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# Nexus between Intellectual Capital and Bank Productivity in India

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**Abstract:** This paper empirically investigates the influence of intellectual capital on changes in total factor productivity of 36 BSE-listed banks in India from 2005 to 2019. This study employs a two-stage analysis that begins by investigating changes in total factor productivity using the Malmquist Productivity Index estimated through Data Envelopment Analysis, and then computes intellectual capital and its sub-components within the Value Added Intellectual Coefficients model framework. Then, using the System Generalised Method of Moments, we investigate the impact of intellectual capital on changes in total factor productivity. According to our findings, productivity growth is primarily driven by efficiency changes rather than technological changes. Furthermore, regression results show that the intellectual capital index and its two sub-components, human capital and capital employed, have a strong positive impact on bank productivity. This research could help bank senior executives measure their productivity and intellectual capital, identify relevant intellectual capital elements that contribute to productivity and develop future policies to encourage and improve their intellectual potential. Furthermore, this is one of the few studies in the Indian context that examines the nexus between intellectual capital and productivity using the Malmquist Productivity Index.

**Keywords:** Value Added Intellectual Coefficients; Malmquist Productivity Index; data envelopment analysis; System Generalised Method of Moments; panel data; Indian banks

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## 1. Introduction

In recent times, due to the growing importance of knowledge and information at the workplace, intellectual capital has been acknowledged as a crucial strategic asset that may be broadly described as the totality of the knowledge assets at a firm's disposal with the ability to produce competitive advantage and potentially contribute to wealth creation (Alipour 2012; Anghel 2008; Barney 1991; Subramaniam and Youndt 2005; Zack 1999). Numerous research has been undertaken all over the world to support the concept of intellectual capital and its effect on corporate performance. However, it was noticed that the majority of these studies have considered traditional performance ratios as a measure of a dependent variable to gauge the effect of intellectual capital on a company's performance. Only a handful of studies have used productivity as a measure of a dependent variable that measures output over time, which can be used as a benchmarking tool in examining a firm's progress.

Among the studies that have used productivity as a measure of performance, many of them have simply used asset turnover ratio (ATO) to measure productivity (Chu et al. 2011; Firer and Williams 2003; Ghosh and Mondal 2009; Kehelwalatenna 2016; Mehralian et al. 2012; Nadeem et al. 2017; Scafarto et al. 2016; Smriti and Das 2018). This study is one of the few that have employed the Malmquist Productivity Index (MPI), one of the most widely used methods for determining how productivity changes over time (Alhassan and Asare 2016; Chen et al. 2014; Oppong et al. 2019), as a measure of productivity. Productivity is defined by data envelopment analysis (DEA) as the ratio of efficiency. Firms are able to evaluate and compare their respective competitive positions with rivals by computing efficiency changes over a specific period of time. By demonstrating the effect of intellectual capital on firm productivity using the MPI for the Indian Banking sector from 2005 to 2019, the current study seeks to extend the body of existing literature. The results of this research will be useful for the banking industry as it attempts to quantify the nexus between intellectual capital and firm productivity. Additionally, it may provide information on intellectual capital elements that must be quickly taken into account in order to increase firm productivity.

The remaining portions of this study are structured as follows. The earlier research in this field is introduced in Section 2. The technique and data used in this investigation are discussed in Section 3. The productivity-intellectual capital regression findings are presented in Section 4. Finally, Section 5 concludes this research.

## 2. Review of Related Studies

### *2.1. Theoretical Background*

The recourse-based view (RBV) of the firm emphasises the significance of productive resources, both tangible and intangible assets, in shaping a firm's success by building competitive advantage (Amit and Schoemaker 1993; Martí 2007; Penrose 1980; Subramaniam and Youndt 2005). The knowledge economy is the engine driving the new millennium, with "... *greater dependence on knowledge, information and high skill levels, and the increasing need for ready access to all of these by the business and public sectors* ... ", (OECD 2005, p. 71). Thus, the management and improvement of a firm's knowledge resources are essential to its ability to succeed (Cabrilo et al. 2009). As a result, one of the best methods to gain an understanding of the dynamics of intangible resources and knowledge management is through a firm's RBV. Intellectual capital is the term used to refer to all of these intangible resources (Edvinsson and Malone 1997; Stewart 1997). Intellectual capital broadly includes human capital (HC), structural capital (SC), and relational capital (RC) (Alipour 2012; Bontis 2002; Edvinsson and Sullivan 1996; Lynn 1998; Stewart 1997; Tovstiga and Tulugurova 2007).

### *2.2. Relationship between Intellectual Capital and Firm Performance*

Studies on the intellectual capital-performance relationship are initially focused on developed economies, but in recent times, surges in studies from emerging economies have been witnessed. The studies are primarily inclined towards the financial services sector, followed by mixed industry and the pharmaceutical sector (Tiwari 2022).

The intellectual capital-performance relationship primarily provides evidence of a strong positive connection (Anifowose et al. 2017; Clarke et al. 2011; Hamdan 2018; Joshi et al. 2013; Kehelwalatenna 2016; Meles et al. 2016; Mondal and Ghosh 2012; Mavridis 2004; Oppong et al. 2019; Ozkan et al. 2017; Riahi-Belkaoui 2003; Singla 2020; Tovstiga and Tulugurova 2007; Vishnu and Gupta 2014; Zeghal and Maaloul 2010). However, exceptions to this were reported by Chu et al. (2011); Chang and Hsieh (2011); Firer and Williams (2003); Gruian (2011); Iazzolino and Laise (2013); Maditinos et al. (2011); Ståhle et al. (2011); and Williams (2001), providing evidence of a significant inverse or no association. Although the likelihood of the hypothesised link is majorly favourable, certain researchers have brought attention to the issue of the intellectual capital's relatively little impact (low coefficient) on business performance (Vidyarthi and Tiwari 2020; Tiwari and Vidyarthi 2018).

