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# TECHNOLOGY MATTERS: EVIDENCE FROM PAKISTANI BANKING SECTOR USING FLEXIBLE TRANSCENDENTAL LOGARITHMIC PRODUCTION FUNCTION

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**Abstract**. Technology has revolutionized the global banking industry. Most studies on the role of technology on Pakistan's banking sector end up without quantifying the change in production due to the adoption of ICT. This study, therefore, is an attempt to investigate the production change due to the adoption of ICT by employing Cobb-Douglas and Transcendental Logarithmic Production Function (Translog production function) using Ordinary Least Squares (OLS) and Seemingly Unrelated Regression Estimation (SURE) techniques. Secondary data of 30 banks for the period of 2006-2013 has been used for analysis. The study finds that most of the ICT surrogates have positive impact on the production of banking sector in Pakistan. It is recommended for the banks to increase investment in such ICT surrogates that are positively impacting the banking sector production in Pakistan.

**Keywords**: Information and Communication Technology (ICT), Transcendental logarithmic production function, Panel Seemingly Unrelated Regression Estimation (Panel SURE)

**JEL classification**: C24, C29, O33

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## I. INTRODUCTION

Impact of information and communication technology (ICT) is a subject that has attained enormous attention from number of economists in the last twenty years. They found its impact on business and economic growth at different levels; *i.e.* industrial, national and international. During 1990s, researchers claimed that impact of ICT on production and economic development was insignificant or non-existent, which they referred as with Solow's Paradox. Solow's Paradox shows the lack of the rise in productivity due to ICT. Recent literature on impact of ICT shows positive contribution of ICT in production processes. Level of production is measured through production function which is the technical relationship between inputs and output. Stella (2010) considered that production process creates wealth that increases the welfare of people, because it tries to satisfy unlimited wants with available resources. Van Biema and Greenwald (1997) suggested that in modern ages, efficiency of production process has become the main issue for executives, both in the industrial and the service sectors. Accordingly, ICT as a factor for increasing efficiency of production process has been considerably debated and investigated by policymakers and researchers.

Banking, during last two decades, has experienced an observable transformation due to ICT that leaders in the field of ICT have started to anticipate the extinction of physical structure of banks.[1] Adeoti (2005) considered ICT as a tool of modernization of processes, controls, and information production by means of computers, telecommunication, software and other utensils that make activities more smooth and efficient. Anayasi and Otubu (2009) state that if technological innovation is at its peak, then one of the main sectors of the economy where technology is at its helm of affairs with reference to customer service is banking. Banking has transformed from a traditional brick-and mortar type to mobile banking where customers queuing for banking services is not required. In today's business, ICT has become one of the prime indicators of competitiveness and development where Solow's Paradox seems to fade away with the evolution of ICT.

Many researchers, such as Gordon (2000), communicated various inferences in some previous studies but now confirm that increasing investment in ICT boost economic growth. Thus, after probably ten years of declaring the paradox, Solow himself confessed that figures now commenced

[1]We need banking but we don't need banks anymore. Do you think someday we can open bank account or ask for loan without physically have to come to the bank? – Bill Gates.

to quantify the technological era, even if discrete at the moment. ICT has become inevitable because without ICT it is not possible to sustain in global banking industry. Spending in ICT has been on the rise during the last decade in Pakistan's banking industry, so there is need to assess the effectiveness to justify the major spendings on it. Although, studies have been conducted related to the impact of ICT in banking sector of Pakistan. But many researchers end up without knowing the contribution of ICT in banking industry of Pakistan. To overcome this problem, this research focuses on studying production change due to deployment of ICT. More specifically, this research quantifies the effect of ICT in banking sector. We use two production functions; Cobb-Douglas production function and Transcendental logarithmic production function for this purpose. Further, we use a number of alternative proxies of ICT, since ICT is diverse and evolving. We think that ICT as an input has the tendency to affect the output in diverse ways.

### OBJECTIVES OF THE STUDY

The objective of this research work is to quantify the impact of ICT on the production of Pakistan's banking sector during the period of 2006 to 2013. In terms of hypothesis, it can be written as:

$H_0$: Information and Communication Technology (ICT) does not contribute in production of banking sector in Pakistan.

$H_A$: Information and Communication Technology (ICT) contributes in production of banking sector in Pakistan.

## II. LITERATURE REVIEW

Relevant studies are reviewed here to explicate the gap in literature. Banker and Kauffman (1988) presented a realistic study of the deliberate influence of ATMs for taming a bank branch's market share of local deposit at the cost of its opponents. They developed an instrument to access the response and evaluated the impact of IT that was not formerly accessed. Their results show that ATM system affiliation is important for increasing bank deposits. Harold and Jeff (1995) find that financial service suppliers should change their outdated working ways to stay in the market. According to them, the main noteworthy deficiency in the banking business at that time was the failure of higher management officials to understand the role of IT.

Woherem (2000) contends that only banks that renovate their complete systems through ICT in their processing would continue and succeed in

future. He recommends that banks should re-check their complete system to bring changes according to the requirement of new technology. Whereas Hall and Khan (2003) clarify in their study that the benefit from latest technology could only be achieved when it is used extensively. Further, they argued that the regulatory bodies and parliamentary establishments have more impact on influential implementation of ICT. According to them, economic by-laws have noticeable effects on banks' performance.

