ISSN 0378 - 4568

anveṣak

Volume 53 July - December 2023 Number 2

Sardar Patel Institute of Economic and Social Research (SPIESR), Ahmedabad

Contents

Volume 53 July-December 2023 Number 2

anveṣak is a UGC-listed, refereed, biannual journal of the Sardar Patel Institute of Economic and Social Research (SPIESR), Ahmedabad, India. It publishes research work on theoretical and applied economics and occasionally on other social sciences. The journal also has a book-review section devoted to recent publications. Original manuscripts for consideration of the journal, along with the letter of declaration stating that the manuscript is not simultaneously sent elsewhere, should be sent to the Editor. The authors are entitled to get a free hard-copy of the issue in which their article appears and a soft-copy (pdf version) of their article.

Editorial Office
Sardar Patel Institute of Economic and Social Research (SPIESR)
Thaltej Road, Near Doordarshan Kendra, Ahmedabad-380 054. Gujarat, India.
Phone: +91-079-26850598, 26851428 | **Fax:** +91-79-26851714.
website: www.spiesr.ac.in | **e-mail:** anvesak@spiesr.ac.in

Subscription and Tariff

Annual Subscription Rates (including postage)

India and its neighbouring countries viz. Pakistan, Nepal, Bhutan, Bangladesh, Sri Lanka, Maldives, Afghanistan and Myanmar

Indian Sub-Continent	
Institutions	₹ 850
Individuals	₹ 450
Other Countries	US $ 110

Subscription payment through Cheque/DD or electronic mode such as RTGS/NEFT/ECS/ CBS should be made in the name of "Sardar Patel Institute of Economic and Social Research, Ahmedabad". Our bank details are: Indian Overseas Bank, Account No. 045002000000130, IFSC IOBA0000450, Type of account: CC account.

Correspondence relating to subscriptions should be sent to the Editorial Office (anvesak@spiesr.ac.in).

Printer & publisher: Director, SPIESR; Owner: SPIESR; Editor: Dr. Subrata Dutta, SPIESR.

Anvesak
Vol. 53(2), 2023, pp. 1-28
Received: 13 Jul 2022; accepted: 30 Sept 2023

SECTOR-WISE CARBON EFFICIENCY FOR SUSTAINABLE DEVELOPMENT OF INDIAN ECONOMY: A DATA ENVELOPMENT ANALYSIS APPROACH

SATRAJIT DUTTA[1] AND SOUMYANANDA DINDA[2]*

[1]*Gorubathan Government College, Kalimpong, West Bengal, India*
[2]*University of Burdwan, Bardhaman, West Bengal, India*

Abstract: Sustainable Consumption and Production (SCP) is an important component of sustainable development for *Just Transition* to reach *Net Zero* by 2050. It encompasses the elements of decoupling economic growth and emission, life cycle approach for minimisation of resource use and inclusiveness with job Causality. The present study investigates the progress of SCP in terms of impact decoupling concept by measuring the relative carbon emission efficiencies and rankings of different economic sectors of India by using Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) methods of Data Envelopment Analysis (DEA) in 1990, 1995, 2000, 2005, 2010, 2015 and 2020. The applied method is in consonance with life cycle approach by calculating carbon emission from both direct and indirect fossil fuel consumption. Industry has the lowest relative ranking in terms of carbon efficiency, followed by transport and residential sectors due to low average scale efficiency. The study identifies carbon-intensive fuel consumption structure as a prime factor. It prioritises carbon efficiency in Industry due to its linkage with other sectors and also in power sector because of growing electrification.

Keywords: Data envelopment analysis, Electricity, Emissions, Overall technical efficiency, Sustainable consumption and production, Total final energy consumption

1. Introduction

Sustainable Consumption and Production (SCP) refer to the use of services and products for meeting basic needs and better quality of life while keeping natural resources extraction and generation of negative output, e.g., wastes and pollutants at a minimum level over their life cycle so that needs of future generation are not jeopardised.[1] SCP—one of the 17 Sustainable Development

*Correspondence to: Soumyananda Dinda, Professor, Department of Economics, University of Burdwan, Bardhaman, West Bengal 713104, India. Email: sdinda@eco.buruniv.ac.in

[1]See "Sustainable Consumption and Production Policies". Available at: https://www.unep.org/explore-topics/resource-efficiency/what-we-do/sustainable-consumption-and-production-policies#:~:text=Sustainable %20consumption%20and%20production%20refers,the%20service%20or%20product%20so. Retrieved August 1, 2023.

Goals (SDG 2030)—is based on three objectives: firstly, decoupling economic growth and negative impact on environment by means of minimisation of resource use for getting optimum output with reduction in environmental pollution and wastes; secondly, life cycle approach for efficient and sustainable management of production and consumption;[2] and thirdly, provision of opportunities of new markets, creation of green and decent jobs, efficient natural resource management for achievement of Millenium Development Goals (MDGs) and avoid inefficient development phases of the developed countries.[3]

The concept of SCP has become more important in view of Just and Inclusive Transition to Net Zero Emissions Scenario by 2050 when all anthropogenic emissions are counterbalanced by carbon removal process from the atmosphere and is consistent with the containment of global temperature increase within 1.5^0 C target of Paris Agreement 2015 (Levin et al., 2023). Almost 75% of GHGs emissions originate from energy sector which is a key sector for avoiding ill effects of climate change (International Energy Agency, 2021).

During the period 1990-2020, Indian economy experienced Coupling between economic growth and carbon emission as evident from high positive correlation (*r = 0.9826*) between Gross Domestic Product (GDP) per capita and CO_2 emission per capita. Positive correlation (*r = 0.6575*) between GDP per capita and total final energy consumption (TFC) per capita implies that higher GDP growth would increase more energy resource consumption (i.e., Resource Coupling). Again, Impact Coupling is evident in positive correlation (*r = 0.6383*) as found between TFC per capita and CO_2 emission per capita. Thus, both the essentiality of energy resource for economic growth and inability to minimise the co-output of CO_2 emission in production and consumption are evident in Indian economy.

In this context, India has undertaken several policies to decouple economic growth and emission. As per the 1st updated nationally determined contributions (NDC) under Paris Agreement (2015), India committed to reduce emissions intensity by 45% by 2030 from the 2005 level and generate about 50% cumulative electric power installed capacity from non-fossil energy resources by 2030.

However, the fuel consumption structure in Industry sector is found to be comparatively more intensive in fossil fuels [direct (final) and indirect (intermediate) consumption (for electricity generation)], mainly coal (with compound annual growth rate) of 4.41% for the period of 1990-2020) whose emissions factor is very high in comparison to other fossil fuels. As a result, Industry has evidenced highest emissions in all seven study years during 1990-2020 (Figure 1). In terms of compound annual growth rate (CAGR) of emissions, Residential sector (5.12%) is leading, followed by Commercial and Public Services (4.81%), Transport (4.74%), Industry (4.29%), Agriculture/Forestry (4.21%), and non-specified sector (4.07%). This emission growth in Residential, Commercial and Public Services sectors is due to urban aggregation and economic expansion leading to high electricity demand, which is mostly met from power stations run on fossil fuels.

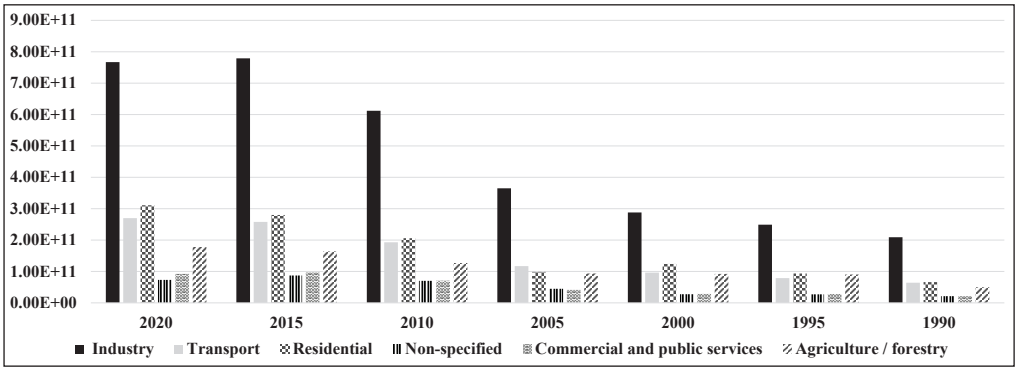
The expenditure on research and development (R&D) for technological improvement (TI) increases ability to harness renewable energy (RE). It also increases energy efficiency (EE) which results in energy use reduction during production and consumption which in turn improves carbon efficiency in Industry sector. The industry sector occupies an important place in carbon efficiency

[2] Resource extraction, generation of intermediate products, marketing and distribution, usage, waste disposal and reuse.

[3] Same as footnote 1

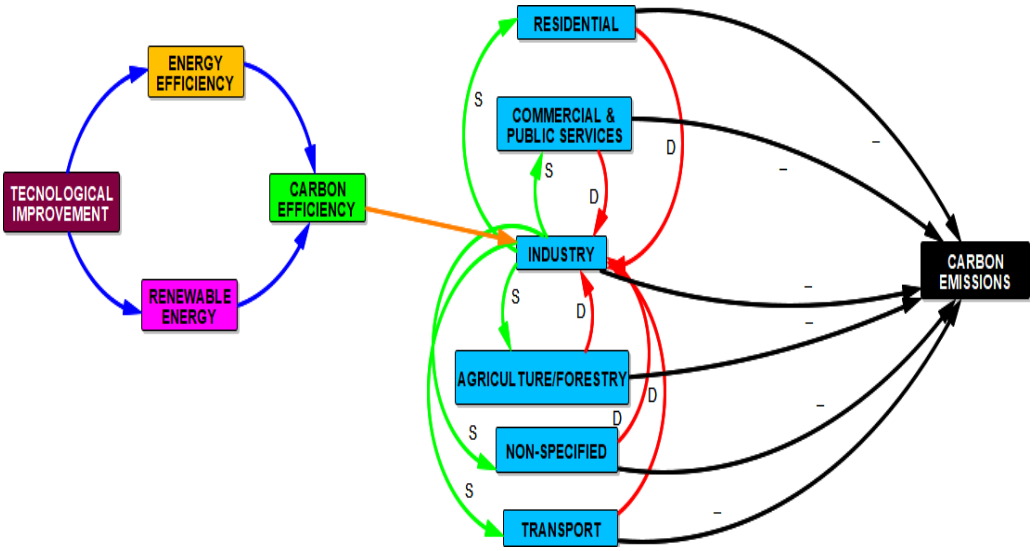
of the economy due to its linkage effect on other major economic sectors or decision making units (DMUs) (Figure 2). In Figure 2, 'D' arrows depict demand flow originated from other DMUs for Industry sector and 'S' arrows indicate supply of carbon efficient inputs, products, raw materials from Industry segment to other DMUs which causes less emission, denoted by arrows with negative (-ve) sign, during their production itself in Industry and also during their final consumption and intermediate use in other DMUs.

Figure 1: Sector-wise Total Emission (Mt) (Direct and Indirect)



Source: Authors

Figure 2: Importance of Carbon Efficiency w.r.t. Linkages of Industry with Other DMUs



Source: Authors

Against this background, it is pertinent to make a relative (in)efficiency analysis with energy consumption and energy-related emissions which are co-outputs while producing the desired target output in different energy-consuming economic sectors in India. This study attempts to measure carbon efficiency of Indian economy for the period of 1990-2020, applying Data Envelopment Analysis (DEA). It provides relative Overall Technical Efficiency (OTE) and its decomposition into

Pure Technical Efficiency (PTE) and Scale Efficiency (SE) in relation to six (6) energy consuming sectors in India which are ranked in terms of carbon efficiency, and discusses India's policies helpful in fulfilling different SDGs with specific focus on energy and SCP. The paper focuses on Impact Decoupling by treating CO_2 emission as output (undesired) and energy consumption as input required in production and consumption process in 6 economic sectors of India, and ranks them by applying DEA during the post-liberalisation period of 1990-2020.

The Life Cycle Assessment (LCA) is a comprehensive and reliable method for assessment of the environmental impacts of products and services and it takes into account the total production process or part of it with consideration of interactions among different inputs and its report acts as a guide for policy makers (Taherzadeh-Shalmaei et al., 2023). But as the present study involves different sectors along with different energy inputs and considers the unwanted output in the DEA ranking analysis, it is not possible to gather data of energy input and emission in a true cradle-to-grave LCA framework; however, it covers partly the cycle by assessing undesired output (carbon emissions) production while producing a major input, i.e., electricity, which is used in different sectors for production of intermediate and final goods and services. The analysis does not cover the input-output interaction in other parts of the life cycle such as the extraction of primary energy inputs, raw materials, etc.

This paper is organised as follows. Section 2 reviews the existing relevant literature. Section 3 provides theoretical background and research design. Section 4 describes research methodology, data and model building. Section 5 provides results and analytical discussion linked with existing policies for carbon efficiency. Finally, section 6 provides conclusion.

2. Literature Review

Applications of Data Envelopment Analysis (DEA) can be found in different aspects of energy-environment area in existing literature. Using DEA method, Ratner et al. (2021) revealed that deterioration in total regional Environmental Management Systems efficiency in Russia during 2011-17 is caused by under-utilisation of production capacities and shortage of funds for resource-efficient technologies. Mandal and Madheswaran (2009) found that energy use efficiencies in cement plants in the states of India such as Gujarat, Chhattisgarh, Kerala, Punjab, Himachal Pradesh, Uttar Pradesh, Uttaranchal and West Bengal are 100 per cent technically efficient. DEA application on a regional scale found that Shanghai and Wuxi provinces in China's Yangtze River Delta (YRD) region are the highest emitters during 2012-16 (Liu et al., 2018). DEA with Multi-Criteria Decision Analysis (MCDA) method like TOPSIS has been used to find that 57 DMUs were eco-efficient out of 94 DMUs (Lee, 2022). Using CRITIC-TOPSIS with DEA, Czyżewski et al. (2020) found that most eco-efficient counties are around biggest cities in richest regions with high economic development in Poland during 2002-2017.

DEA method for undesirable output like energy related emissions has been applied by Wang et al. (2020). The study found India as a bottom-ranked country, while countries like Kuwait, Nigeria, United Kingdom, United States and Norway were the top ranked ones during 2008-17. Zheng (2021) used Slack-Based Measure Data Envelopment Analysis (SBM-DEA) for dealing with undesirable output in 23 cities in China and found declining trend of overall efficiency and its reciprocal relationship with economic development. The analysis showed that decline in total factor productivity is due to low technological innovation and motivation in transport sector during 2012-2018. Application of dynamic slack-based DEA for analysing outputs like electricity generation (desired) and CO_2 emissions (undesired) in 24 countries in Latin America and the Caribbean during

2000-2017 found that Brazil, Cuba, Mexico and Paraguay are most carbon efficient countries (Cuadros et al., 2020). Six provinces in China are found to be the best performers in energy and afforested efficiency according to the Slack-Based Measure Data Envelopment Analysis (SBM-DEA) method (Chen et al., 2022). Shah et al. (2022) used SBM-DEA to find energy efficiency improvements in China's 31 cities and provinces after 2011; and results of DEA-Meta frontier and Kruskal-Wallis analysis show that eastern coastal region is closer to Meta frontier, while Malmquist productivity index indicates that TFP improved in eastern region mainly due to improvement in technology. Shah et al. (2023) utilised SBM-DEA and Malmquist-Luenberger Index (MLI) method to conclude that technical efficiency is the primary reason for energy productivity in cases with only renewables and with both renewables and emission outputs in G-20 countries during 1995-2020.

Using Directional Distance Function (DDF), Yuan et al. (2013) found that industrial regions in eastern China have highest environmental efficiency during 2003-09. Charnes- Cooper-Rhodes (CCR) and Banker-Charnes-Cooper (BCC) models of DEA confirm lower total technical efficiency and pure technical efficiency, respectively, in Chinese coal mining companies in comparison to their American counterparts, and these were due to historical, economic, legislative, political and cultural factors (Fang et al., 2009). Fathi et al. (2021) used traditional DEA and Nash bargaining game cross-efficiency DEA methods with outputs GDP (desired) and CO_2 emissions (undesired) and found that integrated index of Nash bargaining payoff of energy, economy and environment (E3) criteria in China, Bahrain, Oman, Poland and Romania are highest amongst 25 fuel exporting countries during 2015-2017. Guaita Martínez et al. (2022) used one variant of DEA—DEA-intertemporal cross-efficiency—to rank EU countries like Denmark, Sweden, Finland and Germany in terms of Sustainable Production (SP) during 2015-2019, and found independence between commitment for SP and country's wealth; and also used dynamic panel two-step GMM and found strong association between GDP and SP, and positive relationship between SP and government budget allocations for research and development (R&D) in information and communications technology (ICT) and other aspects of digitalisation. Zhou et al. (2021) measured efficiency using network DEA model during 2008-2014 and found low and high efficiency forest bioenergy production in Southern and Northern Sweden, respectively. Badunenko and Kumbhakar (2020) used Stochastic Frontier Approach and found that oil shock in the 1970s decreased energy efficiency in US manufacturing sector due to structural inefficiency until its rebound in the 2000s.

The basic DEA models have been extended by introduction of index methods. Technological change index for non-radial Malmquist CO_2 emissions performance index declined in China (Zhang et al., 2015). Fare et al. (1994) decomposed the productivity by Malmquist Index and found that Japan has the highest productivity growth due to technical efficiency change among 17 OECD countries during 1979-1988.

Using multiplicative exponential environmental Luenberger Productivity Indicator on Chinese industries during 1999-2016, Shen et al. (2022) found that green productivity increased by about 0.4 per cent on an annual basis with average annual technological progress of 0.55 per cent and reduction in average efficiency levels by 0.03 per cent. Super-efficiency SBM-DEA and global Malmquist-Luenberger (GML) index for analysis of carbon emissions efficiency of China's transportation sector found GML values of national and regional samples to be less than 1, except in Shanxi, Guangxi, and Yunnan (>1) (Jiang and Li, 2022). Wang et al. (2019) used SBM-DEA with and without undesirable outputs and Malmquist Productivity Index (MPI) for measuring Energy Efficiency (EE) improvement during 2010-17 on 25 countries and found that India maintained balanced growth and emissions reduction compared to China.

DEA method has been used in conjunction with other econometric methods. For example, pooled mean group (PMG) estimator based on ARDL approach with CO_2 emissions concluded that environmental EE deteriorated in iron and steel industry in late 2000s but improved in chemical, oil, coal and machinery industries in Japan (Shimizu and Tiku, 2023), while, according to Sueyoshi and Goto (2020), Shikoku Electric Power Company has been found to outperform other power companies in Japan during 2003-2020.

There is lack of literature on the relative efficiency of different sectors of Indian economy in terms of carbon emissions output reduction. The carbon efficiencies of different sectors are not the same due to energy consumption structures, technological efficiencies and scales of operations. Relative efficiency of different economic sectors in terms of emission reduction needs to be identified over the years.

The present study is an attempt to measure relative carbon efficiency of different economic sectors in India with respect to generation of single output (i.e., energy-related carbon emissions by use of single input), and Total Final Energy Consumption (TFC) and then rank the sectors accordingly. The study years are 1990, 1995, 2000, 2005, 2010, 2015 and 2020, spreading three decades from 1990 to 2020.

3. Theoretical Background and Research Design

For ensuring SCP to attain Sustainable Development, decoupling between economic activity and environmental ill effects is necessary. Resource Decoupling implies reduction in rate of use of primary resources per unit of economic activity, i.e., resource use efficiency, while Impact Decoupling implies rise in economic output with reduction in negative environmental impacts (Fischer-Kowalski et al., 2011). The Tapio Decoupling Measure is the elasticity ratio between carbon emission (C) and GDP (Y) and it can be decomposed into Resource Decoupling Measure as the elasticity ratio of total final energy resource consumption (TFC = E) to Y, and Impact Decoupling Measure as the elasticity ratio of C (generated from burning of fossil energy resources, i.e., impact on environment) to resource consumption E (Tapio, 2005).

$$Decoupling\ Measure = \frac{\Delta C}{\Delta Y}$$

$$\equiv Resource\ Decoupling \times Impact\ Decoupling = \frac{\Delta C}{\Delta Y} = \frac{\Delta E}{\Delta Y} \times \frac{\Delta C}{\Delta E}$$

The present research work focused on Impact Decoupling by considering final energy consumption in 6 economic sectors in India and carbon emissions caused by energy consumption at the final stage and in the intermediate stage (for electricity generation) which is compatible with the Life Cycle Approach of SCP. The conceptual research design is represented in Figure 3.

4. Materials and Method

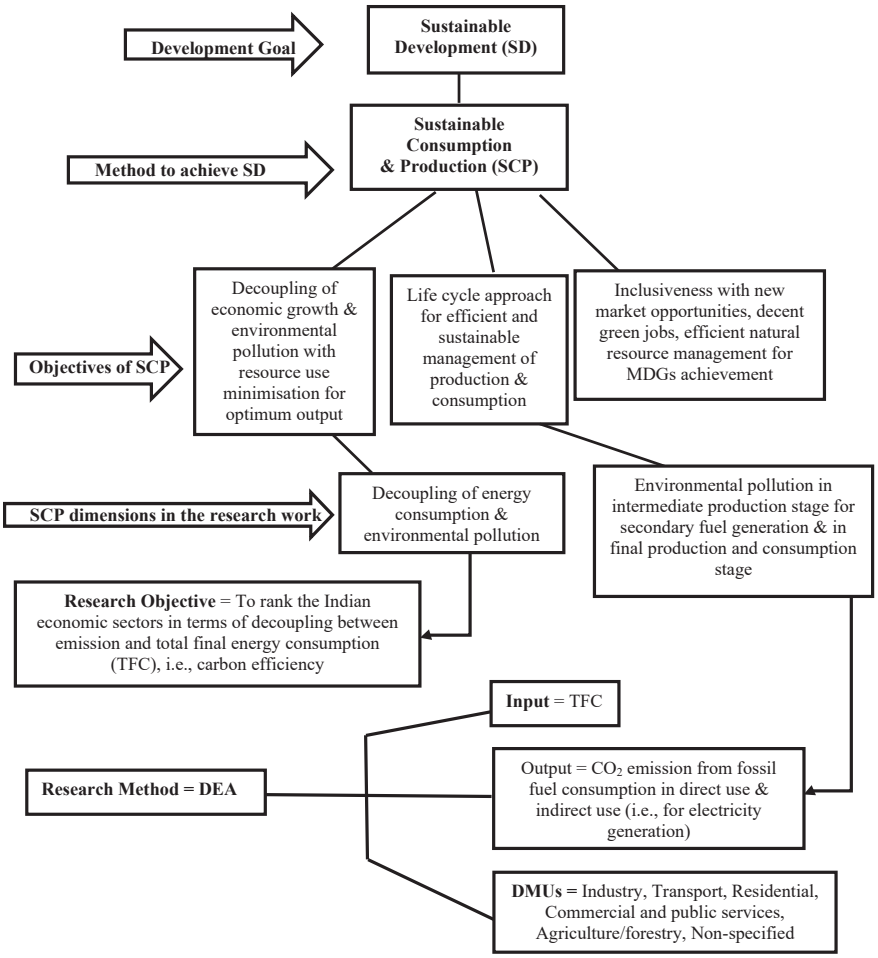
4.1 Research Method

The measurement of relative efficiency using DEA approach was originally introduced by Farrell (1957) and was extended by Charnes et al. (1978) who introduced the Constant Returns to Scale (CRS) model (i.e., Charnes-Cooper-Rhodes or CCR model). Banker et al. (1984) introduced the Variable Returns to Scale (VRS) model (i.e., Banker-Charnes-Cooper or BCC model) (El Husseiny, 2022).

DEA is a benchmarking technique which is applied to inputs and outputs of a population

of DMUs, where DMUs on the efficiency frontier line is regarded as benchmarks (or peers) in comparison to the inefficient DMUs located inside the frontier and these benchmark real DMUs with real data are considered to be associated with best practices but the efficiency frontiers are found to be different in CRS and VRS models (Huguenin, 2012). The relative efficiency of homogeneous units is judged by taking into account several inputs (resources) used by DMU to produce outputs and the efficiency is defined as the ratio of weighted sum of both outputs and inputs (Kumar and Gulati, 2008; Mohammadi and Ranaei, 2011). A DMU is considered effective if it can transform input to output efficiently and efficiency scores are measured in scaler values ranging from 0 to 1 which were assigned to each DMU (Zhou et al., 2022). DEA model is categorised as input or output oriented. While in input orientation case DEA finds out the DMU which can decrease (i.e., minimise) inputs given the output level, the output-oriented analysis indicates how much the firm can maximise output with the given level of input (Huguenin, 2012).

Figure 3: Schematic Presentation of Research Design



Source: Authors

In case of '*n*' DMUs (j = 1,….., n) which produce '*s*' different outputs from '*m*' different inputs, the input and output vectors of DMU_j are $X_j=(x_{1j},\ldots..,x_{mj})$ and $Y_j=(y_{1j},\ldots..,y_{sj})$, respectively, where all $X_j, Y_j \geq 0$, i.e., each DMU has one strictly positive input and output (at least) (Jahanshahloo et al., 2005). Thus, the technology sets formulated in Charnes-Cooper-Rhodes and Banker-Charnes-Cooper models, respectively, are:[4]

$$T_c = \left\{(X,Y) \mid X \geq \sum_{j=1}^{n} \lambda_j X_j, Y \leq \sum_{j=1}^{n} \lambda_j Y_j, \lambda_j \geq 0, j = 1, \ldots., n\right\}$$

$$T_v = \left\{(X,Y) \mid X \geq \sum_{j=1}^{n} \lambda_j X_j, Y \leq \sum_{j=1}^{n} \lambda_j Y_j, \sum_{j=1}^{n} \lambda_j = 1, \lambda_j \geq 0, j = 1, \ldots., n\right\}$$

CRS method measures OTE for determination of inefficiency due to configuration of inputs and/or output and also due to size of operations (Kumar and Gulati, 2008). VRS method decomposes the OTE into two mutually exclusive and non-additive components—PTE and SE. PTE is a measure of managerial performance to organise the inputs in the production process (Kumar and Gulati, 2008). SE (= OTE/PTE) implies choosing the scale of production for achieving expected production level as inappropriate size of a particular sector causes technical inefficiency, known as scale inefficiency. SE is of two types: decreasing returns to scale (i.e., the sector has supra-optimum scale size and is too large to take full advantage of scale) and increasing returns to scale (i.e., the sector has sub-optimum scale size and is too small for its scale of operations). The Decision Making Units (DMUs) (here, sectors)—responsible for turning input into output—are considered scale efficient if these are operating under CRS (Kumar and Gulati, 2008).

Classical DEA models—i.e., CCR and BCC models—are based on the assumptions of input minimisation and output maximisation, but, according to Koopmans (1951), production process generates undesirable outputs (Jahanshahloo et al., 2005). In a situation of multiple outputs, Färe et al. (1989) treated separately the desired and undesired outputs with weak disposability through a hyperbolic efficiency measure which is an advancement of enhanced multilateral productivity index of (Pittman, 1983) as it measures quantity of undesirable output instead of shadow price and the ranking exercise permits asymmetric treatment of inputs, and desirable and undesirable outputs.

Classic Pareto preference is stated to be the building block of any DEA model. In case of desirable output, DMU_1 (X_1,Y_1) is better than DMU_2 (X_2, Y_2) if $X_1 \leq X_2, Y_1 \geq Y_2$, while in case of undesirable output, DMU_1 (X_1,Y_1) is better than DMU_2 (X_2,Y_2) if $X_1 \leq X_2$, $Y_1 \leq Y_2$ (Liu et al., 2010). Another condition is Production Possibility Set (PPS): $PPS = P(\{(X_j,Y_j)\})$ is a set which contains all reliable DMUs and their preferences, and an efficient *DMU* (X_j,Y_j) is the one which is the best in PPS (Liu et al., 2010). The important assumption about PPS is the Strong Disposability which states that the property of free disposal holds if absorption of any additional input amount without any output reduction is possible, i,e., if $(X,Y) \in P$ and $W \geq X$, $Z \leq Y$ then $(W, Z) \in P$ (Liu et al., 2010). With Strong Disposability and Convexity, the PPS with desirable outputs and inputs is:

$$P(\{(X_j,Y_j)\}) = \left\{X \geq X(\lambda) = \sum_{j=1}^{n} \lambda_j X_j, Y \leq Y(\lambda) = \sum_{j=1}^{n} \lambda_j Y_j, \lambda \epsilon S\right\}$$

where either $S = \{\lambda_j \geq 0, j = 1, \ldots., n\}$ *or* $S = \{\lambda_j \geq 0, \sum_{j=1}^{n} \lambda_j = 1\}$..

[4] See Jahanshahloo et al. (2005)

But in the presence of undesirable outputs or inputs, the strong disposability is to be replaced by the Extended Strong Disposability. $(X,Y) = (X^D, X^U, Y^D, Y^U) \in P$, where X^D and X^U are desirable and undesirable inputs, respectively; Y^D and Y^U are desirable and undesirable outputs, respectively. Now, if $W^D \geq X^D$, $W^U \leq X^U$ and $Z^D \leq Y^D$, $Z^U \geq Y^U$, then $(W^D, W^U, Z^D, Z^U) \in$ P for corresponding PPS with convexity (Liu et al., 2010):

$$PPS = \left\{ (X^D, X^U, \quad Y^D, \quad Y^U): X^D \geq \sum_{j=1}^{n} \lambda_j X_j^D, X^U \leq \sum_{j=1}^{n} \lambda_j X_j^U, Y^D \leq \sum_{j=1}^{n} \lambda_j Y_j^D, Y^U \geq \sum_{j=1}^{n} \lambda_j Y_j^U, \sum_{j=1}^{n} \lambda_j = 1, \lambda_j \geq 0 \right\}$$

Based on the Extended Strong Disposability, Seiford and Zhu (2002) used the above PPS, where the undesirable output undergoes transformation using: $\bar{Y}_j^U = Y_j^U + W$, where, $Y_j^U < W$. Seiford and Zhu (2002) assumed standard Strong Free Disposability and also convexity which results in PPS (Liu et al., 2010):

$$\left\{ (X,Y): X \geq \sum_{j=1}^{n} \lambda_j X_j, , Y^D \leq \sum_{j=1}^{n} \lambda_j Y_j^D, \bar{Y}^U \leq \sum_{j=1}^{n} \lambda_j \bar{Y}_j^U, \sum_{j=1}^{n} \lambda_j = 1, \lambda_j \geq 0 \right\}$$

Then again reverting back to the original variable with transformation $\bar{Y}_j^U = -Y_j^U + W$,

$$PPS = \left\{ (X,Y): X \geq \sum_{j=1}^{n} \lambda_j X_j, , Y^D \leq \sum_{j=1}^{n} \lambda_j Y_j^D, Y^U \geq \sum_{j=1}^{n} \lambda_j Y_j^U, \sum_{j=1}^{n} \lambda_j = 1, \lambda_j \geq 0 \right\}$$

where Y^U is bounded up by W (Liu et al., 2010).

In order to find out the most carbon efficient energy consuming sector (DMU), the one-stage output-oriented DEA method with both CCR and BCC models have been applied. The article considers single input, i.e., total final energy consumption, and single undesirable (unwanted or bad) output, i.e., energy-related CO_2 emission. Following Seiford and Zhu (2002), Liu et al. (2010) and Dar et al. (2021), necessary transformations for undesirable (bad) outputs is applied in DEA framework (see sub-section 4.5) for reduction of undesirable output, i.e., CO_2 emissions.

4.2 Data

The variables are selected as per the Rule of Thumb usually followed in DEA method, i.e., $n=3(x+y)$, where n = number of DMUs, x = number of inputs, and y = number of outputs (Limaei, 2020).

Input: The input variable is Total Final Energy Consumption (TFC) (Terra Joule n = Tj) in end-use sectors and in non-energy use. These are collected from open data base of International Energy Agency (IEA) for the years 1990, 1995, 2000, 2005, 2010, 2015 and 2020.

Output: CO_2 emission is considered as the output variable and carbon emission is measured in million tonne (Mt). In this article, total emission in 6 sectors (DMUs) is computed as:

Total Emission (E_T) = Emissions from direct consumption of primary fossil fuels (E_D) + Emissions from indirect consumption of primary fossil fuels for electricity generation (E_{IND}).

Indirect primary fossil energy consumption for electricity generation is calculated for all DMUs in all years in the following method—say, in a particular year, 'a' units of coal was used in production of 'w' units of electricity produced and if 'v' units of electricity is consumed in a particular segment (DMU), then the use of coal = (a/w)×v units. The emission factors (EF) are calculated taking the average of default EFs as per the IPCC-2006[5] of the most used sub-category fuels, e.g., for coal the EF = 94,600 (Kilogram = Kg/Tj) considering the average EFs of coking coal and Bituminous types of coal (IPCC, 2008). Similarly, the EF for Oil and Oil products is 68,833.33 (Kg/Tj) after taking average EFs of Motor Gasoline, Gas/Diesel Oil and Liquefied Petroleum Gases, while for Natural Gas, the EF is 56,100 (Kg/Tj).

DMUs: Six energy consuming sectors are considered as six DMUs: Industry,[6] Transport,[7] Commercial and Public Services, Residential sector (which includes household consumption and excludes fuels used for transport), and Non-specific sector (which includes all fuel consumption apart from Industry, Transport, Commercial and Public Services, Residential sectors and also includes all mobile and stationary consumption for military purpose). This study does not consider Fishing category due to zero total final energy consumption in the study years.

4.3 Checking Applicability of DEA Method

For ensuring 'isotonicity' before application of DEA, Pearson Correlation Coefficient is used between data on input and output (Lee, 2022), where Coefficient value = +1 implying perfect positive linear relationship. However, non-positive coefficient value requires removal of variables and reselection (Wang et al., 2018). The correlation coefficient values are found to be positive (Table 1). Therefore, DEA method can be applied. The increasing correlation coefficient indicates that despite the growth of renewable energy (RE), the rising share of fossil fuels in energy consumption in the energy intensive sectors are causing higher emissions.

Table 1: Correlation Coefficients between TFC (Input) and Emissions (Output)

Year	1990	1995	2000	2005	2010	2015	2020
Corr coeff.	0.477	0.538	0.671	0.594	0.824	0.895	0.931

Source: Authors

4.4 Normalisation of Data

Here, x_{ij}, $i = i^{th}$ *input* = 1, 2,…., m; $j = j^{th}$ DMU = 1,2,…., n; and $y_{rj}^{\ b}$, r = r^{th} output = 1, 2,….., s; j = j^{th} DMU = 1,2,…., n,

where x_{ij} = input (total final consumption of energy),

$y_{rj}^{\ b}$ = bad output (emissions).

In order to convert the data set of x_{ij} and $y_{rj}^{\ b}$ to an equivalent form, following Jahanshahloo et al. (2005) the input and output data are scaled by normalisation by dividing i^{th} input and r^{th} output of all DMUs by R^{-} and R^{+}, respectively, where $R^{-} = Max_{1\le i\le m}\{x_{ij}\}$ and $R^{+} = Max_{1\le r\le s}\{y_{rj}^{\ b}\}$.

4.5 DEA Model with Single Input and Single Unwanted Output

In the first step, following Halkos and Petrou (2018) each pollutant (or undesirable bad output $y_{rj}^{\ b}$) is multiplied by (-1) and a proper weight v_r is used to alter negative environmental variable into positive

[5] IPCC stands for Intergovernmental Panel on Climate Change.

[6] Mining-and-quarrying, construction, manufacturing, etc.

