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Significance and Role of Industrial Inputs in Productivity of Large-scale Manufacturing in Karachi: A Correlation Analysis

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Abstract. In an industrial process, productivity is a basic concern. A combination of production input, namely employment, labour cost, energy and raw material cost, result in value addition expressed as value-added. The effective role of each input in the manufacturing process can be assessed through the influence of variables involved. Pearson's correlation coefficients show various degrees of effects through interrelationships of variables and bring out the outstanding or relatively more important role of one or more variables (inputs) in specific combinations in the manufacturing process. The paper in hand analyses the interrelationship of structuring variables in the major groups of manufacturing in Karachi using Pearson's correlation measurement techniques. The role of the variables has been assessed through sets of ten correlations in each of the six major industrial categories. The results of the analyses show the leading or the dominant contribution of the variables towards value addition and productivity. In the case of the textile industry, strong correlations are indicated between Value Added (VA) and 'Other Cost' (OC) and Average Daily Employment (ADE) and Employment Cost (EC) and also VA and ADE. For chemical and chemical products strong correlation exist between VA and OC, OC and IC (industrial cost) and ADE and EC. In respect of the wearing apparel category, a strong correlation occur between OC and IC, VA and OC, ADE and EC. Basic metal industry shows strong correlation in all ten sets of relationships, thus every variable exercising an equal influence. The food and beverage group has only two strong correlations that are VA and OC, IC, and OC. In the case of motor vehicles and trailers, strong relationships are indicated by all sets of correlation ship.

Keywords: productivity, industrial category, value added, correlation coefficients, input costs

Introduction

The efficiency of the manufacturing industry is indicated by value-added (Pakistan Economic Survey, 2018-19) and also a measure of profitability, which is ensured through an appropriate combination of employment costs raw material and energy costs as essential inputs in the production process (Dowrick and Duc-Tho, 1989; De Long and Bradford, 1988). In the contribution of value-added, each cost component has an effective role that can be seen in the interrelationship of the variables in terms of their influence on each other or as one being determinant of the other. This can be analyzed by coefficients of correlation as calculated by the Pearson formula showing strong and weak correlation between the structural variables of the industrial cost (cost of production) and value-added. The cardinal objective of the study is to identify or determine which input costs as part of the total industrial cost enhance productivity and value addition in the specific case of manufacturing in Karachi, the largest industrial center of Pakistan (Saif ur Rehman and Nor'Aznn Abu Bakar, 2019; Iqbal and Ahsanullah, 2017). It is also the main concern of United Nations Industrial Developent Organization (UNIDO). It is also more probable that, as income grows, demand shifts from necessities to more sophisticated goods (UNIDO, 2018).

In the first three decades, about 54% of capital input was contributed in the large scale manufacturing sector of Pakistan. Technological change by about 29% and labour input cost by about 18% was also contributed in large-scale manufacturing industry (Wazarat, 1989). In the manufacturing sector, large scale manufacturing (LSM), plays a vital role and accounts for approximately 70 percent of overall manufacturing (Ashfaq, 2008). Rehman *et al*. (2008) estimated the trend in total factor productivity growth for eleven major manufacturing sub-sectors/industries listed on Karachi Stock Exchange. The results of this study are showing a mixed trend for all manufacturing sub-sectors/industries in terms of total factor productivity. The main objective of this article is to analyze the interrelationship of variables in the major groups of manufacturing in Karachi using Pearson's correlation measurement techniques.

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Assessment of the role of the variables and their relationship found strong correlations towards value addition and productivity.

Materials and Methods

The census of manufacturing industries (CMI), related to the year 2005-06, forms the basis and source of statistical data for the study in hand (GoP, 2010). According to the latest provisions of the law concerning the CMI, the latest census (2005-06) covered the large-scale manufacturing industries (LSM) employing 10 or more workers. The census provides data on several key variables i.e. the number of manufacturing establishments, average daily employment, gross census value-added, industrial cost (product cost), value of production, employment cost, contribution to GDP, the value of fixed assets and industrial taxes.

Thomas model. ***Differentiation of industrial categories*****.** The CMI categories Karachi's manufacturing units 21 industrial categories. Since the study is concerned with the major categories, a statistical technique known as Thomas's (1963) model has been applied to identify the major and minor industrial categories based on employment and its variance.

