Journal of Industrial and Systems Engineering
Vol. 18, No. 1, pp. 16-27
Winter (January) 2026

JISE

Productivity Analysis in the Banking System with a Short-Run and Long-Run Causality Approach

Ahoo famil Bakhtiyari [1], Kambiz Hojabrkiani [2,*], Abbas Memarnegad [3], Farhad Ghaffari [4]

[1] *Department of Economics, Science and Research Branch, Islamic Azad University, Tehran, Iran.*

[2] *Department of Economics, Science and Research Branch, Islamic Azad University, Tehran, Iran.*

[3] *Department of Economics, Science and Research Branch, Islamic Azad University, Tehran, Iran.*

[4] *Department of Economics, Science and Research Branch, Islamic Azad University, Tehran, Iran.*

Abstract

Enhancing the productivity of financial markets plays a key role in the economic development of countries. Considering the bank-oriented nature of the financial systems in most nations, including Iran, identifying effective methods for measuring and improving productivity levels in banks is of great importance. Accordingly, the present study aims to examine the short-run and long-run causal relationships among capital adequacy, labor force, and total factor productivity (TFP) within a selected sample of ten banks listed on the Tehran Stock Exchange over the period 2010–2017 (1389–1396 in the Iranian calendar). The research results, obtained using the Dynamic Ordinary Least Squares (DOLS), the Vector Error Correction Model (VECM), and the Wald test, reveal a one-way causal relationship from capital adequacy to total factor productivity in the short run. In the long run, however, bidirectional and statistically significant positive relationships are found between labor force and capital adequacy with total factor productivity. Moreover, the error correction term, which represents the speed of short-run adjustment toward long-run equilibrium, is also evaluated.

Keywords: Total Factor Productivity (TFP); Causality; VECM Approach; DOLS Approach

1- Introduction

The banking industry, as the beating heart of the economy, holds immense importance for every country. With the growing advancements and adoption of new technologies, the expansion into various aspects of banking business has intensified, leading to fierce competition in the financial services

* Corresponding Author

ISSN: 1735-8272,

market. Consequently, banks primarily seek to identify and fully exploit available opportunities to enhance their competitive capabilities. As a result, performance analysis in the banking industry has become an essential component of modern management practices. Leading bank executives aim to identify and eliminate the causes of inefficiency in order to gain a competitive advantage or, at the very least, mitigate existing challenges. Therefore, banks focus on performance evaluation as a means of improving profitability. One key performance evaluation indicator is productivity, which allows managers to objectively identify best practices within complex operational environments (Wu et al., 2006).

Resource constraints on one hand and the increasing demand for them on the other underline the critical importance of productivity considerations (Fatehi, 2011). As Bernolak states, "Productivity means how well resources are used for producing goods. If, with the same amount of resources, we produce more or better goods and services—or if we produce the same amount using fewer resources—then productivity has increased." Hence, productivity refers to the efficient and effective utilization of production inputs or factors. According to economic growth theories, production can increase through two main channels: the first is the quantitative increase in inputs, which depends on higher employment and greater physical capital; the second is the improvement of total factor productivity (TFP), achieved through better utilization of existing capacities, improvement in the quality of production inputs, and structural reforms (Dejpasand et al., 2019).

Bank productivity, therefore, represents a crucial factor in the economic development of every nation, and Iran is no exception. In today's competitive business environment, there is an increasing need to identify sources of inefficiency that may not be easily observable through conventional approaches. Accordingly, over recent decades, both academic and managerial literature have shown growing attention to the issue of measuring bank performance, as performance assessment fosters staff motivation, continuous improvement, and enhanced communication and coordination (Chiesa et al., 2009).

Given that total factor productivity, labor, and capital adequacy are endogenous variables, disentangling their roles and mutual effects is often challenging. Thus, examining the causal relationships among these variables—each influencing and being influenced by the others—requires a more precise analytical approach. The fundamental research question concerns to what extent and in which direction these inputs (labor force and capital adequacy) and total factor productivity affect one another, and which of them serves as the cause or the consequence.

Considering the banking industry's vital role in the economic growth and development of countries, including Iran, and the necessity of adopting efficient and internationally aligned approaches, it is essential to focus carefully on productivity within this sector. Accordingly, the objective of this study is to investigate the magnitude and direction of short-run and long-run causal relationships among productivity, the banking sector labor force, and capital adequacy in a selected group of banks. The results of analyzing the mutual relationships among these variables will not only illustrate the importance of productivity in this industry but also identify the key influencing factors relevant to policymaking in this domain.

