Safety Performance and Occupational Injuries of Workers (OIW): A DEA Efficiency Analysis

Muhammad Noman[1*], Ambreen Fatima [2] and Nooreen Mujahid[3]

[1] PhD Scholar, Applied economics Research Centre (AERC), University of Karachi
[2] Associate professor, Applied Economics Research Centre, University of Karachi
[3] Associate professor, Department of Economics, University of Karachi

ABSTRACT

The rapid pace of industrialization and sectoral transformation have not only induced rapid economic progress yet also engaged policy think tanks to consider the safety performance due to the increasing rate of injuries. These increasing workplace hazards have affected occupational efficiencies as well as worker's performance. Hence, a comprehensive analysis of occupation injuries of workers (OIW) is crucial to determine the safety performance of high and low-risk industries in Pakistan. This study aims to incorporate the OIW for the estimation of the safety performance of industries employing Data Envelopment Analysis (DEA). This non-parametric technique allows calculating relative efficiencies incorporating inputs and outputs (both desirable and undesirable). The findings of the SBM-DEA model and sensitivity analyses pointed out improvements in the farm sector and demanded more comprehensive analyses for the non-farm sectors.

1. Introduction

In the contemporary era, agricultural mechanization, the rapid pace of industrialization; and the restructuring of the services sector have not only induced economic growth yet also exerted social obligations (Beriha, Patanik, & Mahapatra, 2011). Considering developing economies, the farm sector mostly remains limited in the agriculture industry as it is the prime source of human incapacitation (Bello, 2012). While the industrial sector still lags behind in terms of removing hazards of

* noman.atiq19@gamil.com

environmental pollution, labour exploitation, and occupation-related injuries (Suri & Das, 2016). Consequently, the commodity-producing sector experiences huge social costs due to social pressure and finds it difficult to grab its true share in the market. On the other side, the services sector is not only doing good in terms of productivity yet also performing better in terms of safety performance (Rodwell & Toe, 2008) as compared to the traditional and manufacturing sectors. These contradictions at the sectoral level provide an intuition for the governments to set the target of zero accidents to ensure workplace safety for the disbursement of labor insurance benefits ensuring sectoral equity (Yeh, 2017). Hence, authorities and industries face pressure to keep workplace injuries at a minimal level (Abdalla et al., 2017).

For this purpose, evaluation of sectoral safety performance is considered vital for industries and organizations to retain efficiency and goodwill in the marketplace. These aspects exhibit multidimensional consequences in terms of competition and employees' motivation ensuring higher profits and productivity. Intuitively, a well-defined and efficient safety management setup can be implemented through safety practices, strategies, policies, procedures, functions, and roles with an integrated mechanism. This mechanism is supposed to control the hazards affecting worker's health and safety at the workplace (Labodová, 2004). Meanwhile, safety measures are supposed to be assertively in compliance with the recent trends and legislation of the economy. Additionally, worker's involvement in the whole process is also a crucial requirement along with strong management support and commitment (Zohar, 1980).

Given these industrial, organizational; and labour factors, occupational injuries of workers (OIW) can conveniently be utilized as a virtual measure to analyze the efficiency and safety performance (Yeh, 2017). The most convincing argument of using the indicator of OIW points out the fact that injuries at work not only affect business activities yet also negatively affect the competitiveness of economies. Hence, investigating the sectoral efficiencies through OIW is critical to improving the strategic paradigm with effective policymaking ensuring low or no injuries at the workplace.

