Trade Liberalization and Industrial Productivity: Evidence from Pakistan

Ahmed, Gulzar and Arshad Khan, Muhammad and Afzal, Muhammad

Pakistan Institute of Development Economics, (PIDE), Islamabad, Comsats Institute of Information Technology, Islamabad, Forman Christian College, Lahore

15 August 2015

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Gulzar Ahmed[1], Muhammad Arshad Khan[2], and Muhammad Afzal[3]

Abstract

This study examines the impact of trade liberalization on industrial productivity for a panel of twenty seven 3-digit manufacturing industries in Pakistan over the period 1980-2006. Following Olley and Pack's (1996) Control Function Approach (CFA) we deal with the endogeneity arises from unobserved productivity shocks. Using a variant of Cobb-Douglas production function, in the first step we estimate output elasticities. We find positive output elasticities with respect to labor, capital and raw materials for the pre-trade liberalization period (1981-1995) and post-trade liberalization period (1996-2006). For the pre-liberalization, we observed positive output elasticity with respect to energy, while it turns out to be negative in the post-liberalization period; probably due to energy crisis in Pakistan. In the second stage, we estimate total factor productivity (TFP) and examine the impact of trade liberalization on TFP for pre-and post-trade liberalization regimes. The results reveal that trade liberalization proxied by excise duty has positive but negligible impact on TFP in the pre-as well as post-liberalization periods. On the other hand, effective rate of protection exerts large negative impact on TFP in the post-liberalization than the pre-liberalization period.

[1] Gulzar Ahmed is M Phil scholar, Department of Econometrics and Statistics, Pakistan Institute of Development Economics (PIDE), Islamabad.(gulzar_maitla@yahoo.com)

[2] Muhammad Arshad Khan is Associate Professor, Department of Management Sciences, COMSATS Institute of Information Technology, Islamabad (arshad.khan@comsats.edu.pk).

[3] Muhammad Afzal is M Phil scholar, Forman Chrisitian College University, Lahore (Pakistan). (afzal.maitla@gmail.com)

1. Introduction

Manufacturing sector in Pakistan is confronting lack of advanced technology, skilled labor force, shortage of energy and inconsistent trade policy adversely affected the productivity of manufacturing industries. Mahmood et al. (2007) reported that import substitution policies and high tariffs are the main constraints that undermine the efficiency of manufacturing sector in Pakistan. Low quality products of exporting industries are unable to compete with world's exports in the international markets. Due to lack of competition in the world market, domestic producers do not expand their market share.[4] Manufacturing industries in Pakistan are lacking behind in terms of technological advancement and adaptation of advanced technology which cause low value added and low quality product segments of exports (Mahmood et al., 2009). Trade liberalization is widely considered as the key feature of industrial development of a country, which refers to dismantling the tariffs and non-tariff barriers such as quotas and other import duties. Trade liberalization is believed to promote industrial development through the diffusion of knowledge, learning by doing, provision of advanced technology, innovation of new products and improvements in product's quality which enhances access to foreign markets.[5] Furthermore, trade liberalization can increase industrial efficiency by eliminating monopoly profits, increasing capacity utilization, allowing optimal resource allocation (Sheikh and Ahmed, 2011). The theory of industrial organization has acknowledged that role international trade in the determination of industrial efficiency through its impact on productivity, profitability and exports. According to the World Bank (2002), reduction in barriers to international trade could accelerate economic growth, provide stimulus to new forms of productivity, enhancing specialization, jobs creation and poverty reduction around the world.

The traditional theories of trade predicted that openness to international trade increase the value of the production in the economy. Trade generates a static improvement in output and improves allocative efficiency of the economy (Lopez, 2005). The Ricardian model explains that trade could be beneficial when a country specializes in the production of the goods in which it has a comparative labour-productivity advantage; and this product is exported. In the Hecksher and

[4]Mehmood (1989) , Mehmood and Siddiqui (2000) found that slow growth of large scale manufacturing industries due to slow total factor productivity growth of manufacturing industries in Pakistan.

[5] Kemal (2002) and Amjad et al. (2013).

Ohlin (HO) model, a country specialize and exports the good which uses abundant factor intensively and import other good whose resources are scarce.[6] As economy opens, there is a shift in resources towards the sectors that uses more abundant factor, and the value of total productivity increases (Ibid, 2005). Samuelson (1948, 1949) extended the HO model and concluded that factor prices equalized between the trading nations when resources are reallocated from less efficient industries to more efficient industries. MacDougal (1951) empirically analyzed the comparative advantage and HO theories by using the British and American manufacturing industries data and concluded that both countries could produce more output by enhancing trade. Krugman (1979, 1990) also found the value of total productivity increases following a movement from autarky to free trade in some models of economies of scale with monopolistic competition. Nataraj (2011) reported that new trade and endogenous growth models predict a variety of channels through which trade liberalization could increase productivity among domestic firms, including increased managerial efforts, innovations, knowledge spillover, technological advancement, exploitation of economies of scale, specialization in research and development (R&D), increased labour skill and industrial learning, and the forces exit for the least productivity firms (see for example, Helpman and Grossman, 1990, Romer, 1990, Rodrik, 1992, Krueger, 1997, Melitz, 2003 and Aghion et al., 2005). The proponents of trade liberalization argue that opening of domestic markets can lead to more efficient allocation of resources that may result in productivity improvements in local industries, which in turn lead to higher economic growth. On the other hand, the opponents of trade liberalization argue that domestic firms may not be able to absorb efficiency gains because of credit constraints that prevent the adaption of foreign technology as well as investments in new technology (Young, 1991, Pack, 1994 and Topalova and Khandelwal, 2011). These two conflicting views about trade liberalization have important implications for trade policy. If the letter holds, benefits of trade may not have realized unless additional policies are formulated to facilitate technology transfer as well as ease credit constraints (Topalova and Khandelwal, 2011).

[6] Salvatore, D., International Economics, 8th (eds.) John Willey and Sons, Inc, pp. 33-36. Firstly, this concept was explained by the Adam Smith (1817) in his book 'The Wealth of Nation' and then David Ricardo in 'On the Principle of Political Economy and Taxation'. They explained that trade could be beneficial when countries specialized according to the principles of absolute and comparative advantages.

This paper examines the impact of trade liberalization on industrial productivity considering 27 major manufacturing industries in Pakistan.[7] Examining the impact of trade liberalization is useful because it help to identify the mechanisms through which trade policy reforms affects industrial productivity. Pakistan initiated a series of trade reforms since 1990 to encourage exports and imports through reduction in tariffs and nontariff barriers. Over a short period of time, Pakistan drastically reduced tariffs and non-tariff barriers to stimulate trade. Existing empirical evidence whether trade liberalization increases firm efficiency are conflicting. For example, Tybout et al. (1990) find no evidence of increased firm productivity following the trade liberalization, whereas Krishna and Mitra (1993), Harrison (1994), Tybout and Wrestbrook (1995), Pacvcnik (2002), Trefler (2002), Fernandes (2007), Amiti and Konigs (2007) and Topalova and Khandelwal (2011) have found some support in favour of the hypothesis that manufacturing sector's productivity increases following trade liberalization.

