1 Introduction

Despite the fact that we live in the era of the Internet, social media and sharing economy, manufacturing still matters. Behind every Amazon, Uber, or Facebook, there are companies producing the goods that we are sharing, consuming, or chatting about in our daily lives.

According to a recent study by McKinsey & Co., manufacturing’s share of the global GDP was 16% in 2010, with China topping the list at 33% (Manyika et al. 2012). There are 45 million manufacturing jobs in developed economies, and although this is significantly lower than the 62 million in 2000, this still represents 14% of the overall number of jobs in these countries (Manyika et al. 2012).

Manufacturing still matters. More so, it is ever more challenged by ongoing changes: evolving and ever more pervasive technologies, the globalization of markets and competition, changing customer needs, societal challenges, changing workforce characteristics, and expectations (e.g., John et al. 2001; Manyika et al. 2012; Chatha and Butt 2015). Having to face these challenges, manufacturing is under pressure to keep its promise as a major competitive weapon, especially in mature economies and developed countries. At the same time, companies in emerging countries are following the same steps that industry followed many years ago in the developed world, but at a different pace and with many distinctive features that require specific theories and practical knowledge.

Numerous studies support the idea that manufacturing can contribute significantly to business performance, especially by building strong manufacturing competencies (e.g., Cleveland et al. 1989; Vickery et al. 1993). The different avenues that can be taken by companies to achieve this result are described in the manufacturing strategy literature and theory development of the last five decades.

Manufacturing Strategy can be defined as “a projected pattern of manufacturing choices formulated to improve fundamental capabilities, and to support business and corporate strategy” (Miller and Hayslip 1989, p. 23). In particular, it refers to the definition of strategic goals. These goals then drive the adoption of practices and improvement programs, in order to improve performance from a medium- or long-term perspective.

In this chapter, we will mainly take an internal (company) perspective, and consider external partners as strategic interfaces to be managed rather than as the key players of the strategy itself.
From this perspective, manufacturing strategy complements, and needs alignment with, the supply chain strategy of a company, rather than being part of it.

Starting from these premises, this chapter aims to take a journey through the consolidated theories on manufacturing strategies which can be linked back to the seminal work of Skinner five decades ago (Skinner 1969). At the same time, we will consider the new challenges that manufacturing companies face in today’s world and the new theories that are developing to provide guidance in this new context. In this way, we try to provide a comprehensive picture of the key concepts and the challenges that companies and researchers need to address when dealing with manufacturing strategy choices.

2 The Strategic Role of Manufacturing Operations

The contemporary concept of manufacturing strategy dates back to the late 1960s. However, older examples can be found in the principles of scientific management, promulgated by Frederick Taylor (1911) and modified and elaborated by the industrialists of that time, among them Henry Ford. Indeed, the production at Ford, which applied the notions of product and work standardization to the assembly line, enabled the Ford Motor Company to gain a significant advantage over their competitors in the automotive industry (e.g., Hounshell 1984). Many companies interpreted the concepts of mass production in such a way as to determine the emergence of the so-called “one best way” to manage manufacturing systems. The only way for a company to differentiate itself from its competitors was to look into other functions, such as marketing or finance.

Through experience matured during years of teaching and case visits, Wickham Skinner developed his fundamental ideas about the role of manufacturing in a company’s strategy, as expressed in a seminal paper of 1969 in the Harvard Business Review: “Manufacturing—missing link in corporate strategy” (Skinner 1969). Three basic concepts, which are the landmarks of manufacturing strategy theory even today, were put forward:

1. Different companies have different strengths and weaknesses and can choose to compete in different ways, and therefore should adopt different “yardsticks of success”;
2. Similarly, different production systems have different operating characteristics;
3. Therefore, rather than adopting an industry-standard production system, the “task” for a company’s manufacturing function is to construct a production system that, through a series of interrelated and internally consistent choices, reflects the priorities and tradeoffs implicit in its specific competitive situation and strategy.

(Hayes and Pisano 1996, p. 26)

From Skinner’s seminal work, the theory of manufacturing strategy began to evolve (e.g., Skinner 1974; 1985; Hayes and Wheelwright 1984; Hill 1985; Voss 1992a). Despite the very important steps that rooted the importance of the manufacturing function within industrial companies, the dominant view was one where manufacturing had a mainly supportive role: the strategic management of manufacturing is “the effective use of manufacturing strengths as a competitive weapon for the achievement of business and corporate goals” (Swamidass and Newell 1987).

The observation of successful companies, however, suggested that the role of manufacturing strategy could go beyond this, becoming the main driver of the competitive strategy by creating unique capabilities. In particular, based on the observation of a number of manufacturing
companies, Hayes and Wheelwright (1984) proposed a model where the strategic role of manufacturing evolves through four stages of increasing relevance:

- **Internally neutral**: manufacturing’s goal is to minimize the negative impact on the overall company, by “doing as told” in a reactive fashion.
- **Externally neutral**: manufacturing has to catch up with competitors in order to maintain parity, usually by following industry practice.
- **Internally supportive**: manufacturing plays a supportive role in business strategy, and competitive priorities are the drivers of manufacturing choices in terms of structure and infrastructure.
- **Externally supportive**: manufacturing assumes a proactive role in building distinctive capabilities for competitive advantage. Competitive strategy is driven by manufacturing capabilities.

Empirical evidence at that time showed that the role of manufacturing in most companies was of the Stage 3 type (Schroeder et al. 1986; Wheelwright and Bowen 1996).

