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Reforms, Incentives and Banking Sector Productivity: A Case of Nepal

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Reforms, Incentives and Banking Sector Productivity: A Case of Nepal

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Abstract:

We model banks as profit-cum-utility maximizing firms and study, *inter alia*, bankers' incentives (optimal effort) and incentive driven productivity following deregulations. Our model puts to test a panel of Nepalese commercial banks which went through deep financial reforms in the recent past. We find that (i) bankers' efforts and productivity have notably improved in Nepal, (ii) bankers' efforts significantly explain the banking sector's productivity, (iii) the proportion of non-performing loans has considerably declined, and (iv) banking services have become costly, although the bank spread has moderately declined. Our approach is different from the widely used data envelopment analysis (DEA) of bank productivity, hence complements the literature. It also informs the current policy debate in Nepal where the Central Bank is seen to be geared towards regulating the financial system and micro-managing the banking institutions.

JEL Codes: G21, G28, O43, O53.

Keywords: Reforms; incentives; productivity; panel integration; cointegration; simulation.

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1. Introduction

The world has seen sustained financial liberalization, increasing privatization and gradual loosening of capital controls since the mid-1990s. The economic thinking behind all this is that the financial entities, functioning under liberalized financial regimes, operate at higher levels of efficiency and productivity. Productivity improvements may ensue from different sources yet the notion that reforms-led private – i.e. the individual institution's – incentive is vital in enhancing productivity and growth is a fundamental one.[1] Put differently, a deregulated financial system is viewed as incentivizing institutions (in this instance banks) for higher levels of effort, productivity and profitability.

A large body of literature (Fare et al., 1994; Humphrey and Pulley, 1997; Wheelock and Wilson, 1999; Mukherjee et al., 2001; Ihsan and Hassan, 2003; Tirtiroglu, 2005; Pasiouras, 2008; Delis et al., 2011; to name but a few) examines bank efficiency and productivity following reforms and regulatory changes. They are panel as well as country-specific studies which mostly employ non-parametric data envelopment analysis (DEA) to compute various efficiency decompositions – technical efficiency, scale efficiency, efficiency change (catching up or falling behind) – and productivity growth. [2]

Whilst valuable, DEA analysis is a measure of relative efficiency with respect to the sample at hand, one cannot be confident that the banks on the efficient frontier are indeed operating optimally; instead, they may merely represent the best practices contained in the data. Whether the best practices are indeed the optimal ones are an entirely different matter. Furthermore, Wheelock and Wilson (1999; p 213) point out that efficiency evaluation through DEA could give a misleading picture, especially when the banking sector is going through major changes.[3]

This paper aims to contribute to the literature by analysing, among other things, bankers' optimal efforts (incentive) and incentive driven productivity following deregulations and reforms. Our approach differs from DEA in that we model banks as profit-cum-utility maximizing firms. We directly model bankers' optimal level of productivity rather than relative productivity, as is done under DEA. Reforms and liberalization avail opportunities and incentivize banks to optimize. It is anticipated that bankers will increase their efforts and productivity.

Our theoretical model combines banks' output technology with their optimizing behaviour. Banks' technical production function is Cobb-Douglas which is standard in the literature (Clark, 1984, 1988; Humphrey, 1991). We derive banks' 'institutional' production function, which embeds banks' profit-cum-utility maximizing optimal levels of effort, thereby capturing bankers' optimal response to institutional changes. In this setup, banking sector productivity becomes endogenous to bankers' optimal level of effort, relative input-output prices and some technical parameters.

Often, bank profitability surges following liberalization but this surge could also be realised through increased volume (quantity) of bank activities – i.e. increased volumes of deposits and credits – and bank spread (cost of bank services) rather than through the productivity gains. Therefore, the effects of financial deregulation and reforms on the cost of bank services and bank productivity remain important public policy issues.

Our analytical model is put to examine Nepalese financial liberalization and reforms. Nepal is one of the least developed and poorest countries of the world which has witnessed Maoist insurgency and the overthrow of the Monarchy in 2008. Nepal embarked on deep and far reaching banking and financial sector reforms through two episodes of liberalization implemented during 1986-89 and 1992-1994. The latter episode, in particular, opened up the country's financial sector and brought about profound structural changes to it. Although financial reforms were concluded in 1994, the activities were lacklustre until after 2000 due to the launch of armed insurgency (People's War) by the Maoists in 1996. However, since 2002 Nepal's financial system has been through fundamental changes (see Section 3). In our view, Nepalese banking sector makes an interesting test case and its scrutiny would provide important policy insights as to whether reforms have produced anticipated productivity improvements in Nepal's banking sector. This analysis is also useful in informing the current policy debate in Nepal where the Central Bank is widely perceived as intruding the free functioning of financial markets through new regulations and attempting to retract from liberal policies in order to micro-manage the banking institutions.

We employ cutting-edge econometric methods in our empirical estimations. To preview our main results, bankers' optimal level of effort, optimal bank productivity and bank profitability have considerably improved in Nepal following financial liberalization. The ratio of non-performing to total loan has considerably declined from 24.6% in 2004 to 3.4% in 2012. Formal tests show that bankers' efforts significantly explain bank productivity. Evidence also suggests that in recent years the bank spread has slightly reduced, indicating competitive pressure, yet banking services have become more costly. On the whole, financial reforms and liberalization have been a fruitful experience in Nepal.

The rest of the paper is organized as follows. We present our analytical model in the following section; Section 3 briefly outlines the financial regimes of Nepal and argues why Nepal is an interesting test case; econometric specification and data are discussed in Section 4; empirical methodologies are discussed in Section 5; empirical results are presented in Section 6; calibrations and simulation of optimal effort and productivity are discussed in Section 7; and Section 8 concludes the paper.

2. Model

Financial liberalization, among other things, frees prices. Interest (deposit and lending) rates, bankers' wages, CEOs' pay and other incentives such as bonuses, are competitively determined but there are always entry and exit restrictions in the banking industry. These restrictions are maintained by the Central Bank which may be motivated by its concerns over financial fragility and/or some notional optimal size of the banking industry in the economy. Restrictions to entry and exit have important implications because they allow banks to earn positive economic profits even in the long run.

We construct a partial equilibrium model where a representative banker, following liberalization, operates with a competitive environment and minimizes its cost function to achieve the maximum feasible level of profit. [4] The representative banker is a decision making unit (DMU) and has full flexibility and freedom in decision making. This can be viewed as the CEO of a large bank making decisions which are fully implemented by his staff.

In order to model the incentive driven productivity, we need to specify banks' production function. There are alternative ways to measure bank inputs and output in the literature. Prominent ones are the *production approach* (Berger and Humphrey, 1992) and the *intermediation approach* (Sealy and Lindley, 1997; Aly et al., 1990; Delis et al., 2011). As in Wheelock and Wilson (1999), 'a mutually exclusive distinction' between inputs and output is vital for modelling productivity hence we follow the intermediation approach. We specify that banks use three inputs, namely, labour (bank staff, N), total fixed asset (F), and total deposits (D) to produce their output (Q). Labour is measured by the number of full-time equivalent bank employees; total fixed asset is the book value of premises and other fixed assets, which is equivalent to physical capital stock; and deposits are the total deposit liabilities. Bank output is measured by total credits and investment.[5] The technical constant returns to scale (CRTS) Cobb-Douglas production function for bank output is:

$$Q = a_0(\varepsilon N)^{a_1}(F)^{a_2}(D)^{a_3} \tag{1}$$

Where $a_0 \in (0,\infty)$; $a_i \in [0,1], i = 1,2,3$ are the share parameters such that $\sum_{i=1}^{3} a_i = 1$. εN is the incentive (effort) augmented labour (N) and a_0 captures the banking technology. The parameter ε denotes the level of effort or broadly defined incentive level of a typical (representative) banker which may change in response to changes in policies and institutions. The idea is that following liberalization banks become more incentivized and increase their level of effort (quality of work). This is precisely the raison d'être of financial liberalization and reforms. Such efforts may include the banker's willingness to embark on new types of lending, investments and services which might have been restricted and/or barred hitherto. It is plausible to think that the quality of N and F may also improve due to the hiring of more qualified staff, computerization and the opening up of new branches in more strategic locations. We assume the quality of inputs and the level of effort to be positively correlated. In other words, banks invest in inputs' quality in order to increase their effort level (or make their effort more effective).