In the context of Pakistan numerous empirical studies has been carried out inter alia, by Ali (2000), Din (2003), Yasmin et al. (2006), Majeed et al. (2010), Sheikh and Ahmed (2011), Amjad et al. (2012), Khan and Qayyum (2007), Qayyum and Khan (2008), Khan and Ahmed (2012), among others. These studies found positive relationship between trade liberalization and economic growth. One problem with these studies is that they utilized sum of exports and imports relative to GDP as a measure of trade liberalization. However, both exports and imports are directly impacted by trade openness, that is lowers import duties and effective rates of protection result in a more trade. This creates potential problem of endogeneity and simultaneity which was not addressed by previous studies while examining the impact of trade liberalization on economic growth. Furthermore, no study is available that examined the impact of trade liberalization on firm's productivity. The present study is significantly different from the earlier studies conducted in Pakistan in at least two aspects: First, to examine the impact of trade liberalization on industrial productivity we apply standard approach following Amiti and Konings (2007) and Fernandes (2007). Initially, we estimate parameters of industrial production function using the methodology of Levinsohn and Petrin (2003) in order to construct industrial productivity measures. In the next stage, we examine the relationship between trade policy and manufacturing sector's Total Factor Productivity (TFP). We also focus on pre- and- post

[7] Details of industries are given in appendix A.

liberalization periods to compare the impact of exogenous variations in trade protection. Second, to deal with endogeneity problem from production function we utilized proxy variable approach following Olley and Pakes (1996), Levinsohn and Petrin (2003) and Kilinc (2013). Moreover, Fernandes (2007) and Nijikam and Cockburn (2007) removed the endogeneity problem from production function and analyzed the impact of trade reforms on firm's productivity at plant-level in different countries. More recently, Kilinc (2013) estimated unobserved productivity of entrants firms by introducing inverse demand function in the structural model. Following Levinsohn and Petrin (2003) and Kilinc (2013) we used an inverse demand function to estimate the structural production model. This methodology is more appropriate to control for the endogeneity of inputs due to productivity shocks. After estimating the TFP, an impact of trade reforms is analyzed for pre- and- post-liberalization periods. Besides, the present study uses import duties and effective rates of protection as alternative measures of trade policy rather than outcome indicator such as trade openness. This has the benefit of being a direct measure of trade liberalization and of being exogenous and more relevant than sum of exports and imports relative to GDP.

The rest of the paper is organized as follows: Section 2 reviews the trade liberalization in Pakistan. Section 3 presents literature review. Model specification, data and econometric methodology is presented in section 4. Empirical results are explained in section 5, while conclusions along with recommendations are given in the final section.

2. An Overview of Trade Liberalization in Pakistan

Before the trade liberalization and formation of World Trade Organization (WTO), Pakistan adopted import substitution policies since 1960s to protect the domestic infant industries from foreign competition and for industrialization. Under this policy regime, Pakistan average protection was exorbitant at 271% in 1963-64, which caused the inefficiency, low quality product, unskilled labour and isolation of Pakistan's industry form foreign market, which caused many industries with negative value added (Ahmed, 2014). In order to stimulate industrial productivity and to expand industrial base, Pakistan followed a partial liberalization policy during 1965-1969 through devaluation and dual exchange rate system (Kemal et al., 2002). However, the growth gained in 1960s was taken off by nationalization of industries in the early

1970s. Prior to 1990, high nominal tariff rates, excessive non-tariff barriers, complex import licensing system, exchange controls and progressive import substitution was the main cornerstone of trade policy regime. The actual reforms period was started in the late 1980s when Pakistan begin a series of major policy reform measures including, liberalization of Foreign Direct Investment (FDI), liberalization of exchange rate and payment systems, the removal of the requirement of operating licenses in most industries, relaxation of import licensing requirement for capital and intermediate goods, and reduction of harmonization tariffs across industries.

Due to the liberalization measures, the maximum tariff rate on imports has come down from 225% in to 13.5% in 2012. The average tariff rate was cut down from 66% in 1990 to 14% in 2008. Further, the number of custom duty slabs was reduced from 14 in 1996-97 to 5 (i.e. 5%, 10%, 15%, 20% and 25%) in 2008, while other quantitative restrictions were lifted except for those items related to security, health, public morals, religion and culture. All para-tariffs have been merged in to the statutory tariff regime and import duties on 4000 items were reduced. These measures have brought down effective rate of protection, reduce anti-export bias and promoted competitive business environment in Pakistan (Hussain, 2005 and Qayyum and Khan, 2008). A number of laws were promulgated to bring the trade regime in line with the WTO regulations.[8]

As a part of tariff and non-tariff reforms, Pakistan liberalized its exchange rate and investment regime to integrate domestic economy with the rest of the world. For example, restrictions on the capital transactions were partially relaxed and foreign borrowing and outward investments were allowed in 1994. Full convertibility of the Pakistan Rupees was established on current international transactions in 1994. Unified exchange rate system in 1999, established interbank foreign exchange market in 2000 and switched over form the managed to free floating exchange rate system in July 2000. Moreover, Pakistan launched Strategic Trade Policy Framework (STPF) 2012-2015 in 2013 to enhance Pakistan's export competitiveness in the short as well as in the long run and to increase Pakistan's cumulative exports to US $95 billion during the period 2012-2015. Furthermore, STPF expected to strengthen the trade sector regulations, strengthen governance and institutional capacity and to enhance exports competitiveness. Pakistan reduced maximum tariff rate from 225 in 1987 to 13.5% in 2013.

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[8] Such as anti-dumping, countervailing measures, intellectual property rights, etc.

Like other developing countries, Pakistan opened its economy under the regulation of General Agreement of Trade and Tariffs (GATT) for foreign firms. Under the agreement of WTO, Pakistan was bounded to reduce tariffs on agricultural and manufacturing goods where 81% of agriculture imports tariffs were bounded, while minerals, leather products, travel goods, wood products and transport equipment's were bounded at 20-30% of tariffs, which developed global culture and enhanced the competition through learning by doings. The export-oriented industries were allowed to import machinery without any trade restrictions and duty free. Further, foreign exchange was easily available for industries and commercial importers (Chudhary, 2004). However, in the onset of Global Financial Crisis of 2007-08, trade reforms back tracked and average import duties were increased for some products. For example, import duties on beverages and tobacco increased from average 46.8% in 2008 to 48.9% in 2012, duties on electrical machinery increased from 14.5% in 2008 to 14.7 in 2012 and duties on non-electrical machinery increased from 9.1 to 9.3 during the same period (WTO, 2014). However, duties on some products remain same or little decreased. For instance, import duty on chemicals and transport equipments showing no change. Similarly, import duty on leather and footwear products decreased from 16.5 to 14.9, whereas duty on cotton products also decreased from 8 to 7 and petroleum products from 13.1 to 10.6 during 2008 to 2012 (WTO, 2014).

Reduction in tariffs on manufactured products stimulates the investors to increase production as well as exports. Relaxation of trade impediments and easy excess to foreign markets foster the exports and imports of manufactured goods. Table 1 depicts the tariff structure and terms of trade after the WTO agreement in 1995.