Considering the economy of Pakistan, the recent Labour Force Survey (LFS) of Pakistan, under an occupational injury, a worker who has gone through a work-related fatal and non-fatal injury can demand an economic return. This implies that both fatal and non-fatal accidents or injuries at the workplace exhibit different levels of severity demanding firms and governments to ensure better measures for worker's safety. Though, this fact had been realized quite early in Pakistan as worker's safety in industries has become a major concern for management ever since the enactment of the Worker's Compensation Act, 1923[online]. However, the execution of such interventions has been widely overlooked. The Labour policy (2010) states that rationalization and consolidation of labour laws in Pakistan are complex, anomalous, overlapping; and difficult to be implemented. The penalties prescribed for the non-compliance and offenses are very low and meanwhile being framed over the years. On the other side, the under-consideration Pakistan Occupational Health and Safety Act

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(2018) aims to develop a balanced and consistent framework for the health and safety of workers and workplaces. Additionally, there exist several limitations in measuring the safety performance of occupations at the sectoral level. Precisely, these include the impediments of data compilation, fund allocation, Occupational health, and safety (OHS) setups, efficiency analyses and lack of performance indicators, etc. Among all these the absence of performance indicators to measure sectoral efficiencies stands out.

These insights demand the implementation of a holistic framework with a comprehensive analysis of safety performance at the sectoral level so that the efficient sectors can be highlighted. This may not only assess to analyze the efficiency of the sectors yet also provide plausible explanations for the better performance of the potential sectors and meanwhile to enhance the poor management setups in less efficient sectors. This paper measures the safety performance of 9 industries in Pakistan through occupational injuries of workers (OIW), keeping in view the two core objectives. First, it follows an approach that incorporates OIW in the Data Envelopment Analysis (DEA) to evaluate the relative efficiencies at the industry level. Second, it stresses the procedures to pace up the implementation process of safety strategies for inefficient industrial sectors in the context of Pakistan.

2.   Literature Review

In literature, the safety performance of industries had been analyzed and measured through variety of research techniques indicating a broader horizon. Considering the recent studies, Namvar and Bamdad (2021) utilized the resilience perspective as a theory of safety management to evaluate process industries. The authors integrated the theory with the DEA methodology and found a strong evidence for the implementation of monitoring and assessment of risk in the sector. Shin et al., (2021) examined the issues of construction industry indicating the need of research for the OHS regulations. Hence, the authors measured the innovative efficiencies for Korea through DEA. The study indicated that companies with appropriate OHS facilities tend to be more inclined towards innovation thus stressed on appropriate measures from both practitioners and governments. Zou et al. (2020) developed a comprehensive index for public safety incorporating outputs and inputs of the respective factor for the regions of China. The authors used the index to measure different efficiencies through DEA procedure for the period of 2014-2018. The findings of this exercise revealed that at regional level the efficiencies were inefficient and redundant. The authors pointed that technological backwardness was the major facet in this respect and thus stressed on the improvement of public safety inputs through effective utilization of public safety resources. On the other side, Yeh (2020) declared socioeconomic cost of occupational accidents as an important determinant for the safety and health development in an economy. For the estimation purpose, insurance payments had been used as proxy for the socioeconomic cost in different industries. The author explained that DEA would be an appropriate methodology to measure the efficiency of industries. The findings of the

study endorsed the significance of socioeconomic factors for the evaluation of health and safety for the economy of Taiwan. However, it is worth mentioning here that all these recent studies had been examined through sophisticated data samples leading to divergent perspectives.

Intuitively, OIW are treated as accidents at job due to the substandard management set ups (Tan et al., 2012). According to the available studies, most of the accidents were caused by poor management (Yu & Jiang, 2007) enhancing a sequence of such deficiencies. The other strand of literature precludes that the injuries among workers create stress and job dissatisfaction enhancing job switch rates (Dawson & Surpin, 2001). Additionally, limited yet prominent economic literature considered workplace injuries as unwanted byproduct of the economic activity (El-Mashaleh et al., 2010). Hence, the negative connotation between OIW and economic indicators have started to contemplate job injuries as undesirable phenomenon for the economy. These negative outcomes of poor safety performance divulge the inefficiency of business maneuvers in an industry or a sector (Egilmez & McAvoy, 2013). The discussion in this section covers the methodological diversities, sectoral divergences, and safety models to identify the research gap.

Turning to the quantitative assessments of occupational injuries, bulk of studies employed econometric modelling techniques to explore the related factors affecting the safety performance and efficiency of industries (Feng at al., 2014; Tan et al., 2012; Ramli et al., 2011). Whereas the other set of studies focused on the anticipation of errors in risky business set ups. However, these econometric techniques portray specific production functions and hence expected values are not necessarily supposed to provide sufficient assessments of the inefficiencies and safety loopholes. Neither these analyses provide amended strategies to rectify the inefficiencies.