Further, it is noted that not all aspects of intellectual capital are equally crucial for determining how well a corporation performs (Bontis 1998). Previous research has offered empirical support for various combinations of components that are important to business performance. The majority of studies carried out in developed economies (Bollen et al. 2005; Chen 2012; Díez et al. 2010; Joshi et al. 2013; Kehelwalatenna 2016; Maditinos et al. 2011; Meles et al. 2016; Santos-Rodrigues 2013; Sardo et al. 2018; Zeghal and Maaloul 2010) shows that HC is the most prevalent and important component of intellectual capital that influences corporate performance. However, research done in developing nations (Alipour 2012; Chen et al. 2005; Goh 2005; Hamdan 2018; Kamukama et al. 2010; Nadeem et al. 2017; Poh et al. 2018; Tovstiga and Tulugurova 2007; Tiwari and Vidyarthi 2018; Vishnu and Gupta 2014) show that the most important components of intellectual capital that influence company performance are SC and HC. Additionally, the literature currently in circulation emphasises how, to varied degrees, one or more aspects of intellectual capital affect company performance (Bontis 2002; Pablos 2004; Wang and Chang 2005). Most research across developed and developing economies has found that HC is the most prevalent intellectual capital factor influencing company performance.

Although empirical evidence using productivity as a dependent variable is uncommon when testing the intellectual capital-performance nexus, the following are a few instances of direct empirical evidence. Chen et al. (2014) explored the influence of intellectual capital on productivity changes estimated using DEA-based MPI and the MPI with bootstrapping approach for Malaysian general insurance firms over the period 2008–2011. They observed that the intellectual capital index and its sub-components have a favourable and significant influence on productivity change. Alhassan and Asare (2016) examined the dynamics of intellectual capital and bank productivity in Ghana from 2003 to 2011. During the study period, they discovered that the intellectual capital index and its two sub-components, HC and capital employed (CE), had a positive impact on bank productivity. Oppong et al. (2019) examined the influence of intellectual capital on DEA-based MPI. Productivity changes for 33 insurance firms in Ghana over the period 2008–2016 were measured. Their results indicated that intellectual capital and its two subcomponents, HC and CE, have a significant positive influence on insurance companies' productivity change. Thus, within the limited empirical evidence, we see evidence of a positive relationship with no studies focusing on India, which limits our knowledge of the intellectual capital-productivity nexus in one of the world's fastest-growing emerging economies (OECD 2022). The current study aims to add to the existing literature by providing evidence of the intellectual capital-productivity nexus in India.

## 3. Methodology and Data

This section is divided into six subsections. The first subsection briefly discusses the DEA used to estimate MPI, namely total factor productivity (TFPCH) and its components technical efficiency change (TEFFCH) and technological change (TECHCH) of the sample banks. The second sub-section illustrates the theoretical approach for measuring intellectual capital using the Value Added Intellectual Coefficient (VAIC) and Modified Value Added Intellectual Coefficient (MVAIC) approaches. The third sub-section explains the choice of control variables used in the model. The fourth subsection briefly discusses hypothesis development. The fifth sub-section describes the regression models used to estimate the impact of intellectual capital and its components on computed TFPCH and its components (TEFFCH and TECHCH) for Indian banks from 2005 to 2019. The final sub-section discusses the study's data sources and duration. In summary the research framework is as below (Figure 1).

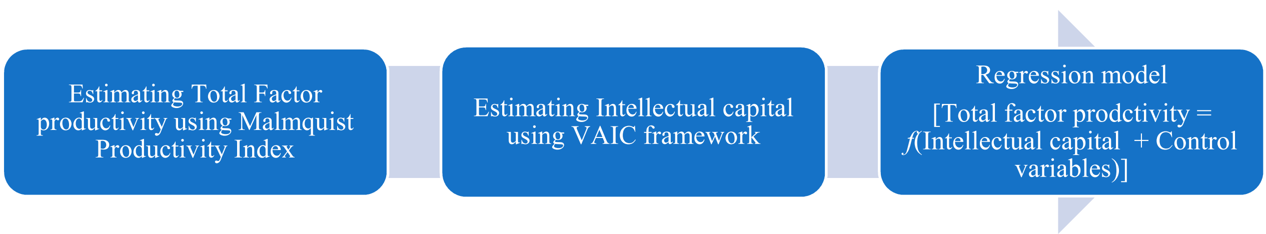


**Figure 1.** Research framework. Source: Author's own compilation.

*3.1. Dependent Variable: Estimating Malmquist Productivity Index (MPI)*

Following Jaffry et al. (2007),this study employs a non-parametric DEA-based output—oriented MPI technique to compute the productivity of Indian banks over the period 2005–2019. Malmquist (1953) pioneered MPI, which was later expanded by Fare et al. (1994). It compares productivity changes over two time periods due to the catching-up effect (changes in technical efficiency) and the frontier-shift effect (changes in technology). The catching-up effect measures how efficiently banks convert inputs into outputs, whereas the frontier-shift effect measures technological progress between two time periods. Furthermore, MPI does not require input and output prices for productivity estimation because it only requires quantity data. Moreover, if the MPI values are higher than one, it represents productivity growth over time; lower than one represents deterioration in productivity growth, and equal to one represents stagnation in bank productivity growth.