Table 1: Terms of Trade and Indices of Unit Value

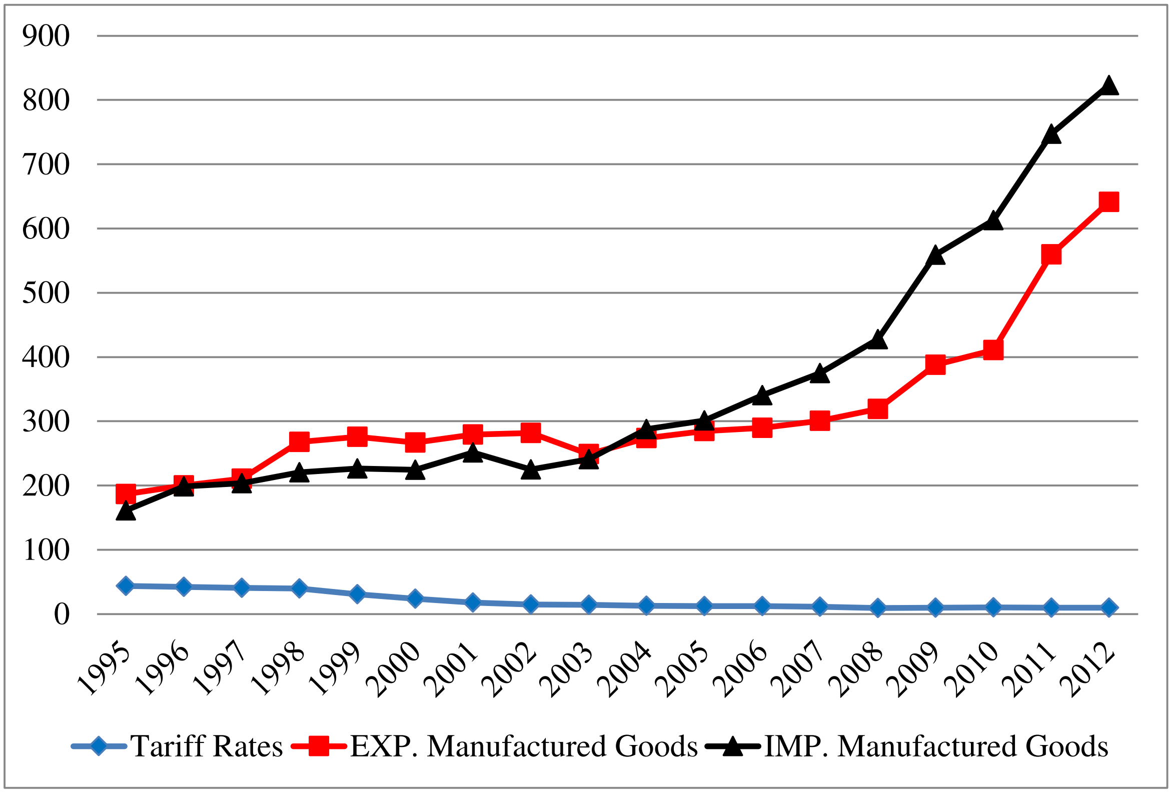
year	Tariff rate, MFN, Trade weighted average.	Exports of Manufactured Goods	Imports of Manufactured Goods	Exports of all Goods	Imports of all Goods
1995	43.47	186.63	161.17	168.61	164.22
1996	42.17	199.88	198.76	185.36	185.48
1997	40.90	210.74	203.43	204.85	201.71
1998	39.73	267.89	220.74	245.62	198.87
1999	30.59	275.59	226.26	258.4	223.32
2000	23.56	266.96	224.61	253.77	259.03
2001	17.89	279.04	251.5	271.47	298.44
2002	14.75	281.83	224.97	271.18	298.56
2003	14.46	248.93	240.82	254.02	309.52
2004	13.02	274.02	287.8	279.65	355.43
2005	12.23	284.72	301	288.84	392.45
2006	12.12	289.58	340.71	299.31	460.38
2007	11.48	300.76	375.06	310.03	495.33
2008	9.15	318.97	427.6	350.4	632.3
2009	9.8	387.9	559.24	450.4	790.82
2010	10.1	411	612.77	478.07	839.60
2011	9.7	559.56	747.32	593.19	1,013.10
2012	10	641.15	823.33	679.44	1,233.49

Source: State Bank of Pakistan, Statistical Bulletins with base year (1990-91=100)

As shown in Table 1, Pakistan reduced tariffs from 43.47 in 1995 to 10 in 2012, which stimulated exports and imports of manufacturing industries as well as overall exports and imports during 1995-2012. The indices of manufactured exports increased from 186.63 in 1995 to 641.15 in 2012, recorded 253.54% growth, while imports of manufacturing goods were increased from 161.17 to 823.33 during the same period, registered 410.85% growth. Similarly, conspicuous increased in overall exports indices from 168.61 in 1995 to 679.44 in 2012, whereas imports indices increased from 164.22 to 1233.49 during the same period.

Figure 1 illustrates that reduction in tariffs enhanced the imports of machinery and technical products that caused to increase the productivity of manufacturing goods and exports as well. It is evident from the Figure 1 that after 1995 tariffs rate followed declining trend, while the imports and exports of manufacturing goods followed increasing trend after 1995 and exports seemed to be larger than imports of manufacturing products. After 2003 there is sharp increase in both exports and imports, however, increase in imports is larger than exports (Figure 1).

Figure 1: Trends in Tariffs, Exports and Imports Indices



2.1 Identification of Reforms Period

Previous studies conceived reform period by ignoring the structural break in the data with reference to trade liberalization and productivity growth nexus. The present study find an evidence of structural break in the data in 1995 using the Chow (1960) structural break test. Based on the structural break test, we divide the data into before and after the break sub-samples[9]. We observed structural break in 1995[10] after the accession of WTO, when tariffs and other trade barriers were reduced and moved towards free trade regime. Figure 2 highlights the behavior of Effective Rates of Protection (ERP) for manufacturing industries. As shown in

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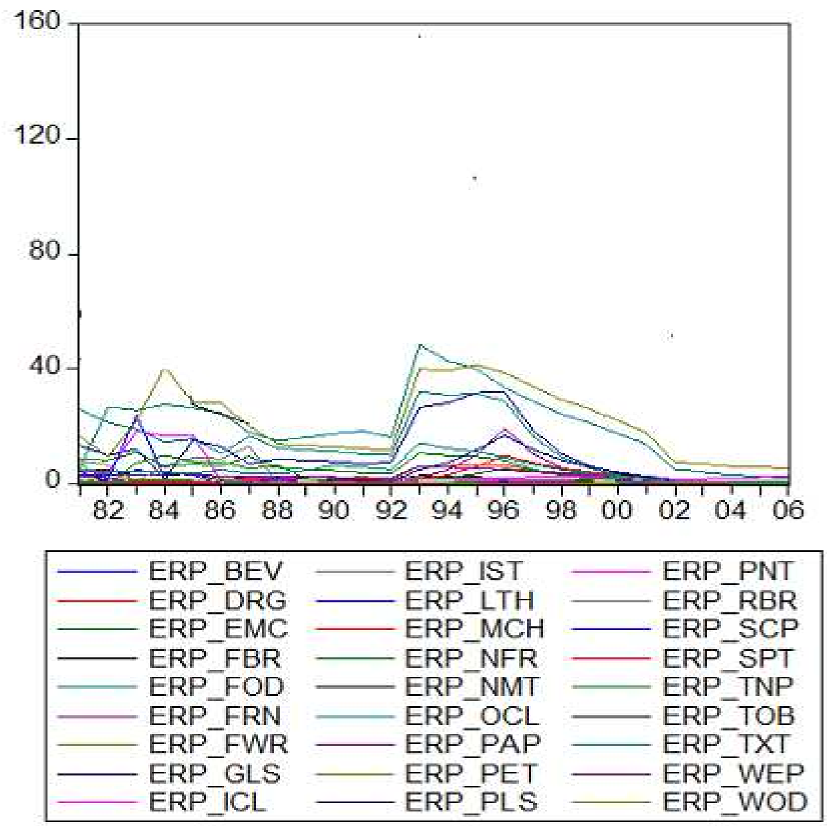
[9] Break shows the impact of WTO reforms in 1995 which reduced tariffs and other barriers that effects industrial productivity (Chaudhary, 2004)

