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A sustainability assessment system for Chinese iron and steel firms

Yunguang Long [a], Jieyi Pan [a], Sami Farooq [b,*], Harry Boer [b]

[a] School of Management, Northwestern Polytechnical University, 127 West Youyi Road, Xi'an Shaanxi 710072, PR China
[b] Center for Industrial Production, Aalborg University, Fibigerstræde 10, 9220 Aalborg Ø, Denmark

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ABSTRACT

The environmental impact of the Chinese iron and steel industry is huge due to its high consumption of ore, coal and energy, and water and air pollution. It is important not only for China but also for the rest of the world that the Chinese iron and steel industry becomes more sustainable. A sustainable assessment indicator system is an important tool to support that development. Currently, however, a sustainable assessment system, specifically designed to match the characteristics of Chinese iron and steel firms, is not available. In this paper such a system is proposed and evaluated using data from financial and sustainability reports of four leading Chinese iron and steel firms. The proposed sustainable assessment system is envisaged to help Chinese iron and steel firms to objectively investigate their sustainability performance, provide clear and effective information to decision makers, and support the Chinese iron and steel firms' sustainable development.

1. Introduction and research background

China is undergoing accelerated industrialization and urbanization, in which the iron and steel (IS) industry plays a fundamental role. IS products are mostly used in the construction and industrial manufacturing sectors, which are the main driving forces of the Chinese economy (Geng and Doberstein, 2008; Xu et al., 2008; Zhang et al., 2013).

China has been the world's largest crude steel producer for 18 continuous years since 1996. The average annual growth rate of crude steel production was over 13% between 1996 and 2013 (Fig. 1). In 2013, the Chinese IS industry produced (WSA, 2014) 779 million tons of crude steel, or 48% of the world's crude steel production. The production of pig iron was nearly as high, 709 million tons, representing 61% of the world's pig iron production. In that year, six Chinese firms were among the world's top ten IS firms (WSA, 2013).

Production of iron and steel is not only important for the development of China, but also unfortunately a source of environmental pollution due to the large consumption of fossil energy and related emissions. In 2010, Chinese IS firms consumed around 461 TWh of electricity and 14,872 PJ of fuel (WSA, 2011; Hasanbeigi et al., 2013; Tian et al., 2013). Coal consumption was 575 million tons, accounting for over 14% of national coal consumption. The corresponding SO_2 and CO_2 emissions were nearly 1.8 million and over 1.2 million tons, which accounted for over 10% and 16% of national SO_2 and CO_2 emissions, respectively (Mao et al., 2013). Even though energy efficiency in the Chinese IS industry has improved greatly in recent years, the energy consumption per ton of steel is still 15–20% higher than the international benchmark (Wang et al., 2007; Zhang et al., 2012). In addition, the Chinese ratio of CO_2 to GDP is one of the highest in the world and the Chinese CO_2 emissions accounted for over 25% (about 8 billion tons) of global CO_2 emissions IEA, 2011 (IEA, 2011). Furthermore, the Chinese IS industry accounts for about 14% of the national total water and gas waste, and for 6% of the total volume of solid waste materials generated (He et al., 2013). Considering all these facts, the Chinese IS industry has great potential for carbon emission reduction and environmental protection. Furthermore, the Chinese IS industry is hard pressed by domestic and overseas stakeholders to think beyond the economic performance of its manufacturing processes and products and also consider environmental and social effects. This creates a need to develop indicators allowing IS companies to assess their sustainability performance, identify “hot spots”, support sustainability reporting, increase stakeholder engagement (Azapagic, 2004) and guide firms to formulate a sustainable development strategy.

Interest in sustainability assessment (SA) is also increasing among academics (Labuschagne et al., 2005; Singh et al., 2012; Joung et al., 2013; Samuel et al., 2013; Schrettle et al., 2014).

* Corresponding author. Tel.: +45 9940 7119.
E-mail address: sami@business.aau.dk (S. Farooq).

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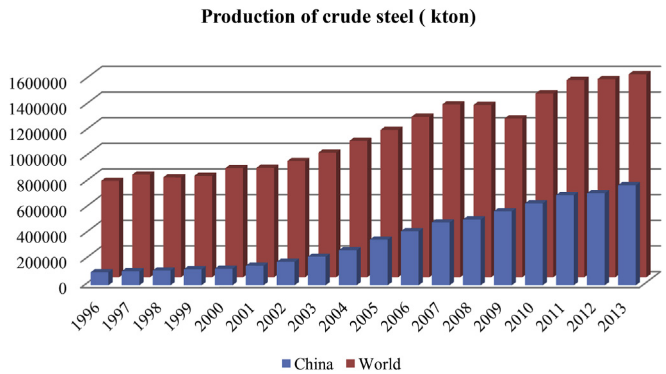

Fig. 1. Comparison of crude steel production between China and the world (based on World Steel Association figures).