Lee, Gholami and Tong (2005) used data from the Iranian industrial sector for the period of 1993-1999; and assessed the productivity at industry level by using panel data. They followed Shao and Lin (2002), and evaluated the impact of ICT on the production in two stages. In the first step, they estimated a production function (both by using Cobb-Douglas and Translog) and abstracted the productivity chain from the residuals. In the second step, they used a separate regression for accessing the effect of ICT on production. The results approved a positive and significant impact of ICT investments on production.

Ovia (2005) mentioned that ICT has made many changes in the banking industry; it completely changed the way banks provided services. By its usage efficiency of banks increased, further its reduced cost of installation encouraged many banks to adopt ICT which improved the bank's likelihood of ICT adoption. Further, Agboola (2007) studied the impact of ICT deployments on Nigerian banks. He used the data for 36 banks out of 89 banks at the end of 2005. He used questionnaires for obtaining data from customers, employees and managers of banks. The study showed that the banking sector has experienced many changes with respect to content and quality during the period 1990-2005. Technology was found to be the main reason of competition in banking sector during the spell. He added that the implementation of ICT in banks provided ease to customers and further improved the business in banking.

Osabuohien (2008) recognizes that the gender of bank executives does not have any link with the use of ICT adeptness; dynamics like age, qualification and computer knowledge are important factors that persuade ICT practice. Further he found that ICT increased the productivity and profitability of banks. Stella (2010) evaluated the production impact of ICT on Nigerian banking industry. He found that impact on productivity was positive after the deductions had been made for depreciation and labour payments. Results revealed that banks' output increased as a result of ICT.

Muhammad, Gatawa and Kebbi (2013) also measured the ICT effects on the banking industry of Nigeria by employing data of eleven selected

Commercial Banks. They found an inverse relationship between surplus persistent investment in ICT and productivity. Their study emphasized more on policies that increase efficiency and encourage proper utilization of ICT gadgets rather than sustained investments. Mehmood, Shafique and Rafaqat (2014) investigated Solow's Paradox for world's leading capital markets in 47 countries. They used ICT expenditure and market capitalization and stock traded turnover ratio as indicators of capital market activity. Pooled mean group technique of cointegration showed long run relationship between the two variables.

Abbas *et al.* (2015) analyzed the service quality of Branchless Banking in Lahore using SERVEQUAL model. Using the primary data from 311 respondents, they subjected factors such as age, gender, education, marital status, monthly income and residence to confirmatory factor analysis (CFA). Results of SERVEQUAL model showed that service reliability, responsiveness and assurance are the most important factors of services quality. Khan, Mehmood and Sair (2015) estimated an unconventional production function known as Constant Elasticity of Substitution (CES) production function for Pakistani banking industry. As per estimates using time series data from 1980-2013, increasing returns to scale (IRS) were found. Econometric tests for stationarity and cointegration were employed in addition to fully modified OLS to estimate the cointegration equation. Results showed that elasticity of substitution between capital and labour is greater than one, reflecting considerable level of substitution between labour and capital.

The recent study of Mustafa and Mehmood (2015) examined the technical efficiency of 11 selected commercial banks in Pakistan using pre and post digital reforms era for the period from 1998 to 2012. Their results proved that technical efficiency considerably increased during post-digital reform period and hence productivity. In addition, their study showed that MCB Bank constantly scored the maximum efficiency and productivity scores. Iqbal, Mehmood and Ahmed (2015) examined the impact of ICT on banks' performance in Pakistan by subjecting the annual data from 2005 to 2013. Fixed effects and random effects models were used. ICT variables did not show statistically significant relationship with banks' performance. Results confirmed the presence of Solow's Paradox.

Till date empirical evidence on Pakistan's banking sector lacks the application of a multi-input production function that quantifies the role of technology (ICT). The literature on impact of ICT on banking sector is still in its infancy and inconclusive. This study is an attempt to overcome the

mathematical, statistical and proxy related shortcomings of previous studies. It does so by using flexible form of production function, seemingly unrelated regression estimation and a number of proxies for ICT. Results of this paper can better help to resolve the enigma of Solow's Paradox.

## III. DATA COLLECTION AND METHODOLOGY

For empirical analysis, the sources of data are the annual reports of commercial banks and State Bank of Pakistan (SBP). Data of 30 banks (including public, private and foreign banks) in Pakistan is used for the period of 2006 to 2013. The data comprises of total deposits as dependent variable and fixed assets (FA), salaries and wages (SA) of bank employees and various proxies of ICT as independent variables. These are Number of ATMs (NOA), Point of sale (POS), Number of credit cards (CC), Number of debit cards (DC), Number of e-banking transactions (NEBT), Value of e-banking transactions (VEBT), Number of ATMs transactions (NATMT), Value of e-banking transactions (VEBT), Number of point of sale transactions (NPOS), Value of point of sale transactions (VPOS), Number of other e-banking channels transactions (NEBCT), Value of other e-banking channels transactions (VEBCT), Number of real time online branches transactions (NOBT) and Value of real time online branches transactions (VOBT).

### SELECTION OF ANALYTIC APPROACH

Commercial banking is considered a very challenging service industry for the purpose of measuring output, technological change and production growth. Many studies with regard to the productivity of banking industry struggle with the most important matter of what should be considered as the 'output' of a bank. There are three methods that researchers used to estimate the output of banks that may be categorized into three main categories: the assets approach, the user-cost approach, and the value-added approach. It is claimed that the value added approach, which describes those activities as outputs that have considerable value added characteristic is best for correctly assessing fluctuations in bank technology and productivity over time (Berger and Humphrey, 1992).