Following Berger and Humphrey (1997), the study uses the intermediation strategy suggested by Sealey and Lindley (1977) for estimating bank-wise MPI namely TFPCH, TEFFCH and TECHCH. The study uses four inputs, namely interest expenditures, non-interest expenditures, personnel expenditures, and deposits, for generating three outputs, namely interest income, non-interest income, and loans and advances.

$$\text{TFPCH index} = m_o\,(y_s,\ x_s, y_t,\ x_t) = \frac{d_o^t\,(y_t,\ x_t)}{d_o^s(y_s,\ \ x_s)}\left[\frac{d_o^s(y_t, x_t)}{d_o^t(y_t, x_t)} \times \frac{d_o^s(y_s, x_s)}{d_o^t(y_s, x_s)}\right]^{\frac{1}{2}}$$

$$\text{TEFFCH} = \frac{d_o^t\,(y_t,\ x_t)}{d_o^s(y_s,\ \ x_s)}$$

$$\text{TECHCH} = \left[\frac{d_o^s(y_t, x_t)}{d_o^t(y_t, x_t)} \times \frac{d_o^s(y_s, x_s)}{d_o^t(y_s, x_s)}\right]^{\frac{1}{2}}$$

Note: TFPCH index = TEFFCH x TECHCH.

Here, $d_o^t(y_s, x_s)$ represents the observational output distance function at time 's' from the production frontier at time 't'.

*3.2. Independent Variable: Measuring Intellectual Capital*

In line with previous studies (Chen et al. 2014; Lu et al. 2014; Tiwari and Vidyarthi 2018; Wang 2013; Young et al. 2009; Zeghal and Maaloul 2010), this study employs the VAIC framework proposed by Pulic (1998, 2000) to calculate intellectual capital sub-components such as the human capital coefficient (VAHC), structural capital coefficient (SCVA), and capital employed coefficient (VACE). Further, the study estimates a bank's relational capital coefficient (RCVA) following Bontis (1998) and Bontis et al. (2000), to get MVAIC suggested by Wang and Chang (2005), and Vishnu and Gupta (2014). These indicators are calculated in the following manner:

$$\text{VA} = \text{OUTPUT} - \text{INPUT} \quad (1)$$

$$\text{VAHC} = \text{VA/HC} \quad (2)$$

$$\text{SCVA} = \text{SC/VA} = \text{(VA-HC)/VA} \quad (3)$$

$$\text{VACE} = \text{VA/CE} \quad (4)$$

$$\text{VAIC} = \text{VAHC} + \text{SCVA} + \text{VACE} \quad (5)$$

$$\text{RCVA} = \text{RC/VA} \quad (6)$$

$$\text{MVAIC} = \text{VAHC} + \text{SCVA} + \text{VACE} + \text{RCVA} \quad (7)$$

Here, Output represents total income consisting of interest and non-interest income for the bank. Input represents gross operational costs excluding personnel expenditures (which are treated as investments but not costs). The terms, VA represents the value added, HC represents total employee compensation, RC represents selling and distribution expenditure, and CE refers to the book value of net assets employed.

### 3.3. Control Variables

In keeping with prior studies, the current study includes several control variables (Adjusted Herfindahl–Hirshman Index, Size, Leverage, Inflation, and GDP growth) in the estimation methods to control for unknown effects that may influence changes in the productivity of banks (Table 1).

**Table 1.** Control variables and references.

| Variable | Definition | Purpose | Expected Sign (+/-) | Reference |
|---|---|---|---|---|
| AHHI | Adjusted Herfindahl–Hirshman Index. AHHI = 1 − [(Non-interest income/Total income)$^2$ + (Net interest income/Total income)$^2$] | The AHHI is used to evaluate the impact of revenue diversification on bank productivity. | +/- | Luhnen (2009); Cummins and Xie's (2013); Alhassan and Biekpe (2016); Ilyas and Rajasekaran (2019); Sharma and Sharma (2015); Nartey et al. (2019) |
| Size | Natural logarithm of the bank's total asset | Size is used to assess whether or not economies of scale exist in the Indian banking industry. | +/- | Grigorian and Manole (2002); Williams and Nguyen (2005); Akin et al. (2009); Sufian (2011); Sharma and Sharma (2015); Nartey et al. (2019) |
| Leverage | Ratio of debt to equity | The term leverage is used to describe the impact of leverage on bank productivity. | +/- | Alhassan and Asare (2016); Akbar et al. (2016); Nartey et al. (2019) |
| Inflation | Consumer price index | This study includes inflation to analyse the impact of price level changes on the efficiency and productivity growth of the Indian banking sector. | +/- | Perry (1992); Sufian (2011); Sharma and Sharma (2015) |
| GDP | GDP growth rate | GDP growth has been included in this study to measure the effect of volatile external conditions on the efficiency and productivity of Indian banks. | + | Fiordelisi and Molyneux (2010); Sharma and Sharma (2015) |

Source: Author's own compilation.

### 3.4. Hypotheses Development

As per the RBV theory of the firm superior corporate profitability is linked to resources, both tangible and intangible, owned by firms (Barney 1991; Galbreath 2005; Wernerfelt 1984). Additionally, in contemporary, fiercely competitive economic contexts, a firm's intangible resources rather than its physical resources serve as the primary driver of value generation (Ahangar 2011; Hsu and Chang 2011). Therefore, to sustain growth in a knowledge-intensive industry like banking, it will have to focus more on its intangible resources, i.e., intellectual capital. Consequently, intellectual capital can be viewed as a crucial resource and strategic asset for enhancing corporate profitability and gaining an advantage over competitors (Wernerfelt 1984). Thus, intellectual capital has emerged as a major factor in improving corporate success. Despite the opposing findings of Andriessen

(2004), Chowdhury et al. (2019), Ståhle et al. (2011), and Yalama and Coskun (2007), the majority of research finds significant proof to reinforce the change in corporate profitability attributed to VAIC/MVAIC (Cabrita and Vaz 2006; Mondal and Ghosh 2012; Saengchan 2007; Xu and Li 2022; Tiwari 2022).