[7] Domestic aviation, road, rail, pipeline transport, domestic navigation, transport, etc.

one. Now, $y_{rj}^{b} = -y_{rj}^{b} + v_r$ is obtained by $v_r = max\{y_{rj}^{b}\} + 1$. The DEA method requires that all the DMUs are positively valued and moreover, it is difficult to interpret the maximisation of negative output. The efficiency scores of the model which have undesirable outputs are derived by using the following CRS and VRS types of DEA model in dual form:

Max h

subject to

$$\sum \varphi_j \, y_{rj}^{b} \geq h y_{ro}^{b}, j = 1, 2, \ldots, n ; r = 1, 2, \ldots, s \quad (1)$$

$$\sum \varphi_j \, x_{ij} \leq x_{jo}, i = 1, 2, \ldots, m \quad (2)$$

$$\sum \varphi_j = 1 \quad (3)$$

$$\varphi_j \geq 0 \quad (4)$$

$$\sum \varphi_j > 1 \quad (5)$$

$$\sum \varphi_j < 1 \quad (6)$$

where y_{rj}^{b} = bad output (emissions); x_{ij} = input (total final consumption of energy); φ = technical efficiency coefficient; and n = Number of DMUs [CRS: Equations (1), (2) and (4); VRS: Equations (1) to (4)]. The additional conditions for non-decreasing returns to scale (NDRS) and non-increasing returns to scale (NIRS) are (5) and (6), respectively.

5. Results and Discussion

5.1 Summary Statistics

Table 2 shows that both the means of input (TFC) and output (CO_2 Emissions) (non-normalised values) across 6 DMUs increased over the years. But there is no consistent trend in variation across DMUs in both input and output over the years, though both of them decreased in 2020 in comparison to 1990.

Table 2: Summary of the Research Samples

Year	Statistic	Input (TFC) (Tj)	Output (Emissions) (Kg)
1990	Min	191485	21261909383
	Max	4308376	2.09E+11
	Mean	1407876.667	71898185786
	SD	1514533.801	63779510810
	CV	1.076	0.887
1995	Min	233922	27154075852
	Max	4619641	2.49E+11
	Mean	1617488.83	94412901329
	SD	1613866.927	74092072739
	CV	0.998	0.785
2000	Min	217569	27570371712
	Max	5012325	2.88E+11
	Mean	1836843.667	1.09E+11
	SD	1815148.725	87377077901
	CV	0.988	0.798

Contd....

Table 2 contd...

Year	Statistic	Input (TFC) (Tj)	Output (Emissions) (Kg)
2005	Min	329060	41356127040
	Max	5366060	3.65E+11
	Mean	2116071	1.27E+11
	SD	2004749.821	1.10E+11
	CV	0.947	0.869
2010	Min	523147	70189409403
	Max	6608433	6.12E+11
	Mean	2858255.167	2.13E+11
	SD	2506513.099	1.86E+11
	CV	0.877	0.872
2015	Min	655603	87150090458
	Max	8487634	7.79E+11
	Mean	3485576	2.77E+11
	SD	3022944.875	2.36E+11
	CV	0.867	0.850
2020	Min	609682	73182379504
	Max	9477135	7.67E+11
	Mean	3779801.83	2.82E+11
	SD	3330415.366	2.33E+11
	CV	0.881	0.828

Source: Authors

5.2 DEA Results

The results of all DMUs under DEA (CRS and VRS method) in years 1990, 1995, 2000, 2005, 2010, 2015, 2020 are shown in Table 3.

Table 3: DEA (CRS and VRS) (Stage-1) Results

DMUs	Rank CRS (1995)	CRS overall technical efficiency (OTE)	Reference weights	Rank VRS	VRS pure technical efficiency (PTE)	NIRS	VRS scale efficiency (SE)	Reference weights	RTS	Input Slack (VRS)
					A: 1990					
Industry	5	0.0408	0.5263	6	0.5263	0.5620	0.0775	0.5263	IRS	0.2786
Transport	4	0.1961	0.8895	4	0.8291	0.8532	0.2204	0.8895	IRS	0.1398
Residential	6	0.0392	0.8842	5	0.8211	1.0000	0.0444	0.8842	IRS	0.8449
Commercial and public services	2	0.7799	1	2	0.9991	1.0000	0.7799	1	IRS	0.01255
Agriculture /forestry	3	0.4913	0.9263	3	0.8873	0.8927	0.5304	0.9263	IRS	0.0365
Non-specified	1	1.000000	1	1	1.000000	1.0000	1.000000	1	IRS	*
Average	-	0.4246	-	-	0.8438	0.8846	0.4421	-	-	0.2625

Contd...

Table 3 contd...

DMUs	Rank CRS (1995)	CRS overall technical efficiency (OTE)	Reference weights	Rank VRS	VRS pure technical efficiency (PTE)	NIRS	VRS scale efficiency (SE)	Reference weights	RTS	Input Slack (VRS)
					B: 1995					
Industry	6	0.0430	0.5291	6	0.5291	0.5786	0.0812	0.5291	IRS	0.3032
Transport	4	0.1905	0.8889	3	0.8889	0.9133	0.2143	0.8889	IRS	0.1651
Residential	5	0.0434	0.8571	5	0.8571	1.000000	0.0506	0.8571	IRS	0.8137
Commercial and public services	2	0.8354	1	2	1.000000	1.000000	0.8354	1	IRS	0.0100
Agriculture /forestry	3	0.3391	0.8677	4	0.8678	0.8769	0.3908	0.8677	IRS	0.068
Non-specified	1	1	1	1	1	1	1	1	IRS	*
Average		0.4086			0.8571	0.8948	0.4287			0.2267
					C: 2000					
Industry	6	0.0323	0.5263	6	0.5263	0.5981	0.0614	0.5263	IRS	0.3494
Transport	4	0.1431	0.8790	4	0.8789	0.9148	0.1628	0.8789	IRS	0.1962
Residential	5	0.0359	0.8263	5	0.8263	1.000000	0.0434	0.8263	IRS	0.7904
Commercial and public services	2	0.8246	1.000000	2	1.000000	1.000000	0.8246	1	IRS	0.0092
Agriculture /forestry	3	0.2980	0.8842	3	0.8842	0.8967	0.3370	0.8842	IRS	0.0755
Non-specified	1	1	1	1	1	1	1	1	IRS	*
Average	-	0.3890			0.8526	0.9016	0.4049			0.2841
					D: 2005					
Industry	6	0.0401	0.5291	6	0.5291	0.5674	0.0758	0.5291	IRS	0.3957
Transport	4	0.1793	0.8889	5	0.8889	0.9088	0.2017	0.8889	IRS	0.2157
Residential	5	0.0561	0.9153	4	0.9153	1.000000	0.0613	0.9153	IRS	0.8592
Commercial and public services	1	1	1	1	1.000000	1.000000	1.000000	1.000000	IRS	*
Agriculture /forestry	3	0.4694	0.920635	3	0.920635	0.925556	0.509836	0.920635	IRS	0.0543
Non-specified	2	0.8558	0.9947	2	0.9947	0.9956	0.8603	0.9947	IRS	0.0099
Average	-	0.4334	-	-	0.8748	0.8996	0.4515	-	-	0.3070

Contd...

Table 3 contd...

DMUs	Rank CRS (1995)	CRS overall technical efficiency (OTE)	Reference weights	Rank VRS	VRS pure technical efficiency (PTE)	NIRS	VRS scale efficiency (SE)	Reference weights	RTS	Input Slack (VRS)
					E: 2010					
Industry	6	0.0421	0.5319	6	0.5291	0.6024	0.0796	0.5291	IRS	0.4788
Transport	4	0.1719	0.8936	4	0.8889	0.9344	0.1934	0.8889	IRS	0.2813
Residential	5	0.0789	0.8830	5	0.8783	1.000000	0.0898	0.8783	IRS	0.6951
Commercial and public services	1	1	1	1	1.000000	1.000000	1.000000	*	IRS	*
Agriculture /forestry	3	0.6134	0.9521	3	0.947090	0.951159	0.6477	0.9471	IRS	0.0263
Non-specified	2	0.8373	1.0053	1	1.000000	1.000000	0.8373	1	IRS	*
Average		0.4573			0.8738978	0.914655	0.4746	-		0.3704
					F: 2015					
Industry	6	0.0409	0.5291	6	0.5291	0.6098	0.0772	0.5291	IRS	0.4882
Transport	4	0.1585	0.8836	4	0.8836	0.9498	0.1794	0.8836	IRS	0.3123
Residential	5	0.0896	0.8677	5	0.8677	1.000000	0.1033	0.8677	IRS	0.5818
Commercial and public services	2	0.8951	0.8677	2	0.9947	0.9964	0.8999	0.9947	IRS	0.0085
Agriculture /forestry	3	0.5973	0.9471	3	0.9471	0.9556	0.6306	0.9471	IRS	0.0428
Non-specified	1	1	1	1	1	1	1	1	IRS	*
Average		0.4636			0.8704	0.9186	0.4817			0.2867
					G: 2020					
Industry	6	0.0339	0.5263	6	0.5263	0.6289	0.0643	IRS	0.5263	0.4925
Transport	4	0.1366	0.8684	4	0.8684	0.9516	0.1573	IRS	0.8684	0.2992
Residential	5	0.0761	0.8368	5	0.8368	1	0.0909	IRS	0.8368	0.5384
Commercial and public services	2	0.7357	0.9895	2	0.9895	0.9950	0.7435	IRS	0.9895	0.0220
Agriculture /forestry	3	0.4772	0.9316	3	0.9316	0.9463	0.5122	IRS	0.9316	0.0571
Non-specified	1	1	1	1	1	1	1	IRS	1	*
Average		0.4099			0.8588	0.9203	0.4280			0.2818

Note: *The input slack is negligible ($<10^{12}$); hence, it is ignored while calculating the average figure.
Source: Authors

As per the CRS method in 1990, Residential sector holds 6th rank. But in all other study years, the Industry DMU is ranked 6th, followed by Residential sector (5th) and Transport sector (4th). Agriculture/forestry sector holds 3rd position, preceded by Commercial and Public Services (2nd) and Non-specified is top-ranked (1st). The Non-specified sector is the benchmark sector in carbon efficiency in the DEA-CRS analysis for the years 1990, 1995, 2000, 2015, and 2020. In the years 2005 and 2010, the DMU for Commercial and Public Services is ranked 1 and Non-specified sector is found at 2nd position in relative ranking of DEA-CRS method while the other DMUs hold the same ranks in the years 1995, 2000, 2015, and 2020. The VRS (BCC) method decomposes the overall efficiency into PTE and SE. For example, the PTE of Industry sector in 1990 is 0.5263 (Table 3). Then, pure technical inefficiency = 1 – 0.5263 = 0.4737. Thus, 47.37% output can be increased with the existing energy inputs, i.e., emissions can still be reduced by the same percentage.

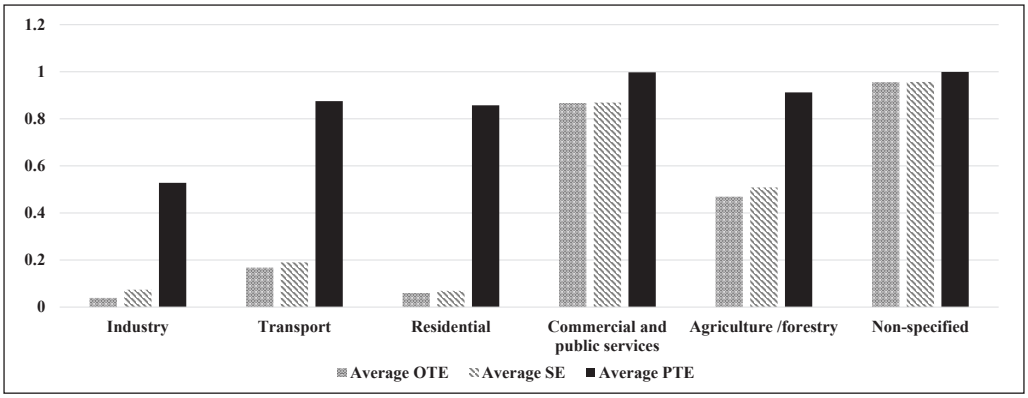
The concept of slack variable arises from the concept of Pareto Efficiency which regards an input-output bundle (x, y) as Pareto efficient on the fulfilment of conditions—firstly, any output is not possible to be increased without reduction of any other output or increase of any other input, and secondly, reduction of any input is not possible without increase of any other input or reduction of some output (Ray, 2004). The problem of slacks in any optimal solution of a radial DEA for technical efficiency in CCR and BCC models arise because of either expansion of all outputs or contraction of all inputs by the same proportion (Ray, 2014). Therefore, any DMU is not Pareto Efficient unless all input and output slacks are zero and when there are presence of input slacks, then for at least one input would be there with no slack variables which is fully efficient (Ray, 2004).

In 1990, the input slack variable in case of Industry sector is 0.2786 (Table 3) which indicates that the inputs can still be reduced even after 17.09 per cent increase in technical efficiency. Similar explanation is applicable for other DMUs in other study years. There are evidences of NDRS as the VRS technical coefficient ≠ NDRS/NIRS technical coefficient in all the years and for all DMUs, implying that there is much scope for output maximisation (i.e., emissions reduction).

In terms of CO_2 emissions reduction, Industry is the least efficient sector due to high consumption of energy (both direct and indirect and lowest PTE and SE scores, followed by Residential and Transport sectors in all the study years. Low overall efficiency scores (CRS-OTE score) of high energy consuming sectors are mainly due to high relative scale inefficiency (= 1 – SE) in comparison to technical efficiency as found in Industry sector, followed by Residential and Transport segments in all the study years. For example, from Table 3, the scale inefficiency in Industrial sector is found to be [(1 – 0.0643) = 0.9357] in 2020. Similarly, residential sector and transport sector have scale inefficiency scores of 0.9091 and 0.8427, respectively, in 2020. Thus, these sectors should optimise the scale of energy input use for minimisation of emissions, i.e., more output can be increased under NDRS situation in the present DEA analysis, i.e., more emissions can be curtailed with the present energy inputs in these DMUs specifically to reach the scale efficiency of CRS.

The value of OTE is derived from DEA-CRS while the value of OTE is decomposed into two non-additive components—PTE and SE by using DEA-VRS method. Figure 4 depicts the average of OTE, PTE and SE in all 6 DMUs for all the study years. The DMU 'Non-specified' is the benchmark DMU with average PTE value (0.9992) and high SE score (0.9568) while the average value of OTE for this DMU is 0.9561. It is closely followed by the DMU Commercial and Public Services with average PTE (0.9976) while the average score for OTE is 0.8672. The DMU Industry is ranked lowest mainly due to very low relative performance in pure technical efficiency and especially in scale efficiency which together pulled down the CRS-OTE score. The sub-optimal scale of operation has caused the low average OTE score in Transport and Residential sectors also.

Figure 4: Average of OTE, PTE and SE in DMUs



Source: Authors

There is much scope for improvement in SE for output maximisation with the given input combination. Average Input Slacks (taking '0' for the slack values < 10^{-12}) in different DMUs for all study years have also been calculated and these slack values imply that energy input can be decreased by that amount for reaching the optimum scale. Highest average input slack value is found for Residential sector (0.7319), followed by Industry (0.3981), Transport (0.2299), Agriculture/forestry (0.0516), Commercial and Public Services (0.0125) and Non-specified sector (0.0099).

5.3 Consistency Analysis

Spearman's Rank Correlation Coefficients on the basis of ranks in CRS and VRS methods are shown in Table 4A and Table 4B. Here,

Spearman's rho= $\rho = 1 - 6\{\sum D^2 / n(n^2 - 1)\}$,

where D = difference between ranks of two series;

$$\text{Spearman's rho} = \rho = 1 - 6\left\{\sum \frac{\left[D^2 + \frac{1}{12}\left(m_i^3 - m_i\right)\right]}{n(n^2-1)}\right\},$$

where m = number of repetitions of any particular rank 'i' and n = number of observations = 6.

Table 4A: Results of Spearman's Rank Correlation Coefficient (ϱ) on DEA-CRS Ranks

	Rank 1990	Rank 1995	Rank 2000	Rank 2005	Rank 2010	Rank 2015	Rank 2020
Rank 1990	1.0						
Rank 1995	0.9429 (0.0048)	1.0					
Rank 2000	0.9429 (0.0048)	1.0 (0.0000)	1.0				
Rank 2005	0.8857 (0.0188)	0.9429 (0.0048)	0.9429 (0.0048)	1.0			

Contd...

Table 4A contd...

	Rank 1990	Rank 1995	Rank 2000	Rank 2005	Rank 2010	Rank 2015	Rank 2020
Rank 2010	0.8857 (0.0188)	0.9429 (0.0048)	0.9429 (0.0048)	1.0 (0.0000)	1.0		
Rank 2015	0.9429 (0.0048)	1.0 (0.0000)	1.0 (0.0000)	0.9429 (0.0048)	0.9429 (0.0048)	1.0	
Rank 2020	0.9429 (0.0048)	1.0 (0.0000)	1.0 (0.0000)	0.9429 (0.0048)	0.9429 (0.0048)	1.0 (0.0000)	1.0

Note: Figures in parentheses are p-values.
Source: Authors

Table 4B: Results of Spearman's Rank Correlation Coefficient (ϱ) on DEA-VRS Ranks

	Rank 1990	Rank 1995	Rank 2000	Rank 2005	Rank 2010	Rank 2015	Rank 2020
Rank 1990	1.0						
Rank 1995	0.9429 (0.0048)	1.0					
Rank 2000	1.0000 (0.0000)	0.9429 (0.0048)	1.0				
Rank 2005	0.8857 (0.0188)	0.7714 (0.0724)	0.8857 (0.0188)	1.0			
Rank 2010	0.9856 (0.0003)	0.9276 (0.0077)	0.9856 (0.0003)	0.9276 (0.0077)	1.0		
Rank 2015	1.0000 (0.0000)	0.9429 (0.0048)	1.0000 (0.0000)	0.8857 (0.0188)	0.9856 (0.0003)	1.0	
Rank 2020	1.0000 (0.0000)	0.9429 (0.0048)	1.0000 (0.0000)	0.8857 (0.0188)	0.9856 (0.0003)	1.0000 (0.0000)	1.0

Note: Figures in parentheses are p-values.
Source: Authors

The Spearman's Rank Correlation Coefficients show that there are positive and statistically significant correlation between Ranks in DEA-CRS and DEA-VRS methods of the DMUs in any two study years which imply that the ranks are consistent over all the study years.

5.4 Inequality Analysis

Following Theil (1967), Lin and Fei (2015) and Liu et al. (2022), the Efficiency Theil Index (ETI) is constructed for detecting inequality in efficiency scores (PTE, SE and OTE) across DMUs over all the study years. Thus,

$$T_t = \sum_{i=1}^{J} \frac{E_{it}}{E_t} \log \left(\frac{E_{it}/E_t}{1/N} \right)$$

where t = time period, T_t = overall Efficiency Theil Index at tth period, N = total number

of DMUs, E_{it}= DEA efficiency scores of ith DMU at tth period and E_t= sum of unified DEA efficiency scores of all DMUs at the tth period. A larger value of T_t [$0 < T_t < \log(N)$] implies that the efficiency level as measured by a particular efficiency measurement (PTE, OTE, SE) is highly different for different sectors or DMUs; thus, the policy makers require to undertake sector-specific carbon efficiency policies to increase the respective efficiency score, which would reduce the inequality. On the other hand, if Ti is low, it requires to undertake general carbon efficiency policies to improve the efficiency levels of all sectors.

Table 5: Efficiency Theil Index of Efficiency Scores

Eff. Measure	1990	1995	2000	2005	2010	2015	2020	Standard Deviation (SD)
PTE	0.00838	0.00811	0.00831	0.00813	0.00827	0.00823	0.00831	0.000092
OTE	0.18109	0.19312	0.21874	0.18153	0.16811	0.17059	0.19087	0.015799312
SE	0.158	0.16482	0.19093	0.15897	0.14589	0.14798	0.15739	0.013799999

Source: Authors

Table 5 shows that both the ETI values and its SD values are very low for PTE, SE and OTE. The ETI values for PTE scores are lower in comparison to that of OTE and SE scores, implying small difference in PTE scores across the DMUs. SD values of ETI for PTE for all years are lower in comparison to SD values of ETI for OTE and SE, implying that extent of inequality in PTE scores across DMUs do not differ much over the study years. Inequality in SE scores is high due to high SE scores in Commercial and Public Services, Agriculture /forestry and Non-specified sector in comparison to other sectors such as Industry, Transport and Residential which need optimisation of scale of operation. Inequality in SE scores results in relatively higher ETI values of OTE scores across the DMUs.

5.5 Sensitivity Analysis

Following methods of Seiford and Zhu (1998) and Limaei (2020), robustness of the result of DEA (CRS and VRS) is checked by applying DEA (CRS and VRS) method after 10% decrease in input variable and 10% increase in output variable. The Spearman's Rank Correlation Coefficients (ϱ) between ranks of CRS (OTE) with original and modified data for all the years is equal to 1, i.e., perfect rank correlation; while that of VRS (PTE) with original and modified data for all the years is also equal to 1, except for the year 1995 ($\varrho = 0.9856$) which is still significant with *p*-value (0.0003), indicating strong rank correlation between VRS ranks of DMUs before and after data modification. Therefore, sensitivity results confirm robustness of DEA (CRS and VRS) rankings.

5.6 Discussion

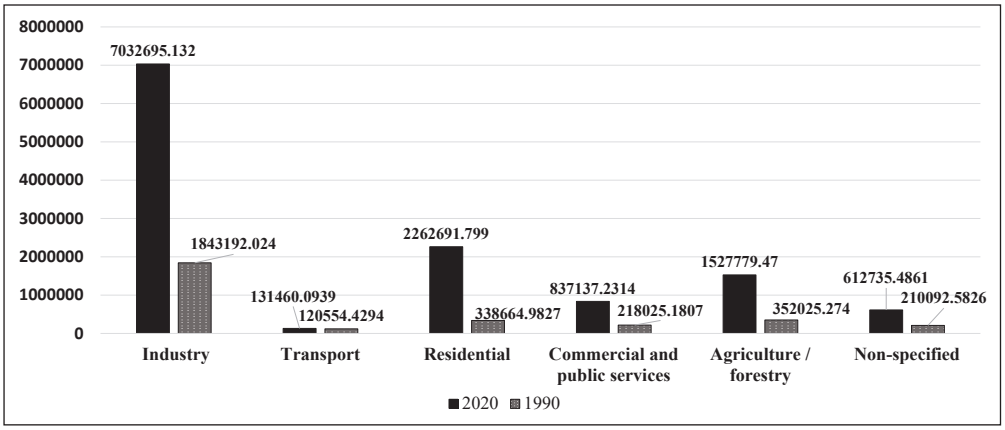
The general Overall Technical Efficiency (OTE) under CRS-DEA is based on TFC and calculated CO_2 emissions which hide energy consumption structure which is different across the DMUs even though fossil fuels hold the major share in all DMUs. Use of coal has increased during 1990-2020 in all sectors (Figure 5), especially in Industry sector (281.5%), because industries like iron & steel, cement, paper, fertilisers, chemicals are dependent on coal for specific processes, which mostly involve firing of the furnaces. Electricity use in Industry increased, leading to increased emissions as indirect coal consumption (738632.024 Tj) was initially lower than direct coal consumption (1104560 Tj) in 1990 but the former (3555044.132 Tj) surpassed the latter (3477651 Tj) in 2020. It resulted in Industry to be ranked at bottom position in efficiency ranking in almost all the study years. Use of

electricity would increase, as there is scope for electrification of more industrial processes, especially, Micro, Small and Medium Enterprises (MSMEs) (Pal and Hall, 2021).

In Transport sector, due to electrification of railways and expansion of surface railways and metro railways, the consumption of electricity increased by CAGR of 5.02% (e.g., electrification in metro transit – 100%, conventional passenger rail activity – 54%, freight activity – 65%).[8] As a result, burning of coal has increased for generation of electricity from 28765.43 Tj to 131460.09 Tj during 1990-2020 in this sector, adding more carbon emissions.

Similarly, the coal indirectly used for meeting high residential sector electricity demand which increased from 223807.98 Tj (in 1990) to 2141494.80 Tj (in 2020) with CAGR of 1.41%, primarily because of increase in electricity access from 50.9% (in 1993) to 96.5% (2020)[9] and increased use of electric appliances.

Figure 5: Sector-wise (Tj) Consumption of Coal (Direct and Indirect)



Source: Authors

Figure 6 depicts that in all the study years, oil consumption is highest in Transport sector (CAGR of 5.16%), where direct oil use has increased due to rise in total registered vehicles (both private and public) from 21.40 million (in 1991) to 295.8 million (in 2019).[10] Use of private vehicles increased due to growing middle class population, increasing urbanisation from 26% (in 1990) to 35% (in 2020) and increased mobility, which would grow further in the event of improvement in Labour Force Participation Rate (48% in 2020).[11]

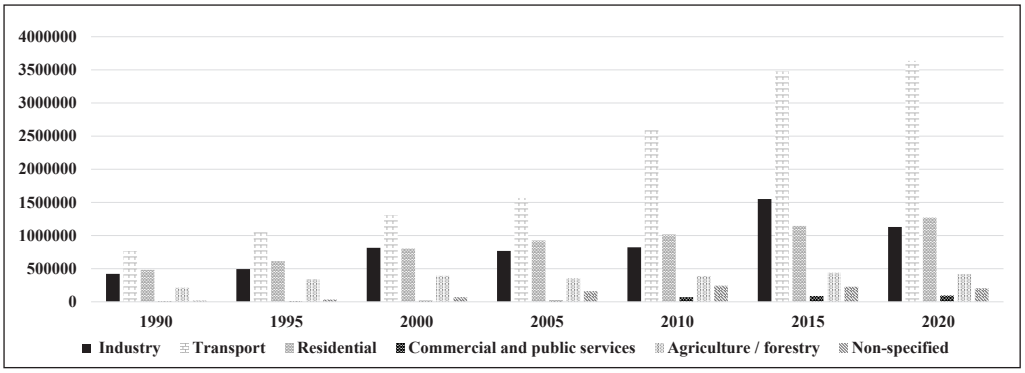
[8] See "Elements of the Electrification Strategy for India", Bureau of Energy Efficiency (BEE), Government of India & EU-India Clean Energy and Climate Partnership (CECP), 2022, pp. 1-70. Available at: https://beeindia.gov.in/sites/default/files/publications/files/Elements%20of%20 Electrification%20Strategy%20for%20India_0.pdf

[9] See: World Bank Open Data.

[10] See "Road Transport Year Book (2017-2018 and 2018-2019)", Government of India, published in 2021. Available at: https://morth.nic.in/sites/default/files/RTYB-2017-18-2018-19.pdf

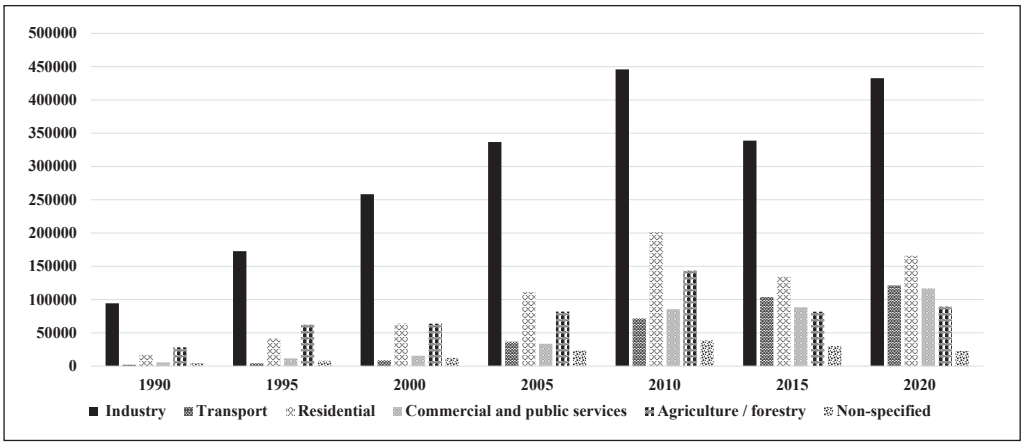
[11] See: World Bank Open Data.

Figure 6: Sector-wise Consumption of Oil Products (Direct and Indirect) (Tj)



Source: Authors

Figure 7: Sector-wise Consumption of Natural Gas (Direct and Indirect) (Tj)



Source: Authors

From Figure 7, it can be seen that direct use of natural gas in Transport sector increased in later years due to introduction of Compressed Natural Gas (CNG) and gradual replacement of the oil products (diesel and gasoline) with natural gas which is to be reducing emissions due to its low relative emissions factor. The Transport sector has already introduced Bharat Stage (BS) – VI fuel standards since April, 2020, under the Vehicle Fuel Efficiency Programme (2014),[12] and India has raised the target of natural gas share from 6.5% to 15% by 2030. Use of natural gas is consistently found to be highest in industry due to direct consumption in industries like fertiliser, etc. Under the City Gas Distribution (CGD) network, 95.21 lakh Piped Natural Gas (PNG) connections to domestic consumers and 4531 CNG stations have been established for transport purpose (as on 31st May, 2022); and under the 'One Nation One Gas Grid', 21,715 km Natural Gas Pipeline network has been operational.[13]

In residential sector, the energy consumption is increasing for high use of Air distribution

[12] See "Elements of the Electrification Strategy for India", 2022.

[13] Press Information Bureau, Government of India.

appliances like fans, coolers, etc. (57% rural and 30% urban), followed by lighting appliances (24% rural and 20% urban)[14] and projected penetration of air conditioning in residential and commercial buildings to 40% by 2037-2038 due to increase in disposable income and temperature rise. Table 6 describes India's policies for carbon efficiency which can help achieve SDGs by 2030.

Table 6: Carbon Efficiency Policies in India

Sectors	Policies	Related SDGs	Implication of policies w.r.t. SDGs	Results
Industry	Perform, Achieve and Trade (PAT) programme: market-based, cost-effective measure for reduction of Specific Energy Consumption in energy intensive industrial sectors, with tradeable certificates of excess energy saving	SDG 7.3: EE improvement with double reduction of energy intensity SDG 12.2: sustainable & efficient management of natural resources measured by material footprint	Resource conservation; emissions reduction vis-à-vis potential output; material footprint reduction of energy resources	Energy savings & Emission avoidance
	National Manufacturing Policy, 2011: Increasing industry share in GDP by 25% by 2022 Make in India: RE & other high energy consuming sectors like thermal power, electrical manufacturing, automobiles, etc.	SDG 8: Inclusive & sustainable economic growth with decent and productive employment SDG 9.2: Inclusive and sustainable industrialisation & increase industry's share in employment and GDP	Inclusive industrial development with employment; high energy consumption requiring sectoral EE improvement and shift of direct & indirect energy consumption to non-fossil fuels	Industry share (including construction): 25.02% of GDP (2020) (*World Bank Open Data*)
Transport	Automotive Mission Plan, 2026: For sustainable, affordable transport system with increased net exports, higher share in GDP (12%) & additional employment (65 million)	SDG 8 & 9	Sustainable Transport system with low vehicular pollution	Transport share in service exports reduced from 21% (1990) to 10% (2020) (*World Bank Open Data*)
	Sustainable Alternative Towards Affordable Transportation (2018): Production of Compressed Biogas (CBG) of 15 million metric ton per annum by 2023-24	SDG 7.2: Substantial increase in share of RE in energy mix	Diversification of energy mix & emission reduction	11,227 ton CBG procured (2022-23) (*Press Information Bureau, Govt. of India*)

Contd...

[14] See "Elements of the Electrification Strategy for India", 2022.

Table 6 contd...

Sectors	Policies	Related SDGs	Implication of policies w.r.t. SDGs	Results
Transport	Ethanol Blended Petrol (EBP) Programme: lower Goods and Services Tax (GST) rate (5%) on ethanol & Govt. fixed procurement price of ethanol produced from C & B heavy molasses, sugar, etc., with blending target of 20% by ESY 2025-26.	SDG 7.2		Increased petrol blending to 8.5% (2020-21) (NITI Aayog, Govt. of India)[15]
	Faster Adoption and Manufacturing of Hybrid & Electric Vehicles in India (FAME India) scheme: incentivising rapid adoption & manufacturing of such vehicles.	SDG 7.3 & 12.2	Reduction of vehicular emission; green manufacturing	2.8 lakh EVs & 520 charging stations till 2019(*Press Information Bureau, Govt. of India*)
Power	National Solar Mission under National Action Plan of Climate Change, 2008 with revised target of 100 GW grid-connected installed solar power capacity	SDG 7.2	Clean energy	Installed capacity of 36.32 GW (October 31, 2020) *(Press Information Bureau, Govt. of India*)
Residential	Market Transformation for EE: Energy efficient Compact Fluorescent Lamps (CFLs) are promoted under Bachat Lamp Yojana (BLY) & technical assistance for LED deployment under 'Unnat Jyoti by Affordable LEDs for All (UJALA)'.	SDG 7.1: universal access to affordable, reliable & modern energy services SDG 12.1: SCP practices, SDG 12.2	Promoting sustainable consumption & reduction of residential sector electricity consumption & fossil fuel consumption	In 2020-21, 28 appliances & more than 15,000 Star-labeled models of energy efficient products caused increased endorsement & savings worth over Rs. 30,000 crore & 46 million Tonnes CO_2 emissions/year (*Press Information Bureau, Govt. of India*)

Contd...

[15] *Roadmap for Ethanol Blending in India 2020-25,* Report of the Expert Committee, NITI Aayog, Ministry of Petroleum and Natural Gas, Govt. of India. Retrieved November 6, 2022, from https://www.niti.gov.in/sites/default/files/2021-06/EthanolBlendingInIndia_compressed.pdf

Table 6 contd...

Sectors	Policies	Related SDGs	Implication of policies w.r.t. SDGs	Results
Agriculture	Pradhan Mantri Kisan Urja Suraksha evem Utthan Mahabhiyan (PM KUSUM): decentralised solar power saving transmission system, other RE generation & reduction of transmission and distribution (T&D) losses	SDG 7.2	Clean energy & emission reduction	89.45 MW small solar plant & 2.09 lakh solar water pump (till Feb., 2023) (*Press Information Bureau, Govt. of India*)
Fiscal Measures	National Clean Energy and Environment Fund (NCEEF): Levy of Rs.400/ton of coal cess but subsumed (2017) in GST compensation fund for meeting revenue shortfall of states till March 31, 2026 (Jayaswal, 2022)	SDG 9.5: Technological upgradation in industries by increased scientific research SDG 12c: Taxation restructuring & removal of environmental impacts & development needs	Increasing share of RE & reduction of fossil fuel dependence	69.42% fund disbursed for RE (2010-18) (*Press Information Bureau, Govt. of India*)
	Deregulation of fuel prices: Petrol in 2010 & Diesel in 2014 (Sreenivas and P.K., 2019).	SDG 12c	Market determined prices eliminated subsidy for these fossil fuels	Higher price of petrol & diesel

Source: Authors

6. Conclusions

Emission of CO_2 is present at different stages of life cycle in production and consumption of goods and services mainly due to high proportion of fossil fuel used in India, despite different policies to improve EE and shift to cleaner fuels. But overall, there are signs of improvement in EE (measured as *Energy Intensity*) from 0.000019 in 1990 to 0.000010 Tj/ US$(2015) in 2020 and decline in Carbon Intensity from 1.22 in 1990 to 0.8105 kg CO_2 / US$(2015) in 2020.[16] Per capita Carbon Emission has increased from 0.607 (1990) to 1.5 t CO_2/Capita (2020)[17]due to higher per capita energy consumption—0.01031 to 0.01811 (Tj/Capita)—attributed to growing consumer demand for goods and services like transportation, and higher access to electricity leading to use of more electric appliances, etc.

The article with a sectoral approach focuses on relative carbon emission efficiency in major energy consuming sectors which is an indicator of achievement of SCP dimensions with special emphasis on Industry. This study used transformed variable of emission as output unlike in an article on BRICS countries, where undesirable output (emission) is used as an input (Castro Camioto

[16] *Energy Statistics Data Browser 2022*

[17] *Energy Statistics Data Browser 2022*

et al., 2016), because it does not reflect the true production process (Jahanshahloo et al., 2005). Moreover, existing literature with DEA application on emission in India either make comparison to other countries (Camioto et al., 2016; Wang et al., 2020) or a particular industry (Singh and Sharma, 2018) or focus on EE (Mandal and Madheswaran, 2009), whereas this article applied DEA method on energy-related emission of different sectors of Indian economy. The method of emissions calculation considered emission generated in production of intermediate electricity input which partially fulfils the Life Cycle Analysis process of generation of emission output in different stages.