### THE ASSET APPROACH

Observation approves that liabilities of banks have features of inputs, so these liabilities also work as raw material for investing resources. On the other hand, the assets of bank have characteristics of output because

eventually the resources create income for banks. In this method, banks perform as monetary mediators between liability repositories and the receivers of funds (Berger and Humphrey, 1992).

## THE USER COST APPROACH

The user cost approach defines rather a financial item as an input or an output on the basis of its ultimate impact on the income of banks. If the monetary earning due to an asset surpasses the opportunity cost of asset or the monetary cost of a liability is less than the opportunity cost, the instrument then will be measured as a financial output. Otherwise, it is measured as a financial input (Berger and Humphrey, 1992).

## THE VALUE ADDED APPROACH

The value-added approach is unlike other methods because it reflects all liability and asset groups to have some output feature. The value added method, used in many studies related to banking sector such as Berger, Hanweck and Humphrey (1987), categorize the major types of received deposits (time, savings and demand) and advances (commercial, installments, real estate) as main outputs. It is so because they are liable for value addition in the substantial extent. Purchased assets (foreign deposits, federal funds purchased, large CDs, other liabilities for borrowed money) are dealt in the intermediation process as financial inputs, because they involve very small amounts which are treated as physical inputs such as labour and capital (Berger and Humphrey, 1992). Further, they claimed that the value added for every financial institution should be measured on the basis of its operational cost and those financial products which have 'significant' characteristic of value-addition should be measured as output of the bank.

The suitable depiction of the bank production procedures and, in particular, the description of bank output is a debatable issue. However, in this research work, we have followed approach which is termed as 'value added approach', in which all the activities that create added value are measured as output of the bank.

## SEEMINGLY UNRELATED REGRESSION ESTIMATION (SURE)

SURE is an application of generalized least squares (GLS) estimation to a group of seemingly unrelated equations. The equations are related through the nonzero covariances associated with error terms across different equations at a given point in time. We can generalize the seemingly unrelated model by writing the system of G equation as follows:

$$Y_i = X_i \beta_i + \mu_i \qquad i = 1, 2, 3, \ldots \qquad \text{(G)}$$

$$\text{Or} \quad \begin{bmatrix} Y_1 \\ Y_2 \\ .. \\ .. \\ Y_G \end{bmatrix} = \begin{bmatrix} X_1 & 0 & 0 & 0 & 0 \\ 0 & X_2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & X_G \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ .. \\ .. \\ \beta_G \end{bmatrix} + \begin{bmatrix} \mu_1 \\ \mu_2 \\ .. \\ .. \\ \mu_G \end{bmatrix}$$

Where $Y = GN \times 1$ matrix

$$X = GN \times \left( \sum_{i=1}^{G} K_i \right) \text{ matrix}$$

$$\beta = \left( \sum_{i=1}^{G} K_i \right) \times 1 \text{ matrix}$$

$$\mu = GN \times 1 \text{ matrix}$$

There is a cross-equation correlation as per the assumptions of the seemingly unrelated model:

$$E\left(\mu_i \mu_j'\right) = \begin{bmatrix} \sigma_{ij} & 0 & .. & 0 \\ 0 & \sigma_{ij} & .. & 0 \\ .. & .. & .. & .. \\ 0 & 0 & .. & \sigma_{ij} \end{bmatrix}$$

where $I$ is a $G \times G$ identity matrix. This relationship applies to the covariances between the two arbitrary equations in the system of G equation. To generalized this result in matrix form, it can be write as follows:

$$\Omega = E\left(\mu\mu'\right) = \begin{bmatrix} E\left(\mu_1\mu_1'\right) & E\left(\mu_1\mu_2'\right) & .. & E\left(\mu_1\mu_G'\right) \\ E\left(\mu_2\mu_1'\right) & E\left(\mu_2\mu_2'\right) & .. & E\left(\mu_2\mu_G'\right) \\ .. & .. & .. & .. \\ E\left(\mu_G\mu_1'\right) & E\left(\mu_G\mu_2'\right) & .. & E\left(\mu_G\mu_G'\right) \end{bmatrix}$$

Substituting, we get:

$$\Omega = \begin{bmatrix} \sigma_{1_1} I & \sigma_{1_2} I & .. & \sigma_{1G} I \\ \sigma_{2_1} I & \sigma_{2_2} I & .. & \sigma_{2G} I \\ .. & .. & .. & .. \\ \sigma_{G_1} I & \sigma_{G_2} I & .. & \sigma_{GG} I \end{bmatrix}$$

$$\hat{\beta} = \left(X'\Omega^{-1}X\right)^{-1}\left(X'\Omega^{-1}Y\right)$$

$$E\left[\left(\hat{\beta}-\beta\right)\left(\hat{\beta}-\beta\right)'\right] = \left(X'\Omega^{-1}X\right)^{-1}$$

$$\hat{\sigma}_{ii} = \frac{\hat{\mu}_i\hat{\mu}_i'}{N-K_i}$$

$$\hat{\sigma}_{ii} = \frac{\hat{\mu}_i\hat{\mu}_j}{\sqrt{\left(N-K_i\right)\left(N-K_j\right)}}$$

$$\hat{\mu}_i = Y_i - X_i\hat{\beta}_i$$

## ESTIMABLE MODEL

Production function defines a technical relation among the maximum output which is obtained from various combinations of probable factors of production. So the production function will be written as:

$$BY = f(L, K, ICT)$$

For the purpose of determining the proceeds from investments in ICT by segments, largely the production theoretical framework is used (Loveman, 1994; Lichtenberg, 1995; Parsad and Harker, 1997). Berdnt (1991) suggested production function methods as the most suitable method to know the effects of *ICT*. However, Berndt (1991) points out that the simplest method of determining the production is Cobb Douglas production function.

