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Impact of Firms' Characteristics on Total Factor Productivity: Evidence from Pakistan

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ABSTRACT

This study has two objectives: First, it measures the firm-level total factor productivity of Pakistan's industrial sector for a panel of 161 firms listed on the Pakistan Stock Exchange over the period 1997-2017. Second, it examines the impact of cost of goods sold, firm size, total borrowings, return on assets, and interest rate on total factor productivity using a multinomial logit model. In order to calculate firm-level total factor productivity, we estimated a variant of the firm-level production function. The results indicate that firm size and return on assets are significantly positively associated with total factor productivity, whereas cost of goods sold and interest rate are significantly negatively related to total factor productivity. Results on the association between total borrowings and total factor productivity show mixed evidence. The findings of the study are important as aggregated total factor productivity at the macro level is a reflection of micro-level total factor productivity. Therefore, to prevent the negative effects of the cost of goods sold, it is recommended that the government formulate policies such as an industry-friendly energy policy, as well as reduce raw materials and tariff rates. Similarly, to reduce detrimental effects on total factor productivity, the State Bank of Pakistan ought to reconsider its interest rate policies.

1 Introduction

The industrial sector is considered vital in the economic growth process as it increases national income, investment, employment, and consumption level in the economy. More precisely, the long-run development of a country depends on the productivity of the industrial sector (Kuznets, 1966) which is a key to modern economic growth. The increase in productivity implies that an economy is producing a higher level of output with the same amount of inputs such as capital and labor (Clark, 2008).

Few economists (Young, 1992; Krugman, 1994) argued that economic growth is governed by two sources, namely, input-driven growth and productivity-driven growth. The input-driven growth can be accredited to factors of production that are subject to diminishing returns in the long run. Whereas the productivity-driven growth cannot be explained by growth in total inputs, it can be attributed to improvements in knowledge, technology transfer, information technology and efficient utilization of factors of production (Young, 1992; Krugman, 1994; Sehgal & Sharma, 2011). Similarly, Bevern (2008), Syverson (2011), and Ghosh (2013) found that the industrial sector's total factor productivity (TFP) is mainly derived from technological advancement and improvement in the quality of raw materials, while other studies (for example Mahadevan & Kim, 2003; Chaudary, 2009) showed that increase in productivity is input-driven.

While calculating TFP, the productivity shocks also act as an unobservable factor that may significantly influence TFP. The firms usually respond to positive productivity shocks through expansion in output by increasing the amount of input, however negative productivity shocks decrease the output of the firms. Therefore, the productivity shocks have significant effects on the survival of firms. For example, few firms may enter (exit) due to increased (decreased) demand for products. Hence it is argued that productivity growth not only increases the output of the industrial sector but also improves its competitiveness in the domestic as well as international market (see, for example, Kuznets, 1966; Ahmed et al., 2017; Bournakis & Malick, 2017)

The empirical literature identified various determinants of TFP at the industrial level. These determinants include research and development, human capital, investments in ICT, and international trade (See Aghion & Howit, 2006; Hall et al. 2009; Luintel et al. 2010 for further details). At macro level Kim et al. (2016) classified the determinants of TFP into four categories: innovation, market efficiency, physical infrastructure, and institutional infrastructure. TFP can be regarded as a vital component of overall economic growth process as it accounts for 90% of differences in per capita income across countries (Hall & Jones, 1999; Hsieh & Klenow, 2010). Most of the studies focused on aggregate TFP which depends on macro-level factors (See Syverson, 2004; Hsieh & Klenow, 2009; Bartelsman et al. 2010; Ahmed et al. 2017; Khan et al. 2020).

Keeping in view the vital importance of TFP, numerous studies estimated TFP using the data envelopment analysis (DEA) and index numbers approach. These techniques do not capture unobservable productivity shocks despite their flexibility about technology specifications. More recently, some studies used the generalized method of moments (GMM) which uses instrumental variables. But GMM does not account for unobservable productivity shocks. The main objective of measuring TFP is to identify the differences in output that cannot be explained by input differences. While measuring TFP, one important issue is the simultaneity problem that arises between inputs and unobserved productivity. With technological heterogeneity, the GMM estimator provides the most robust productivity level and growth estimates (See Biesebroeck, 2007; Gatoo et al. 2011). Various countries, for example, India, Singapore, China and Malaysia have broken the vicious circle of underdevelopment through improvement in TFP, however, Pakistan is lacking far behind in terms of achievement of annual growth rate. In 2018, Pakistan ranked 25th and 41st by Global Competitiveness Index report in terms of GDP. Although this ranking was improved by 07 numbers as compared to 2017, but Pakistan was still ranked low. The low ranking could be attributed to various problems such as energy crisis, inflation, unstable exchange rate, inconsistent economic policies, and high costs of raw materials. These factors undermined both firm-level as well as industrial-level performance in Pakistan. Therefore, analyzing TFP and its determinants is vital for Pakistan.

A few studies (for example, Pasha et al., 2002; Burki & Khan, 2004; Khan, 2006; Ahmed et al., 2017) have analyzed the macro-level determinants of TFP with reference to Pakistan. These studies concluded that TFP and economic growth have the same behavior and thus move in the same direction. This implies that the improvement in TFP would lead to higher economic growth and vice versa. On the other hand, Chaudhry (2009) analyzed the performance of the manufacturing sector by estimating the TFP of large-scale manufacturing agriculture sector and concluded that growth was input-driven rather than productivity-driven. Further, Calix et al. (2012) analyzed the TFP of major sectors of Pakistan and concluded that output growth was attributed to the input factors such as capital and labor rather than TFP. Likewise, Ahmed et al. (2017) examined the impact of trade liberalization on TFP of large-scale manufacturing units using Olley and Pakes (1996) methodology and concluded that import duty exerts a positive but negligible effect on TFP. Further they found that the effective rate of protection exerts negative impact on TFP at aggregated industry level. Besides, a few other studies (for example, Khan et al., 2020) also examined the determinants of TFP at the firm level.