The results of CRS and VRS methods of DEA reveal that Industry sector has the lowest relative ranking in terms of OTE and PTE, respectively. The VRS method of decomposition reveals that the SE is low in Industry and in other low-ranking sectors, e.g., Transport and Residential sectors which pulls down OTE and thus require scale optimisation. The slack values reveal that Residential and Transport sectors are using excess energy input (TFC) which can be reduced for making them carbon efficient.

Fuel shifting to clean energy would improve OTE in especially low relative ranking sectors like Industry, Transport and Residential. Share of RE is very low in final fuel consumption (direct) in all DMUs and residential sector registers highest final fuel consumption (direct) of RE due to various policies to expand RE in household sector like rooftop solar PV, solar appliances, etc. Industry is an important linkage sector with respect to other DMUs for Just and Inclusive transition for fulfilment of Paris Agreement commitments. Therefore, for improving the PTE, measures like more R&D expenditure (*% of GDP*) [India – 0.66, USA – 3.01, China – 2.14][18] and reassignment of NCEEF with its original objectives, digitalisation for energy optimisation, Carbon Capture, Utilisation and Storage measures, etc. are needed to make more carbon efficient Industrial production process as well as products produced therein for use in other DMUs as it generates less emissions with input combinations. Electricity would become more important for energy transition due to various electrification policies like Rajiv Gandhi Grameen Vidyutikaran Yojana which was later subsumed in Deen Dayal Upadhyaya Gram Jyoti Yojana and Sahaj Bijli Har Ghar Yojana, over the years. Policy effort for reduction of direct consumption of primary fossil fuels resulted in growth of electric vehicles (EVs), electrification of railways and industrial process, etc.

Share of electricity generated from coal has been consistently highest in all the study years and it increased from 65.34% (in 1990) to 71.52% (in 2020).[19] India is going to depend more on electricity in the coming years, so indirect fossil fuel consumption for electricity production needs to be curtailed by adopting methods of critical and super-critical boilers in coal-fired power plants and reduction of high T&D losses, besides continuation of existing policies for fuel substitution with RE and improvement of EE in different DMUs, for meeting Paris Agreement commitments and fulfilling UN SDGs.

This study has some limitations. For example, lack of GDP data for all DMUs prevents more comprehensive two output DEA analysis and non-availability of price data does not allow allocative efficiency calculation. But in-depth DEA analysis based on different sub-sectors of industry, the least-efficient DMU like mining, construction, textile, iron and steel industry, etc. can be considered for carbon efficiency in this sector.

[18] *World Bank Open Data*, World Bank.

[19] *Energy Statistics Data Browser 2022*.

Acknowledgement

We are grateful to anonymous reviewers of this journal for their valuable comments and suggestions.

About the authors

Satrajit Dutta is an Assistant Professor at the Department of Economics, Gorubathan Government College, Kalimpong, West Bengal, India. **Soumyananda Dinda** is a Professor at the Department of Economics, University of Burdwan, Bardhaman, West Bengal, India.

References

Badunenko, O. and S.C. Kumbhakar (2020), "Energy Intensity and Long- and Short-term Efficiency in US Manufacturing Industry", *Energies*, 13(15).

Banker, R. D., A. Charnes and W.W. Cooper (1984), "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis", *Management Science*, 30(9): 1078-1092.

Castro Camioto, F. de, D. Rebelatto and R.T. Rocha, (2016), "Energy Efficiency Analysis of BRICS Countries: A Study Using Data Envelopment Analysis", *Gestão & Produção* 1(23): 192-203.

Charnes, A., W.W. Cooper and E. Rhodes (1978), "Measuring the Efficiency of Decision Making Units", *European Journal of Operational Research*, 2(6).

Chen, X., X. Zhang, X. Wu and C.C. Lu (2022), "The Environmental Health and Energy Efficiency in China: A Network Slacks-based Measure", *Energy and Environment*, 33(1): 170-188.

Cuadros, S., Y.E. Rodríguez and J. Contreras (2020), "Dynamic Data Envelopment Analysis Model Involving Undesirable Outputs in the Electricity Power Generation Sector: The Case of Latin America and The Caribbean Countries", *Energies*, 13(24).

Czyżewski, B., K. Smędzik-Ambroży and A. Mrówczyńska-Kamińska (2020), "Impact of Environmental Policy on Eco-efficiency in Country Districts in Poland: How Does the Decreasing Return to Scale Change Perspectives?" *Environmental Impact Assessment Review*, 84.

Dar, A.H., S.K. Mathur and S. Mishra (2021), "The Efficiency of Indian Banks: A DEA, Malmquist and SFA Analysis with Bad Output", *Journal of Quantitative Economics*, 19(4).

El Husseiny, I.A. (2022), "The Efficiency of Healthcare Systems in the Arab Countries: A Two-Stage Data Envelopment Analysis Approach", *Journal of Humanities and Applied Social Sciences*. https://doi.org/10.1108/jhass-10-2021-0168

Fang, H., J. Wu and C. Zeng (2009), "Comparative Study on Efficiency Performance of Listed Coal Mining Companies in China and the US", *Energy Policy*, 37(12): 5140-5148.

Färe, R., S. Grosskopf, C.A. Lovell and C. Pasurka (1989), "Multilateral Productivity Comparisons When Some Outputs are Undesirable: A Nonparametric Approach", *Review of Economics and Statistics*, 71(1).

Fare, R., S. Grosskopf, M. Norris and Zhang Zhongyang (1994), "Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries", *American Economic Review*, 84(1).

Fathi, B., M. Ashena and A.R. Bahari (2021), "Energy, Environmental, and Economic Efficiency in Fossil Fuel Exporting Countries: A Modified Data Envelopment Analysis Approach", *Sustainable Production and Consumption*, 26: 588-596.

Fischer-Kowalski, M., M. Swilling, E.U. von Weizsacker, Y. Ren, Y. Moriguchi, W. Crane, F. Krausmann, N. Eisenmenger, S. Giljum, P. Hennicke, P. Romero Lankao, A. Siriban Manalang and S. Sewerin (2011), "Decoupling Natural Resource Use and Environmental Impacts from Economic Growth: A Report of the Working Group on Decoupling to the International Resource Panel", International Resource Panel.

Guaita Martínez, J.M., R. Puertas, J.M. Martín Martín and D. Ribeiro-Soriano (2022), "Digitalization, Innovation and Environmental Policies Aimed at Achieving Sustainable Production", *Sustainable Production and Consumption*, 32: 92-100.

Halkos, G. and K.N. Petrou (2018), "A Critical Review of the Main Methods to Treat Undesirable outputs in DEA", *Munich Personal RePEc Archive*, 90374(5).

Huguenin, J.M. (2012), *Data Envelopment Analysis (DEA): A Pedagogical Guide For Decision Makers in the Public Sector*, IDHEAP.

International Energy Agency (2021), "Net Zero by 2050: A Roadmap for the Global Energy Sector". https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf

IPCC (2008), "2006 IPCC Guidelines for National Greenhouse Gas Inventories: A primer", prepared by the National Greenhouse Gas Inventories Programme, H.S. Eggleston, K. Miwa, N. Srivastava and K. Tanabe (eds.), Japan: Institute for Global Environmental Strategies (IGES).

Jahanshahloo, G.R., F.H. Lotfi, N. Shoja, G. Tohidi and S. Razavyan (2005), "Undesirable Inputs and Outputs in DEA Models", *Applied Mathematics and Computation*, 169(2): 917-925.

Jayaswal, R. (2022), "Govt. may Extend Coal Cess for Green Mission", *The Hindustan Times,* 19 December.

Jiang, M. and J. Li (2022), "Study on the Change in the Total Factor Carbon Emission Efficiency of China's Transportation Industry and Its Influencing Factors", *Energies*, 15(22).

Koopmans, T.C. (1951), "An Analysis of Production as an Efficient Combination of Activities". In *Activity Analysis of Production and Allocation*, T. C. Koopmans (ed.), pp. 33-97, Cowles Commission for Research in Economics Monograph No.13, New York: John Wiley.

Kumar, S. and R. Gulati (2008), "An Examination of Technical, Pure Technical, and Scale Efficiencies in Indian Public Sector Banks using Data Envelopment Analysis", *Eurasian Journal of Business and Economics*, 1(2): 33-69.

Lee, P. (2022), Ranking Decision Making for Eco-Efficiency Using Operational, Energy, and Environmental Efficiency", *Sustainability*, 14(6).

Levin, K., T. Fransen, C. Schumer, C. Davis and S. Boehm (2023), "What Does 'Net-Zero Emissions' Mean? 8 Common Questions Answered", World Resource Institute. https://www.wri.org/insights/net-zero-ghg-emissions-questions-answered

Limaei, S.M. (2020), "Efficiency Analysis of Forest Management Units Considering Economics and Carbon Dynamic: A Data Envelopment Analysis (DEA) Approach", *Austrian Journal of Forest Science*, 137(3).

Lin, B. and R. Fei (2015), "Regional Differences of CO_2 Emissions Performance in China's Agricultural Sector: A Malmquist Index Approach", *European Journal of Agronomy*, 70.

Liu, W.B., W. Meng, X.X. Li and D.Q. Zhang (2010), "DEA Models with Undesirable Inputs and Outputs", *Annals of Operations Research*, 173(1).

Liu, X., Y. Liu and B. Wang (2022), "Evaluating the Sustainability of Chinese Cities: Indicators Based on A New Data Envelopment Analysis Model", *Ecological Indicators*, 137.

Liu, Z., Y. Geng, H. Dong, J. Wilson, T. Micic, R. Wu, X. Cui, Y. Qian, W. You and H. Sun (2018), "Efficient Distribution of Carbon Emissions Reduction Targets at The City Level: A Case of Yangtze River Delta Region", *Journal of Cleaner Production*, 172.

Mandal, S.K. and S. Madheswaran (2009), *Measuring Energy Use Efficiency in Presence of Undesirable Output: An Application of Data Envelopment Analysis (DEA) to Indian Cement Industry, Working Paper 235*, The Institute for Social and Economic Change, Bangalore (ISBN 81-7791-191-0; 235).

Mohammadi, A. and H. Ranaei (2011), "The Application of DEA Based Malmquist Productivity Index in Organizational Performance Analysis", *International Research Journal of Finance and Economics*, 62.

Pal, P. and W. Hall (2021), *Potential for Electrifying Indian MSMEs*, The Energy and Resources Institute. https://www.teriin.org/sites/default/files/2021-07/potential-for-electrifying-Indian-msme.pdf

Pittman, R.W. (1983), "Multilateral Productivity Comparisons with Undesirable Outputs", *Economic Journal*, 93(372). 3

Ratner, S., A. Lychev, A. Rozhnov and I. Lobanov (2021), "Efficiency Evaluation of Regional Environmental Management Systems in Russia Using Data Envelopment Analysis", *Mathematics*, 9(18).

Ray, S.C. (2004), *Data Envelopment Analysis: Theory and Techniques for Economics and Operations Research*, Cambridge: Cambridge University Press.

Ray, S.C. (2014), "Data Envelopment Analysis: An Overview", *Working Paper 2014-33*, Department of Economics, University of Connecticut.

Seiford, L.M. and J. Zhu (1998), "Sensitivity Analysis of DEA Models for Simultaneous Changes in All the Data", *Journal of the Operational Research Society*, 49(10).

Seiford, L.M. and J. Zhu (2002), "Modeling Undesirable Factors in Efficiency", *European Journal of Operational Research*, 142: 16-20.

Shah, W.U.H., G. Hao, H. Yan, N. Zhu, R. Yasmeen and G. Dincă (2023), "Role of Renewable, Non-renewable Energy Consumption and Carbon Emission in Energy Efficiency and Productivity Change: Evidence from G20 Economies", *Geoscience Frontiers*. https://doi.org/10.1016/j.gsf.2023.101631

Shah, W.U.H., G. Hao, H. Yan, R. Yasmeen and Y. Jie (2022), "The Role of Energy Policy Transition, Regional Energy Efficiency, and Technological Advancement in The Improvement of China's Environmental Quality", *Energy Reports*, 8.

Shen, Z., T. Baležentis and M. Vardanyan (2022), "Evaluating Green Productivity Gains with the Exponential By-Production Technology: An Analysis of the Chinese Industrial Sector, *Environmental Modeling and Assessment*, 27(5).

Shimizu, M. and O. Tiku (2023), "Evaluation of Environmental Energy Efficiency and Its Influencing Factors: A Prefecture-Level Analysis of Japanese Manufacturing Industries", *Journal of Economic Structures*, 12(1).

Singh, A. and B. Sharma (2018), "DEA Based Approach to Set Energy Efficiency Target Under PAT Framework: A Case of Indian Cement Industry", *Central European Review of Economics and Management*, 2(1):103-132.

Sreenivas, S. and P.K. Manoj (2019), "Fuel Pricing Policy of India: Aftereffects of Deregulation", *International Journal of Analytical and Experimental Modal Analysis,* 11(12): 1678-1688.

Sueyoshi, T. and M. Goto (2020), "Performance Assessment of Japanese Electric Power Industry: DEA Measurement with Future Impreciseness", *Energies*, 13(2).

Taherzadeh-Shalmaei, N., M. Rafiee, A. Kaab, M. Khanali, M.A. Vaziri Rad and A. Kasaeian (2023), "Energy Audit and Management of Environmental GHG Emissions Based on Multi-Objective Genetic Algorithm and Data Envelopment Analysis: An Agriculture Case", *Energy Reports*, 10.

Tapio, P. (2005), "Towards a Theory of Decoupling: Degrees of Decoupling in the EU and the Case of Road Traffic in Finland between 1970 and 2001", *Transport Policy*, 12(2): 137-151.

Wang, C.N., H.P. Hsu, Y.H. Wang and T.T. Nguyen (2020), "Eco-Efficiency Assessment for Some European Countries Using Slacks-based Measure Data Envelopment Analysis", *Applied Sciences*, 10(5).

Wang, C.N., Q.C. Luu and T.K.L. Nguyen, (2018), "Estimating Relative Efficiency of Electricity Consumption in 42 Countries during The Period of 2008-2017", *Energies*, 11(11).

Wang, L.W., K.D. Le and T.D. Nguyen (2019), "Assessment of The Energy Efficiency Improvement of Twenty-Five Countries: A DEA Approach", *Energies*, 12(8).

Yuan, P., S. Cheng, J. Sun and W. Liang (2013), "Measuring the Environmental Efficiency of The Chinese Industrial Sector: A Directional Distance Function Approach", *Mathematical and Computer Modelling*, 58: 5-6.

Zhang, N., P. Zhou and C.C. Kung (2015), "Total-Factor Carbon Emission Performance of the Chinese Transportation Industry: A Bootstrapped Non-Radial Malmquist Index Analysis", *Renewable and Sustainable Energy Reviews*, 41.

Zheng, Z. (2021), "Energy Efficiency Evaluation Model Based on DEA-SBM-Malmquist Index", *Energy Reports 7*.

Zhou, W., M. Bostian, R. Färe, S. Grosskopf and T. Lundgren (2021), "Efficient and Sustainable Bioenergy Production in Swedish Forests: A Network DEA Approach", *Data Envelopment Analysis Journal*, 5(2): 363-394.

Zhou, Z., A. Zachariah, D. Conathan and J. Kline (2022), "Assessing Resource-Performance Trade-off of Natural Language Models Using Data Envelopment Analysis", Proceedings of the 3rd Workshop on Evaluation and Comparison of NLP Systems, pp.11-20, November, Association for Computational Linguistics.

Anvesak
Vol. 53(2), 2023, pp. 29-40
Received: 21 Nov 2023; accepted: 8 Dec 2023

FEMALE FARMERS ACCESSING OPPORTUNITIES THROUGH AN EMERGING LAND MARKET IN TANZANIA

MEINE PIETER VAN DIJK*

Maastricht School of Management, Maastricht University, Maastricht, The Netherlands

Abstract: A land market is emerging in Tanzania. To assess its effects on female farmers, a survey has been undertaken. The transformation process started by creating the right ecosystem through initiating frugal innovations (a crop insurance) and allowing private initiatives and thus may lead to a green revolution. To what extent do farmers benefit from this new ecosystem? The results show that they are benefitting less than the male farmers, because they have access to less land and focus on horticultural production for household consumption instead of using the hybrid maize seeds and complementary inputs, needed for commercial production. However, the land market, the specialization in horticulture and the number of projects for women in this sector provide opportunities for women to improve their situation.

Keywords: Land governance; Female farmers; Emerging land market; Hybrid maize; Frugal innovation; Green revolution

Introduction

Climate change resulting in increased drought periods in Tanzania contributes to the problems of farmers. However, their core problems are low agricultural productivity and degradation of the soil. Farmers need to move from traditional to modern ways of agriculture. Private sector initiative can help them (through commercial and non-commercial organizations), for example, by providing crop insurance to farmers who are willing to make the transition to hybrid maize (maize being an important staple food in the country). Van Dijk (2002) analyzes how a land market is emerging in Tanzania, triggered by changes in land governance, reform of land legislation and modernization of agriculture. These changes also influence female farmers, who may own less land but can lease-in additional land more easily.

Tanzania had 60 million population in 2020. There is no acute scarcity of land; rather water is becoming a bottleneck in certain parts of the country. The low productivity of many small farmers is a problem in Tanzania, impacting on both the household income and the food security of the

*Correspondence to: Meine Pieter van Dijk, Professor Emeritus in Economics, Maastricht School of Management, Maastricht University, Tapijnkazerne 11, 6211 ME Maastricht, The Netherlands. Email: meinepietervandijk@gmail.com

country. Agricultural development is stimulated by the government and helped by new opportunities of export to countries of the East African Community (EAC, a free trade organization) to which Tanzania belongs. 54% of Tanzania's land is classified as agricultural land, of which 14.3% is arable, 2.3% is covered with permanent crops and 27.1% is permanent pasture (World Bank, 2014).

To assess the effects of this transition on modern agricultural practices and a functioning land market for male and female farmers, a survey has been undertaken in the Arusha, Mwanza and Iringa regions. In total, 200 farmers were interviewed, of which 80 were female farmers. We used cluster sampling, with the villages as sampling unit; and then selected farmers' households in each village at random. In each village, a stratified sampling of farmers was undertaken, with the objective of interviewing adequate number of female farmers, say 50% of the total sample (see Table 1). Finally, farmers have been interviewed to analyze the effects of the changes mentioned on female farmers. As indicated, we wanted to interview as many female as male farmers through stratification, but it ended up with 60/40 for male/female. In fact, there was a substantial difference per region. Some 55% women were interviewed for the NGO called One Africa Fund (1AF) in Iringa region; 10% women for the organization Mviwata in the Arusha region; and 31% women in the Mwanza region for a seed company (SeedCo) which provided an insurance to the local farmers.

Daley (2005a) notes that, in Tanzania, "[t]here has been a notable lack of attention to gender issues within the emerging literature on land deals, in effect a state of 'overwhelming gender blindness'…. Such "blindness" has been particularly the case with respect to the literature on land deals for biofuels—a key driver in Africa and Asia". Another reason to interview a lot of female farmers is that they seem to be underrepresented in the official statistics. In the literature, women score better than men in repaying micro loans. Could they also be better customers for micro insurance? Finally, the question is: whether there really is a new potential for these women because of more frugal innovations and the developments mentioned.

Table 1: Gender of Interviewed Farmers

	Frequency	Percent
Male	120	60
Female	80	40
Total	200	100

The crop insurance project introduced a frugal innovation. It combined the use of available hybrid maize seed, with a loan and technical assistance, and used a Weather Index Insurance (WII) based on available satellite images to determine whether rains were insufficient in the areas concerned during the agricultural cycle (planting, germination and ripening). If less rain than normal is observed, farmers registered through their mobile phones will be compensated for the loss of money spent on hybrid seed and fertilizers. This can happen by topping up the credit on their mobile phones, which they can use for money transfers, something that is possible due to MPesa type payment systems (Wellen and Van Dijk, 2018). This is a typical frugal innovation, using a combination of existing technologies in an intelligent way (Onsongo and Knorringa, 2020). This was possible because most farmers in Africa now have a mobile phone. They can insure a bag of hybrid seed bought from SeedCo (the seed company) by sending an SMS message. It would only cover the germination period (the first 28 days) in this case. Alternatively, they can sign up for a package of inputs for one acre of land provided through a non-governmental organization (the One Africa Fund or 1AF); or they can use a commercial intermediary to get a crop insurance policy.

The research is concerned specifically with the impact of crop insurance introduced with the support of the Swiss Capacity Building Facility (SCBF, an international NGO, working with the local 1AF). Its effects on household income and assets and on agricultural productivity have been assessed. The local NGO contributed to the training of thousands of male and female farmers about crop insurance and more than 30,000 farmers were insured against a lack of rainfall for their hybrid seeds in the three regions studied. Our research wanted to find out to what extent this is a step towards a green revolution in Africa (Van Dijk, 2022).

Although most farmers do not know how much they pay for the insurance, they are generally positive about it. Insurance offers a feeling of security and the intermediary organizations reduce the loan provided to buy hybrid seed, inputs and an insurance for a rainfall related crisis. Some farmers were critical because no payments were made despite limited rains, or the pay-outs were too low. They want support to find better markets for their produce and transparency concerning calculation of payouts.

The agricultural transformation process in Tanzania started by creating the right ecosystem through legislation. In this eco-system, frugal innovation blossomed, using existing satellite images for rainfall data and mobile telephones for taking an insurance and doing the payouts. The system allowed private (commercial and non-commercial) initiatives in the field of finance and insurance to work together. This created new opportunities, also for women.

The paper first summarizes the issues, formulates the research questions, and also provides a theoretical framework and the research design. The introduction of a frugal innovation that may contribute to a green revolution is discussed. Subsequently, the survey data are presented and an answer is provided to the research questions. After a discussion section, where the results are related to the theory, some conclusions are drawn and some recommendations are given at the end.

The Issues: Women Rights to Land in Tanzania

In 2023, during the International Women's Day (IWD), all newspapers in Tanzania paid attention to IWD. The local newspaper *The Guardian* (8 March, 2023) published two interesting articles on women's ownership of land, which will be used to describe the issues at stake.

In an article titled "Her Land, Her Rights: Advancing Gender Equality and Land Restoration Missions", Meza (2023) writes that "when it comes to land, gender inequalities are pervasive". The situation can be summarized as half of the global agricultural workforce is female, but less than 20 percent of all landowners are women. In the Middle East and North Africa, only 4 percent of women hold land titles. In many countries, women cannot inherit the land of their husband under customary law or because of religious practices. Women are discriminated not only concerning land use and ownership, but also in decision making, in obtaining loans and getting equal pay as men.

Meza (2023) adds that even if women have property rights they often have smaller plots and less fertile land, a statement we will verify for Tanzania with the data from our survey. She also claims that if men and women have equal land tenure rights, women are more likely to invest in soil conservation and sustainable land management. These are the hypotheses to be tested.

The Land Situation in Tanzania and Theoretical Framework

Daley (2005b) traces the historical development of land tenure in Kinyanambo village, Mufindi District, in Tanzania. She suggests that even before 1990 there was already a gradual commoditization of land and the evolution of a predominantly individualized land market. Both processes have been influenced by the long-term commoditization of agriculture and social reproduction:

Local land tenure practices evolved more or less independently of national land tenure policy until 1974, when villagization altered the evolutionary path of local land tenure, marking a fundamental turning point in people's understandings of their land rights... it created conditions for the rapid and more spatially concentrated growth of the local population, for urbanization, and for associated changes in livelihoods, land use, and relations between people and land.

The result is in line with the economic reforms of that period of structural adjustment and liberalization. By 2000, the village she studied had a 'deep-rooted, widespread and socially legitimate market in land'. During the 1990s, the emphasis in Tanzania was on attracting foreign investment, privatisation and restructuring of the public sector (Van Dijk, 2009). Daley (2005b) adds that, in 1992, the country introduced multi-partyism and a separation of the governing party and the state. She notes that land became a pressing public issue and a Presidential Land Commission was established leading to the National Land Policy, adopted in 1995 and enacted in 1999. She concludes that although the new acts were not implemented before 2000, that land practices showed increasing local commoditization of land despite the official statement that "in Tanzania we do not sell land".

Tanzania faces currently a number of challenges concerning landownership such as farmer-pastoralist conflicts (Kariuki et al., 2021), tenure disputes (Simbarashe, 2012) and alienation of peasants (Chachage, 2010), although Tanzania passed a series of land laws and regulations in 1999 that granted customary rights of occupancy equal status to other property rights, or de facto ownership of land. Biddulph and Hillbom (2020) summarize it as: "the law offers registration of private interests in the form of certificates of customary rights of occupancy" (CCROs). These CCROs fit within a broader community land approach in Tanzania. However, Kabigia et al. (2021) are critical about the CCRO system, suggesting that the neo-cadasters in Tanzania, which partly replace customary land institutions, are not yet effective or sustainable. People having them have "less benefited from accessing loans, formalization has not freed rural people from land disputes and still people have immense trust in customary practices".

Explanatory factors reside around low value of produced CCROs and the bank's mistrust of CCROs because they are not linked to national land management systems. Also, approaches of formalization are donor dependent and in conflict with customary perceptions of security of land tenure systems. These findings suggest that the reforms have only established new institutional forms but that these are not sustained nor integrated in customary procedures. Hence, land tenure security is not sufficiently improving. These findings call for a more detailed evaluation of the assumed benefits of the technological and organizational set-ups and of the assumed causal relation between land registration and tenure security for male and female farmers. Do female farmers benefit, measured in terms of the size of their land, from the crops they chose to grow; earn the revenue from their activities; and improve their wellbeing at the household level?

Another relevant finding is that the issuance of CCROs to women needs to be speeded up. It gives these women a proof of ownership and they make ownership more secure (Mfugale, 2023). This requires also regular land surveys and the use of more advanced information and communication technology (ICT). Mfugale mentions that there are also cases where women have given their CCROs to their husbands, wanting to have nothing to do with them. We will study what this means for the functioning of the land market in the rural areas (see also Yefred, 2005). The issue has also been studied by Hayuma and Conning (2004), who were looking at the effects on competitiveness in the private sector of Tanzania's land reform and land policies.

In fact, Hayuma and Conning (2014) also studied Tanzania's land policy and land reform. The reforms created the conditions for the development of a land market. However, women continue

to face barriers to accessing land resources, which limits their ability to improve their livelihood. Women need to know that they have rights to own land, they need help to resolve land disputes and in certain cases the barriers that prohibit women from owning land need to be reduced.

Van Dijk (2022) showed that agricultural modernization can be a driver to different land use and affect the functioning of the land market. Demand for land increased in Tanzania. Because of liberalization of land rights, land can be bought or leased, something the more successful farmers do. Did this also increase the chances of women to use, rent or buy land? The theory of unequal opportunities for women will be used.

Female farmers tend to own less land, have less education and fewer opportunities to develop their farm. Consequently, their income from farming tends to be lower. Table 2 summarizes the assumed causes for unequal opportunities for women and we will look for indicators how these factors are related to each other. The factors can be considered as hypotheses concerning unequal access for female farmers to land, inputs, loans and assistance, resulting in different types of farms, using less land and resulting in smaller rewards from agriculture.

Table 2: The Assumed Causes for Unequal Opportunities for Women

Mechanisms	Resulting position of female farmers
Traditions and the heritage system	Women own less land
Boys were given more chances	Women have less education
Education is an important explanation of the level of farmer's income	Female farmers earn less
Extension work tends to be directed to male famers	Women have fewer opportunities to develop their farm

The Research Questions and Methodology

Land is an important asset for farmers and our study analyses the role of land, owned or leased, and the prices paid for land. Also, the role of the size of the holdings was analysed to find out whether there is something like a functioning land market in Tanzania and whether bigger farmers enjoy more opportunity to get hybrid seeds and inputs and to insure themselves for crop failure. The research also identified the importance of land policies for the success of the introduction of crop insurance for maize farmers in Tanzania and looked at the emerging ecosystem.

The following research questions were formulated:

- What is the profile of female farmers?
- Do women have the same access to resources such as land, credit and crop insurance as men have?
- What are the effects of the land policies, the emerging ecosystem and the promotion of a frugal innovations on the functioning of land markets for female farmers?
- What is the story behind the growing importance of women in agriculture?

A Green Revolution Using Frugal Innovation: Crop Insurance for Tanzanian Farmers

What is the best way to help traditional small maize farmers in Tanzania to increase their production? A crop insurance project in Tanzania showed great success in decreasing the vulnerability of these farmers to drought through a simple frugal innovation called Weather Index Insurance. The insurance

reduces their risks. In addition, a transition from traditional to hybrid seeds is recommended to further decrease vulnerability and increase agricultural productivity.

Droughts occur more frequently in Tanzania, but low agricultural productivity requires local extension services, which are not functioning properly (Lamek, 2016). Farmers are still using traditional seeds instead of hybrid seeds, which could contribute to achieving food security in the country. A non-commercial private sector initiative is helping these farmers by providing crop insurance. Between 2011 and 2014, the Swiss Capacity Building Facility (SCBF), a non-governmental organization (NGO) financed by ten Swiss insurance companies, funded four training projects in Tanzania aiming to familiarize maize farmers in the Iringa, Mwanza and Arusha regions with crop insurance.

No real new technological options were introduced to reach as many farmers as possible at minimum cost. The project used a Weather Index Insurance (WII) based on existing satellite images to determine whether drought prevailed in the area concerned during the seeding, germination or ripening period. If the signal is less rain than normal, the farmers registered through their mobile phones are compensated for the damage, ideally by topping up the amount available for calling or making mobile phone payments. This is a frugal innovation (using existing technology), because farmers can insure using their telephone as little as one bag of hybrid seed bought from the seed company (SeedCo), covering only the germination period, or through signing up for a package for one acre of land through NGOs. The training projects were carried out by Acre Africa (AA), an international NGO, with a local affiliate (Acre Tanzania). The project contributed to the training of thousands of farmers in the three regions studied. In total, more than 20,000 farmers are insured in the Iringa region and more than 10,000 in the Mwanza and Arusha regions taken together.

In this study, different ways of supplying insurance were compared. Farmers supported by a local NGO, the One Acre Fund (1AF), showed that insurance is particularly useful if it is embedded in an institutional support structure that is non-commercial and close to the farmers, not using a profit-oriented intermediary (SeedCo); or a combination of a commercial and non-commercial organisations also led to greater success. All modalities insure the final risks with a local commercial insurance company and a re-insurance company.

Most of the farmers did not know how much they pay for the insurance; but were generally positive about it, since the insurance offers a feeling of security and the intermediary organization reduces the loan in case of a crisis. However, as said, some farmers were critical because no payments were made despite limited rains, or the payouts were too low. They wanted support to find better markets for their produce and more transparency concerning payouts. Transition from traditional to hybrid seeds was required to achieve food security and to make a step towards a green revolution.

The Survey Results for Female Farmers

- **What is the profile of female farmers?**

Who is the average farmer in our sample? Both men and women are working in the field. This was the reason for us to interview as many female farmers as male farmers, if possible. The average age of farmers is 47.6 years (female plus 6 months and male minus 6 months). He/she has a family of, in total, 6.6 people (female farmers have 0.6 persons less and male farmers 0.6 persons more in their households; see Table 3). This may reflect in the number of husbands who migrated, or sons going to school in town, or working elsewhere.

Table 3: Differences between Male and Female Farmers on Key Agricultural Variables

Variables	Average for all farmers	Male farmers (average)	Female farmers (average)
Household size	6.69	7.30	5.76
Age	47.57	47.12	48.19
Number of years of education	6.76	7.02	6.58
Qualitative evidence of innovation	Farmers have taken up hybrid seed and insurance	More land used for maize	More land used for horticulture, more projects
Improvement of the quality of soil, qualitative evidence	Traditionally, not much attention to soil quality	For hybrid maize, some ploughing and fertilizers are used	For horticulture more attention is given to soil fertility

Table 3 gives differences between male and female farmers. Not only the empirical findings in terms of their age (women are a year older at the average) and household size (female farmers' households count 1.5 persons less) are different, but, more significantly, their education levels are also different. Women went at the average almost half a year less to school. In total, 13 farmers have not been at school, while 84% went to primary school. 18 farmers have secondary education, while two have been to university.

In total, 18 (i.e., 9%) farmers had no mobile phone at all, or it was stolen, or broken down, or had no balance/credit in it. As many as 163 (i.e., 81.5%) farmers had a simple mobile phone, while the remaining (i.e., 9.5%) farmers had smart phones with internet. Male farmers had more often mobile telephones than female farmers. They use different providers. The farmers in Iringa, whom we asked explicitly whether they used the phone for payments, almost always answered "yes". Certain providers tend to be strong in certain regions. The data show some improvements in land registration, although the new land policies are not implemented in every part of Tanzania to the same extent.

Female farmers are forced to innovate because they have less land at their disposition and are using modern seeds for many fruits and vegetables, which require additional inputs and attention. New land policies allowed female farmers to lease land and grow more fruits and vegetables, but these require innovation. The women need new skills to adapt to the new eco-system; however, the women who are growing traditional crops may not require the same.

- **Do women have the same access to resources such as land, credit and crop insurance as men have?**

Table 4 indicates that a land market is working and also benefits women. Women are more into growing fruits and vegetables and they have to do farming because men have often left the rural areas. The women have to bear the responsibility of feeding the children and also providing education to the children.

Interviewed farmers owned at the average 4.98 acres of land during the first year and 5.22 acres during the second year (Table 4). Female farmers had only 3.84 acres in the first year and 3.95 acres in the second year.

In 1999, Tanzania passed a series of land laws and regulations that granted customary rights of occupancy equal status to other property rights, or de facto ownership. In a number of cases farmers had bought additional land. 28 farmers had no land during the first year and the others would then have 5.79 acres of land at the average. In the second year, the average size of the farmers owning

land was 6.03 acres. There are around 30 landowners owning more than 10 acres of land. 45 farmers have leased-in land, of which 28 do not own land. In the first year, the average size of leased-in land was 8.3 acres and in the second year, 6.2 acres (possibly because they bought land or found out that one needs less land when using hybrid seeds). Hence, farms are relatively small, but land is available. Only some farmers went into hybrid seeds in a big way in the second year and they often suffered from the poor rains that year. In general male farmers added more land during the second year than the female farmers.

Table 4: Land Owned and Land Leased-in between 2015-16 and 2016-2017 in Acres

Year and change between the two time periods	Land owned (average)	Male farmers (average)	Female farmers (average)	Leased-in land (average)	Male farmers leasing-in (average)	Female farmers leasing-in (average)	Number of farmers leasing-in (27 male and 14 female)
Year 1 (2015-2016)	4.98	5.74	3.84	6.78	1.03	1.39	41, of which 28 do not own land, while 13 added
Year 2 (2016-2017)	5.22	6.07	3.95	10.39	2.31	2.50	46, of which 27 owned no land, while 19 added
Change between the two time periods	+0.24	+0.33	+0,11	+3.61	1.28	1.11	5 more farmers lease land (4 men)

Female farmers own less land, but lease-in more land and more often in relative terms. Spending more energy on horticulture, they may produce in a more intensive way. However, part of that production is meant to feed their children and other household members.

- **What are the effects of the land policies, the emerging ecosystem and the promotion of a frugal innovations on the functioning of land markets for female farmers?**

Table 5 summarizes some of the agricultural indicators, such as inputs used, maize produced and monthly income. Female farmers used more inputs in both year one and year two. However, they produced less maize, which suggests that their land may be used for other purposes and the women often use different inputs for their vegetables and fruits. Also, monthly income is significantly lower for the female farmers. This may reflect that they use some of the fruits and vegetables produced for feeding their households.

Female farmers are certainly not more successful in terms of the quantity of maize produced and their monthly declared income. However, the real story is that there is also potential for developing horticulture for women, because a number of projects are focussing on female farmers and a lot of information is made available on how to grow fruits and vegetables. They also tend to be more innovative.