## COBB-DOUGLAS PRODUCTION FUNCTION

The most commonly used production functions is the Cobb-Douglas and is suitably called as 'Workhorse production function' as well. This is shown in a logarithmic form and can be written as:

$$BY = \alpha L^{\beta_1} K^{\beta_2} ICT^{\beta_3}$$

and estimated as:

$$\ln\left(BY_{i,t}\right) = \alpha + \beta_1 \bullet \ln\left(L_{i,t}\right) + \beta_2 \bullet \left(K_{i,t}\right) + \beta_3 \bullet \ln\left(ICT_{i,t}\right) + \varepsilon_{i,t}$$

Where:

ln = Natural Logarithm

*BY* = Bank Deposits (Bank's Output)

$K$ = Fixed Assets

$L$ = Salaries and Wages

$ICT$ = ATMs, POS, DD, CC and other ICT surrogates

Where α, $\beta_1$, $\beta_2$, $\beta_3$ are parameters to be estimated and $\varepsilon$ is the regression disturbance. Subscripts '*i*' and '*t*' represent bank *i* at time *t*.

## TRANSCENDENTAL LOGARITHMIC PRODUCTION FUNCTION

Translog production function is a more flexible production function, which was suggested by Christensen *et al.* (1973). The benefit of using transcendental logarithmic function is the elasticity as it can estimate almost any functional formula (Intriligator, 1978). The Translog production function is non-homogeneous and it belongs to the flexible functional class (Coelli, Rao and Battese, 1998). The Translog function is distinct flexible function due to presence of both linear and quadratic terms with the ability of using more than two factor inputs. It can be approximated by second order Taylor series (Christensen *et al.*, 1973). The 3-input Translog production function can be written in terms of logarithms as follows:

$$\ln(BY_{i,t}) = \alpha + \beta_L \bullet \ln(L_{i,t}) + \beta_K \bullet \ln(K_{i,t}) + \beta_{ICT} \bullet \ln(ICT_{i,t}) + \tfrac{1}{2}\beta_{LL} \bullet \ln(L_{i,t})^2 + \tfrac{1}{2}\beta_{KK} \bullet \ln(K_{i,t})^2 + \tfrac{1}{2}\beta_{ICTICT} \bullet \ln(ICT_{i,t})^2 + \beta_{LK}(\ln L_{i,t} \times \ln K_{i,t}) + \beta_{LICT}(\ln L_{i,t} \times \ln ICT_{i,t}) + \beta_{KICT}(\ln K_{i,t} \times \ln ICT_{i,t}) + \varepsilon_{i,t}$$

Where α and $\beta$s are the associated output elasticities. Stella (2010) mentions that in Translog-type model there are probably many parameters for estimation. Because with every added variable in the model it is required to involve a squared term and cross-product along with the already existing variables.

Conventionally, symmetry conditions are imposed on Translog function, *i.e.*

$$\beta_{LK} = \beta_{KL}$$

$$\beta_{LICT} = \beta_{ICTL}$$

$$\beta_{KICT} = \beta_{ICTK}$$

Moreover, constant returns to scale (CRS) requires following conditions to hold:

$$\beta_L + \beta_K + \beta_{ICT} = 1$$

$$\beta_{KK} + \beta_{LK} + \beta_{ICTK} = 0$$

$$\beta_{KL} + \beta_{LL} + \beta_{ICTL} = 0$$

$$\beta_{KICT} + \beta_{LICT} + \beta_{ICTICT} = 0$$

Thirdly, for reducing to Cobb-Douglas specification following restrictions can be imposed.

$$\beta_{KK} = \beta_{KL} = \beta_{KICT} = \beta_{LL} = \beta_{LICT} = \beta_{ICTICT} = 0$$

## IV. EMPIRICAL RESULTS

To investigate whether ICT investment improve banks' productivity or not, we used OLS and SURE techniques to measure robustness of estimated parameters. Further we examined the difference between ordinary least square (OLS) and seemingly unrelated regression estimation (SURE) technique for Cobb-Douglas and Transcendental Logarithmic production function. In the first step, results are estimated using Cobb-Douglas specification of production function. In second step, the impact of ICT on banks' production is estimated by using Translog production function employing both OLS and SURE.

Table 1 shows the estimation results for the period of 2006 to 2013 for the banks' production by using Cobb-Douglas production function, whereas Table 2 and Table 3 show results for Translog production function employing OLS and SURE, respectively. The results obtained show positive and statistically significant coefficients for capital (fixed assets) and labour (salaries and wages of employees) in all the estimated models for OLS and SURE estimation techniques, while most of the ICT surrogates also show a positive relation with bank deposits. The estimation results are given in tables, Table 1 shows significantly positive influence of number of ATMs on banks production (total deposits) with the coefficient of 0.2959, this means that number of ATMs positively impacts banks productivity (if we increase the number of ATMs with 10% the deposits of banks will increase by 29%). The empirical literature on the adoption of technological innovation in the banking sector commonly focuses on the deployment of ATMs (*see* for example, Hannan and McDowell, 1984; Escuer *et al.*, 1991; Pennings and Harianto, 1992; Hester, Calcagnini and De Bonis, 2001). Thus, investment in ATMs upturns the value of bank deposit accounts, which is economical in terms of charges of funds than various other sources, like borrowing cash from other organizations, therefore dropping the total cost of funds.