Increased banker's effort (ε) in a deregulated environment is likely to impact on banks' levels of risk. The general perception is that deregulation increases banks' risks. However, conceptually the level of risk could go either way – an aggressive lending by the banker may increase the level of risk whereas a prudent lending may do just the opposite. Since our focus is on the outcome of liberalization and deregulations – i.e. whether reforms incentivized bankers and increased banking sector productivity – the analysis is essentially an *ex post* one. Hence, we can conveniently sidestep the issue of uncertainty and capture the level of bank risk exposure through the ratio of performing to total loans (δ). The higher the δ the lower tends to be the risk exposure and vice versa. Given that the production function

(1) is homogeneous of degree one, inclusion of δ simply scales bank productivity. Any increase in performing (non-performing) loans scales up (down) the level of total factor productivity of banks and vice versa; it does not alter our analytical results which we show in the appendix. The production function in per-banker terms can be expressed as:

$$q = a_0(\varepsilon)^{a_1}(f)^{a_2}(d)^{a_3} \tag{2}$$

Where q, f, and d represent output, total fixed assets and total deposit per banker. The banker chooses the level of inputs such that the total cost (TC) of renting these inputs (i.e. the opportunity cost of owning these factors) is minimized. Let us denote the unit cost of these three inputs by $w_i, i = 1,2,3$. The banker chooses the input set (εN, F and D) in order to minimize:

$$TC = w_1(\varepsilon N) + w_2(F) + w_3(D) \tag{3}$$

subject to (1). The consolidated first order condition associated with this cost minimization problem is:

$$\frac{w_1(\varepsilon N)}{a_1 Q} = \frac{w_2(F)}{a_2 Q} = \frac{w_3(D)}{a_3 Q} \tag{4}$$

Equation (4) is the standard result in cost minimization which states that the ratio of marginal cost to marginal revenue or its reciprocal should be the same across all the inputs employed. Substituting (4) into (3) and imposing the CRTS condition, with some algebraic manipulation, the optimal total cost function is given by:

$$TC^* = \xi \prod_i w_i^{a_i} Q \tag{5}$$

where $\xi = \dfrac{1}{a_0 a_1^{a_1} a_2^{a_2} a_3^{a_3}}$, and TC^* is the minimum value function of TC in (3) subject to (1) which depends on unit input costs, the level of output and share parameters. The optimum cost of production per-banker is therefore:

$$tc^* = \xi \{\prod_i w_i^{a_i}\} q \tag{6}$$

Let p denote the market clearing price per unit of credit. Then, the total revenue per banker is:

$$tr = pq \tag{7}$$

Input and output prices that banks face tend to differ and they are likely to change differently following liberalization. We capture this by $\omega \equiv \frac{\prod_i w_i^{a_i}}{p}$, the ratio of the observed weighted input to output prices. From (6) and (7) and utilizing ω, the profit per banker is given by:

$$\pi = p(1-\xi\omega)q \tag{8}$$

The banker likes profit but dislikes effort and is mindful of the trade-off between profit and the utility cost of effort. The bankers' utility from working in the bank is defined over profits and effort levels as:[6]

$$U(\pi,\varepsilon) = \pi - \sigma\mu(\varepsilon)^{\frac{1}{\sigma}} \tag{9}$$

Where parameter $\sigma \in (0,1)$ is the elasticity of substitution between profit and effort. The marginal utility of profit is constant but the marginal disutility of effort is increasing with the higher level of effort. The relative risk aversion equivalent coefficient of this utility function is given by $\frac{\sigma-1}{\sigma}$. The μ is the disutility parameter; its value ensures that the utility function is jointly strictly quasi-concave. The representative banker chooses effort level, ε, in order to maximize (9) subject to (8) and (2). The representative banker's utility maximization problem is:

$$\begin{aligned} &\max_{\{\varepsilon\}} \quad U(\pi,\varepsilon) \\ &s.t. \quad \pi = p(1-\xi\omega)q \\ &\qquad\;\; q = a_0(\varepsilon)^{a_1}(f)^{a_2}(d)^{a_3} \end{aligned}$$

The solution to this problem gives us the optimal level of effort as:

$$\varepsilon^* = \left[\frac{1}{\mu} p(1-\xi\omega)a_0 a_1 f^{a_2} d^{a_3}\right]^{\frac{\sigma}{1-a_1\sigma}} \tag{10}$$

The variable ε^* is the optimal level of effort of a representative banker following liberalization. It depends on input and output prices, substitution parameter, technical parameters and deposits and fixed assets per banker. When the banking sector goes through reforms, the relative price of input and output – i.e. the spread – changes, which affects bankers' optimal effort (incentive) level. Substituting the optimal level of effort (10) into the technical production function (1), we get:

$$Q = BN^{\theta_1}F^{\theta_2}D^{\theta_3} \tag{11}$$

and the share parameters are

$$\theta_1 = \frac{a_1(1-\sigma)}{1-a_1\sigma} \tag{12}$$

$$\theta_2 = \frac{a_2}{1-a_1\sigma} \tag{13}$$

$$\theta_3 = \frac{a_3}{1-a_1\sigma} \tag{14}$$

In line with McMillan et al. (1989) we label (11) as the "institutional" production function of a bank which is different from the technical production function (1). Whereas equation (1) is the technical relationships between inputs and output, equation (11) additionally captures bankers' optimal responses (efforts) to regulatory changes. Although $\theta_i s$ are empirically different from a_{is} nonetheless $\sum_{i=1}^{3}\theta_i = 1$, which continues to preserve the CRTS assumption. The parameters of the technical production function, $a_i, i = 1,2,3$ and institutional production function, $\theta_i, i = 1,2,3$ are related through the substitution parameter σ.[7] The technical production function (1) contains an unobservable input, εN, whereas the institutional production function (11) is defined over all observable inputs (N, F and D). The effort parameter is now embedded into the optimal productivity parameter, B, which captures the bankers' optimal response to reforms and liberalization. The banking sector's optimal productivity parameter, B, is given by:

$$B = (a_0)^{\frac{1}{1-a_1\sigma}} (a_1)^{\frac{a_1\sigma}{1-a_1\sigma}} \left(\frac{1}{\mu}\right)^{\frac{a_1\sigma}{1-a_1\sigma}} \left[p(1-\xi\omega)\right]^{\frac{a_1\sigma}{1-a_1\sigma}} \tag{15}$$

In equation (15) the bankers' incentive driven productivity (B_{inc}) is captured by the term:

$$B_{inc} = \left[p(1-\xi\omega)\right]^{\frac{a_1\sigma}{1-a_1\sigma}} \tag{16}$$

B_{inc} is directly affected by the reform-induced changes in the input and output prices that shape the incentive structure of the banking sector. The rest of the expression on the RHS of equation (15) is a constant term which only has a scale effect on B_{inc}. Empirically, this scaling effect is close to unity (see below). If the banking sector productivity improves following liberalization, then we expect an evident positive trend in both B_{inc} and B.

3. Financial Regimes and Reforms in Nepal

Nepal is one of the poorest countries of the world with a per capita income of current US$ 619. Nepal is landlocked and sandwiched between two giants of Asia, viz. China and India with over a billion populations each. Nepal has a population of 26.40 million.[8]

Nepal has a banking history of over three-quarters of a century – the country's first ever commercial bank was established in 1937 followed by the establishment of the Central Bank in 1956. However, the financial sector was under the firm grip of the authorities until the reforms that concluded in 1994. Only two commercial banks and one development bank operated until 1984 and the financial sector was largely dormant. The appointment of government bureaucrats, often retired ones, as the banks' CEOs was the norm. Banking and financial sector policies were dominated by a socialist banking philosophy, similarly to those in India (Burgess and Pande, 2005).[9]

Nepal Rastra Bank (the Central Bank of Nepal, henceforth NRB) operated a highly controlled regime of interest rate management: "there were about 20 controlled bank rates differentiated between sectors, use of funds and types of collaterals" (NRB, 1996; p 50). The term structures of interest rates were fully controlled. A liquidity requirement of at least 25% – comprising a minimum of 5% of total deposit in government securities and a further 20% of other liquid assets including reserves at the Central Bank – was in operation. Commercial banks were barred from taking foreign currency deposits. A regime of directed credit programmes existed which made it mandatory for banks to channel as high as 25% of their total lending to the State-defined Priority Sectors, encompassing agriculture, cottage industries, exports etc. Interest rates on Priority Sector lending were always set at low levels and commercial banks were penalised if they did not meet the target of 25%.

Nepal initiated an important step towards financial openness in1984. Foreign banks, for the first time ever, were allowed to open joint venture banks (in a joint investment with Nepalese investors) in the country. This led to the establishment of three foreign joint venture banks under foreign management – Nepal Arab Bank Limited, Nepal Indo Swiss Bank, Nepal ANZ Grindlays Bank – making a total of five commercial banks. They were the sole commercial banks in operation until 1990. The openness of 1984 was followed by the first phase of financial liberalization (1986-1989) which mainly focussed on interest rate liberalization. Initially, NRB relinquished the micro management of interest rates; it only set the minimum deposit rate. Banks were also given freedom to set their lending rates, subject to an upper limit of 15% on the priority sector lending only. NRB completely deregulated its interest rate policy in August 1989 – banks and financial institutions were given a free hand in setting their deposit and lending rates at their own discretion. The statutory liquidity ratio and credit ceilings were abolished and the sale of government securities through open market operations was initiated. The first phase of liberalization was quite important in setting interest rates free to market forces, but the controls on foreign exchange and entry into and exit from the financial sector were tightly maintained.

The second phase of financial liberalization, which started in 1992, focussed on foreign exchange liberalization and further opening up of the financial sector. Nepalese currency was made fully convertible into current accounts in 1993 and measures of capital account liberalization were adopted. Exporters could retain 100% of their export earnings in foreign currencies and maintain bank accounts in convertible currencies. Commercial banks were also authorized to issue credit in foreign currencies; foreign investors could expatriate 100% profit to their habitat. The private sector could enter into the banking and financial sector with ease and with or without foreign participation.

Although the second phase of liberalization concluded in 1994, which fully opened up the financial sector, these policy reforms remained largely dormant – there was no zest in financial sector activities – until after 2000. This was due to the political instability triggered by the launch of Maoists insurgency in 1996. However, post 2000 Maoists entered into dialogue with political parties which saw the end of insurgency in 2005. Following the prospects of the end of Maoist insurgency and the ensuing peace and security, the second phase of liberalisation began to take effect since 2002. [10] This quickly led to deep structural changes and a restructuring of the Nepalese financial sector. The number of commercial banks more than doubled – from 13 in 2000 to 31 in 2013. The number of development banks has reached 88 from only seven in 2000. Furthermore, a whole host of new types of financial institutions have proliferated which either did not exist or had no significant presence pre-1994 reform. They include 69 Finance Companies, 24 Microfinance Development Banks, 16 Savings and Credit Co-operatives and 36 NGOs (financial intermediaries).[11] The old and large banks also went through deep restructuring. Nepal Bank Limited and Rastriya Banijya Bank, the two oldest and largest commercial banks of the country, respectively, had as high as 56% and 60% of their total loan portfolio classed as non-performing in 2002. Both banks had reduced their non-performing loan to around 6% by 2012. Given the scale of structural transformation and the restructuring of the banking sector following the last episode of liberalization, Nepal makes an interesting test case for the financial reforms-led productivity growth in the banking sector and we examine this through our analytical model presented in section 2.