Contrary to econometric modelling, DEA has been religiously considered for safety assessments as it is based on a simple presumption that fewer inputs enhance efficiency generating more desirable outputs. Yeh (2017) developed DEA model for 17 industrial sectors of Taiwan and relative efficiency results declared mining and quarrying industry as the most inefficient sector. Zhang et al., (2013) illustrated the advantages of Slack-Based Measure (SBM) DEA through graphs and modelled the slack inputs with undesirable outputs. Beriha et al. (2011) benchmarked the occupational health and safety performance in industrial settings employing DEA. The authors considered 3 industries and 30 organizations and found construction sector showed consistently low performance in terms of safety measurements. According to Zhou et al. (2008), DEA model was considered as a remarkable alternative for decision making of safety addressing the undesirability of outputs. Feroz et al. (2001) employed DEA to assess the economic costs of the occupational health and safety supervision in the textile industry.

The severity of workplace injuries also varies across industries or occupations as well pointing inclusion of occupational divergences in the model. Yogyorn et al. (2020) estimated medical costs of occupational injury and illness (OII) for the agriculture sector of Thailand. The authors declared that these were approximately 0.2 percent of the total agriculture output. Hence, the study recommended government to use some of the OII funds for prevention programs in the farm sector rather focusing on paying compensations. Hu et al. (2017) stated that given the desirability of high safety in industrial organizations, accident rates are still high. In this respect, the risk knowledge is not more than enough to bring about change in the unsafe behaviors (both employee and employers) due to irrationality of humans (Saari, 1999). Retzer et al. (2013) and Witter et al. (2014) observed highest job fatality rate in the oil and gas extraction industry. Whereas. Tan et al. (2012) explored more deaths in the mining industry due to the perilous nature of the workplace conditions than the other observed occupations. On the other side, the studies of Idrees et al. (2017) and Harper and Koehn (1998) Larsson and Field (2002) declared the construction industry as the most unsafe for the workers. Thus, workplace injuries may be found in any setting, yet these are expected to be found in less efficient or higher risk industries.

Considering the diversity of capturing efficiency of industries, their exists various safety models and plans to reduce the occurrence of workplace accidents. Arocena et al. (2008) explored occupational injuries considering occupational elements and perception practices for supple output technologies in Spain. Teo and Linga (2006) modelled the effectiveness of safety management setups in the construction sector through employing safety index of technical, social and personal elements. These components were specifically related to the work safety technical model. Dejoy et al. (2004) discussed that employee's defiance also played an important part in determining safety issues. The authors also figured out that industrial injuries had not only affected the quality of human capital yet also generated huge financial losses. This would in turn lead to machinery damages, output disruptions, and bad firm's reputation. Further, the safety climate of an industry has been attributed to its compliance with safety measures (Huang et al., 2006; Dejoy et al., 2004; Gershon et al., 2000). These include policies, workplace safety (perceived); and knowledge and ability to maintain safety (Probst, 2004). McCauley-Bell et al. (1999) developed a predictive model to detect risks of occupational injury and illness in modern workplace settings. The model was supposed to significantly help in controlling and preventing the surge in injuries and illnesses and thus minimizes the incidence and severity of these issues. Khan and Abbasi (1999) prepared a plan for hazard management and risk assessment in chemical industries. Zurada et al. (1997) also proposed a diagnostic system in order to categorize the potential risks at jobs due to workplace designs. The author claimed that such system would be useful in injury anticipation and hazard analysis of industries. Meanwhile, the system was effective in placing different jobs into high and low risk categories.

Given these facts, a brief review of literature reveals three plausible explanations. First, the quantitative or qualitative assessments of safety performance are diverse in nature depending on the objectives, industries, and occupations under consideration. Second, DEA method has been widely acknowledged to calculate the safety performance at sectoral or industrial level. Third, to the bets of our knowledge, no such study has been performed to measure the occupational efficiencies through DEA in the context of Pakistan.

