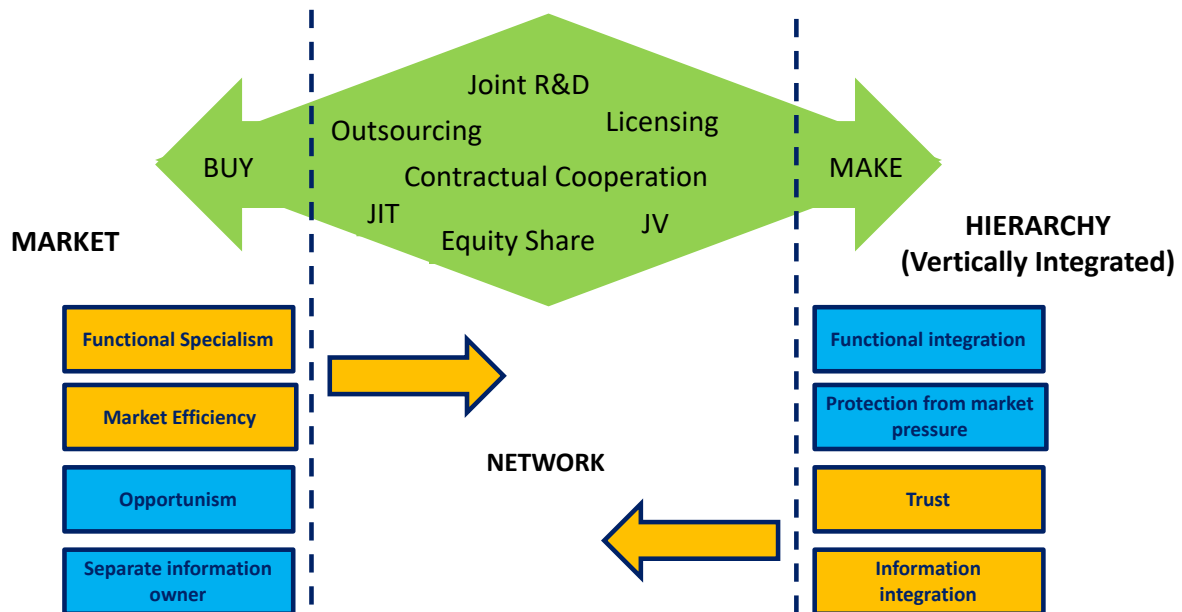


Figure (2): difference between the vertically integrated and the market-based supply chain (adapted from Hinterhuber and Hirsch, 1998).

The fourth step consists in deciding who will manage the network. The complexity of modern supply chains as well as the need of aligning and optimising the processes requires an actor able to coordinate the whole network beyond the boundaries of the specific firm. An example of actor that can have this type of role for modern supply chains are the fourth-party logistics providers (4PL) that manage resources, technology, infrastructure, and even external logistics providers to design, build and provide supply chain solutions.

The fifth and last step consists in ensuring that the network remains dynamic and refreshed. This step highlights the fact that designing a supply chain is a continuous improvement process, rather than a one-off and isolated activity. In keeping the network dynamic and refreshed managers have to observe and track the changes and the dynamics of the market and adapt the choices of the four steps listed above accordingly.

1.4 FUTURE TRENDS

The landscape of supply chain management continues to evolve, and there are two key trends that are profoundly influencing the nature of supply chains and that will play an even greater role in the future. These trends are the Fourth Industrial Revolution, the pressure for a better performance from a triple bottom line perspective, and the need of resilient supply chains.

1.4.1 Supply Chains 4.0

The Fourth Industrial Revolution, known as Industry 4.0 (I4.0), refers to recent technological advances where the internet and supporting technologies serve as a backbone to integrate physical objects, human actors, intelligent machines, production lines and processes across supply chains.

