



## A perspective on manufacturing strategy: Produce more with less

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### ABSTRACT

Over the last decade, the manufacturing landscape has changed worldwide. Parts of the traditional manufacturing activities have moved to world regions, away from the long-established industrial centres in Western Europe, North America and Japan. The demand for goods has been increased and so has the demand for natural resources and energy. However, since resources and energy are finite, new ways of producing more with less ought to be found. In this context, this work discusses the challenges to be addressed and focuses on the technologies, related to novel processes, materials and information/communication, which could deal with the issues pertaining to increased demand on manufacturing goods, the finite resources, and environment-conscious production.

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### 1. Introduction

Manufacturing is global. In fact, international business activity is not a recent phenomenon. It can be traced as far back as the late 19th century when the onset of the industrial revolution resulted in the need for large-scale operations. Over the years, the nature of these operations has changed significantly [1]. The changes can be attributed mainly to the variations at the level of trade barriers and the development of more efficient modes of transportation and communication that have made possible a higher level of coordination. Moreover, during the last few decades the level of innovation has dramatically grown to such an extent that, in order for firms to be familiar with the best products, processes, materials and technologies, they must have access to international operations in all three major industrial centres of the Triad: Western Europe, North America, and Japan as well as the Far East countries.

In 2002, the share of total global manufacturing trade was 18% for the European Union, while the US had 12% and Japan 8%. However, besides the main regions, which have been traditionally active in the manufacturing world, today, there are a lot of other spots all over the globe that significant manufacturing activities take place.

Global manufacturing addresses today a constantly increasing demand for consumer goods. Although consumption patterns may slightly vary from one world region to another, driven by local

cultural, societal and economic factors, the average global consumption expenditure keeps increasing as living standards grow. In order for this trend to be addressed, production of goods is on the increase worldwide. Statistics show that this applies not only to high-tech goods, e.g. computers, but also to goods with long tradition in everyday life use, e.g. bicycles (Fig. 1) [32].

### 2. Environmental facts and challenges

As more goods are produced, human demands on nature increase accordingly, having a great impact on the global environment. A number of analysis methods have been suggested to measure the impact of these demands on the environment.

Life Cycle Assessment (LCA) is one of the most well-known analysis methods. LCA is the assessment of the environmental impact of a given product or service throughout its lifespan. The goal of LCA is to compare the environmental performance of products and services as well as to be able to choose the least burdensome one. The term 'life cycle' refers to the notion that a fair, holistic assessment requires the assessment of raw material production, manufacture, distribution, use and disposal, including all intervening transportation steps. A number of ISO standards are available today so as to consolidate procedures and methods of LCA.

The Ecological Footprint (EF) has been another analysis method suggested in the early 1990s. EF is considered as a means of comparing human demand on nature, against the biosphere's ability to regenerate resources and provide services. It does this by assessing the biologically productive land and marine area,

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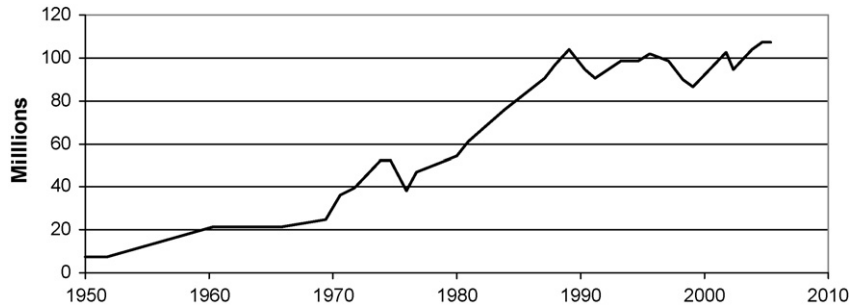


Fig. 1. World bicycle production 1950–2003. Source: Compiled by Earth Policy Institute from Worldwatch Institute.

required to produce the resources a population consumes and to absorb the corresponding waste, using a prevailing technology.

Despite the increased concern on environmental issues worldwide that has dictated the use of such methods in order to monitor the environmental impact of human activities including manufacturing, the situation today seems to be rather alarming.