3.   Research Methodology

Azadeh et al. (2016) claimed that efficiency or inefficiency of an industry is assessed by its decision making which is the choice of a technique that hefts alternatives and provides upgraded approaches for both workers and management. For the purpose, divergent parametric and non-parametric techniques have been employed for developing decision making modules. The DEA is a non-parametric approach which considers the insight of decision-making unit (DMU). Precisely, DEA incorporates the idea of using less inputs for the high or same levels of output in order to measure the efficiency of any entity. However, the DEA perspective can be incorporated through well-known divergent models including the Charnes-Cooper-Rhodes (CCR), Banker-Charners-Cooper (BCC), and Slack-Based Measure (SBM). The CCR and BCC models are presumed to incorporate inefficient inputs or outputs and meanwhile are proportionally adjusted in the measurements. However, the non-radial nature of SBM model simultaneously integrates the inefficiencies ensuing from slack inputs and outputs (Yu, 2010). Further, this model also exhibits greater discerning power and the capacity to address undesirable outputs. This is the reason that the SBM model usually preferred than CCR and BCC models. In this respect, Visbal- Casdavid et al. (2017) explained that CCR and BCC models adopt either input or output orientation while the non-oriented model of SBM indulges the measurement of slack variables (through total input and output).

Besides, the primitive advantage of applying SBM is that it adequately allows to consider the slacks of inputs with both desirable and undesirable outputs in the production sets and models (Hu & Liu, 2017). Hence, the principles of the model can be applied directly to measure the safety performance through efficiency of an industry. Correspondingly, the SBM-DEA model enables to segregate optimization constraints for both inputs and outputs. The other prominent advantage of using this method is that its application does not require any assumptions, price data and measurement units for any specific production functions while measuring efficiencies.

Therefore, the non-orientation procedure of the SBM model in this study allows to measure the safety performance through occupational injuries or slack variable analyses. The SBM model is considered suitable for this study to extract a strong complementary solution in the context of Pakistan. Precisely, the SBM-DEA analysis specializes in measuring overall production efficiency incorporating all input and output

factors. Further, as it mentioned earlier that no national literature yet utilized the SBM-DEA methodology to measure the efficiency of sectors in the occupation domain.

Given the suitability of the SBM model with the limitations of the study, the study incorporates a contemporaneous perspective of including OIW to measure the safety performance and efficiency of sectors in Pakistan. Hence, the study correctly and quantitatively modelled the innovative method of SBM -DEA (Hu & Liu, 2017).

3.1   Model

The SBM-DEA model treats occupational injuries rate as undesirable outputs. The study also presumes that there are n decision-making units to be assessed. Every j decision-making unit (j = 1, . . . , n) use m inputs x_{ij} (i = 1, . . . , m) and gives rise p desirable outputs y_{rj}^d (r = 1, . . . , p) as well as q undesirable outputs of occupational injuries rate y_{kj}^u (k = 1, . . . , q, q = 1). So, the general efficiency (non-oriented) ρ is determined through:

$$Minimize \; \rho = \frac{1 - \frac{1}{m}\left(\sum_{i=1}^m \frac{s_i^-}{x_{i0}}\right)}{1 - \frac{1}{p+q}\left(\sum_{r=1}^p \frac{s_r^d}{y_{r0}^d} + \sum_{k=1}^p \frac{s_k^u}{y_{k0}^u}\right)} \tag{1}$$