A significant change in perspective was introduced by the application of the Resource Based View to manufacturing strategy (e.g., Hayes and Upton 1998; Amundson 1998; Gagnon 1999). This paradigm underlines the key role of strategy in developing and leveraging unique operational resources for competitive advantage (Gagnon 1999). According to this perspective, the content of manufacturing strategy is defined based on those processes, technologies, organizational routines, knowledge, and skills that are needed to build the core capabilities that would allow a company to develop idiosyncratic manufacturing processes that differentiate it from competitors (Prahalad and Hamel 1990; Tranfield and Smith 1998). The perspective—as well as the manufacturing strategy process—is thus reversed (from “market to competencies” to “competencies to market”), therefore fostering the leadership role of manufacturing strategy in company’s competitiveness. Empirical evidence widely supported this new perspective, showing the positive impact on firm performance (e.g., Schroeder et al. 2002; for a review, see Hitt et al. 2016).

### 3 Key Concepts in Manufacturing Strategy

Research into manufacturing strategy generally recognizes the distinction between the process of strategy definition and its content (e.g., Adam and Swamidass 1989; Leong et al. 1990; Voss 1992a). This distinction derives from the business strategy literature (Andrews 1971; Chandler 1962; Ansoff 1965). Fahey and Christensen (1986, p. 168) summarize the concept as “Content focuses on the specifics of what was decided, whereas process addresses how such decisions are reached in an organizational setting”.

A number of models have been developed in the areas of both manufacturing strategy process and content. Research in these fields requires rather different approaches that are often carried out separately. Focusing on one subject or the other leads to greater insight into the problems and research questions that characterize each area. Unfortunately, this distinction led to the different evolution of knowledge in the two fields. Manufacturing strategy content was widely explored, while manufacturing strategy process received less attention, particularly in the early stages of empirical research. Few authors addressed the two subjects in the same study (e.g., Miller and Roth 1994; Schroeder et al. 1986; Kim and Arnold 1996; Cagliano and Spina 2000).

#### 3.1 Manufacturing Strategy Content

Since Skinner’s early work (1969), research on the content of manufacturing strategy distinguishes two broad categories of elements: (i) manufacturing objectives or goals and (ii) decision areas.
According to this model, the competitive environment drives the selection of a suitable business strategy that, in turn, determines mission statements for the manufacturing function. The basic manufacturing mission can be described in terms of competitive priorities—or manufacturing tasks. These tasks will then be translated into practice by taking a coherent set of decisions in a number of key areas, which are generally distinguished in structural and infrastructural decisions. More details about this model and its developments are provided in the following sections.

### 3.2 Manufacturing Strategy Process

The original formulation of the manufacturing strategy process model was proposed by Skinner (1969) and further developed by subsequent authors (Wheelwright 1978; Hill 1989; Fine and Hax 1985; Marucheck et al. 1990; Menda and Dilts 1997).

According to this model, manufacturing strategy is one of the functional strategies of a company. The manufacturing strategy process follows a top-down approach, in accordance with the hierarchy suggested in the traditional definition of corporate, business, and functional strategies (e.g., Chakravarthy and Lorange 1990). The comparison of industry factors with a company's characteristics helps to define business priorities. This in turn leads to the definition of the appropriate manufacturing tasks and manufacturing policies and choices.

An alternative view of the manufacturing strategy process involves a less structured approach, where strategy is formulated through a sequence of decisions informed by market requirements and by the need for external and internal fit (e.g., Papke-Shields et al. 2002; Paiva et al. 2008).

More recently, authors have suggested that a top-down approach is mostly applicable to the internally supportive manufacturing units of the Hayes and Wheelwright framework (Hayes and Wheelwright 1984), while externally supportive units require that manufacturing develops its capabilities autonomously and plays a driving role in building competitive advantage in the long term (Hayes 1985). From this new perspective, the strategy process starts from an analysis of the operating resources and competencies existing in the company. On this basis, a strategy is defined to reinforce or build the selected resources and capabilities so as to allow sustainable competitive advantage (Collis and Montgomery 1995; Gagnon 1999).

### 4 Manufacturing Paradigms

The development of manufacturing strategy theory cannot be seen as separate from other approaches to the study of production systems. One important stream of literature studied the evolution of the basic principles that underpin the different models and practices of manufacturing management over time. The two perspectives have been often seen as conflicting. The conceptualization of manufacturing strategic management does not include the existence of a common "best way"—or model—to manage and organize production systems. The main characteristics of the production system are defined in coherence with the competitive strategy of the company and the internal and external environment. The advocates of the strategic approach to manufacturing also often maintained that the servile imitation of successful managerial and organizational innovations causes companies to become similar, thus narrowing their strategic space (Hayes and Pisano 1994).

Various experiences in different countries and industries, however, demonstrated the existence of general rules of coherence between the levers that define manufacturing strategy. These levers depend on the characteristics of the market, the context, and the evolution of the industrial environment. These sets of coherent principles are often referred to as paradigms. Among these
paradigms are World Class Manufacturing (Schonberger 1986), Lean Production (Womack et al. 1990), and Strategically Flexible Production (Spina et al. 1996).

4.1 The Most Relevant Manufacturing Paradigms

4.1.1 World Class Manufacturing

The World Class Manufacturing paradigm was first introduced by Hayes and Wheelwright (1984) and subsequently developed by Schonberger (1986) as well as many other authors (e.g., Giffi et al. 1990; Flynn et al. 1999). This paradigm concerns the ability to produce products for global markets that are of high quality, at low cost, and have high responsiveness and flexibility. These capabilities are reached through the implementation of best practices, that is, excellent managerial and organizational approaches, in every area of the operation. The key areas are workforce skills and capabilities, management technical competence, competing through superior quality, workforce participation, rebuilding manufacturing engineering, and incremental improvement approaches. Most of these practices were observed in leading companies in Japan, Germany, and the US. Just-in-time and total quality management practices were later included in the paradigm.