Despite the significant impact of TFP on economic growth, the current literature lacks a comprehensive understanding of how various micro-level characteristics such as cost of goods sold, firm's size, firm total borrowings, return on assets, and macro-level factor for example interest rate affect TFP. This study is necessary since firms have heterogeneous characteristics that significantly impact firm-level TFP. Specifically, we explore following research questions:

- How does cost of goods sold affect TFP?

- How does firm's size affect TFP?

- What is the impact of firm total borrowings on TFP?

- What is the impact of return on assets on TFP?

- What is the impact of interest rate on TFP?

This study contributes to the existing literature by analyzing firm-level TFP for a panel of 153 firms listed on the Pakistan Stock Exchange by employing Olly and Pakes (1996) methodology. The aforementioned technique is useful in dealing with the issues of endogeneity and selection bias. Secondly, the present study augments the industrial sector production function by incorporating raw material and overhead costs along with industrial labor. Finally, this study employs a multinomial logit regression model to examine the impact of the cost of goods sold, firm size, return on assets, total borrowings, and rate of interest on TFP.

The rest of the paper is organized as follows: Section 2 presents a brief review of the literature. Section 3 elaborates the data description and methodology. Section 4 discusses empirical results while section 5 concludes the discussion and suggests policy recommendations.

2 Literature Review

The origin of TFP can be traced back to the seminal work of Tinbergen (1942) and Solow (1956). They defined productivity as a residual production function that comprises physical capital and labor force (See Chen, 1997 for further details). Since then various studies (for example, Bartelsman, 2000; Ackerberg et al. 2007) analyzed TFP both theoretically and empirically using the production function approach. A large number of studies, for instance, Olly and Pakes (1996), Sarel and Robinson (1997), Cornejo and Shumway (1997), Jin et al. (2001), Fulginiti et al. (2004), Hall and Scobie (2006), Biesebroeck (2007), Katayama et al. (2009), Eberhardt and Helmers (2010), Gatto et al. (2011), Beveren (2012) and Bournakis and Mallick (2017) employed different approaches for the estimation of TFP. The majority of these studies considered TFP at the aggregate level. However, Khan et al. (2020) estimated TFP at the firm-level using the production function approach.

The commonly used econometric approaches for the estimation of TFP include Ordinary Least Square, fixed effects and random-effects models. However, inferences based on these approaches are biased due to the problem of simultaneity, endogeneity, and selection bias.To address these issues, Olly and Pakes (1996) provided an alternative approach. This approach addressed aforementioned issues by estimating production function using investment function as a proxy for unobserved productivity shocks (Pavcnik, 2002; De Loecker, 2011; Konings & Vandenbussche, 2008; Bournakis & Mallick, 2017; Khan et al., 2020).

Some studies including Levinsohn and Petrin (2003), Fenandes (2007), Javorcik and Spatareanu (2008), Ackerberg et al. (2015), Bournakis and Mallick (2017), Ahmed et al. (2017), and Khan et al. (2020) modified Olly and Pakes (1996) methodology by incorporating the intermediary inputs as a proxy for unobserved productivity shocks. Likewise, Biesebroeck (2007) used index number approach to estimate productivity. He found that said approach was more appropriate when measurement errors were small, data envelopment analysis was best when technology was heterogeneous to firms and when there were productivity differentials across firms, then GMM, parametric or semi-parametric methods are useful. Likewise, Gatoo et al. (2011) surveyed approaches to TFP measurement and classified them into three categories viz. deterministic, parametric, and non-parametric methods, and conclude that the semi-parametric approach is appropriate for analyzing micro-level data.

While estimating TFP, the positive correlation between observable input and unobservable productivity shocks create biasness and endogeneity problems which in turn produces biased inferences. Lederman and Fajnzylber (1999) estimated TFP using the Cobb Douglas production function under the assumption of constant returns to scale for the period 1959 to 1995 for Latin America and Caribbean countries. They found that productivity growth accounted for only 5% of overall growth in TFP. They observed TFP growth to be input-driven. On the other hand, Wooldridge (2009) implemented the proxy variables approach using a one-step GMM estimator and concluded that it better controls the unobserved demand shocks and thus has an advantage over Olly and Pakes (1996) and Levinsohn and Petrin (2003) methodology.