TABLE 1

Dependent Variable:
Bank Deposits with Cobb-Douglas Production Function

| Model No. | ICT Proxy | OLS | | | SURE | | |
|---|---|---|---|---|---|---|---|
| | | FA | SA | ICT | FA | SA | ICT |
| 1 | NOA | 0.3091[a] (0.0515) | 0.3208[a] (0.0798) | 0.2959[a] (0.0708) | 0.3091[a] (0.0511) | 0.3208[a] (0.0791) | 0.2959[a] (0.0702) |
| 2 | POS | 0.3559[a] (0.0501) | 0.5530[a] (0.0498) | –0.2044[a] (0.0335) | 0.3559[a] (0.0497) | 0.5530[a] (0.0494) | –0.2044[a] (0.0332) |
| 3 | CC | 0.3548[a] (0.0500) | 0.5705[a] (0.0496) | –0.2076[a] (0.0336) | 0.3548[a] (0.0496) | 0.5705[a] (0.0491) | –0.2076[a] (0.0333) |
| 4 | DC | 0.3320[a] (0.0487) | 0.2291[a] (0.0697) | 0.4025[a] (0.0580) | 0.3320[a] (0.0483) | 0.2291[a] (0.0692) | 0.4025[a] (0.0575) |
| 5 | NEBT | 0.3179[a] (0.0502) | 0.2559[a] (0.0765) | 0.3674[a] (0.0663) | 0.3179[a] (0.0498) | 0.2559[a] (0.0759) | 0.3674[a] (0.0657) |
| 6 | VEBT | 0.3220[a] (0.0500) | 0.2421[a] (0.0767) | 0.3797[a] (0.0661) | 0.3220[a] (0.0496) | 0.2421[a] (0.0760) | 0.3797[a] (0.0656) |
| 7 | NATMT | 0.3188[a] (0.0506) | 0.2893[a] (0.0750) | 0.3325[a] (0.0643) | 0.188[a] (0.0502) | 0.2893[a] (0.0744) | 0.3325[a] (0.0638) |
| 8 | VATMT | 0.3219[a] (0.0498) | 0.2513[a] (0.0740) | 0.3746[a] (0.0632) | 0.3219[a] (0.0494) | 0.2513[a] (0.0734) | 0.3746[a] (0.0627) |
| 9 | NPOS | 0.3297[a] (0.0529) | 0.6452[a] (0.0586) | –0.1250[a] (0.0464) | 0.3297[a] (0.0525) | 0.6452[a] (0.0581) | –0.1250[a] (0.0460) |
| 10 | VPOS | 0.3282[a] (0.0536) | 0.6568[a] (0.0689) | –0.1129[c] (0.0612) | 0.3282[a] (0.0531) | 0.6568[a] (0.0684) | –0.1129[c] (0.0607) |
| 11 | NEBCT | 0.3272[a] (0.0491) | 0.2307[a] (0.0719) | 0.3984[a] (0.0607) | 0.3272[a] (0.0487) | 0.2307[a] (0.0713) | 0.3984[a] (0.0602) |
| 12 | VEBCT | 0.3360[a] (0.0486) | 0.2297[a] (0.0690) | 0.4013[a] (0.0569) | 0.3360[a] (0.0482) | 0.2297[a] (0.0685) | 0.4013[a] (0.0565) |
| 13 | NOBT | 0.3234[a] (0.0500) | 0.2580[a] (0.0741) | 0.3661[a] (0.0631) | 0.3234[a] (0.0496) | 0.2580[a] (0.0735) | 0.3661[a] (0.0626) |
| 14 | VOBT | 0.3185[a] (0.0503) | 0.2590[a] (0.0762) | 0.3642[a] (0.0658) | 0.3185[a] (0.0498) | 0.2590[a] (0.0755) | 0.3642[a] (0.0653) |

NOTE. Figures in parentheses are standard errors. Whereas [a] indicates significance at 1%, [b] at 5% and [c] at 10%.

The results of our study show significantly negative relation between POS and bank deposits. This mean if we increase the POS by 10% the deposits of banks will reduce by 20%. It shows that increased number of POS facilitates customers in their dealings which can reduce deposits of bank on the other side. Similarly, significantly negative relation was found between numbers of point of sale transactions (NPOS) and value of point of sale transactions (VPOS). Number of credit cards (CC) show a significant and negative effect on deposits of banks. It can be inferred that as the interest on credit cards increases, the bank gives more credit through credit cards from its deposits which in turn reduces its deposits.

Other ICT proxies such as number of debit cards (DC), NEBT, VEBT, NATMT, VATMT, NEBCT, VEBCT, NOBT and VOBT have positive and significant relation with bank deposits employing both estimation techniques. Increased use of these ICT surrogates can have the desirable effect of increasing banks' production (deposits).

On the basis of Scholnick *et al.* (2008) study one can argue that customers have rational behaviour and adopt that mechanism of payment which is less costly and more secure as compared to other payment mechanisms. If the customers use more of POS, then transactions of POS will increase which will in turn reduce the deposits of banks. So in the same way our study shows that number of point of sales (NPOS) transactions and value of point of sales transactions (VPOS) do not have any positive relation with bank deposits.