In line with this objective, the structure of the present paper is organized as follows: Section Two presents the theoretical foundations and literature review; Section Four specifies the model, defines the variables, and describes the research methodology; and finally, the concluding section provides research findings and recommendations.

2- Literature Review

Extensive literature exists on bank productivity, utilizing various sample types, and numerous studies have examined bank productivity and its explanatory factors across both developed and developing countries. According to the definitions provided by the European Productivity Agency and the Japan Productivity Center (JPC), productivity is introduced as a social concept and a mental attitude. This concept underscores efforts to improve upon existing conditions, emphasizing that individuals are capable of performing better each day—in other words, achieving continual improvement. In 1995, three key definitions of productivity were articulated: (1) Productivity as the ratio of output to input; (2)

Productivity as a blend of efficiency and effectiveness, defined as the ratio of production to input plus the ratio of production to target; and (3) Productivity as a broader concept whereby any factor contributing to the establishment of an organization leads to better performance. Additionally, the Asian Productivity Organization (APO) defines productivity as follows (Roghaniyan et al., 2012):

Productivity = Efficiency + Effectiveness = Doing the right things + Doing things right

The term "productivity" encompasses different meanings from various perspectives. From a systems viewpoint, productivity relates to the connection between inputs and outputs, indicating the efficiency of combining factors within the production process—optimal utilization of resources leads to increased productivity. Another perspective considers productivity as achieving higher output while maintaining constant input costs. The producer views productivity through a production lens, whereas the consumer has a distinct definition in mind. In practice, there is no universally accepted definition of productivity, as the term carries a subjective meaning for each expert. The International Labour Organization defines productivity as "the ratio of output to one of the factors of production (land, capital, human resources, and management)," where the ratio of production to each factor serves as a benchmark for productivity measurement. Overall, products are generated through the combination of four principal factors: land, capital, labor, and organization (including management and technology). Consequently, the ratio of product (output or value-added) to these factors constitutes a commonly accepted metric for assessing productivity (Shahabi Nejad et al., 2015).

Enhancing the productivity of financial markets plays a significant role in the national economy. Given the bank-centric nature of the country's financial system, identifying methods for measuring and elevating productivity levels in banks is especially important.

Accordingly, this study focuses on examining the short-run and long-run causal relationships among productivity, capital adequacy, and the bank workforce in a selected group of banks.

2-1-Productivity Measures

Productivity can be examined from various perspectives and analyzed through different conceptual frameworks. In diverse studies, five main measures have been presented, which together offer a relatively comprehensive view encompassing the broad range of definitions and approaches associated with productivity. These five measures are outlined below:

Partial Productivity: Partial productivity refers to the ratio of output to a specific set of inputs. For example, capital productivity, calculated as the ratio of output to capital input, is a measure of partial productivity. Similarly, labor productivity and material productivity—measured as the ratio of output to labor input and material input, respectively—are also considered partial productivity metrics.

Total Factor Productivity (TFP): Total factor productivity represents the ratio of value added to the aggregate inputs of labor and capital. This indicator relates output to the combined inputs of labor and capital. From an economic perspective, particularly in the context of macroeconomics, TFP is highly significant and, in addition to its application in analyzing a nation's economic growth, is widely used as an effective performance benchmark for business enterprises. In economic literature, TFP is often considered synonymous with multifactor productivity, and the terms are used interchangeably.

Overall Productivity: Overall productivity is defined as the ratio of total output to total inputs. Under this definition, the overall productivity measure is a comprehensive indicator that reflects the collective impact of all inputs on output. The inputs typically considered include labor, materials, machinery, capital, and energy. In recent years, and notably during the 1990s, overall productivity has attracted substantial attention.

Multifactor Productivity (MFP): As mentioned regarding overall productivity and TFP, economic literature frequently treats TFP and MFP as equivalent concepts. From this viewpoint, changes in MFP are significant. Multifactor productivity refers to the ratio of output to more than one input, though it does not necessarily include all inputs. Accordingly, if labor and capital are considered as inputs, multifactor productivity is equivalent to total factor productivity.