4.1.2 Lean Production

Lean Production refers to changes in production systems toward a model based on the key principle of reducing any kind of waste while streamlining production processes and adopting a total quality approach (e.g., Womack et al. 1990; Shah and Ward 2003). Lean production has been seen as a philosophy, a set of principles inspiring the design and management of production systems, as well as an approach comprising a wide variety of integrated practices, including just-in-time, total quality management, work teams, cellular manufacturing, and supplier integration. These practices are nowadays widely recognized as part of four different bundles: just-in-time (JIT), total preventive maintenance (TPM), total quality management (TQM), and human resource management (HRM) (Shah and Ward 2003).

4.1.3 Strategically Flexible Production

Strategically Flexible Production (Spina et al. 1996) was proposed as a set of coherent principles that summarize the most important changes that have occurred in production systems in the last decades of the past century. These are multifocusedness and strategic flexibility, that is, the pursuit of different goals simultaneously and the ability to rapidly shift from one set of goals to another; the integration of business processes along the value chain, inside and outside the company; and process ownership, that is, the ability to transfer decision making to the shop floor level, where problems arise. The three principles are described as complementary and are all required in order to obtain superior performance improvement capabilities.

4.1.4 Other Manufacturing Strategy Paradigms

Other models or paradigms have been discussed in the literature. These models or paradigms include agile manufacturing, mass customization, and servitization. Agile manufacturing (Kidd 1994; Goldman et al. 1995; Yusuf et al. 1999) is an approach to manufacturing strategy and management aimed at addressing the challenge of the high volatility
and uncertainty of business environments, including concepts such as virtual (e.g., Shukla et al. 1996) or holonic manufacturing (e.g., McFarlane and Bussmann 2000).

Mass customization (e.g., Pine 1999; da Silveira et al. 2001) is an approach that aims to provide individually designed products and services to every customer at reasonable cost through high process flexibility and integration.

Servitization (or servicing) refers to the innovation of abilities and processes aimed at offering Product-Service Systems, that is, bundles of goods, services, support, and knowledge, instead of just physical goods (Vandermerwe and Rada 1989; Chase and Garvin 1989; Voss 1992b; Baines et al. 2009a).

4.1.5 Smart Manufacturing: The Emerging Manufacturing Paradigm

At the turn of the century, a new wave of models and paradigms were put forward in order to synthesize the latest changes in manufacturing systems, especially the wide diffusion of new technologies such as advanced, human-centered automation, cyber-physical systems, interconnection through the Internet of Things, virtual/augmented reality, and big data analytics. These approaches have been called Smart Manufacturing (or Factory) (Zühlke 2010; Hessman 2013); Industry 4.0 (e.g., Kagermann et al. 2013); or the Factory of the Future (e.g., EU 2013), depending on the emphasis given to the various components. Knowledge of the reconfiguration of manufacturing strategies, organization, and management consequent to the adoption of these technologies is still in its infancy, and it will be one of the main avenues of research in manufacturing strategy in the years to come (see Section 7).

4.2 Manufacturing Paradigm Versus Strategic Choices: The Debate

Despite the different formulations proposed in the literature for the emerging paradigms, and going beyond debate over actual possibility to generalize contingent manufacturing models into strategic paradigms (see Bartezzaghi 1999), there is a key criticism of this approach. Most of the literature about paradigms tends to present normative solutions to manufacturing management that do not take into account either the specific contingencies that the company faces or the different strategies that the company may follow in order to gain competitive advantage.

Spina (1998) suggested a way to overcome the debate between paradigmatic and strategic views of manufacturing, by distinguishing three levels that describe manufacturing:

- **practices and techniques**: used to innovate production systems, they are the bricks that form the strategy and need adaptation to both the competitive environment and the internal context;
- **models**: coherent and systematic combinations of practices which are developed autonomously by the company to respond to their internal and external environment;
- **manufacturing paradigms**: a limited set of principles which underpin different techniques and bring together various manufacturing models. The principles defining the paradigms synthesize the common modus operandi of companies across different settings.

Using these conceptual categories, Spina (1998) asserted and empirically showed that strategic choices are possible—and necessary—to position a company against its competitors, even if they are adopting the same manufacturing paradigm.

Even the traditional exponents of the strategic school recognized that manufacturing strategy experienced a clear change in the reference paradigm around the beginning of the 1990s (Hayes and Pisano 1996; Clark 1996; Skinner 1996), since most of the concepts proposed in the early years had to be revisited.
5 The Strategic Goals of Manufacturing Operations

As mentioned in Section 2, one of the key components of a manufacturing strategy is the set of strategic goals, or competitive priorities, that a company pursues through manufacturing. Competitive priorities involve the translation of business strategy into tasks for the manufacturing function or capabilities that must be developed in order to fulfill its supporting role.

Manufacturing tasks were originally grouped into the broad categories of cost, quality, delivery, and flexibility (e.g., Hayes and Wheelwright 1984; Ward et al. 1998). These categories have been refined to more detailed levels in order to better understand connections and relationships (e.g., Slack 1983; Neely and Wilson 1992; Gerwin 1993; Garvin 1993). Specification of the most important competitive priorities was thought to be essential in order to better understand the specific improvements needed in manufacturing and, thus, to facilitate the planning of a coherent set of actions aimed at providing these improvements (Garvin 1993; Skinner 1996).

Over the years, new competitive dimensions have been highlighted such as time (e.g., Blackburn 1991; Stalk and Hout 1990); customer satisfaction (Chase and Garvin 1989); servicing (Armistead and Clark 1991); product innovation (Hayes et al. 1988); customization (e.g., Kotha 1995; Pine 1999); and, recently, environmental and social sustainability (Jimenez and Lorente 2001; Porter and Kramer 2006). This shift in the focus of manufacturing competitive priorities is fundamental to sustain the competitive advantage of manufacturing companies in developed economies, as the traditional cost-quality-delivery advantage is diminishing and new business models based on innovation, servitization, and sustainability are needed to attract and retain customers (Manyika et al. 2012; Kuivanen 2008; Chatha and Butt 2015).

