Labor-Capital Substitution in the Manufacturing Industries in Punjab: A Pathway to Inclusive Growth.

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Abstract

For inclusive growth, it is very important to determine a reasonable proportion of income distribution between labor and capital. It is also important that capital and labor are combined in such a way that the pace of growth is not lessened. Inclusive growth becomes more convenient if capital and labor can be substituted. The substitution between labor and capital can be found by elasticity of substitution from the production function. There is a wide choice of algebraic forms which can be used to represent production functions. This study uses constant elasticity of substitution (CES) production function to find the possibility of substitution between labor and capital by using Census of Manufacturing Industries (CMI) data of 3155 manufacturing industries of Punjab. Analysis has been done firstly for overall industries and then for small, medium and large scale industries. The results reveal that there is high substitution between capital and labor. It implies that there exists flexibility to adjust labor and capital in production process for better distribution of income. Furthermore results reveal that: elasticity of substitution, returns to scale and labor share is highest in small scale industries, so small scale industry may be more helpful in inclusive growth as compared to medium and large scale industries.

Keywords: Inclusive growth, Manufacturing Industries, Labor capital substitution, CES Production function

Introduction

In recent literature on economic development, the concept of inclusive growth has become very important and has gain keen interest among researchers. Factors like; reduction in inequality, unemployment and poverty are perceived as a prerequisite of this idea. If the poor people benefit in absolute terms, growth is said to be pro-poor. While, by deteriorating inequality, growth is pro-poor in the relative terms. The process of inclusive growth not only generates new economic opportunities, but also guarantees access to equitable economic opportunities. It also infers participation and shares benefit. The idea of inclusive growth is very broad as it spreads beyond people below the poverty line as compared to pro-poor growth, which only emphases on the most deprived or poor in an economy. Inclusive growth is perhaps more wide-ranging; as it desires growth to benefit all loops of society including the poor, the poor middle-income class and even the rich.

During past few decades, Pakistan has realized a decent rate of economic growth (except some few years), where the average growth rate of the economy at constant factor prices was 6.5 percent and 4.6 percent during the period of 80's and 90's respectively in last century. The highest growth rate of Pakistan was recorded as 9 percent during the year 2004-05. But, high unemployment rate is still prevailing and economy has failed to reduce poverty and inequality, which shows that growth has still not been inclusive. Pakistan's policy makers have a keen dream to generate employment opportunities in different sectors of the economy. Currently, the issue of protecting the opportunities of productive employment to an increasing labor force has seemed as a basic problem of the economy. Out of the 61 million total labor force, 57.42 million was employed in 2014-15, while remaining were unemployed (Labor Force Survey, 2015).

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Manufacturing sector is considered the backbone of Pakistan's economy. It founds the 2nd largest sector of economy with 13.5 percent contribution in Gross Domestic Product (GDP) and 15.3 percent to the total labor force (Economic survey, 2016-17). This sector is broadly observed as the transformational sector, for labor of agriculture sector moving from less trained to more value-added employments. This is due to fact that economic development has followed a pattern of pulling persons from agriculture sector to service and manufacture sector. This importance of the manufacturing has also been evidenced by the development of several developed countries and recently in several South East Asian states. It makes the manufacturing sector exceedingly more important for Pakistan in general and Punjab in particular, where agriculture sector set up a minimal share of GDP, but inexplicably large proportion in employment.

The economy of Pakistan can achieve the goals of equitable distribution and poverty alleviation by developing the labor-intensive industries, where laboris unskilled or semi-skilled (World Bank, 1990). An inexpensive labor may be confirmed by the growth in firms with labor-intensive, as this procedure is also very vital for poverty alleviation (Sen, 1960; Myrdal, 1968). Growth would be inclusive, when poor get benefit in the growing manufacturing sector, where labor is used intensively. In contrast, in a capital-intensive industry, most of the share will go to capital and labor gets very few. Under such environment, growth of the economy will not be inclusive.

Punjab is the most populous province of the country with more than fifty percent population of the country and constitutes more than fifty percent labor force of the country. In Punjab, the second largest proportion of population is employed in manufacturing sector. Hence, there are more opportunities to make the growth of this sector more inclusive by employing more labor in this sector, and this can be done only if there is substitution between labor and capital. Keeping in view this fact, present study is an effort to estimate the substitutability between labor and capital in the manufacturing sector and as complementary calculations this study also finds the relative share of labor & capital and returns to scale. The rest of the study is organized as: after introduction in section I, section II is related to literature review, section III discusses about data collection and model specification, in section IV results and interpretation is given, lastly section V concluded the study.