The literature identified a number of determinants of TFP at macro-level, such as research and development (R&D), trade openness, human capital, and investments in ICT (Hall et al. 2009; Luintel, 2010; Aghion & Howit, 2006). Few other studies, for instance, Ahmed et al.(2017) considered trade barriers such as effective rate of protection, domestic investment, and regulatory and excise duties as determinants of TFP in Pakistan. Based on the micro-level data, Melitz (2003) found that differences in TFP at the firm's level underscore the new international trade theory. On the other hand, Bloom and Reenan (2010) examined the impact of quality of managers and labor on TFP and found that the learning process is firm-specific which exerted a positive impact on the firm's level TFP. The firm's characteristic are considered as another important determinant of TFP. In this respect, Kim (2018) argued that large firms can outperform smaller firms due to differential level of economies of scale. He found that the firms who participate in international trade are more productive than those of non-export firms. Likewise, Eaton, Kortum, and Kramarz (2011); Bernard et al. (2012), and Kasahara and Lapham (2013) found a positive relationship between trade and firm's productivity. Specifically, with reference to Pakistan few studies, (for example, Pasha et al., 2002; Burki & Khan 2004; Khan 2006; Ahmed et al., 2017) focused on the macroeconomic determinants of TFP at the aggregated level. These studies concluded that TFP and economic growth move in the same direction, that is, an increase in TFP would increase GDP and vice versa. On the other hand, Chaudhry (2009) analyzed the performance of the manufacturing sector by estimating the TFP of large-scale manufacturing firms for the agriculture sector and found that growth in this sector was input-driven rather than productivity-driven. Similar, Calix et al. (2012) concluded that output growth was attributed to the inputs such as capital and labor rather than TFP. Likewise, Ahmed et al. (2017) found that TFP is significantly determined by domestic investment and effective rate of protection in large-scale manufacturing sector in Pakistan.

Based on above cited literature and gap in literature, this study uses firm-specific variables as determinants of TFP in Pakistan at the firm-level. The present study considerably contributes to the existing literature by incorporating the cost of goods sold, total borrowings, return on assets and interest rate as determinants of TFP for the industrial sector in Pakistan.

3 Model, Data, and Research Methodology

3.1 Modeling framework

This study uses augmented Cobb Douglas production function to estimate firm-specific production function. While estimating industrial production function, there is a correlation between observable inputs and unobservable productivity shocks which are specific to the firms due to their skills and raw material choices. The correlation between observable inputs and unobservable productivity shocks creates endogeneity and selection biases. Therefore, this study uses a semi-parametric approach developed by Olly and Pakes (1996) which is useful to deal with these issues. We estimated firm-level TFP in two steps. In the first step, we estimated the industrial production function and then estimated TFP from the coefficients of input factors of production function following Khan et al. (2020) and Ahmed et al. (2017). For the empirical analysis, we consider the following augmented firm-specific production function of the Cobb Douglas form:

$$Y_{it} = A_{it}K_{it}^{\propto}L_{it}^{\beta}OH_{it}^{\gamma}RM_{it}^{\delta} \quad (1)$$

In Equation (1), Y is the output, proxied by value-added in terms of total sales, A is the total factor productivity, K is capital stock, L is labor, OH is overhead costs including energy consumption and RM is raw material, while *i* denotes for number of cross-sectional units that is firms and *t* represents time period. We used logarithmic transformation of firm-specific production function and can be expressed in logarithmic form in Equation (2);

$$lnY_{it} = lnA_{it} + \propto lnK_{it} + \beta lnL_{it} + \gamma lnOH_{it} + \delta lnRM_{it} + u_{it} + \varepsilon_{it} \quad (2)$$

Following Bournakis and Mallick (2017), we decompose technical efficiency in Equation (3):

$$lnA_{it} = a_0 + \omega_{it} \quad (3)$$

Equation (2), now, can be rewritten as:

$$Y_{it} = a_0 + \alpha lnK_{it} + \beta lnL_{it} + \gamma lnOH_{it} + \delta lnRM_{it} + \omega_{it} \quad (4)$$

In Equation (4), ω_{it} is the unobserved demand shock which affects the output of *i*th firm and$a_0$is the average efficiency of firms. It is also assumed that the unobserved factorω_{it}includes firm-specific η_i and time-specific λ_t effects. Equation (4), therefore, can be rewritten as:

$$y_{it} = a_0 + \alpha k_{it} + \beta l_{it} + \gamma oh_{it} + (\eta_i + \lambda_{it}) + u_{it} \quad (5)$$

In a more compact form, equation (5) can be written as:

$$y_{it} = a_0 + \alpha k_{it} + \beta l_{it} + \gamma oh_{it} + \omega_{it} + u_{it} + \epsilon_{it} \quad (6)$$

The lower case letter represents natural logarithmic values. In estimating equation (4) by ordinary least squares (OLS), there is a problem with unobserved productivity shocks in terms of industry-specific shock and time-specific shock, which are known to the firms within given levels of input. This confirms that the variable inputs $\varepsilon_{i,t}$ are correlated, thus resulting in an endogeneity problem. To this end, various techniques have been used in literature to address the issue of endogeneity in estimation of production function. It can be argued that the use of instrumental variables may get errors uncorrelated with productivity.

The final form of total factor productivity (TFP) can be expressed in Equation (7):

$$\hat{\omega}_{it}=y_{it}-\alpha k_{it}-\beta l_{it}-\gamma\, rm_{it}-\delta\, oh_{it}+u_{it}=a_{it} \quad (7)$$

In Equation (7) is TFP which can be calculated by combining the estimated function$\varphi_{it}(.)$

$$\hat{\omega}_{it}=\hat{\varphi}_{it}(rm_{it},K_{it})-\hat{\gamma}\, rm_{it}-\hat{\alpha} k_{it} \quad (8)$$

Following Besile et al. (2003) and Benfratello and Razzolini (2008), we usedthe firm's size proxied by book value of total fixed assets, return on assets (ROA), total borrowings (TBr) and interest rate (INT) to examine their impact on TFP. In functional form, the determinants of TFP can be expressed in Equation (9);

〖TFP〗 _it=f(〖TA〗 _it, 〖TBr〗 _it, 〖CGS〗 _it, 〖ROA〗 _it, 〖INT〗 _it) (9)

In Equation (9), we have considered TFP as the dichotomous variable that takes a value equal to 1 in case the firm has positive TFP growth and 0 in case the firms have negative TFP growth. Therefore, we employed a multinomial logistic regression model to investigate the impact of TFA, TBr, CGS, ROA, and INT on TFP. The firm size (total fixed assets) is a source of heterogeneity among firms, therefore, can exert a positive impact on TFP (See Castany et, al. 2005). The CGS comprises all the costs associated with the production, therefore, can impact TFP either way that is, an increase in CGS would decrease TFP and vice versa. Likewise, ROA put a positive impact on TFP as highlighted by Svoboda and Novotna (2011).On the other hand, low productivity growth is associated with high-interest rates, therefore, the interest rate would exert a negative impact on firm-level TFP (See Ahmed et al. 2017; Lunsford, 2017).