Concluding the Cobb-Douglas production function we found no startling difference between OLS and SURE results for determining production of banking sector in Pakistan by using different ICT proxies. Throughout the analysis most of the ICT surrogates remain positively related with deposits. This preliminary evidence provides our first insight into evidence of increase in production due to ICT.

Table 2 and Table 3 show the comparison between the OLS and SURE estimation techniques using Translog production function. The results remain consistent using OLS and SURE techniques. In Table 2, number of ATMs has a significant and positive impact on the deposits of banks. The squared term of number of ATMs also show a positive sign with statistical significance. It shows the presence of a non-linear quadratic relationship in addition to linear relationship. Pictorially, this relationship shall be a U-shaped parabola.[2] The results show that production of banks in Pakistan is

[2]U-shaped parabola is also referred as Happy Parabola.

quite responsive to number of ATMs, capital and labour expenses. Squared terms of FA, SA and interaction terms of independent variables did not show any significant result. The most significant technological improvement that brings this change has been the arrival of credit cards, automated teller machines (ATMs) and debit cards.

TABLE 2

Dependent Variable:
Bank Deposits with Translog Production Function

| Model No. | ICT Proxy | OLS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | FA | SA | ICT | $FA^2$ | $SA^2$ | $ICT^2$ | FA×SA | SA×ICT | FA×ICT |
| 1 | NOA | 0.3446[a] (0.0499) | 0.3396[a] (0.0805) | 0.3834[a] (0.0716) | 0.0102 (0.0377) | –0.0003 (0.1211) | 0.0847[a] (0.0836) | –0.1253 (0.1334) | –0.0334 (0.1578) | 0.1084 (0.1282) |
| 2 | POS | 0.3332[a] (0.0510) | 0.4424[a] (0.0634) | –0.2680[a] (0.0510) | 0.0103 (0.0381) | –0.0236 (0.0603) | 0.2231[a] (0.0730) | –0.0357 (0.0674) | –0.2209[a] (0.0634) | 0.0553 (0.0529) |
| 3 | CC | 0.3556[a] (0.0494) | 0.3481[a] (0.0660) | –0.3647[a] (0.0548) | 0.0258 (0.0373) | –0.0099 (0.0603) | –0.2229[a] (0.0712) | –0.0205 (0.0662) | –0.1105[b] (0.0542) | –0.0373 (0.0510) |
| 4 | DC | 0.3493[a] (0.0494) | 0.2705[a] (0.0802) | 0.3454[a] (0.0677) | 0.0084 (0.0372) | –0.0200 (0.0926) | 0.1355[c] (0.0791) | –0.0984 (0.1040) | 0.0200 (0.1232) | 0.1047 (0.1010) |
| 5 | NEBT | 0.3520[a] (0.0492) | 0.2856[a] (0.0797) | 0.3845[a] (0.0670) | 0.0028 (0.0371) | 0.0255 (0.1088) | 0.2747[a] (0.0831) | –0.1816 (0.1210) | –0.0958 (0.1444) | 0.1819 (0.1169) |
| 6 | VEBT | 0.3499[a] (0.0494) | 0.2894[a] (0.0813) | 0.3717[a] (0.0688) | 0.0073 (0.0373) | –0.0569 (0.1137) | 0.1928[a] (0.0800) | –0.0781 (0.1258) | 0.0418 (0.1527) | 0.0661 (0.1233) |
| 7 | NATMT | 0.3452[a] (0.0504) | 0.3476[a] (0.0799) | 0.3058[a] (0.0678) | –0.0020 (0.0381) | 0.0383 (0.1074) | 0.1946[a] (0.0769) | –0.1353 (0.1190) | –0.0726 (0.1393) | 0.1531 (0.1130) |
| 8 | VATMT | 0.3545[a] (0.0491) | 0.2873[a] (0.0794) | 0.3566[a] (0.0652) | 0.0050 (0.0370) | 0.0115 (0.1010) | 0.2693[a] (0.0807) | –0.1638 (0.1138) | –0.0734 (0.1332) | 0.1664 (0.1088) |
| 9 | NPOS | 0.3697[a] (0.0537) | 0.6210[a] (0.0611) | –0.1061[c] (0.0617) | 0.0366 (0.0406) | – 0.0206 (0.0886) | –0.0891 (0.0713) | 0.1572[c] (0.0866) | 0.1914[c] (0.1127) | –0.2076[a] (0.0781) |
| 10 | VPOS | 0.3565[a] (0.0544) | 0.6238[a] (0.0710) | 0.0009 (0.0831) | 0.0305 (0.0411) | –0.0983 (0.1218) | –0.0607 (0.0663) | 0.2121[c] (0.1161) | 0.2741[c] (0.1541) | –0.2247[c] (0.1101) |
| 11 | NEBCT | 0.3517[a] (0.0494) | 0.2862[a] (0.0799) | 0.3427[a] (0.0665) | 0.0109 (0.0371) | –0.0263 (0.0984) | 0.1966[b] (0.0851) | –0.1077 (0.1100) | 0.0070 (0.1326) | 0.1015 (0.1077) |
| 12 | VEBCT | 0.3542[a] (0.0489) | 0.2577[a] (0.0787) | 0.3501[a] (0.0649) | 0.0057 (0.0369) | 0.0142 (0.0903) | 0.1687[b] (0.0788) | –0.1432 (0.1027) | –0.0423 (0.1198) | 0.1630[c] (0.0978) |
| 13 | NOBT | 0.3538[a] (0.0497) | 0.3153[a] (0.0814) | 0.3184[a] (0.0678) | 0.0060 (0.0374) | –0.0247 (0.1023) | 0.2139[a] (0.0749) | –0.0950 (0.1163) | –0.0044 (0.1354) | 0.0947 (0.1108) |
| 14 | VOBT | 0.3602[a] (0.0489) | 0.2856[a] (0.0778) | 0.4008[a] (0.0651) | 0.0061 (0.0368) | 0.0665 (0.1068) | 0.3346[a] (0.0897) | –0.2260[b] (0.1189) | –0.1654 (0.1446) | 0.2262[b] (0.1145) |

