Information technology value engineering through partial adjustment valuation theory

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ABSTRACT

The paper proposes a systems management approach that utilizes information technology (IT) treatment as a framework to help firms enhance future performance by optimising key parameters. The method certifies a valuation approach that enables businesses to better manage their IT infrastructure and improve performance. A case study of A case study of PT Telekomunikasi Indonesia (Telkom) and PT XL Axiata (XL) (2004–2018) shows the method's effectiveness. Once the IT value is identified, specific parameters can be engineered to improve performance without changing other variables. The approach uses a partial adjustment valuation model, enabling performance gains at lower costs. The results show significant improvements in both firms' performance values and ratios compared to their originals. This supports adopting a cost leadership strategy, making IT-based businesses more efficient, cost-effective, and better performing across financial, business, and strategic dimensions.

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1. INTRODUCTION

This paper aims to propose a framework that equips firms with measurable parameters to strengthen their current business positions through information technology (IT), thereby enhancing competitive advantage and long-term sustainability. The motivation for this research is rooted in the growing pressure on firms to justify IT investments not merely as operational support, but as strategic assets that drive measurable performance outcomes. In the digital economy, firms must align IT parameters with financial, business, and strategic objectives to maintain competitiveness and survive market disruptions [1]-[3].

The framework introduced in this paper provides a structured approach to mapping and engineering business positions by utilizing IT as a production factor. These business positions encompass finance, business, and strategy dimensions, all of which are central in IT investment considerations [4]-[6]. The method is anchored in the production function, enhanced by a valuation model, which leverages yield relations and intake coefficients or parameters [5], [7], [8]. By systematically adjusting the relationship between yield (output) and intake (input) parameters, firms can simulate and optimize outcomes achieving higher yields with controlled input changes [8], [9]. This forms the basis of the partial adjustment valuation (PAV) approach.

The PAV method is significant because it bridges economic theory and IT management. Unlike static valuation models, PAV assumes that adjustments in firm performance occur gradually due to costs, constraints, and organizational inertia. It allows firms to partially adjust IT-related parameters toward optimal levels rather than requiring unrealistic, instantaneous changes. In practice, this means IT infrastructure and processes can be engineered incrementally, lowering risks and c0osts while still achieving performance improvements. This partial adjustment mechanism makes the framework practical, cost-efficient, and adaptable to real-world business environments, especially in industries where IT is the backbone of operations [10].

To validate the framework, the study focuses on Indonesia's telecommunications sector, specifically PT. Telekomunikasi Indonesia, Tbk. (Telkom) and PT. XL Axiata, Tbk. (XL), over the period 2004–2018. These firms were chosen for several reasons. First, telecommunications is one of the most IT-intensive industries, where network infrastructure, digital services, and IT-enabled operations directly define competitive advantage. Second, Telkom and XL are among Indonesia's largest telecom firms, with significant market share, making them representative of the industry's dynamics. Third, both firms provide a unique comparison: Telkom is listed on both the Indonesia Stock Exchange and the New York Stock Exchange, reflecting international investor scrutiny, while XL is listed only domestically. This contrast allows the framework to be tested across different regulatory and market environments. Finally, Indonesia itself is a fast-growing digital economy, where the telecom sector plays a pivotal role in enabling national digital transformation [11].

The contributions of this paper to the business world are threefold. First, it introduces an alternative, science-based framework to map business positions that firms can use to guide sustainable strategic navigation. Second, it demonstrates how IT parameters can be quantitatively regulated and systematically engineered, creating opportunities to intensify yields and revenues at lower costs. Third, it integrates with the balanced scorecard (BSC) framework, reinforcing perspectives in finance, customer, and internal processes, thereby strengthening overall business effectiveness. By combining economic modeling, valuation methods, and IT parameter engineering, the framework offers firms a practical pathway to transform IT investments into measurable business value. The case studies of Telkom and XL show that IT-driven business position engineering can significantly enhance performance ratios and values. Ultimately, the findings encourage firms to adopt cost leadership strategies while improving competitiveness, making IT-based businesses more efficient, controllable, and sustainable [11], [12].

Meanwhile, the paper-related works have been associated with [10] which proposed a business positioning system framework based on his past study, providing a framework for future research to determine the required business position according to the preferred firm performance. Additionally, this study is inspired by the BSC framework [13], [14]., which guided the development of a business framework aimed at achieving optimal performance across four key perspectives: finance, customers, internal business, and learning and growth. However, the paper addresses itself in the business environment, which intensively uses IT as a production tool. For example, in telecommunications firms, the needed parameters to undergo an engineering process are IT parameters.

Also, this study has a relation to [14], which measured and improved IT governance through the BSC. The paper focuses on IT BSC to measure the IT function and the board performance. It involves developing scorecards to capture IT governance performance. In the IT BSC, the financial perspective of Kaplan's BSC transforms into the corporate contribution perspective. Therefore, the scorecard measures IT and board performance from this perspective [14].

Furthermore, the systematic paper is structured as follows: section 1 aims to provide an IT-based business position framework as a unique management system. Additionally, this section presents related works relevant to this paper. Furthermore, section two discusses method consisting of a theoretical background, which bases the study on offering framework solutions and the research methodology employed by the study, step by step, resulting in the optimal solution. Section three presents a case study and its results to demonstrate that the research methodology is effective in practice within the business world. Also, section three addresses the discussion of the measurement results. Ultimately, Section four concludes the paper, which addresses the introductory problem and its solution.

2. METHODS

2.1. Information technology value method

Among the IT valuation applications are real options, discounted cash flow, and partial adjustment valuation. [15]-[17]. In this study, the IT valuation method is an approach that enables us to determine the value of IT investments after a specific period, for example, in a firm where IT is found to contribute to the firm's performance. Meanwhile, several IT investment valuation methods have been applied in the field, each with its respective advantages and disadvantages. However, this paper initiates a discussion on the PAV with a dynamic speed of adjustment [16].