[10] The estimation of the structural break is given in the appendix B

Figure 2, Pakistan liberalizes its trade regime through the reduction in trade protection after joining WTO in 1995.

Figure 2: Effective Rate of Protection Trends in Manufacturing Industries



3. Review of Literature

Most theoretical models of trade predicted that trade liberalization increases firm's productivity (see Samuelson, 1948, 1949, MacDougal, 1951, among others). Trade reforms could result in reallocation of resources from less productive to more productive firms (Melitz and Ottaviano, 2008, Bernard et al., 2003, Melitz, 2003, among others). Trade reforms increases competition which may force domestic firms to improve their efficiency by moving down their average cost curves (Helpmand and Krugman, 1985), trade reforms force firms to concentrate on core competency products (Bernad et al. 2006), reduce management slack and increase X-efficiency gains (Hicks, 1935), raise innovation incentives among local firms to prevent entry from foreign competitors (Aghion et al., 2005). Furthermore, trade models also predict productivity gains resulting from better access to superior inputs and technology that increase technical efficiency

(Gross man and Helpman, 1991, Rivera-Batiz and Romer, 1991 and Topalova and Khandelwal, 2011). Helpman and Grossman (1990) and Rodrik (1992) suggested that trade liberalization enhance productivity under imperfect competition through diffusion of knowledge, upgradation of domestic technology and skill development. It is worth mentioning here that all theoretical trade models do not predict that trade liberalization increases aggregate productivity (Topalova and Khandelwal, 2011). For example, Young (1991) argues that trade liberalization may restrict developing countries into a particular sectors that are not conducive to economic growth. Bolaky and Fredund (2004), Hoekman and Javorick (2004) found that the potential gains from trade liberalization will not be realized unless complementary policies will not in place. Particularly, Bolaky and Fredund (2004) find that trade does not stimulate economic in countries with excessive business and labour regulations and these regulations could prevent reallocation of resources among different sectors of an economy. Similarly, Harrison (1994) and Karishna and Mitra (1998) denounce that resources are not allocated in the areas of comparative advantages. They suggested that trade could be made more beneficial by reducing the monopolies and increasing competition. Trade liberalization lowers workers bargaining, reduces supernormal profits enjoyed by the domestic firms and the price-cost markup (Harrison, 1994 and Krishna and Mitra, 1998). Gosh (2011) showed that productivity growth is not reliably higher after reforms than prior to reforms in the case of India. He finds that at sectoral level, interest rate channel, financial acceleration, labour market variables play an important role in determining productivity growth. However, at macro level, trade policy, FDI and credit availability are found to be important in accounting for productivity growth. Ahsan and Mitra (2014) find that trade liberalization led to increase in labour's share in revenue for small labour-intensive firms, but a reduction in this share is observed in the case large less labour-intensive firms. The study also finds that trade liberalization, in general, led to a decline in bargaining power of workers.

A number of studies form Pakistan also found positive relationship trade liberalization and economic growth. For example, Kemal (2002) found positive long run causality between GDP and exports of Pakistan. Yasmin et al. (2006), demonstrated that trade liberalization enhanced economic growth, availability of consumer goods and employment opportunities. However, few of examined the impact of trade reforms on industrial productivity. Khan and Ahmed (2012) showed that trade liberalization stimulates productivity growth through different channels such as private sector investment, manufactured exports and imports of capital goods. Ali (2012) analyzed the impact of trade reforms on Textile, Leather, and Surgical and Sports industries and concluded that imports are the main driver of exports and by reducing tariff would increase exports because imports of industrial inputs become cheaper. Sheikh and Ahmed (2011) found positive effect of trade liberalization on technical efficiency of agro-based manufacturing industries of Pakistan.

Finally, the literature concludes that trade reforms such as reduction in trade barriers and adoption of outward-oriented policies are conducive to industrial productivity of a country. There is further need to analyze the trade dynamics in manufacturing industries of Pakistan. This study tries to estimate the pre and post-liberalization impact on industrial productivity by subjecting the simultaneity problem from production function. In this paper we study not only the effects of import duty on productivity but also the impact of effective rates of protection.

4. Data Description and Specification of Variable

This study is based on the balanced panel data of 3-digit manufacturing industries of Pakistan over the period 1981-2006.[11] The data are taken from Census of Manufacturing Industries (CMI) of Pakistan published by the Pakistan Bureau of Statistics, Government of Pakistan. Initially CMI survey was conducted on yearly basis and later on it has been conducted on five yearly bases. The missing values are interpolated using the compounding growth rate formula. Following Fernandes (2002) and Kim (2000), Effective Rate of Protection (ERP) is used as a proxy for trade liberalization. The industrial value added is used as dependent variable, whereas energy (costs of fuel, electricity and water), capital (all fixed assets), labour cost in terms of employment cost (including non-cash benefits), raw materials include raw and semi-finished materials which consists of imported as well as those domestically produced and ERP are used as independent variables. ERP is calculated as excise duty divided by industrial value added following the Fernandes (2002) and Nijikam and Cockburn (2007). We have also used import duty as an additional measure of trade liberalization.

[11] Twenty seven industries are included and details are given in appendix A.

To capture the effect of price changes, we deflated all variables by Wholesale Price Index (WPI) considering 2004-05 as base year.[12] The data on WPI are collected form Statistical Bulletins published by the State Bank of Pakistan (various issues).