The model is an improvement over the weaver's (1955) calculation originally used for n agricultural crop pattern to differentiate major or representative elements from minor insignificant ones.

In the formula for the calculation of variance:

$$\partial^2 = \frac{\Sigma d^2}{N} = \frac{\Sigma(X_1 - \bar{X})^2}{N}$$

Weaver substituted the expected theoretical percentage of variables for the expected values i.e. mean $\bar{X}$ in an array of variables. To determine a two-crop (variables) region from six variables or crops existing in a region that is 45, 21, 13, 11, 6 and 5 in an area. Weaver used the following formulation:

$$= \frac{[(50\text{-}45)^2 + (50\text{-}21)^2]}{2}$$

$$= (25 + 841) / 2$$

$$= 433$$

Thomas improved the Weaver's formula by inserting actual percentage of remaining crops beyond two major crops.

$$\frac{((50–45)^2 + (50–21)^2 + (0–13)^2 + (0–11)^2 + (0–6)^2 + (0–5)^2)}{6}$$

$$(25+841+169+121+36+25)/6$$

$$= 202.33$$

Correlation coefficient and the use of fitted plots. The correlation analysis involving the use of coefficients of correlation by the Pearson formula and technique of fitted plots is aimed at ascertaining the degree of interrelationship or interdependence between the structural variables of the industrial categories (Alexander and Lindberg, 1961; McCarty *et al*., 1956). Out of twenty-one Industrial categories, only six major Industrial categories have been subjected to this analytical procedure. The analysis yields a set of variables with a high correlation coefficient of 0.5 and above and these serve to define the structural characteristics of industrial categories and to distinguish them in terms of the degree of correlation between the variables.

The correlation coefficient widely used to measure the linear correlation between two variables is given by the Pearson formula as under.

$$r = \frac{[n\Sigma_{i=1}^{n} x_i y_i - (\Sigma_{i=1}^{n} x_1)(\Sigma_{i=1}^{n} y_1)]}{\sqrt{[n\Sigma_{i=1}^{n} x_1^2 - (\Sigma_{i=1}^{n} x_1)^2][n(\Sigma_{i=1}^{n} y_1^2) - (\Sigma_{i=1}^{n} y_1)^2]}}$$

Further, coefficients of determination have been calculated by the use of regression technique to arrive at the value of r^2 to find the proportion of total variables in the values of a dependent variable (y) that can be explained by the linear relationship with the values of the independent variable (x). The fitted plots constructed in respect of the correlation of the structural variables show the values of r^2 and thereby the nature of the linearity.

By the application of the Thomas model six major industrial categories were identified based on average daily employment (ADE) as specialized fields of manufacturing in Karachi and are shown in Table 1.

The correlation analysis has been applied on the six major industrial categories of Karachi, Correlations have been measured between five structural variables, i.e. Average Daily Employment (ADE), Value Added (VA), Industrial Cost (IC), Employment Cost (EC) and "Other Cost" (OC), (Table 2). A set of ten correlations between the variables is brought out for each major industrial category. The analysis results are presented in Tables 3-8.

Manufacture of textiles. The correlation coefficients may be grouped into two subsets: (a) very strong correlation with linearity and very high r^2 and (b) weak correlations with lack of linearity and low r^2.

Table 1. Karachi industrial structure: average daily employment, 2005-06 major and minor industries (Thomas model)

Industrial categories	Average daily employment	Percentage	Variance
Major industries			
Manufacture of textiles	48664	24.44	306.06
Chemicals and chemical products	29614	14.88	113.54
Wearing apparel	27620	13.87	52.53
Basics Metals	22626	11.37	28.01
Food products and beverages	20730	10.41	15.11
Motor vehicles and trailers	11586	5.82	13.8
	160840	80.79	
Minor industries			
Other non-metallic mineral products	6245	3.14	16.52
Machinery and equipment	4306	2.16	19.71
Other transport equipment	3886	1.95	22.42
Radio, TV and communication equipment	3721	1.87	24.67
Tobacco products	3216	1.62	26.73
Leather products	3136	1.58	28.47
Rubber and plastics products	2636	1.32	30.13
Electrical machinery and apparatus	2517	1.26	31.6
Coke and petroleum	2104	1.06	33
Publishing, printing and reproduction	1547	0.78	34.39
Wood and wood products	1514	0.76	35.63
Fabricated metal products	1477	0.74	36.74
Medical and optical instruments	1038	0.52	37.84
Paper and paper products	667	0.34	38.93
Furniture	227	0.11	40.01
	38237	**19.21**	