Therefore, the PAV theory declares that the deviation in the concrete yield of a fabrication process commonly does not accurately correspond to the preferred yield deviation. The deviation measurement is in the present (t), compared with the previous period $(t-1)$ of the concreted deviation and the preferred deviation, in which there must be a coefficient bridging the relationship between the two differentiations, indicating whether a constant or a dynamic speed of adjustment [16], [18]. Therefore, if written in a mathematical formula, the theory is revealed in this fashion:

$$y_t \rightleftarrows -y_{t-1} = \mu(y_t^* - y_{t-1}), (t = 1,2,\ldots,s) \quad (1)$$

where y_t is the concrete yield of a fabrication process unit, for instance, a firm, in time t, as $y_t - 1$ is the concrete yield of the identical fabrication process unit at time $t-1$. Whereas y_t^* is the preferred yield of the fabrication process unit at time t, and μ is the coefficient representing a constant or a dynamic speed of adjustment [16], [19]. In an estimation process, a conventional random error denoted byϵ_t is taken into account to refine the formula. Therefore, the (1) reveals as:

$$y_t = \mu y_t^* + (1-\mu)y_{t-1} + \in_t \ (t = 1,2,\ldots,s) \quad (2)$$

whereas ϵ_t = conventional error, it seems that the concrete yield is equal to the weighted average of the currently preferred yield with the weights μ and the concreted yield at a past time, with weights $1-\mu$. Furthermore, Lin *et al.* [20] suggested that μ in (1) and (2) can vary and be dynamic; therefore, μ may convert to μ_t where t symbolizes variations in time for the dynamic and μ for the constant or static. This pattern trains to deliver more value of μ, for example, the dynamic μ symbolizes the speed of adjustment activities in linking the tangible yield adjustment with alterations in the preferred one. In other words, these two alterations in yield understand the dynamic nature of μ. Soon, the pattern also presents another consequence of the state that warrants further investigation [20].

The (2) shows that actual yield is a weighted average between the desired yield y_t^* and the previous yield y_{t-1}. If $\mu = 0$, there is no adjustment (full inertia). If $\mu = 1$, the firm instantly reaches the preferred yield. At that moment, the (1) and (2) turns to the following (3) and (4) [20], [21]:

$$y_t = \mu_t f(X_t;\beta) + (1-\mu_t)y_{t-1} + \in_t \ (t = 1,2,\ldots,s) \quad (3)$$

$$\mu_t = g(S_t;\gamma), 0 \le \mu_t \le 1, (t = 1,2,\ldots,s) \quad (4)$$

Here $f(X_t,\beta)$ is the alternative function of the preferred yield (y_t^*), which reveals as a fabrication function [22]-[24]. Consequently, X_t could comprise a vector of production such as the normal capital (K_t), the normal labour expense (L_t), and the technology investment, in this research related to IT investment (I_t). For the flexibility of assessing the fabrication function, it may involve two configurations. The first is a blend of K, L, and I that provides accommodations for the elements of capital, labour, and IT investment, approximately, and the second is a blend of K and L that has capacity for the factors of capital and labour. Therefore, there are two models: $X_t = (K_t, L_t, I_t)$ and $X_t = (K_t, L_t)$ whereas β is the unidentified parameters [20], [23].

2.2. Speed of adjustment and fabrication function

In the meantime, the function $\mu_t = g\ (S_t;\ \gamma)$, see (4), stands for a dynamic speed of adjustment that puts up variables, which vary together with the diverse variations of the needed yield such as return on equity (ROE). The scale of μ_t or μ is between 0 and 1 [16], where the value of 0 indicates that the concrete yield at time t is accurately equivalent to the concreted yield of the preceding period, $t-1$. While one designates that the concreted yield corresponds to the preferred yield. On the contrary, μ_t is an S_t function, a vector of the variable, assuming the speed of adjustment of a firm, and γ is the unidentified parameter. Hence, to revert to the novel PAV theory, the (3) is this way:

$$y_t - y_{t-1} = \mu_t f(X_t;\beta) - \mu_t y_{t-1} + \in_t \ (t = 1,2,\ldots,s) \quad (5)$$

In essence, the fabrication function of (3), namely $f(X_t,\beta)$, can originate from various production functions such as the Cobb-Douglas (CD), the Box–Cox, the Box–Tidwell, the translog, and the constant elasticity of substitution functions [23]. The study may focus on all or several of them as a trial focus. Because of that, this research utilizes the CD production function to take the place of $f(X_t,\beta)$ in (3) because of its easiness and fluency in production functions [18], [25], while the CD equation is equally in the (6) [26]:

$$f(X_t;\beta) = \alpha K_t^{\beta_1} L_t^{\beta_2} I_t^{\beta_3} e^{v_t - u_t} (t = 1,2,\ldots,s) \quad (6)$$

The (6) presents the CD function with Xt containing production factors K_t, L_t, and I_t. K_t is the normal capital, L_t is the normal labour expense, and I_t is IT capital. In other words, the (6) considers IT capital insertion. In the meantime, α, β_1, β_2, and β_3 are the unidentified parameters and $v_t \sim N(0, \sigma_v{}^2)$, and $u_t \sim | N(0, \sigma_v{}^2)$. Whereas the (4), the speed of adjustment, can be demonstrated as in (7) [20]:

$$\mu_t = \gamma_1 + \gamma_2 S_t with 0 \leq \mu_t \leq 1 \quad (7)$$

At this point, u_t represents the dynamic speed of adjustment, and S_t is the dynamic factor that utilizes the dynamics of u_t to accommodate time variations. Similarly, it may reveal disparities between the tangible and intangible variables of the firm. Additionally, researchers deliver many degrees to fulfil these elements with several variables of S_t, such as ROE, return on assets (ROA), Tobin's Q, market-to-book value (MTBV), economic value-added, and market value-added [20], [23], in which γ_1 and γ_2 are the unknown parameters. Additionally, if (6) and (7) are substituted into (5), it produces (8) as:

$$y_t = (\gamma_1 + \gamma_2 S_t)(\alpha K_t^{\beta_1} L_t^{\beta_2} I_t^{\beta_3} e^{v_t - u_t}) - (\gamma_1 + \gamma_2 S_t - 1) y_{t-1} + \in_t \ (t = 1,2,\dots,s) \quad (8)$$

The (8) is for the three-factor production function, viz. K_t, L_t, and I_t. It seems that the (8) as mentioned above corresponds to (5), excluding that the production function, viz., $f(X_t, \beta)$, has transformed to the CD function [see (6)] and the speed of adjustment μ_t exchanged by (7). The rationalization of variables and parameters in the equation corresponds to the prior equations that it replaces. Furthermore, the (8) is a nonlinear equation; its solution must also exploit an nonlinear least squares (NLS) application [20].

