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Whether Technological Development and progress in Industrial Ecosystem can lead to sustainable Social Development: A Study in the Context of Indian Iron and Steel Industry

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Abstract:

Metal processing technology, especially steel making technology is synonymous with the progress of human civilization in the last two millenniums. The phenomena observed in steel industry of few countries indicated that growth of steel industry which was aided by deployment of new technology, contributed to social value creation that has led to long term social upliftment. However the question remains that, once the industry attains maturity, what happens to social value creation and the long term sustainable social performance ? Data collected from three different firms of Indian iron and steel industry was analysed to understand this phenomena. It is observed that there is a significant relationship between a few variables of flexibility of steel making technology and social contribution rate which represents the social value created by firms in the "Indian Iron and Steel Industry (IISI) in their operational Ecosystem". Also few variables exhibit no significant relationship between the flexibility of steel making technology and social contribution rate. Hence it can't be inferred with certainty that a significant relationship exists between flexibility of technology and social value created by firms. This study can be further extended to develop a deeper understanding between social value creation and flexibility of technology. The outcome of this study can help firms in understanding the impact of their operation on the social Ecosystem in which they operate. Considering the focus of the companies to become responsible corporate citizens, companies can formulate their technology strategy to improve their long term social performance.

Keywords : Technology, Indian Iron and Steel Industry (IISI), Social contribution rate, Long Term Performance

1.1 Introduction

The landscape for firms to carry out business is fast changing due to the risk and opportunities that emerge in the current environment and thus the business environment is fast changing to take care of the social landscape (Kurznack et al., 2021). In addition to that a lot of uncertainties, vulnerabilities, and inequalities have been observed in secondary sectors across all geographies which resulted in the degeneration of the design processes in secondary ecosystems. (Nayak & Hage, 2020). Another layer of the challenge was added to the existing environment due to the recent pandemic along with climate change, social inequalities, demographic change, migration of labour force.

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These are only few examples of the trends that are emerging in the society that companies have to encounter more in future (Bainton & Holcombe, 2018; Kurznack et al., 2021).To adapt to this changing reality companies need to change their operation philosophy in addition to allocation of capital and managing the supply chain. (Aggarwal, 2011; Kurznack et al., 2021)

Under such a situation focusing on short term value creation for shareholders could be detrimental to the interest of the firm in the long run. Though the shareholder-focussed approach of the firms are holding them back in focussing on long term value creation, the short-term approach of shareholder value creation is now being criticized. (Mayer 2018; Schoenmaker & Schramade, 2019; Kurznack et al., 2021). So, companies are now focussing more on value creation for society and the long-term performance (Mayer, 2018). In addition to the pressure from the Ecosystem in which the companies operate and the reporting Framework with respect to sustainability, companies are now focusing on Integrated Reporting which includes reporting on social dimension also (Arena & Azzone , 2010 ; Husgafvel et al., 2014) . Hence the pressure on companies to prove that they are good and responsible corporate citizen is very high (Mayer, 2018).

While firms focus on long term performance for their sustainability, simultaneously firms also try to expand their operations to generate the revenue. To achieve growth and improve the performance, firms deploy new technology. Technology driven growth of firms has been the hall mark of industrialization in last couple of centuries (Basalla, 1989) and even today firms deploy new technology to achieve growth. Technology has been one of the levers of Organization Design and determinant of firm performance in Industrial Ecosystem (Daft 2004; Nayak 2017). Flexibility of technology, a key dimension of technology has been further classified into two parts i.e., Process flexibility and Structural flexibility. (Chen & Chung, 1996 ; Nelson and Ghods 1998).

Iron and Steel Industry is highly energy intensive, emits approximately one third of the Global Industrial CO_2 and accounts for 7% to 11% of the total CO_2 emission. (Ren et al., 2021; Weigel et.al., 2016, Karakaya et al.,2018). Hence it's imperative for Iron and Steel Industry to focus on reducing CO_2 emission to improve the long term performance for their sustainability (Arena & Azzone , 2010 ; Husgafvel et al., 2014). One aspect of Technology, i.e., flexibility, can act as a lever for achieving sustainability of the organization (Boldrini et al., 2024). Although previous studies explored the relationship between flexibility of Technology and long term Economic, Environmental and Social performance of firms, but study on flexibility of technology and its specific impact on social value creation is scarce, more so in the context of Indian Iron and steel industry. So the flexibility of Technology with respect to Indian Iron and Steel Industry offered opportunities to probe what kind of relationship exists between flexibility of technology and long-term social value creation leading to sustainable social performance for the firms.

So to understand this relationship, we postulated to examine the following Research Question (RQ).