Source: CMI 2005-06

The value gap or difference between the subsets in respect of four categories may be noted. It de-emphasizes the influence or the role of variables showing weak correlations. The group of four very strong correlations consists of VA-IC, VA-OC, OC-IC and ADE-EC with values r^2 as 100%, 99.6%, 99.6% and 93.0%, respectively, showing linearity illustrated in the fitted plots. The coefficients suggest that the value added is far more closely associated with IC and OC than any other variable. The correlation between OC and IC is also as high or strong as between VA and OC and this is indicative of the dominance or far-reaching influence in determining both IC and VA. The high coefficient of ADE-EC signifies the important role of ADE in the manufacturing processes which is also strengthened by a high proportion of EC as part of the total industrial cost (IC). The ADE is also significantly correlated with VA and IC, though the coefficients show weak correlations (0.713, r^2 =50.9%).

It can be conclusively stated that OC is a determinant of VA and IC is the determinant of OC, thus OC being closely related with both VA and IC. Accordingly, the size of OC influences both the IC and VA. Also, EC is a determinant of ADE, implying its very close relationship with the size of the labor force. The analysis identifies OC and ADE (EC) as the dominant variables that significantly affect the size and value of manufactures (Table 3).

Results and Discussion

Chemicals and chemical products. First, significantly very strong correlations to the extent of perfect or complete unity exist between VA-OC, unequivocally signifying the most dominant role of OC in influencing both IC and VA.

Table 2. Karachi's major industrial categories: structural variables, 2005-06

Industrial categories	Average daily employment (ADE)	Employment cost (EC)	Other cost (OC)	Industrial cost (IC)	Value added (VA)
	Numbers	(Value in thousand rupees)			
Manufacture of textiles	48664	8,614,420	83,325,233	91,939,653	54,855,495
Chemicals and chemical products	29614	5,773,379	47,620,917	53,394,296	31,871,987
Wearing apparel	27620	3,928,553	33,940,566	37,869,119	22,604,736
Basics metals	22626	7,381,481	36,595,692	43,977,173	26,250,740
Food products and beverages	20730	3,064,202	49,976,490	53,040,692	31,660,909
Motor vehicles and trailers	11586	3,064,202	61,744,187	64,784,479	38,695,867

Source: CMI 0506

Secondly, ADE and EC are also strongly correlated, showing the strong influence of EC on ADE, but not as strong. Thus, OC and EC are found to be the major determinant of VA as well as IC, which together determine the total value of production. Strong correlations exist between ADE-EC and ADE-IC, signifying a far less influential role of the ADE or EC. There is a set of five weak correlations, of which two are significant. These are ADE-IC, and VA-ADE, both strengthening the conclusion as to the effective role of ADE towards VA and IC. The other four correlations are quite weak, the weakest being between OC and EC (0.665, r^2 = 44.2), (Table 4).

Table 3. Manufacture of textiles: correlation coefficients

Correlation	C.C (Index)	r^2 (Percent)
VA-IC	1.000	100.0
VA-OC	0.998	99.6
OC-IC	0.998	99.6
ADE-EC	0.964	93.0
VA-ADE	0.713	50.9
ADE-IC	0.713	50.9
ADE-OC	0.667	44.5
VA-EC	0.602	36.2
EC-IC	0.601	36.1
OC-EC	0.547	29.9

Table 4. Chemicals and chemical products: correlation coefficients

Correlation	C.C (Index)	r^2 (percent)
VA-IC	1.000	100.0
OC-IC	0.997	99.4
VA-OC	0.997	99.4
ADE-EC	0.908	82.4
ADE-IC	0.769	59.1
VA-ADE	0.769	59.1
ADE-OC	0.728	53.0
VA-EC	0.720	51.8
EC-IC	0.720	51.8
OC-EC	0.665	44.2

Wearing apparel. Very strong correlations, VA-IC, OC-IC, VA-OC and ADE-EC, are indicative of the significant, effective role of OC as determinant of both VA and IC. ADE-EC is significantly strongly correlated to show the important role ADE plays with EC and through it towards contributing to IC, and VA. Among the six weak correlations, three indicate a relatively closer relationship or stronger association than others. These show a much closer relationship of EC to OC, IC, and VA, thus emphasizing the effective role of the ADE in the determination of the value of manufactures, (Table 5).