- **What is the story behind the growing importance of women in agriculture?**

The question is to what extent female farmers benefited from this new ecosystem, measured in terms of the size of their land, the crops they chose to grow, the revenue earned from their activities and their wellbeing at the household level. The results show that they are benefitting less than the male farmers, because they have access to less land and focus on horticultural production for

household consumption instead of using more hybrid maize seeds and complementary inputs with an objective of selling the output in the market (i.e. commercialisation). They may benefit from the assistance provided by NGOs and they seem to be trained more in making agriculture sustainable.

Table 5: Agricultural Inputs and Outputs and Resulting Income

Inputs/Outputs/Income	All farmers	Male farmers	Female farmers
Inputs used, year 1 (in TSh)*	283,825	258,317	322,088
Inputs used, year 2 (in TSh)*	327,450	293,333	380,375
Maize produced (kg), year 1	1922.76	2027.65	1765.43
Maize produced (kg), year 2	2252.90	2380.76	2068.56
Monthly income (in TSh)	92,161	119,342	50,663

Notes: Assuming 50% of the land is used for maize. * Mainly seeds and fertilizers (in Tanzanian Shilling).

The turnover of five farmers in year one was zero because these farmers did not grow maize in that year. In 9 cases, we could not get an answer. The remaining 186 had an average turnover of 1,060,000 TSh. The turnover of only two farmers in the second year was zero because these farmers claimed not to have harvested any maize because of the drought. In one case, we could not get an answer, while the remaining 197 had an average turnover of 1,079,000 TSh, which is slightly more than in the first year, despite the poor weather conditions and the lower average price of the output in the second year.

The story is that the husbands have gone away to study or work in town. Women have to take care of the children; hence, they go into agriculture and horticulture to feed their children. Often they are young, divorced or retired and benefit from many government as well as NGO programmes meant for rural development. Outside agriculture or horticulture, there are limited other employment opportunities in the rural areas. The women see opportunities in growing vegetables and fruits, which the traditional farmers find more difficult because of the lack of required skills and capital. In summary, they also benefit from the new opportunities to lease-in land and improve horticulture, but not as much as the male farmers. The results are summarized in Table 6.

The female farmers rely more on other crops, like fruits and vegetables, which are partially for the household consumption, but can also be very promising if marketed. We interviewed a few very dynamic female farmers, like the ones who have increased the size of land (by leasing-in) from 30 acres to 120 acres in one year!

This is a striking number of women workers who are working for other farmers. Most farmers hire a group of workers to prepare the land, or for sowing, weeding or harvesting. At the average, they employ 3.2 men and 1.9 women, paying about 3000 TSh per day. Poor farmers depend on their family labour, on *ujama* (traditional solidarity groups), or new groups set up, for example, by 1AF. These groups help each other without payment. The main cost of input attributes to the hybrid seed in the case of SeedCo (11,000 TSh for an acre), or for the package of fertilizer, technical advice, or an insurance. The 1AF charges 235,000 TSh (100 Euros) for a package for 1 acre in the form of a loan to be repaid in a period of ten months.

Table 6: Negative and Positive Factors Influencing the Situation of Female Farmers in Tanzania

Negative factors	Positive factors
Female farmers are often alone, because their partner died, migrated or divorced them	A land market has emerged
Traditional customs favour male farmers	Women show agency, when forced by the circumstances
Access to land, education and other assets such as agricultural equipment and mobile telephones is more difficult for female farmers	Many projects are targeted to female headed households
Women have to perform other duties in the house, like cleaning, caring for children, sick people and elderly family members	Female farmers focus on fruits and vegetables, which have a huge potential in an urbanizing and growing economy
	They benefit more from technical assistance and may be more innovative, which is encouraged in horticulture
	They are more concerned about sustainable agriculture

Discussion

Different indicators show that the female farmers own less land and less fertile land and, in that sense, they are disadvantaged. The male farmers are still dominating the local society. However, the land laws and regulations that granted customary rights of occupancy, equal status to other property rights, or de facto ownership in Tanzania, have made the functioning of a land market possible. However, external drivers were necessary to trigger an emerging land market, which is also the result of migration (less labour is available in the rural areas and hence people do not use all their land). Frugal innovations as described and their introduction through private sector initiatives (NGOs and private companies) played an important role.

The process can be summarized as follows: creating the right policy framework, stimulating the development of an ecosystem, allowing private (commercial and non-commercial) initiatives and looking for a smart combination of existing (frugal) technologies. The trigger was the combination of frugal innovations, which had positive effects, and brought money into the system. People are noticing that hybrid maize works if the farmers have the complementary inputs and an insurance. Then they jump on the band wagon, and try to get land or more land, which has contributed to the emergence of a real land market.

Conclusions

There is ample evidence that land can be bought and sold in Tanzania. Even leasing-in is relatively easy. Female farmers own less land than the male farmers. However, they lease-in (more amount of) land more often partially because they own small size of land. They benefit from NGOs and government projects; and the horticultural sector in which they have earned experience has a big potential to develop further, given the economic growth and urbanization process in the country.

There is a need to strengthen women's land rights even in a greater possible way in Tanzania (ESRF, 2013). Successful famers want more land and one fifth of our sample have been able to lease-in additional land. This points to the importance of a functioning land market. Positive effects were found by comparing data for the first and the second year. Women's land rights are essential for their economic empowerment. They managed to increase the size of the land cultivated, most often by leasing-in additional land.

Recommendations

Gender equality is important to advance sustainable land stewardship. As Meza (2023) argues the recognition of women's land and resource rights will accelerate sustainable land management. She recommends governments to take action to assess and reform legal and regulatory frameworks, promote gender-responsive policies and public services and support successful programmes that promote women's right to land and resources.

According to Mfugale (2023), the government should step up legal reforms and budgetary allocation to hasten the realization of women's landownership and protection. International and local NGOs can educate female farmers and raise awareness among women of the importance of owning land and using it for income generation. The NGO project Stand for Her Land (S$HL) is mentioned as an example project trying to educate rural women in Africa on the ownership of land.

Supporting the transition from using traditional to hybrid seeds by spreading the use of the crop insurance is recommended. It increases rural incomes and food supply and contributes to food security in the country. It is important to select the intermediary for delivering the insurance carefully and to consider crop insurance as part of support package, which should also include fertilizers and additional inputs like pesticides and access to water. There is scope for making the innovation more frugal by really using only mobile phones for registration and payouts, which was currently not always the case. There is demand for this service from other regions, for other crops and risks (like caterpillars). Female farmers would in particular benefit from a rainfall insurance for horticultural crops. More information and training should be provided to these farmers and the insurance system needs to be made more transparent. Complaints of farmers should be taken seriously, since they allow to improve the system.

About the author

Meine Pieter van Dijk is a Professor Emeritus in Economics at Maastricht School of Management, Maastricht University, Maastricht, The Netherlands.

References

Biddulph, R. and E. Hillbom (2020), "Registration of Private Interests in Land in a Community Lands Policy Setting: An Exploratory Study in Meru District, Tanzania", *Land Use Policy*, 99.

Chachage, C. (2010), "Land Acquisition and Accumulation in Tanzania: The Case of Morogoro, Iringa and Pwani Regions". http://www.commercialpressureononland.org/research-paper/

Daley, E. (2005a), "Land and Social Change in a Tanzanian Village 2: Kinyanambo, in the 1990s", *Journal of Agrarian Change*, 5(4): 526-572.

Daley, E. (2005b), "Land and Social Change in a Tanzanian Village 1: Kinyanambo, 1920s-1990", *Journal of Agrarian Change*, 5(3): 363-404.

ESRF (2013), *Enhancing Land Tenure Security and Agricultural Productivity for Small Holder Farmers*, *Especially Women in Tanzania*, Dar es Salaam: Economic and Social Research Foundation (ESRF).

Hayuma, M. and J. Conning (2004), "Tanzania Land Policy and Genesis of Land Reform Sub-Component of Private Sector Competitiveness Project", www.oicrf.org/document.asp?ID=6707

Kariuki, R.W., D. Western, S. Willock and R. Marchant (2021), "Assessing Interactions between Agriculture, Livestock Grazing and Wildlife Conservation Land Uses: A Historical Example from East Africa" *Land*, 10(1): 46.

Kabigi, B., Walter T. de Vries and H. Kelvin (2021), "A Neo-Institutional Analysis of Alternative Land Registration Systems in Tanzania: The Cases of Babati and Iringa Districts", *Land Use Policy*, 105: 105435.

Lamek, W. (2016), *Agricultural Extension in Tanzania*, Amsterdam: Free University.

Meza, A. (2023), "Her Land, Her Rights: Advancing Gender Equality and Land Restoration Missions", *The Guardian*, Tanzania, 8 March, p. 12.

Mfugale, D. (2023), "IWD: A Call to Promote Women's Ownership of Land", *The Guardian*, Tanzania, 8 March, p. 11.

Mugabi, C. (2013), "Challenges Facing Land Ownership in Rural Tanzania: What Needs to be Done?" *ESRF Policy Brief*, Dar es Salaam.

Onsongo, E.K. and P. Knorringa (2020), "Comparing Frugality and Inclusion in Innovation for Development: Logic, Process and Outcome", *Working Paper series 7*, The Hague: Centre for Frugal Innovation.

Simbarashe, M. (2012), "Land Efforts Needed to End Conflicts between Farmers and Cattle Elders". http://www.dairlynews.co.tz/index.php/features/popular-features/5820-land-efforts.

Van Dijk, M.P. (2009), "Tanzania: Uneven Growth, Policy Reforms and Poverty Alleviation: An Example of an African Success?" In *African Development Yearbook*, P. Burger, A. Gutowski, J. Afeikhena, T. Knedlik, M. Meyn and T. Urban (eds.), pp. 243-267.

Van Dijk, M.P. (2021), "Hybrid Maize as the Next Step to a Green Revolution: The Importance of the Ecosystem, Frugal Innovation and A Triple Helix Model in Tanzania". In *Climate Smart Agriculture and Water in the Global South: Experiences with Support of the Nuffic*, Proceedings of a seminar held on March 25, 2021 at the Maastricht School of Management (MSM), M.P. van Dijk, H. Nijhoff and D. de Boer (eds.), pp. 56-63.

Van Dijk, M.P. (2022), "Crop Insurance, a Frugal Innovation in Tanzania, Helps Small Maize Farmers and Contributes to an Emerging Land Market", *Land*, 11(7): 954.

Yefred, M. (2005), "Implications of the Recent Land Reforms in Tanzania on the Land Rights of Small Producers". http://www.hakiardhi.org/index.php?option=com_docman&task=doc_do

Wellen, L. and M.P. van Dijk (2018), "Frugal Financial Innovations for Inclusive Finance: The Experience with Customer Care at M-Pesa in Kenya". In *Enterprise Development and Microfinance*, London.

World Bank (2014), *Country Data Report for Tanzania, 1996-2014*, Washington: IBRD.

Anvesak
Vol. 53(2), 2023, pp. 41-55
Received: 30 May 2023; accepted: 17 Aug. 2023

TRADING DYNAMICS OF DIFFERENT INVESTOR GROUPS IN INDIAN STOCK MARKET

SHREYOSI PAL* AND ARUP CHATTOPADHYAY
University of Burdwan, Bardhaman, West Bengal, India

Abstract: Stock market is an attractive destination for investors. To understand how FIIs, DIIs and 'other investors' influence each other's trading activities in the Indian stock market, various econometric tools like Granger Causality, VAR model, Variance decomposition analysis, Impulse Response Function and GMM for estimations are applied. Both way causalities are found between FIIs and DIIs net trading, whereas other investors' net investment is substantially caused by FIIs and DIIs investment pattern. Further, FIIs and DIIs being sophisticated investors are strongly competing with each other in stock trading, following the opposite market strategies. Again, opposite trading relation of domestic investors—both institutional and 'other investors'—with FIIs is evident in contemporaneous period as well. These trading patterns help preserve stability in the Indian stock market.

Keywords: FIIs, DIIs, Other investors, Granger causality, Vector Autoregression (VAR) model, Generalized Method of Moments (GMM)

1. Introduction

Inflows of financial resources sourced from different investor groups hold great significance for the capital market of any country in consideration to its stability, efficiency and growth; the emerging capital market in India is also of no exception. In recent years, a noteworthy feature of the Indian capital market is the growing prevalence of institutional investors along with greater participation of individual common investors, possessing sufficient influence to impact the market trends. At the forefront the major two institutional investor groups governing the Indian capital market are Foreign Institutional Investors (FIIs) and Domestic Institutional Investors (DIIs). FIIs mainly comprise large foreign financial institutions like mutual funds, pension funds, investment banks, hedge funds, insurance companies, endowment funds, etc. which channelize portfolio investments in domestic market. FIIs generally target their investment opportunities in emerging markets, which have higher growth potential and better opportunity of availing more returns than that in the developed nations.

Over the years, India has been able to attract substantial amount of portfolio investment,

*Correspondence to: Shreyosi Pal, UGC Junior Research Fellow (Ph.D. Student), Department of Economics, University of Burdwan, Bardhaman, West Bengal 713104, India. Email: shreyosi101@gmail.com

promoting FIIs to act as market makers thereby realizing their gains by booking profits (Gordon and Gupta, 2003). And it is often argued that the rise and fall i.e., stability of the Indian stock market is associated with FIIs' trading activities. In many studies FIIs' are identified as the opportunistic traders and therefore, can destabilize the market with their selling activities (Dhingra et al., 2016). So, FIIs are also often considered to be a potential threat for any emerging economy's financial system, as sudden capital flight from the market may create major upheavals in the financial markets (e.g., the experiences of Mexico, South-East Asian countries known as Asian Tigers, etc.). So, it is important for the home country to build strong fundamentals of domestic institutional and other domestic investors/traders, as these investors can play deciding roles in the functioning of the overall financial market, including the act of counterbalancing the volatile nature of FIIs' investment.

Domestic institutional investors (DIIs) are large professional domestic investor groups such as banks, insurance companies, mutual funds, domestic pension funds, etc. which are trading in domestic securities on behalf of their clients or beneficiaries or their own behalf, whereas other domestic investors are individual investors, HUFs or any individual entities/non-financial companies who or which invest their personal savings in securities through brokerage accounts. Over the years, mostly the role of DIIs and also other domestic investors have evolved significantly with their increasing participation in the Indian equity market. DIIs have huge funds with them collected from the public to channelize in domestic market, whereas the presence of sheer number of other individual domestic investors or entities also make them important force in the Indian equity market. These domestic investor groups bear significant impact on domestic stock prices, as they can influence the demand and supply dynamics of the market through their trading and thereby provide liquidity and ensure stability in the market by investing and reallocating their funds and securities.

Financial literature mainly argues that FIIs and DIIs are the most significant sophisticated investor groups having perceptible influence on stock market, whereas other domestic investors probably try to follow the footsteps of these institutional investors. Often we perceive competing business strategies between FIIs and DIIs known as Investment Professionals having analytical expertise and access to 'narrowly available information', whereas other domestic investors, mostly amateurs, are lagging behind (Statman, 2019).

In consideration to the practical significance of the present study it delves deeper into the trading dynamics of the two leading investors groups, namely FIIs and DIIs operating in the Indian stock market. Investigating their trading dynamics will enhance our understanding of the association, if any, between the trading patterns of these two investor groups and also understanding on how they influence each other's trading pattern in the Indian stock market contemporaneously or inter-temporally which may have direct bearing on stability and efficiency of the market, and which ultimately determines the width and breadth of greater participation of common investors in the Indian capital market; if common investors are always the followers of FIIs and DIIs they would be the net losers and they cannot survive in the market for a long time, which negatively affects the market efficiency. So to check the vibrancy of capital market, the dynamics of trading pattern of its market players should be analyzed.

The relevance of such research is of two folds. Firstly, the understanding of the trading relation as well as investment strategies of different investor groups helps policymakers and market participants in determining their future course of action and also to gain insights into potential market trends in relation to direction and magnitude of fund flows. Secondly, the study may help the policymakers and regulatory authorities to make appropriate policy decisions related to capital controls, foreign investment limits and other regulatory frameworks by recognizing these trading

dynamics, so that the market attains its stability and efficiency.

The remaining part of the paper is structured as follows: section 2 contains brief literature survey of related prior studies. Section 3 is devoted to data and methodology. Section 4 represents the analysis of empirical results and findings and section 5 concludes the paper.

2. Literature Review

In this study, we have conducted a brief review of several scholarly articles that documented different trading patterns of different investor groups globally as well as in domestic sphere. The notable earlier international studies by Brennan and Cao (1997), Choe et al. (1999), Froot et al. (2001) and Richard (2005) established foreign portfolio investors as a group of positive feedback traders reflected in their tendency to flow funds towards the markets having positive past return. Parallel research was undertaken in the Indian capital market as well. Chakrabarti (2001) argued that return was the dominant factor behind FII inflows in India. Mukherjee et al. (2002), Batra (2003) and Mukherjee and Tiwari (2022) also recognized return chasing trend of FIIs while investing in the Indian stock market. Contrary to the previous findings, Gordon and Gupta (2003) unveiled a significant inverse relationship between lagged domestic return and monthly FII inflows, suggesting negative feedback trading on the part of the foreign investors. But the study of Ananthanarayanan et al. (2004) yielded no evidence in the favour of any feedback trading behaviour of FIIs in regard to the Indian stock market.

Comparative analysis on the trading dynamics of different groups of investors has garnered significant attention in research literature. Grinblatt and Keloharju (2000) identified foreign investors in Finland, where were the most sophisticated investor group exhibiting momentum trading strategy while household investors were contrarians 'buying past losers and selling past winners' thereby portrayed them as less sophisticated market players. Kamesaka et al. (2003) in Japanese market found foreign investors and Japanese individuals were both positive feedback traders but the latter always experienced low market-timing return. Samarakoon (2009) also observed that in Sri Lanka all classes of domestic and foreign investors experienced positive feedback trading in their buying but contrarianism in their selling during normal periods but not in crisis periods. Boyer and Zheng (2009) found that in US market different investor groups exhibited a positive correlation with their own past flows at quarterly interval and also a positive contemporaneous relation between US stock returns and inflows of mutual funds and foreign investors were observed.

Only a few studies have been made which showcase the relationship among different investor groups with reference to India. Studies of Bose (2012) and Thiripalraju and Acharya (2013) recognized a strong negative relationship between net investments of FIIs and domestic mutual funds. Arora (2016) observed that in India FIIs persuaded momentum trading strategy while DIIs adopted contrarian trading strategy and also there was a favourable association between future stock return and investment by DIIs. A reciprocal causal relationship between FIIs and DIIs was evident in the findings of Gahlot (2019). Dhananjaya and Wright (2019) reported in their study that foreign institutional investments were negatively affected by domestic institutional investment but the converse did not hold true. Murthy and Singh (2013) and Bansal (2021) opined that both FIIs and DIIs had an influence on Indian equity market; however, FIIs held more significance.

Our study is an advancement of existing literature in three senses. Firstly, here we take account of other domestic investors named as 'other investors' (mainly consisting of common investors) as a group along with widely used two groups in stock investment, namely, FIIs and DIIs and critically

analyze their trading dynamics. Secondly, apart from considering lead-lag approach, we try to focus on contemporaneous relationship of FIIs and DIIs together with 'other investors' group. Thirdly, we concentrate on the stock trading dynamics of different investor groups for a longer time span of more than 13 years during post financial meltdown period.

As an addition to the existing literature, our study will facilitate the investors to take optimal and well informed investment decisions and also the policymakers to advocate appropriate policy prescriptions by considering the trading dynamics of different investors.

3. Data and Methodology

Our study relies on secondary set of data spanning April 1, 2009 through December 30, 2022. The daily data on gross purchase, gross sale and net purchase of both FIIs and DIIs are obtained from moneycontrol.com which has been compiled from the official website of National Stock Exchange (NSE). These data are aggregated over stock trading data of FIIs and DIIs across the major exchanges in India. DIIs trading data comprises trades executed by Banks, DFIs, Insurance, Mutual Funds (MFs) and New Pension System. We also used Nifty50 continuous return data in our study which is calculated from the daily closing index values. These closing prices of Nifty50 index are obtained from NSE's official website. We also try to throw a light on group of other domestic investors as they undoubtedly are a significant group of investors operating in the Indian stock market which is coined here as 'other investors', comprising mainly domestic common retail investors, domestic large retail investors, HUFs (Hindu Un-divided families), non-financial corporate investors etc. And the investment of other investors in the Indian stock market is taken just the remainder of FIIs' and DIIs' stock trading. Gross purchase, Gross Sale and Net Purchase of 'other investors' are derived as follows:

Gross purchase of other investors = (NSE Turnover + BSE Turnover) – (FIIs' Gross purchase + DIIs' Gross purchase).

Gross Sale of other investors = (NSE Turnover + BSE Turnover) – (FIIs' Gross Sale + DIIs' gross sale)

Net Purchase of other investors = Gross Purchase of other investors – Gross sale of other investors.

We consider here both NSE Turnover data and BSE Turnover data as these two major stock markets together capture most of (more than 90%) the Indian stock trading and these data are obtained from official websites of NSE and BSE respectively. The descriptive statistics pertaining to the data are presented in Table 1, which are self-explanatory.

In order to move forward with time series data, first of all we have checked whether the time series variables of interest are stationary or not. For this purpose we applied Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to each of the series, i.e., FIIs net purchase (FII_NET), DIIs net purchase (DII_NET) and other investors' net Purchase (OTHERS_NET). We have found that all these variables are stationary at level form suggesting the series do not contain any unit roots. The results of ADF and PP tests are reported in Table 2.

Next Granger Causality test has been applied to find out if there exists any directional causal relationship among three stock market investor groups i.e., FIIs, DIIs and 'other investors'. For better understanding of the causality and also to establish the lead-lag relation, if any, between FIIs and DIIs we fit the Vector Autoregression (VAR) model selecting appropriate lag length as per the Akaike Information Criterion (AIC). VAR model helps us to understand whether the past

investment pattern of one investor group can be used to predict the future investment pattern of the other and vice-versa. Also Variance decomposition analysis and Impulse Response Function (IRF) are used to study the dynamics of interdependence between different stock market investor groups over time. Lastly, we go for the Generalized Method of Movements (GMM) estimation to gain insight of how the investment patterns of two domestic investor groups, i.e., DIIs and 'other investors', are affected by FIIs' trading in India in contemporaneous period, taking care of endogenity problem.

4. Empirical Results and Findings

The descriptive statistics of daily net trades of FIIs, DIIs and other investors are presented in Table 1.

Table 1: Descriptive Statistics (Rs. Crores)

Descriptive Stats	FII_NET	DII_NET	OTHERS_NET
Mean	-25.99803	163.0216	-137.0235
Median	28.00500	54.81500	-75.00500
Maximum	28739.17	7667.750	9657.440
Minimum	-9690.840	-5631.990	-28969.61
Std. Dev.	1523.557	976.4186	1178.097
Skewness	2.873465	1.081871	-8.325196
Kurtosis	57.63761	10.37409	175.5464
Jarque-Bera	422309.9	8263.340	4204426.
Probability	0.000000	0.000000	0.000000

During the study period, we observed FIIs and other investors groups were net sellers, while DIIs were net buyers. FIIs exhibit a higher standard deviation compared to other two domestic investor groups. And distributions of net trading of FIIs and DIIs are positively skewed with high positive kurtosis value (i.e., asymmetrical and leptokurtic); i.e., the underlying distributions are fat-tailed distribution. For other investors group, we found negatively skewed leptokurtic distribution, suggesting again that underlying distribution is fat tailed with extreme observations in left side of the distribution.

Parametric Augmented Dickey Fuller (ADF) and non-parametric Phillips-Perron (PP) tests of stationarity (which is suitable in the presence of structural break, if any, in the series concerned) have been performed for the net purchase series of each investor groups, i.e., FIIs, DIIs and 'other investors' and the results of these tests are reported in Table 2. From the table it is visible that net purchase series of all the investor groups are stationary respectively at levels having no unit root. As all series of interest are found to be stationary we may proceed to our further time series analysis.

Table 2: Estimated Results of Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) Unit Root Tests

	ADF test statistic	PP test statistic
FII_NET	-10.92699*	-55.18915*
DII_NET	-12.22833*	-43.91511*
OTHERS_NET	-50.91073*	-52.22455*

Note: * Significant at 1% level.

Table 3 presents the results of Granger Causality test for lag 2 among all the three stock market investor groups. From the results, we observe that there is a bi-directional causal relationship

between FIIs' net purchase and DIIs' net purchase, suggesting that FIIs' investment and DIIs' investment in the Indian stock market roughly cause each-other. Further residual part (i.e., other investors' net purchase) is caused by trading patterns of FIIs and DIIs as empirical findings support the Granger causality here too. Thus, we can conclude that all investor groups are mostly dependent to each other in the Indian stock market. In other words, from these estimated results we can suggest the two sophisticated investors groups, namely FIIs and DIIs simultaneously influence each-others trading thus making the stock market more vibrant, while the 'other investors' comprising mainly common investors try to follow the FIIs' and DIIs' investment pattern.

Table 3: Empirical Findings of Granger Causality Test

Null Hypothesis	Obs	F-Statistic	Prob.
Sample: 1 April 2009 to 30 December 2022			
Lags: 2			
DII_NET does not Granger Cause FII_NET	3356	94.1493*	2.E-40
FII_NET does not Granger Cause DII_NET	3356	76.7529*	3.E-33
FII_NET does not Granger Cause OTHERS_NET	3356	7.01113*	0.0009
DII_NET does not Granger Cause OTHERS_NET	3356	7.01114*	0.0009

Note: * significant at 1% level

As is evident from the foregoing analysis, there is a both-way causal relationship between FIIs' net purchase and DIIs' net purchase and both FIIs' net investment and DIIs' net investment do also Granger cause other investor groups' trading pattern. Further, as all the variables of interest are stationary, next we should estimate Vector Autoregression (VAR) model which takes care of the endogeneity problem in the model. Here, we use the most suitable control variable Nifty50 return for VAR analysis on the ground that Nifty50 stock index is one of the leading and world-wide recognized stock indices of India and often considered as benchmark index as it reflects the overall performance of the Indian stock market. To include stock return as also a variate in VAR model, we should check its statioarity first. It is a common phenomenon in finance literature that share price follows random walk; that means, the price data is non-stationary and generally its first difference, most specifically first difference of log values of share price, i.e., return, is found to be stationary.

In our study, also we observe that Nifty50 return data is stationary by applying both ADF and PP tests. Nifty50 return (NIFTY50_RT) data can, therefore, be included here as a control variable in VAR which controls the left out effect on investment pattern of FIIs, DIIs and 'other investors'. But we failed to incorporate FIIs' net purchase, DIIs' net purchase and other investors' net purchase together in a single VAR Model, as it gave rise to near singular matrix problem. And this possibly happens due to strong interdependence of three investor groups, as we compute trading of 'other investors' as remainder of the stock market trading of FIIs and DIIs. So, we fit the Vector Autoregression (VAR) model taking FIIs' net purchase (FII_NET), DIIs' net purchase (DII_NET) and Nifty50 Return (NIFTY50_RT) into account. The VAR model expresses each variable as a linear combination of its own lagged values and the lagged values of all other variables in the system. We make use of the VAR model for analyzing the dynamics and also to know the lead-lag relationship among the variables in the model over time. We have selected a lag of 7 periods as per Akaike Information Criterion (AIC) which is optimum for the model because, at lag 7, the value of AIC is found to be minimum. The results of optimum lag order selection is reported in Table 4. Further, variance decomposition analysis and Impulse response function are executed for knowing the precise dynamics of stock trading in India.

Table 4: VAR Lag Order Selection Criterion

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-45939.29	NA	1.64e+08	27.42823	27.43371	27.43019
1	-44956.32	1963.603	91616860	26.84676	26.86867	26.85459
2	-44778.69	354.5194	82842413	26.74608	26.78443	26.75980
3	-44694.80	167.2682	79220336	26.70137	26.75615*	26.72097
4	-44666.10	57.18142	78293975	26.68961	26.76082	26.71508
5	-44647.49	37.05308	77845819	26.68387	26.77151	26.71522
6	-44624.61	45.48153	77203860	26.67559	26.77967	26.71282
7	-44605.65	37.67271*	76746123*	26.66964*	26.79015	26.71275*
8	-44599.01	13.19000	76854141	26.67105	26.80799	26.72003

Note: * Significant at 1% level.

The standard specifications of VAR model as applied in the study are as follows:

$$FII\_NET_t = \alpha_0 + \sum_{i=1}^{7} \alpha_{1i} FII\_NET_{t-i} + \sum_{i=1}^{7} \alpha_{2i}\, DII\_NET_{t-i} + \sum_{i=1}^{7} \alpha_{3i}\, NIFTY50\_RT_{t-i} + \varepsilon_{1t} \quad (1)$$

$$DII\_NET_t = \beta_0 + \sum_{i=1}^{7} \beta_{1i} FII\_NET_{t-i} + \sum_{i=1}^{7} \beta_{2i} DII\_NET_{t-i} + \sum_{i=1}^{7} \beta_{3i} NIFTY50\_RT_{t-i} + \varepsilon_{2t} \quad (2)$$

$$NIFTY50\_RT_t = \gamma_0 + \sum_{i=1}^{7} \gamma_{1i} FII\_NET_{t-i} + \sum_{i=1}^{7} \gamma_{2i} DII\_NET_{t-i} + \sum_{i=1}^{7} \gamma_{3i}\, NIFTY50\_RT_{t-i} + \varepsilon_{3t} \quad (3)$$

The first equation of the VAR model tries to give an insight as to whether past trading of both FIIs and DIIs and past stock returns are able to influence current as well as future FIIs' net investment. Similarly, other expressions of VAR can be explained. The results of estimated VAR model are reported in Table 5.

Table: 5 Estimated Results of Vector Autoregression (VAR)

Variables	FII_NET	DII_NET	NIFTY50_RT
FII_NET(-1)	0.135252*	-0.054963*	5.52E-07*
	(0.02011)	(0.01093)	(1.8E-07)
	[6.72486]	[-5.02880]	[3.01284]
FII_NET(-2)	0.033316	-0.027215**	-6.58E-08
	(0.02025)	(0.01101)	(1.8E-07)
	[1.64515]	[-2.47292]	[-0.35677]
FII_NET(-3)	0.074332*	-0.054044*	3.61E-08
	(0.02026)	(0.01101)	(1.8E-07)
	[3.66852]	[-4.90822]	[0.19576]

Contd...

Table 5 contd..

Variables	FII_NET	DII_NET	NIFTY50_RT
FII_NET(-4)	0.063085*	-0.019675	-1.29E-08
	(0.02031)	(0.01104)	(1.9E-07)
	[3.10544]	[-1.78227]	[-0.06956]
FII_NET(-5)	0.008815	0.020191	-1.66E-07
	(0.02028)	(0.01102)	(1.8E-07)
	[0.43458]	[1.83180]	[-0.89940]
FII_NET(-6)	-0.010357	0.005260	-1.78E-07
	(0.02030)	(0.01103)	(1.9E-07)
	[-0.51024]	[0.47683]	[-0.96313]
FII_NET(-7)	-0.043005**	-0.013544	-5.79E-07*
	(0.02007)	(0.01091)	(1.8E-07)
	[-2.14273]	[-1.24178]	[-3.16451]
DII_NET(-1)	-0.174257*	0.246276*	2.07E-07
	(0.03528)	(0.01917)	(3.2E-07)
	[-4.93958]	[12.8463]	[0.64230]
DII_NET(-2)	-0.151986*	0.139416*	-5.43E-07
	(0.03616)	(0.01965)	(3.3E-07)
	[-4.20285]	[7.09428]	[-1.64696]
DII_NET(-3)	-0.090952**	0.048049**	3.70E-07
	(0.03640)	(0.01978)	(3.3E-07)
	[-2.49880]	[2.42920]	[1.11540]
DII_NET(-4)	0.027951	0.054087*	-6.17E-09
	(0.03637)	(0.01976)	(3.3E-07)
	[0.76853]	[2.73666]	[-0.01862]
DII_NET(-5)	-0.025375	0.054651*	4.26E-07
	(0.03624)	(0.01969)	(3.3E-07)
	[-0.70025]	[2.77527]	[1.28960]
DII_NET(-6)	-0.127473*	0.039960**	-9.47E-07*
	(0.03589)	(0.01950)	(3.3E-07)
	[-3.55210]	[2.04903]	[-2.89655]
DII_NET(-7)	-0.083561**	0.032204	-3.72E-07
	(0.03443)	(0.01871)	(3.1E-07)
	[-2.42733]	[1.72143]	[-1.18614]
NIFTY50_RT(-1)	25448.41*	-14240.51*	0.005170
	(1999.75)	(1086.73)	(0.01823)
	[12.7258]	[-13.1041]	[0.28365]
NIFTY50_RT(-2)	3856.501	-7036.905*	-0.026972
	(2066.81)	(1123.17)	(0.01884)
	[1.86592]	[-6.26523]	[-1.43187]

Contd...

Table 5 contd..

Variables	FII_NET	DII_NET	NIFTY50_RT
NIFTY50_RT(-3)	-2690.106	-2939.181*	-0.015098
	(2073.36)	(1126.73)	(0.01890)
	[-1.29746]	[-2.60860]	[-0.79901]
NIFTY50_RT(-4)	326.0019	-1593.439	-0.003334
	(2073.46)	(1126.78)	(0.01890)
	[0.15723]	[-1.41415]	[-0.17644]
NIFTY50_RT(-5)	3029.020	-1943.836	0.050144*
	(2063.38)	(1121.30)	(0.01881)
	[1.46799]	[-1.73355]	[2.66647]
NIFTY50_RT(-6)	-1458.116	-814.3484	-0.075108*
	(2050.85)	(1114.49)	(0.01869)
	[-0.71098]	[-0.73069]	[-4.01838]
NIFTY50_RT(-7)	2569.821	-231.8538	0.078154*
	(2027.60)	(1101.86)	(0.01848)
	[1.26742]	[-0.21042]	[4.22930]
C	66.27480*	73.56451*	0.000584*
	(23.8289)	(12.9493)	(0.00022)
	[2.78128]	[5.68095]	[2.68967]

Notes: *Significant at 1% level, **significant at 5% level. Standard errors are in parentheses and t-statistic values are in square brackets.

From the estimated first equation of the VAR model, it is evident that FIIs' net purchase depends positively on its own past trading at lag 1, lag 3 and lag 4, while at 7th lag we observe its reverse trend. This suggests that FIIs investment decisions are influenced by their own previous actions. Further, FIIs' net purchase negatively depends on DIIs' net purchase for almost all the lag periods (lag 1, lag 2, lag 3, lag 6 and lag 7), implying thereby that these two institutional investor groups, i.e., FIIs and DIIs in the India stock market trade by adopting mostly reverse strategies such that when FIIs increase their buying DIIs tend to sell their holdings and vice-versa. Concerning market return it is observed that Nifty50 return at lag 1 only positively affects FIIs net trading. This suggests that FIIs are driven mainly by immediate past return, which evidences their return chasing behaviour in stock trading.

From the estimated second equation of the VAR model it is found that DIIs' net trading depends positively on its lagged trading suggesting thus the presence of strong positive autocorrelation in their trading. But DIIs' net purchase depends negatively on FIIs' net purchase at lag 1, lag 2 and lag 3, confirming thereby the view that FIIs and DIIs persuade a completely opposite trading pattern. Also it is found that past Nifty50 return at first three lags are significantly and negatively related to DIIs' net purchase. One possible explanation behind this negative relation is that DIIs tend to buy stocks during bearish stock market situation in the hope of grabbing undervalued or underpriced stocks that can generate higher return in future.