5. Model Specification and Methodology

The present study utilizes a variant of standard Cobb-Douglas production function for estimation of industrial productivity. Since, in estimating the industrial production function, it is important to account for the correlation between input levels and productivity, as profit maximizing firms respond to increase in productivity by increasing use of factor inputs (Ghosh, 2013). Therefore, Ordinary Least Squares (OLS) method ignores this endogeneity and assumes that inputs are exogenous and not correlated with external shocks (Griliches and Mairesse, 1995). However, in real world input choices are endogenous and correlated with unobserved productivity shocks because each firm has its own material choices and management skills. To deal with endogeneity problem, we follow Levinsohn and Patrin's (2003) methodology and use firm's raw material inputs as control variable to correct for the endogeneity in the firm's production function because it is more likely to be correlated with unobserved shocks (Fernandes, 2007). We adopt a two-stage approach to analyze the effect of trade policy on industrial productivity (Pavcnik, 2002, Javorcik, 2004, Amiti and Konings, 2007 and Topalova and Khandelwal, 2011). In the first-stage, we estimate the industrial production function specified by equation (1) following the Olley and Pakes (1996) methodology. To compute demand shocks, we control for the simultaneity problem as suggested by the Levinsohn and Patrin (2003) and De Loecker (2011). The industrial production function is briefly describe below:

$$Y_{it} = \alpha + \beta_L L_{it} + \beta_K K_{it} + \beta_{EF} EF_{it} + \beta_{RM} RM_{it} + \omega_{it} + \varepsilon_{it} \qquad (1)$$

Where Y_{it} denotes output of industry i at time t, L_{it}, K_{it}, EF_{it} and RM_{it} denotes labour cost, capital, consumption of electricity and fuel, and cost of raw materials respectively. ω_{it} denotes the unobserved industry-specific productivity shocks that may be correlated with the firm's

[12] WPI is more relevant to manufacturing products. Capital is deflated by building and material component, raw material is deflated by raw material component in terms of WPI, energy is deflated by fuel, lighting and lubricants, excise duty is deflated by manufacturing productivity and other variables are deflated by general WPI.

inputs, and ε_{it} is random error term which is assumed to be independently and identically distributed (iid). All variables are transformed into logarithmic form. The estimation of equation (1) takes two steps.[13] In the first step, we estimate raw materials demand function specified by equation (1a):[14]

$$RM_{it} = RM_{it}(\omega_{it}, K_{it}) \quad (1a)$$

Inversion of the raw materials demand function give an expression for productivity shocks (ω_{it}) as a function of firm's raw materials and capital. The productivity shocks function now depending on the observable industrial variables, such as:

$$\omega_{it} = g_t^{-1}(RM_{it}, K_{it}) \quad (1b)$$

Using equation (1a) and (1b), we can transform equation (1) in the following ways:

$$Y_{it} = \alpha + \beta_L L_{it} + \beta_{EF} EF_{it} + \varphi_{it}(RM_{it}, K_{it}) + \varepsilon_{it} \quad (2)$$

Where

$$\varphi_{it}(RM_{it}, K_{it}) = \beta_0 + \beta_{RM} RM_{it} + \beta_K K_{it} + g_t^{-1}(RM_{it}, K_{it}) \quad (2a)$$

Olley and Pakes (1996) suggested that equation (2a) can be estimated by the OLS, whereas Nijikam and Cockburn (2007) applied forth order polynomial expansion to estimate first stage parameters. However, we used Feasible Generalized Least Squares (FGLS) as an alternative approach which is useful in the presence of autocorrelation and hetroscedasticity. To this end, we first generated the conditional expectations function of the form: $E(Y_{it} \mid RM_{it}, K_{it}), E(L_{it} \mid RM_{it}, K_{it})$ and $E(EF_{it} \mid RM_{it}, K_{it})$ to compute first stage estimates of labour and energy (i.e. $\hat{\beta}_L, \hat{\beta}_{EF}$). Since $E(\varepsilon_{it} \mid RM_{it}, K_{it}) = 0$, the difference between equation (2) and its expectation conditional on raw materials and capital is given by:

$$Y_{it} - E(Y_{it} \mid RM_{it}, K_{it}) = \beta_L (L_{it} - E(L_{it} \mid RM_{it}, K_{it}) - \beta_{EF}(EF_{it} - E(EF_{it} \mid RM_{it}, K_{it}) + \varepsilon_{it} \quad (3)$$

[13]Fernandes (2007, p. 56)

[14] Levinsohn and Petrin (2003) argued that if demand function for intermediate input is monotonic in the firm's productivity at all levels of capital, then raw material can serve as valid proxy for the demand shock (Topalova and Khandelwal, 2011, Fernandes 2002, p. 8 and Nijikam and Cockburn, 2007).

Equation (3) is estimated by the OLS method, and once the conditional expectations are estimated by the OLS regressions of output, labour and energy on raw materials and capital ((RM_{it}, K_{it})), we then obtain consistent parameter estimates for labour and energy. The raw materials demand function $RM_{it} = RM_{it}(\omega_{it}, K_{it})$ does not explicitly depend on industrial input and output prices, we partly address this issue by allowing that demand function (along with the productivity function resulting from its inversion ($g_t^{-1}(RM_{it}, K_{it})$) (see for example, Fernandes, 2002). To get the consistent estimates of function $\varphi_{it}(.)$, we employ FGLS method to regress $V_{it} = (Y_{it} - \hat{\beta}_L L_{it} - \hat{\beta}_{EF} EF_{it})$ on (RM_{it}, K_{it}).

In the second stage, we use two moment conditions consistent with over-identification conditions to derive consistent estimates of (β_K, β_{RM}). It is assumed that productivity shocks (ω_{it}) follow the first order Markov process, i.e. $\omega_{it} = E(\omega_{it} \mid \omega_{it-1}) + \xi_{it}$, where ξ_{it} is unexpected productivity which is assumed to be independently and identically distributed (iid). Following Olley and Pakes (1996), we generate two moment conditions depicted by equation (4) and (5) are estimated by employing the Two Stage Least Squares (TSLS) method. The first moment condition stated that capital at time t is uncorrelated with the unexpected productivity shocks at time t. The second moment condition indicated that raw material at time $t-1$ is uncorrelated with unexpected productivity shocks at time t. That is:

$$E[Y_{it} - \beta_L L_{it} - \beta_{EF} EF_{it} - \beta_{RM} RM_{it} - \beta_K K_{it} - E(\omega_{it} \mid \omega_{it-1}) \mid K_{it-1})] = E(\varepsilon_{it} + \xi_{it} \mid K_{it-1}) = 0 \quad (4)$$

$$E[Y_{it} - \beta_L L_{it} - \beta_{EF} EF_{it} - \beta_{RM} RM_{it} - \beta_K K_{it} - E(\omega_{it} \mid \omega_{it-1}) \mid RM_{it-1})] = E(\varepsilon_{it} + \xi_{it} \mid RM_{it-1}) = 0 \quad (5)$$

Where the residuals in the moment conditions $\varepsilon_{it} + \xi_{it}$ are estimated as:

$$\varepsilon_{it} + \xi_{it}(\beta_K^*, \beta_{RM}^*) = Y_{it} - \hat{\beta}_L L_{it} - \hat{\beta}_{EF} EF_{it} - \beta_{RM}^* RM_{it} - \beta_K^* K_{it} - E(\omega_{it} \mid \omega_{it-1}) \quad (6)$$

Where $(\beta_K^*, \beta_{RM}^*)$, the initial values are might be the OLS values obtained from the estimation of Cobb-Douglas production function. We begin by noting that,

$$E(\omega_{it} \mid \omega_{it-1}) = E(\omega_{it} + \varepsilon_{it} \mid \omega_{it-1})$$

The conditional expectations $E(\omega_{it} | \omega_{it-1})$ will be estimated by the following regression model:

$$\hat{\omega}_{it} + \varepsilon_{it} = \hat{\varphi}_{it0} + \hat{\varphi}_{it-1} \tag{7}$$