NOTE. Figures in parentheses are standard errors. Whereas [a] indicates significance at 1%, [b] at 5% and [c] at 10%.

TABLE 3

Dependent Variable:
Bank Deposits Translog Production Function

| Model No. | ICT Proxy | SURE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | FA | SA | ICT | $FA^2$ | $SA^2$ | $ICT^2$ | FA×SA | SA×ICT | FA×ICT |
| 1 | NOA | 0.3446[a] (0.0489) | 0.3396[a] (0.0788) | 0.3834[a] (0.0701) | 0.0051 (0.0369) | –.0178 (0.1185) | 0.2912[a] (0.0818) | –0.1253 (0.1306) | –0.0334 (0.1545)) | 0.1084 (0.1255) |
| 2 | POS | 0.3332[a] (0.0499) | 0.4424[a] (0.0621) | –0.2680[a] (0.0499) | 0.0103 (0.0373) | –0.0236 (0.0590) | 0.2231[a] (0.0714) | –0.0357 (0.0660) | –0.2209[a] (0.0620) | 0.0553 (0.0518) |
| 3 | CC | 0.3556[a] (0.0484) | 0.3481[a] (0.0646) | –0.3647[a] (0.0536) | 0.0258 (0.0365) | –0.0099 (0.0590) | –0.2229[a] (0.0697) | –0.0205 (0.0648) | –0.1105[b] (0.0531) | –0.0373 (0.0499) |
| 4 | DC | 0.3493[a] (0.0484) | 0.2705[a] (0.0785) | 0.3454[a] (0.0663) | 0.0084 (0.0364) | –0.0200 (0.0907) | 0.1355[c] (0.0774) | –0.0984 (0.1018) | 0.0200 (0.1206) | 0.1047 (0.0989) |
| 5 | NEBT | 0.3520[a] (0.0481) | 0.2856[a] (0.0780) | 0.3845[a] (0.0656) | 0.0028 (0.0363) | 0.0255 (0.1066) | 0.2747[a] (0.0814) | –0.1816 (0.1184) | –0.0958 (0.1414) | 0.1819 (0.1145) |
| 6 | VEBT | 0.3499[a] (0.0483) | 0.2894[a] (0.0795) | 0.3717[a] (0.0674) | 0.0073 (0.0365) | –0.0569 (0.1113) | 0.1928[a] (0.0783) | –0.0781 (0.1232) | 0.0418 (0.1495) | 0.0661 (0.1207) |
| 7 | NATMT | 0.3452[a] (0.0493) | 0.3476[a] (0.0782) | 0.3058[a] (0.0664) | –0.0020 (0.0373) | 0.0383 (0.1052) | 0.1946[a] (0.0753) | –0.1353 (0.1165) | –0.0726 (0.1363) | 0.1531 (0.1106) |
| 8 | VATMT | 0.3545[a] (0.0481) | 0.2873[a] (0.0777) | 0.3566[a] (0.0638) | 0.0050 (0.0362) | 0.0115 (0.0989) | 0.2693[a] (0.0790) | –0.1638 (0.1114) | –0.0734 (0.1304) | 0.1664 (0.1065) |
| 9 | NPOS | 0.3697[a] (0.0525) | 0.6210[a] (0.0598) | –0.1061[c] (0.0604) | 0.0366 (0.0398) | –0.0206 (0.0867) | –0.0891 (0.0698) | 0.1572[c] (0.0848) | 0.1914[c] (0.1103) | –0.2076[a] (0.0764) |
| 10 | VPOS | 0.3565[a] (0.0533) | 0.6238[a] (0.0695) | 0.0009 (0.0814) | 0.0305 (0.0402) | –0.0983 0.1192) | –0.0607 (0.0649) | 0.2121[c] (0.1137) | 0.2741[c] (0.1509) | –0.2247[c] (0.1077) |
| 11 | NEBCT | 0.3517[a] (0.0484) | 0.2862[a] (0.0783) | 0.3427[a] (0.0651) | 0.0109 (0.0363) | –0.0263 (0.0963) | 0.1966[b] (0.0833) | –0.1077 (0.1077) | 0.0070 (0.1298) | 0.1015 (0.1054) |
| 12 | VEBCT | 0.3542[a] (0.0479) | 0.2577[a] (0.0771) | 0.3501[a] (0.0635) | 0.0057 (0.0361) | 0.0142 (0.0884) | 0.1687[b] (0.0771) | –0.1432 (0.1006) | –0.0423 (0.1172) | 0.1630[c] (0.0958) |
| 13 | NOBT | 0.3538[a] (0.0487) | 0.3153[a] (0.0797) | 0.3184[a] (0.0664) | 0.0060 (0.0366) | –0.0247 (0.1002) | 0.2139[a] (0.0733) | –0.0950 (0.1138) | –0.0044 (0.1326) | 0.0947 (0.1085) |
| 14 | VOBT | 0.3602[a] (0.0479) | 0.2856[a] (0.0762) | 0.4008[a] (0.0637) | 0.0061 (0.0360) | 0.0665 (0.1045) | 0.3346[a] (0.0878) | –0.2260[b] (0.1164) | –0.1654 (0.1415) | 0.2262[b] (0.1121) |

NOTE. Figures in parentheses are standard errors. Whereas [a] indicates significance at 1%, [b] at 5% and [c] at 10%.