To estimate the transformation of firm performance due to IT investment, Lin and Kao [16] recommended using performance measures (PM) of the dynamic (μ_{it}) and static (μ_i) speeds of partial adjustment to assess the performance transformation of the processing part. This magnitude is revealed in (9) [18]:

$$PM_t = \mu_t f(X_t; \beta) = g(S_t; \gamma) f(X_t; \beta) \quad (9)$$

To approximate the parameters γ and β, both parameters are further termed as converted $\hat{\gamma}$ and $\hat{\beta}$, thus, the (9) changes to:

$$PV_{it} = \hat{PM}_{it} = \hat{\mu}_{i(t)} f(X_{it}; \hat{\beta}_i) = g(S_{i(t)}; \hat{\gamma}_i) f(X_{it}; \rightleftarrows \hat{\beta}_i) \quad (10)$$

In this case, PV_{it} is the performance value of the firm, estimated in currency values. Moreover, if PV_{it} is divided by the tangible yield (y_{it}), instead of a "divisor" (y_{it}^{Δ}) as suggested by [20], it appears as an index of performance ratio (PR). Consequently, the equation seems like (11).

$$PR_{it} = \frac{PV_{it}}{y_{it}} (i = 1,\dots, randt = 1,\dots, s) \quad (11)$$

2.3. Research methodology
2.3.1. Defining the problem research

The research problem is to create a framework that provides an innovative means for a firm to assess its current business ("as-is") position, thereby opening an opportunity to improve its future ("to-be") position and preserve and enhance its competitive advantage and business sustainability [10]. In other words, the goal is to assess a firm's current business position ("as-is") and engineer improvements toward a better position ("to-be") using IT valuation.

2.3.2. Selecting the firm objects

Data is imperative to corroborate qualified research. Accordingly, two Indonesian telecommunications companies (telcos) appear to complete the research model because both firms dominate 84.1% of the mobile subscribers market share in Indonesia [11]. Thus, Telkom and XL have provided data from 2004 to 2018 concerning six various dynamic factors of the speed of adjustment. They consist of ROE, ROA, Tobin's Q, MTBV, economic value added (EVA), and market value added (MVA) [27]-[32]. In turn, these six dynamic factors represent the firm's three-parameter categories [4], namely finance (ROA and ROE), business (Tobin's Q and MTBV), and strategy (EVA and MVA).

In this case, ROE is the volume of net income returned as a percentage of shareholders' equity. ROA is a measure that evaluates a firm's profitability relative to its total assets [27], [28]. Likewise, the Tobin's Q ratio is the firm's market value divided by the replacement value of the firm's assets, or q = total market value of the firm/total asset value [29]. Meanwhile, MTBV is a ratio that results from comparing a firm's book value to its market value [30]. Furthermore, EVA is a measure of a firm's financial performance based on the residual wealth estimated by subtracting the cost of capital from its operating profit [31]. Likewise, MVA is a calculation that represents the difference between the market value of the firm and the investor's capital [32]. Therefore, two Indonesian telcos: Telkom and XL, with justification, as they controlled 84.1% of Indonesia's mobile subscriber market [11] and provided long-term data (2004–2018). Additionally, they represent IT-intensive industries where IT has a direct impact on performance.

2.3.3. Selecting and estimating a valuation method with a dynamic speed of adjustment to clarify IT values

To determine whether IT investment has impacted firm performance, models must be used that accommodate this. Consequently, using the valuation method PAV, the (8) provides a mathematical model for estimating values that involve the IT value within an IT-based firm [6], [12], [20], [33]. Therefore, using (9)-(11), the model performance measures, its performance values, and its performance ratios are estimable [6], [33].

In this research, the PAV employs the dynamic speed of adjustment through six dynamical factors, viz. ROE, ROA, Tobin's Q ratio, MTBV, EVA, and MVA. The data derives directly from the firm's annual report if the dynamic factors are accessible within. If not, it involves an outside estimation based on the definitions mentioned above. Thus, there are six indicators: ROE, ROA, Tobin's Q, MTBV, EVA, and MVA. They are mapped into three categories [4], [24] finance: ROA and ROE; business: Tobin's Q and MTBV; and strategy: EVA and MVA.

2.3.4. Dealing with adjustable parameters for research

To resolve (8), it depends on (6). In other words, the valuation method estimation requires the CD function with X_t containing production factors K_t, L_t, andI_t, whereas I_t is the IT investment. Therefore, the presence of the I_t variable delivered affirmative contributions to the model, as indicated by parameter β_3, which represents the dynamic speed of adjustment. It means that the production elasticity (β_3) of the IT investment is β_3%, hence, each 1% increase in the IT investment can increase production by β_3%, assuming that other variables are constant, ceteris paribus [8]. Thus, it indicates that the elasticities appeared extraordinarily close to the surveyed yield [7].

In summary, we use (7) (PAV with CD production), we estimate β_1, β_2, and β_3 (the elasticities of capital, labor, and IT), and we estimate μt as a function of the dynamic factors S_t. Hence, we have to focus on IT elasticity (β_3). If β_3 increases, then output and performance values/ ratios increase proportionally. Likewise, keep other variables constant to isolate IT's effect.

2.3.5. Adjusting required performance values and performance ratios

Accordingly, by understanding the relationship between the yield and the IT production elasticity (β_3), the performance values and ratios [see (10) and (11)] can increase as β_3 increases [see (6)] due to the direct proportionality. As a result, the rise of performance values/ ratios also means the increasing yield/ revenue [see (3)]. It is significant to gain attention, so the intended performance value/ ratio improvement is achieved through an engineering process, namely by adjusting the IT production elasticity (β_3) parameter to increase if the R^2 (the determinant coefficient) value exceeds 90% [34]. Thus, the error rate is still within reasonable limits, even though the IT investment (I) remains unchanged. It is achieved through a nonlinear regression process using the SPSS application [8]. In this step, we need to examine nonlinear regression (NLS) in SPSS. Additionally, verify $R^2 > 90\%$ for strong explanatory power [34] and ensure the error rate remains acceptable.

2.3.6. Designing an IT-based business positioning system framework

Subsequent is to map the six dynamic factors into the firms three categories [4], [35] to create a framework providing a firm with its current business positions to enhance its competitive advantage through an engineering effort by increasing the six dynamic factors on permanent IT investment, however, the result is that the firm revenue is boosted, too. Therefore, we have to map improved performance values (PV and PR) into finance, business, and strategy categories. Likewise, use the framework to support cost leadership strategies and sustainable advantage.

3. RESULTS AND DISCUSSION
3.1. Case study

We began by identifying the six dynamic factors needed to estimate (4) and (7). The data came from the annual reports of the two firms for the years 2004–2018. For each firm, the variables K, L, and I were classified and analyzed using nonlinear regression in SPSS, as shown in (8). Then, the (9)-(11) were used to calculate the performance values (PV) and PR of both firms, resulting in the figures presented in Tables 1 to 4 for Telkom and XL [6], [10], [33].