3.2 Data Description

The present study examines the impact of firm-level heterogeneous characteristics on TFP for a panel of 153 firms, listed on the Pakistan Stock Exchange over the period of 1997-2017. The data is collected from Audited Annual Accounts, Pakistan Stock Exchange, Federal Board of Revenue (FBR) and Pakistan Bureau of Statistics (PBS). Missing data is interpolated using the linear interpolation technique. Our total population consisted of 374 firms, listed on the Pakistan Stock Exchange. However we collected data of153 industrial firms only as these firms remained listed on the Pakistan stock exchange during the period 1997-2017 and also complied with the requirements of the Pakistan Stock Exchange.

3.3 Variables Description

We used the firm's value-added proxied by total sales, which is the sum of local sales and exports, as a dependent variable, whereas, capital, labor, raw material, and overhead costs are used as dependent variables. The capital stock is the sum of all property, plant, and equipment held by firms, whereas labor is taken as workforce directly involved in the production process and overhead costs are costs associated with the production process including energy and alternate sources (CMI, 2005-06). We deflated all the variables by wholesale price index (WPI) to capture the effects of price changes. Data on WPI are collected from the World Bank database. Firms' size, proxied by the book value of total fixed assets, total borrowings (TBr), cost of goods sold (CGS), return on assets (ROA), and interest rate are also used to account for the impact of these variables on TFP.

4 Results and Discussion

4.1 Descriptive Statistics

We start our analysis with descriptive statistics and the results of which are reported in Table 1.It can be seen from Table 1 that the mean value of all the variables is positive. The mean value of COGS, TFA and TBR is higher, showing the importance of these variables in the relationship. The lowest mean value isfor ROA and TFP showing least importance in the relationship. The value of the standard deviation indicates that the interest rate is more volatile whereas the volatility of other variables COSG, TFA and TBR is less than that of INT.

Table 1
Descriptive Statistics of Variables

Variables	Observations	Mean	Median	Maximum	Minimum	Std. Dev.
TFP	2848	0.631	1	1	0	0.482
COGS	2829	8.121	8.031	13.593	-1.101	1.497
TFA	2789	7.613	7.585	12.454	-4.993	1.787
TBR	2774	7.817	7.764	12.361	1.153	1.536
ROA	2789	0.056	0.050	0.669	-0.529	0.095
INT	2115	1.841	2.879	8.321	-6.774	4.479

4.2 Correlation Analysis

Table 2 explains the correlation between TFP and other explanatory variables. The correlation analysis indicates that TFP is positively correlated with firm size (TFA) and return on assets (ROA), whereas it has a negative correlation with the cost of goods sold (COGS) and total borrowings (TBR). Likewise, the total borrowings (TBR) and firm's size (TFA) have a strong positive correlation with the cost of goods sold (COGS). The correlation between return on assets (ROA) and firm size (TFA) and total borrowings (TBR) is negative, whereas the correlation between ROA, TFP, and COGS is positive. However, there is a negative correlation between interest rate and TFP.

Table 2
Correlation among Variables

Variables	TFP	COGS	TBR	TFA	ROA	INT
TFP	1.000	.				
COGS	-0.141	1.000				
TBR	-0.027	0.832	1.000			
TFA	0.041	0.729	0.8831	1.000		
ROA	0.095	0.084	-0.0121	-0.022	1.000	
INT	-0.066	0.014	-0.011	0.014	0.003	1.000

4.3 Estimation Results on Firm-Level Production Function

Empirically, we have employed panel least squares (PLS), fixed effect (FE), and random effect (RE) models to estimate the firm-level production function. The FE and RE models were used to check the impact of capital, labor, raw material, and overhead costs on firm-level productivity. It can be seen from Table 3 that the absolute magnitude of parameters obtained from the PLS, FE, and RE models are almost identical. However, based on the Hausman test we find the FE model is more appropriate than RE model. Thus, based on the Hausman test, this study considers the results of FE model for further discussion.

The results of FE model in column 1 of Table 3 reveal a positive relationship between raw materials (RM) and firm-level productivity measured through TS. This suggests that 1% increase in raw materials increases total sales by 5%. Other variable is capital (PPE) which shows a significant negative relationship with total sales. This suggests that a 1% increase in capital expenditure resulted in decreasing productivity by 3%. The decrease in capital may be due to inefficient capital investment or misallocation of capital resources owing to which the firm level productivity decreased. Our findings are consistent with those of Burki and Khan (2004), Ahmed et al. (2017), and Khan et al. (2020).