However, sustainability research focusing specifically on the IS industry is scarce; only few studies can be found. Strezov et al. (2013), for example, assessed the sustainability indicators of the three major IS technologies, the blast furnace, the electric arc furnace and direct reduced iron. Fruehan (2009) defined sustainable steelmaking goals. Zhang et al. (2012) investigated the practices, determinants and effects of CO_2 emission reduction within the Chinese IS industry. Anane et al. (2012) added the social dimension of industrial development and tested a preliminary set of indicators across different molten steel production processes. Zhang et al. (2009) used eMergy synthesis and other methods to evaluate the emission impact of Chinese IS industry between 1998 and 2004.

In summary, there is no hiding from the fact that the Chinese IS industry is a major player in terms of production and energy consumption at national as well as international level. Awareness of sustainability is growing fast, in China just as in the rest of the world. In order to support firms in their attempts to increase the sustainability of their operations, SA indicators are needed. There is limited research on sustainability aspects of the Chinese IS industry and no comprehensive set of SA indicators for Chinese IS firms. The objective of this paper is to explore this gap and develop and evaluate a comprehensive SA system for the Chinese IS industry.

The paper is organized as follows. In Section 2, the concept of sustainability is introduced in terms of the "triple bottom line", followed by a review of existing SA systems. Based on that review, an SA system geared towards the Chinese IS industry is proposed in Section 3. The research method used to evaluate that system is accounted for in Section 4. Results from applying the system in four Chinese IS firms are reported in Section 5. After an evaluation of the system in Section 6, the paper is summarized and concluded in Section 7.

2. Literature review

2.1. The concept of sustainability and the "triple bottom line"

In 1987, the World Commission on Environment and Development (WCED, 1987, p. 43) described sustainability as a "development that meets the needs of the present without compromising the ability of future generations to meet their needs". Since then, many researchers have interpreted and translated this macro-level definition into micro-level definitions from different angles, such as for example business sustainability, which can be defined as "adopting business strategies and activities that meet the needs of the enterprise and its stakeholders today while protecting, sustaining and enhancing the human and natural resources that will be needed in the future" (IISD, 1992, p. 116; see also e.g. Labuschagne et al., 2005).

The most widely recognized and adopted sustainability concept, the "triple bottom line", was developed by Elkington (1994). This concept distinguishes and proposes a balanced approach towards economic, environmental and social aspects of business performance (Gimenez et al., 2012). The concept has been used and applied extensively in research and increasingly so also in practice. Within the concept, economic sustainability is easily understood, and the recent global economic crisis has shown that maintaining economic growth is still an essential and universally accepted objective for firms and the general public (Moldan et al., 2012). Social sustainability requires that the firm's cohesion with society and its ability to work towards common goals be maintained (Gilbert et al., 1996). The World Bank first proposed the concept of environmental sustainability. Initially, the term "environmentally responsible development" was used; later "environmentally sustainable development" became more popular (Moldan et al., 2012). Today, there are plentiful definitions of environmental sustainability developed from many different perspectives, including economic, managerial and ecological viewpoints.

2.2. A review of sustainability assessment systems

Even if the "triple bottom line" is a relatively mature framework, it still remains difficult to express it in concrete, operational terms (Briassoulis, 2001). Yet, many firms have started to find sustainability assessment (SA) solutions and tools to interpret sustainability (Joung et al., 2013). In the last decade, sustainability reports started to emerge as a new trend in corporate reporting, integrating in one report financial, environmental and social indicators (GRI, 2000, 2002), which can be used to assess the sustainability performance of a firm (Krajnc and Glavič, 2005). An SA system helps translate sustainability issues into, preferably quantifiable, measures of economic, environmental and social performance with the ultimate aim of helping firms to address key sustainability concerns and provide information supporting their sustainable development (Azapagic, 2004).

Today, several SA systems are available to analyze sustainability. Different (sets of) indicators and metrics have been developed covering the various levels of decision making for sustainability (Joung et al., 2013), in particular the operational, organizational, regional/national and global levels (OECD, 2006). Since this paper focuses on individual firms, we briefly present existing operational and organizational level SA systems in Table 1.

Table 2, which summarizes the dimensions covered by the six SA systems presented in Table 1, suggests that all but one system address all three "triple bottom line" performance areas.

However, the systems are either industry specific (e.g. Ford PSI for the automotive industry and IChemE for the process industry) or their focus is towards investors and stakeholders (e.g. DJSI). Furthermore, some systems, such as GRI, have more than 70 indicators, which makes it difficult to identify suitable indicators for a particular industry. In short, the universal applicability of the reviewed SA systems is questionable. However, as argued above, the Chinese IS industry, which is not only the world's largest iron and steel producer but also a major consumer of natural resources and ditto source of environmental pollution, urgently needs a suitable SA system supporting full-scale sustainability evaluation. In the remainder of this paper such a system is proposed and evaluated.

3. Proposed SA indicators for Chinese IS industry

This section proposes SA indicators for the Chinese IS industry. Based on these indicators, an SA system will be developed in this section, and illustrated in Sections 4 and 5 using data from four

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