Table 1 shows Telkom's PV, which were calculated by multiplying the dynamic speed of adjustment with the fabrication function, as stated in (10). The case study uses six dynamic factors ROE, ROA, Tobin's Q, MTBV, EVA, and MVA which represent changes in the speed of adjustment and have different scales. Because of this, each factor produces PV values of different sizes. Overall, the PV results show that IT investment influences firm performance. If IT investment were excluded, the PV values would be lower than those shown in Table 1. Table 2 shows Telkom's PR when IT investment is included. Together, Tables 1 and 2 indicate that IT investment has a positive impact on firm performance and still has the potential to further strengthen the firm's competitive advantage. Similarly, the same pattern can be seen in Tables 3 and 4, just as in Tables 1 and 2. These tables show XL's performance values and performance ratios.

Table 1. Telkom's PV of six dynamic factors on IT investment

Year	PV (billion of Rupiah) based on six dynamic factors					
	ROE	ROA	Tobin's Q	MTBV	EVA	MVA
1	2	3	4	5	6	7
2004	24,982	16,866	17,250	21,217	18,368	16,066
2005	28,389	22,218	23,320	24,922	21,980	20,383
2006	37,516	29,879	38,370	39,528	34,350	28,718
2007	41,263	36,353	39,965	38,322	41,673	31,401
2008	33,728	24,900	22,555	25,634	33,790	25,823
2009	35,710	26,826	33,340	34,223	39,372	31,599
2010	33,370	27,486	28,725	27,999	40,838	29,546
2011	32,824	26,546	26,340	25,727	40,470	30,337
2012	37,962	31,819	33,883	31,862	47,395	35,992
2013	39,309	32,925	37,863	34,608	51,688	41,397
2014	38,837	50,412	49,178	42,581	53,823	49,862
2015	54,339	56,292	54,949	51,855	62,972	60,999
2016	64,755	72,887	71,098	63,312	85,608	77,563
2017	70,899	77,636	74,959	66,959	96,921	85,682
2018	59,032	59,551	60,436	54,866	69,835	73,552
Average	42,194	39,506	40,815	38,908	49,272	42,595
β_3	0.170	0.168	0.159	0.142	0.221	0.171
R^2	0.999	0.999	0.999	0.999	0.999	0.999

Table 2. Telkom's PR of six dynamic factors on IT investment

Year	PR (index) based on six dynamic factors					
	ROE	ROA	Tobin's Q	MTBV	EVA	MVA
1	2	3	4	5	6	7
2004	0.736	0.497	0.508	0.625	0.541	0.473
2005	0.679	0.531	0.558	0.596	0.608	0.488
2006	0.731	0.582	0.748	0.771	0.767	0.560
2007	0.694	0.612	0.672	0.645	0.810	0.528
2008	0.556	0.410	0.372	0.422	0.557	0.425
2009	0.553	0.415	0.516	0.530	0.610	0.489
2010	0.486	0.400	0.419	0.408	0.595	0.431
2011	0.461	0.373	0.370	0.361	0.568	0.426
2012	0.492	0.412	0.439	0.413	0.614	0.467
2013	0.474	0.397	0.456	0.417	0.623	0.499
2014	0.433	0.562	0.548	0.475	0.600	0.556
2015	0.530	0.549	0.536	0.506	0.615	0.595
2016	0.557	0.627	0.611	0.544	0.736	0.667
2017	0.553	0.605	0.584	0.522	0.756	0.668
2018	0.451	0.455	0.462	0.420	0.534	0.562
Average	0.559	0.495	0.520	0.510	0.636	0.522
β_3	0.170	0.168	0.159	0.142	0.221	0.171
R^2	0.999	0.999	0.999	0.999	0.999	0.999

Table 3. XL's PV of six dynamic factors on IT investment

Year	PV (billion of Rupiah) based on six dynamic factors					
	ROE	ROA	Tobin's Q	MTBV	EVA	MVA
1	2	3	4	5	6	7
2004	1,463	1,574	1,780	1,239	1,638	1,729
2005	1,816	2,018	2,231	2,223	2,157	2,195
2006	3,459	3,422	3,386	3,430	3,394	3,383
2007	3,955	4,010	4,101	4,184	4,138	4,111
2008	4,903	5,099	5,191	5,604	5,225	4,884
2009	5,205	4,803	4,632	4,979	4,826	4,447
2010	5,643	5,446	5,387	5,122	5,400	5,621
2011	6,901	6,894	6,814	6,666	6,928	6,950
2012	6,369	6,320	6,261	6,047	6,335	6,496
2013	5,305	5,497	5,749	5,728	5,601	5,821
2014	5,377	5,627	6,489	6,586	6,025	6,289
2015	4,791	5,201	5,488	5,847	5,215	5,107
2016	5,361	5,742	5,953	6,478	5,821	5,486
2017	5,138	5,614	5,943	6,446	5,811	5,632
2018	3,358	4,100	4,680	5,158	4,222	4,597
Average	4,603	4,758	4,939	5,049	4,849	4,850
β_3	0.239	0.213	0.209	0.175	0.212	0.214
R^2	0.980	0.980	0.980	0.980	0.980	0.980

Table 4. XL's PR of six dynamic factors on IT investment

Year	PR (index) based on six dynamic factors					
	ROE	ROA	Tobin's Q	MTBV	EVA	MVA
1	2	3	4	5	6	7
2004	0.440	0.474	0.536	0.373	0.493	0.520
2005	0.422	0.469	0.518	0.517	0.501	0.510
2006	0.535	0.529	0.524	0.531	0.525	0.523
2007	0.473	0.479	0.490	0.500	0.495	0.491
2008	0.403	0.419	0.427	0.461	0.430	0.402
2009	0.375	0.346	0.334	0.359	0.348	0.320
2010	0.320	0.309	0.305	0.290	0.306	0.319
2011	0.374	0.373	0.369	0.361	0.375	0.376
2012	0.299	0.297	0.294	0.284	0.298	0.305
2013	0.248	0.257	0.269	0.268	0.262	0.273
2014	0.228	0.239	0.275	0.279	0.256	0.267
2015	0.209	0.227	0.239	0.255	0.227	0.222
2016	0.250	0.268	0.278	0.303	0.272	0.256
2017	0.224	0.245	0.260	0.281	0.254	0.246
2018	0.146	0.178	0.203	0.224	0.184	0.200
Average	0.330	0.341	0.355	0.352	0.348	0.349
β_3	0.239	0.213	0.209	0.175	0.212	0.214
R^2	0.980	0.980	0.980	0.980	0.980	0.980

3.2. Results of engineering

To carry out steps 4 and 5 of the research method, the IT production elasticity (β_3) is estimated using nonlinear regression in SPSS, applied to the original IT investment data. The model must have an R^2 value above 0.90. The results of this estimation are shown in Tables 5 to 8 for Telkom and XL. Tables 5 and 6 show how Telkom's PV and PR increase when the β_3 value is raised. For the six dynamic factors, the higher β_3 (shown in the second-to-last row of each table) leads to higher PV and PR values (shown in columns 2–7). For example, with the original β_3 value of 0.170, Telkom's ROE-based PV was Rp 24,982 billion in 2004, Rp 28,389 billion in 2005, and averaged Rp 42,194 billion from 2004–2018 (see Table 1). When β_3 increased to 0.185, the PV also increased to Rp 28,629 billion in 2004, Rp 32,744 billion in 2005, and an average of Rp 49,007 billion, which is a 16.2% rise (Table 5).