Table 3

Firm-level Production Function (Dependent variable TS)

Variables	FE	RE	PLS
Constant	-0.95*	-0.43*	-0.21*
	(-13.86)	(-10.00)	(-7.34)
RM	0.05*	0.03*	0.01*
	(6.54)	(4.71)	(2.62)
PPE	-0.03*	-0.01*	0.01
	(-4.57)	(-2.70)	1.34
L	-0.02*	-0.01**	0.01
	(-3.96)	(-1.95)	1.05
OH	1.12*	1.06**	1.02*
	(84.44)	(104.10)	(114.70)
Adjusted R^2	0.98	0.95	0.98
F-Stat	937.22	10410.91	24385.59
Hausman Test		0.00	

Note: * and ** indicate significance at 1% and 5% level, respectively. The values in (.) are t-values. FE stands for Fixed effect model, RE stands for Random Effect and PLS stands for Panel Least Square

The coefficient of labor is negative and significant which shows that1% increase in labor input decreases sales by 2%.Among the independent variables, energy (OH) has the highest positive impact on dependent variable ($\beta = 1.12$, t =84.44). Unlike earlier studies, (for example, Burki & Khan, 2004; Mehmood, 2012; Shakeel et al. 2013; Ahmed & Nawaz, 2013; Ahmed et al., 2017), our results are positive. The aforementioned studies reported a negative impact of energy on output at the aggregate level. Our findings show positive impact of energy on firm-level output and results are consistent with the findings of Khan et al. (2020). The reason for this deviation might be the inclusion of an alternate source of energy. It is added that, this study has included in-house electricity generation in the construction of energy variables (OH), which have exerted a positive impact on the firms-level productivity. Based on these results, it can be argued that energy acts as a key component in the industrial production process, and an uninterrupted supply of electricity could yield an optimal level of a firm's productivity.

4.4 *Firm-Level Total Factor Productivity*

Following, Levinsohn and Petrin (2003) and Ahmed et al. (2017), the firm-level TFP is estimated by incorporating raw material, labor, capital and energy by employing the FE model after accounting for the unobserved productivity shock. The firm-level TFP can be estimated as:

$$TFP_{it} = TS_{it} - \beta_K K_{it} - \beta_{RM} RM_{it} - \beta_L L_{it} - \beta_{OH} OH_{it} \quad (10)$$

TFP of individual firms is estimated using equation (10) for each year over the period 1997-2017. Afterward, we calculated the average TFP of the individual firms. Figure 1 shows the industry-wise average TFP of selected firms.

Figure 1 shows industry-wise positive average TFP of firms related to cement, engineering, paper and board, pharmaceutical and chemicals whereas, few firms have negative TFP, and these are automobiles, electrical, construction, food, oil and gas, textile, telecommunication, and tobacco. The paper and boards sector has the highest positive TFP, followed by the cement sector, engineering, Pharma and chemical. The positive TFP attributes to an increase in the demand for cement due to the expansion of the construction business in Pakistan and Afghanistan. The intense competition, unhindered supply, cost savings and quality of product forced the individual firms to work on research and development especially by focusing on technology.

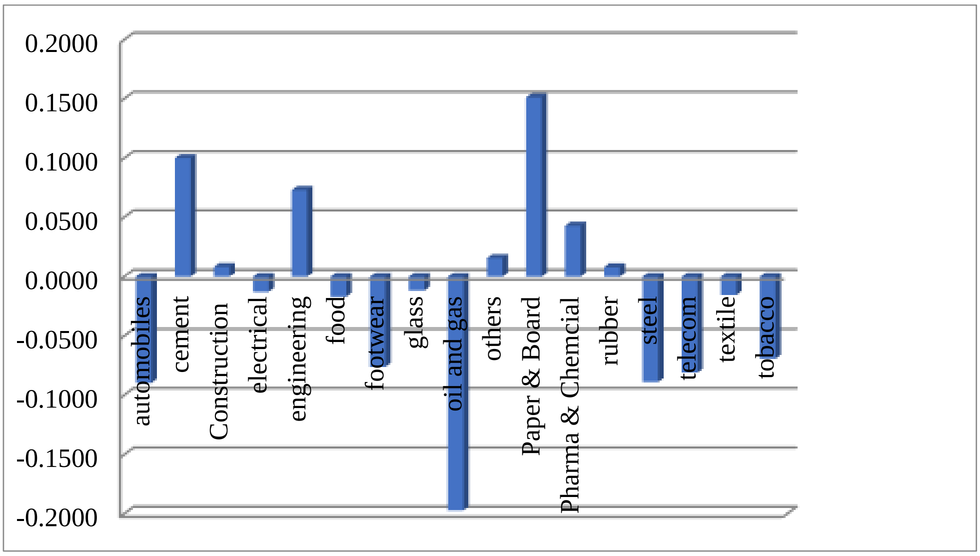

Figure 1
Industry-wise average TFP

On the other hand, the negative average TFP of the oil and gas industry could be attributed to an increase in international prices of oil and its related products over the years. The high tax rate, petroleum levy, and regulatory duties also make the situation adverse. The negative average TFP of the automobile industry can be due to an increase in the number of imported (both new and reconditioned) vehicles that have a relatively low price but high quality as compared to the local manufactured or assembled vehicles. Whereas, the negative average TFP of steel, textile, and footwear industries is due to the high cost of production and insufficient availability of quality raw materials viz-a-viz an energy shortage undermined the performance of these industries. The textile industry was significantly impacted by energy outages which halted the production process resulting in a productivity decline. The average TFP of the textile sector firms is also negative, which is mainly due to insufficient energy supply. This halted the production process of many textile firms. The other reasons may be insufficient availability of low-cost quality raw material and an increase in imports of finished textile products. The tobacco industry also faced a negative TFP due to the higher rate of taxes and duties on tobacco products. Besides, the illicit trade of cigarettes by local manufacturers and smugglers also contributed to negative TFP.