Complementing this view, Hill (1985) proposed distinguishing competitive priorities into those that drive the competition of the company in the marketplace, and the performance goals for manufacturing. The former are the performance dimensions on which the company wins orders or projects against its competitors (“order winners”) or those that the company has to satisfy at a minimum level in order to stay in the market (“order qualifiers”). The latter are measurable performance goals for manufacturing.

A new wave of studies began in more recent years around the concept of manufacturing capabilities. In particular, Swink and Hegarty (1998) highlighted the necessity of discerning the differences between competitive priorities (called product differentiation dimensions), manufacturing performance goals (manufacturing outcomes), and manufacturing capabilities. Manufacturing capabilities are the activities that a company can do better than its competitors and are the basis for the development of superior products. This concept was developed within the stream of strategic literature focused on core competencies and capabilities (e.g., Prahalad and Hamel 1990; Stalk et al. 1992; Barney 1991). The concept of manufacturing capability has been used by many authors, many of whom maintain that decisions in manufacturing have to be made according to the core capabilities that a company wants to build in order to sustain future competitive advantage (e.g., Hayes and Pisano 1994; 1996; Hayes and Upton 1998; Jayanthi et al. 2009). Developing capabilities that create new opportunities for the competitive strategy of the firm is the main goal of manufacturing units that are in the externally supportive stage (Hayes and Wheelwright 1984; see Section 2).

5.1 Strategic Trade-Offs and Cumulative Capabilities

A very important issue that has been widely debated in the manufacturing strategy literature almost since the beginning, is the interaction between different manufacturing objectives. Three
contrasting approaches in particular are present in the literature: the trade-off model, the cumulative model, and the integrative model (Boyer and Lewis 2002).

5.1.1 The Trade-Off Model

The trade-off model was first posited by Skinner in his early work (Skinner 1969; 1974). He asserted that no manufacturing unit can perform equally well on every performance measure and that manufacturing objectives need to be traded off against each other. The decisions that are made when developing manufacturing strategy result often in improvements in one performance dimension, while a second dimension is worsened. Managers therefore have to decide which performance is the most important for their company.

Trade-offs and their importance for manufacturing strategy have been widely studied, either by empirically testing them or by exploring their nature and motivations (see da Silveira 2005 for a review).

The success of Japanese manufacturing firms proved that these compromises are not always necessary, however, since their management practices allowed them to improve performance measures that were traditionally thought to be antithetical (Wheelwright 1981; Schonberger 1982; New 1992; Collins and Schmenner 1993). In a similar vein, other authors suggested that advances in manufacturing technology and organization minimize the effect of trade-offs and the need for focus (e.g., Goldhar and Jelinek 1983; Corbett et al. 1993).

5.1.2 The Cumulative Model

Taking a different perspective, Nakane (1986) suggested, and Ferdows and De Meyer (1990) supported with empirical evidence, that most companies follow definite sequences of improvement that aim at building capabilities in a cumulative way. The best sequence found is quality-time-cost-flexibility—this model is often referred to as the sandcone model (Ferdows and De Meyer 1990). A number of empirical tests in different contexts and with different contingent factors were subsequently performed, thus providing growing evidence to support the cumulative model (Amoako-Gyampah and Meredith 2007; Rosenzweig and Roth 2004; Größler and Grubner 2006). As pointed out by Schroeder et al. (2011), however, the cumulative model does not find undisputed support, and contingencies still prove to have a major impact.

In a similar vein, the concept of multifocusedness has also been put forward and tested, to contrast the trade-off view. Spina et al. (1996) used empirical evidence in order to show that companies that are “multifocused” aim to improve different goals simultaneously and obtain superior performance improvements if supported by adequate investments in process integration and worker empowerment. Rosenzweig and Easton (2010) later conducted a meta-analysis of the literature to contribute to the debate about the ability of manufacturing to focus on multiple competitive capabilities at the same time and use the theory of performance frontiers to justify the lack of empirical support to the trade-off model.

5.1.3 The Integrative Model

The debate about trade-offs versus cumulative competencies continued for several decades. In 1996, Skinner maintained that:

While trade-off relationships change and performance on most criteria improves with new technologies, this does not mean that trade-offs go away. The trade-offs will be
different in kind, their mathematical relationships altered, and new different perfor-
mance criteria become more important for success or failure.

(Skinner 1996, p. 9)

Along the same lines, Hayes and Pisano (1996) asserted the minor importance of “first order” trade-offs between performances when compared to the “dynamic, second order tradeoffs” which do not involve performance dimensions, but instead involves their rate of improve-
ment. Similarly, Schmenner and Swink (1998) proposed that the trade-off model involves the
importance placed on different competitive priorities, while the cumulative model involves the
improvement of capabilities over time.

These authors are generally seen as proposing an integrative model (Boyer and Lewis 2002),
that considers both previous models (trade-off and cumulative) to be valid, but at different logical
levels.

5.2 Strategic Configurations

A complementary perspective has been adopted by a number of researchers in manufacturing
strategy when dealing with the definition of a strategy’s content. Specifically, manufacturing
strategy is seen from a holistic perspective in this stream of studies, where the content is defined
by an integrated set of goals and actions—a manufacturing strategy configuration.

The configuration view was widely adopted in the strategy and organization studies literature
(e.g., Miles and Snow 1978; Mintzberg 1979; Porter 1980; for a review, see McGee and Thomas
1986 or Dess et al. 1993). Organizations are seen as a holistic synthesis of multiple, independent
characteristics. Miller (1996) pointed out that configurations are particularly useful when the
relationships between individual variables are too complex to be modelled.