Things become clearer when we explore the factors included in VAIC/MVAIC, i.e., HC, SC, RC, and CE. HC refers to the sum-total of an employee's knowledge, abilities, creativity, experiential, and sage judgement. It is essential for a company because it can propel the enterprise to success. Since workers carry these distinguishing traits with them when they leave the organisation, attracting and keeping good employees is essential. SC includes unique systems and procedures, as well as copyrights, patents, trademarks, databases, and know-how that an organisation develops over time and supports the productivity of its human capital (Bontis 2002). RC is the company's capacity to sustain friendly connections with its stakeholders, which may result in new clients, continuous raw material supply, and simplified government processes, among other things (Anam et al. 2012; Montequín et al. 2006; Tiwari and Vidyarthi 2018; Xu and Li 2022). CE is a tangible resource required for a company's survival. Furthermore, it is argued that the presence of capital employed is required for the HC to contribute to value generation (Goh 2005; El-Bannany 2008; Tiwari and Vidyarthi 2018). Factor exploration gives us a comprehensive understanding of why and how intellectual capital can influence performance. In this study, we anticipate that VAIC/MVAIC and its members, represented as VAHC, SCVA, RCVA, and VACE will have a favourable impact on the productivity index-based measures of bank performance.

Thus, we presume a positive association between changes in intellectual capital resources and changes in productivity. We investigate the effects of VAIC / MVAIC and their individual components on TFPCH and its components, which are used as a performance measure in this study. Thus, the following hypotheses are proposed:

**Hypothesis 1.** *VAIC has a significant positive impact on TFPCHa/TEFFCHb/TECHCHc.*

**Hypothesis 2.** *VAHCa/SCVAb/VACEc has a significant positive impact on TFPCH.*

**Hypothesis 3.** *VAHCa/SCVAb/VACEc has a significant positive impact on TEFFCH.*

**Hypothesis 4.** *VAHCa/SCVAb/VACEc has a significant positive impact on TECHCH.*

**Hypothesis 5.** *MVAIC has a significant positive impact on TFPCHa/TEFFCHb/TECHCHc.*

**Hypothesis 6.** *VAHCa/SCVAb/RCVAc/VACEd has a significant positive impact on TFPCH.*

**Hypothesis 7.** *VAHCa/SCVAb/RCVAc/VACEd has a significant positive impact on TEFFCH.*

**Hypothesis 8.** *VAHCa/SCVAb/RCVAc/VACEd has a significant positive impact on TECHCH.*

### *3.5. Regression Models*

The direct impact of intellectual capital on bank productivity is estimated through a two-step System Generalized Method of Moments (Sys-GMM) regression because of its ability to overcome endogeneity, heteroscedasticity, and reverse causality (Nadeem et al. 2017; Smriti and Das 2018). We perform two specification tests (Arellano–Bond test and Sargan test) to confirm the precision of the Sys-GMM estimators: for zero autocorrelation in first-differenced residuals and over-identifying constraints. The following regression models are used to estimate the effect of VAIC/MVAIC and its subcomponents (Equations (1)–(4)).

*Model 1:*

$$Y_{it} = \alpha_0 + \delta\ Y_{it-1} + \beta_1 \text{VAIC}_{it} + \beta_2 \text{AHHI}_{it} + \beta_3 \text{Leverage}_{it} + \beta_4 ln\text{Size}_{it} + \beta_5 \text{GDP Growth}_{it} + \beta_6 \text{Inflaton}_{it} + \varepsilon_{it}$$

*Model 2:*

$$Y_{it} = \alpha_0 + \delta\ Y_{it-1} + \beta_1 \text{MVAIC}_{it} + \beta_2 \text{AHHI}_{it} + \beta_3 \text{Leverage}_{it} + \beta_4 ln\text{Size}_{it} + \beta_5 \text{GDP Growth}_{it} + \beta_6 \text{Inflaton}_{it} + \varepsilon_{it}$$

*Model 3:*

$$Y_{it} = \alpha_0 + \delta\ Y_{it-1} + \beta_1 \text{VACE}_{it} + \beta_2 \text{VAHC}_{it} + \beta_3 \text{SCVA}_{it} + \beta_4 \text{AHHI}_{it} + \beta_5 \text{Leverage}_{it} + \beta_6 ln\text{Size}_{it} + \beta_7 \text{GDP Growth}_{it} + \beta_8 \text{Inflaton}_{it} + \varepsilon_{it}$$

*Model 4:*

$$Y_{it} = \alpha_0 + \delta\ Y_{it-1} + \beta_1 \text{VACE}_{it} + \beta_2 \text{VAHC}_{it} + \beta_3 \text{SCVA}_{it} + \beta_4 \text{RCVA}_{it} + \beta_5 \text{AHHI}_{it} + \beta_6 \text{Leverage}_{it} + \beta_7 ln\text{Size}_{it} + \beta_8 \text{GDP Growth}_{it} + \beta_9 \text{Inflaton}_{it} + \varepsilon_{it}$$

Here, Y represents TFPCH, TEFFCH, and TECHCH respectively. VAIC and MVAIC represent the intellectual capital index. VACE, VAHC, SCVA, and RCVA represent components of the intellectual capital index. AHHI, Leverage, Size, GDP Growth, and Inflation represent the adjusted Herfindahl–Hirshman index, total borrowings/total assets, natural logarithm of total assets, annual GDP growth rate, and change in the consumer price index. Further, $\varepsilon_{it}$ denotes the error term for bank *i* at time *t*.