Subject to:

$$\sum_{j=1}^n \lambda_j x_{ij} + s_i^- = x_{i0} \qquad (i = 1,\ldots,m) \tag{1.1}$$

$$\sum_{j=1}^n \lambda_j y_{rj}^d + s_r^d = y_{r0}^d \qquad (r = 1,\ldots,p) \tag{1.2}$$

$$\sum_{j=1}^n \lambda_j y_{kj}^u + s_k^u = y_{k0}^d \qquad (k = 1,\ldots,q) \tag{1.3}$$

$$\lambda \geq 0, s^- \geq 0, s^d \geq 0, s^u \geq 0 \tag{1.4}$$

Where s_i^- is the slack input, s_r^d is the slack desirable output, and s_k^u is the slack undesirable output. This model assumes, $\rho^* = 1$ and $s^* = 0$ and $0 < \rho^* \leq 1$ are illustration of a specified decision-making unit with Slack-Based Measure efficiency. By employing the optimal slacks in Equation (1), the Slack-Based Measure efficiency score ρ^* can be disintegrated as mentioned below:

$$\rho^* = \frac{1 - (\sum_{i=1}^m \alpha_i)}{1 + (\sum_{r=1}^p \beta_r^d + \sum_{k=1}^p \beta_k^u)} \tag{2}$$

where:

$$\alpha_i = \frac{1}{m} \frac{s_i^{-*}}{x_{i0}} \tag{2.1}$$

$$\beta_r^d = \frac{1}{p+q} \frac{s_r^{d*}}{y_{r0}^d} \tag{2.2}$$

$$\beta_k^u = \frac{1}{p+q} \frac{s_k^{u*}}{y_{k0}^u} \tag{2.3}$$

Equation 2.3 is beneficial for calculating the magnitudes as well as sources of inefficient sectors concerning to the corresponding undesirable and desirable outputs as well as inputs of occupational injuries rate for a given decision-making unit.

3.2 Data Sources and Variables

Intuitively, occupational injuries are assumed to be directly associated with the rapid increase in economic activity (Li et al., 2011). Therefore, scholars now prefer to include economic indicators to measure the safety performance of an economy at industrial level (El-Mashaleh, & Rababeh, 2010). Given this insight, the study incorporates four variables to evaluate the efficiency of the industrial sector in Pakistan. For inputs, gross fixed capital formation at sectoral level has been taken as proxy consumption of fixed capital (x_1)) while employed persons in a specific sector are considered to include the labour market turnover (x_2). For the estimation of desirable output and undesirable output, gross production value (y^d) and occupational injury rate (y^u) are considered, respectively. It is pertinent to mention here that the selection of these variables has been done by following the study of Yeh (2017) for Taiwan. ***Table 1*** provides a quick glimpse of the details of the variables. Further, the study evaluates the safety performance of 9 main commodity producing and services sectors in Pakistan for the year 2017-18. These sectors include agriculture, mining & quarrying, manufacturing, electricity generation and gas distribution, construction, wholesale and retail trade, transport and communication, finance and insurance and housing services (ownership and dwelling).

Table 1: Description of Input and Output Variables

Category	ID	Variables (Unit)	Data Source
Inputs	x_1	Gross Fixed Capital Formation (Million Rupees)	Pakistan Economic Survey 2017-18
	x_2	Employed Persons (Number in Millions)	Labour Force Survey 2017-18
Desirable Output	y^d	Gross Value of Production (Million Rupees)	Pakistan Economic Survey 2017-18
Undesirable Output	y^u	Occupational Injury Rate (%)	Labour Force Survey 2017-18

Source: Compiled by Authors

3.3   Results

This study examines the occupational injuries rate for safety performance, and the outcomes are summed up in the Table 2.

Table 2: Efficiency scores through Slack-Based Measure Model among Sectors

No.	DMU	2017-18	Ranks
1	Agriculture	0.16	7
2	Mining & Quarrying	1.00	1
3	Manufacturing	0.24	5
4	Electricity Generation and Distribution & Gas Distribution	0.26	4
5	Construction	0.19	6
6	Wholesale & Retail Trade	1.00	1
7	Transport & Communication	0.33	2
8	Finance & Insurance	1.00	1
9	Housing Services (O.D)	0.27	3
	Average	0.4944	
	Standard Deviation	0.3821	

Source: Estimated by Authors

Table 2 depicts the ranks of the respective sectors based on the estimated efficiency scores of each sector. The results show that three out of nine sectors attain the efficiency score of 1 including mining and quarrying, wholesale and retail and finance and insurance. Hence, these sectors can be used as benchmark to evaluate the efficiency or inefficiency of other sectors. Based on the scores of efficient sectors it can be concluded that all other six sectors were inefficient in the given year of 2017-18. Showing the consistency with the data, the SBM measurement affirms that agriculture is the most inefficient sector among all with the lowest score of 0.16. Additionally, the average efficiency score of all sectors remains to be 0.4944. On the whole, these results indicate that Pakistan's sectors persist to have a room to enhance their efficiency through ensuring better safety measures and performance.