Sweeney (1991), and later on Bozarth and McDermott (1998), reviewed studies in search of
generic manufacturing strategies or configurations. The most influential conceptualization is
one initially proposed by De Meyer (1990) and then worked on by Miller and Roth (1994), in
Europe and North America, respectively. Using manufacturing tasks as grouping criteria, they
identified three groups of companies: caretakers, those that competed first on price and second
on reliability and consistency; marketeers that competed on product range and quality; and inno-
vators, companies competing on product quality and innovativeness. De Meyer (1990) added a
new configuration, the high-performance product, which competes on a wide range of dimen-
sions, but primarily on flexibility. A number of subsequent works further tested this framework
in different contexts and time periods (e.g., Kathuria 2000; Frohlich and Dixon 2001; Zhao
et al. 2006; Sum et al. 2004). Cagliano et al. (2005) used longitudinal data to test the stability
of manufacturing configurations over time. They were able to demonstrate that the existing
manufacturing configurations did not change over more than a decade, while single companies
showed a certain strategic flexibility, moving often from one configuration to the other over
a relatively short period of time. Recently, this framework was extended to include the newer
manufacturing goals: environmental and social sustainability (Longoni and Cagliano 2015). The
analyses show that consideration of the new priorities translates into an extension of the existing
configurations rather than a relevant change to them, since the new priorities are added to the
existing configurations, according to the best strategic fit.

6 Manufacturing Decisions

Manufacturing objectives are achieved through a pattern of actions that move a set of con-
trol levers within main decision areas. Decisions are generally categorized as structural and
infrastructural (Hayes and Wheelwright 1984). The former are the “brick-and-mortar” decisions about capital investment while the latter decisions deal with softer aspects of manufacturing such as management and organization.

Structural decisions include the design of production capacity and process technology, the selection of the factory type and location, vertical integration, and sourcing decisions. Infrastructural decisions have to do with operational policies, quality assurance, labor and staffing, performance measurement, and the introduction of new products.

The decision categories first suggested by Skinner (1969) were generally confirmed and enriched by subsequent contributions (Hayes and Wheelwright 1984; Buffa 1984; Fine and Hax 1985; Hill 1989). A number of studies empirically validated the conceptual categories proposed by the literature (e.g., Schroeder et al. 1986; Ward et al. 1988).

Most of the literature reported the choice of the manufacturing process as central to the development of manufacturing strategy (e.g., Hayes and Wheelwright 1984; Hill 1989) and that the other choices should be considered as part of process choice. In general, earlier studies placed a greater emphasis on structural decisions, according to a “static” view of manufacturing operations, where investments were the key strategic decisions.

The emergence of the new ideas about both corporate and manufacturing strategy asserted the importance, and even the centrality, of the infrastructural aspects of manufacturing strategy. Most authors underline the strong cumulative effect of infrastructural decisions, which determine the irreversibility of choices and their impact in the long run, due to path dependency (Hayes and Pisano 1996). The integration of structural and infrastructural choices was considered essential in order to build competitive advantage (e.g., Berry and Hill 1992; Misterek et al. 1992; Kinnie and Staughton 1991).

6.1 Manufacturing Decisions from a Contingency Perspective

Manufacturing choices are generally made in a contingent perspective, that is, choices are aligned to the business environment and the business strategy (external consistency or fit) and are internally coherent, that is, coherent within the manufacturing function and across functions in the company (internal consistency or fit) (Hayes and Wheelwright 1984).

Early examples of studies addressing external fit are Miller and Roth (1994) and Kotha and Orne (1989), which highlighted suitable strategies to fit business requirements and the external environment. Ward and colleagues empirically tested the links between the external environment, the competitive strategy, and manufacturing strategy (Ward et al. 1996; Ward and Duray 2000). Finally, after reviewing OM studies using a contingency approach, Sousa and Voss (2008) underline not only its importance, but also its limitations, and suggest a way forward for this type of research.

6.2 Manufacturing Improvement Programs and Best Practices

Internal fit between the elements of manufacturing is dependent upon the complex interactions of a wide range of interdependent variables that are at play when dealing with the main structural and infrastructural decisions. The challenge of internal coherence between manufacturing choices is often faced by proposing configurations of structural and infrastructural decisions that fit specific environments and strategic tasks, such as manufacturing improvement programs or manufacturing best practices.

Although the traditional framework, based on structural and infrastructural decisions is conceptually powerful, few studies have explored it empirically. Rather, manufacturing strategy content was explored in terms of best practices, or “ready-to-wear” strategic action programs. As Kim
and Arnold (1996, p. 46) pointed out, “manufacturing executives are continuously looking at improvement programmes as the place where manufacturing strategy should be operationalized”.

The best practice approach derives from the evidence that best practice leads to better operating performance (e.g., Hanson and Voss 1993; Voss 1995; Voss et al. 1997; Flynn et al. 1999; Laugen et al. 2005). Their popularity is explained by their accessibility and their *a priori* solution to the problem of internal consistency. As noted by Mills et al. (1995, p. 24), best practices, “can be considered as bundles of actions in certain majority view decision areas, which tend to work well together”.

The literature reports a vast number of best practices. To the original list of programs implemented by Japanese firms, other actions were included over time for empirical exploration, including: concurrent/simultaneous engineering (e.g., Womack et al. 1990; Aggarwal 1995; Ahmed 1996); continuous improvement (Hayes et al. 1988; Harrison 1998; Garver 2003); advanced manufacturing technologies (e.g., Schonberger 1986; Gunn 1987; Hayes et al. 1988; Ettlie 1988; Giffi et al. 1990; Aggarwal 1995; Bates and Flynn 1996); and human resource management and organization (e.g., Schonberger 1986; Gunn 1987; Hayes et al. 1988; Ettlie 1988; Womack et al. 1990; Giffi et al. 1990; Bates and Flynn 1996). The most recent additions to the list involve the most advanced technologies (e.g., human centered automation, digital technologies, 3D printing, high precision technologies), and environmental (e.g., Sarkis 1998; Klassen and Whybark 1999; Kleindorfer et al. 2005) and social sustainability programs (Veleva and Ellenbecker 2001; Das et al. 2008).