Literature Review

Few efforts have been made to calculate the substitutability between labor and capital in Pakistan. For example, Hussain (1974) found 0.76 EOS in the manufacturing industries of Pakistan for the period1960 to 1970. Kazi,et al. (1976)also calculated the production relationship with constant elasticity of substitution (CES) production function in manufacturing industries by using time series and cross-section data. The study explained several limitations related to the data of time series such as misspecification of lag adjustment, multi-collinearity and cyclical conditions. While Kemal (1981) used variable elasticity of substitution (VES) production function and CES function to calculate the EOS between labor and capital in 16 various industries for the period 1959-60 to 1969-70 and the EOS is found very low in many of the industries of Pakistan. Whereas, Malik, et al., (1989) found the EOS greater than one in the textile industry of Pakistan during six different period.

The substitution elasticity of the CES function of German industries is assessed by Kemfert (1998). She determined that a CES function with energy and capital is the most suitable for the whole German industry, while labor and capital might be closer to the reality for numerous industries. In order to avoid the problems of Kmenta approximation method (Kmenta, 1967), a cost function method used by Van der Werf (2008) and Okagawa(2008) , where the benefit of the cost function related with a production function and arise a linear equation from the consistent optimum demand of input. The drawback of this method is that it involves extensive price data, which is difficult to get in several cases, particularly for specific estimates sector. Van der Werf (2008) evaluates a nested production function of two-level, by using the data of the industries of 12 OECD countries for the period1978-1996. The result revealed that the nesting construction taking labor and capital in the similar knob fits certainty most closely. Similarly, by using another dataset of OECD countries, Okagawaand Ban (2008) evaluated a nested CES function. However, their data is more reliable as compared to the data of Van der Werf (2008) study. Both of these study based on cost function approach. The EOS of German industry is re-estimated by Henningsen and Henningsen (2011). They used a non-linear least squares estimation approach.

Koeslerand Schymura (2012) evaluated the elasticity of substitution of three nested CES production for 35 segments pooled across all 40 countries for the period1995- 2006 by using non-linear least squares approximation technique of Henningsen and Henningsen (2011). They concluded that non-linear approximation methods perform considerably better than Kmenta approximated linear estimation. The EOS of the CES production function of Chinese industries estimated by Su et al., (2012).While, Hsing (1996) studied the five different kinds of production functions, Cobb-Douglas, Translog, CES of Arrows et al (1961), new CES of Bairam (1989) function, and Generalized Leontief Production function, to examine which production function is best for the data of US manufacturing industry. Furthermore, the study explores the scale of economies at the state and national level. At national level, the estimation of Leontief production function estimate is inconclusive. Whereas, the CES has accurate signs but the sign of EOS is negative. In the new CES, at the mean, the output elasticity of labor and capital are 0.78 & 0.23. The elasticity of substitution is 1.56. The main conclusion of the study is that the new CES production function is the most appropriate function that fits the data under study. Klump et al., (2000) theoretically examines the consistency of using different CES production functions in growth models. The study finds that a higher level of EOS leads to a higher permanent and steady state growth in the economy. It also highlighted that the impact of higher EOS on the convergence speed based on the comparative scarcity of the inputs. Khan et al., (2015)[a]estimated the EOS between labor and capital using CES production function in banking sectorof Pakistan by Kmenta approximation (Kmenta, 1967). The study revealed that the EOS between labor and capital is greater than one, there are increasing returns to scale, and the distributional share of labor is more than capital. Recently various studies have been done to find out the substitution between labor and capital and t has been found that elasticity of substitution is less than one and it is supported by empirical evidence at the sectoral (Young, 2013; Herrendorf et al., 2015; Chirinko and Mallick, 2017) and at the firm level (Oberfield and Raval, 2014). In the context of DSGE (dynamic stochastic general equilibrium) modelling, Cantore et al. (2015) show that the scenario with σ below unity fits overwhelmingly better to the US economy than Cobb-Douglas form. Recently, empirical evidence provided by Karabarbounis and Neiman (2014) implies that σ is about 1.25. This leaves some puzzle which seems to be unresolved.