Turning to the SBM, it is presumed to evaluate the performance and improvement of the under-consideration indicators (Zhao et al., 2018). Therefore, in order to evaluate the inefficient variations of industries, the slack based analysis has been performed.

Table 3 portrays the projection values of inputs and outputs for inefficient sectors of industry along with potential addition in outputs given the potential reduction in inputs. Column 3 and 4 reveals overall inefficiency of input (x_1 and x_2). Column 5 and 6 explains slacks and projection targets of indicating that whether an increase in output or decrease in inputs results in efficiency. Precisely, columns 5 is used to analyze that how the current level of output can be produced with less inputs. Whereas Column 6 evaluates the production of higher level of output with current level of inputs. Additionally, column 7 and 8 decomposed the inputs and outputs, respectively.

The potential improvements of the SBM-DEA show areas of improvement in input-output activity needed to put an inefficient sector onto the efficient frontier. To move onto the efficient frontier, for the agriculture sector, the labour can be reduced by 78.27% and the injury rate can be reduced by 85.03 percent improving total farm output by 179.65 percent. Likewise, in construction (which is 2nd most inefficient sector) needs to reduce its capital input by 36.61 percent and use 68.25 percent less injuries enhancing its share by 235.71 percent. The similar conclusions can conveniently be drawn for other inefficient sectors.

The performance of the three efficient sectors (finance & Insurance, Mining & Quarrying, and wholesale & retail trade) is up to the mark. This can be evident from column 3 and 4 where the inefficiencies of input and output are zero. The primary sources and magnitudes of most inefficient industrial sectors is presumed to be labour issues and injury rates. Davies et al. (2009) observed and explained that injuries are higher in high labour employment sectors. Indeed, higher number of workers can lead to greater risk of injuries, which can undermine employees' safety awareness and health. This information may increase the Pakistani government's understanding of the improvements required for each industrial sector and enable it to make subsequent improvements.

Table 3: SBM Projections and Inefficiency Decomposition

No (1) DMU	(2) Efficiency Score	(3) Input Inefficiency	(4) Output Inefficiency	(5) Slack				(6) Projection				(7) Input Reduction (%)		(8) Output Reduction (%)	(9) Output Addition (%)
				X_1	X_2	Y^u	Y^d	X_1	X_2	Y^u	Y^d	X_1	X_2	Y^u	Y^d
1 Agriculture	0.16	0.54	1.796500	0.00	-20.42	-35.37	4198046.41	1000659.00	5.67	6.23	6534817.41	0.00	78.27	85.03	179.65
2 Construction	0.19	0.35	2.357100	-27574.32	0.00	-11.81	824478.62	47745.68	4.51	5.49	1174256.60	36.61	0.00	68.25	235.71
3 Electricity Generation and Distribution & Gas Distribution	0.26	0.19	2.116000	-87651.00	-0.06	0.00	464405.00	155350.00	0.20	0.60	683868.00	36.07	21.95	0.00	211.61
4 Finance & Insurance	1.00	0.00	0.000000	0.00	0.00	0.00	0.00	64266.00	0.36	0.40	419690.00	0.00	0.00	0.00	0.00
5 Housing Services (O.D)	0.27	0.25	1.802800	-159708.12	0.00	-2.11	1457090.75	514596.88	0.65	1.99	2265312.75	23.68	0.00	51.52	180.28
6 Manufacturing	0.24	0.49	1.079900	0.00	-6.43	-13.57	1814408.36	535114.00	3.03	3.33	3494569.36	0.00	67.95	80.29	107.99
7 Mining & Quarrying	1.00	0.00	0.000000	0.00	0.00	0.00	0.00	77675.00	0.10	0.30	341934.00	0.00	0.00	0.00	0.00
8 Transport & Communication	0.33	0.50	0.489900	0.00	-2.39	-5.69	791725.02	546958.00	0.70	2.11	2407770.02	0.00	77.47	72.92	48.99
9 Wholesale & Retail Trade	1.00	0.00	0.000000	0.00	0.00	0.00	0.00	95622.00	9.03	11.00	2351726.00	0.00	0.00	0.00	0.00