4. Econometric Specification and Data

The analytical model presented in Section 2 derives the optimal level of incentivized effort (ε^*) of a banker which is embedded in the institutional production function (11). In order to compute bankers' incentivized optimal productivity, we need to estimate the structural parameters (θ_1, θ_2 and θ_3) of the institutional production function. The log-linearized auxiliary regression of the institutional production function, for a panel of banks, takes the following form:

$$\log Q_{it} = \alpha_i + \gamma_t + \theta_{1i} \log N_{it} + \theta_{2i} \log F_{it} + \theta_3 \log D_{it} + e_{it} \tag{17}$$

(i= 1,…,M; and t=1,…,T).

Specification (17) is a fixed effects panel model. The subscripts "i" and "t" denote the cross-sectional and time series dimensions, respectively; α_i captures the bank-specific fixed effects and γ_t captures the time effects. Since the regression is specified in logarithms, the parameters are elasticities. Equation (17) specifies parameters as bank (panel unit) specific. In the estimation we allow both for the heterogeneity (bank-specific) and the homogeneity (industry-wide) of parameters across panel units. All parameters are expected to resume positive signs *a priori* and one would expect the point estimate (elasticity) of total deposit liabilities to be by far the largest in a bank's production function.

We have collected data on Nepalese individual commercial banks' total deposits (D), total loans and advances (L), investments (I), fixed assets (F), interest expenses on deposits (RE), interest income (RY), bank staff (N), staff expenses (NE), other operating expenses (OE) and operating profit (π). As of 2013, 31 commercial banks are in operation in Nepal but 14 of them are new: they came into operation in 2007 or later. These 14 new banks, due to their very short data length, could not be considered for any credible econometric analysis. Furthermore, most of these new entrants have yet to consolidate their banking activities. Of the remaining 17 banks, we have obtained complete and consistent quarterly data for 12 banks covering a sample period of 11 years – 2002(1) to 2012(1). [12] The choice of this sample period is deliberate to focus on the most intense period of banking activities following liberalization. As stated above, policy reforms remained largely dormant until the cessation of Maoists insurgency that began in 2002 and the insurgency ended in 2005 hence the choice of the sample. Our data set consists of an unbalanced panel of 12 banks with 420 quarterly observations. They are the major commercial banks of Nepal accounting for about 70% of the banking activities of the country. Analysis of this sample of banks is deemed sufficient to discern whether reforms and liberalization have incentivized bankers in Nepal and whether the banking sector productivity has improved. All data series have been directly obtained from the office of the Governor of NRB. [13] The relevant nominal variables are deflated by CPI as the deflator. [14]

5. **Empirical Methodology**

Macro-panel data of this nature are widely reported to be non-stationary (unit root) processes (see, among others, Luintel et al., 2008) requiring an application of non-stationary panel data econometrics in estimating the parameters of (17). Panel unit root and panel cointegration tests are shown to have better power properties than the time series tests in small or moderate samples.

A number of panel unit root tests are proposed in the literature which can be summarized as the first and second generation tests. The former assume cross-sectional independence – a prickly issue in macro panel data – while the latter allow for cross-sectional dependence. The frequently applied first generation panel unit root tests in the empirical literature include those of Im, Pesaran and Sin (2003; hereafter IPS), Fisher-ADF (Maddala and Wu, 1999) and Hadri (2000). The IPS test tests the null of a unit root for each cross-sectional unit against the alternative that only a fraction of cross-sectional units may contain a unit root. This test does not maintain stationarity across all groups under the alternative hypothesis. Further, it also allows for the heterogeneity of persistence, dynamics and error variance across groups.

The Fisher-ADF test employs the p-values of a unit root test. Under the null of a unit root for all M (cross-sectional) units, the quantity: $\sum_{i=1}^{M}\log(\psi_i)$ is asymptotically χ^2_{2M}; where ψ_i is the p-value of the unit root test on the ith series of the ith panel unit. Hadri's test tests the null of stationarity against the alternative of a unit root; a common persistence parameter is assumed across all cross-sectional units. Hadri also derives autocorrelation and heteroskedasticity consistent LM tests under the null of stationarity. Hlouskova and Wagner (2006), however, warn that Hadri's tests suffer from size distortion in the presence of autocorrelations.

The second generation tests are relatively new and are gaining momentum in empirical applications for obvious reasons. Gengenbach et al.(2010) show that the cross-sectionally augmented IPS (CIPS) test (Pesaran, 2007) is one of the powerful second generation panel unit root tests. This test accounts for both cross-sectional dependence and residual serial correlation while testing for the null of a unit root. For the sake of robustness, we employ IPS, Fisher-ADF, Hadri and the truncated CIPS tests on each of the data series of our panel.

Pedroni (1999) and Kao (1999), among others, propose panel cointegration tests to explore if non-stationary panel data form a linear cointegrating (long-run equilibrating) relationship. They are residual-based tests of cointegration – extensions of the time series tests of Engle and Granger (1987) on panel settings. Pedroni (ibid.) proposes seven tests of panel cointegration – four of them are within-dimension tests that assume homogeneous cointegrating vectors across panel units and the remaining three are between-dimension tests (referred to as Group Mean Statistics), which allow for heterogeneous cointegrating vectors across panel units. The between-dimension estimators exhibit lower size distortions than the within-dimension estimators and the group t-statistic is shown to be the most powerful one amongst the three between-dimension panel cointegration tests (Pedroni, 2004). The Kao (1999) test is similar to Pedroni's tests except that Kao allows for heterogeneous intercepts but assumes homogeneous slope parameters across panel units. We report a range of cointegration tests proposed by Pedroni (1999) and Kao (1999) so that we could reach a robust conclusion on the cointegrating relationship vis-à-vis our institutional production function.

The OLS level regressions, employed to test cointegration in the panel, are not informative of the significance or otherwise of the cointegrating vectors because of the well-known inference problems (cf. Engle and Granger, 1987). Therefore, we estimate the cointegrating parameters through Fully Modified OLS (FMOLS; Phillips and Hansen, 1990) and Dynamic OLS (DOLS; Stock and Watson, 1993; Kao et al., 1999).

6. Empirical Results

Results of panel unit root tests are reported in Table 1. The first three columns pertain to the first generation of panel unit root tests. The IPS and ADF-Fisher tests do not reject the null of a unit root for any of the level series in the panel. Hadri's test decisively rejects the null of level stationarity. Both types of first generation tests (those testing the null of a unit root and the null of stationarity) reveal that our panel data is non-stationary. This is further confirmed by the CIPS – a second generation – test which accounts for cross-sectional dependence. CIPS tests cannot reject the null of unit root for any of the data series in our panel. The results in Table 1 are based on the most general specifications that include cross-section-specific intercepts and linear trends. All individual series in the panel are found to be first-difference stationary, signifying that our panel data series are unit root processes.[15]

Table 1 about here

Table 2 reports the results of panel cointegration tests on bankers' institutional production function (11). Both the between-dimension and the within-dimension tests proposed by Pedroni (1999) are reported. These tests are performed under two deterministic settings including: (i) bank-specific constant only, and (ii) bank-specific constants and linear time trend. We also report the panel cointegration tests proposed by Kao (1999) for the sake of robustness. We attach more importance to the between-dimension tests and, particularly, the $t_{Pedroni} - test$, which is shown to have better power properties.

Table 2 about here

The null of non-cointegration of bankers' log linearised institutional production function (17) is decisively rejected by all the tests reported in Table 2. The precision of these tests is very high and the results are robust to different test methods that vary considerably in their underlying assumptions. Overall, there is strong empirical support for the bankers' institutional production function as a long-run equilibrium relationship.

Estimates of the cointegrating parameters (vectors) are reported in Table 3. Results show that two covariates of institutional production function, namely, the bank staff and the total deposit liabilities appear positively signed and highly significant across all specifications, which is consistent with *a priori* expectations. The stock of total fixed assets, however, shows mixed results. It appears positive and statistically significant under pooled (within-dimension) estimators but insignificant under grouped (between- dimensions) estimators. The insignificance of total fixed assets is somewhat surprising but this may be partly explained by the relative constancy (the lack of sufficient variation) of fixed assets in these banks.[16]

Table 3 about here

One of the fundamental assumptions of our analytical model is that the bankers' production function follows CRTS. We explicitly test this restriction and report the results in row $\Re_1$. In no case is the CRTS restriction rejected by the data. We re-estimate two (Grouped) specifications by dropping the insignificant $\log F_{it}$ variable and re-assessing the CRTS assumption. Results show that CRTS is maintained.

On balance, one would prefer the between-dimension FMOLS estimates of industry-wide parameters because they allow share parameters to differ across individual banks. The within-dimension (Pooled) estimates treat the share parameters as being the same across all banks. In view of the significance of all three covariates, we report simulation results based on the pooled FMOLS estimates. However, the qualitative nature of our simulation results is robust, irrespective of the set of parameter used.