By summing up the discussion on Figure 1, we observed that the majority of industries in sample had a negative TFP. Aggregated TFP at the macro level is the reflection of micro-level TFP. Therefore, our results are consistent with earlier studies (see please, Mahmood, 2012; Shakeel et al. 2013; Ahmed et al. 2017; Khan et al. 2020) with reference to Pakistan. Summary of firms with TFP details is presented in Table 4. This shows that 62 firms possess positive average TFP, 78 firms with negative average TFP, whereas 13 firms remain with zero average TFP. The firm-level TFP estimates are presented in Appendix A and Appendix B.

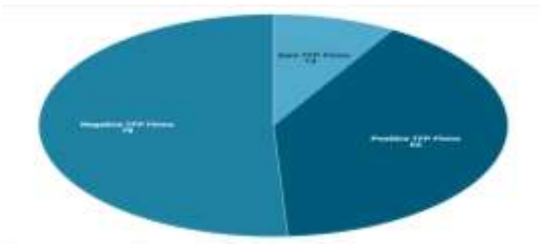

Figure 2
Summary of Firm-Level TFP

Table 4
Summary of Firm-Level TFP

No. of Zero TFP Firms	No. of firms with positive TFP	No. of firms with negative TFP	Total No of firms
13	62	78	153

4.5 *Estimation Results on the Determinants of Firm-level TFP*

We have constructed a binary variable for TFP and assigned value equal to "1" where estimated TFP is zero or positive and "0" otherwise. We have also examined the impact of a firm's size, firm total borrowings, return on assets, and rate of interest on the TFP by employing the multinomial logit model. The results of which are reported in Table 5. The results in column 1 of Table 5 show the aggregate level results, while column(s) 2-8 presents industry-wise results.

The column1 of Table 5 shows that the likelihood of improvement in overall TFP declined with increase in the cost of goods sold (Odd ratio < 1). The obvious reason for this negative impact is due to the increase in the cost of production including the increase in prices of energy, raw material, and unskilled labor. The impact of costs of goods sold on TFP is significant in the sectors except communication services at column 7 which means that with an increase in COGS, the probability of TFP improvements would decrease. Therefore, an increase in COGS would result in a TFP decline at the micro level as well as macro level. On the other hand, increase in firm size (TFA) increases the likelihood of improvement in TFP (Odd ratio > 1). Likewise, results show that firms' size positively affects TFP of all sectors except communication services.

Table 5
Logit Model Results

Sector								
Variables	**Overall**	**Industrial**	**Materials**	**Consumer Discretion**	**Health Care**	**Consumer Staples**	**Comm Services**	**Energy**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
COGS	[0.508]	[0.138]	[0.505]	[0.409]	[0.313]	[0.703]	[1.59E+21]	[0.151]
	(0.034)*	(0.063)*	(0.083)*	(0.066)*	(0.159)*	(0.122)**	(8.20E+22)	(0.075)*
TFA	[1.456]	[1.739]	[3.07]	[2.291]	[15.09]	[0.766]	[7.8E-31]	[2.38]
	(0.088)*	(0.361)*	(0.525)*	(0.357)*	(9.779)*	(0.099)**	(5.1E-29)	(0.916)**
ROA	[19.71]	[30.651]	[6973.23]	[22.489]	[0.001]	[0.115]	[2.31E+28]	[0.0003]
	(15.64)*	(66.71)*	(8903.61)*	(25.72)*	(0.007)*	(0.141)	(9.85E+29)	(0.001)*
TBr	[1.115]	[1.671]	[0.456]	[0.584]	[0.083]	[1.451]	[1.04E+27]	[8.61]
	(0.096)	(0.755)	(0.097)*	(0.11)*	(0.064)*	(0.265)**	(5.67E+28)	(5.92)*
Int	[0.968]	[0.989]	[24.62]	[0.935]	[0.953]	[0.931]	[0.353]	[0.923]
	(0.01)*	(0.046)	(16.56)	(0.021)*	(0.05)	(0.022)*	(0.369)	(0.054)
Constant	6.495	[8337.01]	[(24.626]	[101.526]	12822.93]	[8.21]	[2.6E-142]	[0.0004]
	(1.835)*	(15960.85)*	(16.561)*	(62.053)*	34173.72)*	(7.602)**	(7.9E-140)	(0.001)*
Observations	2014	156	605	593	112	371	40	137

Number of Firms	161	11	44	47	8	31	10	10
Pseudo R-Squared	0.069	0.263	0.147	0.142	0.246	0.161	0.751	0.491
Chi² Stats	193.76	53.05	113.31	112.93	36.69	26.71	22.1	90.29

Note: [-] denotes odds ratio, (.) represents robust standard errors. The* *, ** ** indicate significance at 1% and 5% level, respectively.

An increase in total fixed assets also suggests that firms are using updated plants and machinery in the production process, which in turn leads to an increase in productivity. Likewise, the firms with obsolete and outdated plants have lower productivity. Our results indicate that the firms in the health care sector have the highest odds ratios of 15.091 for firm size. As the health care business is more research-oriented and such firms consume a handful of budgets on R & D. Therefore, they expand more and have higher TFP. Our findings are consistent with those of Biesebroeck (2005); Shahzad and Javed (2015); Ahmed et al. (2017) and Satpathy et al. (2017).