Table 4: Outcomes of the Sensitivity Analysis

DMUs	Efficient DMUs				
	Mining & Quarrying	Construction	Wholesale & Retail Trade	Finance & Insurance	Housing Services
	Score	Score	Score	Score	Score
Agriculture	0.359624	1	0.421506	0.359624	0.359624
Mining & Quarrying	-	1	1	1	1
Manufacturing	0.518651	1	0.518651	0.52718	0.518651
Electricity Generation and Distribution & Gas Distribution	0.51	0.344935	0.344935	0.344935	0.344935
Construction	1	-	1	1	1
Wholesale & Retail Trade	1	1	-	1	1
Transport & Communication	0.710095	1	0.673265	0.673265	0.673265
Finance & Insurance	1	1	1	-	1
Housing Services (O.D)	1	1	1	1	-

Source: Estimated by Authors

In addition to the SBM-DEA outlook, the study has also performed sensitivity analysis in table 4. This mathematical exercise takes in to account the stability of efficiency scores by omitting an efficient sector and subsequently alters a reference set for the respective sector. The outcomes showed that efficiency scores of efficient sectors (mining and quarrying, construction, wholesale and retail trade, finance and insurance, and housing services) considerably affected the efficiency magnitudes of inefficient sectors. This implies that the omission of these efficient sectors would produce better scores for the inefficient sectors at the level. For instance, the omission of mining and quarrying sector from DMUs improves the efficiency of electricity generation and gas distribution from 0.345 to 0.51. Further, the transport and communication sector also experienced a slight increase from 0.673 to 0.71. Similarly, the omission of other efficient sector (construction) enhances the efficiency scores of all other sector except the electricity and gas distribution (remains same). The exclusion of wholesale and retail trade improved the efficiency of the farming sector while all other sectors remained same in terms of efficiency scores. Finally, the removal of finance and insurance and housing sector did not have any impact on other sectors of the economy. Therefore, on the whole, the sensitivity analysis declared the construction sector as the most influential or safe occupation for workers among all other DMUs.

Intuitively, the analysis points out two plausible explanations for the study. First, the efficient performance of efficient and less risky industries would have reasonable outcomes for the efficiency of high-risk sectors. Second, grouping of divergent sectors would demand a unified, well defined, and an integrated policy mechanism for health and safety of workers in the economy of Pakistan.

4.   Discussion

The DEA analysis of all nine sectors of Pakistan has assessed to utilize the OIW in an innovative manner indicating rudimentary facts of the occupational domain. The divergence in the outcomes of SBM-DEA and sensitivity analyses not only explained the variations at occupation level yet also pointed out the need to perform more efficiency analyses in order to evaluate the performance of the sectors at more disaggregated level. Additionally, the divergence at the sectoral level points out the fact that still the agriculture and manufacturing sectors lag behind given its potential due to high inefficiencies. This finding is consistent with the study of Yogyorn et al. (2020).

Despite the fact that the labour policy (2010) of Pakistan includes core laws for industries, employment, service conditions; and occupational safety and health, the implementation of the policies have not been achieved yet in these sectors. Meanwhile, the policy considers the construction industry as a backbone of all the development activities, and this could be the reason that it performs well in terms of efficiency in the DEA evaluation. However, a detailed analysis of the sector has been recommended as the construction industry of Pakistan is going through new challenges and problems due to rapid expansion (Harper and Koehn, 1998). It is a well-evident fact that the expansion of this particular industry causes health, safety, and occupational hazards (Witter, 2014). This could be the reason that there has always been stressed by policy makers to ensure safe working conditions for the workers in the construction industry. In this respect, as prescribed earlier by Teo and Linga (2006) and Probst (2004) in the literature, measures of workmen's compensation, social security, old age pension interventions have been proposed to ensure the worker's safety.