### *3.6. Data*

We collect the relevant banking data from the Centre for Monitoring Indian Economy (CMIE)'s PROWESS database and macroeconomic parameters from the World Development Indicator 2019 for the period 2005 to 2019. The summary statistics of the variables used in this research are presented in Appendix A as Table A1 (descriptive statistics and correlation matrix).

## **4. Empirical Results and Discussions**

### *4.1. Empirical Results*

We begin our empirical analysis by estimating DEA-based TFPCH and its mutually exclusive and exhaustive components, which are technical efficiency change (TEFFCH) and technological change (TECHCH) for all 36 listed banks present at the beginning as well as ending year (2005 and 2019). It excludes banks that entered or exited the market during the research period. A productivity index value higher than 1 indicates progress, while a value less than 1 indicates regress.

The average (geometric mean) TFPCH score for sample banks is 0.982, which indicates that most banks have shown a decrease in productivity during the study period. Further, productivity change regressed over the study period due to a consistent decline in both TEFFCH and TECHCH (with a mean of 0.996 and 0.986, respectively) (Table 2).

**Table 2.** MPI summary of annual means, during 2005–2019.

| Year | Technical Efficiency Change (TEFFCH) | Technical Change (TECHCH) | Change in Total Factor Productivity (TFPCH) |
|---|---|---|---|
| 2005 | 1 | 1 | 1 |
| 2006 | 1.011 | 0.949 | 0.96 |
| 2007 | 1.006 | 0.991 | 0.997 |
| 2008 | 1.004 | 0.984 | 0.988 |
| 2009 | 0.998 | 0.995 | 0.993 |
| 2010 | 0.998 | 1.013 | 1.011 |
| 2011 | 1.001 | 0.981 | 0.982 |
| 2012 | 0.999 | 1.001 | 1 |
| 2013 | 0.997 | 0.989 | 0.986 |
| 2014 | 0.988 | 0.989 | 0.977 |
| 2015 | 1.003 | 0.992 | 0.995 |
| 2016 | 0.975 | 0.964 | 0.94 |
| 2017 | 1.014 | 0.977 | 0.991 |
| 2018 | 0.945 | 0.987 | 0.933 |
| 2019 | 1.007 | 0.991 | 0.998 |
| Geometric Mean | 0.996 | 0.986 | 0.982 |

Source: Author's own estimation derived from DEAP 2.1 Software. Note: The year 2005 is taken as the reference year for productivity change in the Indian banking sector, and therefore, it takes an initial score of 1 for the MPI and its sub-components.

Furthermore, the TEFFCH change is greater than one in seven sub-periods and less than one in the remaining eight. Similarly, the TECHCH is greater than one in only two sub-periods and less than one in the remaining sub-periods. Turning to the individual bank results, we found that only 6 out of 36 banks have TFPCH scores that are higher than one, indicating that a relatively lesser number of banks have experienced a rise in productivity during the study period. Further exploring the sources of inefficiency revealed both technological and efficiency regress (Table 3).

All regression results in Tables 4 and 5 were computed using the Sys-GMM. The choice of a dynamic model is justified by the significant lagged dependent variables. Furthermore, the AR (2) and Sargan test p-values are insignificant, indicating that the models are free of diagnostic errors. Further, to address the issue of instrument proliferation, the study restricts the instruments of lagged dependent variables.

Table 4 confirms that lagged endogenous variables are significant and negative, with parameter values ranging from −0.0199 to −0.283, thus confirming the presence of a high degree of persistence in bank productivity and its sub-components. Table 4 (Model-1) displays the impact of VAIC on TFPCH and its sub-components (TEFFCH and TECHCH) as estimated using the Sys-GMM approach. Empirical results confirmed that VAIC has a favourable and significant impact on TFPCH and its sub-components (TEFFCH and TECHCH) at a 1 percent significance level. The VAIC influence is highest in the case of TFPCH (0.0042), followed by TEFFCH (0.0030) and TECHCH (0.0009) respectively. Thus, we infer that higher investment in intellectual capital leads to higher growth in productivity. Thus, empirical results confirm the findings of Alhassan and Asare (2016); Chen et al. (2014); Oppong et al. (2019) and Zakery and Afrazeh (2015) that intellectual capital has a significant and favourable impact on a firm's productivity.