Comprehensive Productivity Index: The comprehensive productivity index is obtained by multiplying the overall productivity index by the index of intangible factors. This metric is a more sophisticated measure, expanding the concept of overall productivity to incorporate various qualitative factors such as product quality, process quality, timeliness of delivery, market share, social perception, and more (Shahbazian et al., 2014).

It should be noted that, according to the criteria introduced above, the present study utilizes the total factor productivity index as the principal metric for analyzing the results.

2-2-Total Factor Productivity (TFP)

Total factor productivity (TFP) is a contemporary concept in the literature on economic growth and development, which has expanded over recent decades to help explain the residuals of output growth more thoroughly. This concept has been interpreted and defined differently over time, depending on individuals' experiences, perspectives, and objectives. Scholars, sometimes due to the abstract nature of TFP, have sought to break it down into its constituent components or, alternatively, have presented it as the aggregate quality of all production factors.

TFP can be defined as a composite productivity measure encompassing all inputs. By virtue of this definition, TFP overcomes the limitations inherent in single-factor productivity measures (such as labor or capital productivity). Researchers using TFP are therefore not confined to selecting any single production factor for measuring productivity growth, since all factors are involved in determining overall productivity. Additionally, the influence of each production factor on TFP may vary.

TFP examines changes in output in relation to changes in a set of production factors or inputs. In essence, this approach accounts for those factors that play the most significant role in the production process and can correctly describe efficient and productive utilization of inputs, making it highly valuable for policymakers in both economic and industrial contexts. The use of TFP provides advantages such as eliminating the shortcomings of partial productivity measures, considering all measurable outputs and inputs, and offering a more accurate depiction of a firm's or sector's economic performance.

In practice, when the concept of average output is generalized to all inputs consumed in the production of a given quantity of product, TFP is obtained. In other words, total factor productivity is the average output produced per unit of inputs used during a certain period in a given production unit or economic sector. This metric is formally defined as the ratio of the quantitative output index to the quantitative input index, and thus, TFP can be expressed mathematically as Equation (3):

$$\frac{Q_t}{q_0} = Q(q_0, q_t, w_0, w_t) \tag{1}$$

$$\frac{X_t}{x_0} = X(x_0, x_t, p_0, p_t) \tag{2}$$

$$TFP(q_0, q_t, x_0, x_t, w_0, w_t, p_0, p_t) = \frac{Q_0}{X_0} = \frac{\frac{Q_t}{q_0}}{\frac{X_t}{x_0}} = \frac{\frac{Q_t}{X_t}}{\frac{q_0}{x_0}} \tag{3}$$

Among the above relationships, Equation (1) represents the output index, Equation (2) the overall input index, and Equation (3) the total factor productivity (TFP) index. In these relationships, Q and W denote, respectively, the vectors of output quantities and their prices, while X and P denote, respectively, the vectors of input quantities and their prices. The subscripts 0 and t refer to the base year and the target year, or to the reference production unit and the production unit being compared.

According to Equation (3), TFP compares the output produced with the inputs consumed at two different points in time in order to evaluate the performance of the economic unit. Essentially, this measure seeks to quantify that portion of changes in the level of production which cannot be attributed to variations in the amount of inputs used. From a mathematical perspective, the unexplained residual in output—representing growth in total factor productivity—is expressed as the difference between the growth rates of output and input over time, that is:

$$\frac{\partial \ln TFP}{\partial t} = \frac{\partial \ln Q(q_0, q_t, w_0, w_t)}{\partial t} - \frac{\partial \ln X(x_0, x_t, p_0, p_t)}{\partial t} \quad (4)$$

TFP=Q-X

$$\ln\left[\frac{TFP_t}{TFP_0}\right] = \ln\frac{Q_t}{q_0} - \ln\frac{X_t}{x_0} \quad (5)$$

In Equation (4), the first term on the right-hand side of the equation represents output growth, while the second term denotes growth in total inputs. Put differently, Equation (4) expresses the continuous form of productivity growth, whereas Equation (5) represents its discrete form (Central Bank of the Islamic Republic of Iran, 2018).

2-3- Productivity Status in the Selected Sample of Banks

With regard to Iran, the data obtained from the selected set of banks in the country indicate that the total factor productivity (TFP) of the sampled banks increased during the period under review (2010–2017). This rise in productivity occurred despite the fact that the quantitative utilization of certain resources in the banks displayed a declining trend, while other resources exhibited a rising trend over the same period.