Where;

$$\hat{\omega}_{it} + \varepsilon_{it} = Y_{it} - \hat{\beta}_L L_{it} - \hat{\beta}_{EF} EF_{it} - \beta^*_{RM} RM_{it} - \beta^*_K K_{it} \tag{7a}$$

$$\hat{\omega}_{it-1} = \hat{\varphi}_{it}(RM_{it-1}, K_{it-1}) - \beta^*_{RM} RM_{it-1} - \beta^*_K K_{it-1} \tag{7b}$$

Finally, we obtain the $(\hat{\beta}_K, \hat{\beta}_{RM})$ by applying the TSLS method, where the TSLS function weights moment conditions by their variance-covariance matrix. We included over-identifying conditions as mentioned by the Levinsohn and Petrin (2003), population moment conditions given by the vector of expectations $E[(\xi_{it} + \varepsilon_{it})Z_{it}]$.Where Z_{it} is the vector of instruments namely $\{K_{it-1}, RM_{it-1}, L_{it-1}, EF_{it-1}, RM_{it-2}\}$, finally we estimate the $(\hat{\beta}_K, \hat{\beta}_{RM})$ by estimating the following TSLS function.

$$Q(\beta^*) = \{\sum(\xi_{it} + \varepsilon_{it})Z_{it}\} = 0 \tag{8}$$

Since the main focus of this study is to investigate the impact of trade liberalization on the industrial productivity using effective rates of protection (ERP) and excise duty as measures of trade policy.[15] The Total Factor Productivity (pr_{it}) based on equation (1) can be expressed as:

$$\hat{\omega}_{it} + \varepsilon_{it} = Y_{it} - \hat{\beta}_L L_{it} - \hat{\beta}_{EF} EF_{it} - \hat{\beta}_{RM} RM_{it} - \hat{\beta}_K K_{it} = pr_{it} \tag{9}$$

Where pr_{it} is the Total Factors Productivity (TFP_{it}) computed from combining the estimated function $\varphi_{it}(.)$.

$$\hat{\omega}_{it} = \hat{\varphi}_{it}(RM_{it}, K_{it}) - \hat{\beta}_{RM} RM_{it} - \hat{\beta}_K K_{it} \tag{9a}$$

$$TFP_{it} = \beta_0 + \lambda_t + \beta_1 ED_{it} + \beta_2 ERP_{it} + \alpha_i + u_{it} \tag{10}$$

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[15] Edward (1998) criticized the use of trade volume as proxy of trade liberalization. He argued that trade volume is not related to the actual trade orientations of a country. He argued that tariff levels and quota reflect the degree of government interventions and trade policy and its opening raises the productivity.

Where TFP_{it} is computed after controlling the endogeneity and simultaneity problem, excise duty on imports (ED_{it}) and effective rates of protection (ERP_{it}). Having obtained the TFP_{it}, first we examine the impact of industry-level inputs on industrial productivity. Subsequently, we examine the impact of trade policy reforms on total factor productivity. Particularly, we mainly focus on the impact of trade liberalization on total factor productivity in the pre-and-post liberalization periods.

6. Empirical Results and Discussion

Based on the Chow's (1960) structural break test, we divided data sample into two sub-samples, that is from 1981-1995 (pre-trade liberalization) and 1996-2006 (post-trade liberalization). We have estimated output elasticities with respect inputs for the pre-and- post-liberalization period separately.

6.1 Pre-Liberalization Output Elasticities

Table 2 presents the production function coefficients estimated using the OLS, Fixed Effects (FE) and Random Effects (RE) method for the pre-liberalization period. To account for cross sectional heterogeneity, we have estimated FE and RE models using cross section weights. The results reveal that the coefficients on energy, labour and raw materials exert positive and statistically significant effect on industrial output. The results are same in almost all the specifications. The Hausman statistic is insignificant, suggesting that RE model is more appropriate than FE model.

Table 2: Estimates of Input Elasticities (Pre-Liberalization, 1981-1995)

Dependent Variable: Y_{it}			
Variables	OLS (1)	FE (2)	RE (3)
Constant	1.27* (21.67)	1.78* (16.72)	1.51* (6.55)
EF_{it}	0.13* (10.78)	0.14* (8.61)	0.12* (4.03)
L_{it}	0.17* (9.73)	0.17* (8.14)	0.17* (3.33)
K_{it}	-0.03 (-1.44)	0.01 (0.84)	0.03 (0.96)
RM_{it}	0.73* (61.00)	0.64* (30.98)	0.67* (14.67)

R^2	0.99	0.99	0.86
$\bar{R}^2$	0.99	0.99	0.86
$DW-stat$	0.75	1.49	2.00
$F-stat$	8936.71	4989.97	621.99
CRS	0.79 [0.373]	13.36 [0.000]*	1.34 [0.248]
Hausman Test: $\chi^2(4) =$ 1.91 [0.752]			

Note: * indicate significant at the 1% level of significance. Values in the parenthesis are the t-statistics. OLS, FE and RE indicate Ordinary Least Squares, Fixed Effects Model and Random Effects Model respectively. CRS= Constant Returns to Scale. The RE model is estimated by employing the Swamy and Arora estimator of component variance. [.] indicate p-values.

Results shown in column (1)-(3) are almost similar in terms of their size and signs. However, the Hausman test supports the results shown in column (3). Under OLS, the coefficients of energy and labor are positive and significant, and equal 0.13 and 0.17 respectively, the same under RE (FE) model are 0.12 (0.14) and 0.17 (0.17), confirming the theoretical predictions that increase in labour and energy inputs causes industrial productivity to increase in the pre-liberalization period. The coefficient of capital is negative and equals -0.03 based on the OLS method. However, it turns to be positive and equals 0.04 (0.01) under RE (FE) models and it remain statistically insignificant. One reason of this insignificant finding could be the inefficient allocation of capital resources in the large scale manufacturing industries in Pakistan during the pre-liberalization period. Burki and Khan (2004) also find similar results. The other reason could be the problem of autocorrelation as indicated by the value of Durbin-Watson (DW) statistic in columns (1)-(2). The coefficient of raw materials under OLS method equals 0.73, and the same is equal to 0.64 under the FE method. However, this coefficient equals 0.67 under RE model. The bias in the coefficients of capital and raw materials could be due to correlation among the inputs and the productivity shocks (Ghosh, 2013). The results suggest that a 1% increase in energy, labour and raw materials would lead to increase industrial productivity by 0.12%, 0.17% and 0.67% respectively in the pre-liberalization period under the RE model. Finally, the estimated elasticities verify the constant return to scale property of Cobb-Dauglas production function. This implies that all decision making units are operating at optimal scale (Mahmood, 2012).

6.2 *Post-Liberalization Input Elasticities*

The output elasticities with respect to inputs for the post-liberalization period (1996-2006) are reported in Table 3. As shown in column (1)-(3), the coefficients with respect to labour, capital and raw materials are positive and statistically significant, whereas the coefficient of energy is negatively signed and statistically significant using either of estimation method. The output elasticities under RE model are relatively higher than the OLS and FE models. The Hausman test also confirms the appropriateness of RE model. The results suggest that a 1% increase in labour, capital and raw materials lead to increase industrial output by 0.25% (0.50%), 0.26 (0.12%) and 0.53% (0.55%) respectively when OLS (FE) method is employed. However, we find that a 1% reduction of energy supply would reduce industrial productivity by 0.06% (0.07%) under OLS (FE) method.