Estimates for POS, CC and NPOS show significantly negative relation with bank deposits. According to the study of Ishii (2005), the high interest rates and heavy surcharges by banks on credit card (CC) can affect bank deposits negatively. In the same way, this study also found a significantly negative relation between bank CC and deposits. As more credit cards used

and surcharges paid by customer it will reduce to the deposits of bank. Square of number of CC is also significantly negative and should yield an inverted U-shaped parabola.[3] The interaction terms of other independent variables in models, except for SA × CC, do not show any significant result in contributing to bank deposits.

Table 3 gives the results using SURE technique. DC affects the production of banks in a positive manner. Its coefficient is positive and statistically significant. The total number of e-banking transactions (NEBT) have positive effect on bank deposits with statistical significance level of 1%. Whereas we found that value of e-banking transactions (VEBT) and its squared term also affect the banks' deposits positively with 1% significance level. The squared terms of FA, SA and interaction terms did not show any significant result in the model.

Findings as in Saloner and Shepard (1995) and Ishii (2005) indicate that ATMs facilitates bank customers which will in turn increase the deposits of bank and impact positively and significantly to bank deposits. In similar veins, number and value of ATMs transactions (NATMT & VATMT) positively contribute to banks' deposits. Hence it is visible in Table 2 and Table 3 that both NATMT and VATMT contributing to banks' deposits using Translog production function. It can be inferred that banks' adoption of ICT channels, that facilitate to bank customers, can increase the deposits of banks.

In empirical results of this paper, number and value of other e-banking channels (NEBCT and VEBCT) show a positive impact on deposits of banks. This study other e-banking channels include Internet, Call Centre and Mobile Banking. Whereas Dar (2012) delimits his approach by suggesting e-banking as a vital segment of banking industry. Positive relationship also holds for squared terms of NEBCT and VEBCT. However, the interaction terms did not show any significant result except for model with term FA × NEBCT. Number and value of real time online branches transactions (NOBT & VOBT) and their squared terms shows positive relationship with banks' deposits.

On the basis of this interpretation, a positive relationship between ICT proxies and banks deposits in Pakistan's banking industry is contrary to Solow's Paradox. These findings are in contrast to that of Iqbal, Mehmood and Ahmed (2015).

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[3]Inverted U-shaped parabola is also referred as Sad Parabola.

**OLS VS SURE**

Stucka (2002) in his study concluded that tourism proceeds have a great impact on the Croatian economy. He used two estimation techniques which are OLS and SURE for comparing demand models. He further concluded that SURE model results are more accurate estimates. The same way the results of Cadavez and Henningsen (2012) on carcass composition of lambs showed that the SURE estimation technique performed better than the OLS estimator. They argue that the parameters obtained by SURE are characterized by lower standard errors, proving SURE as a better technique than OLS. We also find the same results in our study of determining impact of ICT on bank's deposits of Pakistan that standard errors of parameters in SURE technique are lower as compare to OLS. Resultantly, it is better to confide in the results produced via SURE.

## V. CONCLUSION

The increased demand for ICT in banking industry has become inevitable. The statistical concern of over-estimated standard errors is also resolved by using SURE. It is in line with the study of Cadavez and Henningsen (2012). We concluded that SURE is a better estimation technique than OLS. Using Translog production function in addition to Cobb-Douglas production function has rendered rigor to our results. Further the results of study show that ICT have a positive impact on the output of Pakistan's banking industry. For the majority of ICT proxy variables and bank deposits the positive relation is found. This study adds to Mustafa and Mehmood (2015) by quantifying the impact of ICT whereas authors ranked banks on the basis of technical efficiency before and after digital restructuring in Pakistan.

The results of this study induce banks to increase investment in those ICT surrogates that results in increase in bank deposits in Pakistan. Further, it is suggested that banks should improve their services, increase public awareness and ensure secure banking system to increase its deposits. Further research work can be commenced in different departments of banking sector to know about the impact of ICT in that specific departments to get insight into validity of these results. Moreover, primary data and bank specific studies including the impact of education of banking staff and digital literacy can also be included in future studies.

In this study, Solow's Paradox has been ruled out in the banking sector of Pakistan, which in recent times, seems to be fading away as found in other studies as well (Abbas *et al.*, 2015; Iqbal, Mehmood, and Ahmed, 2015;

Khan, Mehmood and Sair, 2015; Mehmood, Azim and Asghar, 2013; Mehmood, Shafique and Rafaqat, 2014; Mustafa and Mehmood, 2015; among others). Perhaps it has become safer to say that, you could see the ICT everywhere and 'now' also in the productivity statistics and hence technology matters.

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