It is important to note that although the CRTS is not rejected statistically, the sum of the point estimates of the within-dimension estimates under FMOLS amounts to 1.049 rather than 1.0 but we need parameters to sum exactly to unity for simulations. Since the sum of these point estimates is 4.9% higher than unity, we scaled down all three parameters by 4.9% each and tested whether this restriction is data acceptable. Indeed, we find the scaled down parameters of $\theta_1 = 0.057$, $\theta_2 = 0.027$ and $\theta_3 = 0.916$, which sum to unity, are data acceptable – a test of these parametric restrictions as the cointegrating vector generates a p-value of $\chi^2(3) = 0.110$ under the null. We use these data congruent parameters which pass CRTS restrictions and sum to unity for simulations.[17]

7. Bankers' Incentive and Bank Productivity

In order to simulate the bankers' optimal level of effort (10) and the incentivized optimal productivity (15), we need solutions for the parameters of technical production function (1) - $a_{0,}a_1, a_2, a_3$; the elasticity of substitution, σ; the disutility parameter, μ; and the series of input and output prices – w_1, w_2, w_3 and p. We use the CRTS consistent estimates of $\theta_1 = 0.057$, $\theta_2 = 0.027$ and $\theta_3 = 0.916$ as the structural parameters of our institutional production function (11). Given the restriction $\sigma \in (0,1)$, some iteration reveals that for $\sigma \in [0.40, 0.55]$ the system converges, hence we use $\sigma = 0.51$. The parametric value of $\sigma = 0.51$ combined with equations (12), (13) and (14) and the point estimates of $\theta_i s$ provide solutions: $a_1 = 0.110$, $a_2 = 0.025$ and $a_3 = 0.865$. The remaining parameters ξ and a_0 are related through the equilibrium condition $\xi = \dfrac{1}{a_0 a_1^{a_1} a_2^{a_2} a_3^{a_3}}$. Since all denominators are constants, we set $a_0 = 1$ which gives $\xi = 1.586$.[18] The disutility parameter has a scale effect on the optimal level of effort (ε^*) and productivity (B). Simulations conveniently converge for $\mu \in [0.09, 0.4]$ hence we employ $\mu = 0.10$.[19]

The marginal cost of bank staff (w_1) is proxied by the average hourly wage rate of a banker in 12 sample banks. Each bank employee is assumed to work 40 hours per week and there are 48 bank working weeks per year giving, on average, 12 bank working weeks per quarter.[20] However, the simulated results remain robust to hourly wages based on 36-44 working hours per week and/or 13 weeks per quarter. The unit cost (shadow price) of total fixed assets (w_2) for the ith bank is taken to be the deposit weighted market (market for the ith bank is defined as all the banks in the sample except the ith bank) interest (one year fixed deposit) rate. The unit cost of deposits (w_3) is the average deposit rate (total interest payment on deposits/total deposits) for each bank. The unit output price (p) is computed as the ratio of loan interest income over total bank loan (i.e. the average unit price of a loan). Using the above parameter values and input-output prices, we simulate, among others, bankers' optimal level of effort, effort driven productivity, average input cost and revenue per unit of bank output, and the spread for the banking industry.

Figure 1 plots the banking sector's average input cost per unit of output, average output price and the bank spread expressed as profit per unit of output. The average input cost per unit of output is calculated as $\xi\{\prod_i w_i^{a_i}\}$ from equation (6) and the average output price (p) is as defined above. These average unit cost-price measures are per Nepalese rupee of bank output (i.e. the rental cost of inputs to produce one rupee of bank output and the price of that output).[21] Commercial banks' average cost and price per unit of output have changed over the years – both have increased. Plots indicate that the bank spread (profit per unit of output) declined during 2003(3) - 2004(4); it then slightly picked up in 2005(1) and remained at a higher level until 2006(4); subsequently it narrowed down a little until 2010(4) and again slightly opened up thereafter. Our calculations show an average spread of 3.25 percentage points for the whole period (2003-2011); 3.3 percentage points for 2003-2008 and 3.17 percentage points for 2009-2011. Nepalese commercial banks' spread appears to have narrowed down in recent years indicating competitive pressure. One striking feature is that since 2008(4) the bank spread has become smaller than the input cost per unit of output. This suggests that while banks have managed to hold on to their spread by transmitting costs to their customers, the banking services in general have become considerably more expensive in Nepal in recent years. The overall cost of banking, measured by the average cost and price per unit of bank output, shows a positive upward trend in recent years.

Bankers' optimal effort index, plotted in Figure 2, shows some fluctuations, but the overall trend is clearly an upward one. During the initial years (2004-2006), the optimal effort index shows a sharp rise but it decelerates quite sharply for a brief period from 2007(1) - 2007(4). The effort index then recovers and shows a rapid rise since 2009(3). Overall, the optimal level of bankers' effort appears to have increased by 43% by the end of 2011 compared to its level in 2004. Plots also reveal that the banks' actual profit increases sharply, peaking at 70% higher in 2010 than its 2004 level. The index of actual output (loans and investment) peaks during 2008-2009 at 46% higher than its 2004 level. The bank output index decelerates during 2009(3) - 2010(1) and then shows signs of slow recovery thereafter. The profit index takes a dip in 2010(3). These recent declines in output and profit indices are due to the slump in

Nepal's real estate market which began in 2008 and has yet to turn its corner. Despite some dents in profitability, the optimal effort index shows a continuous rise.

The banking sector's total optimal incentivized productivity (B) is plotted in Figure 3. We also plot the unscaled component of B, which is B_{inc}, just to illustrate that scaling really does not matter. In fact, the scaling factor on the RHS of equation (15) resumes a value of 1.005, which implies that the role of technical parameters in our measure of incentive (effort) driven optimal productivity is virtually nil (these parameters are treated as fixed). The optimal productivity shows a clear positive trend during 2003(1) - 2006(4) with a sharp blip in 2006(1); productivity seems to have flattened thereafter until 2009(1) and shows some movement from 2010(1). The sharp rise in banking sector productivity is credited to the Peace Accord of 2005 between the war waging Maoists and the political parties of Nepal which effectively ended the People's War. Cessation of Maoists' insurgency reduced uncertainty which led to sharp upturn in productivity. [22] This also paved the way to the first ever election of the Constituent Assembly in Nepal. Although productivity growth has been minimal since 2006(4), nonetheless, it increased by almost 12 percentage points by 2007 and beyond, compared to its 2003 level.

The derivation of incentive driven optimal productivity (B) treats technical parameters as constants.[23] However, technology changes over time. It is, therefore, important to establish what proportion of the banking sector TFP (total factor productivity), measured by Solow residuals using the CRT consistent θ_s, is accounted for by the bankers' incentive-driven optimal productivity. Figure 4 plots the proportion of TFP accounted for by the incentive-driven productivity (B). The plot shows that the proportion of TFP accounted for by incentive-driven productivity is somewhat oscillatory, yet it shows a positive trend. The proportion of TFP accounted for by B increased from below 23% to above 26% during 2003-2011 – the sample average is 24.75%.

A comparison of the optimal effort index (in Figure 2) and optimal bank productivity (in Figure 3) reveals that during the initial years (2004-2006) both bankers' efforts and bank productivity went hand-in-hand; they increased. However, during 2007(1) - 2007(4), the effort index declines rather sharply which coincides with some decline in bank productivity. However, the effort index shows a rapid rise since 2009(3) which does correspond to some productivity gains but the association appears much weaker than those witnessed during 2004-2006. It is hard to elucidate why this apparently close association between bankers' efforts and bank productivity waned post 2009(3). One possible explanation, however, is that after some initial years of productivity push, bankers' effort may have focussed on quantity (volume). This is borne out by the sharp rise in the volumes of deposits and credits post 2010(2) which are plotted in Figure 5. These sharp rises in deposits and credits are at the backdrop of fall in their volumes during 2008(3) - 2009(4).

Finally, we formally test if the bankers' effort statistically explains the incentivized productivity by regressing the index of optimal total productivity on the index of bankers' effort. Both OLS and Instrumental Variables estimates reveal that bankers' effort significantly explains the optimal bank productivity. A 10% increase in bankers' effort increases the banking sectors' optimal total productivity by roughly 0.6%.[24]

8. Conclusion

A large body of literature examines whether banking sector efficiency and productivity improves following financial deregulation and reforms. The literature mainly employs data envelopment analysis (DEA). However, DEA only measures relative efficiency and it is not clear whether banks on the efficient frontier are indeed operating optimally. This paper develops an analytical framework that takes the study of deregulation (reforms) and banking sector productivity beyond the realm of DEA. We model commercial banks as profit-cum-utility maximizing firms and analytically derive, *inter alia*, bankers' optimal level of effort and optimal productivity which are of policy relevance following liberalization and reforms. We apply our model to scrutinize a panel of Nepalese commercial banks and evaluate if deregulations and reforms have worked in Nepal. Nepal concluded her deep financial reforms in 1994. However, due to Maoist insurgency and political instability, these policy reforms started to take effect since 2002 only which quickly and deeply transformed the country's banking and financial system.

Our analysis provides important insights on deregulations, reforms and banking sector productivity in Nepal. The main findings can be summarized as follows. First, we find that financial liberalization has made Nepalese bankers more incentivized (effort oriented) – evidence shows a clear rise in the level of bankers' efforts following liberalization. Nepalese bankers' optimal level of effort has increased considerably (by 43% during 2004-2011) and it is on the rise. Second, the banking sector's incentive-driven productivity rose markedly until 2007 (by 12% during 2003-2007) but the productivity growth has since slowed down significantly. The association between the optimal levels of effort and optimal productivity seemed very close in early years but appears to have weakened since 2008; it is hard to explain why this is so. However, *prima facie* evidence suggests that after the initial years of productivity push, bankers appear to have focussed on quantity (volume) rather than quality (productivity). Third, despite the weaker association in the latter period of sample, formal tests show that the bankers' optimal effort significantly explains the banking sector's optimal productivity in Nepal. Our calculations show that incentive-driven productivity accounts for about a quarter (24.75%) of banking sector TFP (measured by Solow residuals) in Nepal. The proportion of non-performing loans to total loans has declined from 24.0% in 2003 to less than 4.0% in 2012.