Table 3: Estimates of Input Elasticities (Post-Liberalization, 1996-2006)

Dependent Variable: Y_{it}			
Variables	OLS (1)	FE (2)	RE (3)
Constant	1.50^{*} (64.66)	0.54^{*} (2.53)	0.67^{*} (2.95)
EF_{it}	-0.06^{*} (-10.51)	-0.07^{*} (-2.48)	-0.14^{*} (-3.33)
L_{it}	0.25^{*} (13.31)	0.50^{*} (22.20)	0.46^{*} (8.21)
K_{it}	0.26^{*} (13.34)	0.12^{*} (4.22)	0.21^{*} (5.61)
RM_{it}	0.53^{*} (48.97)	0.55^{*} (14.18)	0.55^{*} (10.54)
R^2	0.99	0.99	0.88
$\overline{R}^2$	0.99	0.99	0.88
$DW-stat$	0.26	0.69	0.35
$F-stat$	8739.96	2562.43	554.47
CRS	0.79 [0.373]	13.36 [0.000]*	4.58 [0.033]**
Hausman Test: $\chi^2(4) =$ 0.00 [1.000]			

Note: see notes below Table 2. ** indicate significant at the 5% level of significant.

Similarly, the results show that a 1% increase in labour, capital and raw materials would increases industrial output by 0.46%, 0.21% and 0.55% under RE model in the post liberalization period. The output elasticity with respect to energy input is negative and significant, which implies that a 1% reduction in energy supply would reduces industrial output by 0.14% in the post-liberalization period using the RE method. The negative impact of energy on industrial productivity could be due to load-shedding and high prices of electricity. Mahmud (2000) has noted that energy crisis is perpetual and major constraint for the manufacturing industries in

Pakistan. Similarly, Siddiqui (2004), Mahmood (2012) and Shakeel et al. (2013) also reported that energy outages adversely affected exports and trade benefits.

One the whole, we may deduce that output elasticities with respect to labour, capital and raw materials are generally positive during the pre and post liberalization periods, however, the size of elasticities are relatively larger in the post-liberalization than pre-liberalization period. It is worth mentioning here that during the post-liberalization period, we observed that industries are adopting advanced technology because the size of the coefficient of capital increased from 0.03 to 0.21 from the pre-liberalization to post-liberalization period. This is in line with Liberman and Johnson (1999) who finds that investment in new equipments led higher productivity. The other important finding is the output elasticity of energy which turns from positive in the pre-liberalization to negative in the post-liberalization periods. This implies that outages of energy supply have adversely impacted manufacturing industries in Pakistan during the post-liberalization. In addition, in both pre-and-post-liberalization regimes raw materials appeared as major determinant of industrial productivity as compared to labour and capital in Pakistan. This implies that availability of high quality raw material in the domestic market produces significant positive impact on manufacturing productivity. This finding is consistent with the earlier finding of Mazumder et al. (2009) and Mahmood (2012).

6.3 Estimation of Total Factors Productivity

TFP for the industrial sector is estimated in two-stages following the Levinsohn and Petrin (2003). In the first stage, coefficient of labour and energy is estimated separately for pre- and post liberalization periods. Using the coefficients of labour and energy, we compute demand shocks from the function, $\varphi_{it}(.)$ as:

$$\varphi_{it} = Y_{it} - 0.18L_{it} - 0.12EF_{it} \tag{11}$$

Where Y_{it} is regressed on capital and raw materials to estimate the demand shock $\varphi_{it}(RM_{it}, K_{it})$ (equation (2a)) using the FGLS method. After estimating the demand shock, the estimates of capital and raw materials are obtained by employing the TSLS method to control for the endogeneity problem. By conditioning the simultaneity problem, we computed firm's TFP using the following equation.

$$TFP_{it} = Y_{it} - 0.18L_{it} - 0.12EF_{it} + 0.28K_{it} - 0.53RM_{it} \quad (12)$$

For the post-liberalization period (1996-2006), φ_{it} is computed by using the coefficients of energy and labour, that is:

$$\varphi_{it} = Y_{it} - 0.22L_{it} + 0.13EF_{it} \quad (14)$$

Now φ_{it} is regressed on capital and labour to estimate the demand shock $\varphi_{it}(RM_{it}, K_{it})$. The firm's TFP for the post-liberalization period is computed using the coefficients of capital and raw materials, obtained from the TSLS method. That is:

$$TFP_{it} = Y_{it} - 0.22L_{it} + 0.13EF_{it} + 1.028K_{it} - 1.73RM_{it} \quad (15)$$

After the computation of TFP, the impact of trade liberalization is analyzed for pre-and post-liberalization periods.

6.4 Impact of Trade Liberalization on TFP

The impact of trade liberalization on firm's TFP is reported in Table 4 (panel A and B). As shown in Table 4 (Panel A and B), the impact of effective rate of protection (ERP) on TFP in the pre-and post-liberalization periods using either OLS, FE or RE models. However, the Hausman test confirms the appropriateness of RE model which provides more consistent estimators than OLS and FE models.

Table 4: Trade Liberalization on Total Factor Productivity

Dependent Variable TFP_{it}			
Panel A: Pre-Liberalization Period			
Variables	OLS (1)	FE (2)	RE (3)
Constant	5.88* (150.94)	5.98* (235.90)	5.97* (18.96)
ERP_{it}	-0.006* (-4.50)	-0.01* (-5.30)	-0.008* (-2.64)
ED_{it}	9.34E-06* (7.30)	5.16E-06* (5.63)	4.42E-06* (4.46)
RIO_{it}	-0.47** (-2.09)	-0.23 (-1.64)	-0.36** (-1.92)
R^2	0.24	0.94	0.07
$\overline{R}^2$	0.24	0.94	0.07
$DW-stat$	0.36	0.82	1.19
$F-stat$	42.96	204.66	9.64
Hausman Test: $\chi^2(3) =$ 0.00 [1.000]			
Panel B: Post-Liberalization Period			
Constant	2.51* (51.35)	2.80* (56.29)	2.76* (6.18)
ERP_{it}	-0.0006 (-0.15)	-0.02* (-8.10)	-0.02* (-7.00)
ED_{it}	7.29E-06* (3.74)	3.99E-06* (3.37)	6.08E-06* (4.81)
RIO_{it}	1.59* (2.64)	1.14* (4.95)	1.13* (3.91)
R^2	0.13	0.96	0.12
$\overline{R}^2$	0.13	0.96	0.11
$DW-stat$	0.15	0.69	0.31
$F-stat$	15.14	245.30	13.26
Hausman Test: $\chi^2(3) =$ 0.00 [1.000]			

Note: See notes below Table 2.