With regard to return on assets (ROA), it is positively associated with productivity as Odd ratio is greater than 1 (Odd ratio = 19.71). Total borrowings (TBr) are insignificantly associated with productivity of overall sample of firms. However with respect to firms groups, consumer staples sector and energy sector, total borrowing is significantly positively associated with productivity. As consumer staples are essential products, that includes food, beverages, household, tobacco, etc. and their demand remains fairly constant at all times, therefore, the firms in this sector have more credit availability due to greater liquidity. Likewise, the energy sector which comprises of electricity, gas, and other petroleum products has higher demand and needs greater liquidity. Therefore, firms in this sector have more access to credit. Our findings are consistent with those of Satpathy et al. (2017).

Consistent with the findings of Duval et al. (2017) and Lunsford (2017), interest rate is negatively associated with TFP of overall sample firms (ROA = 0.968). Interest rate of consumer discretionary and consumer staples are significantly negatively associated with TFP. Odd ratio of interest rate for consumer discretionary sector is (0.935). Similarly for consumer staples sector it is (0.931). Interest rate of various sectors such as industrial, materials, health care, communication services and energy are insignificantly associated with TFP.

5 Conclusion and Policy Recommendations

Keeping the importance of total factor productivity, this study examines the TFP of 161 firms listed on the Pakistan Stock Exchange covering the period of 1997 to 2017. An augmented Cobb Douglas production was used to estimate firm-level input elasticities using the fixed effect model. We have calculated firm-level TFP from the estimated firm-level input elasticities. To examine the impact of the cost of goods sold, firm size, return on total assets, total borrowings, and interest rate on firm-level TFP, we employed the multinomial logistic model. In overall terms, the majority of firms possess negative TFP, however, few firms possess positive TFP because these firms use alternate energy sources such as in-house electricity generation. The majority of firms that are not using alternate energy sources lacked productivity. From these findings, we can deduce that the increasing costs of raw material and energy clubbed with inefficient capital investment decisions adversely affected the TFP of the majority of sampled firms. Therefore, the provision of high quality and low-cost raw materials may enhance firm-level productivity. Many of the sampled firms are using obsolete plants and machinery in their production process that causes more wastage, thereby increasing the cost of production which ultimately resulted in TFP decline. Hence, the import of capital goods might be encouraged, which is the main source of technological transfer. The other important factor which contributed to declining TFP includes the increasing cost of overhead (electricity, gas, and other fuels). Hence, these costs need to be reduced through policy reforms. For industry, energy may be provided at a concessionary rate. The result of this study would help industrialists and policymakers to identify factors affecting productivity.

The results suggest that an increase in firm-level TFP is mainly derived from factors of production (input-driven). The firms with zero or positive TFP are attributed to the size of the firm and return on assets, whereas negative TFP is explained by an increase in cost of goods sold and rate interest. Likewise, findings at the sectoral level also reveal that cost of goods sold, total borrowings, firm size, return on assets, and rate of interest are important determinants of firm-level TFP.

This study offers important policy implications. Firstly, the firms are facing high industrial costs due to an increase in the cost of energy and fuel. Therefore, the government needs to address this issue by formulating an industry-friendly energy policy so that firm's cost of production could be lowered. One of the major factors affecting TFP is the increasing cost of quality raw materials. Therefore government should formulate policies so that the manufacturing concerns may obtain quality raw material at cheaper rates which will lower their cost of production and increase output. Trade policy needs to be reshuffled so that tariffs on the import of raw materials can be minimized and manufacturers obtain high-quality raw materials at a cheaper rate. State Bank of Pakistan should reconsider its interest rate policies to minimize negative effects on total factor productivity. Similarly government should implement fiscal policies that promote productivity growth to offset the negative effects of interest rates.

Appendix A

Firms with Estimated Negative TFP

S.No.	Name of Firm	TFP	S.No.	Name of Firm	TFP
1	Atlas Honda Limited	-0.14	40	Wyeth Pakistan Limited	-0.07
2	Ghani Automobile Industries Limited	-0.14	41	sanofi-aventis Pakistan Limited	-0.05
3	Hinopak Motors Limited	-0.08	42	Berger Paints Pakistan Limited	-0.05
4	Al-Ghazi Tractors Limited	0.00	43	ZIL Limited	-0.05
5	Power Cement Limited	-0.01	44	Nimir Industrial Chemicals Limited	-0.04
6	Dandot Cement Company Limited	-0.32	45	Dynea Pakistan Limited	-0.02
7	Pakistan Cables Limited	-0.03	46	Buxly Paints Limited	-0.01
8	Siemens (Pakistan) Engineering Co. Ltd.	-0.08	47	Crescent Steel and Allied Products Limited	-0.09
9	Waves Singer Pakistan Limited	-0.03	48	Telecard Limited	-0.08
10	KSB Pumps Company Limited	-0.01	49	Dewan Textile Mills Limited	-0.21
11	Fauji Foods Limited	-0.13	50	Dar Es Salaam Textile Mills Limited	-0.11
12	Dewan Sugar Mills Limited	-0.12	51	Dewan Khalid Textile Mills Limited	-0.11
13	Haseeb Waqas Sugar Mills Limited	-0.09	52	Chakwal Spinning Mills Limited	-0.08
14	Husein Sugar Mills Limited	-0.08	53	Ghazi Fabrics International Limited	-0.07
15	Faran Sugar Mills Limited	-0.05	54	Rupali Polyester Limited	-0.07
16	Shezan International Limited	-0.05	55	The Crescent Textile Mills Limited	-0.07
17	Shahtaj Sugar Mills Limited	-0.04	56	Jubilee Spinning & Weaving Mills Limited	-0.06
18	National Foods Limited	-0.03	57	Gul Ahmed Textile Mills Limited	-0.05
19	Jauharabad Sugar Mills Limited	-0.03	58	Ibrahim Fibres Limited	-0.05
20	Noon Sugar Mills Limited	-0.03	59	Gatron (Industries) Limited	-0.05