Considering the declining share of agriculture sector in the total output and increasing inefficiencies, the sector persists to move towards the rapid mechanization demanding technical expertise of farmers (Devkota et al., 2020). Consequently, unskilled farm workers are becoming unemployed (Rao, 1972). Additionally, no labour laws have been implemented in the sector so far depriving the benefits of various welfare legislations. These legislations were fully or partly been offered to the counterparts of farmers in the non-farm establishments. Though, the governments over the years tend to extend the coverage of workmen's Compensation Act, 1923 for the farm sector which states that in case of any injury or death to workers of mechanized farm in the rural sector.

According to Forastieri (1999), the better performance of the services sector can be attributed to the fact that informal economy (including domestic workers) is persistently improving health and safety, and social security arrangements. Whereas the payments of minimum wages also contributed to this regard as the employer-employee relationship is much more evident here than the other sectors of the economy (Baig, 2005).

The sensitivity analysis of the study demands an advocacy and harmony in the rights of workers (Dawson & Surpin, 2001) given the occupational diversity. This goal can easily be attained through promoting the concept of providing decent work (Blackett, 2011). The labour policy (2010) envisages a harmonious working relationship between workers and employers to enhance the performance and efficiency of the industry sector.

This efficiency analysis offers several vital contributions in terms of prevailing knowledge and new insights which may lead to better theoretical perceptions and methodologies. Correspondingly, the existing literature is not enough for precise assessments of efficiencies at occupational and industrial levels. Predominantly, qualitative studies could not correctly measure the efficiencies and safety performance leaving a research gap for quantities investigations. The SBM-DEA perspective not only contributes to the quantitative investigation yet also adds up slack indicators. This would tend to reduce resource consumption minimizing hazards together with enhancing production value. Hence, with the help of the study findings, both theoretical and practical insights underpin the utilization of DEA in measuring efficiency at the sectoral level (Song et al., 2012).

5. Conclusion

The present study endeavors to evaluate 0the safety performance of industries through employing OIW. For this purpose, the SBM-DEA perspective has assessed to derive relative efficiencies of all the nine available occupations for the year 2017-18. Meanwhile, the sensitivity analysis adds up an insight to differentiate between high-risk and low-risk occupations. In a nutshell, the agriculture sector is found to be the inefficient sector with low scores while the construction sector was efficient among all other nine sectors. Besides, the services sector has shown better safety performance in terms of efficiency and considered relatively safe for workers in Pakistan.

Hence, an integrated safety policy is required to reduce workplace hazards with a policy design with the optimal set of measures. The outcomes of the study could also be helpful for the authorities for upgrading safety performance established on the situations in each industry. To attain these objectives, the study recommends a few doable policy options. The labour policy must oblige the employers to follow rules for working hours with an incentive of worker's training specifically in high-risk industries. Using inefficiency corrosions, the principal sources and magnitudes of highly inefficient manufacturing sectors must also be incorporated. Additionally, expanding safety investment in the professional and management personnel could contribute to less severe injuries and deaths. Future research may consider the effects of other economic factors on the safety performance of business operations as the incidence of workplace injuries varies with economic fluctuations. Considering the socio-economic protection of labour, a strategy must be progressed and tracked in compliance with the idea of decent work in the labour market.

This study does not address occupational diversity through DEA as the information of respective injury rates is not available. Further, the available dataset incorporates only nine major sectors ignoring the heterogenous sectors in terms of injury rates. Last, the dynamics of the OIW have not been considered due to simplicity purposes.

Given these data limitations, it can be recommended that future studies may incorporate the survey data analyses for capturing sectoral diversities. Besides, the DEA model of the study can be extended using the dynamic DEA to quantify variations in efficiency scores over time. The model could also be employed to explore the effects of conventional components of a business on safety performance.

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