Similarly, DIIs tend to sell stocks during bullish market trend to reap immediate profit as they expect in near future stock price may fall. These results support the findings of some previous

studies such as Dhingra et al. (2016), Batra (2003), Arora (2016), and Dhananjaya and Wright (2019), where FIIs are referred to as 'return chasers' and DIIs are referred as 'contrarian traders'. From these two equations of VAR model, we may infer that the complete reverse trading strategies are followed by FIIs' and DIIs' in the Indian stock market and their opposite outlook in respect of market returns helps them maintain somewhat stability in the stock market. From the third estimated equation of the VAR model, it is evident that Nifty50 return does not exclusively depend either on FIIs' investment or DIIs' investment except a few exceptional cases: Nifty return depends positively on FIIs' net purchase at lag 1 but negatively on FIIs' net purchase at lag 7. Again DIIs' net purchase at lag 6 has a negative and significant impact on Nifty return.

In regard to Nifty returns, it is also observed from estimated equation three of the VAR model that those are mainly independent to each other for all lags except at three distant lags. This observation supports the EMH (Efficient Market Hypothesis) in its weak form because of independency of stock returns and disorderly behaviour of day-effect. From these findings we make some inferences regarding remaining traders in the stock market referred to as 'other investors' that they might have a significant role in generating positive or negative stock market returns. We take here Nifty50 return as a control variable in VAR model, and this Nifty return in its continuous form can also play as a proxy of other investors' trading being the residual of trading of FIIs and DIIs in generating return, especially when latters remain insignificant in it.

Variance Decomposition Analysis

Variance Decomposition analysis shows how much of total variation in a variable can be attributed to other variables in the system. The estimated results of Variance Decomposition analysis are presented in Table 6.

Table 6: Estimation Results of Variance Decomposition

Period	S.E.	FII_NET	DII_NET	NIFTY50_RT
		Variance Decomposition of FII_NET		
1	1270.025	100.0000	0.000000	0.000000
2	1342.244	95.11887	0.559548	4.321581
3	1366.890	93.76040	1.440341	4.799260
4	1390.350	92.99929	2.291261	4.709451
5	1409.644	92.67061	2.412397	4.916990
6	1426.314	91.93205	2.687829	5.380118
7	1442.622	90.86907	3.663519	5.467414
8	1457.515	89.51641	4.816398	5.667193
9	1469.015	88.71844	5.324015	5.957548
10	1478.965	88.17502	5.654438	6.170542
		Variance Decomposition of DII_NET		
1	690.1704	18.38068	81.61932	0.000000
2	749.0238	22.40337	73.25108	4.345542
3	790.7312	25.09832	68.22613	6.675543
4	824.6084	28.39440	64.05670	7.548897
5	850.9684	30.42246	61.47962	8.097923
6	869.7686	31.03889	60.21989	8.741221
7	885.7055	31.63274	59.18102	9.186248
8	902.1591	32.50477	58.26127	9.233956

Contd...

Table 6 contd..

Period	S.E.	FII_NET	DII_NET	NIFTY50_RT
9	915.0539	32.83879	57.55263	9.608582
10	925.6682	33.07814	57.05098	9.870878
		Variance Decomposition of NIFTY50_RT		
1	0.011575	10.18806	0.078437	89.73350
2	0.011594	10.47699	0.090828	89.43218
3	0.011602	10.47282	0.193072	89.33410
4	0.011603	10.47194	0.200524	89.32754
5	0.011603	10.47418	0.202962	89.32286
6	0.011621	10.44346	0.256342	89.30020
7	0.011671	10.39975	0.491123	89.10912
8	0.011714	10.39155	0.587109	89.02134
9	0.011714	10.39128	0.589093	89.01962
10	0.011715	10.39483	0.592174	89.01300

From Table 6, it is evident that any variation in FIIs' net purchase can be explained mainly by its own lagged trading (100% in lag 1, more than 92% in lag 5 and more than 88% thereafter and so on). Other variable DIIs' net trading is able to explain up to 5% and Nifty50 return is able to explain up to 6% variation in FIIs' net purchase after 10 days. From the variance decomposition of DIIs' net purchase, it is seen that around 81% to 57% (more than 81% in lag 1, more than 61% in lag 5 and more than 57% thereafter) variation in DIIs' net purchase is explained by its own shock. And 33% variation in DIIs' net purchase is due to FIIs' net trading after 10 days, and Nifty 50 return is able to explain up to 9% variation in DIIs' net purchase after 10 days. Variance decomposition of Nifty50 return shows that more than 89% variation in Nifty50 return is explained by its own lagged return. And more than 10% variation in Nifty50 return is explained by FIIs' net purchase, whereas DIIs' net purchase does not have any strong influence in explaining variation in Nifty50 return. These results broadly support the evidence of interdependence of FIIs', DIIs' and Nifty50 returns, as we find in the VAR analysis.

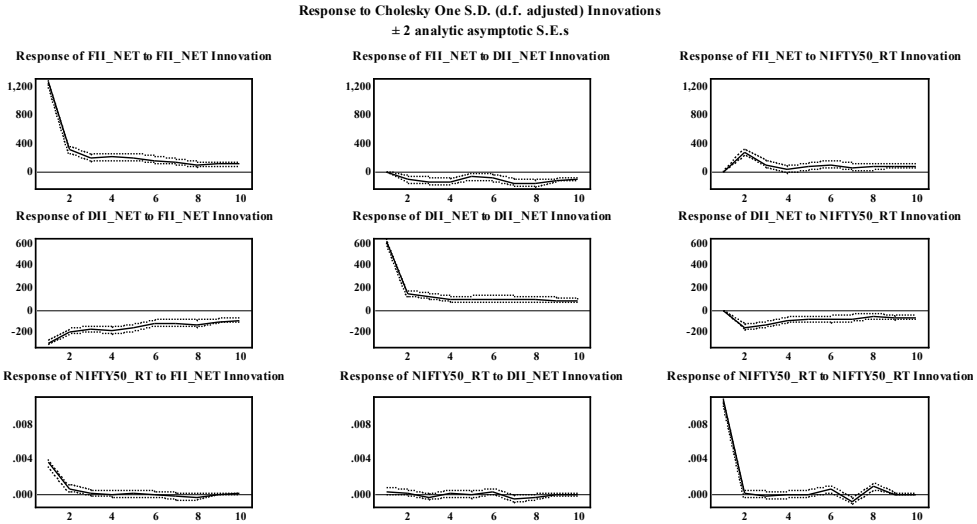
Impulse Response Function (IRF)

The Impulse Response Function (IRF) depicts the dynamic response of a variable to one standard deviation shock in all the endogenous variables connected with the VAR model. The response was subject to Cholesky decomposition. The thick lines in this multiple graphs (Figure 1) represent the estimated impulse responses while the dotted lines are plus/minus two standard deviation error bands. From Figure 1, it is seen that response of FIIs' net purchase to one standard deviation own shock is positive but decay sharply for the first 2 days and then decay moderately for the next 8 days. The response of FIIs' net purchase to one standard deviation shock in nifty 50 return is positive but gradually narrowed down over time. And the response of FIIs' net purchase to one standard deviation innovation in DIIs' net trading is negative and gradually declining.

These findings support our result in VAR analysis that two professional investor groups, i.e., FIIs and DIIs exhibit completely opposite response in their trading. Similarly, the impulse response of DIIs' net purchase to its own shock has positive but sharp declining response for the first 2 days and then gradually faded out. And the responses of DIIs' net purchase to one standard deviation shock in both FIIs' net trading and Nifty50 return are negative and slowly diminishing over the next 10 days. Lastly, the impulse responses of Nifty 50 return to one standard deviation own shock, to one SD shock in FIIs' net trading and to one SD shock in DIIs' net trading are visibly positive for the first 2 days and then mostly die out. From these findings, we can conclude that (i) the estimated

impulse response functions corroborate the results obtained earlier in estimating VAR model; (ii) shocks are not explosive in nature rather converging within a specified period having short memory.

Figure 1: Impulse Response Functions



Contemporaneous Relation

Lagged relations among variables concerned, namely, FIIs net purchase, DIIs net purchase and Nifty50 Return are estimated using VAR model followed by Variance Decomposition Analysis and Impulse Response function (IRF). We would not estimate VAR model incorporating 'other investors' as another variable due to singularity problem because here we defined 'other investors' as algebraic resultant of FIIs and DIIs stock market trading. Now to get their contemporaneous relations OLS method of estimation cannot be used due to the presence of endogenity problem, which can be somewhat taken care of by Generalized Method of Moments (GMM) approach of estimation. Here also we cannot apply system GMM incorporating all three endogenous variables (viz., FIIs, DIIs and 'other investors') due to singularity problem. As our prime objective is to know the domestic investment pattern to be influenced by foreign investment in the Indian stock market, we have estimated two regressions (one for 'other investors' and other for DIIs) by GMM taking FIIs as explanatory variable and one period lagged Nifty50 return as instrument variable. We also estimated another contemporaneous relationship taking FIIs net purchase as dependent variable and DIIs net trading as explanatory variable with the same one period lagged Nifty50 return as instrument in the model. These estimated relations using GMM (Table 7) give good fit in all cases with significantly moderate values of R-Squared and fairly insignificant low values of J-statistic which signifies the absence of identification problem.

Table 7: Estimated Results of GMM

Variable#	Coefficient	t-Statistic
Dependent variable: OTHERS_NET		
Constant	-147.8776	-8.583226*
FII_NET	-0.417098	-8.980106*
Dependent variable: DII_NET		
Constant	147.8777	8.583230*
FII_NET	-0.582902	-12.54984*
Dependent variable: FII_NET		
Constant	253.6924	7.378501*
DII_NET	-1.715555	-12.54984*

Note: * indicates 1% level of significance. # As one variable is resultant to other variables, three separate regression equations are estimated to avoid singularity problem, where dependent variables are mentioned in the table. Constant implies intercept term and all other variables are explanatory ones. NIFTY50_RT (-1) is taken as the instrument variable in all the three models.

From the results of GMM Estimation we observe that domestic investors groups, both institutional and others, exhibit opposite trading relation with FIIs' net investment in contemporaneous period also. That again put forward the view that when FIIs make their investment in the Indian stock market domestic investors tend to de-invest their holdings. This opposite behaviour of domestic and foreign investors helps to sustain balance in the Indian stock market thereby Stock prices do not move too far from their fundamentals or equilibrium levels.

5. Conclusions

Apart from two considerably dominant groups of stock market investors, namely, FIIs and DIIs this paper accounts for other remaining domestic traders to be termed as 'other investors' in the Indian stock market. Here we have analytically tried to investigate the trading dynamics of FIIs, DIIs together with 'other investors' and their impact on one another using Granger causality test, VAR model, Variance Decomposition Analysis, Impulse Response Function (IRF) and GMM estimation. The result of Granger causality test depicts that net stock trading activities of FIIs and DIIs influence each other in the Indian stock market and other investors' trading pattern is again caused by investments of FIIs and DIIs. The results of Vector Autoregression (VAR) model, Variance Decomposition Analysis and Impulse Response Function (IRF) justify strong interdependence between FIIs and DIIs in stock trading by demonstrating that the net investment of FIIs does not only positively depend on their own past periods' investment but also negatively depends on the past net investment of DIIs. And the similar trading relation is observed in case of DIIs also where net investment of DIIs does not only positively depend on its own past periods' investment but also negatively depend on the past net investment of FIIs.

These results suggest that FIIs and DIIs in the Indian stock market practice an opposite trading pattern inferring that when FIIs increase their buying, DIIs tend to sell their holdings. The study also indicates that FIIs' net investments are positively related to immediate past return, whereas DIIs' net investments are negatively related to past returns over three consecutive lags. These observations confirm return chasing behaviour of FIIs and contrarian behaviour of DIIs in stock trading. From these findings we may summarize that their completely opposite investment patterns along with their different outlooks for the market return help the Indian stock market to sustain its balance to some extent. Using GMM estimation, the negative trading relation of domestic investor

groups (i.e., DIIs and 'other investors') with foreign institutional investor group (i.e., FIIs) is evident in contemporaneous period also. From these results, we may conclude that the so-called popular proposition that 'FIIs lead the Indian stock market' does not hold in recent times, as domestic institutional investors (DIIs) along with other domestic traders are continuously beating the market following the reverse market strategies and have the ability to influence their foreign counterparts.

These findings hold significant implication from the perspective that well-defined business strategies and strong interplay of different investor groups would lead to efficient pricing of shares, making the stock market stronger and attractive with less chance of becoming any investor group to be consistently net losers in the market. This is a fundamental characteristic for the market to be efficient. Also, the policymakers get the idea where limit should be imposed on stock market investment by different groups because aggressive investment decisions of the market participants may create turbulence in the market affecting its stability and give rise to uncertainty and thus shake the entire financial system. There remains the scope for further study on how different investor groups can impact stock market volatility, accommodating both high and low frequency data.

About the authors

Shreyosi Pal is a PhD student / full-time research scholar (UGC-JRF) at the Department of Economics, University of Burdwan, Bardhaman, West Bengal, India. **Arup Chattopadhyay** is a Professor (retired) at the Department of Economics, University of Burdwan, Bardhaman, West Bengal, India.

References:

Ananthanarayanan, S., C. Krishnamurti and N. Sen (2004), "Foreign Institutional Investors and Security Returns: Evidence from Indian Stock Exchanges", *Working Paper*, Hyderabad: Indian School of Business.

Arora, R.K. (2016), "The Relation between Investment of Domestic and Foreign Institutional Investors and Stock Returns in India", *Global Business Review*, 17(3): 654-664.

Bansal, P.K. (2021), "Critical Study of Indian Stock Market Relationship with Domestic (DIIs) and Foreign Institutional Investors (FIIs)", *Materials Today: Proceedings*, 37(2): 2837-2843.

Batra, A. (2003), "The Dynamics of Foreign Portfolio Inflows and Equity Returns in India", *ICRIER Working Paper No.109*, ICRIER.

Bose, S. (2012), "Mutual Fund Investment, FII Investments and Stock Market Returns in India", *Money and Finance*, ICRA Bulletin, September: 89-110.

Boyer, B. and L. Zheng (2009), "Investor Flows and Stock Market Returns", *Journal of Empirical Finance*, 16(1): 87-100.

Brennan, M.J. and H.H. Cao (1997), "International Portfolio Investment Flows", *Journal of Finance,* 52(5): 1851-1880.

Chakrabarti, R. (2001), "FII Flows to India: Nature and Causes", *Money and Finance*, 2(7): 61-81.

Choe, H., B.C. Kho and R.M. Stulz (1999), "Do Foreign Investors Destabilize Stock Markets? The Korean Experience in 1997", *Journal of Financial Economics*, 54(2): 227-264.

Dhananjaya, K. and R. Wright (2019), "Do Domestic Institutional Investors (DIIs) Neutralize the Impact of Large Reversal by Foreign Institutional Investors (FIIs)? Recent Evidence from Indian Stock Market", *Wealth-International Journal of Money, Banking and Finance*, 8(1): 65-72.

Dhingra, V.S., S. Gandhi and H.P. Bulsara (2016), "Foreign Institutional Investments in India: An Empirical Analysis of Dynamic Interactions with Stock Market Return and Volatility", *IIMB Management Review*, 28(4): 212-224.

Froot, K.A., P.G.J. O'Connell and M.S. Seasholes (2001), "The Portfolio Flows of International Investors", *Journal of Financial Economics*, 59(2): 151-193.

Gahlot, R. (2019), "An Analytical Study on Effect of FIIs and DIIs on Indian Stock Market", *Journal of Transnational Management*, 24(2): 67-82.

Gordon, J. and P. Gupta (2003), "Portfolio Flows into India: Do Domestic Fundamentals Matter?" *IMF Working Paper WP/03/20*.

Grinblatt, M.S. and M. Keloharju (2000), "The Investment Behavior and Performance of Various Investor Types: A Study of Finland's Unique Data Set", *Journal of Financial Economics*, 55(1): 43-67.

Kamesaka, A., J.R. Nofsinger and H. Kawakita (2003), "Investment Patterns and Performance of Investor Groups in Japan", *Pacific-Basin Finance Journal*, 11(1): 1-22.

Mukherjee, P. and S. Tiwari (2022), "Trading Behaviour of Foreign Institutional Investors: Evidence from Indian Stock Markets", *Asia-Pacific Financial Markets*, 29(4): 605-629.

Mukherjee, P., S. Bose and D. Coondoo (2002), "Foreign Institutional Investment in the Indian Equity Market: An Analysis of Daily Flows during January 1999 - May 2002", *Money and Finance*, ICRA Bulletin, April-Sept: 21-51.

Murthy, K.V. and A.K. Singh (2013), "Do Foreign Institutional Investors really drive the Indian Stock Market?", *Asia-Pacific Journal of Management Research and Innovation*, 9(1): 45-53.

Richards, A. (2005), "Big Fish in Small Ponds: The Trading Behavior and Price Impact of Foreign Investors in Asian Emerging Equity Markets", *Journal of Financial and Quantitative Analysis*, 40(1): 1-27.

Samarakoon, L.P. (2009), "The Relation between Trades of Domestic and Foreign Investors and Stock Returns in Sri Lanka", *Journal of International Financial Markets, Institutions and Money*, 19(5): 850-861.

Statman, M. (2019), *Behavioral Finance: The Second Generation*, CFA Institute Research Foundation.

Thiripalraju, M. and R. Acharya (2013), "Dynamic Interaction between Institutional Investment and Stock Returns in India: A Case of FIIs and MFs", *Finance India*, 27(4): 1173-1191.

Anvesak
Vol. 53(2,) 2023, pp. 56-71
Received: 12 Dec 2022; accepted: 20 Apr 2023

DECENTRALISATION AND DISTRICT DEVELOPMENT PLANNING IN MAHARASHTRA: A DISTRICT LEVEL ANALYSIS

PRIYANKA BOKIL AND ANURAG ASAWA*

Gokhale Institute of Politics and Economics, Pune, India

Abstract: Fiscal and political decentralisation is a distinctive characteristic of democratic countries in present times. The 73rd and 74th constitutional amendments to the Indian constitution aimed at strengthening the decentralised structure of Indian Polity and devolution of fiscal responsibility to the lowest levels of government. The same amendments propagated the idea of decentralised development planning (Art. 243ZD) wherein the local self-governments were entrusted with the responsibility to develop the plans for social and economic development and ensure socio-economic justice, and it also mandated setting up of District Planning Committee (DPC). This paper analyses the distribution of plan funds for district-level planning in Maharashtra for the period from 2011-12 to 2020-21, along with exploring the history and structure of decentralised planning in Maharashtra. The findings show that the distribution or allocation of plan funds to the districts for district-level planning differs significantly for certain districts compared to the formula-based allocations which are used to convey the initial allocation or ceilings to the districts for formulating the district annual plan. The divergence is attributed to additional demand put forward and justified by the districts over and above the formula-based allocations and its acceptance by the Planning Department of the state. However, there is no fixed criterion for approval of higher/additional demands and the proportion of additional allocation approved over and above the ceiling. The paper suggests that adherence to formula-based allocation is better suited for the equitable distribution of district plan funds.

Keywords: Decentralisation, District planning committee, Grassroot level planning, Local self government, District plan allocations

Introduction

Fiscal and political decentralisation is a distinctive characteristic of democratic countries today. The significance of fiscal decentralisation is highlighted by various theories in the field of economics ranging from Oates' seminal work on decentralisation propagating fiscal decentralisation for efficiency in provision of public services (Oates, 1972), to the second generation literature on fiscal

*Correspondence to: Anurag Asawa, Associate Professor, Gokhale Institute of Politics and Economics, Pune 411004, India. Email: anurag.asawa@gipe.ac.in

decentralisation highlighting the role of governance with the help of principal agent framework. The 73rd and 74th constitutional amendments to the Indian constitution aimed at strengthening the decentralised structure of Indian Polity and devolution of fiscal responsibility to the lowest levels of government. The same amendments propagated the idea of decentralised development planning (Art. 243ZD), wherein the local self-governments were entrusted with the responsibility to develop the plans for social and economic development and ensure socio-economic justice. They have also provided for statutory machinery to be set up at the district level—which is called the District Planning Committee (DPC)—to "consolidate the development plans prepared by the rural and urban local bodies within the district into a draft district development plan" (Art. 243ZD).

Delegating the responsibility to plan implies the delegation of power to make decisions that are best suited to the local preferences or emergencies and needs. So, there is a greater emphasis on grassroots level decision making along with providing them sufficient fiscal space to translate their plans into reality. This fiscal space was provided by carving out a portion of the Five Year Plan (FYP) funds allocated to the states specifically for district-level plans. The planning commission of India issued regular guidelines for the furtherance of decentralised planning right since the Fourth FYP, yet the adoption of decentralised and multi-level planning varies in its degree and appearance as per the degree and status of its Panchayati Raj structure.

Maharashtra has had a long history of Panchayati Raj Institutions. We can trace back the history of decentralised planning in this State to establishment of the Zilla Parishads in 1962 and the establishment of District Planning Boards within the jurisdiction of Zilla Parishads in 1972. These efforts further culminated into setting up of District Planning and Development Councils (DPDCs) in 1975 and finally these DPDCs were transformed into District Planning Committees in 1998 as per the requirements set out by the 73rd and 74th Constitutional Amendments. Along this journey, the decentralised district plans evolved from being mere wish-lists of demands to becoming recognisable and quantifiable documents in the State Plan, wherein a clear segregation of district sector schemes from state sector schemes can be seen along with the fund allocated for them in case of each district.

In the literature of public finance, we have come across formula-based allocation strategies such as the Gadgil Formula[1] governing the Plan transfers to states, with objectives of achieving horizontal and vertical equity in terms of public service delivery within and between the states. Buehler and Holtgrave (2007) argues that a formula-based approach of redistribution or fund allocation is usually adopted for its simplicity and transparency attributes). In case of district plans too, the state government has followed a formula-based approach in conveying the yearly upper limit for district annual plans (also known as ceilings) to the districts. Yet, while making the actual allocation to the district, a provision for approving additional demand of funds made by the districts over and above the ceilings conveyed is maintained. This provision alters the formula-based distribution of funds for district plans and has the potential to screw the distribution in favour of certain districts. The skewed distribution of funds generates fundamental (research) questions:

1. Whether the departure from the formula-based approach of distribution of the fund is common practice for the all the districts of Maharashtra or it is confined to a few districts.
2. Whether the actual allocations received by the districts differ significantly from the formula based modelled allocations.

[1] The Gadgil formula was formulated with the formulation of the third five-year plan for the distribution of plan transfers amongst the states. It was named after D.R. Gadgil, then deputy chairman of the Planning Commission.

Review of Literature

There are plenty of published materials, including reports and data sets, available in the area of centre and state finances such as study of budgets by the Reserve Bank of India (RBI) (annual publication), Planning Commission (1984) (High Level Expert Committee Report on Efficient Public Expenditure), Mohanty and Bhanumurthy (2018) (state public expenditure and its relative efficiency with respect to each other), Shankaranand and Biradar (2015) (analysis of the patterns of individual state public expenditures), Devarajan et al. (1996) (trends in plan-non-plan expenditures vis-à-vis growth of GDP for understanding the linkage between public spending and growth) and Paternostro et al. (2007) (understanding the composition of public spending which denotes that the policy needs to be framed as per country-specific empirical analysis), among others.

There is not much literature specifically devoted in understanding the financial relations between state and local governments, especially in district level planning and the district plan funds received by the districts. Although, in recent times, we do come across analysis on the finances of urban local governments like the Report on Municipal Finances by the Reserve Bank of India (RBI, 2022), it does not cover finances for the districts as a unit of planning. This paper is an attempt to explore the opportunities of analysis of district-level planning and its finances with respect to the state of Maharashtra.

In case of the literature that is available on the decentralisation of development planning in India, greater amount of it belongs to literature reviews on the genesis, expansion and structure of decentralised of planning, regional planning and Panchayati Raj Institutions (Adik, 1987), discussion papers studying the evolution of Panchayati Raj Institutions and development of bottom-top approach of district planning in individual states like Kerala and Karnataka further discussing the structure of planning machinery at the state and district level, the composition of district plans in these states (Charvak, 2000; Vaddiraju and Satyanarayana, 2011).

At large, the source of information on the decentralisation of the planning process is limited to the guiding documents, circulars, and expert group reports brought about by the Government of India and the Government of Maharashtra from time to time. It must be noted that these documents provide the envisaged structure of decentralised district-level planning and what ought to be done for its execution, but the data required for analysing the actual process of planning, its efficiency and effectiveness in utilisation of the resources allocated to districts are not available through them. A Maharashtra-specific study of district-level planning with respect to its features, institutional structures, budgets and outcomes is not found in our search for literature. This paper is an attempt to fill the gap. With this backdrop of the genesis and development of decentralised planning in India as well as Maharashtra, this paper has the following two objectives:

1. To analyse the utility of district plan funds in the developmental functions carried out in the district and
2. To explore whether the formula-based approach conforms to the basic objectives for adopting decentralised district-level planning.

Scope and Hypotheses

This paper attempts to understand the genesis and history of the development of district planning in Maharashtra, its structure and the distribution of plan allocations made to all the districts from 2011-12 till 2020-21. The research hypothesis is formulated according to our research question of whether the actual allocations received by the districts differ significantly from the formula-based modelled allocations:

H0 = Mean Actual Allocation for a given district of Maharashtra is equal to Mean Modelled Allocation for the same district

H1= Mean Actual Allocation for a given district of Maharashtra is not equal to the mean modelled allocation for the same district

Data and Statistical Tools

Government resolutions and circulars were referred to understand the current district plan fund allocations process. The data on the district-wise allocation of district plan funds is not readily available and had to be meticulously collected from budget books/documents of the government of Maharashtra related to the District Plan for the period of 2011-12 to 2020-21. Moreover, accessing the data is a big task as it is not available in a single source or document. The authors have gone through each district plan document for 10 years for 36 districts with the data in pdf format. It was a painstaking task carried out with patience and hard work.

The limitation of data availability hampered our aim to ally with sensitive statistical tools. Therefore, to find out whether the actual allocations made to the districts differ significantly from formula-based allocations, we have first worked out the formula-based allocations as per the formula prescribed by the Government of Maharashtra for conveying allocation ceilings[2] to the districts and then applied a paired t-test to examine if there is any significant difference between the mean allocations between the two series of allocations for all districts in Maharashtra over the given time period.

This paper is structured in four parts, wherein Section 1 briefly gives the history and genesis of decentralised district planning in Maharashtra, Section 2 provides an overview of the financial allocations done for District Plans in Maharashtra, Section 3 contains the objective question of parity in fund allocations with respect to formula-based allocations vis-a-vis actual allocations made to districts and the results from the study and Section 4 has the limitation of the paper and policy suggestions along with further discussion.

History and Genesis of Decentralised District Planning in Maharashtra

Maharashtra has had a robust history of Panchayati Raj as it was amongst the first few states to implement the recommendations of the Balwant Rai Mehta Committee. It has adopted a three-tier Panchayati Raj structure since 1st May 1962 by adopting Maharashtra Panchayat Samiti and Zilla Parishad Act, 1961 and Mumbai Gram Panchayat Act, 1958. In the subsequent years, various committees were formed to review the functioning of Panchayati Raj Institutions.

The L.N. Bongirwar Committee[3] constituted in 1970 emphasised the need to strengthen the Panchayati Raj Institutions financially and provide greater autonomy to them to realise the goal of consolidating the democratic institutions to the grassroots level. One of the main recommendations of this committee was the constitution of District Planning and Development Boards, which were established in 1972, and they began formulating district-level plans in 1974.[4]

---

[2] Ceilings are initial plan outlays conveyed to the districts before finalisation of their plans in order to give them a tentative idea about funds that will be made available to them for the coming financial year. - Draft Annual Plan 2012-13, Planning Department, Government of Maharashtra

[3] The L.N. Bongirwar Committee was formed to evaluate the functioning of the Panchayati Raj Institutions in Maharashtra in the year 1970.

[4] Rural Maharashtra: A Saga of Development, Rural Development Department, Government of Maharashtra, 2012, p. 11.

However, these plans were a collection of felt needs of the people without taking into account local resources, finances and infrastructure. Sometimes, they aggregated departmental or sub-departmental proposals, often handed over to the district from State headquarters, without integration (Prasad, 1988).

In its subsequent efforts, Maharashtra established district-level planning machinery/offices as guided by the Seventh Five Year Plan and the Working Group on District Planning set up by the Planning Commission of India (1982). They were called District Planning and Development Councils, and at each district level, they were entrusted with the responsibility of preparation, coordination, implementation, and evaluation of Annual District Plans, which were an aggregation of schemes prepared individually by different departments at the district level, based on the annual plan outlay allotted to them by their respective heads of departments at the State level. It underlines that even at the decentralised level, planning in Maharashtra was heavily influenced by departmental hierarchy and lacked people's participation as envisaged by the Seventh Five Year Plan (FYP) makers. In the words of Kamta Prasad, "the so-called district plans had no common perspective or unifying framework" (Prasad, 1988).

After implementing the 73rd Constitutional Amendment Act, the State needed to alter its existing rules and regulations regarding governance and functioning of Panchayati Raj, to make them in tune with the said amendment. Consequently, the required amendments were made to Maharashtra Panchayat Samiti and Zilla Parishad Act, 1961 and Mumbai Gram Panchayat Act 1958. Along with these changes, in tune with the Art. 243 ZD of 73rd CAA, Maharashtra adopted the District Planning Committees (constitution and functions) Act, 1998.

As mentioned earlier, this brought about a change in the structure of planning machinery working at the district level and paved the way for people's participation in preparation of the district plans by mandating that four-fifths of the members of the District Planning Committees were to be elected from the elected representatives of the rural and urban local bodies in the district. Yet, in the initial years of the Eleventh Five Year Plan period, the District Planning Committees were finally constituted as per the act and started functioning in the districts of Maharashtra.

Currently, there are 36 District Planning Committees, one each, for the Districts in Maharashtra. Their structure is outlined in the Maharashtra District Planning Committees (constitution and functions) Act, 1998. The rules of election to DPC and meetings of DPCs were also enacted in the subsequent year.[5] Relevant changes have been made to these rules as per the changes in Panchayati Raj Institutions in terms of reservation of seats and quotas for women from time to time.

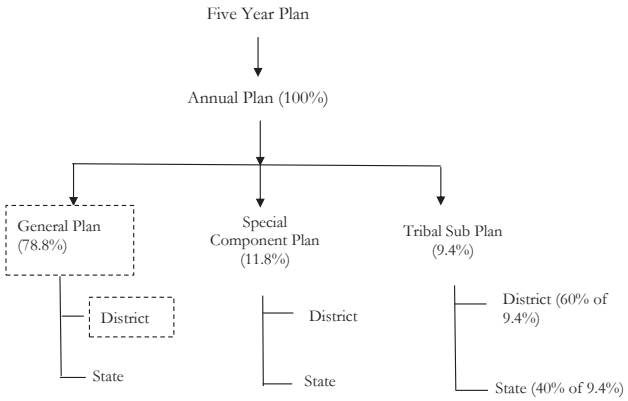
Financial Allocation under District Plan in Maharashtra

The corpus of a five-year plan allocated to the state is divided into annual plans. An annual plan is first divided into the General Plan, Special Component Plan (SCP) and Tribal Sub Plan (TSP) in proportion to the percentage of General, SC and ST population in the state. As per the census of 2001, that percentage stands at 78.8%, 11.8% and 9.4%, respectively. Each categorial annual plan is then subdivided into 'State Plan' and 'District Plan'.

The ratio of this division into state plan and district plan is not based on any particular formula or rule of thumb for General and Special Component Plan. Tribal sub plan follows the ratio of 40:60 for dividing the funds into state and district plans.

[5] Maharashtra District Planning Committees (Conduct of Election) Rules, 1999 and Maharashtra District Planning Committees (Conduct of Meetings) Rules, 1999.

Figure 1



However, if we compare the total figures of state and district plans (without considering the categorical divisions, i.e., combining the district component of 3 categories shown in Figure 1 over the years from 2011-12 to 2020-21), we find that, on average, around 18% of total annual plan funds are allocated for district plans, compared to 30% as recommended by the Expert Group on Grassroot Level Planning[6] and the 2008 guidelines from the Planning Commission of India (see Table 1).

Table 1: Annual District and State Plan Outlays (In Rs. Crore)[7]

Year	District Annual Plan	State Annual Plan	Total Annual Plan	District plan as % of Total Plan	District Annual Plan (General)	District Annual Plan (General) as % of Total Plan
(1)	(2)	(3)	(4) = (2+3)	(5) = (2/4)*100	(6)	(7) = (6/4)*100
2011-12	7114.67	34885.36	42000	16.94	4319.52	10.28
2012-13	8766.11	36233.91	45000	19.48	4950	11.00
2013-14	9203.02	39797.03	49000	18.78	5200	10.61
2014-15	10518.29	40704.25	51223	20.53	5902	11.52
2015-16	12416.9	42582.11	54999	22.58	7127.93	12.96
2016-17	13073.92	43923.08	56997	22.94	7562.02	13.27
2017-18	13315.91	63868.11	77184	17.25	7562	9.80
2018-19	14003.9	80996.09	95000	14.74	8250	8.68
2019-20	13977.14	85022.86	99000	14.12	9000	9.09
2020-21	14454.53	100545.44	115000	12.57	9800	8.52
Average	11684.44	56855.82	68540.26	17.99	6967.35	10.17

Source: Annual District Plan Documents, Planning Dept., Government of Maharashtra, and authors' calculations

[6] The Expert Group on Grassroot Level Planning and the 2008 guidelines from Planning Commission of India have stressed the need to devolve at least 30% of the state plan funds to Panchayati Raj Institutions, in order to enable Panchayats at different levels to formulate and implement locally relevant schemes in respect of functions that have been devolved to them and out of these funds, 25% shall be of untied nature. Planning at the Grassroot Level: An Action Programme for Eleventh Five Year Plan Report of the Expert Group, March 2006, Chapter 2, p. 16.

[7] 1 crore = 10,000,000

In this paper, we are focusing on the financial aspects of the District level funds of the General Plan Component, hence called the District Plan, outlined with the square box in Figure 1 and shown in column (6) of Table 1. It is worth noting from the table that the average share of the General District Plan Fund amounts to only 10.17% of the average total annual plan outlay over the 10 years. The possible reasons behind not being able to achieve a higher allocation of funds for decentralised plan preparation are discussed in the section titled 'Limitations to the Study'.

District-wise Allocation of Plan Funds and the Question of Parity in Allocation

There is no formula or a set percentage to divide the general plan funds into a district and state plans. But, once the corpus for General District Plan is fixed, it gets subdivided into proposed or initial outlays/allocations to be made to each district based on the formula as mentioned in Table 2. This formula is only used to convey initially proposed allocations to the districts.[8] It is to be noted that the actual allocations made to the districts could be higher or lower than the formula-based allocation.

Table 2: Formula for District-level Allocation

Sl. No.	Item	% weight
1	Total General Population of the District	30
2	General Rural Population in the District	20
3	Area of the District	30
4	Human Development Index	20
5	Total	100

To understand how the initial allocations are worked out, let's assume that a corpus of Rs. 100 is to be distributed within 36 districts by assigning weights to them based on the four aspects mentioned in Table 2. First, the corpus is divided into these four categories in the ratio of 3:2:3:2, i.e., Rs. 30 to be distributed based on the General Population of the District, Rs. 20 to be allocated based on the General Rural Population of the district, Rs. 30 to be distributed based on Area of the district, and remaining Rs. 20 to be distributed as per the Human Development Index of the district.

For the first aspect/category, the proportion of the total general population of the district with respect to the total general population of the state is calculated and multiplied by Rs. 30, which are kept aside for distribution based on the total general population to arrive at the individual district allocation based on its total general population. Similarly, to distribute the amount of Rs. 20 based on the general rural population of the districts, the proportion of the general rural population of the district with respect to the total general rural population of the state is calculated and multiplied by Rs. 20. Similar process is followed to distribute the amount of Rs. 30 based on area of the districts.

In the case of making the allocations based on Human Development Index (HDI), a different method is employed, wherein a score of "1 – HDI" (read one minus HDI score) is calculated for each district and is multiplied by the total general population of that district. The resulting figure or quantity for each district is then converted into a proportion with respect to the state total of this quantity. The resulting proportion is then multiplied by the Rs. 20 kept aside for distribution/allocation to arrive at the individual district allocation based on its Human Development Index.