The same pattern appears in the other five dynamic factors: ROA increased by 10.5%, Tobin's Q by 17.4%, MTBV by 13.9%, EVA by 15.0%, and MVA by 16.3% from 2004–2018. A similar effect is also seen in the PR estimates, which use the same β_3 values, as shown in Table 6. The same way of reading the tables also applies to Tables 7 and 8, which show how XL's PV and PR increase as β_3 rises. The second-to-last row in each table shows the β_3 values used. As β_3 increases, XL's PV, PR, and overall performance also improve, and all six dynamic factors show similar behavior. From 2004 to 2018, XL's average PV increased as follows: ROE by 9.0%, ROA by 18.8%, Tobin's Q by 18.8%, MTBV by 18.8%, EVA by 29.5%, and MVA by 19.8%. A similar pattern appears in the PR estimates when β_3 increases, as shown in Table 8. This finding supports the potential to build the intended framework.

Table 5. Telkom's PV of six dynamic factors on IT investment after β_3 engineering with $R^2 > 0.90$

Year	PV (billion of Rupiah) based on six dynamic factors					
	ROE	ROA	Tobin's Q	MTBV	EVA	MVA
1	2	3	4	5	6	7
2004	28,629	18,470	19,949	23,877	20,816	18,412
2005	32,744	24,436	27,154	28,203	24,999	23,510
2006	43,428	32,940	44,851	44,872	39,185	33,243
2007	47,702	40,042	46,649	43,454	47,632	36,301
2008	39,192	27,521	26,473	29,197	38,878	30,006
2009	41,403	29,606	39,038	38,903	45,207	36,636
2010	38,450	30,208	33,412	31,657	46,618	34,043
2011	37,902	29,218	30,707	29,142	46,290	35,029
2012	43,945	35,080	39,607	36,171	54,340	41,664
2013	45,755	36,432	44,520	39,475	59,566	48,185
2014	45,199	55,776	57,815	48,564	62,009	58,029
2015	63,304	62,325	64,671	59,194	72,619	71,064
2016	75,553	80,779	83,812	72,367	98,862	90,497
2017	82,880	86,152	88,543	76,662	112,126	100,161
2018	69,022	66,093	71,404	62,827	80,807	85,999
Average	49,007	43,672	47,907	44,304	56,664	49,519
β_3	0.185	0.178	0.175	0.155	0.235	0.186
R^2	0.938	0.977	0.927	0.958	0.907	0.931

Table 6. Telkom's PR of six dynamic factors on IT investment after β_3 engineering with $R^2 > 0.90$

Year	PR (index) based on six dynamic factors					
	ROE	ROA	Tobin's Q	MTBV	EVA	MVA
1	2	3	4	5	6	7
2004	0.843	0.544	0.588	0.703	0.613	0.542
2005	0.783	0.584	0.650	0.675	0.691	0.562
2006	0.847	0.642	0.874	0.875	0.875	0.648
2007	0.803	0.674	0.785	0.731	0.925	0.611
2008	0.646	0.453	0.436	0.481	0.641	0.494
2009	0.641	0.458	0.604	0.602	0.700	0.567
2010	0.560	0.440	0.487	0.461	0.679	0.496
2011	0.532	0.410	0.431	0.409	0.650	0.492
2012	0.570	0.455	0.513	0.469	0.704	0.540
2013	0.551	0.439	0.537	0.476	0.718	0.581
2014	0.504	0.622	0.645	0.541	0.691	0.647
2015	0.618	0.608	0.631	0.578	0.709	0.694
2016	0.649	0.694	0.720	0.622	0.850	0.778
2017	0.646	0.672	0.690	0.598	0.874	0.781
2018	0.528	0.505	0.546	0.480	0.618	0.658
Average	0.648	0.547	0.609	0.580	0.729	0.606
β_3	0.185	0.178	0.175	0.155	0.235	0.186
R^2	0.938	0.977	0.927	0.958	0.907	0.931

Table 7. XL's PV of six dynamic factors on IT investment after β_3 engineering with $R^2 > 0.90$

Year	PV (billion of Rupiah) based on six dynamic factors					
	ROE	ROA	Tobin's Q	MTBV	EVA	MVA
1	2	3	4	5	6	7
2004	1,577	1,830	2,069	1,441	2,053	2,024
2005	1,970	2,374	2,624	2,615	2,752	2,603
2006	3,759	4,040	3,997	4,050	4,354	4,028
2007	4,320	4,785	4,894	4,993	5,394	4,949
2008	5,384	6,146	6,258	6,755	6,915	5,943
2009	5,671	5,702	5,498	5,910	6,242	5,324
2010	6,142	6,454	6,383	6,070	6,965	6,717
2011	7,534	8,217	8,122	7,946	9,017	8,358
2012	6,985	7,601	7,530	7,272	8,356	7,885
2013	5,799	6,569	6,870	6,845	7,317	7,019
2014	5,876	6,719	7,748	7,864	7,861	7,577
2015	5,207	6,144	6,483	6,907	6,695	6,083
2016	5,844	6,823	7,074	7,698	7,540	6,575
2017	5,568	6,594	6,980	7,570	7,396	6,668
2018	3,630	4,791	5,469	6,028	5,334	5,414
Average	5,018	5,653	5,867	5,998	6,279	5,811
β_3	0.249	0.233	0.229	0.195	0.242	0.235
R^2	0.977	0.964	0.962	0.959	0.937	0.959

To complete steps 4 and 5 of the research method, the IT production elasticity (β_3) is estimated using nonlinear regression in SPSS, based on the original IT investment data. The model must have an R^2 value above 0.90 to ensure accuracy. The results of this process are shown in Tables 5 to 8 for Telkom and XL [34]. The findings show that increasing β_3 leads to significant improvements in both PV and PR across all six dynamic factors (ROE, ROA, Tobin's Q, MTBV, EVA, and MVA). For example, Telkom's average ROE-based PV rose by 16.2%, while XL's rose by 9.0%. EVA showed some of the largest gains 15.0% for Telkom and 29.5% for XL [18].