How the flexibility of steel making Technology with respect to inputs needed for steelmaking is related to social value creation and long term sustainable Social performance of firms in Indian Iron and Steel Industry ?

This article is organised into four parts. The first section is a general introduction, while the second section focusses on the review of literature. The third section details the research methodology, which includes the data collection method, analysis of the data and discusses the outcome of our research. We conclude our chapter by spelling out the conclusion and scope for further investigation in the fourth section.

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1.2 Literature Review

Geels and Schot (2007) examined the socio-technical transitions using multi-level perspectives. The Sociotechnical regime is an extension of the "technological regime" concept propounded by Nelson and Winter(1977) and later sociologists of technology expanded this horizon and argued that scientists, policy makers, users and special-interest groups also contributed to shaping of technologies, which they called as social construction of technology (Bijker et al., 1985)

Nayak and Hage (2020) saw Technology as one of the variables of Industrial Organization (IO) Design and plays an important role in delivery of sustainable performance by the Organization. Flexibility of technology, a key dimension of technology has been further classified into two parts i.e., Process flexibility and Structural flexibility.The flexibility of the steel making technology has been divided into three parts i.e., Scrap flexibility, Ore flexibility and product flexibility, which have been broadly grouped into two baskets, raw material flexibility and product flexibility (Maddala & Knight , 1967). Flexibility in process technology has been identified as one of the variables for growth of the industry. Raw material flexibility and Product flexibility are the two variables which were crucial for the growth of the steel industry in Pittsburgh of United States of America (Tweedale , 1986). The scale effect of technological change is enhanced through choice and application of appropriate technologies suited to different sizes and scales of firms (Arens et al. 2014; Qin et al. 2019; Ren et al. 2021; Zhang et al. 2018; Weigel et al. 2016; Schumacher et al. 2007). Aleksashin et al. (2007), viewed that due to flexibility of converter technology, this process of steel making could continue for few more decades as the predominant process. Flexibility of process technology to adapt to various scenarios could contribute to the sustainability of the industry, Basic Oxygen Furnace (BOF) Process of steel making is one of the less flexible processes and the future of the steel making technology needed to be more flexible. (Szekely, 1996). Literature on flexibility of steel making technology is not only scarce, but there are also contradictory opinions amongst researchers regarding the flexibility of steel making through Basic Oxygen Furnace route.

Based on their study on Iron and Steel Sector in UK, Griffin and Hammond (2019) assessed that, steel Industry could become a negative carbon emitter by 2050 through adoption of best available negative emission technology. Similarly, water and energy consumption are closely linked to the sustainability of the industry. Gu et al. (2015) studied water foot print in Chinese Iron and Steel Industry and concluded that instead of water consumption per ton of steel, water foot print per ton of steel can be promoted as an indicator. They proposed that reduction in water footprint can result in cleaner production. Karakaya et al. (2018) view that direct reduction technology using hydrogen can achieve zero CO_2 emission by 2045 in Swedish Iron and Steel industry. To increase efficiency, promotion of green technologies and Renewable Energy (RE) aimed at pollution prevention and waste abatement in Iron and Steel production, should be given greater priority (Zhang et al. 2018). Using Analytical Hierarchical Processing (AHP) Method, Singh and Gupta (2017) carried out a social life cycle assessment study with respect to Indian steel sector and concluded that training and skill development, infrastructure, access to education and workplace safety for workers were key areas which required attention.

Adhering to Corporate Social Responsibility (CSR) norms is one of the regulatory/statutory requirement for firms and also through CSR initiatives firms interact with it's stakeholders and the society in and around it's operational location. Udayasankar (2008) explained that similar level enthusiasm is displayed by large and small firms for CSR activity, while medium sized firms show lesser interest in CSR activity. Kroeger & Weber (2014) developed a framework for comparison of social value creation by not-for -profit organizations. For developing the framework they have incorporated the literature on Subjective well-being and theory of organizational effectiveness. Chakrabarty (2020) examined the value creation in Industrial cluster through strategic relationship with stakeholders and policy environment using the relationship theory. He found that the nature of relationship with the stake holder can act as a catalyst or a retardant for value creation depending upon the nature of relationship and the policy environment. Bice (2014) examined the relationship between CSR and Social Impact Assessment (SIA) and found that both shared a common value and suggested that a cultural shift, attitudinal shift and behavioural change can link both CSR and SIA in a much better way. Dendena and Corsi (2015) suggested that the way forward for both Environmental Impact Assessment (EIA) & Social Impact Assessment (SIA) is a combination of both i.e Environmental and Social Impact Assessment (ESIA). Bice (2015) examined the implementation of Corporate Social Responsibility (CSR) through an institutional perspectives in Mining Industry as against the earlier way of looking at CSR only as a Business case. They have selected mining Industry due to the impact of CSR in it's operation. Brueckner et al. (2014) examined the impact of the Social License to Operate (SLO) on the Mining Industry in Western Australia and found that there is a gap in understanding between the community, the Industry and Government about the SLO. Friede et al. (2015) found a positive relationship between Environment Society and Governance (ESG) and profit for an Organization. They have also found that the impact to be stable over a period of time, region and asset class.