**Table 3.** MPI summary of bank-specific means, during 2005–2019.

| Bank | Technical Efficiency Change (TEFFCH) | Technical Change (TECHCH) | Change in Total Factor Productivity (TFPCH) |
|---|---|---|---|
| Allahabad Bank | 0.985 | 1.007 | 0.992 |
| Andhra Bank | 0.986 | 0.995 | 0.98 |
| Axis Bank | 1.002 | 1.003 | 1.005 |
| Bank of Baroda | 0.999 | 0.991 | 0.99 |
| Bank of India | 0.986 | 1 | 0.986 |
| Bank of Maharashtra | 0.988 | 0.991 | 0.979 |
| Canara Bank | 0.997 | 0.99 | 0.988 |
| Catholic Syrian Bank | 0.996 | 0.967 | 0.964 |
| Central Bank of India | 0.987 | 0.988 | 0.975 |
| City Union Bank | 1 | 0.993 | 0.993 |
| Corporation Bank | 0.992 | 0.968 | 0.96 |
| D C B Bank | 1.011 | 0.983 | 0.994 |
| Dhanlaxmi Bank | 1.005 | 0.987 | 0.992 |
| Federal Bank | 1.006 | 1.004 | 1.01 |
| H D F C Bank | 1 | 0.989 | 0.989 |
| I C I C I Bank | 1 | 0.986 | 0.986 |
| I D B I Bank | 0.986 | 0.919 | 0.906 |
| Indian Bank | 0.997 | 0.988 | 0.985 |
| Indian Overseas Bank | 0.984 | 0.993 | 0.977 |
| Indusind Bank | 1 | 1.006 | 1.006 |
| Karnataka Bank | 1.002 | 0.978 | 0.981 |
| KarurVysya Bank | 0.992 | 0.996 | 0.988 |
| Kotak Mahindra Bank | 1 | 0.984 | 0.984 |
| Lakshmi Vilas Bank | 0.995 | 0.982 | 0.977 |
| Oriental Bank of Commerce | 1 | 1.002 | 1.002 |
| Punjab & Sind Bank | 0.995 | 0.979 | 0.974 |
| Punjab National Bank | 0.99 | 0.989 | 0.979 |
| R B L Bank | 1.009 | 0.992 | 1.001 |
| South Indian Bank | 1.008 | 0.999 | 1.007 |
| State Bank of India | 0.995 | 0.992 | 0.987 |
| Syndicate Bank | 0.992 | 0.995 | 0.987 |
| Tamilnadu Mercantile Bank | 0.997 | 0.967 | 0.965 |
| Uco Bank | 0.978 | 0.998 | 0.977 |
| Union Bank of India | 0.991 | 0.995 | 0.986 |
| United Bank of India | 1 | 0.963 | 0.963 |
| Yes Bank | 1 | 0.94 | 0.94 |

Source: Author's own estimation derived from DEAP 2.1 Software.

Further, revenue diversification is having an inverse and significant influence on all productivity indicators except TEFFCH, thus suggesting that diversifying revenue may adversely impact the productivity change and technology change components (Luhnen 2009). Other control variables, such as leverage, are having a favourable and significant impact on TFPCH and TECHCH at the 1% significance level. Though bank size is inversely related to TFPCH and its subcomponents, this relationship is only significant for TECHCH. Similarly, the economic growth rate is negatively related to TFPCH and TECHCH but positively related to TEFFCH. Further, inflation is having a positive impact on TFPCH and its sub-components. Sign expectations of control variables are consistent with prior studies except for the GDP growth rate that provides negative relation with TFPCH and TECHCH, probably because during the study period, India experienced a relatively volatile growth in GDP (Sharma and Sharma 2015).

**Table 4.** Productivity—Intellectual Capital Nexus (VAIC™).

| Variables | TFPCH | | TEFFCH | | TECHCH | |
|---|---|---|---|---|---|---|
| | **Model 1** | **Model 3** | **Model 1** | **Model 3** | **Model 1** | **Model 3** |
| Lagged DV | −0.0907 * | −0.0998 * | −0.282 * | −0.283 * | −0.0199 | −0.0304 *** |
| AHHI | −0.0924 * | −0.0848 * | −0.0181 | −0.0128 | −0.0961 * | −0.115 * |
| VAIC | 0.00429 * | | 0.00304 * | | 0.000919 * | |
| VAHC | | −0.00159 | | 0.00503 * | | −0.00770 * |
| SCVA | | 0.00469 * | | 0.00302 * | | 0.00126 * |
| VACE | | −0.0183 ** | | −0.0018 | | −0.00134 |
| Leverage | 0.0999 * | 0.0689 ** | −0.0227 | −0.0176 | 0.146 * | 0.128 * |
| Size | −0.00044 | −0.00402 *** | −0.00033 | 2.26E−05 | −0.00380 ** | −0.00533 ** |
| Inflation | 0.291 * | 0.304 * | 0.0908 * | 0.0922 * | 0.214 * | 0.211 * |
| GDP | −0.120 *** | −0.0923 | 0.0999 ** | 0.0919 ** | −0.269 * | −0.269 * |
| Constant | 0.986 * | 1.087 * | 1.286 * | 1.274 * | 0.947 * | 1.018 * |
| AR(1) | −4.3787 * | −4.4001 * | −3.0836 * | −3.087 * | −3.926 * | −3.9004 * |
| AR(2) | 0.62441 | 0.486 | −0.5393 | −0.5798 | 0.01734 | −0.1827 |
| Sargan | 0.4585 | 0.3405 | 0.2787 | 0.2752 | 0.3611 | 0.4259 |

Source: Author's own estimation. Note: *, **, and *** denote the statistical significance at 1, 5 and 10 percent levels, respectively.