The best practice approach has been widely debated. First of all, it may hamper the ability of managers to understand and design their own strategy aimed at building distinctive competitive advantage. Often programs are thought of as a panacea or cure-all for virtually all company problems. Instead, best practices should be tailored to the specific context and situation of a company, and incorporated into a coherent strategic framework rather than being seen as fixed recipes for the improvement of manufacturing (Mills et al. 1995).

The selection and adoption of manufacturing improvement programs should be oriented to build long-term capabilities from a strategic perspective (Hayes and Pisano 1994; 1996; Wheelwright and Bowen 1996). In this view, some authors discuss the complementarities between the best practice and the strategic choice approaches. Voss (1995) suggests that these two approaches should be used together in order to fully exploit manufacturing strategy development. Miller and Hayslip (1989) contend that strategic planning (i.e., decisions on structure and infrastructure) is the exclusive province of top management while improvement programs arise from the operating levels.

### 7 Manufacturing Strategy and the Evolution of Technology

Manufacturing strategy has always been strictly connected with the evolution of manufacturing technology and its adoption. Probably the most famous historical example is the case of the Ford Motor Company at the beginning of the 20th century. In order to make its Model T affordable to a large number of customers, Henry Ford designed a production system that was capable of producing many more cars at a much lower unit cost compared to competitors. In the company’s factory at Highland Park, Ford developed the concepts of production mechanization and the assembly line. Combined with product standardization and work specialization, this gave birth to the concept of mass production (Chandler 1977).

Since the early days indeed, production technology has been considered a key dimension in the design of manufacturing systems that should be aligned with the manufacturing goals of the company and with the other structural and infrastructural decisions (see Section 6).
7.1 Automation

In the 1950s, production technology evolved into automation, the substitution of machines for manual work to pursue two fundamental goals: increasing productivity by reducing cycle time and improving quality by ensuring identical repetition of operations. Automation was associated with high production volumes, which justified the required investments since they allowed a shorter payback.

The evolution of technology clearly impacted products significantly, but for a given product technology, the choice of the process technology is associated with the manufacturing strategy, that is, with the strategic goals pursued by the company. Process automation was therefore associated with high volumes of low cost, standard products; and manual processing was associated with low volumes of high cost, customized products. Hayes and Wheelwright (1979) synthesized this concept very well in their well-known product-process matrix.

7.2 The Role of Information Technology

With the development of electronics, information technology (IT), and computers, manufacturing technology has changed significantly. The fundamental role of IT has been to change the way machines are programmed and controlled, allowing the development of concepts such as numeric control, computer aided design and manufacturing (CAD/CAM), material requirements planning (MRP), and many other systems. Information technology thus allowed the integration of multiple machines. This created interconnected production systems that could be better programmed and controlled, thus giving birth to the concept of Computer Integrated Manufacturing (CIM) (Gerwin 1982; Parthasharty and Yin 1996). Many authors, such as Rosenthal (1984), Beatty (1992), and Boyer et al. (1997), adopted the term “Advanced Manufacturing Technologies” (AMT) as a general concept representing the combination of mechanical and electronic manufacturing technologies.

7.3 Flexible Technologies

IT enabled a new strategic orientation towards automation: the quest for flexibility (Gerwin 1993). Essentially, computerized manufacturing was seen as a possible way to “escape” from the traditional concept of automation as a synonym for rigid, dedicated systems. Concepts such as Flexible Manufacturing Systems (FMSs) were introduced, emphasizing the ability to adapt to different products, with lower adjustment costs and set-up times (Nemetz and Fry 1988; Babbar and Rai 1990).

Despite claims of their flexibility, such systems failed at first to provide the promised benefits and to meet the challenges of increasingly fast, volatile, and changing products and markets, thus often resulting in systems with worse performance than those less integrated and automated (Meredith 1987; Boer et al. 1990).

The Toyota Production System was an alternative approach to automation and flexibility, combining automation with human work (“automation with a human touch”), instead of aiming at completely substituting machines for people. In this way, technology could enhance productivity while still allowing the flexibility inherent to human activities (Shingo and Dillon 1989).

7.4 Digital Technologies

Towards the end of the century, the role of technology in manufacturing evolved further, introducing the possibility of monitoring processes in real time, at first adopting tools such as barcodes,
subsequently Radio Frequency Identification (RFID) and now the more general approach of the Internet of Things (IoT) (Huang et al. 2012; Wong et al. 2014; Meyer et al. 2011). At first monitoring was focused on tracking and tracing materials, parts, and products throughout the process, in order to control the progress of activities. More recently, the adoption of advanced sensors, capable of measuring size, shape, temperature, speed, etc., and connected through wired or wireless networks, allows comprehensive control of the entire process.

From a strategic perspective, these recent developments are in line with the pursuit of both quality, embedded in the process and controlled at the source, and responsiveness (i.e., the ability to respond to an increasingly unpredictable demand), by enabling the real-time visibility of flows and stocks. These technologies allow self-adjustment and self-optimization by machines, as well as a shift from reactive to predictive maintenance. This, therefore, affects the role of personnel, who can now monitor machines remotely and are required to develop new advanced skills in order to perform complex, decision-making tasks.

### 7.5 New Technologies

Green Technologies and Additive Manufacturing are the most recent developments that are expected to significantly modify the manufacturing processes.

With the increasing attention on environmental issues, the adoption of energy efficient and green technologies has become a priority for manufacturing strategy, in order to improve environmental sustainability as well as reducing energy costs (Dangayach and Deshmukh 2001; Chatha and Butt 2015).