A part of the academic literature related to technology focuses on the relationship between technology, firm growth and long term environmental performance (Tweeddale, 1986; Zhang et al., 2018; Weigel et al., 2016). The literature related to steel making technology mostly covers the relationship between attributes of steel making technology, Green House Gas reduction and consumption pattern of water and energy during steel making process. In addition to that, the existing literature related to social aspects covers the CSR and Social value creation and the relationship between CSR and firm performance.

The relationship between flexibility of steel making technology and social value creation is significantly absent in academic literature. Also, research is scarce on the relationship between flexibility of Technology and long term social performance of firms in IISI. The present study has strived to formulate a set of hypotheses based on these gaps in extant literature, to test the relationship between Flexibility of Technology with social value creation leading to long term sustainable performance of the firms in IISI.

1.3 Research Methodology:

1.3.1 : Research Question and Hypotheses :

For long-term value creation, The theoretical framework was based on two frameworks i.e. socio-economic transitions (Loorbach, Frantzeskaki & Avelino 2017; Kurznack et al., 2021) and capability development for sustainability transitions (Kurznack et al., 2021). To explore the relationship between Flexibility Technology and Social value creation leading to long term performance in IISI, we examined the following Research Question (RQ) in line with the capability development framework for sustainability transitions.

How the flexibility of steel making Technology with respect to inputs needed for steelmaking is related to social value creation and long term sustainable Social performance of firms in Indian Iron and Steel Industry ?

The following hypotheses are proposed to be tested to understand the RQ.

HP1.1: *Flexibility in Scrap and water consumption for steel making is positively related to social contribution rate (social value creation).*

Null HP1.1: *Flexibility in Scrap and water consumption for steel making is not related to social contribution rate (social value creation).*

HP1.2: *Flexibility in Scrap and water consumption for steel making is positively related to employee injury rate(Long term social performance).*

Null HP1.2: *Flexibility in Scrap and water consumption for steel making is not related to employee injury rate (Long term social performance)*

1.3.2: Data Collection:

The analysis was done with the help of panel data for three firms in the IISI. The data was collected , for the period from 2008-2023. One of the firm is a public sector steel company, set up by the Government of India after independence. The other firms are from the private sector of the IISI. One of the Steel firms is the oldest steel in the Indian iron and steel industry and the second one is one of the youngest firms set up in the 1990's. The data was collected from the integrated report of both the firms. The collected data is for the period from 2008 to 2023 covering a total duration of fifteen years. . The data collected for the firms is the annual average data presented by firms in their annual report.

1.3.3 : Data Analysis, Discussion and Results:

The equations for both social value creation and long term social performance was estimated by us using multiple regression to identify the relationship between the flexibility of steelmaking technology with respect to the use of input material and the social and performance of firms in the IISI. The collected data were sorted out, arranged and analysed using Eview software. To remove the dissimilarity and bring linearity, data for all the variables were converted into their natural logarithm (Ln).

1.3.3.1 *: Dependent Variable*

Considering the three dimensions of sustainability, variables identified were: carbon dioxide (CO_2) emission; earnings before interest, tax and depreciation (EBITDA); profit after tax (PAT); training (man-hour/employee/year); and corporate social responsibility (CSR) spend, Employee injury rate /Year and Social contribution rate. Since the objective of the study is to understand the relationship between Flexibility Technology and Social value creation leading to long term performance of firms in Indian Iron and Steel Industry, so Social contribution rate/Year was considered as the dependent variable for social value creation and Employee injury rate /Year was considered as the dependent variable for long term social performance.

1.3.3.2 *: Independent Variable*

Consumption of raw materials is an important dimension of steel making technology and also one of the attributes which will define the sustainability of the industry. Flexibility in using raw materials can impact the sustainability of the industry. The use of scrap in the steelmaking process (Scrap consumption/TCS) and specific water consumption (SWC-Water Consumption/TCS), were identified as the independent variables for flexibility of technology.