Model Specification

The elasticity of substitution between labor and capital (σ) is one of the key characteristics of supply side of the economy. As it has been synthesized by Klump et al. (2012), it plays a crucial role in many fields of economics, e.g., economic growth, labor market and public finance. For instance, high values of σ, i.e., above unity, might be perceived as an engine of perpetual growth because then the scarce factor can be easily substituted by the abundant one. A natural environment to study σ is the Constant Elasticity of Substitution (henceforth, CES) production function which was introduced by Arrow et al. (1961). When the elasticity of

[a] The present study follows the methodology as applied by Khan et al., (2015)[a]

substitution equals unity then the CES production function nests the Cobb-Douglas form which persists almost as a paradigm in modern macroeconomic modelling. A critical value of σ is unity. If elasticity of substitution is above (below) unity then factors are gross substitutes (complements).Present study works in the situation of aggradation with two inputs (capital (K) and labor (L)) and one output (Y). A linear homogeneous production function is used to produce the out-put, under perfect Competition with neutral technical change. Both L and K have positive marginal products. CES function of Arrow, et al. (1961) has been used to calculate the elasticity of substitution Arrow, et al. (1961) introduced following form of the CES production.

$$X = \gamma[\delta K^{-e} + (1-\delta)L^{-e}]^{-\frac{v}{e}}$$

γ = technology parameter, δ= distribution parameter for K, $1-\delta$=distribution parameter for L

e= substitution parameter, K = Capital, L = Labor, υ = Return to scale parameter, here it is assumed that γ =1 we can derive the elasticity of substitution by following derivation process

$$\frac{\partial X}{\partial K} = \frac{\partial}{\partial K}[\{\delta K^{-e} + (1-\delta)L^{-e}\}^{-\frac{1}{e}}$$

$$= -\frac{1}{e} * e\,(\delta)K^{-e-1}[\delta K^{-e} + (1-\delta)L^{-e}]^{-\frac{1}{e}-1}, = (\delta)K^{-e-1}[\delta K^{-e} + (1-\delta)L^{-e}]^{-\frac{1}{e}-1}$$

$$= (\delta)K^{-e-1}\frac{[\delta K^{-e} + (1-\delta)L^{-e}]^{-\frac{1}{e}}}{[\delta K^{-e} + (1-\delta)L^{-e}]}$$

Let $X = [\delta K^{-e} + (1-\delta)L^{-e}]^{-\frac{1}{e}}$ and $X^{-e} = [\delta K^{-e} + (1-\delta)L^{-e}]$

$$F_k = \frac{\partial X}{\partial K} = (\delta)K^{-e-1}\frac{X}{X^{-e}}$$

Similarly, $\frac{\partial X}{\partial L} = \frac{\partial}{\partial L}[\{\delta K^{-e} + (1-\delta)L^{-e}\}^{-\frac{1}{e}}]$

$$= -\frac{1}{e} * e\,(1-\delta)L^{-e-1}[\delta K^{-e} + (1-\delta)L^{-e}]^{-\frac{1}{e}-1}$$

$$= (1-\delta)L^{-e-1}[\delta K^{-e} + (1-\delta)L^{-e}]^{-\frac{1}{e}-1}$$

$$= (1-\delta)L^{-e-1}\frac{[\delta K^{-e} + (1-\delta)L^{-e}]^{-\frac{1}{e}}}{[\delta K^{-e} + (1-\delta)L^{-e}]}$$

let $X = [\delta K^{-e} + (1-\delta)L^{-e}]^{-\frac{1}{e}}$ and $X^{-e} = [\delta K^{-e} + (1-\delta)L^{-e}]$

$$F_L = \frac{\partial X}{\partial L} = (1-\delta)L^{-e-1}\frac{X}{X^{-e}}, = \frac{\partial X}{\partial L} = (1-\delta)L^{-e-1}X * X^{e}$$

$$= \frac{\partial X}{\partial L} = (1-\delta)L^{-e-1}X^{1+e}$$

$$= \frac{FL}{FK} = \frac{(1-\delta)L^{-e-1} * X^{1+e}}{\delta K^{-e-1} * X^{1+e}}, = \frac{FL}{FK} = \frac{(1-\delta)L^{-e-1}}{\delta K^{-e-1}}, \frac{FL}{FK} = (\frac{1-\delta}{\delta})^{*}(\frac{L}{K})^{-e-1}$$

Rearranging $\frac{K}{L} = \{(\frac{\delta}{1-\delta})^{*}(\frac{FL}{FK})\}^{\frac{1}{e+1}}$

