

# Chapter 1

## The Evolution of Manufacturing Systems: From Craftsmanship to the Era of Customisation

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### ABSTRACT

*The transition from local economies to the global competitive landscape and the current fluctuating customer demands drives a never-ending transformation of manufacturing systems. In combination with prominent technological advances and other socio-political reasons of each era, such changes led to the evolution of manufacturing paradigms systems from craftsmanship to automation and decentralisation. This transition created the necessity for new means of designing, planning, and controlling manufacturing companies and networks. In production early stages, manufacturing was viewed as a functional area. On the other hand, current production paradigms are based on the customer focus and view manufacturing as an enterprise. This major diversification led to the gradual reorganisation of manufacturing systems in order to achieve mass customisation of typically mass-produced products. The purpose of this chapter is to specify the evolution of manufacturing paradigms, their basic principles, and the links among them. A discussion on future trends of manufacturing paradigms derives from the review and is finally presented.*

### INTRODUCTION

Manufacturing is among the key driving forces of any modern economy. Specifically, in Europe, in 2010, 34 million people were employed in the EU-27 manufacturing sector, representing 15.9% of the total employment. Indirectly (with related

sectors and activities), manufacturing accounts for close to 50% of the European economy (Eurostat, 2011).

During the last decades, local economies have evolved into global and highly competitive players. Industries started to operate on an intercontinental basis, expanding the limits of their business. The

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export of finished goods to foreign markets has been the dominant theme in the international trade up to the 1990s, and gained even more attention the last decade. Moreover, location-specific factors such as low-cost labour and highly-skilled personnel enabled the rapid globalisation. Enterprises started to seek fertile production environments into developing or developed countries (Abele et al., 2006). In addition, the advent of the Internet and the increasing computational power led to the development of virtual entities (Chryssolouris, 2005) and transformed competition and collaboration practices (Lazonick, 1991 and Mourtzis, 2011).

Historically, manufacturing paradigms, driven by the change of the environment in which they operate, change in character and evolve in patterns over time. The various patterns witnessed up to now can be roughly correlated to movements between three stages: (i) craft shops that employ skilled artisans, (ii) long-linked industrial systems using rigid automation and (iii) post-industrial enterprises characterised by flexible resources and information intensive intellectual work (Gunasekaran and Ngai, 2012).

## **METHODOLOGY OF THIS REVIEW CHAPTER**

For the preparation of this review chapter, a search was performed between for academic journals, articles and books primarily in the Scopus and Google Scholar databases using as main keywords the fields of interest. These keywords include: production paradigm, evolution, craft production, mass production, lean production, just in time, Kanban, mass customization/customisation, additive manufacturing, sustainable production, rapid manufacturing, personalized/personalised production, personalization/personalization, global manufacturing networks, cluster concepts and agile manufacturing.

This literature review considered a number of constraining criteria. The first one was the time span of the journals or articles, which was set from

1985 to 2013, with only minor notable exceptions. This constraint was not considered for books. In Scopus, additional limitations were imposed. Journals from the scientific areas of: materials of science, chemistry, chemical engineering science, physics, astronomy, agricultural sciences, earth and planet sciences, medicine, toxicology, biological sciences and other referring to health professions were excluded from the results. Sciences that were included were: engineering, management, business, economic, mathematic and environmental.

## **STRUCTURE OF THE CHAPTER**

The rest of the chapter is structured in the following way. Section 2 contains the evolution of manufacturing systems from the era prior to the Industrial Revolution up to currently dominant paradigms of mass customisation and personalisation. Section 3 includes a comparison of the different manufacturing paradigms based on the technologies used in each one, economic perspectives and criteria of social nature, such as the consideration of the human factor. Section 4 concludes the chapter and outlines future directions for manufacturing paradigms.

## **EVOLUTION OF MANUFACTURING PARADIGMS**

The manufacturing industry, since its birth two centuries ago, has evolved through a number of paradigms. The most prevailing manufacturing paradigms that characterised significant periods of time are chronologically: Craft Production, American Production, Mass Production, Lean Production, Mass Customisation and Global Manufacturing. Each paradigm had its time-span, was supported by a specific type of manufacturing system and operated based on specific business model (Table 1).

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