Godsell et al. (2020) highlighted that the Fourth Industrial Revolution is changing the nature of supply chains by intervening on six different dimensions: Products and Services, Manufacturing and Operations, Strategy and Organisation, Supply Chain Business Models, and Legal Considerations.

Products and Services are typically made in large batch sizes with limited late differentiation. The I4.0 technologies are enabling late differentiation for most make-to-order products, up to the case in which a production batch has a size of 1 unit. The digital features of products are also changing towards a situation in which products exhibit high digital features and value from intellectual property licensing. Data-driven services are gaining an increasingly important role, and while they currently account for a minor share of revenue (<2.5%), they will play an important role in revenue (>10%) in the next future.

The nature of Manufacturing and Operations is evolving from situations in which automation can control few machines to a situation in which automation can completely control Machines and systems, with the adoption of autonomously guided work-pieces and self-optimising processes. While currently only few processes use digital modelling, the I4.0 technologies will create production plants that adopt complete digital modelling for all the relevant processes. IT security solutions are now in their infancy and in the next future they will guarantee the safe exchange of data for all the mentioned applications and they will continuously evolve with the complexity of the systems and of the data exchanged.

Industry 4 is also changing the way of defining the Strategy and Organisation of the companies. Connected and automated machines will increase the productivity and dynamically adapt to the priorities and the objectives of the firm. In this context, Industry 4.0 will evolve from a functional specialism to a strategy fully implemented across the business and departments, and it will enable a more efficient cross company collaboration for mutual improvements. Higher levels of Industry 4.0 maturity will require widespread support of the leadership team as well as leading edge digital and analytics skills across the business. This represents an evolution from the current situation in which only some technology focused areas of the companies have employees with evolved digital skills.

The implementation of I4 can make a revolutionary change to the traditional way of managing supply chains, by providing real-time information about upcoming demand, inventories, site location, capacity, and operations. This enhanced visibility will guarantee higher levels of supply chain integration, a more agile response from upstream suppliers to downstream logistics providers, and ultimately a better response to customers' needs. From a situation in which the response to market changes is relatively slow, the digital supply chain will be able to give an immediate response to changes in market environment and as well as a response that is tailored to individual customer requirements.

The new technologies are facilitating the creation of new business models, and an example is the shift from ‘ownership based’ to ‘service based’ business models, in which periodic payments ensure dedicated access to services. Service based business models will require real-time tracking of the products as well as real-time and automated scheduling of maintenance activities. These new business models will benefit of the more integrated supply chains, especially in terms of customer integration, and IT supported business will continue proliferating, with IT systems supporting and integrating all company processes.

It is finally necessary to consider that for companies to successfully harness the full potential of Industry 4, new regulation will be needed. Innovations in the legal profession will follow the challenges opened by the new configuration of business models and supply chains, and they will include new contracting models, legal risk, data access procedure, and intellectual property enforcement. These dimensions pose the areas of greatest legal risk but also of greatest opportunity when handled in the most effective way.

1.4.2 Resilient supply chains

Recent supply chain disruptions caused by the COVID crisis and by Brexit highlighted the fundamental importance of supply chain resilience. Higher levels of supply chain resilience imply the capability of preparing for, responding to, and recovering from disruptions more effectively. In more academic terms, supply chain resilience has been defined as “the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function” (Ponomarov and Holcomb, 2009, p. 131)”.

There are different practices aiming that can improve supply chain resilience. For instance, improving supply chain visibility and collaboration enable more effective planning, access to real-time data, as well as joint commitments in managing activities. Specific inventory policies can also improve the resilience of the supply chain: managers can flex up and down the inventory and production capacity to buffers against the volatility caused by disruptions. In more structural terms, an adaptable and flexible supply chain will respond more effectively when reacting to a disruption.