Basic metals. All correlations are significantly very strong and strong, meaning thereby that all the structural elements or variables are interdependent so that change in one would cause a corresponding change in the other. VA is very strongly correlated with both ADE and OC which are also equally very strongly correlated with IC, implying the determinant role of ADE and OC in contributing to 1C and VA. Significantly strong correlations, ADE –OC, ADE –EC mean that both OC and EC are strong, influential variables affecting ADE. Further, a strong correlation of VA –EC indicates that EC is an equally important determinant of VA, as are the other major variables, IC, ADE and OC (Table 6).

Table 5. Wearing apparel: correlation coefficients

Correlation	C.C (Index)	r^2 (Percent)
VA-IC	1.000	100.0
OC -IC	0.999	99.7
VA -OC	o.999	99.7
ADE-EC	0.991	98.2
VA -EC	o.771	59.4
EC -IC	0.771	59.4
OC -EC	0.737	54.3
ADE -IC	0.680	46.3
VA -ADE	0.680	46.3
ADE -OC	0.642	41.2

Table 6. Basic metals: correlation coefficients

Correlation	C.C (Index)	r^2 (Percent)
VA-IC	1.000	100.0
VA -ADE	0.999	99.7
ADE -IC	0.999	99.7
VA -OC	0.998	99.7
OC -IC	o.998	99.7
ADE -OC	0.994	98.9
ADE -EC	o.990	97.9
VA -EC	0.982	96.3
EC -IC	0.982	96.3
OC -EC	0.969	93.9

Food products and beverages. Of ten correlations, only three i.e. VA –IC, VA –OC and IC –OC are significantly very strong. These are indicative of OC and IC as being the sole determinant of VA. The rest seven correlations are weak and very weak. Among them, relatively closer correlations are VA –EC, EC –IC, which implies the important role of EC in both IC and VA. The correlations of VA –ADE and ADE –IC, mean the limited role of ADE towards VA contribution and the size or the scale of IC. The weak correlations between ADE, IC, and OC or EC are indicative of the main role the IC, OC and EC play in influencing the ADE (Table 7).

Motor vehicle and trailers. All ten correlations are very strong and strong, implying a very high degree of interdependence and mutual influence, a condition quite similar to and parallel with the Basic Metals manufacturing.

Table 7. Food products and beverages: correlation coefficients

Correlation	C.C (Index)	r^2 (Percent)
VA-IC	1.000	100.0
VA-OC	0.999	99.8
IC -OC	0.999	99.8
VA-EC	0.688	47.3
EC - IC	0.688	47.3
OC -EC	0.659	43.5
VA -ADE	0.648	42.0
ADE -IC	0.648	42.0
ADE -OC	0.638	40.0
ADE -EC	0.630	39.7

Table 8. Motor vehicles and trailers: correlation coefficients

Correlation	C.C (Index)	r^2 (Percent)
OC -IC	1.000	100.0
VA-OC	1.000	99.9
VA-IC	0.999	99.9
ADE-EC	0.997	99.3
EC-IC	0.990	98.1
OC-EC	0.990	97.9
VA-EC	0.987	97.4
ADE-IC	0.979	95.9
ADE-OC	0.978	95.7
VA-ADE	0.973	94.7

VA is very strongly correlated with OC which is rather equally perfectly correlated with IC. ADE –EC shows a similarly very strong correlation which underscores the high cost of ADE. Just as the size of IC and OC is a determinant of VA, IC is also a significant influence on EC which also affects very closely both OC and VA. Comparatively somewhat lesser but effective role is exercised by ADE which is strongly correlated with IC and OC and also closely affects VA (Table 8).

Conclusion

The degree of interdependence and mutual influence in contributing the value-added in any industry is measured by coefficients of correlations. High correlations between the structural variables are suggestive of the strong role they have in the manufacturing process and its effectiveness towards value addition.