In the end, all these four allocations for each district are clubbed to arrive at total formula-based allocations, also called initial district plan allocations or ceilings, to be conveyed to districts to

[8] Draft Annual Plan 2012-13, Planning Department, Government of Maharashtra.

prepare their plans for the upcoming financial year. In short, the initial formula-based allocation for each district can be arrived at by the equation given below.

Initial or Modelled Allocation Per District:[9]

(w1 × 30% of the total corpus of the General District Plan) +

(w2 × 20% of the total corpus of the General District Plan) +

(w3 × 30% of the total corpus of the General District Plan) +

(w4 × 20% of the total corpus of the General District Plan),

where

w1 = proportion of the total general population in the district to total general population in the state

w2 = proportion of the general rural population in the district to total general rural population in the state

w3 = proportion of the area of the district to total area of the state

w4 = proportion of the quantity {(1-HDI of the District) × (Total General Population of the District)} for a given district to ∑ {(1-HDI of the District) × (Total General Population of the District)} over all the districts.

Based on this formula, model allocations were worked out for all 10 years i.e. from 2011-12 to 2020-21 for all the districts in Maharashtra. The actual total general district plan fund (shown in column 6 of Table 1) in each year is taken as the corpus for distribution through the formula. This helped in comparing the two allocations i.e. actual allocation received by each district and the outlay arrived at through applying the formula for each district, which we will call formula-based modelled allocation henceforth.

A formula-based allocation system is expected to be fair and equitable in ensuring proper fund management within the competing districts. The question we would like to follow is whether the actual allocations received by the districts differ significantly from the formula based modelled allocations. The hypothesis we would like to test is, whether the mean modelled allocation for any given district is the same as the mean actual allocation received by that district over the 10 years considered for the study. If there is a statistically significant difference between the two types of allocations, then we may be able to establish that each district has been able to receive its fare share, which is assumed to have been gauged with the formula-based allocations as the formula capture the needs of the districts through its four aspects as mentioned in Table 3.

A paired t-test for the difference of means is used for testing our hypothesis. Paired because each district has 10 paired observations in the form of actual and modelled allocations and we would like to know if the difference between these two is statistically significant. This is to be tested for each individual district separately and independently.

H0= Mean Actual Allocation for a given district is equal to Mean Modelled Allocation for the same district.

H1= Mean Actual Allocation for a given district is not equal to the mean modelled allocation for the same district.

---

[9] This is a mathematical representation of the fund distribution criterion devised and finalised by the Planning Department of Government of Maharashtra for allocation of general district plan fund vide its Government Resolution No. 1009 पुर. क्र. 205/का-1481 dated 17 April, 2010.

The results of the tests are summarised in Table 3. It is evident that for 21 districts, we can reject the null hypothesis, which claims a parity between mean allocations of the two series and establishes that the difference between modelled and actual outcomes for these districts is statistically significant at 5% level of significance. See Appendices 1 and 2 for the values of actual allocations made to the districts and the formula-based allocations. Appendix 3 gives the difference calculated between the actual and formula-based allocations for the particular year and district.

Table 3: Paired t-Test Results for Actual and Modelled Allocations for 36 Districts

Sl. No.	District	Two-Tailed Test P Values
1	Mumbai City	0.17
2	Mumbai Suburban	0.00***
3	Thane	0.00***
4	Raigad	0.00***
5	Ratnagiri	0.12
6	Sindhudurg	0.00***
7	Nashik	0.01**
8	Dhule	0.23
9	Nandurbar	0.30
10	Jalgaon	0.04**
11	Ahmednagar	0.01**
12	Pune	0.02**
13	Satara	0.28
14	Sangli	0.02**
15	Solapur	0.01**
16	Kolhapur	0.02**
17	Buldhana	0.09*
18	Akola	0.32
19	Washim	0.05**
20	Amravati	0.18
21	Yavatmal	0.58
22	Nagpur	0.02**
23	Wardha	0.01**
24	Bhandara	0.04**
25	Gondia	0.02**
26	Chandrapur	0.04**
27	Gadchiroli	0.05**
28	Aurangabad	0.01**
29	Jalna	0.21
30	Beed	0.11
31	Parbhani	0.11
32	Hingoli	0.60

Contd...

Table 3 contd..

Sl. No.	District	Two-Tailed Test P Values
33	Nanded	0.01**
34	Osmanabad	0.14
35	Latur	0.56
36	Palghar	0.53

Notes: *** significant at 1%, ** significant at 5%, * significant at 10%
Source: Author's calculations

As Sundaram (1979) argued, the District Planning in Maharashtra had two main objectives as follows which influenced the State Government to adopt the district as the unit of planning:

(i) removal of the inter-district and intra-district imbalances in development; and

(ii) desire to ensure that the districts will be given an opportunity to attain full development with regard to their potential, available manpower and other resources.

Keeping in view the first objective of removing inter-district imbalances in development, if we are to place importance on fairly allocating the resources between districts and the administrative zones, it is important to note that the difference is significant for all districts in Nagpur Division i.e. Nagpur, Bhandara, Gondia, Chandrapur, Wardha and Gadchiroli and for all but one district in Pune Division namely Pune, Ahmednagar, Sangli, Kolhapur and Solapur (Satara being the exception). In the case of Aurangabad Division, only two districts out of 8 show significant values; so is the case with Amaravati and Nashik Divisions. For Konkan Division, the districts having significant values are 4 out of 6, namely, Mumbai Suburban, Thane, Raigad and Sindhudurg.

Discussion

The significant values for 21 districts indicate that the actual allocation of district plan funds under the general component followed by the government lacks equitability in terms of the parameters of population, area and development indicators that were supposed to be considered for fairer distribution. Annexure III gives the table indicating the difference between actual allocations and formula-based modelled allocations where the negative values denote under-allocation i.e. the concerned district has received less than its technically fair share calculated by formula-based modelled allocation and vise-a-versa where the difference is a positive value. Thus, it can be said that the practice of allowing approval of additional demands for district plan funds distorts the parity that a formula-based distribution could provide given the parameters to be taken into account.

As mentioned in the introductory part about the perceived fairness of a formula-based allocation, any deviations from such a rule can give impetus to widening the regional imbalances within the state. Nagpur, Konkan and Pune divisions with most of their districts receiving significantly different shares than the formula-based allocation indicate the potential for widening the developmental gap between these regions and the rest of the state. This argument can be substantiated by the fact that out of the 21 districts with significant results, 14 districts are categorised as having high and very high Human Development Index as per the Human Development Report of Maharashtra 2012.[10]

This paper does not explore the possible reasons for certain districts getting more than their formula-based technically fair share while others receive less; however, it forms an area for further research and investigation which needs more data and information which is largely either not

[10] Maharashtra Human Development Report 2012, p. 14

available or if it available, the authenticity of the same is questionable. The relative strengths of districts from their geo-economic-political characteristics such as composition of primary to tertiary activities in the districts, number of MLAs and MPs having alignment with the ruling party etc., infrastructural robustness and relative income levels, relative employment from primary to tertiary activities could be the factors that help in the bargaining process for additional funds sanctioned to the districts. But, these need to be explored further in an elaborate manner.

Limitations to the Study

It is to be noted that while trying to analyse the district plans in Maharashtra, the authors have considered only the part of fund allocation under the general component of district annual plans. There are counterintuitive arguments in literature over the importance of allocation of funds vis-a-vis utilisation of these funds. A common view articulated in this aspect by ground-level planning staff[11] points to the fact that the ability to utilise or spend the allocated amount gives an impetus to next year's allocations. Even though the Planning Department has devised a formula for distributing the district plan funds to each district, which is put to use as per the plans prepared by the District Planning Committees of respective districts, the department has made it clear that this formula is used only to convey the prospective or tentative fund amount, receivable by the districts in the upcoming financial year so that they can start planning for it.

However, when allocation is being finalised, the additional demands over and above the tentative fund or ceiling, are made by the districts for completing certain plan targets. In this case, the state-level committee on district planning decides on such additional demand for funds in their annual meeting. Then, the actual allocations are finalised, which differs from the formula-driven tentative allocations. The exercise done in this paper outlines the fact that the final allocations vary significantly (in the case of 21 districts) from the modelled allocations had the distribution formula been followed by the department even at the time of fixing final allocations.

It is assumed for the analysis purpose that the formula-based allocations are fair and more equitable than actual ones because the formula captures needs of the district by considering its population, geographical area, and human development index. This assumption can be challenged if any improvements to the formula can be brought about to make it more equitable.

There is more to explore about the scheme-bound structure of district plans which gives a better idea about what works are carried out through the district plan funds and their relative importance in the budgets of Panchayati Raj Institutions (PRIs), but it is not kept under the scope of this paper due to lack of segregated data on state plan funds made available to each district and each PRI along with the district plan funds.

Policy Suggestions

The analysis of District Annual Plans in Maharashtra over the last 10 years indicates that there is scope for improving the allocation of plan funds to the districts, specifically for the General Plan component. The following suggestions can be made in that direction:

1. Adherence to formula-based allocation is a better strategy for fair and equitable allocation of resources between districts and will help reduce the resource backlog in comparatively

[11] The authors had an opportunity to interact with some District Level Officials who are directly involved in the process of district plan preparation from the District Osmanabad, Maharashtra, India in the months of Jan-Feb 2022. The views expressed by them in the semi-structured interviews conducted to understand the district planning process are presented here.

backward districts.

2. The quantifiable parameters used at present, including the district's total and rural general population, area and district HDI, are suitable for creating the base of a workable formula that has both simplicities in calculation and feasibility of application for making the district plan allocations. However, the parameters shall have an element of dynamism in the sense that, for each year, projected population values shall be used instead of using only one value for ten years given by previous census data. Furthermore, a similar projected value/score for HDI shall be calculated based on the yearly data collected for the constituent indicators of HDI.
3. Not just the district but even block level allocations shall be guided with a suitable formula that will help address the imbalances in resource allocation within a district. This is in line with the erstwhile suggestions put forward by the expert group on grassroot level planning (2006), which pointed out that the block-level panchayats have an important role to act as a facilitator in various steps of planning and have to plan for works such as inter-village road formation and multi panchayat irrigation structures which are mostly outside the purview of gram panchayats but have a significant role to play in the balanced development of the block as a whole.
4. The absence of data on sector-wise, scheme-wise outcomes from district plan funds along with the district-wise expenditure data of state plan funds utilised in the districts for the same purpose/scheme/works etc, its distribution in the blocks and Panchayati Raj Institutions, is the major hindrance in evaluating the importance and impact of this exercise. The mechanisms to address this data gap shall be the priority of the nodal statistical organisation of the State.

Although these policy suggestions are generic in nature and have been reiterated by various government reports and committees in their recommendations, this paper has attempted to provide a data-driven quantitative basis for the same.

About the authors

Priyanka Bokil is a PhD student at Gokhale Institute of Politics and Economics, Pune, India. **Anurag Asawa** is an Associate Professor at Gokhale Institute of Politics and Economics, Pune, India.

References

Adik, B.R. (1987), "Regional and District Planning—Concepts, Experiences and Approaches: A Review of Literature", Gokhale Institute of Politics and Economics.

Buehler, J.W. and D.R. Holtgrave, (2007), "Challenges in Defining an Optimal Approach to Formula-based Allocations of Public Health Funds in the United States", *BMC Public Health*, 7(1): 44.

Charvak (2000), "From Decentralisation of Planning to People's Planning: Experiences of the Indian States of West Bengal and Kerala", Kerala Research Programme on Local Level Development, Centre for Development Studies, Thiruvananthapuram.

Devarajan, S., V. Swaroop and H. Zou (1996), "The Composition of Public Expenditure and Economic Growth", *Journal of Monetary Economics*, 37(2): 313-344.

Mohanty, R.K. and N.R. Bhanumurthy (2018), *Assessing Public Expenditure Efficiency at Indian States*, New Delhi: NIPFP.

Oates, W.E. (1972), *Fiscal Federalism*, NY: Harcourt Brace Jovanovich.

Paternostro, S., A. Rajaram and E.R. Tiongson (2007), "How Does the Composition of Public Spending Matter?" *Oxford Development Studies*, 35(1): 47-82.

Planning Commission (1984), "Report of the Working Group on District Planning", Government of India, New Delhi.

Prasad, K. (1988), *Planning at the Grassroots*, New Delhi: Sterling Publishers Private Limited.

RBI (2022), "Report on Municipal Finances", Reserve Bank of India Annual Reports, Reserve Bank of India (RBI), Mumbai.

Shankaranand, G. and R.R. Biradar (2015), "Dynamics of Public Expenditure in Karnataka: An Analysis of Its Trends and Patterns", *Journal of Economic and Social Development*, 11(1).

Sundaram, K.V. (1979), "District Planning: The Case of Maharashtra", *Indian Journal of Public Administration*, 25(1): 57-73.

Vaddiraju, A.K. and S. Satyanarayana (2011), *Decentralised Governance and Planning in Karnataka, India*, Cambridge Scholars Publishing.

APPENDIX

Appendix 1 : Actual Allocations Made to the Districts in Maharashtra from 2011-12 to 2020-21 (In Rs. Lakh)[12]

Sl. No.	District	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
1	Mumbai City	5100	6000	6300	10000	10000	10287	11105	11628	12500	15000
2	Mumbai Suburban	13300	15000	16000	17000	23900	25612	29420	31015	32900	37136
3	Thane	20150	22500	24000	30000	25233	26687	30672	32335	33300	39600
4	Raigad	10500	12000	12700	13500	14949	16005	17970	18917	21100	23400
5	Ratnagiri	11500	13000	14000	15000	15749	15800	17099	18313	20100	21100
6	Sindhudurg	9500	9500	9500	10000	12500	13000	15943	18917	22500	14300
7	Nashik	20000	24000	25000	27500	31318	31937	32138	33880	34600	42500
8	Dhule	8000	9700	10000	11500	13650	14556	13567	14303	14700	19000
9	Nandurbar	4500	5200	5500	6000	7200	7640	6734	8766	11200	11500
10	Jalgaon	17900	21000	22000	23500	27367	30599	28676	30178	30800	37500
11	Ahmednagar	21000	25000	25500	28000	33150	35659	35135	37040	37400	47500
12	Pune	28500	30900	32400	38000	42150	45071	47975	50575	52100	65000
13	Satara	17500	19000	20000	22000	25584	26130	24365	25685	26500	32500
14	Sangli	13000	15000	15500	17500	19850	21220	21265	22418	23100	28500
15	Solapur	20000	24200	25000	27500	32166	33249	32230	33977	34700	42400
16	Kolhapur	16500	18400	19000	21500	22650	22650	24952	26304	27100	33000
17	Buldhana	12500	14500	15500	18000	22271	22886	20283	21863	23300	26725
18	Akola	8000	9000	10000	11000	13996	14194	12324	13951	15900	16500
19	Washim	6000	7000	7300	8500	11573	11666	9757	12725	16300	17000
20	Amravati	12500	15000	15500	17500	21792	22408	20191	21286	24900	27140
21	Yavatmal	15000	17000	18000	20000	25371	25714	22509	24697	25400	30000
22	Nagpur	16000	16000	17500	22500	30000	35000	40008	45216	52500	40000
23	Wardha	7000	8000	8500	9500	13068	14306	14010	15564	19000	16360
24	Bhandara	6000	7000	7100	8000	9373	9968	12011	13981	16000	12914
25	Gondia	6000	7500	7600	8500	11492	11838	13568	14610	17000	16045
26	Chandrapur	11000	13000	13600	15000	20058	22738	26153	30057	37500	24860
27	Gadchiroli	8500	9500	10600	11700	15698	16314	17203	22252	28500	25640
28	Aurangabad	14500	16500	17200	20500	24219	26005	24475	27302	28800	32550
29	Jalna	10500	12500	13000	15000	18333	19082	18412	20316	21200	23500
30	Beed	13000	15500	16200	18500	24078	26754	22370	23583	25300	30000
31	Parbhani	9000	10100	10700	12500	15046	15982	14446	15229	15400	20000
32	Hingoli	6000	7000	7200	8000	10079	10809	9567	10075	10400	13500
33	Nanded	14000	16500	18000	20000	24014	25546	23521	24796	27100	31500
34	Osmanabad	9000	10500	11300	12500	15954	17492	14813	19319	24700	26080
35	Latur	10500	12500	12800	14500	17829	20004	19304	21269	23200	24000
36	Palghar	NA	NA	NA	NA	11133	11394	12029	12658	13000	15750
	Total	431952	495000	520000	590200	712793	756202	756200	825000	900000	980000

Source: District Annual Plan Documents, Department of Planning, Government of Maharashtra

[12] 1 lakh = 100,000

Appendix 2: Formula-based Allocations calculated for the Districts in Maharashtra from 2011-12 to 2020-21 (In Rs. Lakh)

Sl. No.	District	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
1	Mumbai City	5245	6010	6314	5767	9850	10450	10450	11401	12437	13543
2	Mumbai Suburban	13686	15683	16475	17583	30041	31870	31870	34770	37931	41302
3	Thane	20678	23697	24894	31737	31753	33687	33687	36752	40093	43657
4	Raigad	10621	12172	12787	14288	17849	18936	18936	20659	22537	24540
5	Ratnagiri	11863	13595	14282	14114	16041	17018	17018	18567	20255	22055
6	Sindhudurg	6040	6922	7271	7475	8937	9481	9481	10344	11284	12287
7	Nashik	20492	23483	24669	28677	32836	34836	34836	38005	41460	45146
8	Dhule	8646	9908	10409	11620	13260	14068	14068	15348	16743	18231
9	Nandurbar	4558	5223	5487	6149	7189	7627	7627	8320	9077	9884
10	Jalgaon	18278	20946	22004	24363	28303	30027	30027	32758	35736	38913
11	Ahmednagar	21859	25050	26315	29818	35901	38087	38087	41552	45329	49359
12	Pune	26448	30308	31839	39454	49014	51999	51998	56729	61886	67388
13	Satara	16109	18461	19393	20804	24895	26412	26411	28814	31434	34228
14	Sangli	12907	14791	15538	17392	21726	23049	23049	25146	27432	29870
15	Solapur	20822	23861	25066	28643	32931	34937	34937	38115	41580	45276
16	Kolhapur	15809	18117	19032	21256	25491	27044	27044	29504	32186	35047
17	Buldhana	13352	15301	16074	17650	20823	22091	22091	24101	26292	28629
18	Akola	8488	9727	10218	10587	11985	12715	12715	13872	15133	16478
19	Washim	6115	7007	7361	8438	9794	10391	10391	11336	12367	13466
20	Amravati	12916	14801	15548	17421	20633	21890	21890	23881	26052	28368
21	Yavatmal	15271	17500	18384	20746	22385	23748	23748	25909	28264	30776
22	Nagpur	13494	15463	16244	18512	22826	24216	24216	26419	28821	31383
23	Wardha	6911	7919	8319	8944	10428	11063	11063	12069	13166	14337
24	Bhandara	5855	6709	7048	7815	8998	9546	9546	10414	11361	12371
25	Gondia	6383	7314	7684	8628	10071	10684	10684	11656	12716	13846
26	Chandrapur	11386	13048	13707	14950	17037	18074	18074	19719	21511	23423
27	Gadchiroli	8900	10199	10714	12043	14095	14953	14953	16313	17796	19378
28	Aurangabad	14389	16490	17323	20907	25021	26545	26545	28960	31593	34401
29	Jalna	10813	12391	13017	15377	17031	18068	18068	19712	21504	23416
30	Beed	13529	15503	16286	19264	22857	24248	24248	26455	28860	31425
31	Parbhani	8896	10195	10710	12543	14549	15435	15435	16840	18370	20003
32	Hingoli	6032	6913	7262	8218	9781	10376	10376	11320	12349	13447
33	Nanded	15005	17196	18064	20855	24029	25492	25492	27812	30340	33037
34	Osmanabad	9449	10829	11375	12960	15135	16057	16057	17518	19110	20809
35	Latur	10706	12269	12889	15202	18188	19296	19296	21051	22965	25006
36	Palghar	NA	NA	NA	NA	11110	11786	11786	12859	14028	15274
	Total	431950	495000	520000	590200	712793	756202	756200	825000	900000	980000

Source: Author's calculations based on the formula prescribed in Maharashtra State Government Resolution No. 1009/ प्र. क्र. 205/का-1481 dated 17/04/2010

Appendix 3: Difference between Actual Allocations and Formula based Allocations Calculated for the Districts in Maharashtra from 2011-12 to 2020-21 (In Rs. Lakh)

Sl. No.	District	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
1	Mumbai City	-145	-10	-14	4233	150	-163	655	227	63	1457
2	Mumbai Suburban	-386	-683	-475	-583	-6141	-6258	-2450	-3755	-5031	-4166
3	Thane	-528	-1197	-894	-1737	-6520	-7000	-3015	-4417	-6793	-4057
4	Raigad	-121	-172	-87	-788	-2900	-2931	-966	-1742	-1437	-1140
5	Ratnagiri	-363	-595	-282	886	-292	-1218	81	-254	-155	-955
6	Sindhudurg	3460	2578	2229	2525	3563	3519	6462	8573	11216	2013
7	Nashik	-492	517	331	-1177	-1518	-2899	-2698	-4125	-6860	-2646
8	Dhule	-646	-208	-409	-120	390	488	-501	-1045	-2043	769
9	Nandurbar	-58	-23	13	-149	11	13	-893	446	2123	1616
10	Jalgaon	-378	54	-4	-863	-936	572	-1351	-2580	-4936	-1413
11	Ahmednagar	-859	-50	-815	-1818	-2751	-2428	-2952	-4512	-7929	-1859
12	Pune	2052	592	561	-1454	-6864	-6928	-4023	-6154	-9786	-2388
13	Satara	1391	539	607	1196	689	-282	-2046	-3129	-4934	-1728
14	Sangli	93	209	-38	108	-1876	-1829	-1784	-2728	-4332	-1370
15	Solapur	-822	339	-66	-1143	-765	-1688	-2707	-4138	-6880	-2876
16	Kolhapur	691	283	-32	244	-2841	-4394	-2092	-3200	-5086	-2047
17	Buldhana	-852	-801	-574	350	1448	795	-1808	-2238	-2992	-1904
18	Akola	-488	-727	-218	413	2011	1479	-391	79	767	22
19	Washim	-115	-7	-61	62	1779	1275	-634	1389	3933	3534
20	Amravati	-416	199	-48	79	1159	518	-1699	-2595	-1152	-1228
21	Yavatmal	-271	-500	-384	-746	2986	1966	-1239	-1212	-2864	-776
22	Nagpur	2506	537	1256	3988	7174	10784	15792	18797	23679	8617
23	Wardha	89	81	181	556	2640	3243	2947	3495	5834	2023
24	Bhandara	145	291	52	185	375	422	2465	3567	4639	543
25	Gondia	-383	186	-84	-128	1421	1154	2884	2954	4284	2199
26	Chandrapur	-386	-48	-107	50	3021	4664	8079	10338	15989	1437
27	Gadchiroli	-400	-699	-114	-343	1603	1361	2250	5939	10704	6262
28	Aurangabad	111	10	-123	-407	-802	-540	-2070	-1658	-2793	-1851
29	Jalna	-313	109	-17	-377	1302	1014	344	604	-304	84
30	Beed	-529	-3	-86	-764	1221	2506	-1878	-2872	-3560	-1425
31	Parbhani	104	-95	-10	-43	497	547	-989	-1611	-2970	-3
32	Hingoli	-32	87	-62	-218	298	433	-809	-1245	-1949	53
33	Nanded	-1005	-696	-64	-855	-15	54	-1971	-3016	-3240	-1537
34	Osmanabad	-449	-329	-75	-460	819	1435	-1244	1801	5590	5271
35	Latur	-206	231	-89	-702	-359	708	8	218	235	-1006
36	Palghar	NA	NA	NA	NA	23	-392	243	-201	-1028	476

Source: Authors' calculations

Anvesak
Vol. 53(2), 2023, pp. 72-86
Received: 29 Dec. 2022; accepted: 23 Mar. 2023

DETERMINANTS OF INCOME EARNED BY WOMEN WORKING IN THE URBAN INFORMAL SECTOR IN INDIA: AN EMPIRICAL STUDY

PARAMJIT[1], SONIA GOEL[2]*, APOORVA GUPTA[3] AND SUMANJEET SINGH[2]

[1]*Delhi School of Economics, University of Delhi, Delhi, India*
[2]*Ramjas College, University of Delhi, Delhi, India*
[3]*Hansraj College, University of Delhi, Delhi, India*

Abstract: Income earned by women has a close link with their empowerment. Good work conditions can bring about changes in women's ability to earn better income which in turn improves women's intra household bargaining power, help them to access and use resources for their betterment, and encourage them to make better decisions. Using the data from a primary survey of working women in the urban informal sector in three states of India, viz., Rajasthan, Haryana and Delhi, this paper argues that access to good work conditions increases women's ability to earn higher income. This paper finds that there is a direct relationship between income earned by the women in the highest income category and improvement in work conditions, while there is an inverse relationship between the income earned by the women in the lowest and middle income slabs and the work condition.

Keywords: Work condition, Women empowerment, Income of women, Informal sector, India

1. Introduction

Millennium Development Goal (MDG) Number 3 aims at promoting gender equality and empowerment of women. Sustainable Development Goal (SDG) Number 3 aims at promoting good health and wellbeing. Although a lot of efforts have been made in improving the lives of women by trying to provide them comparatively better work conditions, there is still a long way to go.[1] One of the ways by which these goals can be achieved is through creating awareness among women about the need of better work conditions at workplace which can lead to greater efficiency in work and thus better income as well. Better work conditions have important positive effects on physical health, mental health, income and overall wellbeing. Poor enforcement of laws in small

*Correspondence to: Sonia Goel, Associate Professor, Department of Economics, Ramjas College, University of Delhi, Delhi, India. Email: sonia@ramjas.du.ac.in

[1] See "Sustainable Development Goals", United Nations Development Programme (undp.org), accessed in April, 2022.

enterprises and in the informal sector leads to inability of workers to assert their rights. It also leads to deprivation of fair income required to suffice various needs (Hensmen, 2001). Access to better work conditions can bring about changes in women's ability to earn higher incomes which in turn improve women's intra household bargaining power, to access and use resources for their betterment and encourage them to make better decisions (Benach, et al., 2007). The concept of work condition comprises physical setting, geographical location and the immediate surroundings of a workplace as well as the facilities and benefits associated with an employment. Besides, work conditions are defined as the circumstances such as working hours, stress, degree of safety, or danger that affect the workplace. It is seen that, in India, a slightly higher proportion of women are employed in the informal sector compared to men (Chakraborty, 2020). Women are employed in all kinds of work in the informal sector such as domestic workers, street vendors, factory workers and others. They constitute the most vulnerable section, with low levels of education, little or no social security, facing occupation segregation and wage discrimination, no minimum wages or medical and maternity leaves and others (Chakraborty, 2020; Deshpande, 2020). This paper thus investigates whether working women have access to good work conditions and whether work condition has any positive (or negative) effects on their incomes.

We did this by conducting a primary survey among women working in the urban informal sector in three states of India, viz., Delhi, Haryana and Rajasthan. The paper is organized as follows. The next section reviews the pertinent literature. Section 3 describes the data. Section 4 gives the empirical strategy and estimation results. Section 5 discusses the results and concludes the paper.

2. Literature Review

Some researchers argued that women's well-being is strongly influenced by women's ability to find employment outside the home, to earn an independent income, to have ownership rights, to have literacy and education and to become participants in decision making processes—both within the household and outside the family setup (Sen, 1999). There are evidences where women's scope for having contacts with outside world (after working hours) is limited, mainly because women themselves accept family responsibilities as their primary work and give subsidiary status to their paid work (Radcliffe and Cassell, 2015). Women in India are unable to participate fully in the labour market because they are required to combine their household activities with income yielding jobs. They are constrained to work in the neighbourhood of their residence and can access jobs only through informal contacts because of other commitments, reducing their bargaining power, and they continue to receive low wages (Mitra, 2005). Informal work is seen as interrelated to poverty and viewed as comprising highly insecure and unstable work, long hours, poor conditions, no legal or social protection, limited access to credit and very limited bargaining power (Lund and Srinivas, 2000; Kapoor, 2007). When women engage in informal jobs, they operate out of necessity and are engaged in low-paid, menial, exploitative work in the absence of alternative means of livelihood (Chen et al., 2004; ILO, 2002).

Around 92 percent of the workforce in India belong to the informal sector. This is mainly due to inadequacy of existing laws. Factories Act, 1948 covers work conditions, health safety, basic amenities like working hours, toilets and others which does not apply to work places with fewer than ten workers. Employees' State Insurance Act, 1948 that provides sickness, accident and maternity benefits is not applicable to work places with less than twenty workers. The women in our sample are the ones who work in the urban informal sector where such laws are not applicable. Even if they do work in places where workers exceed the number required, employers have various ways to evade these laws. The Contract Labour (Regulation and Abolition) Act, 1971, restricts the

employment of contract labour for work for a very long time (Hensmen, 2001). The laws do exist, but because of poor enforcement of legislations, the workers in the informal sector are bound to be exploited. Government and their agencies should provide comprehensive standards and laws, and more importantly should see that these laws are enforced. (Benach et al., 2007). Poor enforcement of laws in small enterprises and in the informal sector leads to inability of workers to assert their rights. It also leads to deprivation from fair income sufficient to guarantee an adequate livelihood relative to their needs, no job protection; poor working facilities, all of which have an important effect on chronic diseases and mental health. The insecurity and vulnerability associated with their jobs lead to more hazardous work conditions and to higher income inequality. For example, temporary employees are exposed to hazardous work conditions, work more often in painful and tiring conditions, are more exposed to intense noise, perform more frequent repetitive movements, have less freedom to choose when to take personal leave, and are far less likely to be represented on health and safety committees (Benach et al., 2007). In a case study of household engaged in beedi-making, the women in this industry get wages below the statutory minimum rates fixed by the government. It is difficult to enforce legislation because the industry which is highly labour-intensive is using very little capital and is diffused and can easily move from village to village or house to house (Bhatt, 1987; Bhatty, 1980). There is urgent need to end the exploitation which impede women progress. Access to education is an important determinant of women empowerment. Education helps women to gain social and economic independence. According to Acharya (2008), education is a key instrument in empowering women in the household because it helps them gain a better understanding of their rights and responsibilities. Chudasma and Moitra (2009) find education as an important factor which can improve the position and status of women within and outside their families bringing about more empowerment of women, both across space and time (Kapila et al., 2016; Paul, 2019; Banerji et al., 2013).

If such are the aftermaths of working in the informal sector, one can imagine how poor would be the situation of the females who work in the informal sector where no laws are applicable. Thus we feel to increase the efficiency and productivity of women working in such very small units; government should provide standards and see that these are enforced. Good work conditions at workplace are required to increase the efficiency of working women which would help them increase better income levels. Given that poor work conditions at workplace may restrict women's choices on jobs and thus restrict her mobility (Anderson, 2017; Kabeer, 2008), it may result in a lower income earned by them, leading to reduced autonomy of women in taking independent decisions—be it financial or others (Kapila et al., 2016). In this paper, we study the relationship between work condition available at work place in the urban informal sector and the income earned by them.

A growing number of studies do not view the informal sector as a residue. Instead, these studies talk of the informal sector as an extensive, continuing and even growing in many populations. (Charmes, 2012; Feige and Urban, 2008; Schneider, 2008; Minard, 2009; Venkatesh, 2006). They view this sector as an absorber of surplus labor, provider of income earning opportunities for the poor, a provider of goods and services often unavailable in the formal sector and a primary means of maintaining a low cost of living by providing cheaper goods and services than otherwise would be the case.

Given this background, the present study aims to examine the extent of work conditions that women working in the urban informal sector enjoy. To the best of our knowledge, we have not come across any study which investigates the relationship between work condition at workplace

of women and income earned by them. Our contribution in this paper is the work condition (WC) index which we have constructed. This index is similar to what Besley-Burgess (BB) Index is on labour regulations (Besley and Burgess, 2004). The study tries to determine the factors that affect the work conditions at work place for women. Nineteen such variables have been identified from the questionnaire. We then try to find out what work conditions women are facing on their jobs; whether those are pro-worker or against; and how these work conditions affect the income a woman. We find that apart from type of occupation, type of contract, and other factors that determine income of a woman, work conditions also affect the probability of higher or lower level of income that women earn.

Our paper is different from earlier literature on three accounts: One, we not only make use of the special module in the questionnaire on work conditions of a woman within a household, but we identify nineteen questions from the questionnaire to capture the work conditions. Two, our study specifically focuses on working women in urban informal sector, when other studies have focused on either all women (irrespective of working or non-working), or focused on women in both formal and informal sectors. This has substantial policy implications, as it allows us to dig out specific problems related to inadequate work conditions at work place of working women in urban informal sector. Three, our paper tries to determine how income earned by working women is affected by the access to work conditions. This again has implications for policy formulation, especially when it comes to the debate on whether improving quality of working environment matters or quantity of factors which go in to determine the adequacy of work conditions at work place.

3. Data and Descriptive Statistics

The study is mainly based on the primary data collected through a questionnaire-based survey from a cross-section of 476 women working in the urban informal sector of three northern states of India: Rajasthan, Haryana and National Capital Region of Delhi. From each state, we have chosen two districts, namely, Sikar and Jaipur from Rajasthan, Rohtak and Sonepat from Haryana, and Delhi and Gurugram from Delhi-NCR. These states were chosen for three reasons: they are comparable as per their Gross State Domestic Product (GSDP) 2018-19, they are patriarchal in nature, and a large number of working women in informal sector are seen in these states. The study adopted a simple convenience sampling, that is, a non-probability sampling technique to select the target respondents. This method was deemed suitable to minimize and control the bias and cut down the time and cost related to this survey. In the process of data collection, the snow ball technique was employed. The survey was conducted during September 2021 to March 2022. This was the time period in India when lockdown restrictions were almost lifted in India and the market operations were assuming normalcy.

The questionnaire was prepared in two phases. In the first phase, unstructured in-depth interviews were conducted to create an initial questionnaire. Further, expert opinions on the questionnaire were collected and, accordingly, improvements were made in the questionnaire. In the second phase, a pilot survey was conducted with 45 women working in informal sector to evaluate how well the questionnaire was understood, and also to test alternative framing of the questions. Based on the responses received during the pilot, the questionnaire was again revised. The validation of the questionnaire was done through the feedback from academicians, practitioners and the issues identified in the relevant literature. Finally, the structured questionnaire was prepared, and the survey was conducted by explaining the purpose of research to the respondents. The research team conducted personal interviews to secure and collect all correct and necessary information. A total of 750 questionnaires were distributed personally to all the respondents, and 538 valid data samples

were gathered. Finally, 476 questionnaires were selected that fulfilled the criteria of completeness and accuracy of information.