### 2.1. Material reserves and outlook

The consumption of raw materials, already from the industrial revolution time, has been on constant increase worldwide. Available data, recorded and analyzed, mainly during the last 50–60 years, widely prove this fact for a number of materials being critical for manufacturing activities, such as steel, aluminum, copper, nickel, zinc, wood, etc. As far as steel is concerned, consumption per capita has been increased between 1950 and 2004 by 241%. The constant increase is also verified by the recent data, showing an average growth rate of 6% in the production of crude steel between 2000 and 2005 (Fig. 2) [36]. The situation is more or less similar when it comes to other critical raw materials. The primary production of aluminum, for example, has been increased between 1950 and 2004 by 386% [2].

The emergence of China as a major manufacturing region in the early 2000s had a great additive impact on this increasing demand for raw materials (Fig. 3) [29]. China has become a new major

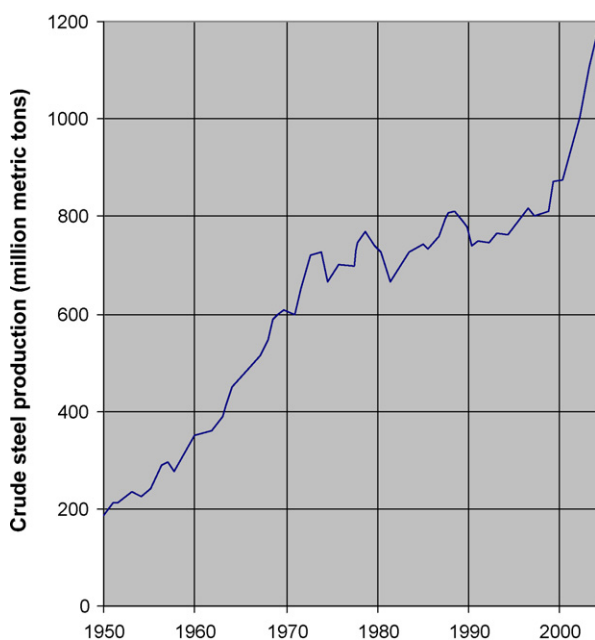


Fig. 2. Crude steel production. Source: International Iron and Steel Institute, 2006.

player in the global manufacturing environment and the trends show that it can bring the demand for critical raw materials to new unknown levels.

The consumption trend for raw materials had a major impact on their price as well. Due to the finite reserves available and consequently to the limited offer, the prices of the major raw materials have been increased. Available data on steel show for example, that the minimum price of hot-rolled coil has almost doubled between 1982 and 2005 (Fig. 4) [36]. Although prices are significantly affected by other economic and political factors as well, the long-term trend of prices is clearly imposed by offer and demand.

### 2.2. Energy issues

Energy is today the key to economic growth, and in turn, fossil fuels are still the key to energy production worldwide. Oil is one of the most important fossil fuels with respect to its use in transport and industry. It is compact and cheap, while huge investments and networks are available around the world for its production and transportation. Historic data show a massive growth in the world's consumption of oil, having been doubled in about 30 years (Fig. 5) [27]. Falls and plateaus tend to be caused by recessions, as in the 1970s and 1980s, rather than a change in consumption trends. The change between 2004 and 2005 was a 1.3% rise, i.e. an extra 370 million barrels.

Similar to all commodities and fossil fuels, oil reserves are of finite capacity. Until 1980, the oil reserves discovered had been, in principle, more than the overall quantity consumed. Since then, the trend has gone into negative and the oil reserves discovered do not cover the increased consumption (Fig. 6) [33]. As discovery is expected to continue falling and consumption rising, this situation can only get worse. At the end of 2006, the proven oil reserves were estimated to be 1208.2 thousand million barrels, while the “reserves/production” ratio was estimated to be equal to 40.5.

Due to the finite capacity of oil reserves and the increase in consumption, oil prices keep increasing (Fig. 7) [27]. The rise in the 1970s was sharp, jumping in 1-year leaps, due to the political nature of events. The present rise is more of a geometric curve, suggesting a different underlying cause.

The situation is similar when it comes to other critical fossil fuels. As far as coal is concerned, for example, the global consumption rose by 4.5% in 2006, compared with a 10-year average of 2.8%. Following this trend of increasing demand, the coal price (Northwest Europe marker price) has more than doubled over the last 20 years.

Under these circumstances, an increased interest in alternative energy sources has been raised during the last decades. Despite the relevant discussions and studies though, the world still relies heavily on fossil fuels for energy production (Fig. 8) [28].

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