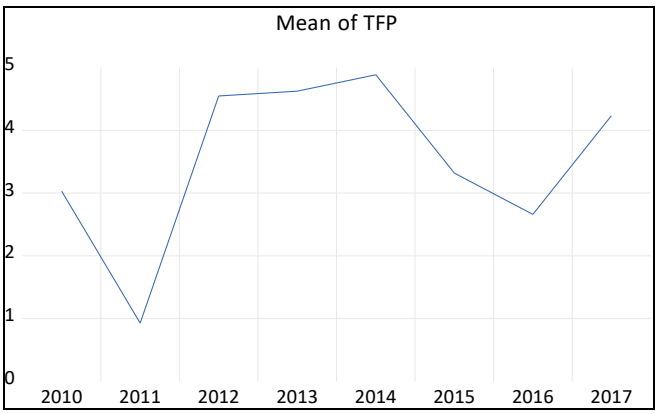

Fig 1. Total Factor Productivity of Banks Listed on the Tehran Stock Exchange

Statistics indicate that, quantitatively, the country's banking network has experienced growth and expansion over time in the utilization of certain inputs, while the use of others has declined. Furthermore, according to the reported data and information, the productivity trends for each of the banks reveal that some have not been successful in optimizing the use of inputs. Figures (2) and (3) respectively illustrate the trends of the labor force and capital adequacy for each of the banks in the sample.

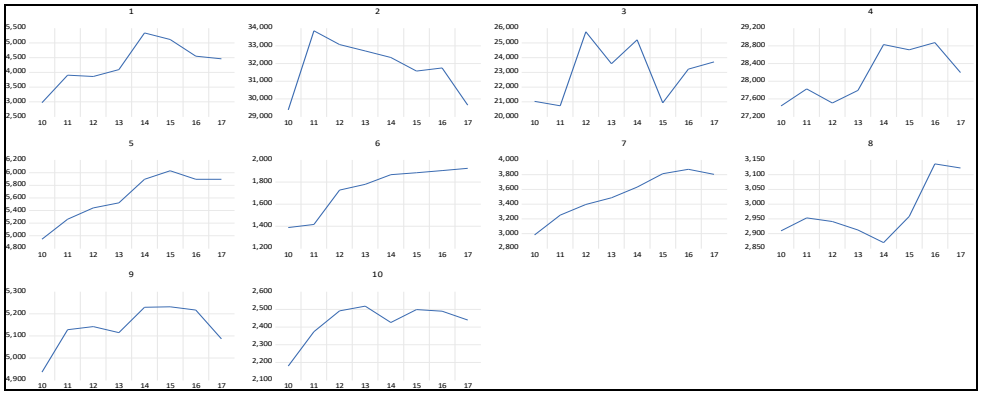

Fig 2. Labor force employed in the selected sample of banks.

The trend in the employed labor force, as depicted in Figure (2), indicates that during the period under review the number of employees in the banks—despite numerous fluctuations—has, overall, increased. The theoretical foundations of productivity suggest that the labor force plays a crucial role in generating banking value-added. In this study, the statistic representing the number of employees has been used as the labor input index.

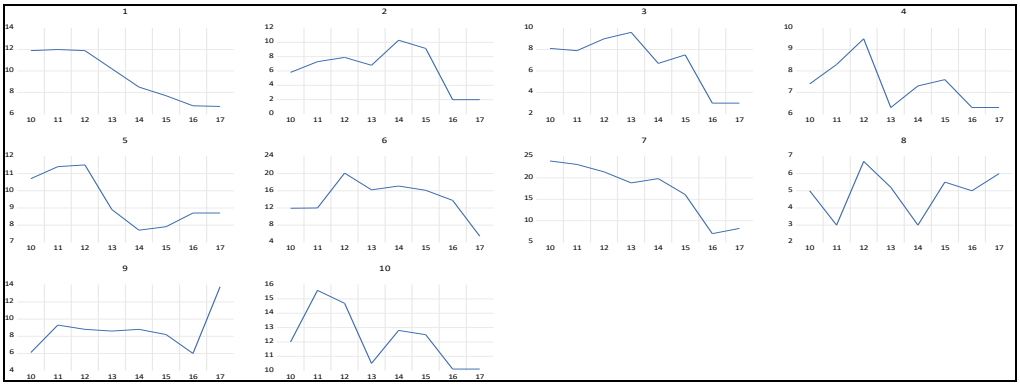

Fig 3. illustrates capital adequacy in the selected set of banks.