Finally, we find that Nepalese banks earned an average bank spread (profit per unit of bank output) of 3.25 percentage points during the sample period but this has slightly declined in recent years (3.17 percentage points) perhaps reflecting the competitive pressure. However, a downside is that the banking services in Nepal have become costly in recent years – the average cost and price per unit of bank output has increased notably. The latter is, however, not unexpected, given that deregulation abolishes authorities' control on interest rates and various concessionary lending programmes. Overall, financial liberalization and reforms have been a good experience for Nepal, especially from the perspectives of more incentivized (effort-oriented) bankers, increased optimal productivity and higher volume of deposits, credit and bank profitability. In the light of these findings, any attempt by the authorities to retract from liberalist policies may do more harm than good.

Table 1: Results of Panel Unit Root Tests

	IPS [W-Stat]	ADF-Fisher [Chi-Square]	Hadri [Consistent Z-stat]	CIPS
lnQ	0.898	0.374	0.000	-0.246
lnN	0.914	0.930	0.000	-0.164
lnF	0.326	0.401	0.000	-0.360
lnD	0.542	0.369	0.000	-0.371

For all tests, except for the CIPS, P-values under the null are reported. For CPIS t-ratios are reported. The 5% critical value for the CIPS test for T/M (200/15) is -2.25; where T is the sample size and M is the cross-section units. The null under all test statistics, except that of Hadri, is unit root; the latter tests the null of stationarity. The sample consists of 420 unbalanced panel observations. In all tests, constant and linear time trends are included as exogenous variables. Given the quarterly data, the lag length is set to 4 for all tests except the CIPS where second order lag is used. CIPS requires lead and lag augmentations. W-Stat is the standardized $\bar{t}_{NT}$ test of IPS. ADF Fisher tests are χ^2 (24)-distributed. The Hadri test is computed using Newey-West bandwidth selection and Bartlett kernel; heteroskedasticity-consistent Z-statistics are reported. CIPS is the cross-sectionally augmented IPS tests (a second generation test). The variable mnemonics are: lnQ = log of real total loan and investment (output measure), lnN = log of number of bank staff, lnF = log of total fixed assets in real terms; lnD = log of total deposits in real terms.

Table 2: Results of Panel Cointegration Tests

	Between Dimension (Group Mean)		Within Dimension (Pooled)	
	α_i	α_i & γ_t	α_i	α_i & γ_t
$\rho_{Pedroni} - test$	-4.835(0.000)[a]	-2.995(0.001) [a]	-6.146(0.000) [a]	-4.817(0.000) [a]
$t_{Pedroni} - test$	-11.922(0.000) [a]	-12.732(0.000) [a]	-9.755(0.000) [a]	12.839(0.000) [a]
$t_{KAO} - test$	NA	NA	-19.183(0.000) [a]	NA

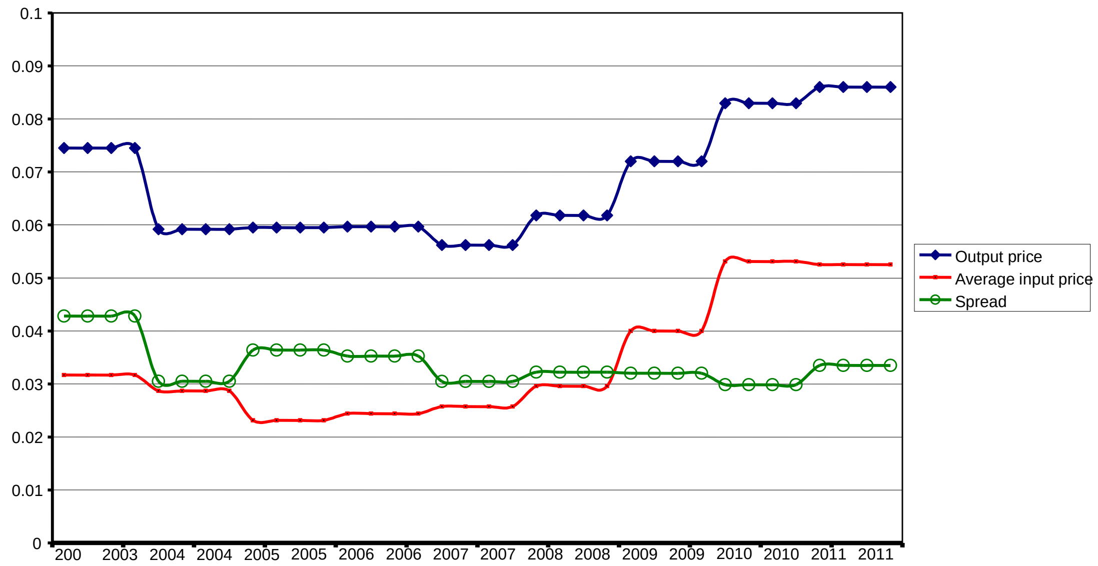
$\rho_{Pedroni} - test$ and $t_{Pedroni} - test$ are panel rho- and ADF-statistics of Pedroni (1999); $t_{KAO} - test$ is the ADF_t-statistic of Kao (1999). Columns α_i and α_i & γ_t indicate the deterministic component in the model, namely, constants (fixed effects) only, and constants and linear time trends. Lag lengths are based on SIC information criteria. Superscripts "a" denote significance at 1% or better. Kao test statistics are a within-dimension test which allows fixed effects only, hence NAs in three columns.

Table 3: Estimated Cointegrating Parameters

	$\log Q_{it} = \alpha_i + \gamma_t + \theta_1 \log N_{it} + \theta_2 \log F_{it} + \theta_3 \log D_{it} + e_{it}$ (11)					
	FMOLS			DOLS		
	Grouped		Pooled	Grouped		Pooled
θ_1	0.146[a] (0.000)	0.115[a] (0.005)	0.060[b] (0.050)	0.214[a] (0.002)	0.136[a] (0.005)	0.060[b] (0.041)
θ_2	-0.013 (0.673)	-	0.028[b] (0.039)	-0.053 (0.240)	-	0.033[a] (0.010)
θ_3	0.888[a] (0.000)	0.891[a] (0.000)	0.961[a] (0.000)	0.800[a] (0.000)	0.848[a] (0.000)	0.937[a] (0.000)
$\Re_1$	0.686	0.900	0.126	0.625	0.758	0.344

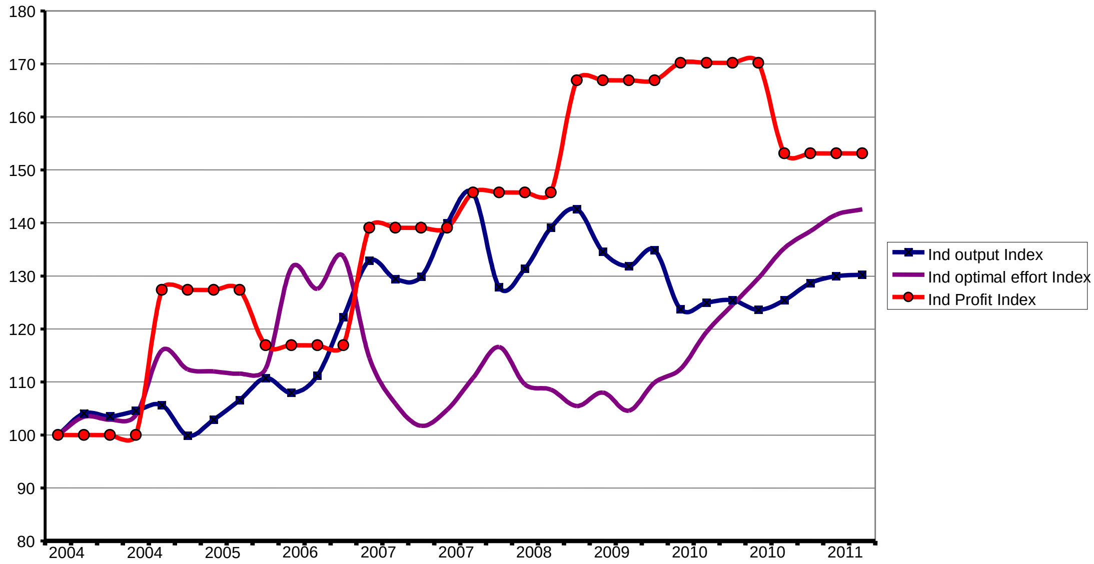
FMOLS is the fully Modified OLS of Phillips and Hansen (1990) as shown in Panel setting by Pedroni (2001). DOLS is the Dynamic OLS as described in Kao et al. (1999). Given their significance, both deterministic terms (bank specific constants and linear time trends) are retained in the estimation. Figures within parentheses (.) are p-values under the null. $\Re_1$ reports the P-values of the test of the null of CRTS, i.e., $\theta_1 + \theta_2 + \theta_3 = 1$; the test statistic is $\chi^2(1)$ distributed. Under the between-dimension specifications $\log F_{it}$ appears insignificant; we also report results excluding this insignificant covariate. Superscripts "a" and "b" denote significance at 1% and 5% or better.

Figure 1: Average input cost, output price and spread (industry); Paisa per Rupee of output.