These results are consistent with international studies. Brynjolfsson and Hitt (2000) found that U.S. firms improved performance elasticity by 10–25% through IT. Likewise, Japan's NTT DoCoMo improved EVA by about 20% due to IT investments. This shows that the improvements seen in Telkom and XL align with global trends. Overall, the increase in β_3 strengthens PV and PR and confirms that Indonesian telecom firms are gaining IT value at levels comparable to international firms. This supports the development of the proposed IT valuation framework and ensures its global relevance [36]-[38].

Table 8. XL's PR of six dynamic factors on IT investment after β_3 engineering with $R^2 > 0.90$

Year	PR (index) based on six dynamic factors					
	ROE	ROA	Tobin's Q	MTBV	EVA	MVA
1	2	3	4	5	6	7
2004	0.475	0.551	0.623	0.433	0.618	0.609
2005	0.458	0.552	0.610	0.608	0.640	0.605
2006	0.581	0.625	0.618	0.626	0.673	0.623
2007	0.516	0.572	0.585	0.597	0.645	0.592
2008	0.443	0.506	0.515	0.556	0.569	0.489
2009	0.409	0.411	0.396	0.426	0.450	0.384
2010	0.348	0.366	0.362	0.344	0.395	0.381
2011	0.408	0.445	0.440	0.430	0.488	0.453
2012	0.328	0.357	0.354	0.342	0.393	0.371
2013	0.272	0.308	0.322	0.321	0.343	0.329
2014	0.249	0.285	0.329	0.334	0.334	0.321
2015	0.227	0.268	0.282	0.301	0.292	0.265
2016	0.273	0.319	0.330	0.360	0.352	0.307
2017	0.243	0.288	0.305	0.331	0.323	0.291
2018	0.158	0.208	0.238	0.262	0.232	0.235
Average	0.359	0.404	0.421	0.418	0.450	0.417
β_3	0.249	0.233	0.229	0.195	0.242	0.235
R^2	0.977	0.964	0.962	0.959	0.937	0.959

3.3. Discussion

The six dynamic factors are grouped into three categories: finance, business, and strategy. These categories reflect changes in both PV and PR. When β_3 increases, PV and PR also improve, which naturally boosts firm performance (see (3)). Figures 1 to 6 visually show how PR fluctuates. In the financial category (ROE and ROA), Figure 1 shows Telkom's PR fluctuations both visually and in numbers (see Tables 2 and 6). After applying the β_3 engineering process, Telkom's ROE-based β_3 increased by an average of 15.9%, and ROA-based β_3 increased by 10.4%.

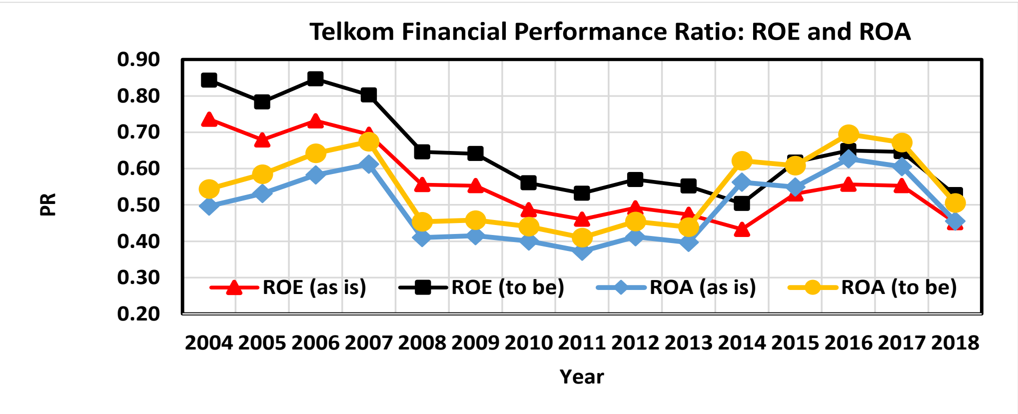

Figure 1. Telkom financial performance ratio: ROE and ROA

Similarly, Figures 2 and 3 show the PR fluctuations for the business and strategic categories. In the business category, the average β_3 increase was 17.1% for Tobin's Q and 13.7% for MTBV. In the strategic category, β_3 increased by 14.8% for EVA and 16.0% for MVA. XL shows a similar performance to Telkom. Figure 4 displays the fluctuations in XL's financial PR for ROE and ROA, both visually and in the data shown in Tables 4 and 8. After applying the β_3 engineering process, XL's ROE-based PR increases by an average of 8.9%, while its ROA-based PR increases by an average of 18.6%. Figures 5 and 6 show similar results for XL's business and strategic categories, both visually and in the data from Tables 4 and 8. In the business category, β_3 increases by an average of 18.5% for Tobin's Q and 18.6% for MTBV. In the strategic category, β_3 increases by 29.1% for EVA and 19.5% for MVA.