Apart from personal information of the respondents, the questionnaire has various modules on: occupational details, work conditions at work place, financial autonomy of women, insurance schemes, discrimination or harassment faced by women at workplace, and domestic violence. In this paper, we make use of the special module in the questionnaire on work conditions available to a woman at work place. We have nineteen questions in the questionnaire to capture the work conditions. They are: (1) *Do you do overtime work?* (2) *If you ever have to do overtime work, will you be paid for that?* (3) *Can you sometimes leave early from work* (4) *Is salary deducted if you leave early from work?* (5) *Is salary deducted if you reach late to work?* (6) *Is salary deducted if you take more than prescribed leaves in a month?* (7) *How many weekly days-off do you get?* (8) *How many paid leaves are you entitled to?* (9) *How many paid holidays do you get?* (10) *How many sick leaves do you get?* (11) *Do you get extra salary if you come on an off day?* (12) *Do you get compensatory leave for coming on an off day?* (13) *Do you get medical leaves?* (14) *Do you get maternity leaves?* (15) *Do you get any leave other than medical and maternity leave?* (16) *Do you get benefits in kind, e.g., in terms of free clothes, etc.?* (17) *Do you get benefits in kind, e.g., in terms of free books?* (18) *Do you get benefits in kind, e.g., in terms of free food?* and (19) *Do you get any other benefits in kind?*

All the work conditions are zeroed down as a binary variable, indicating whether the workers have this benefit in their employment place or not. Two categories of work conditions have been identified: Positive and Negative. Positive means good work conditions, whereas negative means bad work conditions. While creating the work condition index, positive variables are given '+1', while negative variables are given '–1'. Of 19 variables, 15 are positive, while four are negative. All are "0/1" type. Thus, work condition index is created in the following manner: First, we created the work condition positive index by adding all positive variables. The work condition positive index is an equal weighted summation of all the 15 variables mentioned above. With the binary coding of all the variables, the work condition positive index value lies between 0 and 15, where 0 means no access to any of the positive variables to the women; and as the index value increases it reflects higher access to positive variable to the women. Then, we created the work condition negative index by adding all negative variables; the work condition negative index values lie between 0 and 4, where 0 means no access to any of the negative variables to the women; and as the index value increases it reflects higher access to negative variable to the women. Finally, we created the work condition index which is the difference between the work condition positive and the work condition negative values. The list of variables from the above listed nineteen variables which are considered as positive are as follows: *Overtime pay; leave early from work; weekly off; paid leaves; paid holidays; sick leaves; extra salary given if come on an off day; compensatory leave for coming on an off day; medical leave; maternity leave; any other leaves; and benefits in kind, e.g., in terms of free clothes, free food, free books, and others.*

The variables which are considered as negative are the following ones: *overtime work, salary deducted if leave early from work, salary deducted if come late, and salary deducted if take more than prescribed leaves in a month.*

Although we agree that these questions may not fully capture the work conditions available to the woman at workplace, these are indicative measures which can throw light on the extent of benefits and facilities which a working woman gets from her employer. However, merely getting a leave from the employer may not guarantee that it is a positive indicator. If the leave is a paid one, only then it can benefit the workers. If salary is deducted, then it does not benefit the workers.[2]

[2] Expanding Women's Access to Financial Services (worldbank.org), Accessed in April, 2022.

Thus, we consider having leave entitlement in the name of a woman to be a necessary condition or a starting point of enjoying better work conditions, and may not be the sufficient condition for the same. We expect that the further questions in the questionnaire on the leaves and compensation for the leaves and questions on in kind benefits which a working woman can get can provide us some useful insights on the sufficiency of work conditions of working women in the urban informal sector. Women that we have surveyed were employed in a variety of occupations, like being a household maid, street vendor, *presswali* (clothes ironing work), construction workers, beauty parlours, sales women (both in shops and door-to-door selling items), washers, cleaners, sweepers, cooks, and others. For some of these categories, the number of observations were way too less to do any meaningful analysis. Thus, we club them into three broad categories. One, household maids (who were indeed the biggest in number in our sample); two, washers, cleaners, sweepers and other related activities; and three, all other types of works.

Talking of the religion category, we have clubbed Muslims and all other religion into one group, as Hindus were making the biggest chunk. As far as social groups are concerned, we found that around a quarter of the sample did not know their caste groups. Given that caste plays an important role, even in the contemporary Indian society, this astonished us quite well. Thus, for the analysis, we divide all the individuals into forward castes and non-forward castes. Forward castes include the upper caste individuals. And the rest are included in the non-forward castes. Talking about the nature of work, there are four categories. Since this is informal sector work, it is not expected that women will have a permanent job; they can have long term contract work. However, it could be the case that when a woman is working at some place for quite a long time, it is usually considered to be a permanent job or long term contract job. Thus, rather than considering four categories, we have considered only two categories, permanent or long term contract job and non-permanent, in the regression analysis later in the paper. There are three categories of this variable—written, oral and no contract. They are informal sector jobs, with usually no written contracts. It may be the case that at the time of payment of wages, the employer gets the signature. It is usually the oral contract or the mutual understanding between the employer and the employee. Thus, finally, rather than taking three categories, we will consider only two categories—contract or no contract—for the regression analysis. The above variables have been considered as potential variables affecting the income earned by women. Table 1 gives the description of the data.

Table 1: Descriptive Statistics

Categories	In Percentage Term
Education	
Illiterate	20.59
Up to primary	48.95
Middle and secondary	22.06
Above secondary	8.4
Total	100
Occupation	
Household maid	37.82
Cleaners	23.53
Others	38.66
Total	**100**
State	
Delhi	31.3

Contd...

Table 1 contd..

Categories	In Percentage Term
Haryana	39.08
Rajasthan	29.62
Total	**100**
Marital Status	
Unmarried	48.11
Married	51.89
Total	**100**
Religion	
Hindu	63.66
Muslim	14.71
Sikh	9.45
Others	12.18
Total	**100**
Social Groups	
Forward castes	87.37
Non-Forward castes	12.61
Total	**100**
Staying with Family	
Yes	87.37
No	12.61
Total	**100**
Nature of Work	
Seasonal	4
long term contract work	36
Casual	35
Daily	25
Total	**100**
Migrated	
Yes	67
No	33
Total	**100**
Average Age (years)	36.57
Number of observations	476

Source: Authors' calculations based on survey data

Table 1 gives the descriptive statistics and the details of the variables that are used in the regression analysis. Majority women in the sample are up to primary level of education. Only 8.4 percent of women in the sample have secondary education. In our sample, 37.82 percent of women were employed as household maids; 23.53 percent were employed as washers, cleaners and sweepers; and the rest 38.66 percent were involved in other types of informal work, mentioned above.

The state-wise sample composition is as follows: 31.30 percent of the sample comes from Delhi, 39.08 percent from Haryana and 29.62 percent from Rajasthan. In our sample, 51.89 percent of women are married; 63.66 percent of women are Hindu; 14.71 percent are Muslim; and the rest belong to other religions such as Sikh, Christianity, Jainism and others. In our sample, 24.37 percent of women are from forward castes and 87.37 percent of women in the sample are staying with their families. Further, 67 percent of women have migrated, while the rest are local. The most important

reason for migration is marriage and women come to urban areas with their spouses. Secondly, they migrate in search of jobs. In our sample, 25 percent of women are daily workers; 35 percent of women are casual workers; four percent are seasonal workers; and the rest 34 percent have long-term contract jobs. Only five percent of women have written contracts from their employer, and 34 percent of women work with oral contracts while the remaining 61 percent of women have no contracts with them. Table 2 gives the descriptive statistics of the responses of women to the questions on work conditions available to women at work place; and the work condition indices.

Table 2: Work Condition Indices of Variables

Variable	Observations	Work Condition Positive				Work Condition Negative				Work Condition Index			
		Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Occupation													
Cleaners	112	8.71	1.54	3	10	1.42	1.44	0	4	7.27	1.45	2	8
Household maid	180	5.71	1.79	2	8	1.28	1.07	0	3	4.43	1.78	0	8
Other occupations	184	6.05	3.33	1	11	1.22	1.09	0	3	4.83	3.11	0	8
Nature of work													
Long term contract	175	5.71	1.79	3	10	1.28	1.07	0	4	4.43	1.78	2	8
Non permanent	301	6.28	2.79	1	11	1.39	1.13	0	3	4.89	2.71	0	8
Nature of contract													
Written	23	3	0	3	3	1	0	1	1	2	0	2	2
Oral	164	9.09	1.31	2	11	1.51	1.34	0	4	7.58	0.97	1	8
No contract	289	5.38	2.31	1	9	1.19	1.11	0	3	4.19	2.34	0	8
Income category (Rs.)													
Less than 10,000	94	2.76	1.11	1	5	1	1.21	0	3	1.76	1.49	0	4
10,000-15,000	175	7.44	2.41	3	10	1.39	1.17	0	4	6.04	1.75	3	8
More than 15,000	207	7.51	1.92	2	11	1.34	1.14	0	3	6.16	2.22	0	8

Source: Authors' calculations based on survey data

The descriptive statistics in Table 2 show the average value (mean), the variability value (SD) and the range (min and max) for all the three categories of variables (i.e. occupation, nature of contract and income category) under three work conditions – i.e., positive work condition, negative work condition and combined (both positive and negative) work condition.

Table 2 gives the descriptive statistics which shows the average value, the variability value and the range for all the three indices, that is, index of positive work conditions, index of negative work conditions and index of combined positive and negative work conditions.

We find in Table 2 that as women move towards other occupations like cooking, beauticians and others, the variability in the value of the positive work condition index rises. This shows the higher bargaining power of the women as they work in better off jobs. Similar results are seen for total work condition index which depicts that women engaged in relatively well-to-do jobs can ask and get better work conditions at their workplace.

While talking about the income category, the women in the highest income category have the lowest variability for negative work condition index and its maximum value is also less than the maximum value of negative conditions at work place for the women in the lowest income category. This again highlights the fact that as women move to higher income jobs, their ability to get better work conditions at work place rises. The average value of the positive work condition index is

highest for women earning higher incomes. The maximum variability in the positive work condition index lies in the highest income group which highlights the fact that the higher the income a woman earns, the higher the possibility to get better work conditions at the work place. The maximum number of positive factors the women get in the lowest income category is just five, which shows that getting better facilities for a lower income group is not as easy as compared to higher income groups.

The maximum value of the negative work condition is lowest for the women in the highest income category. This shows that as woman earns more, they bargain and try to have less unfavorable facilities at their work place. While talking about the nature of contract, we find that there is no variability in the written contract-based employment: what the employer will provide at workplace is discussed and decided beforehand, i.e., at the time of recruitment. This reflects that the employers do not resort to unfair practice of cheating the workers and violate the contract. The average values are higher than those when contract is a written one, which indicates that the designated variables which have been used for construction of the indices have not been specified in the contract, but they might be availed by the worker women when the need arises.

In the absence of any such contract, the women can bargain for better work conditions over time. Overtime if they work hard and the employer is happy with their work, then the probability of getting better facilities at work rises and that is why we find higher variability in the case of 'no contract' jobs. Also, the maximum value is higher in the case of oral and no contract.

In case of the nature of work, we find that for non-permanent employees, there is large variability in the positive work condition index. It depends upon the women who work on non-permanent basis and keep shifting their jobs frequently. In such case, women's ability to keep their employers satisfied with their work counts a bit. This will determine their benefits or better work conditions they can get at their work place.

4. Estimation and Results

We find that apart from type of occupation, type of contract, and other factors that determine income of a woman, work conditions also influence the probability of higher or lower level of income of women. To determine the income earned by the women working in the urban informal sector, we use the index of work condition. Now,

$$Income_i = \alpha_1 + \alpha_2 * WCI_i + Z_i \alpha_3' + \varepsilon_i \quad (1)$$

The dependent variable "income earned" has three categories which are ranked in increasing order. The three income (in Rs.) categories are "Less than 10,000", "10,000-15,000" and "Above 15,000". Thus, ordered probit model is used in estimating the above regression where the dependent variable takes values equal to 1, 2 and 3, respectively, for the three income categories. In the Probit model, the inverse standard normal distribution of the probability is modeled as a linear combination of the predictors.

WCI_i is the work condition index. This index is the indicator of work condition. As mentioned earlier, the main variable of interest is the work condition index. Thus, we are interested in understanding the marginal effects of the right hand side variables. Since the main variable of interest is the work condition index, the marginal effects pertaining to captures the change in the probability of a woman earning income in a particular income category with respect to improvement in the work condition index.

Z_i is a vector of control variables, which includes occupation of a woman, state dummies, age,

marital status, her religion, caste categories, whether staying with family, number of dependents in the family, migration status, nature of job, and type of contract. We included all these variables in the model because income earned by women is not just affected by the work conditions at work place, but is also influenced by the above mentioned factors as well. Since the survey was conducted in three states, it could be the case that the women in different states have different probabilities of earning income in different income categories. The details of all the control variables have been discussed above except the variable 'age'.

Usually, for experience, age variable is used. However, in our data, we have information on the number of years, since the person is in current work. In our main regressions, we will use years in current profession as our variable. In Appendix, we show our results, wherein we re-run our regressions with age variable. This is for robustness check. Table 3 gives the estimation results. Columns (1) to (3) give the marginal effects from the probit regressions of the three categories of income level.

Table 3: Estimation Results for Income Earned

Variables	Less than Rs. 10,000 (1)	Rs. 10,000-15,000 (2)	Above Rs. 15,000 (3)
hh_maids	-0.139***	-0.0864***	0.225***
	(0.030)	(0.028)	(0.056)
cleaners	0.461***	0.287***	-0.748***
	(0.057)	(0.052)	(0.092)
primary	-0.232***	-0.145***	0.377***
	(0.049)	(0.035)	(0.079)
secondary	-0.152***	-0.0945***	0.246***
	(0.048)	(0.031)	(0.076)
above Secondary	-0.212**	-0.132*	0.343*
	(0.106)	(0.072)	(0.176)
married	-0.126*	-0.0785*	0.205*
	(0.065)	(0.045)	(0.109)
hindu	0.0102	0.00636	-0.0166
	(0.018)	(0.011)	(0.029)
forwardcaste	0.203***	0.126***	-0.329***
	(0.030)	(0.027)	(0.051)
staying_with_family	0.601***	0.374***	-0.975***
	(0.100)	(0.078)	(0.160)
dependents	-0.0305***	-0.0190***	0.0494***
	(0.006)	(0.006)	(0.012)
haryana	-0.0110	-0.00685	0.0179
	(0.022)	(0.014)	(0.036)
rajasthan	0.00391	0.00243	-0.00634
	(0.031)	(0.019)	(0.050)
migrated	0.113	0.0701	-0.183
	(0.069)	(0.049)	(0.117)
years_currentprofession	-0.0127**	-0.00793*	0.0207**
	(0.006)	(0.004)	(0.010)
permanent	-0.169***	-0.105***	0.274***
	(0.035)	(0.033)	(0.066)

Contd...

Table 3 contd..

Variables	Less than Rs. 10,000 (1)	Rs. 10,000-15,000 (2)	Above Rs. 15,000 (3)
contract_new	-0.0342	-0.0213	0.0555
	(0.035)	(0.021)	(0.056)
wc_index	-0.0726***	-0.0452***	0.118***
	(0.009)	(0.010)	(0.018)
Observations	476	476	476

Notes: Standard errors are in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1. Base categories are: illiterate, all other occupations, Delhi, not forward class, not married, not migrated, not permanent or not long term contract work and no contract.

Source: Authors' calculations based on survey data.

The incomes earned by the women belonging to the lowest and middle income slabs decrease with the decrease in work condition index, whereas incomes earned by the women belonging to the highest income slab increase with the increase in the work condition index. The probability of women to take jobs in the lowest and middle income categories is likely to fall with the improvement in work condition index. However, the probability of women taking highest income jobs is likely to rise with the increase in work condition index.

With increase in the number of years in current profession, a fall in the probability of income earned in the lowest and middle income categories is seen, whereas the income earned in the highest income slab is likely to rise. As number of years in the current work increases, a more efficient and experienced person can claim higher wages.

The results clearly show that the level of education has a negative and statistically significant relationship with the income earned by a woman in the lowest and middle income category and a positive relationship with highest income category. The higher the level of education, there is a probability of earning income of the "up to Rs 15,000" group to fall, whereas there is a probability of income of the "Above Rs. 15,000" group to rise. With rise in education, the probability of getting jobs of higher remuneration increases and probability of getting jobs of lowest and middle income categories decreases. This means that education plays an important role in the rise in income of working women. For marital status, we get mixed results. The probability of earning lowest and middle incomes is lower for married women than for unmarried women. This is expected as married women have more family commitments and other responsibilities and hence have less working hours leading to fall in their income. However, a rise in the probability of income earned in the highest slabs increase for married women as compared to unmarried women. The concerned family members may compromise and allow women to work and they take care of the household chores and other family responsibilities as the income earned by them is relatively high.

For women staying with families, we get mixed results. Probability of earning incomes within the lowest and middle income slabs is higher and statistically significant, if women stay with family. This is expected as the economic conditions of such women are very poor and need to work to earn their livelihoods. Such women can afford to go out and work even if it is for low levels of income because the women stays with the family and need not worry so much about household activities.

The probability of earning income within the highest slab increases as the number of dependents increases. Family members may compromise and allow women to work and earn. This will supplement to other family members' income and thus increase the disposable income of the family. However, the probability of earning income up to Rs 15,000 falls with the increase in the number of dependents in the family. For such a low income, women do not find it worthwhile to

leave the children and other family members who need to be looked after.

The probability of a statistically significant fall and a rise in income within the lowest and middle income category is seen for the household maids and cleaners, respectively, compared to women working in other jobs in the lowest and middle income category. Opposite but statistically significant results are seen for the household maids and cleaners for the highest income category. One of the reasons could be that women employed in other occupations, e.g. those working in beauty parlours or working as sales women to mention a few, are willing to work for lower income as long as they are sure that they are in higher category jobs. However, for women working as cleaners are not skilled enough to take up the work of beauticians or sales jobs and hence compromise with lower income. For the nature of job, we again get mixed results. The probability of earning lowest and middle level incomes is lower for women who are in long-term contract than others. In long-term contract jobs, a rise in income is expected.

The probability of Hindu women getting highest income is lower than non-Hindu women, and the probability of Hindu women getting lowest and middle category income is higher than non-Hindu women but the results are insignificant. Women who belong to forward castes enjoy increase in income in the lowest and middle income category while a fall is seen for highest income class. However, these results are also statistically insignificant. The probability of rise in income in both the lowest and middle income category and the highest income category is seen for women who live in Haryana compared to those living in Delhi, while women from Rajasthan see a rise in the lowest and middle income category and a fall in the highest income category. These results are, however, statistically insignificant.

As mentioned above, we have data on both age and years in current profession. We find that the results relating to age are statistically insignificant and it has opposite sign with respect to the variable called years in current profession. With increase in age, a rise in the probability of income earned in the lowest and middle income categories is seen, whereas the probability of income earned in the highest income slab sees a fall.

5. Discussion and Concluding Remarks

One of the findings of our paper is that with rise in income there is a rise in the other benefits, leading to rise in mean index value. Besides, this research finds the evidence of increasing inequality in the availability of benefits in the form of positive and negative variables. As found, there is an inverse relationship between the income earned in the lowest and middle income slabs and the work condition, and a direct relationship between income earned in the highest income category and work condition.

There is a need to provide better work conditions at work place to empower women and to ensure greater efficiency and productivity of women. There is substantial literature which shows that better work conditions can help women to work more efficiently and productively (Mitra, 2005; Kapoor, 2007). Our results also support the same. Awareness about access to better work conditions can be imparted to women through self-help groups, non-governmental organizations and informal talks with the workers. Infact, as mentioned above, a growing number of studies do not view the informal sector as a residue. Instead, these studies view the informal sector as an extensive, continuing and even growing in many populations (Charmes, 2012; Feige and Urban, 2008; Schneider, 2008). They view this sector as an absorber of surplus labour, and provider of income earning opportunities for the poor. Thus, it is important for the concerned authorities and government to provide better work conditions in the work place.

This study has a number of limitations. One, due to the logistical reasons, the sample size of the study is small; however, we have tried to get as much heterogeneity in the sample as possible by surveying various districts in the three states under the study. Two, we did not ask *jati* (castes) of the individuals, which could have helped us in identifying the specific caste groups of the women to make the analysis better, instead of clubbing all the so-called backward castes into one group. Three, we have clubbed various occupation categories into a broad group of "others". If we had enough observations, we would have carried out a detailed analysis of women employed in diversified fields of work. Four, we did not cover men in the analysis. We have only surveyed women in this study. If we had surveyed husbands and/or fathers of women (as applicable), we would have got a better idea about the work conditions available to them. We hope to overcome these shortcomings in future research work.

Acknowledgments:

We are extremely grateful to anonymous reviewers of this journal for careful reading of our manuscript and their many insightful comments, constructive criticisms and suggestions, which have helped us to improve the quality of our manuscript. Usual disclaimers apply.

About the authors

Paramjit is a Professor of Economics at the Department of Economics, Delhi School of Economics, University of Delhi, Delhi, India. **Sonia Goel** is an Associate Professor at the Department of Economics, Ramjas College, University of Delhi, Delhi, India. **Apoorva Gupta** is an Assistant Professor at the Department of Economics, Hansraj College, University of Delhi, Delhi, India. **Sumanjeet Singh** is a Professor at the Department of Commerce, Ramjas College, University of Delhi, Delhi, India.

References

Acharya, Y. (2008), "Women's Education and Intra-household Autonomy: Evidence from Nepal", *Journal of Development and Social Transformation*, 5: 5-12.

Anderson, B.J. (2017), "The Politics of Pests: Immigration and the Invasive Other", *Social Research: An International Quarterly*, 84(1): 7-28

Banerji, M., S. Martin and S. Desai (2013), "Are the Young and Educated More Likely to Have 'Love' than Arranged Marriage? A Study of Autonomy of Partner Choice in India", *Working Paper Series*, New Delhi: NCAER.

Benach, J., C. Muntaner and V. Santana (2007), "Employment Conditions and Health Inequalities", *International Journal of Health Services*, 40(2): 269-280.

Besley, T. and R. Burgess (2004), "Can Regulation Hinder Economic Performance? Evidence from India", *Quarterly Journal of Economics,* 119(1): 91-134.

Bhatt, E. (1987), "The Invisibility of Home-based Work: The Case of Piece-rate Workers in India". In *Invisible Hands*, A.M Singh and A. Viitanen (eds.), pp. 29-33, New Delhi: SAGE Publications.

Bhatty, I.Z. (1980), "Economic Role and Status of Women: A Case Study of Women in the Beedi Industry in Allahabad", *ILO Working Paper*, International Labour Organization (ILO).

Chakraborty, S. (2020), "COVID-19 and Women Informal Sector Workers in India", *Economic and Political Weekly*, 55(35):17-21.

Charmes, J. (2012), "The Informal Economy Worldwide: Trends and Characteristics", *Margin: The Journal of Applied Economic Research*, 6(2):103-132.

Chen, M.J., M. Carr and J. Vanek (2004), "Mainstreaming Informal Employment and Gender in Poverty Reduction", *Handbook for Policymakers and Other Stakeholders,* London: Commonwealth Secretariat.

Chudasama, R., N. Godara and M. Moitra (2008), "Women's Position and Their Behavior towards Family Planning", *Internet Journal of Family Practice*, 7(2).

Deshpande, A. (2020), "What Does Work from Home Mean for Women?", *Economic and Political Weekly*, 55(21): 23.

Feige, E.L. and I. Urban (2008), "Measuring Underground (Unobserved, Non-observed, Unrecorded) Economies in Transition Countries: Can We Trust GDP?" *Journal of Comparative Economics*, 36: 287-306.

Hensman, R. (2001), "Organizing Against the Odds: Women in India's Informal Sector", *Socialist Register*, 37: 249-257.

ILO (2002), "Decent Work and the Informal Economy", 19th Session, International Labour Organisation (ILO), Geneva.

Kabeer, N. (2008), "Paid Work, Women's Empowerment and Gender Justice: Critical Pathways of Social Change", *Working Paper*, Department for International Development, Institute of Development Studies (IDS), Sussex.

Kapoor, A. (2007), "The SEWA Way: Shaping another Future for Informal Labour", *Futures*, 39(5): 554-568.

Kapila, M., A. Singla and M.L. Gupta (2016), "Impact of Microcredit on Women Empowerment in India: An Empirical Study of Punjab State", *Proceedings of the World Congress on Engineering*, pp. 821-825, London: Newswood Limited.

Lund, F.J. and S. Srinivas (2000), "Learning from Experience: A Gendered Approach to Social Protection for Workers in the Informal Economy", International Labour Organization.

Minard, S. (2009), "Valuing Entrepreneurship in the Informal Economy in Senegal", *Social Enterprise Journal*, 5(3): 186-209.

Mitra, A. (2005), "Women in the Urban Informal Sector: Perpetuation of Meagre Earnings", *Development and Change*, 36(2): 291-316.

Paul, P. (2019), "Effects of Education and Poverty on the Prevalence of Girl Child Marriage in India: A District-level Analysis", *Children and Youth Services Review*, 100: 16-21.

Radcliffe, L.S. and C. Cassell (2015), "Flexible Working, Work-family Conflict, and Maternal Gatekeeping: The Daily Experiences of Dual-earner Couples", *Journal of Occupational and Organizational Psychology*, 88(4): 835-855.

Schneider, F. (2008), *The Economics of the Hidden Economy*, Edward Elgar Publishing.

Sen, A.K. (1999), *Development as Freedom*, New York: Alfred A. Knofp.

Venkatesh, S.A. (2006), *Off the Books: The Underground Economy of the Urban Poor*, Cambridge, Massachusetts: Harvard University Press.

Appendix

Variables	Less than 10000 (1)	10000-15000 (2)	Above 15000 (3)
hh_maids	-0.158***	-0.0954***	0.253***
	(0.032)	(0.029)	(0.058)
cleaners	0.413***	0.249***	-0.662***
	(0.048)	(0.047)	(0.078)
primary	-0.213***	-0.129***	0.341***
	(0.045)	(0.035)	(0.074)
secondary	-0.130***	-0.0788**	0.209***
	(0.049)	(0.033)	(0.080)
above Secondary	-0.170*	-0.103	0.273*
	(0.094)	(0.063)	(0.155)
age_new	0.000491	0.000296	-0.000787
	(0.001)	(0.001)	(0.002)
married	-0.0469	-0.0283	0.0752
	(0.050)	(0.032)	(0.082)
hindu	0.0205	0.0124	-0.0328
	(0.019)	(0.012)	(0.031)
forwardcaste	0.203***	0.122***	-0.325***
	(0.028)	(0.028)	(0.049)
staying_with_family	0.503***	0.304***	-0.807***
	(0.093)	(0.076)	(0.155)
dependents	-0.0231***	-0.0139***	0.0370***
	(0.004)	(0.004)	(0.008)
haryana	-0.0121	-0.00731	0.0194
	(0.023)	(0.014)	(0.036)
rajasthan	0.00156	0.000942	-0.00250
	(0.029)	(0.018)	(0.047)
migrated	0.0577	0.0348	-0.0925
	(0.046)	(0.031)	(0.077)
permanent	-0.178***	-0.107***	0.285***
	(0.040)	(0.033)	(0.069)
contract_new	-0.0405	-0.0244	0.0649
	(0.035)	(0.021)	(0.055)
wc_index	-0.0624***	-0.0377***	0.100***
	(0.006)	(0.008)	(0.012)
Observations	476	476	476

Notes: Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Base categories are: illiterate, all other occupations, Delhi, not forward class, not married, not migrated, not permanent or not long term contract work and no contract.

Source: Authors' calculations based on survey data.

Anvesak
Vol. 53(2), 2023, pp. 87-101
Received: 28 Feb 2023; accepted: 3 Apr 2023

LABOUR PROCESS ORGANIZATION IN CARPET INDUSTRY OF KASHMIR WITH SPECIAL FOCUS ON DESKILLING OF CARPET WEAVERS

ISHFAQ MAJEED*
Aligarh Muslim University, Aligarh, Uttar Pradesh, India

Abstract: The present paper attempts to study the labour process in carpet industry of Kashmir. The researcher also investigate the production relationships, economic analysis, organisational hierarchy, and deskilling in the carpet manufacturing sector. Weavers heavily rely on the capital of middlemen and master weavers, and the character of institutional arrangements has a significant impact on the labour process. The relationship between middlemen/master weavers and dependent/wage workers is related to the deskilling characteristic. In some cases, the labour process is defined by the unity of conception and execution, which is associated with independent weavers.

Keywords: Labour process, Deskilling, Carpet industry, Organization of production, Production relations.

Introduction

The relationship between labour and their work is referred to as the labour process. The analysis of the labour process provides a distinctive and significant view of the structure of work in capitalist societies. Work is not only done in societies to meet requirements or to help people survive; it also serves as the basis for capital owners to ensure the appropriation of surplus (Thompson, 1983). In *Capital* (volume 1, chapters 14 and 15), Marx (1976) investigated the labour process in England during the shift from pre-capitalism to capitalism. The labour process has shifted from simple cooperation to manufacturing to the industrial stage, resulting in the elimination of skilled craft workers' ability to exert judgement and control over their labour power. Marx describes numerous production relations, such as independent production of products, the putting-out system, and wage labour. Capital innovates and changes the employment process in order to optimize the appropriation of surplus from labour.

Braverman (1998) made an effective attempt to renew Marx's theory of the labour process by looking at skill, technology, and work organisation in a new context. He contended that the

*Correspondence to: Ishfaq Majeed, Research Scholar, Department of Sociology, Aligarh Muslim University, Aligarh, Uttar Pradesh, India. Email: naikishfaq82@gmail.com

introduction of new forms of technology and science into the service capital increased the potential of managerial control (Taylorism), resulting in widespread worker deskilling. Braverman tries to show how the detailed division of labour, introduction of managerial control, and routinization of traditional work within capitalist societies remove craft workers away from their skill. Capitalists, in order to gain larger control over the labour process, introduced the concept of *scientific management* that completed the transition to real subordination.[1] The main focus of the scientific management is to ensure the management control of the labour process (Braverman, 1998).

The labour process debate (post-Braverman approach) tries to include the significant changes in the labour process that occurred in the late 1970s in the discussion. The first issue stems from Braverman's foresight in science management. He contended that capitalists on both sides of the Atlantic had embraced Taylorism. However, European and American industrialists hustled to implement the work reorganisation urged by scientific management. Braverman is criticized for his specific assumption that capitalism evolved in a particular way, that is, deskilling and degradation of craft work while excluding workers' enskilling, workers' resistance, and management control as the sole form of control. The criticisms can be divided into three categories: one relates to the concept of class struggle or worker resistance (Elger, 1979; Zimbalist, 1979; Littler, 1982), another to the concept of control (Littler and Salaman, 1982; Friedman, 1977; Burawoy, 1982), and the third to the concept of skill (Becker, 1964; Gallie, 1991).

From mid-1980s, the growth of post-Fordism and flexible specialisation paradigm breakage theories (Piore and Sabel, 1984). The new forms of labour organisation and labour deployment in the manufacturing sector that emerged in advanced industrial countries in the 1980s came from a variety of reasons other than the need to manage labour control and reduce costs (Hirst, 1989). According to Piore and Sabel, this new 'flexible specialisation' of craft production, which includes the use of flexible computer technology, represents an attempt to break away from the system of mass production. It makes use of new flexible technology to quickly adapt the production of specialised products to changing market demands. This process improves employee's skills and allows them to apply their knowledge in a wider range of manufacturing processes (Piore and Sabel, 1984). Under the umbrella term flexible specialisation or Japanization, labour process theorists have been at the pioneering of investigating rapid changes in technology, management strategies, and production techniques. When flexible specialisation methods surpassed scientific management, the first and second waves of the labour process were severely criticised. Flexible specialisation is linked to flexible technology, which creates mass-produced standard products. This organises the manufacturing process by utilising workforces that have been trained to manufacture a broad range of goods. This enables workers to broaden their skill set by practicing a variety of tasks, teamwork, and more conceptual tasks and responsibilities in the workplace (Kaufman, 2002).

Labour Process in Handicraft Sector

The discussion about labour process in the Indian handicraft sector is relatively a recent development which took place during the nineteenth and twentieth centuries. The scholars to a great extent ignored the subordination of labour to capital in informal, small-scale, artisanal enterprise. The analyses of capital-labour relations in Indian industry during the colonial period have generally been

[1] 'Scientific management' for Taylor is a process in which the human labour is replaced by machine power became the solution for increasing the speed and volume of production started in Ford's Highland Park Auto Assembly Plant in 1915. The role of the workers becomes passive. Workman is told minutely just what he is to do and how he is to do it without asking any question or making suggestion.

confined to studies of large-scale units. The possible reason is a Marxist tradition that prompted scholars to look at capitalist relations, principally in large- scale enterprise.

The understanding of the growth and expansion of capitalist production relations in Europe during the classical period provides the insights to the analysis of the growth of capitalism in India. The Marxian view of modern industry's evolution is also struck by the character of Indian informal production today. In the Indian informal manufacturing sector, the widespread of putting-out relationships and the domination of merchant capital are still prevalent. In the craft-based industry, such kind of sub-contracting or putting-out arrangement is also common. This system has been described as a living testimony of the exploitation of the home-based rural enterprises by the master enterprises or the contractors through contrived trade devices (Sahu, 2007). Historically, the putting-out system of production is the effect of the subordination of artisanal production to merchant capital or intermediaries. A merchant or intermediary or master weaver usually supplies the artisans with raw materials and collects the finished product at a negotiated price or piece-wage.

There has been limited focus on the study of labour process within the informal production during more recent periods. However, few scholars have paid attention to relations of production during the 17th and 18th century (Chaudhuri, 1974; Hossain, 1979). Without an examination of the labour-capital relationship within artisanal production, there were significant implications for understanding twentieth-century capitalism. After the mid-1980's, a number of scholars have paid attention to issues like labour-capital relationships within the artisanal production system, its relation to the organization of work, the process of appropriation, exploitation, and the workplace conflicts (Roy, 1994; Haynes, 2008).

Roy (1994) in his book titled *Artisans and Industrialization: Indian Weaving in the Twentieth Century* has made relations of production a central theme and focuses on the production relations among gold-thread producers, handloom weavers, carpet makers, and leather workers over the larger part of India during the first half of the 20th century. He viewed the Indian artisan manufacturing sector as being part of capitalist development. There was a transition in the organization of labour in India's artisanal industry during the first half of the twentieth century from independent weavers to different kinds and degrees of dependence. Haynes (2012: 132) in his book titled *Small Town Capitalism in Western India* criticized Roy, saying that there is transition in the organization of labour in India's artisanal industry during the first half of the twentieth century from independent weavers to different kinds with degrees of dependence. Haynes showed that, in western India, many features of capitalist production such as the relation of subordination and dependence upon capitalist actors were already present in pre-colonial artisanal manufacture and continued to be found in the 20th century. There is considerable evidence of the existence of master-weaver or putting-out systems as well as small *Karkhanas* with multiple looms worked on wage labour. More critically, Haynes questioned the view that Indian artisan manufacturing moves towards any kind of universal model (proletarianization) during the late colonial period. Artisanal production was characterised by a wide range of structures and practices (Haynes, 2012: 129). There are four types of labour-capital relations: (1) independent weaving household, (2) dependent weaving households, (3) independent *Karkhanas* and (4) dependent *Karkhanas* (Haynes, 2008: 9). There are two types of production systems under which weavers work in handloom industry. Firstly, the weavers under this production system produce independently of *mahajan*. Under this system the weaver buys yarn directly from the market, produces with or without the help of the wage labour and sells the product to the market independently. Secondly, the weaver works under *mahajan*. Under this production system *mahajan* organizes production in any of the three ways and exercise his control over the weavers—*Dadan*

System (DS); Forward Contract System (FCS) and Job on wage-basis popularly known as *Tana Ana* System (TAS) in the locally (Khasnabis and Nag, 2001). In the handicraft sector, the merchant or intermediary agent exercises tight control in the market of raw materials and finished goods under the putting-out arrangement. Through the supply of raw material to production sites spread out in homes, production is organized. At many stages, a variety of middlemen and contractors work. These levels are so numerous in certain cases that the producer does not know anything about the master. In textiles, hosiery, readymade garments, small machines and leather works, this system has spread rapidly. Later on, ironwork, clay-work, carpentry and stonework were also brought under it (Basole and Basu, 2011). Presently, the term subcontracting is given to putting-out. The subcontracting agreements are in close conformity with the classical putting out arrangements where an artisan or small producer is put out to work by a merchant or middlemen. The merchant supplies raw materials along with details about what product type is required. The instruments of manufacturing usually belong to the worker. The final product is procured by the merchant and piece-wages are paid to the worker.

The present paper attempts to study the labour process in handicraft sector with special focus on carpet industry of Kashmir. The researcher investigates the production relationships and organisational hierarchy in the carpet industry. The study also attempts to analyse the issue of deskilling among carpet weavers in carpet industry, on the basis of field survey in Pulwama district.