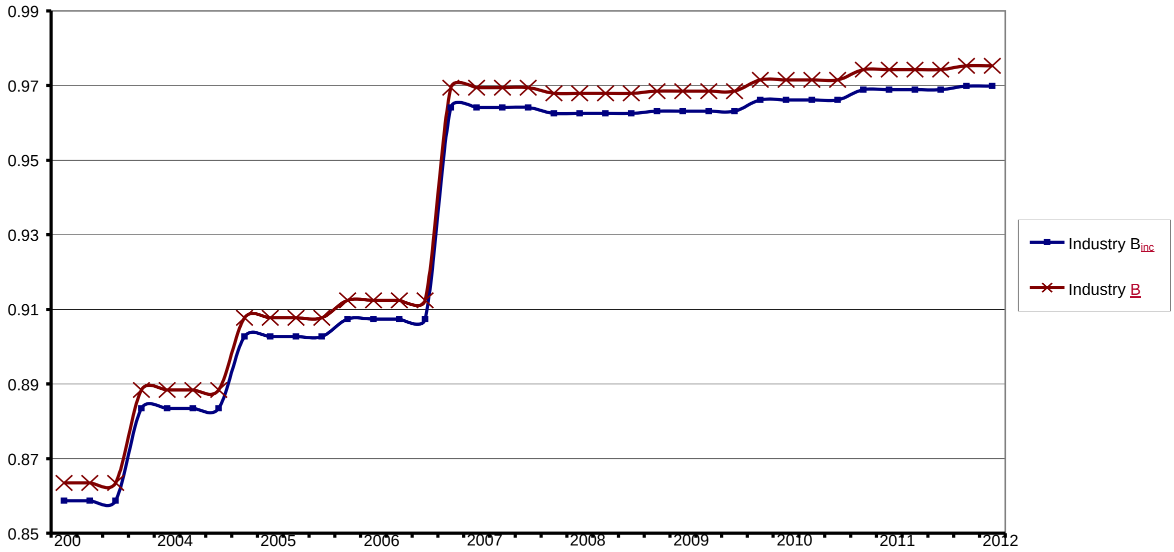
Industry implies the banking sector, comprised of 12 sample banks. The average input cost per unit of output is calculated as $\xi\{\prod_i w_i^{a_i}\}$ from equation (6). The average output price is the average loan rate computed as the ratio of loan interest income over total bank loan. The average input cost, output price and spread (profit) are per unit of bank output. In the vertical axis 0.1 means ten paisa. One Nepalese rupee consists of 100 paisa.

Figure 2: Industry optimal effort index (2004=100), actual output index and actual profit Index.



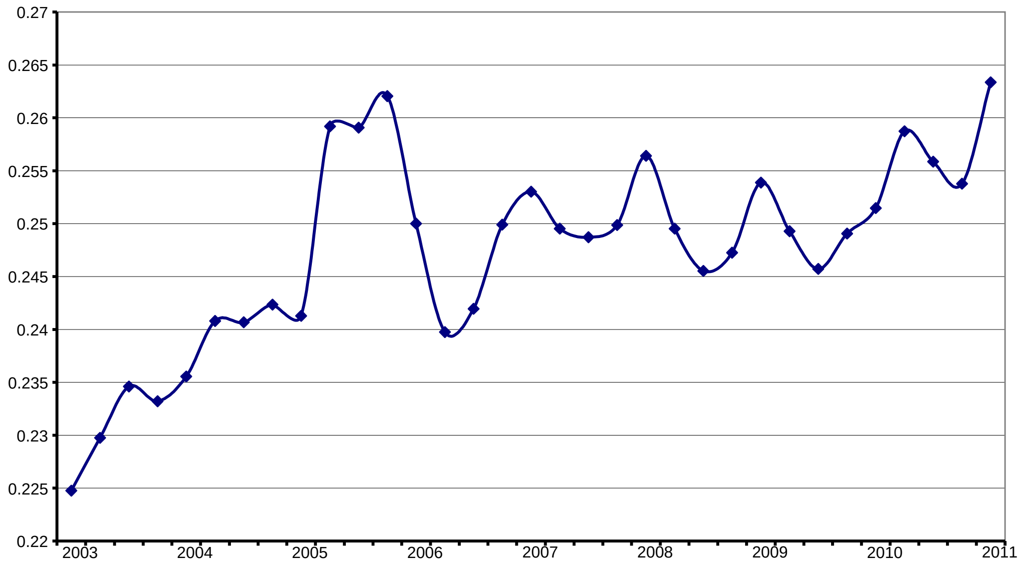
Industry implies the banking sector comprised of 12 sample banks. Output and profit index are actual figures for the banking sector. The optimal effort index is the simulated series, equation (10).

Figure 3: Banking Sector's Optimal Productivity: (B) and (B_{inc})



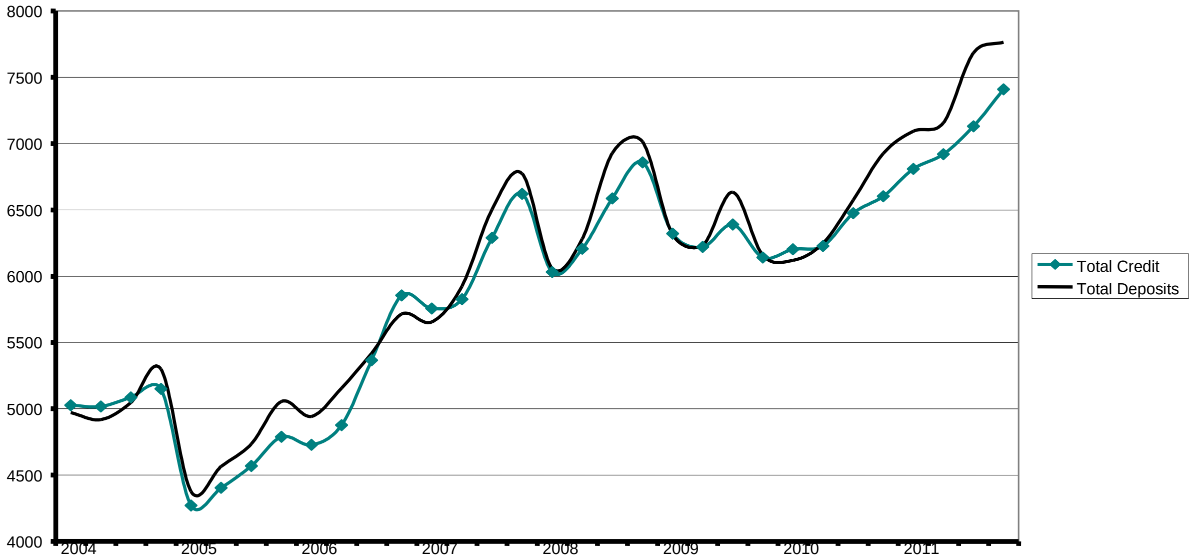
The banking industry implies 12 sample banks. The banking sector's optimal productivity (B) is as in equation (15) and unscaled, B_{inc} , as in equation (16). Plots are absolute figures not indices.

Figure 4: Proportion of TFP (measured by Solow Residual) explained by the incentive-driven productivity (B).



The industry implies the banking sector comprised of 12 sample banks. The banking sector's Solow Residual-based TFP is computed using the θ parameters of institutional production function (equation (11)). The incentive driven optimal total productivity, B, is defined in equation (15).

Figure 5: Total Credits and Deposits of Commercial Banks, Millions of Rupees (2004-2012).



The industry implies a banking sector comprised of 12 sample banks. Plots are actual total deposits and credits of 12 sample banks.

Appendix:

We capture the *ex post* riskiness of banks by the ratio of performing to total loans, $\delta \in (0,1]$; where $(1-\delta)$ is the proportion of non-performing loans. Since the production function (1) is homogeneous of degree one, it takes the following form:

$$\widehat{Q} = (a_0\delta)(\varepsilon N)^{a_1}(F)^{a_2}(D)^{a_3} \qquad (1A)$$

Where, as before, $a_0 \in (0,\infty)$; $a_i \in [0,1], i = 1,2,3$ and $\sum_{i=1}^{3} a_i = 1$. A 'hat' denotes that the relationship accounts for δ. A high proportion of non-performing loans, $\delta \to 0$, scales down the total factor productivity, whereas a high proportion of performing loans, $\delta \to 1$, scales the total factor productivity up. When non-performing loans are zero, $\delta = 1$; and (*1A*) collapses to equation (1). The production function, (*1A*), per banker is:

$$\widehat{q} = (a_0\delta)(\varepsilon)^{a_1}(f)^{a_2}(d)^{a_3} \qquad (2A)$$

The cost minimization problem for the bank remains unchanged. From (5), we have:

$$TC^* = \widehat{\xi}\left\{\prod_i w_i^{a_i}\right\}\widehat{Q} \qquad (5A)$$

where $\widehat{\xi} = \dfrac{1}{(a_0\delta)a_1^{a_1}a_2^{a_2}a_3^{a_3}}$. The optimum cost of production per banker is:

$$tc^* = \widehat{\xi}\left\{\prod_i w_i^{a_i}\right\}\widehat{q} \qquad (6A)$$

The total revenue and profit per banker are same as in (7) and (8), except that now $q = \widehat{q}$, and $\xi = \widehat{\xi}$. Bankers' utility function remains unchanged, and the solution to the optimal level of effort is:

$$\widehat{\varepsilon}^* = \left[\frac{1}{\mu} p(1-\widehat{\xi}\omega)(a_0\delta)a_1 f^{a_2} d^{a_3}\right]^{\frac{\sigma}{1-a_1\sigma}} \qquad (10A)$$