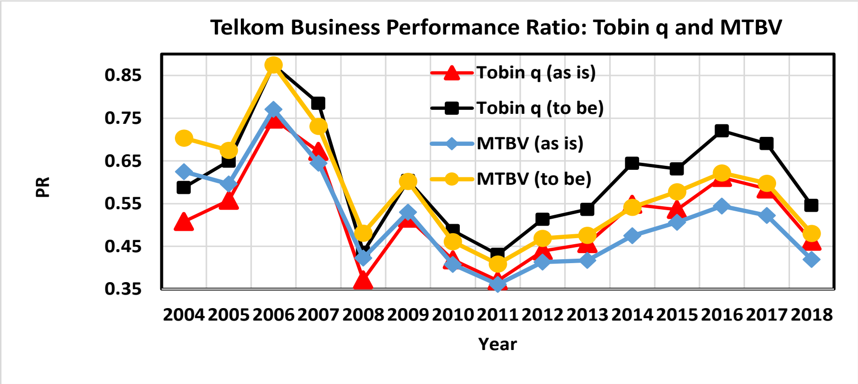

Figure 2. Telkom business performance ratio: Tobin's Q and MTBV

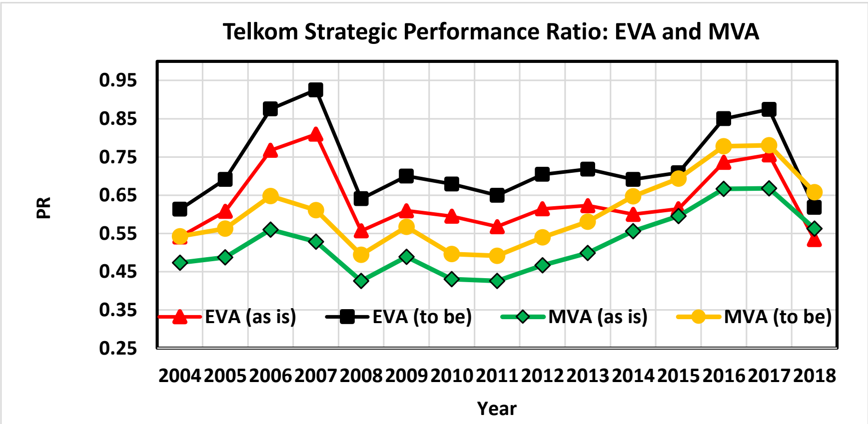

Figure 3. Telkom strategic performance ratio: EVA and MVA

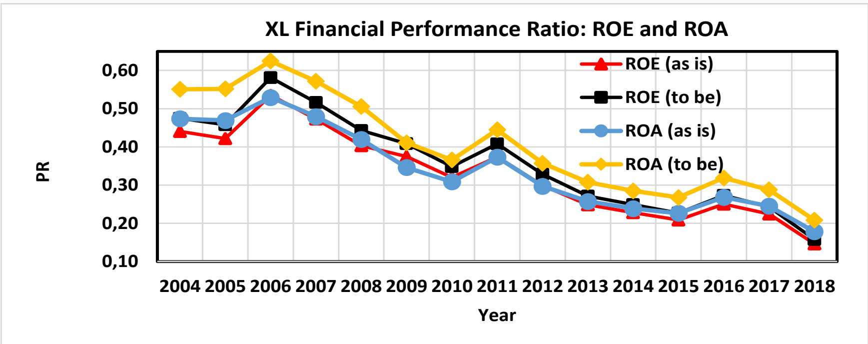

Figure 4. XL financial performance ratio: ROE and ROA

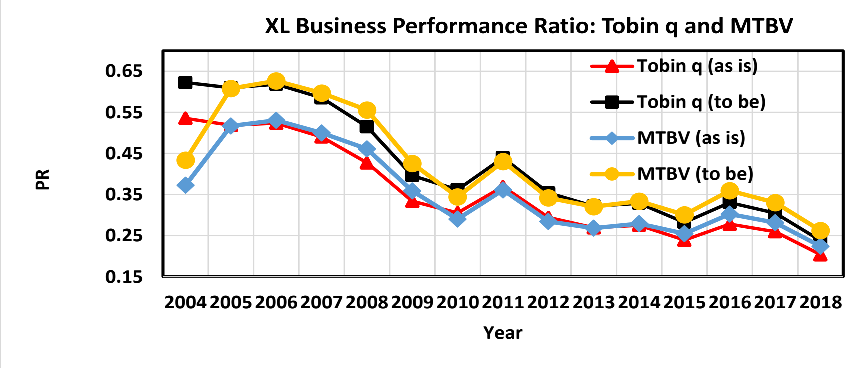

Figure 5. XL business performance ratio: Tobin's Q and MTBV

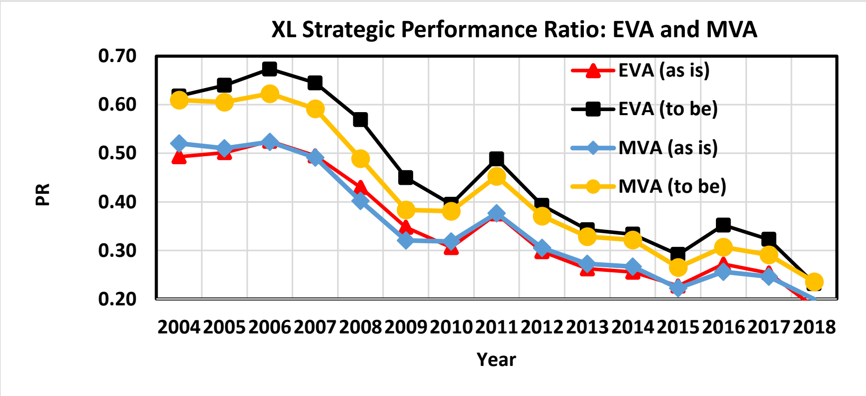

Figure 6. XL strategic performance ratio: EVA and MVA

In summary, Telkom's results show that the β_3 engineering process increases β_3 in the financial category by 7.39%, which leads to an average increase of 13.5% in PV and 13.1% in PR. In the business category, β_3 rises by 9.6%, causing PV to increase by 15.7% and PR by 15.4%. In the strategy category, β_3 increases by 7.6%, resulting in similar gains: a 15.7% rise in PV and a 15.4% rise in PR. For XL, the β_3 engineering process increases β_3 in the financial category by 6.8%, leading to average increases of 13.9% in PV and 13.8% in PR. In the business category, β_3 rises by 10.5%, which increases PV by 18.8% and PR by 18.6%. In the strategy category, β_3 increases by 12.0%, raising PV by 24.7% and PR by 24.3%.

These results show that the three business categories financial, business, and strategic can improve performance when IT investment is supported by adjusting IT production elasticity (β_3), while keeping the model reliable as shown by the R^2 value. Figure 7 illustrates this idea as a framework for helping firms develop IT-based business solutions at lower cost within a set budget. In short, Figure 7 shows the company's current IT-based position ("as-is") and how engineering efforts can move it toward a better future position ("to-be"). When compared with global examples, the improvements seen in Telkom and XL are similar to international trends. Brynjolfsson and Hitt reported that U.S. firms adopting IT-based production systems achieved productivity elasticity gains of 10–20% [4], [35]. Japan's NTT DoCoMo increased EVA by 18–22% and MVA by 15–19% through IT investment. Likewise, European telecom companies like Deutsche Telekom and Vodafone recorded PV increases of 12–20% after strengthening their IT capital [38].

In this context, Telkom's PV increases (13.5–15.7%) and XL's PV increases (13.9–24.7%) match and in some cases exceed international benchmarks. XL's strategic improvements, such as a 29.1% rise in EVA and a 19.5% rise in MVA, even outperform averages reported in Organisation for Economic Co-operation and Development (OECD) telecom studies. This shows that Indonesia's results not only follow global trends but also demonstrate a stronger impact from IT elasticity engineering in strategy-related performance [38], [39]. Thus, grouping the results into finance, business, and strategy confirms that both Telkom and XL are improving their current "as-is" positions through β_3 adjustments and remain competitive with global industry standards. This supports the use of the IT-based business positioning framework (Figure 7) to guide cost-efficient and performance-focused IT investment decisions.