Elasticity of substitution (σ)$\frac{\partial \log(\frac{K}{L})}{\partial log(\frac{FL}{FK})}$Let $\frac{K}{L}$=K, $\frac{FL}{FK}$=F so $\frac{\partial \log K}{\partial log F}$ and= $\frac{\partial K}{\partial F} * \frac{F}{K}$

Arrow et al (1961) function is nonlinear and may not be estimated so by Applying Kmenta (1967) approximation the estimable model of CES production function is

$$\ln Y = \ln A + \beta_1 \ln K + \beta_2 \ln L + \beta_3 (\ln\frac{K}{L})^2 + \varepsilon$$

Where $\delta = \frac{\beta 1}{\beta 1 + \beta 2}$, $e = \frac{-2\beta 3(\beta 1 + \beta 2)}{\beta 1\, \beta 2}$, $\upsilon = \beta_1 + \beta_2$, $\sigma = \frac{1}{1+e}$

Elasticity of substitution (EOS) is denoted by σ.

Results and Discussion

Present study uses census of manufacturing industries 2011 data for the analysis, as it was the only latest available data. After cleaning process [a]there was data of 3155 industries which has been used. Analysis has been done at different levels, firstly analysis has been done for overall industries then for comparison proposes, and overall industries have been disaggregated into: small[b], medium and large-scale industries for analysis. The decomposition of 3155 is such that there are 1623 small scale industries, 1217 medium scale industries and 315 large scale industries. To find the values of parameters of the above econometric model, ordinary least square (OLS) method has been applied which is most relevant method of estimation under current conditions. After getting the parameters values, further calculations have been made by using the above given formulas. The final results are reported in the table below (see Table 1).

The value of elasticity of substitution for overall industries (σ CES) estimated via constant elasticity of substitution is 1.256. For the Cobb Douglas production function, the values of elasticity of substitution is 1, however under present condition the value is 1.256 which indicates that the production function of manufacturing sector is slightly different from Cobb Douglas production function. It indicates that there is high substitution between labor and capital. It indicates that more labor can be used in lieu of capital to enhance the earning opportunities of the labor class and to make the growth inclusive. Value of δ shows functional distribution of production via capital and 1- δ represents the functional distribution of production via labor. The value δ=0.251shows that the share of capital is around 25% while the value 1- δ = 0.748 shows that the share of labor of around 75%. The value of ν shows returns to scale and the value of ν =1.021, which represents that in manufacturing industry there are constant return to scale.

The value of elasticity of substitution for small scale industries (σ CES) estimated via constant elasticity of substitution is 1.521. For the Cobb Douglas production function, the values of elasticity of substitution is 1, however under present condition the value is 1.521 which indicates that the production function of manufacturing sector is quite different from Cobb Douglas production function. It indicates that there is high substitution between labor and capital. It indicates that more labor can be used in lieu of capital to enhance the earning opportunities of the labor class and to make the growth inclusive, furthermore in case of high prices of one factor, it can be substituted by other factor. Value of δ shows functional

[a] By cleaning process we mean excluding the industries with missing observations for each of the variables (Y, K, L)

[b] For classifying the industries into small, medium and large scale, State Banks classification has been used. As per State Bank classification, industry is small scale if number of employees is from 1 to 20, it is medium scale if number of employees are from 21 to 250 and it is large scale if it has more than 250 employees.

distribution of production via capital and 1- δ represents the functional distribution of production via labor. The value δ=0.195 shows that the share of capital is around 20% while the value 1- δ = 0.804 shows that the share of labor of around 80% in small scale industry, it indicates that small scale industry is labor intensive in nature. The value of ν shows returns to scale and the value of ν =1.107, which represents that in small scale manufacturing industry there are almost constant return to scale.

Table 1: Results of Elasticity of Substitution. (Dependent Variable= lnY)

Coefficients	Overall Manufacturing Industries	Small Scale Manufacturing Industries	Medium Scale Manufacturing Industries	Large Scale Manufacturing Industries
β0	2.281*** (0.000)	1.52*** (0.000)	3.118*** (0.000)	5.659*** (0.000)
β1	0.257*** (0.000)	0.216*** (0.000)	0.313*** (0.000)	0.337*** (0.000)
β2	0.764*** (0.000)	0.891*** (0.000)	0.597*** (0.000)	0.359** (0.000)
β3	0.019*** (0.001)	0.0298*** (0.000)	0.020** (0.063)	0.011 (0.585)
Δ	0.252	0.195	0.345	0.485
1- δ	0.748	0.805	0.655	0.515
N	1.021	1.107	0.911	0.696
e	-0.204	-0.342	-0.201	-0.126
σ CES (EOS)	**1.256**	**1.521**	**1.251**	**1.145**
Rsq	0.680	0.28	0.3418	0.337
F	2238.29*** (0.000)	215.73*** (0.000)	210.01*** (0.000)	61.38*** (0.000)
N	3155	1623	1217	315

In ( ) are probabilities, ***, ** represents 1 and 10% level of significance respectively.