Substituting (10A) in (1A), the institutional production function of a bank is:

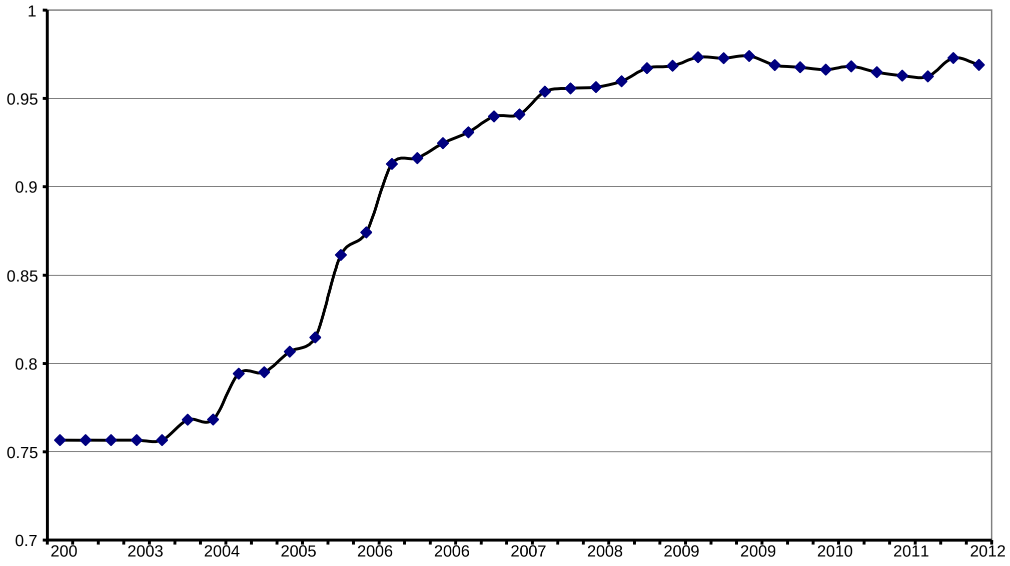
$$\widehat{Q} = \widehat{B}N^{\theta_1}F^{\theta_2}D^{\theta_3} \qquad (11A)$$

The banking sector's optimal productivity coefficient, $\widehat{B}$, is given by:

$$\widehat{B} = (a_0\delta)^{\frac{1}{1-a_1\sigma}}(a_1)^{\frac{a_1\sigma}{1-a_1\sigma}}\left(\frac{1}{\mu}\right)^{\frac{a_1\sigma}{1-a_1\sigma}}\left[p(1-\widehat{\xi}\omega)\right]^{\frac{a_1\sigma}{1-a_1\sigma}} \qquad (15A)$$

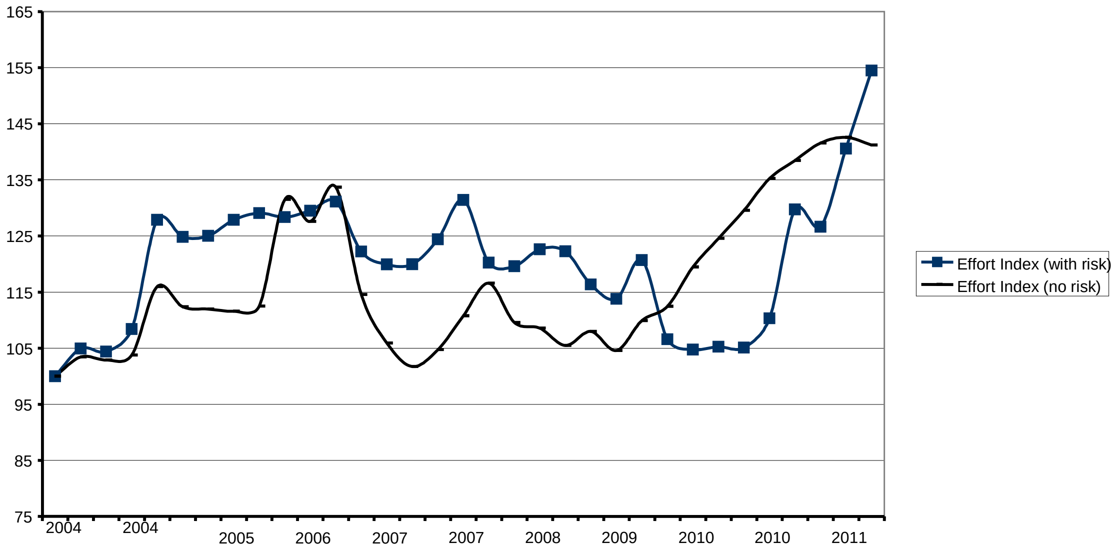
It is evident that the inclusion of an *ex post* measure of risk (δ) does not change our analytical results, except the pure scaling effects. In Figure A1 we plot the industry δ which improved quite rapidly in initial years and has stabilised since 2007. The ratio of performing loans has significantly improved in Nepal from 76% in 2003 to almost 97% in 2012. Put differently, the ratio of non-performing loans has gone down from 24% to less than 4%, which is a substantial improvement in the health of the banking sector. When the bank risk, measured by the non-performing loan ratio, goes down, both bankers' optimal effort and bank productivity goes up and it also improves their net profit margin, [$p\left(1-\hat{\xi}\omega\right)$]. Figure A2 plots the productivity indices computed from equations (15) and (15A). The later plot shows sharp rise reflecting the improving proportion of performing loans. In Figure A3, banks' optimal productivity (level) with and without δ is plotted. The index of optimal productivity with δ shows relatively sharper trend again reflecting the improvements in the proportion of performing loans.

Figure A1: Ratio of Performing to Total Loans (δ Industry)



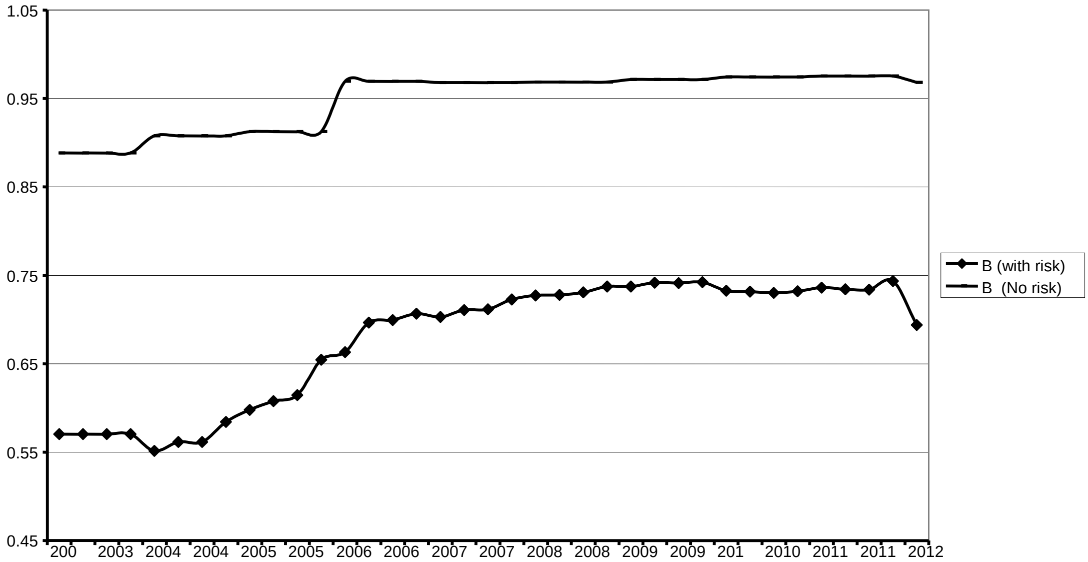
The industry implies the banking sector is comprised of 12 sample banks.

Figure A2: Optimal Effort (ε^*) with and without risk (δ)



Risk (δ) is measured by the proportion of performing to total bank loans. The proportion of non-performing loans is $(1-\delta)$. We apply time varying δ in computing effort index with risk.

Figure A3: Optimal Productivity (B) with and without risk (δ)



Please refer to notes for Figure A2.

References

Aly, H. Y., R. Grabowski, C. Pasurka, and N. Rangan (1990) "Technical, scale and allocative efficiencies in US banking: An empirical investigation", *The Review of Economics and Statistics*, 72, 211-218.

Berger, A.N., and D.B. Humphrey (1992) "Measurement and Efficiency Issues in Commercial Banking", in Z. Griliches (ed.), Output Measurement in the Service Sectors, *National Bureau of Economic Research*, Studies in Income and Wealth, Vol. 56, University of Chicago Press (Chicago, IL), 245-279.

Burgess, R. and R. Pande (2005) "Do Rural Banks Matter? Evidence from Indian Social Banking Experiment", *American Economic Review*, 95(3), 780-795.

Clark, J. (1984) "Estimation of Economies of Scale in Banking Using a Generalized Functional Form", *Journal of Money, Credit, and Banking*, 16, 53-68.

Clark, J. (1988) "Economies of Scale and Scope at Depository Financial Institutions: A Review of the Literature", *Federal Reserve Bank of Kansas City Economic Review*, 73, 16-33.

Delis, M. D., P. Molyneux and F. Pasiouras (2011) "Regulations and Productivity Growth in Banking: Evidence from Transition Economies", *Journal of Money, Credit and Banking*, 43(4), 735-764.

Engle, R. F and C. J. Granger (1987) "Co-integration and Error Correction: Representation, Estimation, and Testing", *Econometrica*, 55(2), 251-276.