21	Mehran Sugar Mills Limited	-0.02	60	Quetta Textile Mills Limited	-0.04
22	Baba Farid Sugar Mills Limited	-0.02	61	Nishat Mills Limited	-0.04
23	Chashma Sugar Mills Limited	-0.02	62	International Industries Limited	-0.04
24	Habib Sugar Mills Limited	-0.01	63	Gadoon Textile Mills Limited	-0.03
25	Al-Noor Sugar Mills Limited	0.00	64	Dewan Mushtaq Textile Mills Limited	-0.03
26	Mitchell's Fruit Farms Limited	0.00	65	Sapphire Textile Mills Limited	-0.03
27	Service Industries Limited	-0.08	66	Indus Dyeing & Manufacturing Company Limited	-0.02
28	Bata Pakistan Limited	-0.02	67	Shadab Textile Mills Limited	-0.02
29	Balochistan Glass Limited	-0.17	68	Feroze1888 Mills Limited	-0.01
30	Pakistan Refinery Limited	-0.25	69	Nagina Cotton Mills Limited	-0.01
31	Shell Pakistan Limited	-0.25	70	Kohinoor Mills Limited	-0.01
32	Attock Refinery Limited	-0.23	71	GlaxoSmithKline Pakistan Limited	-0.01
33	National Refinery Limited	-0.22	72	Shams Textile Mills Limited	-0.01
34	Burshane LPG (Pakistan) Limited	-0.04	73	Elahi Cotton Mills Limited	-0.01
35	Packages Limited	-0.06	74	Faisal Spinning Mills Limited	-0.00
36	Nestlé Pakistan Limited	-0.05	75	Ismail Industries Limited	-0.01
37	Colgate-Palmolive (Pakistan) Limited	-0.02	76	Bhanero Textile Mills Limited	-0.01
38	Bolan Castings Limited	-0.01	77	Philip Morris (Pakistan) Limited	-0.11
39	ICI Pakistan Limited	-0.07	78	Pakistan Tobacco Company Limited	-0.03

Appendix B

Firms with Estimated Positive TFP

S.No.	**Name of Firm**	**TFP**	**S.No.**	**Name of Firm**	**TFP**
1	Fecto Cement Limited	0.03	32	Clover Pakistan Limited	0.04
2	Gharibwal Cement Limited	0.03	33	EcoPack Limited	0.05
3	Maple Leaf Cement Factory Limited	0.12	34	Century Paper & Board Mills Limited	0.01
4	Cherat Cement Company Limited	0.13	35	Pakistan Paper Products Limited	0.17
5	Lucky Cement Limited	0.16	36	Security Papers Limited	0.28
6	D.G. Khan Cement Company Limited	0.17	37	Otsuka Pakistan Limited	0.00
7	Pioneer Cement Limited	0.18	38	Highnoon Laboratories Limited	0.01
8	Fauji Cement Company Limited	0.22	39	The Searle Company Limited	0.05
9	Kohat Cement Company Limited	0.24	40	Sana Industries Limited	0.05
10	Bestway Cement Limited	0.25	41	Archroma Pakistan Limited	0.05
11	Dawood Hercules Corporation Limited	0.11	42	Abbott Laboratories (Pakistan) Limited	0.06
12	GOC (Pak) Limited	0.21	43	Wah Nobel Chemicals Limited	0.09
13	Pakistan Engineering Company Limited	0.23	44	Pakistan Oxygen Limited	0.11

14	Pak Elektron Limited	0.01	45	Sitara Chemical Industries Limited	0.11
15	Dadex Eternit Limited	0.01	46	Ferozsons Laboratories Limited	0.19
16	Fauji Fertilizer Company Limited	0.17	47	Biafo Industries Limited	0.32
17	Fauji Fertilizer Bin Qasim Limited	0.00	48	The General Tyre and Rubber Company of Pakistan Limited	0.01
18	Engro Corporation Limited	0.00	49	Pakistan Services Limited	0.15
19	JDW Sugar Mills Limited	0.01	50	Reliance Cotton Spinning Mills Limited	0.08
20	Al-Abbas Sugar Mills Limited	0.01	51	Artistic Denim Mills Limited	0.10
21	Tandlianwala Sugar Mills Limited	0.01	52	Bannu Woollen Mills Limited	0.18
22	Ansari Sugar Mills Limited	0.02	53	Shahtaj Textile Limited	0.00
23	Shahmurad Sugar Mills Limited	0.03	54	Salfi Textile Mills Limited	0.00
24	Tri-Pack Films Limited	0.07	55	Reliance Weaving Mills Limited	0.01
25	Habib-ADM Limited	0.07	56	Premium Textile Mills Limited	0.02
26	Rafhan Maize Product Company Limited	0.08	57	Pakistan Synthetics Limited	0.02
27	Tariq Glass Industries Limited	0.02	58	Nishat (Chunian) Limited	0.03
28	Ghani Glass Limited	0.11	59	Dewan Cement Limited	0.03
29	Treet Corporation Limited	0.01	60	Tata Textile Mills Limited	0.03
30	Merit Packaging Limited	0.02	61	Island Textile Mills Limited	0.04
31	Cherat Packaging Limited	0.03	62	Sapphire Fibres Limited	0.05

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