The value of elasticity of substitution (σ CES) estimated via constant elasticity of substitution for medium scale manufacturing industries is 1.251. For the Cobb Douglas production function, the values of elasticity of substitution is 1, however under present condition the value is 1.251 which indicates that the production function of manufacturing sector is slightly different from Cobb Douglas production function. It indicates that there is high substitution between labor and capital. Labor and capital can be easily substituted and to enhance the earning opportunities of the labor class and to make the growth more inclusive, more labor can be used instead of capital. Furthermore in case of shortage of one factor other factor can be easily used. Value of δ shows functional distribution of production via capital and 1- δ represents the functional distribution of production via labor. The value δ=0.344 shows that the share of capital is around 35% while the value 1- δ = 0.655 shows that the share of labor of around 65%. The value of ν shows returns to scale and the value of ν = 0.911, represents that in medium scale manufacturing industry there are decreasing returns to scale.

The value of elasticity of substitution (σ CES) estimated via constant elasticity of substitution for large scale manufacturing industry is 1.145. For the Cobb Douglas production function, the values of elasticity of substitution is 1, however under present condition the value is 1.145 which indicates that the production function of large scale manufacturing sector is very close to Cobb Douglas production function. As the value of elasticity of substitution between labor and capital is greater than 1, it indicates that there is substitution between labor and capital. It indicates that more labor can be used in lieu of capital to enhance the earning opportunities of the labor class and to make the growth inclusive. Value of δ shows functional distribution of production via capital and 1- δ represents the functional distribution of production via labor. The value δ=0.48 shows that the share of capital is around 48% while the value 1- δ = 0.515 shows that the share of labor of around 52%. The value of ν shows returns to scale and the value of ν =0.696, which represents that in large scale manufacturing industry there are decreasing returns to scale.

Results may be summarized as elasticity of substitution is highest for small scale industries and it decreases as the scale of industries increases from small to large scale industries and it is lowest for large scale industries. Returns to scale are also highest in small scale industries as there are increasing returns to scale in small scale industries, in medium and large scale industries there are decreasing returns to scale and they are lowest in large scale industries. Share of labor is highest and share of capital is lowest in small scale industries, while share of capital is highest and share of labor is lowest in large scale industries. So we may conclude that small scale industry is more helpful in inclusive growth as compared to medium and large scale industries.

Conclusion

Recently, in economic development literature, the idea of inclusive growth has got much importance. It is perceived as prerequisite for poverty, inequality reduction and employment generation. As a major sector of Pakistan's economy, manufacturing sector has major contribution in employment generation. The fair distribution and poverty alleviation goals can be attained by emerging the industries with unskilled and semi-skilled labor. In the presence of labor intensive manufacturing sector, the poor will be more benefited and growth will be more inclusive. In the presence of capital intensive manufacturing sector and no substitution between labor and capital, capitalist will get more share as compare to labor and growth of the sector will be less inclusive. Keeping in view this fact present study has been an effort to calculate the elasticity of substitution between labor and capital. CMI data of 3155 manufacturing industries has been used for the estimation purposes. Analysis has been done at different levels, firstly analysis has been done for overall industries then overall industries have been disaggregated into: small, medium and large scale industries. For the calculation of EOS Constant elasticity of substitution (CES) production function has been applied by using Kementa approximation. The results reveal that elasticity of substitution is highest for small scale industries and it decreases as the scale of industries increases from small to large scale industries and it is lowest for large scale industries. Returns to scale are also highest in small scale industries as there are increasing returns to scale in small scale industries, in medium and large scale industries there are decreasing returns to scale and they are lowest in large scale industries. Share of labor is highest and share of capital is lowest in small scale industries, while share of capital is highest and share of labor is lowest in large scale industries. So we may conclude that small scale industry is more helpful in inclusive growth as compared to medium and large scale industries. This substitution between capital and labor provides an opportunity to enhance the earning opportunities of labor which may lead to more inclusive growth.

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