Fare, R., S. Grosskopf, M. Norris and Z. Zhang (1994) "Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries", *The American Economic Review*, 84(1), 66-83.

Gengenbach, C. F. Palm and J. Urbain (2010) "Panel Unit Root Tests in the Presence of Cross-Sectional Dependencies: Comparison and Implications for Modelling", *Econometric Reviews*, 29(2), 111-145.

Hadri, K. (2000) "Testing for stationarity in heterogeneous panel data", *Econometrics Journal* 3(2), 148-161.

Hlouskova, J. and M. Wagner (2006) "The performance of panel unit root and stationarity tests: results from a large-scale simulation study". *Econometric Reviews* 25(1), 85-116.

Humphrey, D. B. (1991) "Productivity in Banking and Effects from Deregulation" *Economic Review,* Federal Reserve Bank of Richmond, March/April: 16-28.

Humphrey, D. B. and L. B. Pulley (1997) "Bank's responses to deregulation: profits, technology, and efficiency", *Journal of Money, Credit and Banking*, 29, 73-93.

Ihsan, I. and M. Hassan (2003) “Financial deregulation and total factor productivity change: An empirical study of Turkish commercial banks”, *Journal of Banking & Finance*, 27(8), 1455-1485.

Im, K. S., Pesaran, H. and Shin, Y. (2003). “Testing for unit roots in heterogeneous panels”, *Journal of Econometrics* 115(1), 53-74.

Kao, C. (1999) “Spurious regression and residual-based tests for cointegration in panel data”, *Journal of Econometrics*, 90(1), 1-44.

Kao, C., M-H. Chiang and B. Chen (1999) “International R&D Spillovers: An Application of Estimation and Inference in Panel Cointegration”, *Oxford Bulletin of Economics and Statistics* (61), 693-711.

Luintel, K. B., M. Khan, P. Arestis and K. Theodoridis (2008) “Financial Structure and Economic Growth”, *Journal of Development Economics*, 86(1), 181-200.

Maddala, G. and S. Wu (1999) “A comparative study of unit root tests with panel data and a new simple test”, *Oxford Bulletin of Economics and Statistics* 61(S1), 631-652.

McMillan, J., J. Whalley and L. Zhu (1989) “The Impact of China’s Economic Reforms on Agricultural Productivity Growth”, *Journal of Political Economy*, 97 (August), 781-807.

Mukherjee, K., S. C. Ray and S. Miller (2001) “Productivity growth in large US commercial banks: The initial post-deregulation experience”, *Journal of Banking & Finance*, 25(5), 913-939.

Nepal Rastra Bank, “40 Years of Nepal Rastra Bank”, Kathmandu, April 1996.

Pasiouras, F. (2008) “International evidence on the impact of regulations and supervision on banks’ technical efficiency: an application of two-stage data envelopment analysis”, *Review of Quantitative Finance and Accounting*, 30(2), 187-223.

Pedroni, P. (1999) “Critical values for cointegration tests in heterogeneous panels with multiple regressors”, *Oxford Bulletin of Economics and Statistics*, 61(Special Issue), 653-670.

Pedroni, P. (2001) “Purchasing power parity tests in cointegrated panels”, *The Review of Economics and Statistics*, 83(4), 727-731.

Pedroni, P. (2004) “Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis”, *Econometric Theory*, 20(3), 597-625.

Pesaran, M. H. (2007) “A simple panel unit root test in the presence of cross-section dependence, *Journal of Applied Econometrics*, 22(2), 265-312.

Phillips, P. C. and B. E. Hansen (1990) "Statistical Inference in Instrumental Variables Regression with I(1) Processes", *Review of Economic Studies*, 57(1), 99-125.

Sealey, C. W and J. T. Lindley (1997) "Inputs, outputs and a theory of production and cost at depository financial institutions", *Journal of Finance*, 32, 1251-1266.

Stock, J. and M. Watson (1993) "A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems", *Econometrica*, 55, 1035-1056.

Tirtiroglu, K., K. Daniels and E. Tirtiroglu (2005) "Deregulation, Intensity of Competition, Industry Evolution and the Productivity Growth of US Commercial Banks", *Journal of Money, Credit and Banking*, 37(2), 339-360.

Wheelock, D. C. and P. W. Wilson, (1999) "Technical Progress, Inefficiency, and Productivity Change in U.S. Banking, 1984-1993", *Journal of Money, Credit and Banking*, 31(2), 212-234.

[1] For example, McMillan et al. (1989) in analysing Chinese agricultural reforms that incentivised (rewarded) individual farmers, concluded that “rewarding individual effort yields large benefit” (ibid., p. 783).

[2] Some of these studies subsequently employ parametric methods to model the productivity and efficiency measures computed through DEA.

[3] To see this, imagine a scenario where the whole of the banking industry makes an average efficiency gain of 5% but this gain would look inefficient if the efficient frontier moves up by 10%.

[4] The non-zero profit in the long-run raises the theoretical possibility of banks producing an infinite amount of output. While we acknowledge this theoretical possibility we do not regard it as being of much practical relevance.

[5] Lack of data prevented us from using the off-balance-sheet items in our measure of bank output. However, our measure of bank output is consistent with those of Delis et al. (2011), among others.

[6] Utility from profit could be seen as tangible (bonuses) and intangible (fame) rewards which tend to be positively associated with the level of profits. Given that our focus is on bank productivity, we do not model the details of incentive packages.

[7] It is trivial that from (12), (13) and (14) that: $a_1 = \frac{\theta_1}{1-\sigma(1-\theta_1)}$,

$a_2 = \theta_2\left[1-\left(\frac{\theta_1}{1-\sigma(1-\theta_1)}\right)\sigma\right]$ and $a_3 = \theta_3\left[1-\left(\frac{\theta_1}{1-\sigma(1-\theta_1)}\right)\sigma\right]$.

[8] Data on GDP per capita in current US dollars are for 2011 and obtained from the World Bank at http://www.worldbank.org/en/country/nepal. Population figures are from the 2011 census, Nepal.

[9] Under the social banking philosophy authorities, among other things, dictated that commercial banks expand their branch networks across countries in tandem with nationally declared banking density objectives of one bank branch per 30,000 head of population.

[10] The precise year 2002 is suggested by the seminar participants (high ranking officials of the Central Bank, Commercial Banks and the Government and of Nepal) at the Nepalese Bankers' Association seminar, Kathmandu, December 2013. We are grateful for this suggestion.

[11] Figures on the growth of financial institutions are taken from Banking and Financial Statistics, mid-July, 2012, No. 58, NRB.

[12] One of our sample banks has a minimum data length of 7 years – 2006(3) to 2012(1) – as it was opened in 2006.

[13] We are thankful to the Governor of NRB, Dr Y R Khatiwada, for the data. The 12 commercial banks covered are: Bank of Kathmandu Ltd. (1995), Everest Bank Ltd. (1994), Global Bank Ltd. (2006), Himalayan Bank Ltd. (1993), Kumari Bank Ltd. (2001), Laxmi Bank Ltd. (2002), Machhapuchhre Bank Ltd. (2000), Nabil Bank Ltd. (1984), Nepal Bank Ltd. (1937), Nepal Investment Bank Ltd. (1986), Rastrya Banijya Bank Ltd. (1966) and Standard Chartered Bank Nepal Ltd. (1987). Figures within parentheses (.) indicate the date of bank operation. As stated in the text, they constitute the major commercial banks of Nepal.

[14] Data on quarterly GDP deflator are not available in Nepal.

[15] Results of first difference stationarity are not reported, to conserve space, but are available on request.

[16] The fixed assets of banks tend to change slowly compared to bank output, employment and total deposit liabilities.

[17] The parameter estimates of the last column of DOLS results reported in Table 3 sum to 1.03. A reduction of 3.0% of each parameter to make them sum to unity is also not rejected by the test. The p-value of the test is $\chi^2(3) = 0.194$. The Grouped parameters under FMOLS and DOLS sum to 1.006 and 0.984, respectively (columns which delete the insignificant F_{it}).

[18] Parameter a_0 is the constant term of the technical production function (equation (1)). The estimates of the constant term of the institutional production function range between 0.024 to 2.498 under different specifications (not reported in Table 3). Our simulation results are robust to values of $0 \le a_0 \le 10$.

[19] Iteration reveals that for wide-ranging values of $0.01 \le \mu \le 10$ the simulated values of ε^* and B remain fairly robust.

[20] The average hourly wage rate (w_1) is calculated as follows. First, the quarterly average wage bill for staff is computed by dividing the total quarterly wage bill by the total number of staff. Then the quarterly average wage bill is divided by 40x12; where 40 represents the hours worked per week and there are 12 working weeks in a quarter.

[21] Nepalese currency is known as Rupees and one Rupee consists of 100 Paisa.

[22] We are thankful to the seminar participants at the Nepal Bankers' Association, Kathmandu, in explaining (reconciling) this sharp upturn in banking sector productivity with the Peace Accord of 2005.

[23] A time varying approach of estimation would allow the technical parameter to be time dependent but data constraints preclude us from using it.

[24] The estimated regression is: $\log B = 4.441 + 0.054 \log \varepsilon^{*} + 0.005\,\text{sldmy}$; where B is the index of simulated total optimal productivity, ε^{*} is the index of simulated optimal effort and 'sldmy' is the slope dummy for 2006(1)-(2) to capture the blip in productivity (see Figure 3). The constant term and the slope parameters resume p-values of 0.000, 0.024 and 0.000, respectively, hence are statistically highly significant. The reported results pertain to the first order residual serial correlation (AR(1)) correction. The R-bar square is 0.93 and DW statistic is 1.72. Results appear almost identical when the IV estimator is used.