**Table 5.** Productivity—Intellectual Capital Nexus (MVAIC™).

| Variables | TFPCH | | TEFFCH | | TECHCH | |
|---|---|---|---|---|---|---|
| | **Model 2** | **Model 4** | **Model 2** | **Model 4** | **Model 2** | **Model 4** |
| Lagged DV | −0.0902 * | −0.100 * | −0.282 * | −0.286 * | −0.0198 | −0.0257 |
| AHHI | −0.0946 * | −0.0819 ** | −0.0186 | −0.00278 | −0.0964 * | −0.124 * |
| MVAIC | 0.00445 * | | 0.00317 * | | 0.000961 * | |
| VAHC | | −0.00153 | | 0.00534 * | | −0.00797 * |
| SCVA | | 0.00474 ** | | 0.00216 ** | | 0.00453 * |
| VACE | | −0.0178 ** | | −0.00066 | | −0.00341 |
| RCVA | | 0.00312 | | −0.0217 | | 0.0772 * |
| Leverage | 0.102 * | 0.0671 ** | −0.0222 | −0.0184 | 0.147 * | 0.139 * |
| Size | −0.00031 | −0.00378 | −0.00023 | −0.00046 | −0.00379 ** | −0.00487 *** |
| Inflation | 0.292 * | 0.305 * | 0.0911 * | 0.0934 * | 0.214 * | 0.195 * |
| GDP | −0.120 *** | −0.0873 | 0.0995 ** | 0.104 ** | −0.268 * | −0.269 * |
| Constant | 0.981 * | 1.084 * | 1.284 * | 1.281 * | 0.947 * | 0.997 * |
| AR(1) | −4.3793 * | −4.4059 * | −3.0854 * | −3.0751 * | −3.9255 | −3.879 * |
| AR(2) | 0.62338 | 0.4763 | −0.541 | −0.602 | 0.0167 | −0.2941 |
| Sargan | 0.46 | 0.3355 | 0.2763 | 0.2807 | 0.3618 | 0.4378 |

Source: Author's own estimation. Note: *, **, and *** denote the statistical significance at 1, 5 and 10 percent levels, respectively.

We expanded the examination by using sub-components of intellectual capital rather than aggregate intellectual capital (VAIC) as per Model 3. It was found that SCVA has a significant and positive influence on the TFPCH and its sub-components. VAHC has a positive impact on TEFFCH while having a negative impact on TECHCH. VACE has a significant inverse impact only in the case of TFPCH. Further, all the control variables, including AHHI, leverage, size, GDP growth, and inflation, were found to have a similar impact on TFPCH and its sub-components with an exception to Size and GDP in the case of TFPCH.

Furthermore, we extended the analysis by employing MVAIC and its sub-components, an extension of the VAIC framework as per Model (2) and Model (4) respectively (Table 5). We observed that MVAIC and its sub-components have similar impacts on TFPCH and its sub-components. The RCVA, which was an addition to the VAIC framework to compute MVAIC, was found to be significant only in the case of TECHCH. Moreover, control variables have a similar impact on TFPCH and its components with the exception of GDP in the case of TFPCH.

*4.2. Discussions*

Based on the above findings it can be inferred that intellectual capital has a significant impact on productivity. Thus, we accept H1a, H1b and H1c in the case of VAIC and H5a, H5b and H5c in the case of MVAIC. Our findings are consistent with that of Alhassan and Asare (2016) and Oppong et al. (2019). Further, components of intellectual capital were also found to have a significant impact on productivity. Thus, while using the VAIC framework we accept H2b and H2c in the case of TFPCH, H3a and H3b in the case of TEFFCH, and H4a and H4b in the case of TECHCH, meaning that structural capital and capital employed influences TFPCH, whereas human capital and structural capital influences TEFFCH and TECHCH. Furthermore, while using the MVAIC framework we accept H6b and H6d in the case of TFPCH, H7a and H7b in the case of TEFFCH, and H8a, H8b and H8c in the case of TECHCH, implying that structural capital and capital employed influence TFPCH, whereas human capital and structural capital influence both TEFFCH and TECHCH. Another factor influencing TECHCH was relational capital (See, Table 6 for Hypotheses testing results).

**Table 6.** Hypotheses testing results.

| Hypothesis | Details | Accept |
|---|---|---|
| Hypothesis 1 | VAIC has a significant positive impact on TFPCHa/TEFFCHb/TECHCHc. | H1a, H1b and H1c |
| Hypothesis 2 | VAHCa/SCVAb/VACEc has a significant positive impact on TFPCH. | H2b and H2c |
| Hypothesis 3 | VAHCa/SCVAb/VACEc has a significant positive impact on TEFFCH. | H3a and H3b |
| Hypothesis 4 | VAHCa/SCVAb/VACEc has a significant positive impact on TECHCH. | H4a and H4b |
| Hypothesis 5 | MVAIC has a significant positive impact on TFPCHa/TEFFCHb/TECHCHc. | H5a, H5b, and H5c |
| Hypothesis 6 | VAHCa/SCVAb/RCVAc/VACEd has a significant positive impact on TFPCH. | H6b and H6d |
| Hypothesis 7 | VAHCa/SCVAb/RCVAc/VACEd has a significant positive impact on TEFFCH. | H7a and H7b |
| Hypothesis 8 | VAHCa/SCVAb/RCVAc/VACEd has a significant positive impact on TECHCH. | H7a, H7b and H7c |

Source: Author's own compilation.

In summary, it can be concluded that the intellectual-capital index influences TFPCH and its components. Further, structural capital and capital employed influence TFPCH, whereas human capital and structural capital commonly influences TEFFCH and TECHCH. Furthermore, relational capital was only significant in the case of TECHCH.