The results reveal that reduction in ERP would increases TFP in the post-liberalization period. The magnitude of the coefficient of ERP is -0.02 suggests that a 1% reduction in ERP is associated with a 0.02 increase in TFP in the post-liberalization period. In other words, higher trade protection lowers TFP: a 1% increase in ERP would lower TFP by 0.02%. This result is consistent with the finding of Topalova and Khandelwal (2011), which indicates a beneficial impact of trade liberalization on industrial productivity in the case of India. In contrast, a 1% reduction in ERP leads to a 0.008% increase in TFP in the pre-liberalization. Moreover, excise duty has positively impacted TFP in both the pre-and post-liberalization periods, though the effect is very small and negligible. Yu (2009) find similar finding for Japan. The ratio of investment to output (RIO) bears a negative sign, suggesting that increase in RIO exerts negative impact on TFP in the pre-liberalization period. The coefficient on RIO indicates that a rise in RIO by 1% lowers TFP by 0.36%. One reason could be the lack of new investment in the manufacturing sector and inefficient use of existing capital resources produces negative impact on industrial productivity. The other reason could be the high cost of investment which produces adverse affect on TFP. This finding is consistent with the earlier findings of Ghosh (2013) in the case of India. However, in the post-liberalization period, RIO exerts positive impact on TFP. We find that a 1% increase in RIO would increases TFP by 1.13% in the post-liberalization period. One important implication of this finding is that trade liberalization reinforced with efficient use of capital resources that can lead to removal of inefficiencies in manufacturing industries in Pakistan. Sheikh and Ahmed (2011) find similar results for the agro-based industries in Pakistan.

In overall term, ERP exerts relatively large impact on TFP in the post-liberalization period than pre-liberalization period. This implies that reduction in ERP significantly enhances TFP in the post-liberalization period in Pakistan. This further implies that reduction ERP is pre-requisite to enhance TFP. The reduction in excise duty produces positive but minimal impact on TFP in the pre-liberalization as well as post-liberalization periods in Pakistan. Finally, we observed large positive impact of investment on TFP in the post-liberalization period which implies that trade liberalization enhance resource utilization more efficiently than protected trade regime.

7. Conclusion and Policy Implication

Manufacturing industries in Pakistan has been facing tariffs, non-tariff barriers and other trade restriction for a long period of time. Lack of technological advancement and low quality products adversely influences industrial competitiveness in the international market. This study examines the impact of trade liberalization on industrial productivity for a panel of twenty seven 3-digit manufacturing industries in Pakistan over the period 1981-2006. The sample is divided into two sub-periods, namely pre-liberalization regime (1981-1995) and post liberalization regime (1996-2006). A variant of Cobb-Douglas production function is used to estimate the output elasticities with respect to inputs by employing the OLS, FE and GLS-based RE models. The results show that output elasticities have positive and significant on industrial productivity in the pre- and post-liberalization periods except for the elasticity with respect to energy. The output elasticity with respect to energy seemed to be negative in the post liberalization period.

In the second stage, TFP is estimated for all industries and analyzed the impact of trade liberalization separately for the pre-and post-liberalization regimes. For the pre-liberalization regime, our results indicate that reduction in ERP exerts positive effect on TFP, however, the magnitude is very low (-0.008). On the other hand, the findings imply that reduction in ERP significantly enhances TFP with reasonable magnitude (i.e. -0.02) in the post-liberalization period. These results, in general, imply that protection of industrial sector through trade barriers and other impediments are the major hurdles on the industrial development and economic growth in Pakistan. The import tariffs proxied by excise duty have positive effect on TFP; however, the size of the coefficient of ED_{it} is almost zero in the pre- and post-liberalization regimes. Investment relative to industrial productivity exerts negative impact on TFP in the pre-liberalization; however, it has positive impact in the post-liberalization period. On the whole, the results appear to indicate that trade liberalization have played a significant role in explaining TFP. The evidence suggest that trade liberalization policy enhances industrial productivity significantly in post-reform than pre-reform era.

On the basis of above discussions we can deduce some policy implications. *Firstly,* reduction in ERP significantly increases TFP. Therefore, further reduction in rates of protection, tariffs and non-tariff barriers could enhances industrial productivity, improves quality of products and increases exports potential. *Secondly*, results in the post liberalization period reveal that energy input adversely affected industrial productivity; therefore, measures are needed to address the issues related to load-shedding and shortage of energy supply to the industrial sector on priority basis. *Third*, availability of raw materials is the most significant variable in the pre-liberalization and post-liberalization period. Therefore, there is need to provide cheap and quality raw material to the industrial sector. To this end, there is need to develop of trade related infrastructure, reduce import restriction on raw material and improve the quality of raw material through research and development. *Finally*, the results show that effect of capital in industrial output seems negative in the pre-liberalization period, which turns to be positive and significant in the post-liberalization period. Therefore, import of capital goods should be encouraged which is the main source of technological advances.

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Appendix A

List of 3-Digit Manufacturing Industries

1.Beverage 2. Drug & pharmaceutical products 3. Electrical Machinery Apparatus & Appliance 4. Fabricated Metal Products 5. Food 6. Furniture and Fixture 8. Footwear 9. Glass and Glass Proudcts 10. Industrial chemical 11. Iron & Steal 12. Leather & Leather Products 13. Machinary 14. Non-Ferous Metal	15. Non-Metalic Minerals 16. Other Chemical Products 17. Paper Products 18. Petrolum and Refining 19. Plastic products 20. Printing & Publishing 21. Rubber products 22. Scientific Measuring & Optical Goods 23. Sports 23. Transports Equipment 24. Tobacoo 25. Textile 26. Wearing Apparel 27. Wood and Wood Products

Appendix B

The model for total time period is given by equation (1)

$$y_{it} = a + bLit + cK_{it} + dE_{it} + eM_{it} + fERP_{it} + gED_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

No we estimate model expressed in equation (1) for sub-periods which is represented by equations (i) and (ii).

$$y_{it} = a_1 + b_1 Lit + c_1 K_{it} + d_1 E_{it} + e_1 M_{it} + f_1 ERP_{it} + g_1 ED_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(i)$$

$$y_{it} = a_2 + b_2 Lit + c_2 K_{it} + d_2 E_{it} + e_2 M_{it} + f_2 ERP_{it} + g_2 ED_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(ii)$$

Equation (1) is specified for the period 1981 to 2006, whereas equations (i) and (ii) and specified for two sub periods 1981 to 1995 and 1996 to 2006.[16]

5.1.1 To Test the Hypothesis

$$H_0 = a_1 = a_2, b_1 = b_2$$
$$H_a = a_1 \neq a_1, b_1 \neq b_2$$

Testing the hypothesis for structural breaks we apply Chow test and the F-Statistics is given by:

$$F = \frac{RSS_C - (RSS_1 + RSS_2)/k}{RSS_1 + RSS_2 / n - 2k}$$

RSS = is the residual sum of squares for combined data set.

RSS_1 = is the residual sum of squares for before the break period data set.

RSS_2 = is the residual sum of squares of after the break data set.

$$F = \frac{38.49 - (17.48 + 15.51)/7}{17.48 + 15.51/26 - 2(7)}$$

$$F = \frac{38.49 - (32.99)/7}{32.99/12}$$

[16] These equations are estimated by OLS and the results are shown in Appendix B at the end.

$$F = \frac{38.49 - 4.71}{2.75} = \frac{33.78}{2.75} = 12.28$$

$$d.f = \frac{K}{n - 2k} = \frac{7}{12}$$

Critical value at 5 % level of significance is 2.91.

Critical value at 1% level of significance is 4.64.

The calculated value of F-statistics is greater than critical value so we reject the null hypothesis and conclude that there exists the structural break in the industrial output