The proposed equations for the analysis are given below:

Y_1 (Social Contribution Rate/Year) = $\alpha_1 + \beta_1$* Scrap consumption / TCS +β_2* Water consumption / TCS + u_1

Y_2 (Employee injury rate/Year) = $\alpha_2 + \beta_3$* Scrap consumption / TCS +β_4* Water consumption / TCS + u_2

1.3.3.3 : Data Analysis

To enquire about RQ-1 and test the related hypotheses, multiple regression is conducted between the dependent and independent variables, using. E-view software and the output of the regression model is appended below.

Table-1.1: Firm wise Regression Statistics.

Independent Variables →		Scrap Consumption/TCS	Water Consumption/TCS
Dependent Variable ↓	**Firm-I**		
	R2 Value	0.635	0.635
	Slope coefficient	0.012	0.384
	Significance	0.902	0.000
	Collinearity Statistics	1.337	1.337
	Firm-II		
	R2 Value	0.678	0.678
	Slope coefficient	-1.425	6.591
	Significance	0.039	0.000
	Collinearity Statistics	1.838	1.838
Social Contribution Rate	**Firm-_III**		
	R2 Value	0.097	0.097
	Slope coefficient	0.827	1.743
	Significance	0.206	0.019
	Collinearity Statistics	1.919	1.919

Table 1.2 : Firm Wise Regression Statistics.

Independent Variables →		Scrap Consumption/TCS	Water Consumption/TCS
Dependent Variable ↓	**Firm-I**		
	R2 Value	0.281	0.281
	Slope coefficient	-0.977	0.215
	Significance	0.003	0.146
	Collinearity Statistics	1.337	1.337
	Firm-II		
	R2 Value	0.593	0.593
	Slope coefficient	-0.031	4.393
	Significance	0.945	0.000
	Collinearity Statistics	1.838	1.838

Employee injury rate	**Firm-III**		
	R2 Value	0.834	0.834
	Slope coefficient	-1.581	3.480
	Significance	0.000	0.000
	Collinearity Statistics	1.919	1.919

Table 1.3 : Panel Data Analysis (Social Contribution Rate) -Random Effect Model

Independent Variable →	Scrap Consumption/TCS	Water Consumption/TCS
Intercept	3.592	3.592
R2 Value	0.152	0.152
Slope Coefficient	-0.716	0.369
Probability	0.171	0.185

Table 1.4: Panel Data Analysis (Employee Injury Rate) -Random Effect Model

Independent Variable →	Scrap Consumption/TCS	Water Consumption/TCS
Intercept	6.012	6.012
R2 Value	0.373	0.373
Slope Coefficient	-1.567	0.049
Probability	0.000	0.807

1.3.3.4 : Discussion and Results:

Two nos. of hypotheses and the corresponding null hypotheses were formulated to test the relationship between flexibility of technology and their relationship with social value creation and long term sustainable social performance for firms in IISI. Based on the output of regression model the hypotheses were either accepted or rejected which is being explained below.

HP1.1: *Flexibility in Scrap and water consumption for steel making is positively related to social contribution rate (social value creation) for firms in IISI.*

Null HP1.1: *Flexibility in Scrap and water consumption for steel making is not related to social contribution rate (social value creation) for firms in IISI.*

From the output of multiple regression Model for individual firms, the following is inferred.

The R^2 value for social contribution rate/year for firm-I was 0.635, for firm -II, was 0.678 and for firm-III, it was 0.097. (Table-1.1). This implied that the explanatory power of the regression model was good for firm -I & II and is weak for firm-III.

For firm-I, the dependent variable, social contribution rate/year has a positive slope coefficient with both the independent variables i.e. Scrap consumption/TCS and Water Consumption/TCS. Although the p-value for the independent variable Water Consumption/TCS is significant (0.000), but the p-value for the independent variable Scrap Consumption/TCS is not significant (0.902).

For firm-II, the dependent variable, social contribution rate/year has a negative slope coefficients with the independent variables S crap consumption / TCS and positive slope coefficient with independent variable Water Consumption/TCS. But the p-value for both the independent variable Water Consumption/TCS (0.039) and Scrap Consumption/TCS (0.902) are significant.

For firm-III, the dependent variable, social contribution rate/year has a positive slope coefficient with both the independent variables i.e. Scrap consumption/TCS and Water Consumption/TCS. Although the p-value for the independent variable Water Consumption/TCS is significant (0.019), but the p-value for the independent variable Scrap Consumption/TCS is not significant (0.206).

From the output of the regression Model for the Panel data , the followings are inferred.

The R2 value based on Random Effect Model is 0.152. The slope coefficient is negative for Scrap consumption/TCS and positive for Water Consumption/TCS. The probability of Scrap consumption/TCS is 0.171 and Water consumption/TCS is 0.185 (Table-III).