As shown in Figure (3), capital adequacy has increased for some banks, while it has declined for most others. Capital adequacy is recognized as one of the most important pillars and determinants of profitability and marketing in modern banking. Therefore, a key research question arises: What are the short-term and long-term causal relationships among these input factors and the productivity of the selected banks with their differing components?

This section presents a review of several domestic and international studies related to the present research topic.

Alkhasneh et al. (2020) examined the productivity characteristics of a number of U.S. banks during the years 1992–2003. The findings revealed that large merged banks exhibit productivity levels similar to those of their counterparts, whereas smaller banks undergoing merger processes experience lower productivity.

Jreisat et al. (2018) investigated the factors influencing total factor productivity in 14 Egyptian banks between 1997 and 2013. Using the Data Envelopment Analysis (DEA) method, they found that the ratio of bank loans to deposits, the size of banks, and their age have a positive and significant effect on productivity, while the net interest rate and non-interest expenses do not exert any significant impact.

Abdi (202023) analyzed the determinants of bank productivity in Nigeria over the period 2001–2015. The results indicated that efficiency ratio, credit risk, and capital adequacy are among the key long-term determinants of bank productivity. Furthermore, among these factors, capital adequacy exerts the most substantial and influential effect on productivity.

Das and Patra (2016) explored the productivity and efficiency of 26 Indian public banks after the global financial crisis. Employing the DEA approach, they concluded that changes in productivity and efficiency vary considerably among state-owned banks and that some suffer from inefficiency due to ineffective policy frameworks.

Lastly, Alhassan and Biekpe (2016) assessed productivity changes in 18 banks in Ghana during 2003–2011 through panel regression analysis. Their results revealed that bank size, market concentration, income diversification, and risk are among the key factors influencing productivity variations across Ghanaian banks.

Among domestic studies, Dejpasand et al. (2019) examined the factors affecting productivity in a selected group of Iranian banks during the period 2009–2013. Using panel data analysis, they identified the roles of human capital, electronic banking technology, scale of activity, degree of asset liquidity, loan-to-deposit ratio, and economic boom-recession cycles as significant determinants of improvements in total factor productivity.

Fa'aljoo and Kalantari (2019) investigated the trends of efficiency and productivity among Iranian banks. Their findings indicated that the choice of input–output approach and whether risk is considered as a negative output considerably affect the performance evaluation of banks. According to their results, the average productivity of private banks, under both intermediary and production approaches, exceeds that of state-owned banks.

Alirezaei and Rajabi (2017) introduced a fourth factor termed the "balance factor of the decision-making unit," concluding that productivity growth is influenced by changes in this balance factor and by branch size throughout the evaluation period.

Yazdanshenas and Shojaei (2016), in a study conducted on Bank Melli branches in Qom Province, identified and explained the model of factors affecting productivity. Based on questionnaire data, their findings showed that professional expertise, problem-solving and thinking skills, communication skills, self-regulatory motivation, persistence, endurance, and creative disruption significantly explain the status of knowledge-based productivity in the studied organization. Among these, self-regulatory motivation and thinking ability played the most influential roles.

Fazel Yazdi and Moein-al-Din (2016) evaluated the efficiency and productivity of Iranian commercial banks using the Malmquist productivity index for the period 2007–2011. Their results revealed that among input variables, the total assets index, and among output variables, the balance of granted facilities and receivables, had the highest importance.

A review of these studies shows that, although the causal relationship among total factor productivity, capital adequacy, and labor force indicators in the banking sector has been investigated in foreign research, such a relationship—examined in the specific manner targeted by the present study—has not been addressed in domestic research. Therefore, this study seeks to focus on both short-term and long-term causal linkages among the mentioned variables and explore their various dimensions. This constitutes the novel contribution of the present research. Accordingly, based on the foregoing and in line with the main objectives of this study, the next section turns to the research methodology and presentation of the obtained results.