Additive manufacturing (known as 3D printing), is expected to disrupt the conventional production models (Eyers and Potter 2015). This approach to production is based on adding layers of materials so as to obtain the desired product, on demand and in a short time, thus enabling distributed, flexible, and customized manufacturing. At the moment, additive manufacturing is mostly used for prototypes and very small production lots and is not yet a real alternative for large-scale production; however, it is indeed well suited to enable strategies oriented towards customization, leading to the so-called factory on demand (Noori and Lee, 2002), although this still has to demonstrate its potential.

We can conclude that the relationship between manufacturing strategy and technological evolution has always been strong and is still providing new and interesting challenges for both research and practice, opening the way to new developments.

### 8 Global Manufacturing Strategies

Manufacturing strategy research has today broadened its scope to consider multi-plant organizations, located in either one or multiple countries (often referred to as offshoring), and increasingly sourcing and selling internationally.

Given the focus of this chapter on manufacturing strategy, we will now examine decisions related to the location and management of production facilities, with direct (full or partial) ownership. We will not consider sourcing and distribution decisions, however, which are generally considered as part of a broader global supply chain strategy.

#### 8.1 Enablers and Drivers

This phenomenon was possible thanks to a variety of enabling factors: the reduction or elimination of both trade and investment barriers, the development of emerging economies and
their opening to international trade and investments, the improvement in transportation and communication infrastructures, and the enlargement of international trade agreements and organizations.

In addition to these enabling factors, other strategic drivers fostered the phenomenon, as theorized by Buckley and Casson (1976): the very different costs of labor, materials, and energy in different countries and continents encouraged the shift of production activities to low-cost countries (an efficiency-seeking strategy). In other cases, the opening and fast growth of vast new markets, with increasing income, in contrast to the slowing of mature markets, encouraged companies, not only to sell, but also to produce locally in order to quickly reach their target markets and to avoid logistics and customs costs (a market-seeking strategy). A third driver for moving production activities was the availability of scarce resources, which could be financial, material, or human, and in particular, high-skilled labor (a resource-seeking strategy). Finally, a fourth driver could be described as the search for complementary assets, capabilities, or products (strategic asset-seeking strategy).

8.2 Plant Location

It is therefore clear, as proposed since the early frameworks used in the field (see Section 6), that plant location is one of the key decisions in the definition of the manufacturing strategy. The models that can support companies in such decisions have been carefully investigated by several authors, often combining multiple variables. A major stream of research (e.g., Schmenner 1979; Aikens 1985; DuBois et al. 1993) proposed a “total cost” perspective, combining the multiple cost elements involved in manufacturing (production, transportation, custom duties, taxes, etc.).

A challenge arising from the internationalization of manufacturing is connected to national cultures, which affect the way and the effectiveness of transferring managerial and production methods. A well-known and much-studied case was the transfer of the Japanese production model to US plants, as shown by Schonberger (1982) and Liker et al. (1999). The study of the role of culture in designing and managing international manufacturing operations was, and still is, a relevant and promising research direction (Pagell et al. 2005).

8.3 Manufacturing Networks

Today many companies operate multiple plants, often in different countries, and therefore a network perspective is needed, considering the configuration of the network, the role of each plant, and the relationships among them.

Ferdows (1997), in his seminal work subsequently tested and extended by Vereecke and Van Dierendonck (2002) and Vereecke et al. (2006), conceptualized the role of the plant as a combination of two dimensions: the strategic reason for establishing a factory in a specific country (location advantage—as discussed above) and the site competence, which can range from being a simple production center, with no design or engineering responsibility, to being a center of excellence for the whole company. The combination of the two dimensions leads to the identification of six possible roles for each plant, which have to be defined consistently with the overall manufacturing network strategy of the company.

DuBois et al. (1993) proposed a framework for manufacturing network strategy that combines competitive priorities, manufacturing performance goals, market orientation, experience, and product characteristics. Shi and Gregory (1998) proposed a map of international manufacturing network configurations based on the level of geographic dispersion and coordination between international manufacturing operations, identifying the required strategic capabilities.
Rudberg and Olhager (2003) proposed a combined analysis of manufacturing networks and supply chains from an operations strategy perspective, analyzing coordination approaches according to the number of facilities and the level of vertical integration. Miltenburg (2009) proposed a definition consisting of six objects: generic international strategies, manufacturing networks, network manufacturing output, network levers, network capability, and factory types.

### 8.4 Recent Trends

Recently, a new research trend has emerged that focuses on the relocation of manufacturing operations around the world, as a consequence of changing factors and drivers at a global level, as well as new strategic orientations. Terms such as “reshoring/backshoring” (i.e., bringing back manufacturing operations in western countries) or “nearshoring” (i.e., moving manufacturing operations closer to the home country) have become popular in both research and practice (e.g., Kinkel and Maloca 2009; Kinkel 2012; Ellram et al. 2013; Gray et al. 2013). There has been strong emphasis on these topics, given their potential impact on the employment and the economy in mature countries, but whether this is a real and relevant phenomenon, or just political “hype,” still has to be demonstrated.

### 9 How to Research Manufacturing Strategy

Manufacturing strategy was investigated over the decades using multiple methods, as reported in the various literature reviews published on the subject (Dangayach and Deshmukh 2001; Chatha and Butt 2015), including both conceptual and empirical papers, and both qualitative and quantitative methods, therefore exploiting the strengths of each method and compensating for their weaknesses.

Conceptual papers were very useful at the initial stages of research to define fundamental concepts and to formulate new theory to be subsequently tested by means of empirical studies. Today, conceptual papers are still a valid option with which to propose new theoretical developments, without neglecting the vast amount of literature already published. Conceptual papers today should be based on a sound theoretical basis, maybe combining different streams of research, even borrowing from other disciplines, to propose new directions and research propositions.