The context in which supply chains operate, and the infrastructure that can support supply chain flows, also play a pivotal role in enabling supply chain resilience. Therefore, achieving resilient supply chains requires a collective effort by managers and policy makers. An example of critical infrastructure that plays a pivotal role for SC resilience and that is implemented at national level is the connectivity network. With the advent of 5G, connectivity will move beyond the bounds of homes, offices, and factories to create connected or smart cities and roads. There is a growing competition among different countries in ensuring the best operative conditions for their supply chains: the Chinese government, for instance, is heavily investing in infrastructure programmes to support economic recovery. Similar investments are being implemented in Europe and in the US. The recent SC disruptions should drive

policy maker in investing towards higher level of resilience and in coordinating their efforts with SC managers.

1.4.3 Sustainable supply chains

Several societal and environmental challenges are increasing the relevance of the concept of sustainability for companies and supply chains. Among the environmental challenges it is possible to mention the CO₂ emission and on the related climate changes consequences, the production of solid waste, and the depletion of natural resources. Societal challenges created by the way in which modern supply chains operate include modern slavery, decent wages, and Occupational Health and Safety in the production plants and building sites of hazardous industries.

While a tension between the needs of companies and the protection of the environments and the humans is born with the first industrial revolution, the scale of this tension has dramatically grown in terms of importance, in parallel with the growth of the impact of the business activities on the natural environment.

The news of the last months have seen the younger generations protesting for the consequences of climate change, and the top management of the largest corporations is fully aware of the urgency of adopting sustainable business practices. An example is David Taylor, Procter & Gamble Company's Chairman, President and Chief Executive Officer recently, who stated that "Consumers expect the brands they trust to deliver superior performance and to also help solve some of the most complex challenges facing our world. Our global reach, our understanding of the five billion consumers we serve, and our innovation capabilities give us a unique ability to make a positive difference" (P&G webpage). It is easily possible to find similar statements among the CEOs of other companies operating in different industries.

The environmental challenges are promoting the transition to a Circular Economy (CE) that proposes new patterns of production, consumption, and use based on circular flows of resources (Ghisellini et al. 2016). The traditional supply chains are being progressively replaced by Closed-Loop Supply Chains that maximize value creation over the entire life cycle of a product and the dynamic recovery of value from different types and volumes of returns over time (Guide and Van Wassenhove 2009). The introduction of Closed-Loop Supply Chains is increasing the importance of activities that were marginal just a few years ago, such as the collection of used products from customers, reverse logistics, inspections and sorting, recovery operations, and finally remarketing. The supply chains managers of the future will have to manage these new activities, and the nature of the business models and of the traditional linear supply chains activities will change to better accommodate the design and the implementation of the reverse flows. New actors such as NGOs and interest groups are playing a more active role within supply chains, by facilitating awareness at the different levels and by promoting and facilitating the adoption of practices that guarantee the protection of the environment.

The social challenges within supply chains are prompting changes in terms of better supply chain visibility and supply chain integration. Supply chain managers realised that the tool traditionally adopted to ensure the social sustainability of supply chains such as the certification schemes can only work in a limited number of cases, and they are difficult to implement beyond the first tiers of the supply chains. Suppliers in developing countries often do not have the resources or the capabilities to afford these certification schemes. In the light of this situation, supply chain managers are realising that a close integration with suppliers and a diffusion of a sustainability culture can trigger an authentic change and spread its positive effect along the upstream side of the supply chains.

It is increasingly clear that these transition towards more sustainable business practices also have positive implications from a business perspective. The mechanisms creating synergies between environmental sustainability and business objectives are often straightforward, since cutting the consumption of energy and resources and optimising efficiency implies direct cost savings. Similarly, the mechanisms creating synergies between social sustainability and business objectives include a better perception of the brand and all the positive implications of a more integrated supply chain, that have been widely documented in the scientific literature. It is important to highlight that this transition does not only regard the western developed economies, but also the companies operating in the developing economy currently put sustainability at the heart of their agendas. The future therefore looks bright, and supply chains are more and more giving their contribution in making the world a better place.

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