4-Research Methodology

In light of the discussions presented in the preceding sections, the primary objective of this study is to examine the causal relationship between the variables of employed labor force in banks (LAB) and capital adequacy (CAP) with the total factor productivity (TFP) of banks. Accordingly, this relationship may be unidirectional, bidirectional, or nonexistent among the mentioned variables.

For the measurement of the labor input, the number of employees working in the selected banks under study has been considered. Capital adequacy (CAP) refers to the ratio of a bank's capital to its

risk-weighted assets. The formula used to calculate the capital adequacy ratio is presented in Equation (6):

Capital Adequacy Ratio=Capital Base(Upper Line of Items × Risk Weight)+(Lower Line of Items × Conversion Factor × Risk Weight)Capital Adequacy Ratio= (Upper Line of Items × Risk Weight)+(Lower Line of Items × Conversion Factor × Risk Weight)Capital Base

This equation expresses the capital adequacy ratio as the proportion of a bank's capital base to the sum of risk-weighted assets—both on-balance-sheet and off-balance-sheet items—adjusted by their respective risk coefficients and conversion factors.

Causality is one of the fundamental issues in examining the relationships among economic variables. Determining the direction of causality is applied to variables for which there is no completely explicit theoretical foundation (Asgari Moqaddam et al., 2019). In this regard, it is assumed that there exists a positive relationship among the variables labor force employed in banks, capital adequacy, and total factor productivity. Therefore, the question arises as to whether an increase in labor force and capital adequacy leads to an improvement in total factor productivity, or conversely, whether higher productivity causes banks—through the expansion of their operations—to inevitably employ more labor and capital. In order to test causality, a Vector Autoregressive (VAR) model is constructed in the form of Equations (7) and (8).

$$\Delta \mathrm{TFP}_{\mathrm{it}} = \alpha + \sum_{\mathrm{i}=1}^{\mathrm{m}} \beta_{\mathrm{i}} \Delta \mathrm{LAB}_{\mathrm{it}} + \epsilon_{it} \qquad (7)$$

$$\Delta \mathrm{TFP}_{\mathrm{it}} = \alpha + \sum_{\mathrm{i}=1}^{\mathrm{m}} \beta_{\mathrm{i}} \Delta \mathrm{CAP}_{\mathrm{it}} + \epsilon_{it} \qquad (8)$$

Accordingly, if for i=1,2,…,k

i=1,2,…,k, the coefficients βi=0 β i =0, then the variables labor force and capital adequacy are not the cause of total factor productivity. In this test, the lag length K is somewhat arbitrary. Gweicke (1984) argues that the validity of the test depends on the order of the VAR model and on whether the variables are stationary or non-stationary; if the variables are non-stationary, the reliability of the test decreases.

Granger (1969) states that the VAR causality test is valid only when the variables are not cointegrated. Based on this principle, the present study was conducted in three stages:

(1) examination of the stationarity of variables,

(2) testing for cointegration, and

(3) determining the appropriate causality model according to the cointegration results.

If a cointegration relationship exists among the variables, the Vector Error Correction Model (VECM) is employed to examine their causal interactions; otherwise, the Vector Autoregressive (VAR) model is applied. According to Engel and Granger (1987), if the variables are cointegrated, the Granger causality test within the VAR framework is inappropriate because it omits the error-correction term, which adjusts short-run disequilibrium. Consequently, to analyze the long-run causal relationships among the variables, the VECM framework must be used.

Finally, the Wald test is employed to evaluate the magnitude of short-run causal relationships (Asgari Moqaddam et al., 2019).

5- Results and Discussion

In this study, the long-run and short-run causal relationships among the variables of the labor force employed in the banking sector, capital adequacy, and total factor productivity (TFP) were examined for ten banks listed on the Tehran Stock Exchange during the period 2010–2017 (1389–1396). The required data were obtained from the Central Bank of Iran as well as from the balance sheets of the selected banks included in the research sample.