Empirical methodologies were adopted in the past with both an exploratory/descriptive purpose, as well as an explanatory/interpretative aim. Qualitative methods, such as case studies, have been very useful in the theory-building phase, allowing the analysis of complex phenomena and relationships between multiple variables, of different natures. They often allow the formulation of new models and research propositions. Quantitative methods, such as cross-sectional surveys on large samples, contributed most to the theory-testing phase, allowing hypotheses testing and the generalization of results.

Today, purely exploratory/descriptive studies may only be used to analyze very new and emerging phenomena, where for more consolidated phenomena, explanatory and theory-testing methods are required.

### 9.1 Large-Scale Surveys

A very important stream of research on manufacturing strategy is based on large-scale, multi-country surveys, thanks to the joint efforts of researchers from different universities, which allowed the gathering of very broad sets of data, with a very international perspective, in some cases also allowing longitudinal analyses thanks to the iteration of the survey over time.
The most important projects of this kind are:

- The Manufacturing Futures Project Survey (Miller 1982; De Meyer et al. 1989)
- World Class Manufacturing (subsequently renamed High Performance Manufacturing) (Flynn et al. 1997; Schroeder and Flynn 2001)

9.2 Limitations and Future Developments

Some authors have devoted their attention to reviewing the methodology adopted in researching manufacturing strategy and suggesting directions for improvement (Boyer and Pagell 2000; Barnes 2001). Some methodological limitations emerge. These limitations may be useful directions for future development. One limitation is the difficulty of conducting longitudinal studies. This is due to the lengthy data collection process from cause to effect. It is essential to be able to track the adoption of a specific manufacturing strategy, and then to be able to observe how it evolves over time while measuring results. A second limitation is the small number of papers adopting multiple methods, thus compensating their strengths and weaknesses, although this is also difficult to include in a single paper given the usual space limitations (and the effort required to conduct data collection). A third limitation is the small number of surveys addressing multiple respondents, which is also a challenging task, but may provide richer and more robust data. A fourth limitation is reliance on a single source of data, where the combination of multiple sources (e.g., both primary and secondary data) may enable triangulation and greater reliability.

10 New Challenges for Manufacturing Strategy

We now summarize the current and future challenges for manufacturing strategy, including those already mentioned in the previous pages, as well as some additions, to support young scholars in focusing their research efforts.

Our first challenge looks at flexibility, agility, and ambidexterity. We have already discussed the concepts of flexibility and agility (Gunasekaran 1998; Sharifi and Zhang 1999). More recently, however, a new challenge has emerged: the need to be simultaneously flexible and highly efficient. Borrowing a concept from the strategic management literature, the term “ambidexterity” has been used, referring to the ability to combine both the exploitation of current existing capabilities and the exploration of new ones (March 1991; Patel et al. 2012). It is still necessary to understand how firms can combine these two traditionally antithetical objectives.

Next is the servitization of a manufacturing/sharing economy. Servitization means that users are no longer owners of the product. While this business model is already quite common in business-to-business contexts, more recently it has also spread in consumer markets, thanks to the so-called sharing economy. One example is in the form of car sharing or bike sharing (users pick up cars or bikes that are available around the city for short-term rental, and drop them off where they want). The way this phenomenon affects manufacturing strategy, the way products are designed and produced, however, is still worth further exploration (Neely 2008; Baines et al. 2009a; Baines et al. 2009b).

The third challenge is sustainability (closed loop, circular economy, remanufacturing, cradle to cradle, etc.). This fundamental concept within the sustainability domain is the reduction of waste
and the re-use, re-cycling, or re-manufacturing of products, thus creating closed-loop supply chains or, more in general, circular economy models. To make this happen, however, multiple enabling factors are needed, such as reverse logistic networks and economic incentives, but also an appropriate manufacturing strategy, starting from product and process design (Jayaraman et al. 1999; Östlin et al. 2008; Kumar and Putnam 2008; Zhu et al. 2011).

Next, we look at the changing nature of work. Challenges such as the aging of the population, the massive employment of millennials with their peculiar needs and competencies (native–digital), the globalization of the workforce as a consequence of the immigration flows, etc. are some of the many forces requiring a rethinking of the way work is designed and organized (e.g., Gratton 2011). At the same time, the evolution of manufacturing technology is continuously placing a number of challenges—but also opportunities—in front of workers, in terms of involvement, contribution, motivation, but also work intensity, strain, safety, and eventually well-being. The relationship between manufacturing strategy choices and work organization cannot be neglected in future research (Brown 1996; Askenazy 2001; Longoni et al. 2013; Longoni et al. 2014; Lampela et al. 2015).

Additive manufacturing/3D printing and virtual manufacturing are new forms of technology that also serve as challenges to marketing. These new technologies could enable and enhance the potential of the “old” idea of virtual manufacturing as a distributed set of independent organizations, collaborating on demand to deliver a customized product to the customer (Martinez et al. 2001; Noori and Lee 2002; Zhang et al. 2014; Eyers and Potter 2015). Will additive manufacturing make it happen for real?

Digitalization (the Internet of Things, big data analytics, etc.), our next challenge, is the development of digital technologies and their spread on the shop floor, as well as across all company functions, has opened new opportunities for manufacturing. The latest opportunities now include the possibility to monitor progress and performance in real time, thus collecting a huge amount of data and enabling self-optimizing and self-improving systems, thanks to new algorithms and computational power. The way this phenomenon will affect manufacturing strategies is still open to question (Zhong et al. 2015; Opresnik and Taisch 2015).

As already mentioned in Section 8, reshoring/backshoring/nearshoring as a phenomenon is still worth further investigation in order to understand its real potential and sustainability, as well as developing appropriate and consistent manufacturing strategies (Kinkel and Maloca 2009; Kinkel 2012; Ellram et al. 2013; Gray et al. 2013). The contribution of this phenomenon to regain competitiveness in the manufacturing industries of developed economies is a very important matter for study.

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