We can also discuss several managerial implications from this study: (a) IT investments improve firm performance. Both Telkom and XL show increases in PV and PR when IT elasticity (β_3) is raised. This proves that IT is not just a cost, but a key driver of financial, business, and strategic performance [40]; (b) stronger justification for IT budgets. Since higher IT elasticity leads to significant performance gains (up to +16% for Telkom and +29% for XL), managers have solid, data-based reasons to allocate more funding to IT projects, especially those supporting productivity, digital infrastructure, and customer experience [37], [41]; (c) better financial performance. Financial indicators like ROE and ROA improve when IT elasticity increases (Telkom: +13.5% PV, XL: +13.9% PV). This means IT investment can help raise shareholder value and investor confidence [42]; (d) support for business growth and competitiveness. Business-related measures such as Tobin's Q and MTBV also rise with higher β_3 (Telkom: +15.7%, XL: +18.8%). This shows IT investment helps improve market valuation and strengthens the company's competitive position [40], [42]; (e) strategic value creation. Strategic indicators like EVA and MVA show large increases (Telkom: +15–16%, XL: up to +29.5%). This means IT acts as a long-term strategic tool that helps the company create more economic value and increase market capitalization [15].

Additional managerial implications include: (f) better performance monitoring using IT metrics. Figure 7 shows that IT elasticity can be adjusted to move a company from its current ("as-is") to its desired ("to-be") performance level. Managers can use IT-based dashboards to track financial, business, and strategic indicators and ensure IT investments support business goals [17], [37]; (g) greater confidence in IT projects. The high R^2 values (above 0.90) indicate strong reliability in the model's results. This gives managers more confidence when presenting IT investment plans to executives or stakeholders [37]; (h) using IT engineering for continuous improvement. The results show that performance improves whenever IT elasticity (β_3) is adjusted. Managers can adopt an "IT elasticity engineering" approach regularly reviewing and fine-tuning IT investments to maintain steady performance growth [40], [42]; (i) applicability across different firms. Both Telkom (a large incumbent) and XL (a challenger) benefit from IT elasticity improvements, though at different levels. This means the framework can be used by companies of various sizes and industries to achieve similar performance gains [17]; and (j) a practical strategy framework for IT-driven business planning. The IT-based business positioning system (Figure 7) offers a useful tool for assessing current performance and planning future IT-supported growth. Managers can use it to align IT spending with strategic goals, ensuring both efficiency and competitive strength [37].

This paper has several limitations. First, it only applies to IT-based firms whose IT capital makes up at least 20% of their total capital. If IT capital is below 20%, the formulas used in this study may not work properly. Second, it is difficult to find data that shows a firm's performance without the influence of IT capital. As a result, the calculations cannot fully separate the value created by IT from the value that would exist without IT.

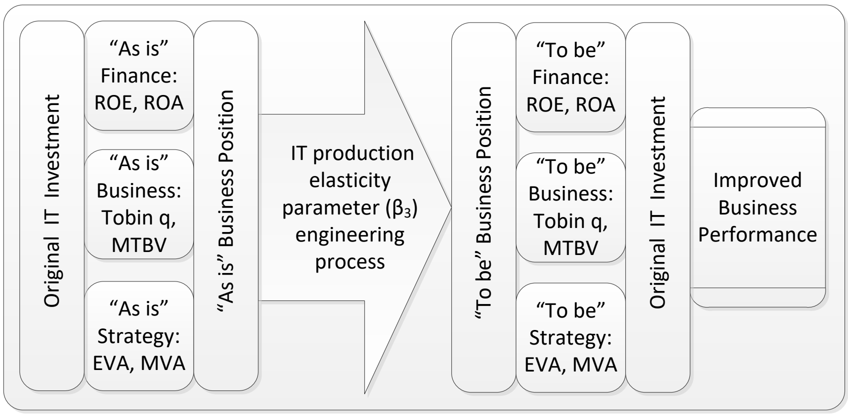

Figure 7. IT-based business positioning system's framework

4. CONCLUSION

In essence, the PAV valuation method facilitates an understanding of the existence of IT value in an IT-based firm. Furthermore, within the PAV, there is a production function, such as the Cobb-Douglas function, which enables the IT variable engineering process to operate with IT product elasticity parameters. Thus, the study has convinced us that through an engineering effort to optimize these parameters of the firm's dynamic factors, the firm's performance can be technically enhanced. Additionally, the exhausted dynamic factors consist of three categories: finance, business, and strategy, in this research. Therefore, to simplify this study on a practical level, it is necessary to realize it within a framework called the IT-based business positioning system framework to ensure accurate operation. In turn, this means that an engineering effort at the technical level requires tactical and managerial translations at the real-world level.

This research is currently limited to the laboratory scale; field testing has not been conducted. However, the data used is field data. This deficiency is primarily related to the ability to convey mathematical theoretical conditions to real-world conditions in the field, as a managerial impact of theory. Thus, for scientific contribution, this study advances the literature on IT value by embedding the Cobb–Douglas production function within the PAV method. Unlike conventional IT valuation studies that treat IT investment as a cost, this approach explicitly models IT production elasticity (β_3) as a parameter that can be engineered to optimize firm performance. In doing so, the research bridges the gap between production theory and IT valuation, offering a quantitative pathway to map dynamic factors finance, business, and strategy into measurable improvements in PV and PR. This provides a rigorous methodological foundation for future studies on IT elasticity and firm competitiveness.

However, from a practical contribution, the study introduces the IT-based business positioning system Framework, which translates technical parameter optimization into actionable managerial insights. Managers can use the framework to (i) identify their firm's "as-is" IT performance position, (ii) apply elasticity-based engineering to simulate "to-be" improvements, and (iii) integrate the results into cost leadership and sustainability strategies. This equips decision-makers with a structured tool to justify IT investments not merely as expenses, but as drivers of financial, business, and strategic advantage. In addition, the value of this paper lies in its contribution to science by extending production and valuation theory into the IT domain through PAV, and its contribution to practice by providing managers with a systematic framework to align technical optimization with strategic execution.

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AUTHOR CONTRIBUTIONS STATEMENT

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Candiwan Candiwan		✓				✓		✓	✓	✓	✓	✓		

C : **C**onceptualization	I : **I**nvestigation	Vi : **Vi**sualization
M : **M**ethodology	R : **R**esources	Su : **Su**pervision
So : **So**ftware	D : **D**ata Curation	P : **P**roject administration
Va : **Va**lidation	O : Writing - **O**riginal Draft	Fu : **Fu**nding acquisition
Fo : **Fo**rmal analysis	E : Writing - Review & **E**diting	

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

For the case studies, the data obtained from https://www.telkom.co.id/sites/hubungan-investor/id_ID/page/laporan-1025 and https://www.xlaxiata.co.id/id/ruang-investor/laporan-tahunan – this statement is mandatory.

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