From the above it is inferred that, there is a significant relationship between Social Contribution rate /year and the Water consumption/TCS for all the firms. But the relationship between Social Contribution rate /year and Scrap consumption/TCS is insignificant for two firms and significant for one firms. Similarly, based on the regression model for panel data , the relationship is insignificant for both Scrap consumption/TCS and Water Consumption/TCS.. So the alternate hypotheses is rejected.

HP1.2: *Flexibility in scrap and water consumption for steel making is positively related to employee injury rate/year (long term social performance) of firms in IISI.*

Null HP1.2: *Flexibility in crap and water consumption for steel making is not related to employee injury rate/year (long term social performance) of firms in IISI.*

From the output of the regression model for individual firms the followings are inferred.

The R^2 value for employee injury rate/year was 0.281 for firm-I, 0.593 for firm-II, and 0.834 for firm-III (Table 1.2). This implied that the explanatory power of the regression model was good for firm-II and firm-III and moderate for firm-I.

For firm-I, the dependent variable, employee injury rate/year, has a positive slope coefficient with the independent variables Water Consumption/TCS and negative slope coefficient with the independent variable Scrap Consumption/TCS. But the p-value for the independent variable, Scrap Consumption/TCS is significant (0.003) and Water consumption/TCS is insignificant (0.146).

For firm-II, the dependent variable, employee injury rate/year, has a negative slope coefficient with independent variable Scrap Consumption/TCS and positive slope coefficient with independent variable Water Consumption/TCS. But the p-value is insignificant for Scrap Consumption/TCS (.945) and significant for Water consumption/TCS (0.000).

For firm-III, the dependent variable, employee injury rate/year, has a negative slope coefficient with independent variable Scrap Consumption/TCS and positive slope coefficient with independent variable Water Consumption/TCS. Also the p-value is significant for both Scrap Consumption/TCS and Water consumption/TCS (0.000).

From the output of the regression Model for the Panel data , the followings are inferred.

The R2 value based on Random Effect Model is 0.373. The slope coefficient is negative for Scrap consumption/TCS and positive for Water Consumption/TCS. The probability of Scrap consumption/TCS is 0.000 and Water consumption/TCS is 0.807 (table-IV).

Since both the sets of dependent and independent variables are showing different type of relationship with each other for both the firms, so it is proposed to further examine the hypothesis before accepting or rejecting the same.

1.4: Conclusions and Scope for future Research :

The steelmaking process was in existence for quite a long time and modern steelmaking technology was developed by Sir Henery Bessemer in 1855 and the BOF process of steel making was developed in 1949. After that world steel production grew at a rapid pace with deployment of BOF process of steel making. The objective of this study was to explore the relationship between flexibility of steel making technology and social value created by the firms leading to long term sustainable social performance by the firms in IISI.

From literature review, the flexibility of technology with respect to the use of inputs for the production of steel was identified as one of the attributes of steel-making technology that could deliver growth. Similarly from many of the variables that are linked to performance of firms, Social contribution rate/year and employee injury rate/year are considered as dependent variables for our analysis. Similarly scrap consumption/TCS and water consumption/TCS are considered as the independent variables. Two nos. of alternate hypothesis along with the null hypotheses were formulated to examine the research questions. The summary of the outcome of the analysis is outlined below.

- The Water consumption/TCS is showing a significant relationship with social contribution rate for all the three firms individually , but when the data is clubbed it is showing an insignificant relationship.
- The Scrap consumption/TCS is showing an insignificant relationship with social contribution rate for two firms and significant relationship for one firm. But when the data is clubbed it is showing an insignificant relationship.
- Similarly, the Water consumption/TCS is showing a significant relationship with employee injury rate for two firms and insignificant relationship for one firm. When the data is clubbed it is showing an insignificant relationship.
- Similarly, the Scrap consumption/TCS is showing a significant relationship with employee injury rate for two firms and insignificant relationship for one firm. When the data is clubbed it is showing a significant relationship.

Since few variables exhibit a significant relationship between flexibility of steel making technology and social performance of both the firms and few variables didn't exhibit a significant relationship between flexibility of steel making technology and social performance of both the firms, so it could not be concluded with certainty, that technology deployment leads to social value creation thus leading to long term social performance.

Steelmaking being a complex manufacturing process, multiple technologies are used in combination at various stages of production from raw material to finished steel, and hence the attributes of one technology may not significantly impact all the dimensions of sustainability. So further exploration is required to ascertain this phenomena. These shortcomings in my current research can be potential topics for future research.

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