The analysis has been limited to major industrial categories which according to the pattern of the interdependence of variables are differentiated into two groups, (1) Basic metals and motor vehicles and trailers which display high correlation among all the variables and (2) Manufacture of textiles, chemicals, and chemical products, wearing apparel, food products, and beverages which have a mix of both strong and weak correlations. In the Manufacture of textiles category out of ten correlations, four are very strong and these are VA-IC, VA-OC, OC-IC and ADE-EC the value-added is more closely related with both IC and OC. The correlation between VA and OC is equally as strong as between VA and OC and which is also indicative of dominant influence in determining both IC and VA. It is conclusively shown that OC and ADE are the determinant variables affecting the size and value of production. The category of chemicals and chemical products has four strong correlations while the other six correlations are considerably much weaker. VA is strongly influenced by both OC and IC. Also, ADE and EC are strongly correlated which shows the significance of EC and ADE. Both OC and EC are found to be major determinants of VA. In the category of Wearing Apparel, four correlations are very strong which indicate the effective role of OC towards determining both VA and IC. The strong correlation between ADE and EC is indicative important role of the ADE in contributing to VA and influencing the level of IC.

The basics metals category is characterized by the strong correlation between all variables showing near equal importance of all the variables VA is shown to be very

Table 9. Major industrial categories: matrices of correlation coefficient

Manufacture of textiles
correlations: ADE, VA, IC, EC, OC

	ADE	VA	IC	EC	OC
ADE	1.00				
VA	0.713	1.00			
	0.176				
IC	0.713	1.000	1.00		
	0.176	0.000			
EC	0.964	0.602	0.601	1.00	
	0.008	0.283	0.284		
OC	0.667	0.998	0.998	0.547	1.00
	0.219	0.000	0.000	0.340	

Chemical and chemical products
correlations: ADE, VA, IC, EC, OC

	ADE	VA	IC	EC	OC
ADE	1.00				
VA	0.769	1.00			
	0.129				
IC	0.769	1.000	1.00		
	0.129				
EC	0.908	0.72	0.72	1.00	
	0.033	0.171	0.171		
OC	0.728	0.997	0.997	0.665	1.00
	0.163	0.000	0.000	0.221	

Wearing apparel
correlations: ADE, VA, IC, EC, OC

	ADE	VA	IC	EC	OC
ADE	1.00				
VA	0.680	1.00			
	0.320				
IC	0.680	1.000	1.00		
	0.320	0.000			
EC	0.991	0.771	0.771	1.00	
	0.009	0.229	0.229		
OC	0.642	0.999	0.999	0.737	1.00
	0.358	0.001	0.001	0.263	

Food product and beverages
correlations: ADE, VA, IC, EC, OC

	ADE	VA	IC	EC	OC
ADE	1.00				
VA	0.648	1.00			
	0.237				
IC	0.648	1.000	1.00		
	0.237				
EC	0.630	0.688	0.688	1.00	
	0.254	0.199	0.199		
OC	0.638	0.999	0.999	0.659	1.00
	0.247	0.000	0.000	0.226	

Basic metals
correlations: ADE, VA, IC, EC, OC

	ADE	VA	IC	EC	OC
ADE	1.00				
VA	0.999	1.00			
	0.000				
IC	0.990	0.982	1.00		
	0.001	0.003			
EC	0.994	0.998	0.968	1.00	
	0.001	0.000	0.006		
OC	0.999	1.000	0.982	0.998	1.00

Motor vehicles and trailers
correlations: ADE, VA, IC, EC, OC

	ADE	VA	IC	EC	OC
ADE	1.00				
VA	0.973	1.00			
	0.005				
IC	0.979	0.999	1.00		
	0.004	0.000			
EC	0.997	0.987	0.990	1.00	
	0.000	0.002	0.001		
OC	0.974	1.000	1.000	0.99	1.00
	0.004	0.000	0.000	0.001	

strongly correlated with both ADE and OC contributing strongly to VA and IC. A strong correlation between ADE and EC means high effort of ADE on the volume of VA. Food products and beverages category shows only three strong correlations, OC and IC being the main determinant of ADE, while the role of ADE in value addition remains limited. In the motor vehicles and Trailers industry, all correlations are very strong with a pattern quite similar to the basics metals industry. VA is strongly correlated with OC and also perfectly with IC. ADE and EC are strongly correlated showing significant influence of EC on both OC and VA.

Conflict of Interest. The authors declare no conflict of interest.

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