Research Methodology

The researcher employed purposive sampling in selecting the blocks from district Pulwama in Kashmir. Of 11 blocks in district Pulwama, 4 blocks were purposively selected namely Newa, Kakapora, Shadimarg and Aripal. The concentration of carpet weavers was founded mostly among these four blocks. Purposive sampling helps the researcher in choosing the participants/areas that have appropriate characteristics and are relevant to the research problem under study. This also was more useful because the researcher was dealing with the workers employed in the unorganized sector that helped him in selecting the units from the universe based on his own judgment.

Further for the selection of the individual respondents from these four blocks of Pulwama district, the researcher used snowball sampling. For the present study, 180 respondents were selected; out of a total sample 180 respondents were selected for quantitative analysis. The primary data collected through semi-structured interview schedule and observation method.

Table 1: Block-wise Distribution of Samples

Blocks	Frequency	Percent
Kakapora	48	26.67
Newa	46	25.56
Shadimarg	44	24.44
Aripal	42	23.33
Total	180	100.0

Source: Field survey

Carpet Handicraft Industry

The carpet industry of Kashmir occupies an important place in handicrafts and one of the largest informal manufacturing sectors. The tradition of carpet manufacture in Kashmir goes back to the time of Zain-Ul-Abidin (1420-1470 A.D.) who brought weavers from Persia and Central Asia

into Kashmir and trained local Inhabitants. Since then, carpet heritages have continued and got encouragement and patronage of different rulers and visitors to the valley. The Hand-Knotted Kashmiri Carpets are woven by all locales of Kashmir, specifically Srinagar, Anantnag, Bandipora, Ganderbal, Budgam, Pulwama, Kulgam, Shopian, Baramulla and Kupwara. The Carpet industry in Kashmir has made a great contribution to production, employment, and export of handicraft products and still contributes to the economic development. The production and export of carpet handicraft since 1990-91 to 2016-17 have been quite encouraging. The production of carpet handicraft in 1990-91was of Rs. 84.55 crore, and increased to Rs. 821.50 crore in 2016-17. The export of carpet handicrafts increased from Rs. 26.41 crore in 1990-91 to Rs. 369.81 crore in 2016-17.

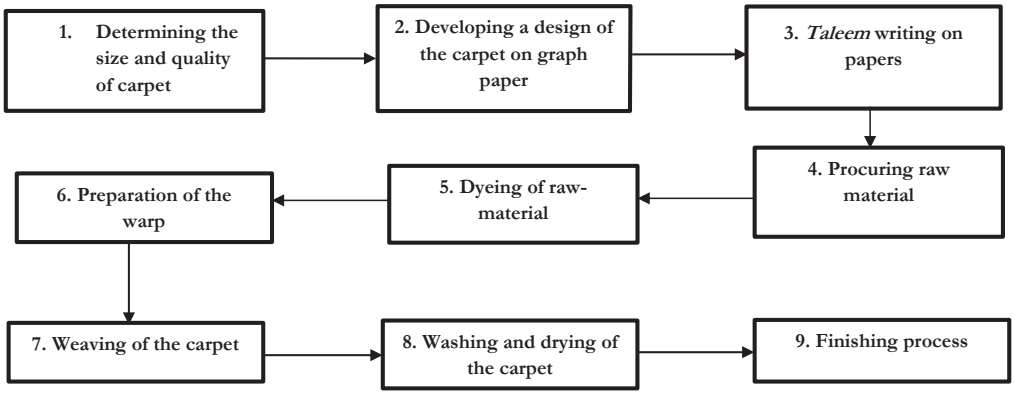
Production Process

To investigate the labour process and the degree to which the phenomenon of alienation leading to deskilling is evident in the labour process, one may start first the discussion on the features of the production process in the field area. The production process in the carpet weaving is quite simple. The different processes in carpet manufacture include determination of the size and quality of the carpet, developing design on graph paper, taleem writing, procuring raw material, dyeing of raw material, preparation of wrap, weaving, washing and drying and finishing process. Each step requires the involvement of labour power separately. The sequence of operations is described in Figure 1. The insights from the field revealed that weavers perform their work either independently or under the control of merchants through middlemen. The putting-out system or subcontracting system is very much prevalent in carpet production in Kashmir, where the weavers in the carpet industry work exclusively for large merchants, middlemen, or master weavers. The carpet weaver may own part of the means of production (loom, hooked knife and metal comb), but for main inputs such as raw materials, designs and wages, he relies on intermediaries or merchants or master weavers. The weavers are supplied with yarn, designs and taleem papers by middlemen/merchants/traders.

It may be noted that designing is the most crucial step in carpet weaving. The design of the finished product has to be planned well before weaving takes place. To be specific the design must be known before the dyeing of the yarn and wrap preparation on the rolling beams, because the quantity of threads of different colours to be contained in the rolling beams depends on the design. The observation from the field area reveals that designing, which is so important, is seldom done by the weaver himself. There exists a design master (Naqash) to produce the design. Usually, the principal producers (traders/merchants or middlemen or master weavers) of the carpet only exercise the option as regards the type of design to be taken.

Weaving is a major part of carpet production. Weavers weave the carpet on looms either in their homes or in the master's workshop. The weavers mostly have their own looms. Just a few do not have their looms and weave on the looms of the master. Weavers are typically contractually bound by intermediaries who have given them money in advance. It is only socially sanctioned contract; not any formal legal arrangement exists.

Figure 1: Production Process



Institutional arrangements in carpet industry

The organizational arrangement of the carpet industry is diverse in nature. The carpet weavers have been classified into three groups like independent weavers, dependent weavers and wage workers. Of total respondents, 12.22% are independent weavers; 60% respondents are dependent weavers; and 27.78% respondents are wage-workers. The findings, therefore, reveal that the ratio of dependent weavers to wage-workers is significantly higher than the independent weavers. Crisis in carpet industry in the last few decades is one of the significant reasons for the low presence of independent weavers in Pulwama District.

Table 2: Distribution of Weavers as per Their Nature of Work

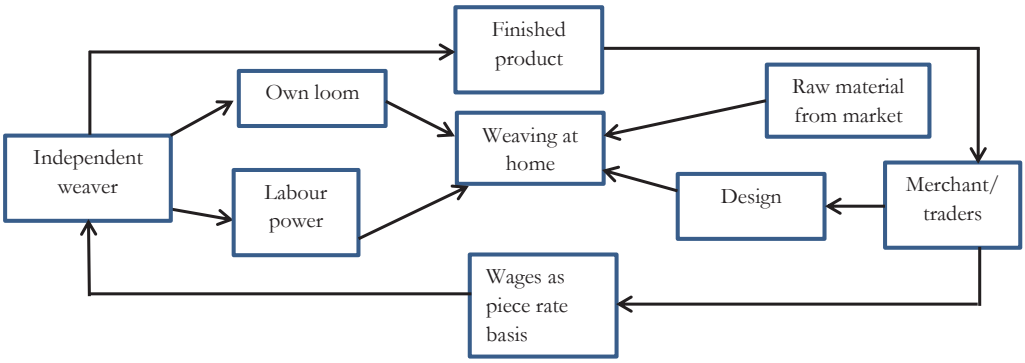
Nature of work	Frequency	Percent
Independent Weavers	22	12.22
Dependent Weavers	108	60.00
Wage Workers	50	27.78
Total	180	100.0

Source: Field survey

In the field area, it was observed that the weavers perform their work either independently or under the control of middlemen (i.e., they work as dependent weavers) and master weaver (i.e., they work as wage workers). The independent weavers have their own loom and buy own raw material. The Independent weaver works in his own premise, with its own capital, weaves the actual product and then sells it to the merchants or traders (Figure 2). Independent weavers lose independence in the market and work either exclusively or partially on the order of the merchants or traders. Thus, he or she is not always free to dispose of the product as desired. He or she depends upon the same merchant for credit. The weaver has some control over the capital and the labour process, but little control over access to the market. These weavers can be individual weavers or master weavers. The number of such weavers is on the decline over the last few decades. These are the minority (12.22%), as shown in Table 2. The independent weaver should get better prices, but lack of holding capacity and fluctuating raw material prices force him to compromise with the payment delaying

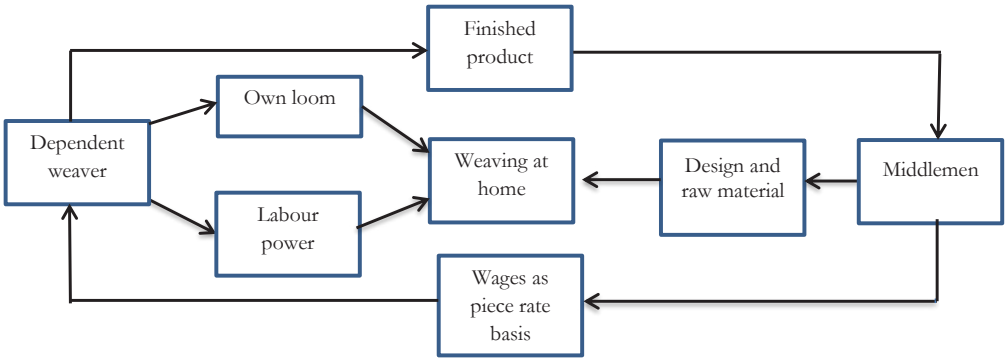
tactics of the traders. The weaver often fails to meet these requirements as he has no enough capital to do this job. For performing the work, the weaver needs the yarn, has to prepare a wrap, and has not confronted the volatility of a market. So, the only option for him is to come under the control of middleman or master weaver.

Figure 2: Independent Weaver



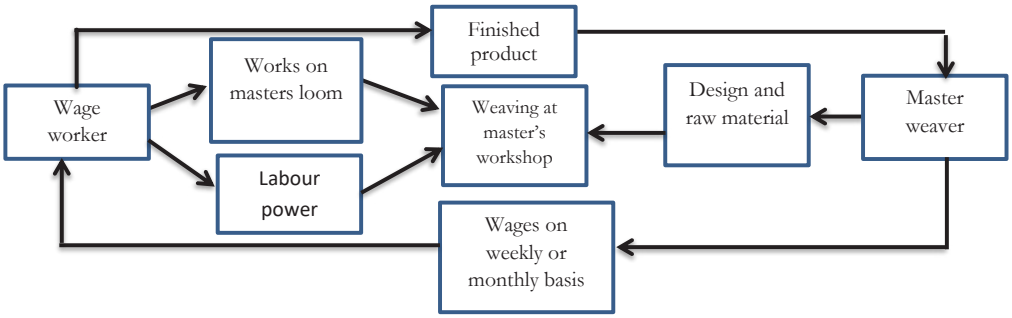
The middleman provides the capital (raw materials and design) to the dependent weaver to utilize the same in a self-directed labour process, and the weaver uses his own tools to create the product in his own place (Figure 3). The middlemen do not control the weavers by directly supervising their work, but they do impose a simple discipline on them by adjusting the workflow to the relative productivity of each weaver and adjusting wage rates by penalizing deficient work and rewarding good ones. This is the most common form of contract (putting-out) arrangement among carpet weavers (60% as shown in Table 2).

Figure 3: Dependent Weaver



The wage worker works in the premises of the master's workshop (*Karkhanas*) without independent access to capital and market (Figure 4). Compared to the dependent weavers, they are the minority (27.78%), shown in Table 2. They still form a significant part of the working class in carpet industry. The surplus is derived from wage workers by confirming that workers generate higher value than that returned to them in the form of wages.

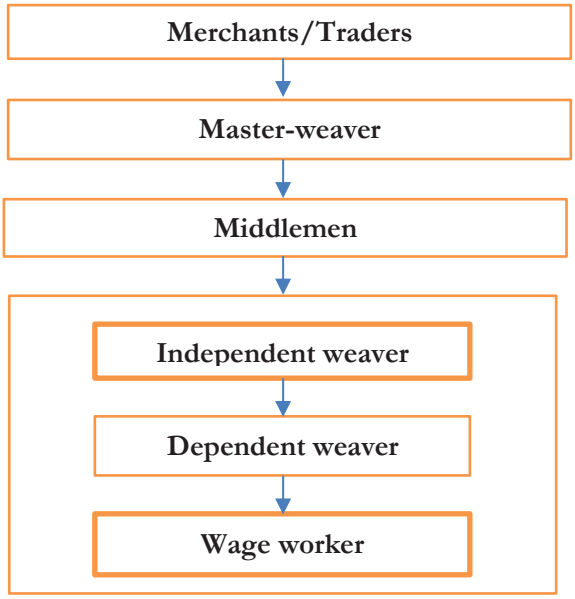
Figure 4: Wage Worker



Organisational Hierarchy

The organisational structure of the carpet industry is diverse in nature. The organisation of production in the Pulwama District is mainly consisted of (i) merchants/traders (*baparis*), (ii) master-weavers (*wostas*), (iii) middlemen *(dalaal*) and (iv) weavers, including independent, dependent and wage workers. The merchants, master-weavers, middlemen and weavers constitute the hierarchy in carpet manufacturing in a downward order on the basis of their roles and responsibilities and their ranks. The weavers are further constituted in the hierarchal order on the basis of access to the raw material, design, and control over their labour process, shown in Figure 5.

Figure 5: Organisational Hierarchy in the Carpet Industry



Source: Field survey

The merchants/traders are chiefly engaged in marketing and providing raw-materials and designs (encrypted on *taleem* papers) to the weavers through middlemen or master weavers. The merchants often engage middlemen who take the raw materials and other necessary inputs to the weavers and

finally receive the final product at piece rates. The merchants also engage some master weavers, who get orders from them. These master weavers employ weavers on wage labour in his *karkhanas*. The merchants do not take active participation in the production system, but they have active control over production and marketing in the carpet industry in Kashmir and enjoy a large share of the profit. The master weavers of the Pulwama District sometimes take the burden of investment on several steps of carpet production. The master weavers even weave themselves and engage wage workers on the other looms. Nevertheless, the position of the master weavers is comparatively lower than that of the merchants in comparison to their possession of resources and the amount of investment. The middlemen usually work as subordinate employees under merchants/traders, or master weavers, and are placed comparatively higher than weavers. The middlemen provide the raw materials and copies of the design of the *taleem* papers to the weavers and expect a woven carpet in return. On the basis of their ownership of means of production (looms, raw materials and other tools) and their control over the labour process, the weavers are divided into three groups in which independent weavers occupy top of the hierarchy followed by dependent weavers and wage workers.

Relations of Production

During the field investigation, the researcher gathers information about the prevalent production relations that characterise Kashmir's carpet industry. In the Pulwama District, three forms of productions relations in the carpet industry exist which are partially related with the production relations outlined by Marx (1976):

1. Direct Contract: Under this system, the weavers have direct contracts with the merchants or traders, independent of middlemen or master weavers, who exercise control over the weaver through the putting-out system by supplying raw materials and designs. The weaver works on the orders provided by the merchants or traders. Under this system, the weaver has choice of choosing the design of the carpet, buys the yarn from the market, produces it with or without the help of family labour and supplies the product directly to the merchants or traders. The weavers do not have independent market access and work on the orders of the merchants or traders. The weaver has control over the capital and the labour process but little control over access to the market. Therefore, the product is not always available to him according to his desires. He relies on the same merchant for credit. The weaver controls the capital but does not control over the market. The ownership of capital does not mean a self-management of the labour process, as argued by Marx's 'the position of this specialised worker, who works in his place do for the capitalists, is very distinct from that of the independent craftsman, who works for his own clients (Marx, 1976).

2. Putting-out System I: Under this system, production is a result of the subordination of artisanal production to merchant capital. Typically, under this system, the merchant/trader, through middlemen, supplies raw material and *taleem* papers, on which designs are encrypted, to the producer and collects the finished product at a predetermined wage per square feet. The weaver controls his own loom and is the owner of other tools used in carpet weaving. A number of middlemen operate at several levels. In many cases, these levels are so numerous that the producer knows nothing about the merchants or traders. The middlemen do not directly control over the weavers by supervising their work. They do impose a simple discipline on them by adjusting the workflow to each weaver's relative productivity and adjusting wage rates by penalising poor work and rewarding good work. While such weavers possess certain autonomy over the labour process in his premise but they lack much control over the disposal of their product. The weavers to a great extent preserved their control over the labour process but have little or no control over the raw material and market of their product. The weavers working on the loose timetable sometimes stretched from early morning

to very late at night, but include breaks for smoking, prayers, and visiting out. In most cases, the weaver working under the putting-out system sustains their relationship with particular middlemen for a longer period. There is no fixed rule that one has to work under particular middlemen forever. This contract is only socially sanctioned; there is no formal legal agreement. There is no problem in shifting from one employer to another in search of getting better wages per square feet of carpet.

3. Putting-out System II: Under this system of production the weavers who do not own their looms works in a centralized location, away from their homes in the master's workshop (*karkhanas*). The *karkhanas* seem to represent general characteristics that were present in a system of factory organisation based on wage employment, places where supervision and discipline would have seemingly been much easier to accomplish. Under this system, the master weaver (*wosta*) takes responsibility for an order, performs part of the job itself, and also hires additional weavers in his *karkhanas* as needed to fulfill the order. The master weaver receives the contract on a piece rate basis from exporters/traders/merchants, but he pays wages on a time basis to weavers who work under him. Under this system master weavers who hire the weavers in his workshop were bound by dependent relations with particular merchant/trader. The master weaver takes advances from merchants for raw materials and other inputs; they are obliged to provide the final product to the merchants. The wage worker has no independent access to capital and market. He owns nothing except his labour power. Therefore, has no control over their labour process. The *karkhanas* allows the merchants/exporters to expand their production levels and also helps them to avoid the risks of participating in an unstable market. When the demand of carpet was low, the owners, through their master weavers, reduce the number of looms working under him and release their workers to unemployment. When the demand of carpet is good, they could rehire workers to meet the new demand.

Economic Analysis under Different Production Relations

The earnings of the weaver under the different production relations determine the economic condition and the standard of living of the weaver and his family. The earnings of the weavers play a crucial role in their motivation or demotivation for work. The findings reveal that the majority of the independent weavers under direct contract system earn more income per day. None of the dependent under putting-out system I and wage workers under putting out-system II earns more than Rs. 301 per day. The majority of wage workers and dependent weavers earn in between Rs.100-200 per day (see Table 3). In a nutshell, wage workers and dependent weavers per-day income is lower than that of independent weavers. Therefore, wage workers and dependent weavers have more deteriorating socio-economic conditions. Their earnings decline day by day, which results they are becoming poorer and poorer while master weavers/middlemen are getting richer. The present study findings, supported by many studies on the handicraft industry in India, reported the existence of low wages among artisans (Venkateswarlu et al., 2006; Karimi, 2016; Rajiv and Shah, 2017). During the field investigation, many respondents revealed that the reason for low earnings among wage workers and dependent weavers is due to the exploitative nature of middlemen and master weavers. The carpet weavers who put their physical and mental abilities into making beautiful patterns of carpet are forced to live a hard life. They cannot afford proper clothes, proper meals, and quality schools for their children.

Table 3: Distribution of Average Daily Earnings among Carpet Weavers

Production Relations	Category of Carpet Weavers		Average Daily Earning			
			Up to 100	101-200	201-300	301 and above
Direct contract	Independent weavers	N	0	0	8	14
		%	0.0	0.0	36.36	63.64
Putting-out system I	Dependent weavers	N	15	63	30	0
		%	13.89	58.33	27.78	0.00
Putting-out system II	Wage workers	N	34	16	0	0
		%	68.00	32.00	0.00	0.00
Total		N	49	79	38	14
		%	27.22	43.89	21.11	7.78

Source: Field survey

Issue of Deskilling among Carpet Weavers

The separation between planning and execution is the core element of a detailed division of labour which results in the alienation of labour from the production process, which is the primary cause for deskilling of workers. To what extent this process is prevalent in carpet weaving, we will discuss the incidence of separation between planning and execution as it has developed under different production systems in the carpet industry in the field area.

Table 4: Participation in the Selection of the Design in Weaving

Production Relations	Category of Carpet Weavers		Participation in the Selection of Design		Nature of Participation		
			Yes	No	Often	Sometimes	Rarely
Direct contract	Independent weavers	N	15	7	6	4	5
		%	68.18	31.82	40.00	26.67	33.33
Putting-out system I	Dependent weavers	N	10	98	1	3	6
		%	9.26	90.74	10.00	30.00	60.00
Putting-out system II	Wage workers	N	8	42	0	2	6
		%	16.00	84.00	0.00	25.00	75.00
Total		N	33	147	7	9	17
		%	18.33	81.67	21.21	27.27	51.52

Source: Field survey

Under the direct contract system, the independent weaver selects his own designs, *taleem* papers, and carpet size from merchants or traders, as well as purchasing raw material from the market. The independent weaver works in his own premise, with its own capital (tools, loom and raw-material), weaves the actual product and then sells it to the merchants or traders. The independent weavers have full control over their labour process, i.e., how to work, when to work, and how much to work. The majority of the independent weavers (see Tables 4 and 5) have a choice of the design, size, and raw material from the market, and full control over the labour process seems that the unity of conception and execution to a great extent in this production system. The labour thus largely remains de-alienated from the means of production in this case. However, this is just one aspect of the ground reality in the field area.

Table 5: Participation in the Selection of Raw Material and Taleem Papers in Weaving

Production Relations	Category of Carpet Weavers		Participation in the Selection of Raw material and *Taleem* Papers		Nature of Participation		
			Yes	No	Often	Sometimes	Rarely
Direct contract	Independent weavers	N	20	2	10	6	4
		%	90.91	9.09	50.00	30.00	20.00
Putting-out system I	Dependent weavers	N	30	78	2	8	20
		%	27.78	72.22	6.67	26.67	66.67
Putting-out system II	Wage workers	N	10	40	0	3	7
		%	20.00	80.00	0.00	30.00	70.00
Total		N	60	120	12	17	31
		%	33.33	66.67	20.00	28.33	51.67

Source: Field survey

Another aspect of the reality must be noted. As we have observed, there are some units in which core operations is now being performed by outside labour. Under the putting-out system I, the dependent weaver due to the working capital problem, takes the raw materials, the *taleem* papers, and the design from the middlemen but works on his own loom. Under this system, the majority of the dependent weavers (see Tables 4 and 5) are under the middlemen who direct the weaver about the design, size of carpet and raw materials. So, a deskilling tendency seems to exist under this system. This deskilling tendency is associated with the tied bondage relationship between middlemen and weavers, rather than with detailed labour division and scientific management. A conceptual part of the choice of the design, size, and raw material shifted from the weaver to the middlemen. However, the dependent weavers, to a great extent, preserved their control over their labour and worked on a self-directed labour process but have little or no control over the raw material, size, and design of the carpet. These are the nascent capitalist units in which the direct producers, that is, the workers who are owners of the loom and perform the core operation but remain alienated from choosing raw material, size, and design of the carpet. They do not remain completely de-linked from the production process.

Under the putting-out system II, the master weavers who owns the multiple looms hires outside labour for weaving. The owners concentrate only on planning the work, leaving the main part of the execution work to the outside labour (wage workers). The wage worker owns nothing but his labour power. The wage worker works in the master's *karkhanas* on the master's loom and tools. Under this system, the master weaver concentrates on the planning, whether the choice of design, *taleem* papers, raw material, or size of carpet, and the wage worker executes the work planned by the master weaver. Here, the separation between planning and execution is more intense as compared to the putting-out system I. The majority of the wage workers (see Tables 4 and 5) have no control over their labour process. His worker is directed by the master weavers as to what to do and what not to do. Theoretically speaking this is the beginnings of capitalist production in the carpet industry were the owners now becoming the capitalists in a rudimentary form and the weavers now performing the role of an industrial proletariat.

The observation from the field reveals that the design selection (planning) is done mostly by the merchants/middlemen/master-weavers and the weaving (execution) is done by the weavers. This has a severe impact on the skill level of the weavers. The findings reveal that the involvement of the weavers in both planning (selecting the design) and execution (weaving) will help them to preserve

and enhance their skills because weaving is the interplay of psychological and physical labour. In the present study, most of the dependent weavers and wage workers have bondage relation with middlemen and master-weavers and, therefore, have little or no control over the labour process. They do not generally make or choose the raw material and *taleem* papers of the product. The implication is that deskilling in the labour process is developing with the emergence of dependent weavers and becoming intense with wage workers.

Conclusions

From the above discussion, we have tried to explore the organisation, hierarchy, production relations, income and deskilling in the carpet manufacturing industry in Pulwama District. The diversity of organisational production has been found in carpet industry. The production is organised through independent weavers, dependent weavers, and wage labour. Production relations in the carpet industry do not solely engage the independent producers (characterized by the control of the labour process and the ownership of capital), nor even those called the capitalist producers (characterised by time-wage workers). Rather, varieties of putting-out relations prevail, and the dominance of middlemen, master-weavers and merchant capitalists prevails in the carpet industry. The merchants, master-weavers, middlemen and weavers constitute the hierarchy in the carpet production system in descending order on the basis of their roles and responsibilities and their ranks in the production system. The weavers are further constituted in the hierarchal order on the basis of access to the raw material, design, and control over their labour process. These features of the labour process in carpet industry have some sort of similarity what Marx had outlined in the European context. The diversity of production relations, including independent production of goods or direct contract, dependent or putting-out labour and wage labour or putting-out II, has been recognized. The economic analysis under different production relations reveal that the majority of the independent weavers under direct contract system earn more income per day than dependent weavers and wage workers.

The process of deskilling which is the main focus of the present study, developed in Putting-out system I, when the dependent weaver's loss the control over the raw materials, size and designs of the product but have little control over their labour process. The deskilling tendency is associated with the tied bondage relationship between middlemen and weavers, rather than with detailed labour division and scientific management, as this happens in case of capitalism proper. The presence of middlemen in the economy of small weavers has an effect on the labour of their economy. A conceptual part of the choice of the design, size, and raw material shifted from the weaver to the middlemen. However, the dependent weavers, to a great extent, preserved their control over their labour and worked on a self-directed labour process but have little or no control over the raw material, size, and design of the carpet. These are the nascent capitalist units in which the direct producers, that is, the workers who are owners of the loom and perform the core operation but remain alienated from choosing raw material, size, and design of the carpet. They do not remain completely de-linked from the production process.

The small proportion of independent weavers under direct contract system remains outside the hegemony of middlemen or master weavers. Such weavers maintain the independent pre-capitalist labour process in which there exists unity of conception and execution to a large extent. They have full control over their labour process, i.e., how to work, when to work, and how much to work. The labour, thus, largely remains de-alienated from the means of production.

The wage workers under the putting-out system II work under the master weavers. The master

weavers concentrate only on planning of the work such as the choice of the design, *taleem* papers, raw material, and size of carpet, leaving the main part of the execution work to wage workers. The wage worker owns nothing but his labour power. The wage worker works in the master's *karkhanas* on the master's loom and tools. Here, the separation between planning and execution is more intense as compared to the putting-out system I. The wage workers have no control over their labour process. His worker is directed by the master weavers as to what to do and what not to do. Theoretically speaking, this is the beginning of capitalist production in the carpet industry where the owners are now becoming the capitalists in a rudimentary form and the weavers are now performing the role of an industrial proletariat. The deskilling features of labour process in carpet industry of Kashmir have some similarities to what had been outlined by Marx (1976) and Braverman (1998) in their studies on the labour process in the context of Western European and American society.

About the author

Ishfaq Majeed is a Research Scholar at the Department of Sociology, Aligarh Muslim University, Aligarh, Uttar Pradesh, India.

References

Basole, A. and D. Basu (2011), "Relations of Production and Modes of Surplus Extraction in India: Part II – 'Informal' Industry", *Economic and Political Weekly*, 46(15): 63-79.

Becker, G.S. (1964), *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education*, Chicago and London: The University of Chicago Press.

Braverman, H. (1998), *Labour and Monopoly Capital: The Degradation of Work in the Twentieth Century*, New York: Monthly Review Press.

Chaudhuri, K.N. (1974), "The Structure of Indian Handloom Industry in the Seventeenth and Eighteenth Centuries", *The Indian Economic and Social History Review*, 11(2-3): 127-182.

Elger, T. (1979), "Valorization and 'Deskilling': A Critique of Braverman", *Capital & Class*, 3(1): 58-99.

Friedman, A. (1977), *Industry and Labour: Class Struggle at Work and Monopoly Capitalism*, London and Basingstoke: The Macmillan Press Ltd.

Gallie, D. (1991), "Patterns of Skill Change: Upskilling, Deskilling or the Polarization of Skills?" *Work, Employment & Society*, 5(3): 319-351.

Haynes, D.E. (2008), "The Labour Process in the Bombay Handloom Industry, 1880-1940", *Modern Asian Studies*, 42(1): 1-45.

Haynes, D.E. (2012), *Small Town Capitalism in Western India*, Cambridge: Cambridge University Press.

Hirst, P. (1989), "After Henry". In *New Times: The Changing Face of Politics in the 1990s*, *S*. Hall and M. Jacques (eds.), pp. 321-332, London: Lawrence & Wishart.

Hossain, H. (1979), "The Alienation of Weavers: Impact of the Conflict between the Revenue and Commercial Interests of the East India Company, 1750-1800", *Indian Economic and Social History Review*, 16(3): 323-346.

Karimi, A. (2016), *Bhadohi Carpet Industry: Dynamics of Social Exclusion*, Aligarh Muslim University.

Kaufman, B.E. (2002), "Theoretical Perspectives on Work and the Employment Relationship", Industrial Relations Research Association Series: Proceedings of the Annual Meeting, Annual Research Volume.

Khasnabis, R. and P. Nag (2001), "Labour Process in the Informal Sector: A Handloom Industry in Nadia District", *Economic and Political Weekly*, 36(52): 4836-4845.

Knorringa, P. (1999), "Artisan Labour in the Agra Footwear Industry: Continued Informality and Changing Threats", *Contribution to Indian Sociology*, 33(1-2).

Littler, C.R. (1982), *The Development of the Labour Process in Capitalist Societies*, London: Heinemann Educational Book Ltd.

Littler, C.R. and G. Salaman (1982), "Bravermania and Beyond: Recent Theories of the Labour Process", *Sociology*, 16(2): 251-269.

Marglin, S.A. (1974), "What Do Bosses Do? The Origins and Functions of Hierarchy in Capitalist Production", *Review of Radical Political Economics*, 6(2): 60-112.

Marx, K. (1976), *Capital: A Critique of Political Economy*, Volume One (1867), UK: Penguin Books Ltd.

Piore, Michael and Charles J. Sabel (1984), *The Second Industrial Divide: Possibilities for Prosperity*, New York: Basic Books.

Prasanna, M. (2019), "Labour Reforms: No One Knows the Size of India's Informal Workforce, Not Even the Govt.", mimeo.

Raju, G.N. and K.V. Rao (2014), "A Study on the Socio-Economic Conditions of Handloom Weavers", *Journal of Rural Development*, 33(3): 309-328.

Roy, T. (1994), *Artisans and Industrialisation: Indian Weaving in the Twentieth Century*, New Delhi: Oxford University Press.

Sahu, P.P. (2007), "Subcontracting in India's Small Manufacturing Enterprises: Problems and Prospects", *Working Paper 2007/01*, New Delhi: Institute for Studies in Industrial Development.

Singh, M. (1990), *The Political Economy of Unorganised Industry: A Study of the Labour Process*, Newbury Park (California): Sage Publications.

Thompson, P. (1983), *The Nature of Work: An Introduction to Debates on the Labour Process*, London and Basingstoke: The Macmillan Press.

Varman, R. and M. Chakrabarti (2006), "Case Studies on Industrial Clusters: A Study of Kanpur Leather and Footwear, Varanasi Silk Sari and Moradabad Brassware Clusters", Department of Scientific and Industrial Research, Govt. of India Report.

Venkateswarlu, D., R.V.S.S. Ramakrishna and M.A. Moid (2006), *Child Labour in Carpet Industry: Recent Developments*.

Vijayagopalan, S. (1993), *Economic Status of Handicraft Artisans*, New Delhi: NCAER.

Weber, W.C.M. (1997), "Skill, Dependency, and Differentiation: Artisans and Agents in the Lucknow Embroidery Industry", *Ethnology*, 36(1): 49-65.

Zimbalist, A. (1979), *Case Studies on the Labour Process*, New York and London: Monthly Review Press.

Reviewers of *Anvesak* (1 July 2022 to 31 December 2023)

(Released in second issue of each volume)

- **Prof. Amit Kundu**, Jadavpur University, Kolkata
- **Prof. Arijita Dutta**, University of Calcutta, Kolkata
- **Prof. Arup Chattopadhyay**, University of Burdwan, Bardhaman, West Bengal
- **Prof. Bhaskar Goswami**, University of Burdwan, Bardhaman, West Bengal
- **Prof. Biswa Swarup Misra**, Xavier Institute of Management, Bhubaneswar.
- **Prof. C.N. Ray**, CEPT University, Ahmedabad
- **Prof. Indira Hirway**, Centre for Development Alternative, Ahmedabad
- **Prof. Madhusudan Datta**, University of Kalyani, Kalyani, West Bengal
- **Prof. Manoranjan Pal**, Indian Statistical Institute, Kolkata
- **Dr. Nomita P. Kumar**, Giri Institute of Development Studies, Lucknow
- **Prof. S.P. Premaratna**, University of Colombo, Colombo, Sri Lanka
- **Prof. Pushpa Trivedi**, Shivnadar University, Chennai
- **Prof. S.S. Kalamkar**, Sardar Patel University, Vallabh Vidyanagar, Gujarat
- **Prof. Samarjit Das**, Indian Statistical Institute, Kolkata
- **Prof. Sarita Agrawal**, Central University of Gujarat, Gandhinagar
- **Dr. Saswata Ghosh**, Institute of Development Studies Kolkata (IDSK), Kolkata
- **Dr. Satyaki Roy**, Institute for Studies in Industrial Development, New Delhi
- **Prof. H.S. Shylendra**, Institute of Rural Management, Anand
- **Prof. Siddhartha Mitra**, Jadavpur University, Kolkata
- **Prof. Soumyananda Dinda**, University of Burdwan, Bardhaman, West Bengal
- **Dr. Subhendu Chakrabarti**, Indian Statistical Institute, Kolkata
- **Dr. Subrat Kumar Mishra**, National Institute of Rural Development & Panchayati Raj, Rajendranagar, Telangana
- **Dr. Subrata Mukherjee**, Institute of Development Studies Kolkata (IDSK), Kolkata
- **Prof. Sushil Haldar**, Jadavpur University, Kolkata
- **Prof. Tara Nair**, Gujarat Institute of Development Research, Ahmedabad
- **Prof. Utpal Kumar De**, North-Eastern Hill University, Shillong
- **Dr. Vachaspati Shukla**, Sardar Patel Institute of Economic and Social Research, Ahmedabad
- **Prof. Viswanath Pingali**, Indian Institute of Management, Ahmedabad
- **Prof. Vivekananda Mukherjee**, BITS Pilani Hyderabad Campus; and Jadavpur University, Kolkata (on leave)

Instructions to Authors

Manuscripts for contribution should be mailed to the Editor. They should be typed in double space, using Times New Roman font in 12 point. A manuscript must be accompanied with an abstract (100-125 words), five keywords, authors' institutional affiliations, complete addresses of authors, their contact numbers and their active email IDs for communication on a separate page (i.e. first page). The length of the paper should approximately be between 6000 and 8000 words. The paper should be accompanied by a declaration as follows:

"I declare that the paper is original and has not been simultaneously submitted elsewhere for publication."

Figures and Tables should be kept to the minimum. All Figures (including graphs and maps) should be produced in black colour and be in our journal's printable format. Tables and figures should not exceed the A-4 size format of a page. A large table could be broken into small tables for easy accommodation. All numbers and numerical figures in tables and graphs should be clearly visible. The equations (if any) should be composed in "MS Word equation editor".

For more detailed guidelines, please see the "Guidelines for Contributors" given in the 'Journal' section on our website: www.spiesr.ac.in. Manuscripts should be sent to: anvesak@spiesr.ac.in (manuscripts sent to other email IDs will not be acknowledged and considered). Authors should be aware of the fact that some fraudulent publishers are bringing out fake *Anvesak* journals, illegally using our ISSN Number. Publications in fake *Anvesak* journals shall not be considered as legitimate publications.