*4.3. Practical Implication of the Study*

Several practical implications of this study are presented below based on the above findings. *First* and foremost, decision-makers will be able to estimate intellectual capital using VAIC/MVAIC framework, which will help them understand banks' intellectual-capital status. *Second*, it is evident from the findings of the study that intellectual capital i.e., both VAIC and MVAIC have a significant positive influence on bank productivity and its components with low coefficients. Therefore, by improving the overall intellectual capital within an organization, banks can increase their output. Thus, this study will motivate the decision-makers in framing policies favourable to improving intellectual capital within an organization for the purpose of enhancing productivity. *Third*, component-wise analyses will empower decision-makers in identifying the important drivers of intellectual capital that drive the overall productivity of banking firms. In the present study, TFPCH is influenced by structural capital and capital employed, whereas TEFFCH and TECHCH are commonly influenced by human capital and structural capital, implying that productivity is influenced by select intellectual capital factors. This information will help in optimum resource allocation in the short term to maximize intellectual capital within an organization, which will ultimately get reflected through increased productivity. However, as the intellectual capital index has a significant positive impact on productivity, decision-makers needed to focus on all the intellectual-capital components in the long term. *Finally*, the findings of this research from India, one of the fastest-growing developing economies (OECD 2022), have essential connotations for developing nations because the study confirms the findings of Oppong et al. (2019) that intellectual capital is an essential driver of firm productivity, which can foreseeably contribute to economic expansion. Thus, developing nations may frame conducive policies for enhancing investments into intellectual capital to achieve a higher intellectual-capital coefficient to attain higher productivity.

## 5. Conclusions

This research investigates the effect of intellectual capital on changes in total factor productivity for 36 Indian listed banks from 2005 to 2019. For computing changes in total factor productivity and intellectual capital, we use a DEA-based MPI approach and a VAIC/MVAIC model framework, respectively. According to our findings, intellectual capital has a strong favourable impact on *total factor productivity* and its sub-components in the Indian banking sector (Alhassan and Asare 2016; Chen et al. 2014; Oppong et al. 2019; Zakery and Afrazeh 2015). Further, structural capital and capital employed influence *total factor productivity*, whereas human capital and structural capital commonly influences *technical efficiency change* and *technological change.* Furthermore, relational capital was only significant in the case of *technological change*. Thus, our findings imply that corporate investments in intellectual capital could improve the productivity of Indian banking firms.

### *Limitations and Future Scope*

One of the potential limitations of this study is that it provides a case study of India that is limited to a single industry; thus, the generalisation of findings should be done with caution. However, as this study is among the first few studies in India, we encourage researchers to conduct similar studies in India, considering other sectors, as all the sectors in today's dynamic environment are heavily dependent on intellectual capital. Further, we encourage country and sector-specific studies from other developing economies to understand the country and sector-specific characteristics of the relationship. Furthermore, while intellectual capital measurement has been guided by past studies, for future studies, the latitude of intellectual capital can be enhanced by including an innovation capital coefficient that can be measured using research and development expenses.

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## Appendix A

**Table A1.** Descriptive statistics and Correlation matrix.

| Details | Mean | Std. Dev. | TFPCH | TEFFCH | TECHCH | VAIC | MVAIC | VAHC | SCVA | VACE | RCVA | AHHI | Leverage | Size | Inflation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TFPCH | 0.9859 | 0.0716 | | | | | | | | | | | | | |
| TEFFCH | 0.9972 | 0.0455 | 0.6265 ** | | | | | | | | | | | | |
| TECHCH | 0.9886 | 0.0562 | 0.7841 ** | 0.0092 | | | | | | | | | | | |
| VAIC | 0.2399 | 0.0673 | 0.1012 ** | 0.1353 ** | 0.0265 | | | | | | | | | | |
| MVAIC | 2.8487 | 3.0522 | 0.0989 ** | 0.1340 ** | 0.0244 | 0.9996 ** | | | | | | | | | |
| VAHC | 2.887 | 2.9658 | −0.0207 | 0.0519 | −0.0683 | 0.5100 ** | 0.5273 ** | | | | | | | | |
| SCVA | 2.148 | 1.2533 | 0.1299 ** | 0.1324 ** | 0.0666 | 0.8941 ** | 0.8845 ** | 0.0763 | | | | | | | |
| VACE | 0.4179 | 2.6231 | −0.0263 | 0.0037 | −0.0367 | 0.3012 ** | 0.3111 ** | 0.4588 ** | 0.0455 | | | | | | |
| RCVA | 0.2827 | 0.2251 | −0.1268 ** | −0.1274 ** | −0.0687 | −0.7120 ** | −0.6912 ** | 0.0582 | −0.8587 ** | 0.0285 | | | | | |
| AHHI | 0.0383 | 0.1232 | −0.0209 | −0.0035 | −0.0244 | 0.0728 | 0.0803 | 0.0882 ** | 0.0369 | 0.0664 | 0.1295 ** | | | | |
| Leverage | 0.932 | 0.0541 | 0.0019 | −0.0261 | 0.0231 | −0.1198 ** | −0.1253 ** | −0.2310 ** | −0.0227 | −0.0743 | −0.0486 | −0.0395 | | | |
| Size | 13.5186 | 1.4938 | −0.038 | −0.0148 | −0.0363 | −0.0335 | −0.0344 | 0.0383 | −0.0532 | −0.0479 | 0.0017 | 0.0669 | 0.2010 ** | | |
| Inflation | 0.07 | 0.0279 | 0.1025 ** | 0.057 | 0.0832 | 0.0328 | 0.0324 | −0.021 | 0.0513 | −0.0357 | −0.0331 | 0.0777 | −0.0729 | 0.0232 | |
| GDP | 0.0705 | 0.0141 | −0.0407 | 0.0301 | −0.0754 | −0.0099 | −0.0089 | 0.0306 | −0.0238 | −0.0263 | 0.0294 | −0.0097 | 0.0048 | −0.0352 | −0.2613 ** |

Source: Author's own estimation. Notes: ** significant at 5% level.

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