As previously mentioned, given the presence of a cointegration relationship among the variables, the Vector Error Correction Model (VECM) was employed to test for causality. In the VECM framework,

the long-run causality relationship is identified through the error-correction term. Accordingly, the relationships represented in Equations (9), (10), (11), and (12) specify the VECM equations formulated for this study.

$$\Delta LAB_{it} = \alpha_{it} + \beta_{it} ECT_{it-1} + \sum_{i=1}^{l} \gamma_{it} \Delta LAB_{it-1} + \sum_{i=1}^{l} \delta_{it} \Delta TFP_{it-1} + \epsilon_{it} \quad (9)$$

$$\Delta TFP_{it} = \alpha_{it} + \beta_{it} ECT_{it-1} + \sum_{i=1}^{l} \gamma_{it} \Delta TFP_{it-1} + \sum_{i=1}^{l} \delta_{it} \Delta LAB_{it-1} + \epsilon_{it} \quad (10)$$

$$\Delta CAP_{it} = \alpha_{it} + \beta_{it} ECT_{it-1} + \sum_{i=1}^{l} \gamma_{it} \Delta CAP_{it-1} + \sum_{i=1}^{l} \delta_{it} \Delta TFP_{it-1} + \epsilon_{it} \quad (11)$$

$$\Delta TFP_{it} = \alpha_{it} + \beta_{it} ECT_{it-1} + \sum_{i=1}^{l} \gamma_{it} \Delta TFP_{it-1} + \sum_{i=1}^{l} \delta_{it} \Delta CAP_{it-1} + \epsilon_{it} \quad (12)$$

In this context, i=1,…,N i = 1, …, N i=1,…,N represents the cross-sections (i.e., the selected banks), and t=1,…,T t = 1, …, T t=1,…,T denotes time. The variable LABit LAB_{it} LABit refers to the number of employees in the banking sector for bank ***i*** at time ***t***. The variable CAPit CAP_{it} CAPit represents the capital adequacy of bank ***i*** in year ***t***, and TFPit TFP_{it} TFPit indicates the total factor productivity for bank ***i*** in year ***t***.

Based on these specifications, the first step is to assess the stationarity of the research variables to avoid the problem of spurious regression. In this study, the stationarity of variables has been examined using the Im-Pesaran-Shin (IPS) test. The results of the stationarity test for the research variables are presented in Table (1) below:

Table1. Results of the Stationarity Test of Research Variables

Variable	Statistic	Probability
Total Factor Productivity (TFP)	0.05	0.52
Labor Force (LAB)	0.17	0.56
Capital Adequacy (CAP)	-8.32	0

Based on the results of the stationarity test, the variables total factor productivity (TFP) and employed labor force (LAB) are non-stationary at level, while the variable capital adequacy (CAP) is stationary at level. Since not all variables are stationary, the cointegration test is employed to avoid spurious or misleading regression results. The outcomes of the Pedroni cointegration test are presented in Table (2) below:

Table2. Results of the Pedroni Cointegration Test

Statistic	TFPit and LABit	TFPit and CAPit
Test Statistic	Probability	Test Statistic
Group Rho Statistic	0.89	0.81
Group PP Statistic	-3.74	0.0001
Group ADF Statistic	-2.73	0.0031

Based on the results of the stationarity test, the variables total factor productivity (TFP) and employed labor force (LAB) are non-stationary at level, while the variable capital adequacy (CAP) is stationary at level. Since not all variables are stationary, the cointegration test is employed to avoid spurious or misleading regression results. The outcomes of the Pedroni cointegration test are presented in Table (2) below:

Table2. Results of the Pedroni Cointegration Test

Relationship	Coefficient	Probability
TFP → LAB	0.0012	0.009
TFP → CAP	0.25	0.000
LAB → TFP	73.8	0.07
CAP → TFP	5.7	0.00

As shown by the results in Table (3), the long-run impact coefficients among the variables are positive and statistically significant. After obtaining the quantitative magnitude of the long-run relationships among the model's variables, the Vector Error Correction Model (VECM) was applied to interpret the Granger long-run causality relationships. The findings derived from estimating the VECM model, which illustrate the long-run causal interactions among the variables, are presented in

Table4. Results of the Long-Run Relationship between Variables using the VECM Approach.

Model	Variable	Term	Coefficient
Model 9	LAB	TFP(-1) Δ	10.99
Model 9	LAB	TFP(-2) Δ	30.49
Model 9	LAB	Error Correction Term	-44.56
Model 10	TFP	LAB(-1) Δ	0.00063
Model 10	TFP	LAB(-2) Δ	0.00062
Model 10	TFP	Error Correction Term	-0.82
Model 11	CAP	lnFRT(-1) Δ	0.009
Model 11	CAP	lnFRT(-2) Δ	0.07
Model 11	CAP	Error Correction Term	0.02
Model 12	TFP	lnGDP(-1) Δ	0.24
Model 12	TFP	lnGDP(-2) Δ	0.27
Model 12	TFP	Error Correction Term	-0.82

At the 90% confidence level, one of the coefficients is statistically significant, while the remaining variables are statistically insignificant.

Based on the results of the VECM model, the long-run relationships among the variables can be explained as follows:

The findings related to the error-correction term, which represents the adjustment of short-run disequilibrium toward long-run equilibrium, indicate that this coefficient is significant and negative only in the one-way relationship leading from the variables toward total factor productivity (TFP). This coefficient implies that any factor causing disequilibrium in the above model will disturb the long-run equilibrium relationship, and the adjustment process will take a certain period of time. The estimated coefficient equals 0.8 percent.

In the case of the other two models, this does not hold true—that is, TFP does not Granger-cause the labor force employed in the banking sector or capital adequacy in the long run.

Short-Run Causality

In the short run, the magnitude of the relationship was measured using the Wald test.

Accordingly, the summarized results of the long-run and short-run causality tests (Wald test) are presented in Table (5): Summary of Long-Run and Short-Run Causality Results.

Table5. Results of Long-Run and Short-Run Causality Relationships

Null Hypothesis	Long-run Causality (DOLS)	Short-run Causality (Wald Test)
TFP_it → CAP_it	0.25 *	33.50 *
CAP_it → TFP_it	5.7 *	0.22
TFP_it → LAB_it	0.0012 *	0.33
LAB_it → TFP_it	73.8 *	0.46

The results of the Wald test presented in Table (5) show that, in the short run, there exists only a unidirectional causal relationship from Capital Adequacy (CAP) toward Total Factor Productivity (TFP). For the other three relationships, no short-run causality is observed. In addition, the results of the long-run causality test indicate that, in the long run, both Labor Force (LAB) and Capital Adequacy (CAP) have a positive and statistically significant impact on Total Factor Productivity, and they are, in turn, influenced by it as well.

6. Conclusion

The present study aimed to examine the short- and long-term causal relationships among Capital Adequacy (CAP), Labor Force (LAB), and Total Factor Productivity (TFP) for a selected group of banks. Using data from ten banks listed on the Tehran Stock Exchange over the period 2010–2017 (1389–1396), the results revealed that, in the short run, only Capital Adequacy acts as the cause of TFP, while the other causal relationships are statistically insignificant. Conversely, in the long run, bidirectional and positive relationships were found between CAP and LAB with TFP.

Based on the findings, in the long run, the labor force (LAB) is a determinant of total factor productivity in banks, and this relationship is mutual, meaning that productivity also significantly affects labor. The estimated coefficient can be interpreted as follows: over the long term, benefiting from a skilled and specialized workforce that performs assigned tasks correctly leads to an improvement in productivity; in turn, as productivity increases—together with profitability and the expansion of banking operations—the need for employing additional and more qualified personnel also rises. Therefore, recruiting and utilizing competent human resources enhances productivity, which itself encourages further employment of skilled labor.

Furthermore, the results confirm a bidirectional long-run relationship between Capital Adequacy (CAP) and Total Factor Productivity (TFP). In the short run, however, the direction of causality runs from CAP toward TFP. This can be explained by the fact that capital acts as a link between inputs and human resources, thereby completing the production and productivity process. As financial markets advance, capital becomes increasingly complex and essential—its effective use in forms such as machinery, technological tools, and financial assets plays a decisive role in enhancing production and productivity. Capital adequacy also contributes to labor productivity; therefore, the causal impact of efficient capital utilization on productivity is undeniable. The results substantiate the effective use of this input in banking operations of the selected sample both in the long and short run. Prioritize merit-based human resource management:

Banking managers should consider that the organization of their workforce must be based not only on general employee characteristics but also on knowledge and professional expertise as a fundamental principle in recruitment and promotion. Establishing a merit-based human resource system aimed at attracting and retaining qualified labor will have a substantial impact on improving productivity.

Emphasize capital adequacy as the key driver of productivity:

To enhance productivity in both the short and long term, banking managers should pay particular attention to maintaining sufficient capital adequacy. Adequate capital provides the essential means for sustaining operational efficiency, increasing productivity, and strengthening financial stability across time horizons.

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